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# Conceptual Site Based Stormwater Management Plan

**RIVA VUE ESTATE**

PLANNING PROPOSAL

STAGE 4

**NEWLAND DEVELOPERS PTY LTD**

NOVEMBER 2011

REVISION 03


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# 1 Introduction

## 1.1 Background and Philosophy

Yeats Consulting Pty Ltd (Yeats) has been engaged by Newland Developers Pty Ltd to undertake a Site Based Stormwater Management Plan for Stage 4 of the Riva Vue Estate located at Barnby Street, Murwillumbah, within the local authority of Tweed Shire Council (TSC).

This plan addresses the proposed stormwater management strategy, including:

- Pre and post development flows for the 5 and 100 year return interval storms;
- Preliminary design of Stormwater Management systems; and
- Nomination of the legal points of discharge.

## 1.2 Site Description

### 1.2.1 Location

| | |
|---|---|
| Street Address - | Rous River Way, Murwillumbah (Refer Figure 1.1) |
| RP Description - | Part Lot 332 DP 1158142 |
| Site Area - | 10.80 Ha |
| Proposed Use - | Residential |
| Local Authority - | Tweed Shire Council (TSC) |

Refer to Figure 1.1 for the site location.

### 1.2.2 Topography

The existing site is predominantly grassed open space; it comprises of an elevated ridge with scattered vegetation to the south but is predominantly low lying land. The site grades away from Rous River Drive, towards the Rous River to the north. One existing natural gully currently traverses the centre of the site. Additionally, an existing open drain crosses the subject site adjacent to the north-western boundary and directs the up-stream stormwater run-off towards the Rous River. The site reaches a maximum RL of approximately 15.5m to the south adjacent to the northern side of the Rous River Way and a minimum RL of approximately 1.0m within the open drain at the north-eastern corner.

Existing stormwater run-off is currently conveyed overland towards the northern boundary and into the open drain before discharging into the Rous River.

Refer to Figure 1.2 for the existing aerial view.


Figure 1.1 Site Location (Source: Google Maps)


Figure 1.2 Site Aerial Photo (Source: Google Maps)

# 2 Proposed Development

The proposal is for a rezoning/planning proposal on Lot 332 on DP1158142. The development is part of a master plan for Riva Vue Estate and is a continuation of an existing approval for 96 allotments spread over three stages.

Refer to Appendix A for a conceptual development layout that has been provided for information purposes only and is subject to detailed design and survey.

# 3 Hydrology

## 3.1 Hydrologic Objectives

Hydrologic objectives for the site have been set in accordance with Tweed Shire Council Development Design Specification D5, Section D5.02, and the Queensland Urban Drainage Manual (QUDM), including but not limited to:

- To ensure that inundation of private and public buildings located in flood-prone areas occurs only on rare occasions and that, in such events, surface flow routes convey floodwaters below the prescribed velocity/depth limits;
- To provide convenience and safety for pedestrians and traffic in frequent stormwater flows by controlling those flows within prescribed limits;
- To ensure a development does not drain areas nearby zoned as Wetlands (Environmental Protection);
- No adverse impact on adjoining or downstream properties; and
- The proposed development shall ensure that all stormwater drainage is directed to a Lawful Point of Discharge in accordance with QUDM Section 3.02.

## 3.2 Background

The analysis of surface water runoff from the subject site was performed using the non-linear runoff routing program XP-Rafts.

The XP-RAFTS model involved analysis of separate sub catchments, derivation of various physical properties of the sub catchments and assembly of the sub catchments by way of a nodal network.

Appendix B illustrates the catchment sub-division as used for the XP-Rafts hydrologic modelling.

### 3.2.1 Data Collection

Data sourced and used in this hydraulic impact assessment includes:

- Site specific topographic survey;
- Site visit; and
- Council supplied contour information of the site surrounding area.

### 3.2.2 Design Rainfall

The design rainfall Intensity-Frequency Duration (IFD) data for storm events up to the 100 year Average Recurrence Interval (ARI) flood event were derived based upon the procedures outlined in Book 2 of the Australian Rainfall and Runoff (AR&R) 2001 edition. The design IFD data for the catchment is summarised below in Table 3.1 below.

Table 3.1 IFD Data for Murwillumbah

| 2-Yr ARI Intensities | 50-Yr ARI Intensities | Skewness and Geographical Factors |
|---|---|---|
| ${}^{2}I_{1}$ = 50.11 | ${}^{50}I_{1}$ =93.52 | Skewness, G = 0.05 |
| ${}^{2}I_{12}$ = 11.32 | ${}^{50}I_{12}$ = 25.33 | Geographical Factor, $F_2$ = 4.41 |

| 2-Yr ARI Intensities | 50-Yr ARI Intensities | Skewness and Geographical Factors |
|---|---|---|
| ${}^{2}I_{72}$ = 3.7 | ${}^{50}I_{72}$ = 8.63 | Geographical Factor, $F_{50}$ = 17.07 |

Rainfall temporal patterns used in the XP-Rafts analysis were also prepared in accordance with Australian Rainfall and Runoff (AR&R), 2001 edition.

#### 3.2.3 **XP-Rafts Model Parameters**

Rainfall loss for each sub-catchment was applied using an initial and continuing rainfall loss model. Design loss parameters for the XP-Rafts model were based on guideline values as recommended by Book 3 of Australian Rainfall and Runoff, and other industry standards. The adopted loss parameters applied for the XP-Rafts model are summarised in Table 3.2 below.

Table 3.2 Adopted XP-Rafts Initial and Continuing Loss Parameters

| ARI (years) | Pervious Areas | | Impervious Areas | |
|---|---|---|---|---|
| | Initial Loss (mm) | Continuing Loss (mm) | Initial Loss (mm) | Continuing Loss (mm) |
| 2,5 | 15 | 2.5 | 1 | 0 |
| 10,20 | 10 | 2.5 | 1 | 0 |
| 50, 100 | 0 | 2.5 | 0 | 0 |

#### 3.2.4 **XP-Rafts Model Validation**

Calibration of the XP-Rafts hydrological model was achieved by comparing XP-Rafts flow rates to rational method calculations.

The rational method adopted a $C_{10}$ coefficient of runoff ranging from 0.74 to 0.84, depending on the percentage impervious for the individual catchments, for the pre-development scenario in accordance with Table 4.05.3(a) of QUDM. As shown in Table 3.3, the flows from the rational method are generally comparable to the results obtained from the XP-Rafts model; therefore, the flows generated from the XP-Rafts model have been adopted for the purposes of this assessment.

Refer to Appendix C for the Rational Method calculations.

#### 3.2.5 **Critical Duration Analysis**

Storm durations ranging from 15 minutes to 720 minutes were simulated in the XP-Rafts model analysis to determine design flow estimates.

### 3.3 Hydrologic Analysis

#### 3.3.1 **Pre-development Hydrology**

Percentage impervious figures ranging from 10% to 70% have been adopted for the pre-development catchments depending on their current development. The Pre-development catchment details are presented in Table 3.3 below:

Table 3.3 Pre-development Catchment Details

| Catchment | Total Area (ha) | Average Slope (%) | Pervious Area (ha) | Impervious Area (ha) | Percentage Impervious (%) |
|---|---|---|---|---|---|
| A | 4.74 | 8.4 | 4.2634 | 0.4737 | 10 |
| B | 12.66 | 2.6 | 3.7988 | 8.8639 | 70 |
| C* | 0.83 | 12.8 | 0.2506 | 0.5838 | 70 |
| X1 | 0.51 | 11.7 | 0.2550 | 0.2548 | 50 |
| X2 | 6.52 | 4.3 | 1.9555 | 4.5629 | 70 |
| X3 | 8.10 | 4.1 | 5.6734 | 2.4315 | 30 |
| X4 | 2.16 | 22.3 | 0.6475 | 1.5110 | 70 |
| X5 | 0.70 | 12.3 | 0.2101 | 0.4905 | 70 |
| **TOTAL** | **36.22** | **-** | **17.0543** | **19.1721** | **-** |

**Note: Although Catchment C and a portion of Catchment B is currently undeveloped, they were part of Catchment A in the original Council approved Stormwater Report prepared by Gilbert and Sutherland. As the drainage reserve proposed in the Gilbert and Sutherland report for Catchment A has already been constructed, Catchments B and C were therefore assumed as being developed.*

Pre-development catchment discharges for the 2 and 100 year ARI are presented in Table 3.4 below:

Table 3.4 Pre-development Catchment Discharges

| Catchment | XP-Rafts Results | | Rational Method | |
|---|---|---|---|---|
| | Q5 ($m^3/s$) | Q100 ($m^3/s$) | $C_{10}$ | Q100 Flow ($m^3/s$) |
| A | 1.300 | 2.696 | 0.74 | 3.03 |
| B | 5.067 | 8.021 | 0.84 | 7.22 |
| C | 0.436 | 0.654 | 0.84 | 0.61 |
| X1 | 0.253 | 0.392 | 0.80 | 0.32 |
| X2 | 2.701 | 4.495 | 0.84 | 3.12 |
| X3 | 1.826 | 4.111 | 0.76 | 3.36 |
| X4 | 1.107 | 1.699 | 0.84 | 1.57 |
| X5 | 0.362 | 0.552 | 0.84 | 0.51 |

### 3.3.2 **Post-development Hydrology**

As Catchment A was the only undeveloped catchment modelled in the Pre-developed scenario, this is the only Catchment that has seen an increase in impervious area in the Post-developed scenario. A percentage impervious figure of 70% has been adopted for Catchment A in accordance with QUDM Table 4.05.1 for a Urban Residential - High Density development. The Post -development catchment details are presented in Table 3.5 below:

Table 3.5 Post-development Catchment Details

| Catchment | Total Area (ha) | Average Slope (%) | Pervious Area (ha) | Impervious Area (ha) | Percentage Impervious (%) |
|---|---|---|---|---|---|
| A | 4.94 | 8.4 | 1.4833 | 3.4611 | 70 |
| B | 12.46 | 2.6 | 3.6682 | 8.7871 | 70 |
| C* | 0.83 | 12.8 | 0.2506 | 0.5838 | 70 |
| X1 | 0.51 | 11.7 | 0.2550 | 0.2548 | 50 |
| X2 | 6.52 | 4.3 | 1.9555 | 4.5629 | 70 |
| X3 | 8.10 | 4.1 | 5.6734 | 2.4315 | 30 |
| X4 | 2.16 | 22.3 | 0.6475 | 1.5110 | 70 |
| X5 | 0.70 | 12.3 | 0.2101 | 0.4905 | 70 |
| **TOTAL** | **36.22** | **-** | **17.0543** | **19.1721** | **-** |

Table 3.6 summarises the post-developed peak flow rates for each catchment.

Table 3.6 Post-Development Outlet Flow Summary

| Catchment | XP-Rafts Results | |
|---|---|---|
| | Q5 ($m^3/s$) | Q100 ($m^3/s$) |
| A | 2.001 | 3.189 |
| B | 5.021 | 7.939 |
| C | 0.436 | 0.654 |
| X1 | 0.253 | 0.392 |
| X2 | 2.701 | 4.495 |
| X3 | 1.826 | 4.111 |
| X4 | 1.107 | 1.699 |
| X5 | 0.362 | 0.552 |

### 3.3.3 **Flow Increase Due to Development**

The peak discharges for the pre-development and post-development catchments are shown below in Table 3.7.

Table 3.7 Comparison of Pre and Post-Development Discharges

| Catchment | Q5 Flow ($m^3/s$) | | | Q100 Flow ($m^3/s$) | | |
|---|---|---|---|---|---|---|
| | PRE | POST | INCREASE | PRE | POST | INCREASE |
| A | 1.300 | 2.001 | 53.92 | 2.696 | 3.189 | 18.29 |
| B | 5.067 | 5.021 | -0.91 | 8.021 | 7.939 | -1.02 |
| C | 0.436 | 0.436 | 0.00 | 0.654 | 0.654 | 0.00 |
| X1 | 0.253 | 0.253 | 0.00 | 0.392 | 0.392 | 0.00 |
| X2 | 2.701 | 2.701 | 0.00 | 4.495 | 4.495 | 0.00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| X3 | 1.826 | 1.826 | 0.00 | 4.111 | 4.111 | 0.00 |
| X4 | 1.107 | 1.107 | 0.00 | 1.699 | 1.699 | 0.00 |
| X5 | 0.362 | 0.362 | 0.00 | 0.552 | 0.552 | 0.00 |

As can be seen in Table 3.7 above, the proposed development will cause an increase in stormwater flows discharged from Catchment A. This is due to the increase in impervious area and a small increase in total area. Catchment B however shows a small decrease in discharge due to the small reduction in catchment area.

## 3.4 Stormwater Quantity Strategy

It is proposed that no stormwater quantity mitigation measures be implemented for flows discharging from Catchment A. This is due to the fact that the flows will be discharged directly into the Rous River, with the increase in flows being relatively minor compared to the total volume of water flowing in the river. Also, as the flows will be discharged through the proposed open channel, there will be no detrimental effects to the surrounding natural environment caused by the increase in stormwater discharge.

# 4 Trunk Drainage Infrastructure Analysis

## 4.1 Background

In the Memorandum Of Understanding between TSC and the developer, it is noted that the existing open drain in the south-western corner of the site is not functioning as intended. This has led to water ponding within the channel leading to issues such as odours, boggy grounds etc. that have been the focus of complaints from current residents.

## 4.2 Existing Culvert

Currently there are two 1200mm RCP culverts existing beneath Rous River Way located just to the north of the intersection of Rous River Way and Joshua Street. An analysis of this culvert has been carried out utilising the computer program CulvertW. As part of this analysis a tailwater level of 4.7m was assumed, determined form a flood analysis undertaken by Yeats Consulting for the Riva Vue development. The analysis has shown that the existing culvert can convey the entire Q100 flow from the upstream Catchment, X3, without overtopping the road.

Please refer to Appendix F for the CulvertW results.

## 4.3 Proposed Works

As mentioned above, the existing open drain in the south-west corner of the site is not performing as intended leading to complaints from local residents. Therefore, as part of the Stage 4 works, it is proposed to reconstruct this drain to ensure that it functions effectively. Please refer to the Stormwater Management Layout in Appendix D for the indicative location of the reconstructed drainage channel.

Further analysis of the culvert and drainage channel will be conducted at the Development Application stage of the development to ensure that they have the capacity to cater for stormwater flows from both the upstream catchments and the subject site.

# 5 Stormwater Quality Management Plan

## 5.1 Introduction

A stormwater quality assessment for the subject site has been previously completed by Gilbert and Sutherland, as part of the existing approval for 96 allotments to the east. Therefore the following strategy only addressed any variations from the original, council approved stormwater quality management plan.

## 5.2 Relevant Water Quality Objectives

It is understood that the Tweed Shire Council are currently in the process of reviewing their stormwater quality approach and water quality objectives (WQOs). Accordingly, MUSIC modelling has been undertaken to provide an assessment of the treatment effectiveness of the proposed treatment train.

The current TSC water quality objectives for urban development are specified in Table 5.4 of the TUSQMP. These objectives are reproduced in Table 5.1:

Table 5.1 TSC Load Reduction Objectives (LRO’s)

| Pollutant Types | Dry Year | Average Year | Wet Year |
|---|---|---|---|
| Total Suspended Solids (TSS) | 120kg/ha/yr | 300kg/ha/yr | 400kg/ha/yr |
| Total Phosphorous (TP) | 0.35kg/ha/yr | 0.80kg/ha/yr | 1.10kg/ha/yr |
| Total Nitrogen (TN) | 1.5kg/ha/yr | 4.5kg/ha/yr | 6.0kg/ha/yr |

Development applications must demonstrate that these objectives will be achieved, but it is recognised that the above water quality objectives are near impossible to accomplish.

The Water by Design “Design Objectives for Water Management” are considered to be best practise for water quality treatment in the industry and is endorsed by numerous Local and State Government agencies. These design objectives and adopted targets for stormwater quality management are as follows:

Table 5.2 Water by Design Load Reduction Objectives (LRO’s)

| Pollutant Types | Site Water Quality Objective |
|---|---|
| Total Suspended Solids (TSS) | 80% Reduction |
| Total Phosphorous (TP) | 60% Reduction |
| Total Nitrogen (TN) | 45% Reduction |
| Gross Pollutants > 5mm | 90% Reduction |

Therefore, the Water by Design objectives should be adopted for the basis of the water quality design for the proposed development as it is achievable, practicable and meaningful. It shall also be noted that all South East Queensland Council’s, including neighbouring Gold Coast City Council, refer to the Water by Design “Design Objectives for Water Management” and the above water quality objectives/targets.

## 5.3 Stormwater Quality Catchments

The stormwater quality catchments adopted for the MUSIC modelling were in line with the original council approved stormwater quality strategy prepared by Gilbert and Sutherland.

Within their strategy, Gilbert and Sutherland identified two stormwater quality catchments. Catchment A mainly comprised of Stages 1-3 and part of Stage 4, while Catchment B contained the remainder of Stage 4, as well as the proposed drainage reserve and public open space. As part of the original strategy two constructed wetlands (Pond 1 and Pond 2), for Catchments A and B respectively were proposed, as stormwater quality treatment measures.

Appendix E shows DWG. GJ0322.1.5: Catchment Boundaries and Stormwater Treatment Measures prepared by Gilbert and Sutherland.

As pond 1 has already been constructed as part of the existing approval for 96 allotments (Stages 1-3), the areas draining to this pond will not be covered in this report. Therefore Catchment A has remained unchanged, while the original Catchment B has been revised. Refer Appendix B for both the original and the revised catchment boundaries.

Based on the above information the strategy proposed within this report shall address the stormwater quality of the revised Catchment B (Catchments B1 and B2) only.

## 5.4 Proposed Treatment Measures

The adopted treatment measures for the proposed development are detailed below:

### 5.4.1 Rainwater Tanks

It is proposed to utilise rainwater tanks across the proposed development as the primary source of treatment to all roof areas, providing pollution reduction through both sedimentation and reuse.

Rainwater tanks act as a settling tank, allowing the settlement of course sediments and solids which would otherwise have entered that natural water course. The collected roof water will also be re-used for grey water applications, reducing the demand on town water supply. In order to allow for a reduction in the required bio-retention filter area, the rainwater tanks shall comply with the following:

- Minimum 5000 litre capacity;
- Permanent connection to all toilets and laundry cold water;
- Other connections for outdoor use are optional;
- Automatic pressure pump to replenish tank when level falls below 15%; and
- Comply with TSC's 'Rainwater Tanks' policy.

The following table outlines the rainwater and roof catchment properties adopted for the development.

Table 5.3 Rainwater Tank Parameters

| Development/Lot Type | Council Requirements | | Adopted Parameters | |
|---|---|---|---|---|
| | Connected Roof Area | Min. Rainwater Tank Size | Connected Roof Area | Min. Rainwater Tank Size |
| Detached Dwelling | 160m$^2$ min. | 5,000L | 160m$^2$ | 5,000L |

With regard to water reuse, based on the TSC water demand management strategy and previous discussions with TSC, a daily demand of 220 L/ET/day has been adopted for each tank, catering for outdoor use, toilets and cold water washing machines.

#### 5.4.2 Bio-retention Basins

Two bio-retention basins are proposed to treat the pollutant laden stormwater from the development. These basins will be constructed adjacent and offline to the proposed open drain to the north, and shall ensure that water quality objectives are met before entering the open drainage channel.

The bio-retention basins will accept flow from the underground piped drainage system, retain this runoff within an extended detention depth of 0.35m and percolate this water through the filter media (sandy loam topsoil). Filtered stormwater is then recovered at the base of the filter media via a drainage layer containing perforated pipes. The surface of the bio-retention device is to be densely planted out with locally occurring native ground cover species and shrubs. The vegetation should be selected in consultation with a landscape architect and the approved landscaping plans for the site. A typical section of a bio-retention basin is presented in Figure 5.1. Further details of the bio-retention basins proposed within the development site will be included in future Construction Certificate applications.

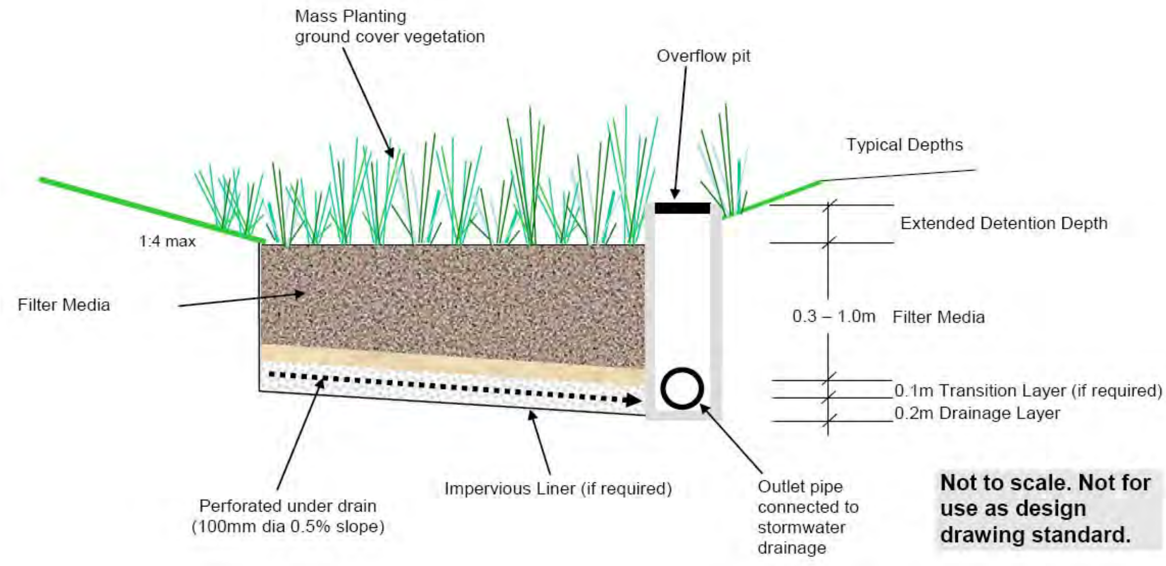



Figure 5.1 Bio-retention Basin – Typical Section

(Source: Healthy Waterways WSUD Technical Design Guidelines)

### 5.5 MUSIC Modelling

The proposed Stormwater Management Layout is shown in Appendix D with details of the modelling procedure described in the following sections.

#### 5.5.1 Meteorological Data

The meteorological data utilised by MUSIC to simulate catchment hydrology processes includes rainfall data (at intervals relevant to the time step being modelled) and average areal potential evapo-transpiration (measured in millimetres per day).

Meteorological data used for the model was the Tweed standard rainfall data – Murwillumbah 58158 (6 minute time step 3/01/1978-31/12/1978) within the Music Model software program.

#### 5.5.2 **Source Nodes**

The Urban source node properties were adopted for all catchments and were obtained from TSC Development Design Specification D7, Section 7.13.3, Table 1 and are tabulated below in Table 5.4:

Table 5.4 Mean EMC Values for Source Nodes

| Mean EMC (mg/L) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Land Use | | TSS | | TP | | TN | |
| | | Storm Flow | Base Flow | Storm Flow | Base Flow | Storm Flow | Base Flow |
| Urban | Mean | 2.000 | 0.800 | -0.680 | -1.00 | 0.193 | -0.100 |
| | Std Deviation | 0.145 | 0.200 | 0.280 | 0.340 | 0.050 | 0.050 |

The relevant runoff parameters were sourced from the TSC Development Design Specification D7, the parameters can be seen listed below in Table 5.5.

Table 5.5 Runoff Parameters

| Parameter | Urban Land Use |
|---|---|
| Rainfall threshold (mm) | 1 |
| Soil Capacity (mm) | 150 |
| Initial Storage (%) | 25 |
| Field Capacity (mm) | 50 |
| Infiltration Coefficient | 50 |
| Infiltration exponent | 2 |
| Initial Depth (mm) | 50 |
| Daily Recharge Rate (%) | 0.65 |
| Daily Drainage Rate (%) | 0.85 |

### 5.6 **Performance Assessment**

The site has been modelled as a number of Urban Residential source nodes, divided into a roof area and urban area. The roof (Urban) nodes discharged into rainwater treatment devices, and then to bio-retention basins before entering the open drain. The urban areas are discharged directly into bio-retention basins prior to the open drain. MUSIC model parameters were adopted according to the Guidelines for Tweed Shire Council. The parameters adopted for the MUSIC model are outlined in Tables 5.6 and 5.8.

Table 5.6 Adopted MUSIC Model Treatment Node Parameters – Source Data

| Parameter | Value |
|---|---|
| Source Data | |
| Rainfall data setup | Murwillumbah |
| Model time step | 6 Minute |
| Directly connected impervious area | Road |
| Soil properties (Runoff generation parameter) | Urban Residential |

Table 5.7 Development Summary

| Catchment | Detached Dwelling | Roof Area (ha) | Urban Area (ha) | Total Area (ha) |
|---|---|---|---|---|
| B1 | 9 | 0.144 | 0.936 | 1.08 |
| B2 | 48 | 0.768 | 4.042 | 4.81 |

Table 5.8 Adopted MUSIC Model Treatment Node Parameters – Treatment Devices

| Parameter | Value |
|---|---|
| Treatment Devices | |
| TYPICAL BIO-RETENTION DETAILS | Extended Detention Depth = 0.35m (Basin)<br>Filter Depth = 0.6m<br>Filter Median Particle Diameter = 0.45mm<br>Saturated Hydraulic Conductivity = 180mm/hr |
| Bio-Retention Basin B1 | Surface Area = 320m$^2$<br>Filter Area = 256m$^2$ |
| Bio-Retention Basin B2 | Surface Area = 1,280m$^2$<br>Filter Area = 1,024m$^2$ |
| Rainwater Tank Details – Roof B1 | Volume below overflow pipe = 40.5 m$^3$<br>Permanent depth = 0.2m<br>Surface Area = 22.5m$^2$<br>Overflow pipe diameter = 270mm<br>Assumed demand = 2kL/day |
| Rainwater Tank Details – Roof B2 | Volume below overflow pipe = 216 m$^3$<br>Permanent depth = 0.2m<br>Surface Area = 120m$^2$<br>Overflow pipe diameter = 624mm<br>Assumed demand = 10.6kL/day |

## 5.7 Water Quality Objectives Performance

Table 5.9 summarises the load reduction by MUSIC using the WSUD strategy outlined above.

Table 5.9 Mitigated Pollution Export Concentrations

| Parameter | Sources | Residual Load | Reduction (%) |
|---|---|---|---|
| Total Suspended Solids (kg/yr) | 7300 | 998 | 86.3 |
| Total Phosphorous (kg/yr) | 17.6 | 5.48 | 68.8 |
| Total Nitrogen (kg/yr) | 111 | 61.2 | 45.0 |
| Gross Pollutants (kg/yr) | 1530 | 0 | 100.0 |

As Tables 5.9 illustrates, the water quality load based reduction objectives from the Water by Design guidelines of 80% for Total Suspended Solids, 60% for Total Phosphorous, 45% for Total Nitrogen and 90% for Gross Pollutants have been achieved for the proposed development. The MUSIC Modelling schematic and pollutant concentration results are presented in Appendix G.

As described in Section 5.2 of this report, the current TSC water quality objectives for urban development are considered to be impracticable and are near impossible to accomplish. The Water by Design "Design Objectives for Water Management" are considered to be best practice for water quality treatment in the industry and is endorsed by numerous Local and State Government agencies.

We believe the proposed method of water quality treatment demonstrates the most meaningful solution and requires minimal ongoing maintenance by Council and provides a high level of stormwater treatment.

# 6 Monitoring and Maintenance

## 6.1 Monitoring

A monitoring program, including reporting, will be established to determine the pollutant removal efficiencies of the proposed treatment devices, as per section D7.A12 of the TSC Development Design Specification - D7 Stormwater Quality.

## 6.2 Maintenance

Proper maintenance of the bio-retention basins is critical in ensuring that filtering capacity of the system will not be reduced. This will be primarily achieved by maintaining complete vegetation covering of the soil throughout the length or area of the system, and prevent activities that could compact the soil and limit the infiltration rate of water through it. Other maintenance works will include:

- Watering, replanting and weeding to maintain vegetation cover especially during establishment;
- Mowing of the grassed surface;
- Removal of litter and debris from the bio-retention basin surface; and
- Checking for channelling or erosion.

Maintenance works, including but not limited to the collection of litter, mowing and maintenance of the buffer strips, will be the responsibility of the property owners and will be undertaken on a regular basis. Major stormwater systems including the proposed drainage channel and piped stormwater network shall be owned and maintained by Council.

In order to ensure the integrity and durability of the treatment devices in the early stages of the development, it is proposed to turf the bio-retention basins temporarily to cater for the house construction phases of the project. Once the house construction phase reaches 90% complete for the contributing treatment device catchment, the temporary turf will be removed and the bio-retention basins will be completed by the developer, with the nominated vegetation and surface works.

# 7 Summary and Conclusion

A conceptual stormwater management strategy has been developed to manage potential impacts from the proposed Stage 4 of the Riva Vue Estate residential development located Barnby Street, Murwillumbah.

The stormwater management strategy has the following components:

- No onsite detention is proposed due to the proximity to the Rous River and the relatively minor increase in Stormwater discharge from the post-developed site;
- Construction of a piped drainage system to cater for the minor 5 year ARI storm;
- Ensure overland flow paths are able to accommodate the major 100 year ARI storm;
- Provide a temporary drainage channel through the site, within the future road reserve and ensure adequate capacity during future detail design; and
- Deemed to Comply stormwater quality treatment measures incorporating roof water tanks and bio-retention basins utilised to treat flows before discharging from the subject site to the Rous River.

It is considered that the development of the site, with the implementation of the stormwater management strategy developed in this report, will result in no worsening in drainage conditions upstream or downstream of the site.

# 8 References

Healthy Waterways, Water Sensitive Urban Design, Technical Design Guidelines for South East Queensland, Version 1 June 2006.

Tweed Shire Council, 2000, Tweed Urban Stormwater Quality Management Plan.

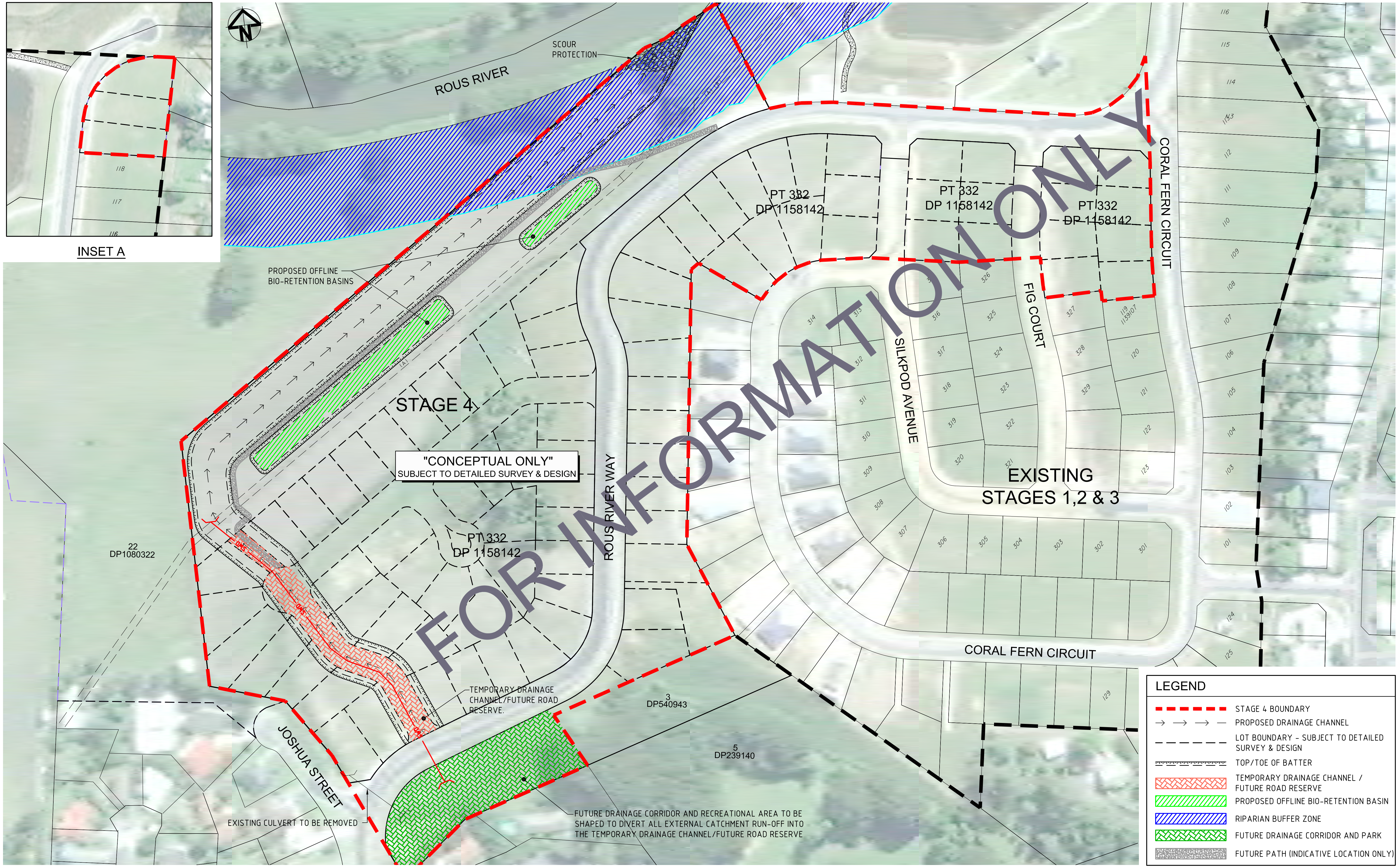
Tweed Shire Council, 2005, Development Design Specification D7 – Stormwater Quality, Version 1.3

"Queensland Urban Drainage Design Manual (QUDM)", Volume 1, Second Edition 2007

Gilbert & Sutherland Pty Ltd, 2004, "Acid Sulphate Soil Assessment and Management Plan, Stormwater Management Plan. Erosion and Sedimentation Control Plan, Agricultural Suitability Assessment and Preliminary Site Contamination Assessment", for the proposed Residential Development, Barnby Street, Murwillumbah.

Appendix A

# Stage 4 Concept Plan




STATUS PRELIMINARY — NOT FOR CONSTRUCTION

| REV | DESCRIPTION | DRAWN | DATE |
|---|---|---|---|
| B | GENERAL AMENDMENTS | K.E. | 22.11.11 |
| A | ORIGINAL ISSUE | T.W. | 02.11.11 |



DRAWING IS NOT TO BE SCALED

SCALE (AT ORIGINAL SHEET SIZE)
SCALE 10 0 10 20 30 40 50 1:1000
ORIGINAL SHEET SIZE A1

CLIENT NEWLAND DEVELOPERS PTY LTD

PROJECT RIVA VUE ESTATE - STAGE 4
MURWILLUMBAH, NSW 2484

YEATS CONSULTING ENGINEERS
LEVEL 1, 193 FERRY ROAD SOUTHPORT QLD 4215 AUSTRALIA
T 07 5571 2232 F 07 5503 1672 info@yeats.com.au www.yeats.com.au

# STAGE 4 CONCEPT PLAN

| TASK | BY | INITIAL | DATE |
|---|---|---|---|
| REVIEW | A.C. | | 02.11.11 |
| DESIGN | T.W. | | 02.11.11 |
| DRAWN | T.W. | | 02.11.11 |

APPROVED — RPEQ No N/A

DRAWING NUMBER YC0291- SK18 — REVISION B

YC0291_SK18 Stage 4 Concept Plan.dwg 24.11.2011 A3 PDF A3 CLR.pc3 Kate Ermolova

Appendix B

# Stormwater Catchment Plans


## CATCHMENT TABLE

| CATCHMENT | AREA (Ha) | IMP. AREA (Ha) |
|---|---|---|
| A | 4.7371 | 0.4737 |
| B | 12.6627 | 8.8639 |
| C | 0.8344 | 0.5838 |
| X1 | 0.5098 | 0.2548 |
| X2 | 6.5184 | 4.5629 |
| X3 | 8.1049 | 2.4315 |
| X4 | 2.1585 | 1.5110 |
| X5 | 0.7006 | 0.4905 |
| TOTAL | 36.2264 | 19.1721 |

## LEGEND

- 20.0 EXISTING CONTOURS (0.5m INTERVALS)
- A CATCHMENT NAME
- CATCHMENT BOUNDARY
- OVERLAND FLOW
- EXISTING DRAINAGE CHANNEL
- STAGE 4 BOUNDARY

STATUS PRELIMINARY NOT TO BE USED FOR CONSTRUCTION

| REV | DESCRIPTION | DRAWN | DATE |
|---|---|---|---|
| C | GENERAL AMENDMENTS | K.E. | 22.11.11 |
| B | GENERAL AMENDMENTS | T.W. | 15.06.11 |
| A | ORIGINAL ISSUE | K.E. | 12.05.11 |



DRAWING IS NOT TO BE SCALED

SCALE (AT ORIGINAL SHEET SIZE) 20 10 0 20 40 60 80 100 1:2000

ORIGINAL SHEET SIZE A1

CLIENT NEWLAND DEVELOPERS PTY LTD

PROJECT RIVA VUE ESTATE MURWILLUMBAH, NSW 2484

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T 07 5571 2232 F 07 5503 1672 info@yeats.com.au www.yeats.com.au

TITLE PRE-DEVELOPED CATCHMENT PLAN

| TASK | BY | INITIAL | DATE |
|---|---|---|---|
| REVIEW | S.W. | | 12.05.11 |
| DESIGN | S.S. | | 12.05.11 |
| DRAWN | K.E. | | 12.05.11 |

APPROVED RPEQ No N/A

DRAWING NUMBER YC0291-SK09 REVISION C


## CATCHMENT TABLE

| CATCHMENT | AREA (Ha) | IMP. AREA (Ha) |
|---|---|---|
| A | 4.9444 | 3.4611 |
| B | 12.4553 | 8.7871 |
| C | 0.8344 | 0.5838 |
| X1 | 0.5098 | 0.2548 |
| X2 | 6.5184 | 4.5629 |
| X3 | 8.1049 | 2.4315 |
| X4 | 2.1585 | 1.5110 |
| X5 | 0.7006 | 0.4905 |
| TOTAL | 36.2263 | 22.0827 |

## LEGEND

- 20.0 EXISTING CONTOURS (0.5m INTERVALS)
- A CATCHMENT NAME
- CATCHMENT BOUNDARY
- OVERLAND FLOW DIRECTION
- EXISTING DRAINAGE CHANNEL
- SITE BOUNDARY
- PROPOSED DRAINAGE CHANNEL
- TOP/TOE OF BATTER
- STAGE 4 BOUNDARY
- LOT BOUNDARY - SUBJECT TO DETAILED SURVEY & DESIGN

RIVA VUE STAGE 4 LAYOUT IS CONCEPTUAL ONLY AND IS SUBJECT TO DETAILED SURVEY & DESIGN

STATUS PRELIMINARY NOT TO BE USED FOR CONSTRUCTION

| REV | DESCRIPTION | DRAWN | DATE |
|---|---|---|---|
| D | DRAINAGE CHANNEL AMENDED | S.P. | 22.11.11 |
| C | DRAINAGE CHANNEL AMENDED | T.W. | 14.06.11 |
| B | CULVERT AMENDED | T.W. | 27.05.11 |
| A | ORIGINAL ISSUE | K.E. | 12.05.11 |



DRAWING IS NOT TO BE SCALED

SCALE (AT ORIGINAL SHEET SIZE)

SCALE 20 10 0 20 40 60 80 100 1:2000

ORIGINAL SHEET SIZE A1

CLIENT NEWLAND DEVELOPERS PTY LTD

PROJECT RIVA VUE ESTATE
MURWILLUMBAH, NSW 2484

YEATS CONSULTING ENGINEERS

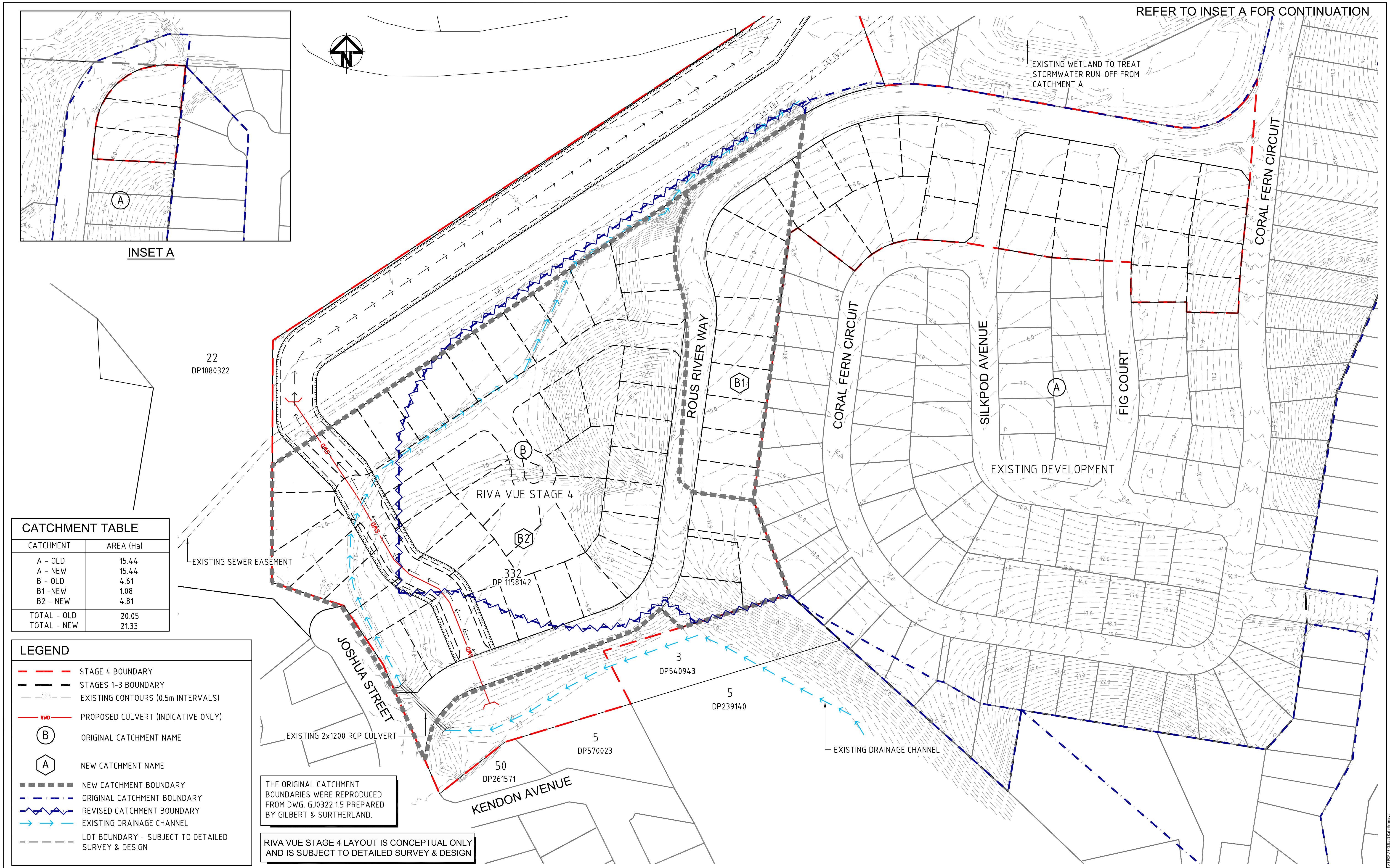
LEVEL 1, 193 FERRY ROAD SOUTHPORT QLD 4215 AUSTRALIA
T 07 5571 2232 F 07 5503 1672 info@yeats.com.au www.yeats.com.au

TITLE POST-DEVELOPED CATCHMENT PLAN

| TASK | BY | INITIAL | DATE |
|---|---|---|---|
| REVIEW | S.W. | | 12.05.11 |
| DESIGN | S.S. | | 12.05.11 |
| DRAWN | K.E. | | 12.05.11 |

APPROVED RPEQ No N/A

DRAWING NUMBER YC0291-SK11 REVISION D




## CATCHMENT TABLE

| CATCHMENT | AREA (Ha) |
|---|---|
| A - OLD | 15.44 |
| A - NEW | 15.44 |
| B - OLD | 4.61 |
| B1 - NEW | 1.08 |
| B2 - NEW | 4.81 |
| TOTAL - OLD | 20.05 |
| TOTAL - NEW | 21.33 |

## LEGEND

- STAGE 4 BOUNDARY
- STAGES 1-3 BOUNDARY
- EXISTING CONTOURS (0.5m INTERVALS)
- PROPOSED CULVERT (INDICATIVE ONLY)
- ORIGINAL CATCHMENT NAME
- NEW CATCHMENT NAME
- NEW CATCHMENT BOUNDARY
- ORIGINAL CATCHMENT BOUNDARY
- REVISED CATCHMENT BOUNDARY
- EXISTING DRAINAGE CHANNEL
- LOT BOUNDARY - SUBJECT TO DETAILED SURVEY & DESIGN

THE ORIGINAL CATCHMENT BOUNDARIES WERE REPRODUCED FROM DWG. GJ0322.1.5 PREPARED BY GILBERT & SURTHERLAND.

RIVA VUE STAGE 4 LAYOUT IS CONCEPTUAL ONLY AND IS SUBJECT TO DETAILED SURVEY & DESIGN

STATUS: PRELIMINARY — NOT TO BE USED FOR CONSTRUCTION

| REV | DESCRIPTION | DRAWN | DATE |
|---|---|---|---|
| C | AMENDED CATCHMENTS | S.P. | 22.11.11 |
| B | GENERAL AMENDMENTS | T.W. | 15.06.11 |
| A | ORIGINAL ISSUE | S.S. | 17.03.11 |



DRAWING IS NOT TO BE SCALED

SCALE (AT ORIGINAL SHEET SIZE) 10 0 10 20 30 40 50 SCALE 1:1000 — ORIGINAL SHEET SIZE A1

CLIENT: NEWLAND DEVELOPERS PTY LTD

PROJECT: RIVA VUE ESTATE MURWILLUMBAH, NSW 2484

YEATS CONSULTING ENGINEERS
LEVEL 1, 193 FERRY ROAD SOUTHPORT QLD 4215 AUSTRALIA
T 07 5571 2232 F 07 5503 1672 info@yeats.com.au www.yeats.com.au

TITLE: STORMWATER QUALITY CATCHMENT BOUNDARIES

| TASK | BY | INITIAL | DATE |
|---|---|---|---|
| REVIEW | S.W. | | 17.03.11 |
| DESIGN | S.S. | | 17.03.11 |
| DRAWN | S.S. | | 17.03.11 |

APPROVED — RPEQ No N/A

DRAWING NUMBER: YC0291-SK08 — REVISION: C

Appendix C

# Rational Method Calculations

# RATIONAL METHOD CALCULATIONS

| | |
|---|---|
| Project: | Riva Vue |
| Date: | 13-May-11 |
| Designed: | K.Ermolova |
| Comments: | Pre Developed Catchment |

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| PARAMETERS | VALUE | |
|---|---|---|
| Catchment Name | X1 | |
| Catchment Size | 0.51 | ha |
| C10 Coefficient of Runoff | 0.80 | |

**Equal Area Calculation** Equation 5.05.03 from QUDM

| | | |
|---|---|---|
| Area under slope | 1735.0522 | m2 |
| Length (km) of flow path from catchment divide to outlet **(L)** | 172.22 | m |
| Equivalent Height of Triangle | 20.15 | m |
| Equal Area Slope | 117.00 | m/km |

**Bransby-Williams' Equation** Equation 5.05.03 from QUDM

| | | |
|---|---|---|
| Length (km) of flow path from catchment divide to outlet **(L)** | 0.17 | km |
| Equal Area Slope of stream slope path **(S)** | 117.00 | m/km |
| Factor of proportionality (F) | 92.7 | |
| Time of concentration **(tc)** | **6.6** | **mins** |

**Total Time of Concentration** Overland flow tc (E12) + Stream flow tc (E20)

| | | |
|---|---|---|
| Total time of Conentration **(tc)** | **6.6** | **mins** |

**Rational Method for Peak Catchment flow** Q = 0.00278 x C x I x A

| ARI | Rainfall Intensity (mm/h) | Rainfall Depth (mm) | Fy | Coefficient of Runoff | Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 3 month | | | | | 0.04 |
| 1 | 113.80 | 12.50 | 0.67 | 0.54 | 0.09 |
| 2 | 144.16 | 15.83 | 0.81 | 0.65 | 0.13 |
| 5 | 177.18 | 19.46 | 0.92 | 0.74 | 0.18 |
| 10 | 195.62 | 21.48 | 1.00 | 0.80 | 0.22 |
| 20 | 221.19 | 24.29 | 1.07 | 0.86 | 0.27 |
| 50 | 254.20 | 27.91 | 1.01 | 0.81 | 0.29 |
| 100 | 279.05 | 30.64 | 1.02 | 0.82 | 0.32 |

# RATIONAL METHOD CALCULATIONS

| | |
|---|---|
| Project: | Riva Vue |
| Date: | 13-May-11 |
| Designed: | K.Ermolova |
| Comments: | Pre Developed Catchment |

| PARAMETERS | VALUE | |
|---|---|---|
| Catchment Name | X2 | |
| Catchment Size | 6.52 | ha |
| C10 Coefficient of Runoff | 0.84 | |

## Equal Area Calculation

Equation 5.05.03 from QUDM

| | | |
|---|---|---|
| Area under slope | 3945.0298 | m2 |
| Length (km) of flow path from catchment divide to outlet **(L)** | 426.11 | m |
| Equivalent Height of Triangle | 18.52 | m |
| Equal Area Slope | 43.45 | m/km |

## Bransby-Williams' Equation

Equation 5.05.03 from QUDM

| | | |
|---|---|---|
| Length (km) of flow path from catchment divide to outlet **(L)** | 0.43 | km |
| Equal Area Slope of stream slope path **(S)** | 43.45 | m/km |
| Factor of proportionality (F) | 92.7 | |
| Time of concentration **(tc)** | **15.4** | **mins** |

## Total Time of Concentration

Overland flow tc (E12) + Stream flow tc (E20)

Total time of Conentration **(tc)** **15.4 mins**

## Rational Method for Peak Catchment flow

$Q = 0.00278 \times C \times I \times A$

| ARI | Rainfall Intensity (mm/h) | Rainfall Depth (mm) | Fy | Coefficient of Runoff | Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 3 month | | | | | 0.41 |
| 1 | 79.65 | 20.45 | 0.67 | 0.56 | 0.81 |
| 2 | 101.27 | 26.00 | 0.81 | 0.68 | 1.25 |
| 5 | 125.63 | 32.25 | 0.92 | 0.77 | 1.76 |
| 10 | 139.39 | 35.78 | 1.00 | 0.84 | 2.12 |
| 20 | 158.26 | 40.63 | 1.07 | 0.90 | 2.58 |
| 50 | 182.74 | 46.91 | 1.01 | 0.85 | 2.81 |
| 100 | 201.23 | 51.66 | 1.02 | 0.86 | 3.12 |

# RATIONAL METHOD CALCULATIONS

| | |
|---|---|
| Project: | Riva Vue |
| Date: | 13-May-11 |
| Designed: | K.Ermolova |
| Comments: | Pre Developed Catchment |

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| PARAMETERS | VALUE | |
|---|---|---|
| Catchment Name | X3 | |
| Catchment Size | 8.10 | ha |
| C10 Coefficient of Runoff | 0.76 | |

**Equal Area Calculation** — Equation 5.05.03 from QUDM

| | | |
|---|---|---|
| Area under slope | 4583.6015 | m2 |
| Length (km) of flow path from catchment divide to outlet **(L)** | 475.69 | m |
| Equivalent Height of Triangle | 19.27 | m |
| Equal Area Slope | 40.51 | m/km |

**Bransby-Williams' Equation** — Equation 5.05.03 from QUDM

| | | |
|---|---|---|
| Length (km) of flow path from catchment divide to outlet **(L)** | 0.48 | km |
| Equal Area Slope of stream slope path **(S)** | 40.51 | m/km |
| Factor of proportionality (F) | 92.7 | |
| Time of concentration **(tc)** | **17.1** | **mins** |

**Total Time of Concentration** — Overland flow tc (E12) + Stream flow tc (E20)

| | | |
|---|---|---|
| Total time of Conentration **(tc)** | **17.1** | **mins** |

**Rational Method for Peak Catchment flow** — Q = 0.00278 x C x I x A

| ARI | Rainfall Intensity (mm/h) | Rainfall Depth (mm) | Fy | Coefficient of Runoff | Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 3 month | | | | | 0.44 |
| 1 | 75.90 | 21.58 | 0.67 | 0.51 | 0.87 |
| 2 | 96.54 | 27.45 | 0.81 | 0.62 | 1.34 |
| 5 | 119.92 | 34.10 | 0.92 | 0.70 | 1.89 |
| 10 | 133.15 | 37.86 | 1.00 | 0.76 | 2.28 |
| 20 | 151.26 | 43.01 | 1.07 | 0.81 | 2.77 |
| 50 | 174.75 | 49.69 | 1.01 | 0.77 | 3.02 |
| 100 | 192.52 | 54.74 | 1.02 | 0.78 | 3.36 |

## RATIONAL METHOD CALCULATIONS

| | |
|---|---|
| Project: | Riva Vue |
| Date: | 13-May-11 |
| Designed: | K.Ermolova |
| Comments: | Pre Developed Catchment |

| PARAMETERS | VALUE | |
|---|---|---|
| Catchment Name | X4 | |
| Catchment Size | 2.16 | ha |
| C10 Coefficient of Runoff | 0.84 | |

### Equal Area Calculation

Equation 5.05.03 from QUDM

| | | |
|---|---|---|
| Area under slope | 429.1478 | m2 |
| Length (km) of flow path from catchment divide to outlet **(L)** | 61.979 | m |
| Equivalent Height of Triangle | 13.85 | m |
| Equal Area Slope | 223.43 | m/km |

### Time of Concentration

Standard Inlet Time

Time of Conentration **(tc)** **5.0 mins**

### Rational Method for Peak Catchment flow

Q = 0.00278 x C x I x A

| ARI | Rainfall Intensity (mm/h) | Rainfall Depth (mm) | Fy | Coefficient of Runoff | Discharge ($m^3$/s) |
|---|---|---|---|---|---|
| 3 month | | | | | 0.21 |
| 1 | 125.51 | 10.46 | 0.67 | 0.56 | 0.42 |
| 2 | 158.84 | 13.24 | 0.81 | 0.68 | 0.65 |
| 5 | 194.73 | 16.23 | 0.92 | 0.77 | 0.90 |
| 10 | 214.70 | 17.89 | 1.00 | 0.84 | 1.08 |
| 20 | 242.49 | 20.21 | 1.07 | 0.90 | 1.31 |
| 50 | 278.32 | 23.19 | 1.01 | 0.85 | 1.42 |
| 100 | 305.27 | 25.44 | 1.02 | 0.86 | 1.57 |

## RATIONAL METHOD CALCULATIONS

| | |
|---|---|
| Project: | Riva Vue |
| Date: | 13-May-11 |
| Designed: | K.Ermolova |
| Comments: | Pre Developed Catchment |

YEATS CONSULTING ENGINEERS

| PARAMETERS | VALUE | |
|---|---|---|
| Catchment Name | X5 | |
| Catchment Size | 0.70 | ha |
| C10 Coefficient of Runoff | 0.84 | |

### Equal Area Calculation

Equation 5.05.03 from QUDM

| | | |
|---|---|---|
| Area under slope | 977.226 | m2 |
| Length (km) of flow path from catchment divide to outlet **(L)** | 125.92 | m |
| Equivalent Height of Triangle | 15.52 | m |
| Equal Area Slope | 123.26 | m/km |

### Time of Concentration

Standard Inlet Time

Time of Conentration **(tc)** **5.0 mins**

### Rational Method for Peak Catchment flow

Q = 0.00278 x C x I x A

| ARI | Rainfall Intensity (mm/h) | Rainfall Depth (mm) | Fy | Coefficient of Runoff | Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 3 month | | | | | 0.07 |
| 1 | 125.51 | 10.46 | 0.67 | 0.56 | 0.14 |
| 2 | 158.84 | 13.24 | 0.81 | 0.68 | 0.21 |
| 5 | 194.73 | 16.23 | 0.92 | 0.77 | 0.29 |
| 10 | 214.70 | 17.89 | 1.00 | 0.84 | 0.35 |
| 20 | 242.49 | 20.21 | 1.07 | 0.90 | 0.42 |
| 50 | 278.32 | 23.19 | 1.01 | 0.85 | 0.46 |
| 100 | 305.27 | 25.44 | 1.02 | 0.86 | 0.51 |

# RATIONAL METHOD CALCULATIONS

| | |
|---|---|
| Project: | Riva Vue |
| Date: | 13-May-11 |
| Designed: | K.Ermolova |
| Comments: | Pre Developed Catchment |

YEATS CONSULTING ENGINEERS

| PARAMETERS | VALUE | |
|---|---|---|
| Catchment Name | A | |
| Catchment Size | 4.74 | ha |
| C10 Coefficient of Runoff | 0.74 | |

**Equal Area Calculation** — Equation 5.05.03 from QUDM

| | | |
|---|---|---|
| Area under slope | 757.9032 | m2 |
| Length (km) of flow path from catchment divide to outlet **(L)** | 134.59 | m |
| Equivalent Height of Triangle | 11.26 | m |
| Equal Area Slope | 83.68 | m/km |

**Bransby-Williams' Equation** — Equation 5.05.03 from QUDM

| | | |
|---|---|---|
| Length (km) of flow path from catchment divide to outlet **(L)** | 0.13 | km |
| Equal Area Slope of stream slope path **(S)** | 83.68 | m/km |
| Factor of proportionality (F) | 92.7 | |
| Time of concentration **(tc)** | **4.4** | **mins** |

**Total Time of Concentration** — Overland flow tc (E12) + Stream flow tc (E20)

| | | |
|---|---|---|
| Total time of Conentration **(tc)** | **5.0** | **mins** |

**Rational Method for Peak Catchment flow** — Q = 0.00278 x C x I x A

| ARI | Rainfall Intensity (mm/h) | Rainfall Depth (mm) | Fy | Coefficient of Runoff | Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 3 month | | | | | 0.41 |
| 1 | 125.51 | 10.46 | 0.67 | 0.50 | 0.82 |
| 2 | 158.84 | 13.24 | 0.81 | 0.60 | 1.25 |
| 5 | 194.73 | 16.23 | 0.92 | 0.68 | 1.74 |
| 10 | 214.70 | 17.89 | 1.00 | 0.74 | 2.09 |
| 20 | 242.49 | 20.21 | 1.07 | 0.79 | 2.53 |
| 50 | 278.32 | 23.19 | 1.01 | 0.75 | 2.74 |
| 100 | 305.27 | 25.44 | 1.02 | 0.75 | 3.03 |

## RATIONAL METHOD CALCULATIONS

| | |
|---|---|
| Project: | Riva Vue |
| Date: | 13-May-11 |
| Designed: | K.Ermolova |
| Comments: | Pre Developed Catchment |

| PARAMETERS | VALUE | |
|---|---|---|
| Catchment Name | B | |
| Catchment Size | 12.66 | ha |
| C10 Coefficient of Runoff | 0.84 | |

**Equal Area Calculation** Equation 5.05.03 from QUDM

| | | |
|---|---|---|
| Area under slope | 3088.2542 | m2 |
| Length (km) of flow path from catchment divide to outlet **(L)** | 488.88 | m |
| Equivalent Height of Triangle | 12.63 | m |
| Equal Area Slope | 25.84 | m/km |

**Time of Concentration** Standard Inlet Time

Time of Conentration **(tc)** **10.0 mins**

**Rational Method for Peak Catchment flow** Q = 0.00278 x C x I x A

| ARI | Rainfall Intensity (mm/h) | Rainfall Depth (mm) | Fy | Coefficient of Runoff | Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 3 month | | | | | 0.95 |
| 1 | 96.36 | 16.06 | 0.67 | 0.56 | 1.91 |
| 2 | 122.28 | 20.38 | 0.81 | 0.68 | 2.93 |
| 5 | 150.94 | 25.16 | 0.92 | 0.77 | 4.10 |
| 10 | 167.03 | 27.84 | 1.00 | 0.84 | 4.94 |
| 20 | 189.23 | 31.54 | 1.07 | 0.90 | 5.98 |
| 50 | 217.95 | 36.32 | 1.01 | 0.85 | 6.50 |
| 100 | 239.60 | 39.93 | 1.02 | 0.86 | 7.22 |

## RATIONAL METHOD CALCULATIONS

| | |
|---|---|
| Project: | Riva Vue |
| Date: | 13-May-11 |
| Designed: | K.Ermolova |
| Comments: | Pre Developed Catchment |

YEATS CONSULTING ENGINEERS

| PARAMETERS | VALUE | |
|---|---|---|
| Catchment Name | C | |
| Catchment Size | 0.83 | ha |
| C10 Coefficient of Runoff | 0.84 | |

### Equal Area Calculation

Equation 5.05.03 from QUDM

| | | |
|---|---|---|
| Area under slope | 224.7762 | m2 |
| Length (km) of flow path from catchment divide to outlet **(L)** | 59.36 | m |
| Equivalent Height of Triangle | 7.57 | m |
| Equal Area Slope | 127.58 | m/km |

### Time of Concentration

Standard Inlet Time

Time of Conentration **(tc)** **5.0 mins**

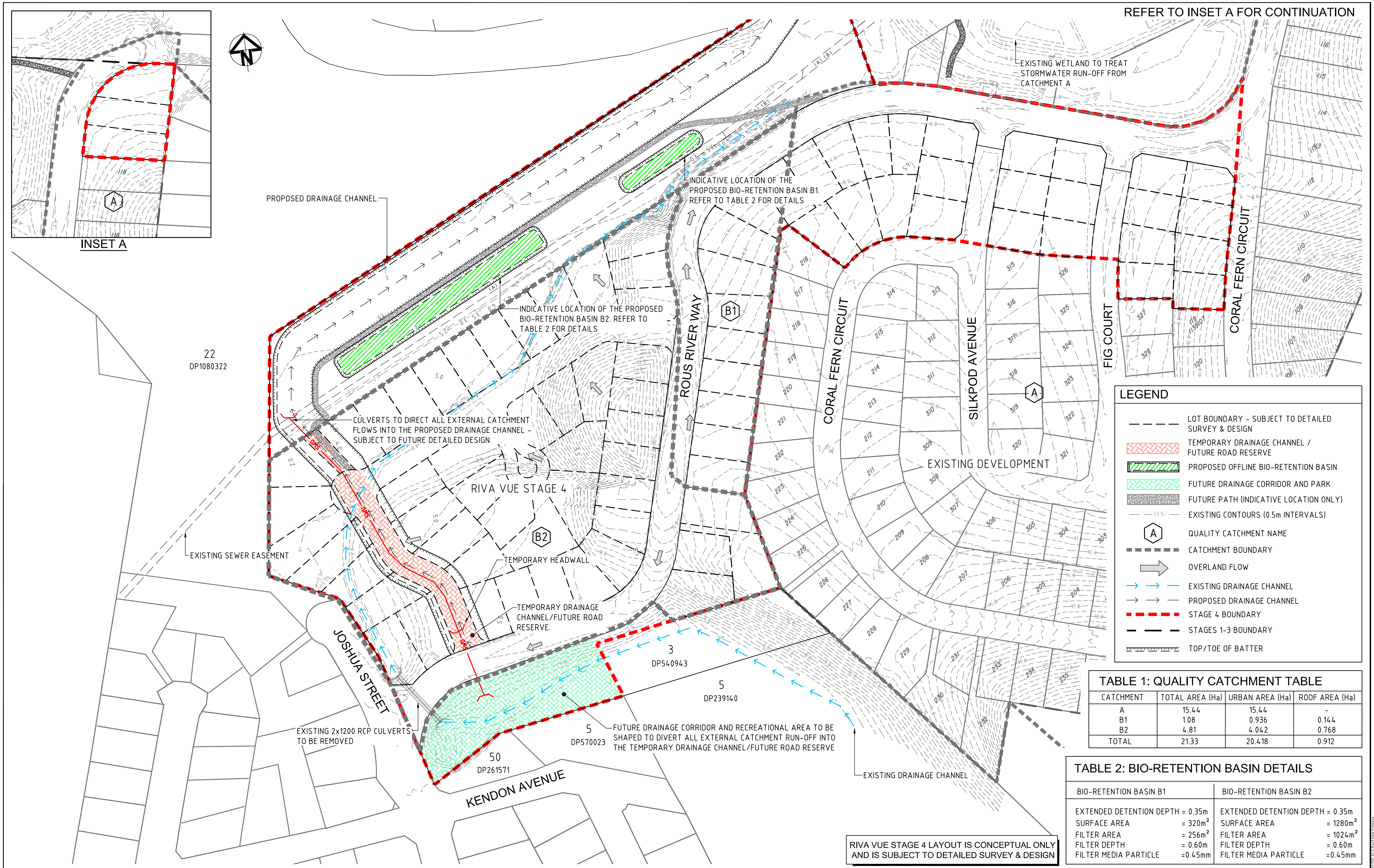
### Rational Method for Peak Catchment flow

Q = 0.00278 x C x I x A

| ARI | Rainfall Intensity (mm/h) | Rainfall Depth (mm) | Fy | Coefficient of Runoff | Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 3 month | | | | | 0.08 |
| 1 | 125.51 | 10.46 | 0.67 | 0.56 | 0.16 |
| 2 | 158.84 | 13.24 | 0.81 | 0.68 | 0.25 |
| 5 | 194.73 | 16.23 | 0.92 | 0.77 | 0.35 |
| 10 | 214.70 | 17.89 | 1.00 | 0.84 | 0.42 |
| 20 | 242.49 | 20.21 | 1.07 | 0.90 | 0.51 |
| 50 | 278.32 | 23.19 | 1.01 | 0.85 | 0.55 |
| 100 | 305.27 | 25.44 | 1.02 | 0.86 | 0.61 |

Appendix D

# Stormwater Management Layout




## LEGEND

- LOT BOUNDARY - SUBJECT TO DETAILED SURVEY & DESIGN
- TEMPORARY DRAINAGE CHANNEL / FUTURE ROAD RESERVE
- PROPOSED OFFLINE BIO-RETENTION BASIN
- FUTURE DRAINAGE CORRIDOR AND PARK
- FUTURE PATH (INDICATIVE LOCATION ONLY)
- EXISTING CONTOURS (0.5m INTERVALS)
- QUALITY CATCHMENT NAME
- CATCHMENT BOUNDARY
- OVERLAND FLOW
- EXISTING DRAINAGE CHANNEL
- PROPOSED DRAINAGE CHANNEL
- STAGE 4 BOUNDARY
- STAGES 1-3 BOUNDARY
- TOP/TOE OF BATTER

## TABLE 1: QUALITY CATCHMENT TABLE

| CATCHMENT | TOTAL AREA (Ha) | URBAN AREA (Ha) | ROOF AREA (Ha) |
|---|---|---|---|
| A | 15.44 | 15.44 | - |
| B1 | 1.08 | 0.936 | 0.144 |
| B2 | 4.81 | 4.042 | 0.768 |
| TOTAL | 21.33 | 20.418 | 0.912 |

## TABLE 2: BIO-RETENTION BASIN DETAILS

| BIO-RETENTION BASIN B1 | | BIO-RETENTION BASIN B2 | |
|---|---|---|---|
| EXTENDED DETENTION DEPTH | = 0.35m | EXTENDED DETENTION DEPTH | = 0.35m |
| SURFACE AREA | = 320m$^2$ | SURFACE AREA | = 1280m$^2$ |
| FILTER AREA | = 256m$^2$ | FILTER AREA | = 1024m$^2$ |
| FILTER DEPTH | = 0.60m | FILTER DEPTH | = 0.60m |
| FILTER MEDIA PARTICLE | =0.45mm | FILTER MEDIA PARTICLE | =0.45mm |

RIVA VUE STAGE 4 LAYOUT IS CONCEPTUAL ONLY AND IS SUBJECT TO DETAILED SURVEY & DESIGN

STATUS: PRELIMINARY — NOT TO BE USED FOR CONSTRUCTION

| REV | DESCRIPTION | DRAWN | DATE |
|---|---|---|---|
| D | AMENDED CATCHMENTS | S.P. | 22.11.11 |
| C | GENERAL AMENDMENTS | T.W. | 15.06.11 |
| B | CULVERT AMENDED | T.W. | 27.05.11 |
| A | ORIGINAL ISSUE | S.S. | 17.03.11 |



DRAWING IS NOT TO BE SCALED

SCALE (AT ORIGINAL SHEET SIZE) 1:1000 — ORIGINAL SHEET SIZE A1

CLIENT: NEWLAND DEVELOPERS PTY LTD

PROJECT: RIVA VUE ESTATE, MURWILLUMBAH, NSW 2484

YEATS CONSULTING ENGINEERS
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T 07 5571 2232 F 07 5503 1672 info@yeats.com.au www.yeats.com.au

TITLE: STORMWATER MANAGEMENT LAYOUT

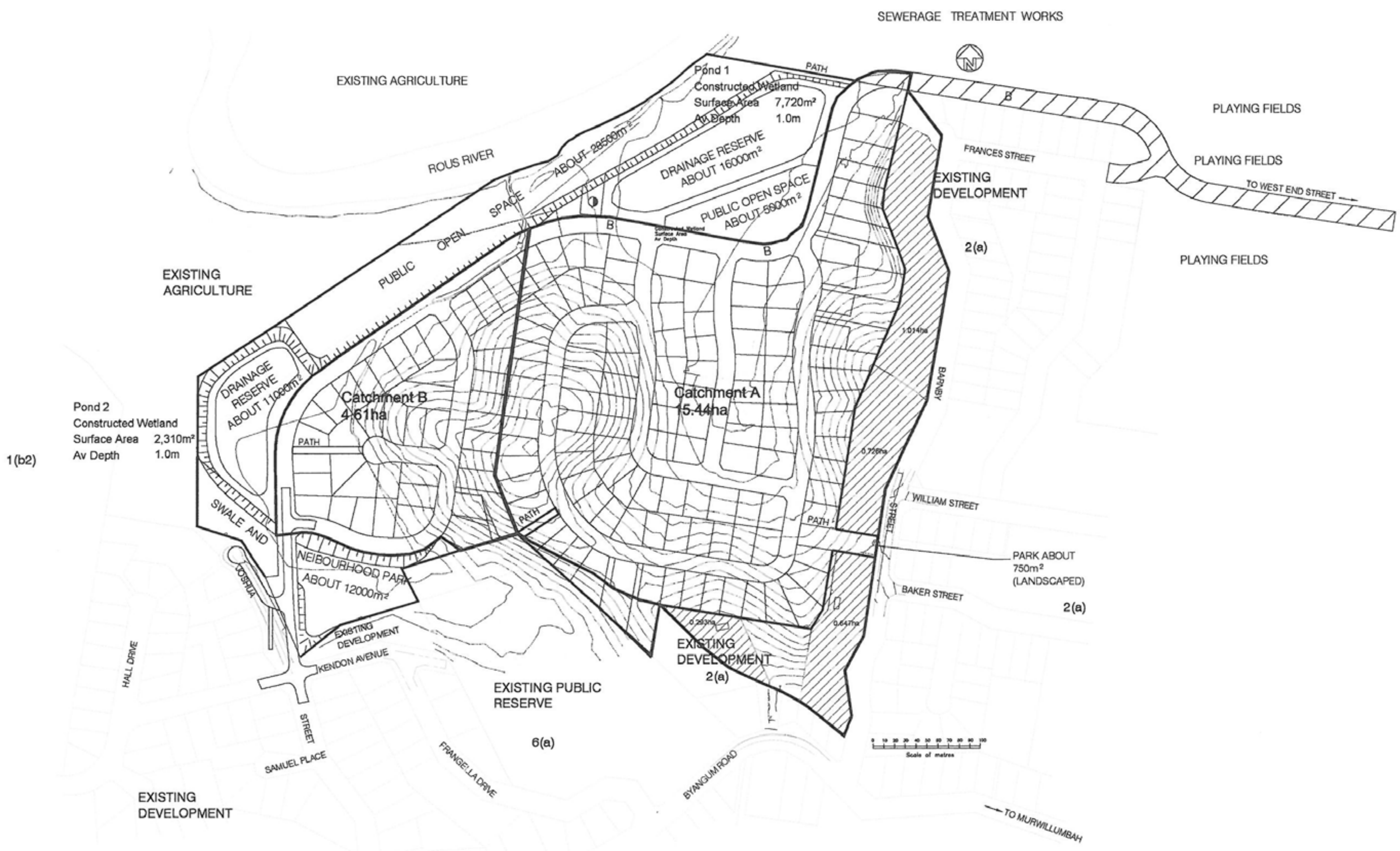
| TASK | BY | INITIAL | DATE |
|---|---|---|---|
| REVIEW | S.W. | | 17.03.11 |
| DESIGN | S.S. | | 17.03.11 |
| DRAWN | S.S. | | 17.03.11 |

APPROVED — RPEQ No N/A

DRAWING NUMBER: YC0291-SK07 — REVISION: D

Appendix E

# Gilbert & Sutherland - Catchment Boundaries and Stormwater Treatment Measures




**Gilbert & Sutherland**
Specialist Soil and Water Scientists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PROJECT
METRICON (QLD) PTY LTD
BARNBY STREET, MURWILLUMBAH
CATCHMENT BOUNDARIES &
STORMWATER TREATMENT MEASURES

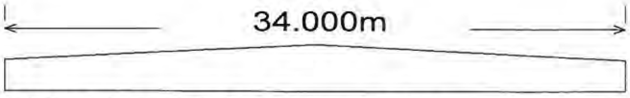
| | | | | |
|---|---|---|---|---|
| FIGURED DIMENSIONS TO BE READ IN PREFERENCE TO SCALING. | APPROVED | SCALE AS SHOWN | DRAWN A.G.G. | DRAWING No. |
| | | DATE 30.04.04 | CHECKED | GJ0322.1.5 |

Appendix F

# Culvert Analysis

# CulvertW - Design Case No 1

(File: CUL2.CUL - Date: 14-6-2011)




2 No 1200 cl 2 RCP (1.220m dia) at a slope= 0.8824%

Inlet RL 3.400m Outlet RL 3.100m

## Culvert Data

| | |
|---|---|
| Using Mannings 'n' | = 0.013 |
| Entrance Loss Coefficient 'k' | = 0.500 |
| Entrance - Sqr end & headwall | |

## No Weir Data specified to be used

## Outlet Channel Data

| | |
|---|---|
| Channel Width= 10.000m | Channel Roughness = 0.045 |
| Channel Slope= 0.0040m/m | Right Slope: 1 Vert.to 4.0000Hor. |
| Left Slope: 1 Vert.to 4.0000Hor. | Velocity of Flow = 0.766m/s |

## Headwater

| | |
|---|---|
| Approach Flow | = 4.111m3/s |
| Flow in each Culvert | = 2.056m3/s |
| Tailwater depth | = 1.600m (RL 4.700m) |
| Using fixed Tailwater depth | |
| Critical depth at outlet | = 0.783m (RL 3.883m) |
| Effective tailwater depth | = 1.600m (RL 4.700m) |
| Head Loss in Culvert | = 0.323m |
| Depth at outlet adopted to calculate outlet velocity | = 1.220m (RL 4.320m) |
| Outlet Velocity | = 1.758m/s |

## OUTLET control

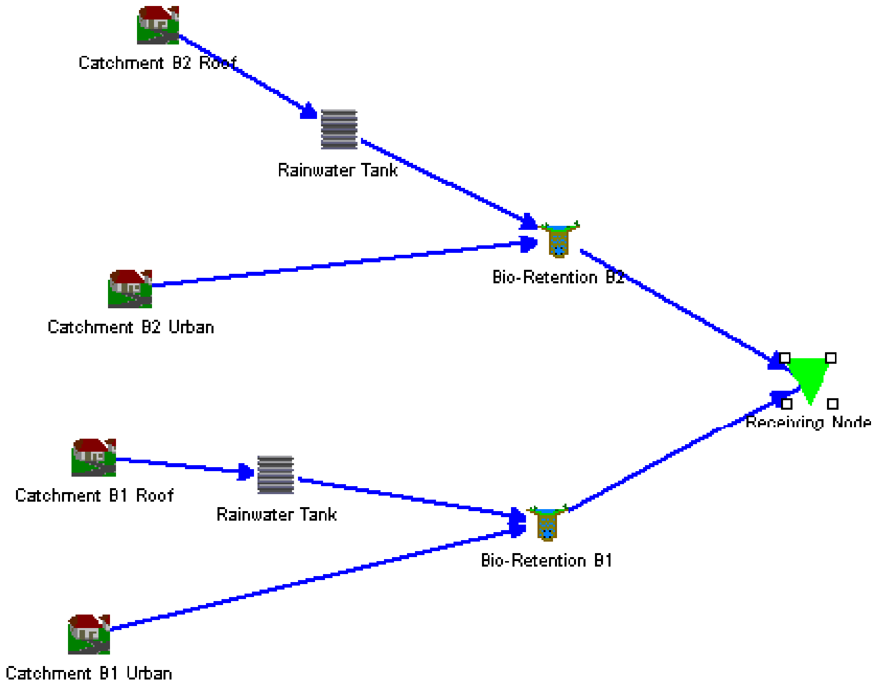
Headwater is 1.623m above culvert inlet invert

Headwater is at RL 5.023m - 0.403m above inlet obvert

Tailwater is at RL 4.700m - 0.380m above outlet obvert

Appendix G

# MUSIC Modelling Inputs




**Treatment Train Effectiveness - Receiving Node**

| | Sources | Residual Load | % Reduction |
|---|---|---|---|
| Flow (ML/yr) | 71.8 | 67.9 | 5.3 |
| Total Suspended Solids (kg/yr) | 7.30E3 | 998 | 86.3 |
| Total Phosphorus (kg/yr) | 17.6 | 5.48 | 68.8 |
| Total Nitrogen (kg/yr) | 111 | 61.2 | 45.0 |
| Gross Pollutants (kg/yr) | 1.53E3 | 0.00 | 100.0 |

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