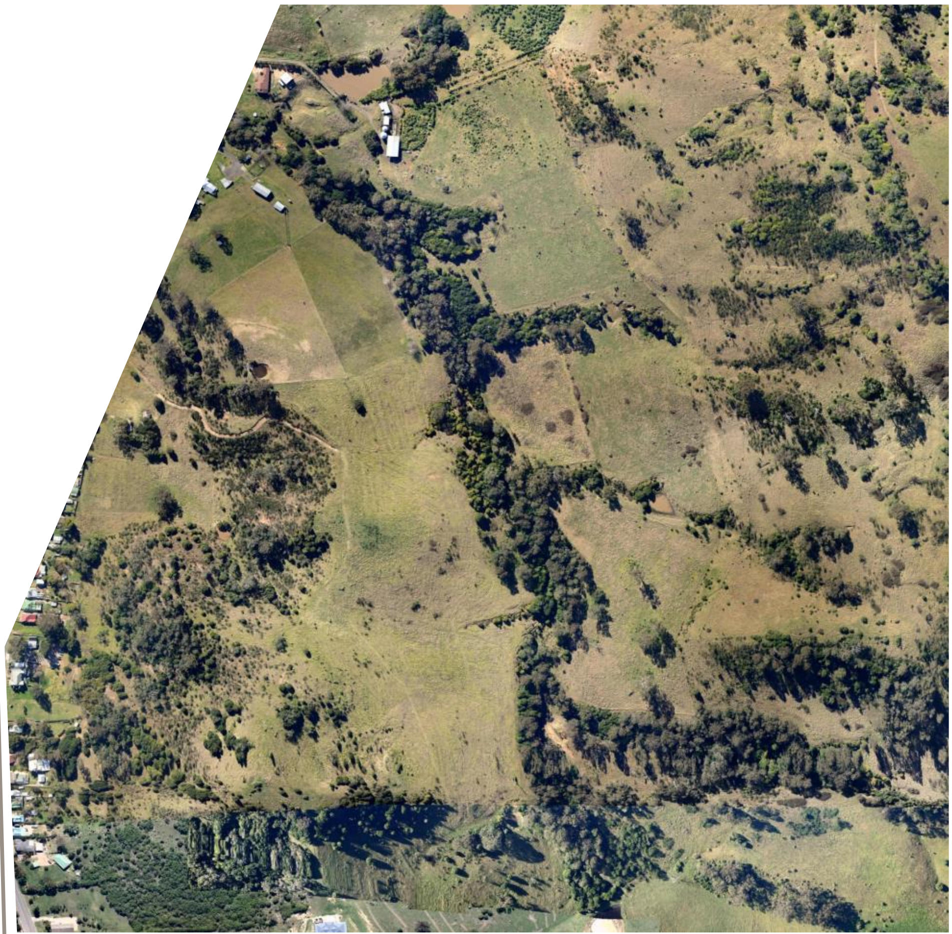

Stormwater Management Report

Reeves Creek Rezoning

Prepared for Dartanyon Pty Ltd
April 2015

Cardno
Shaping the Future

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1	23/01/2014	First Draft	Pak Lau		Richard Hardy	
2	10/03/2014	Second Draft	Pak Lau		Richard Hardy	
3	26/6/2014	Issue for Rezoning	Pak Lau	PL	Richard Hardy	RH
4	8/12/2014	Re-issue for Rezoning	Pak Lau	PL	Rob Lenferna	RL
5	21/04/2015	Revised for new lot and road layout	Stephen Gribble	SEG	Rob Lenferna	RL
6	06/05/2015	Minor Basin Batter Adjustments	Stephen Gribble	SEG	Rob Lenferna	RL
7	07/05/2015	Minor Basin Batter Adjustments in figures	Stephen Gribble	SEG	Rob Lenferna	RL
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9	25/05/2015	Adjustment of figures	Gijs Roeffen	GR		

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1 Introduction

1.1 Background

Cardno has been commissioned to prepare this Stormwater Management and Flooding Report on behalf of Dartanyon Pty Ltd to support the re-zoning application for the land at 1735 Remembrance Drive, 108-114 and 116-118 Menangle Street, Picton. The application is to rezone the land use from rural landscape to low density residential area, medium density residential area and public recreation area.

This report considers the stormwater behaviour for the proposed change of land use, in order to develop a strategy for stormwater quantity and quality management that follows Water Sensitive Urban Design (WSUD) principles. The findings will guide the future development of the precinct and the subsequent detailed works required to give effect the strategy.

In particular this report assesses the following:

- Water quality objectives in accordance with Wollondilly Shire Design Specification;
- Opportunity to incorporate the principles of WSUD and managing urban stormwater as outlined in the OEH General Guidelines for Strategic Planning;
- Stormwater management strategy to limit the peak post developed runoff to existing condition;
- Proposals for ensuring surface water are protected from overuse; and
- Rehabilitation of riparian corridors.

1.2 The Site

The proposed land zoning site is located within Wollondilly Shire Council area and is approximately 700m to the north east of Picton train station. The site is bounded by an existing residential area to the north, Menangle Street to the east and extends approximately 550m along Reeves Creek to the southeast. The proposed rezoning has a total area of 37.5ha, with around 33ha draining to Reeves Creek and then to the culvert at Menangle Street. The other 4.5ha drains to the drainage easement at Emmett Cl to the north of the site. The area being submitted for rezoning (bounded by the red dotted line) is shown in Figure 1-1 below.

The existing site is currently used as pastures; with slopes varying between 10% and 25%. Reeves Creek flows from the southeast to northwest towards Menangle Street. There are four other identified watercourses, which contribute flows to Reeves Creek and then into Stonequarry Creek. The total catchment area draining to the existing culvert at Menangle Street is 145ha with the other 10ha draining to the north separated by the ridge. Figure 1-1 also shows the location and the existing landscape of the site.

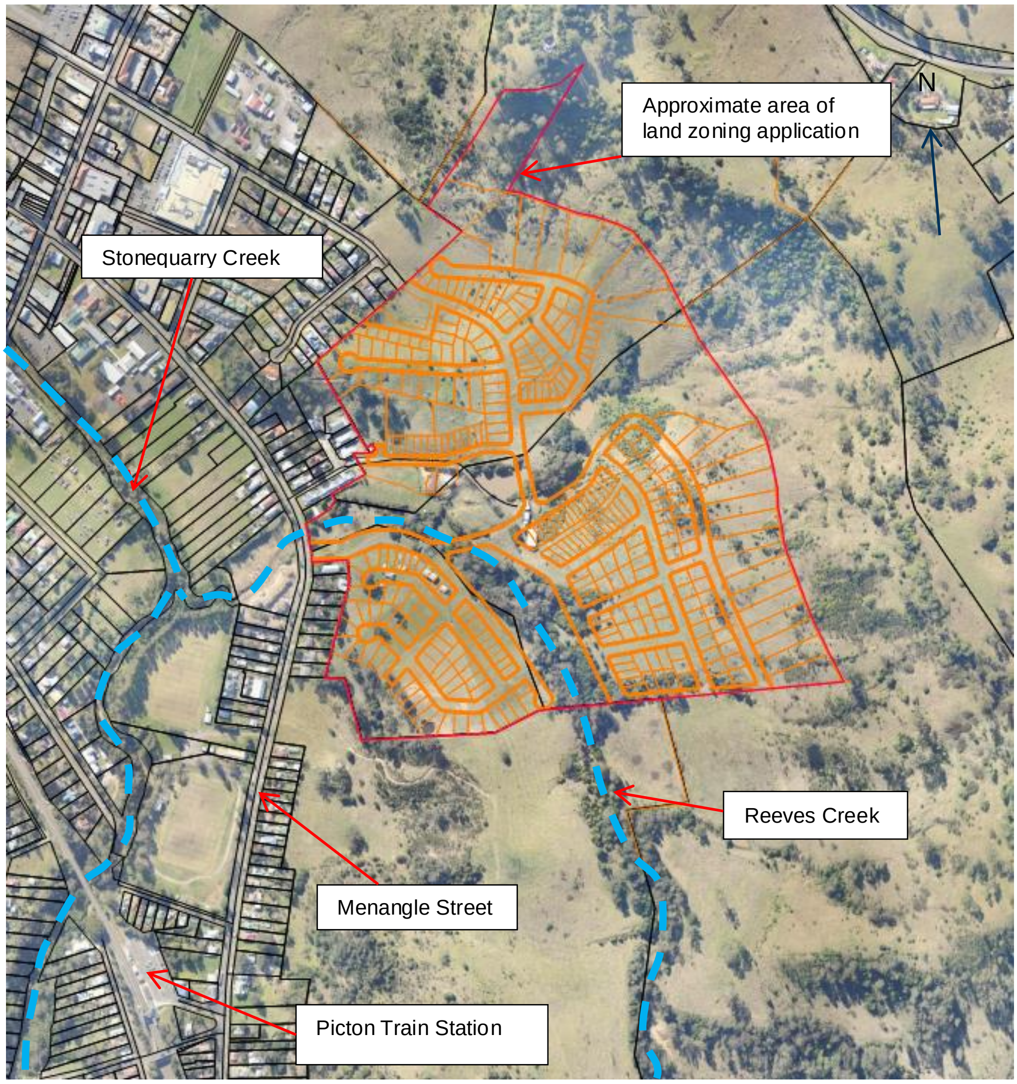

Figure 1-1 - Proposed Development

2 Riparian Corridor

2.1 Watercourse Classification

EcoLogical Australia (ELA) has undertaken a detailed site assessment in order to determine the watercourse classification for streams located within the site. The watercourses have been classified using the Strahler system of waterway classification which assigns an "order" according to the number of additional tributaries associated with each watercourse, indicating the complexity of a system. A map showing the order of the classified waterways is shown in Figure 2-1.

The findings by ELA shows the majority of the Reeves Creek is a Second Order watercourse. Approximately 200m of Third Order watercourse extends to the east from Menangle Street towards the junction where the two Second Order watercourses join. There are three other first order watercourses further upstream, which are tributaries to Reeves Creek.

2.2 Watercourse Quality and Quantity Requirements

Due to the increased imperviousness of the developed site, detention basins will be required to attenuate the increase in peak flows. The current Guidelines for Riparian Corridors on Waterfront Land released by the NSW Department of Water (using the Strahler classification guidelines) allow for on-line basins in 1st and 2nd order creeks. Water quality treatment however, is to remain off-line such that runoff is treated prior to discharge to the watercourses.

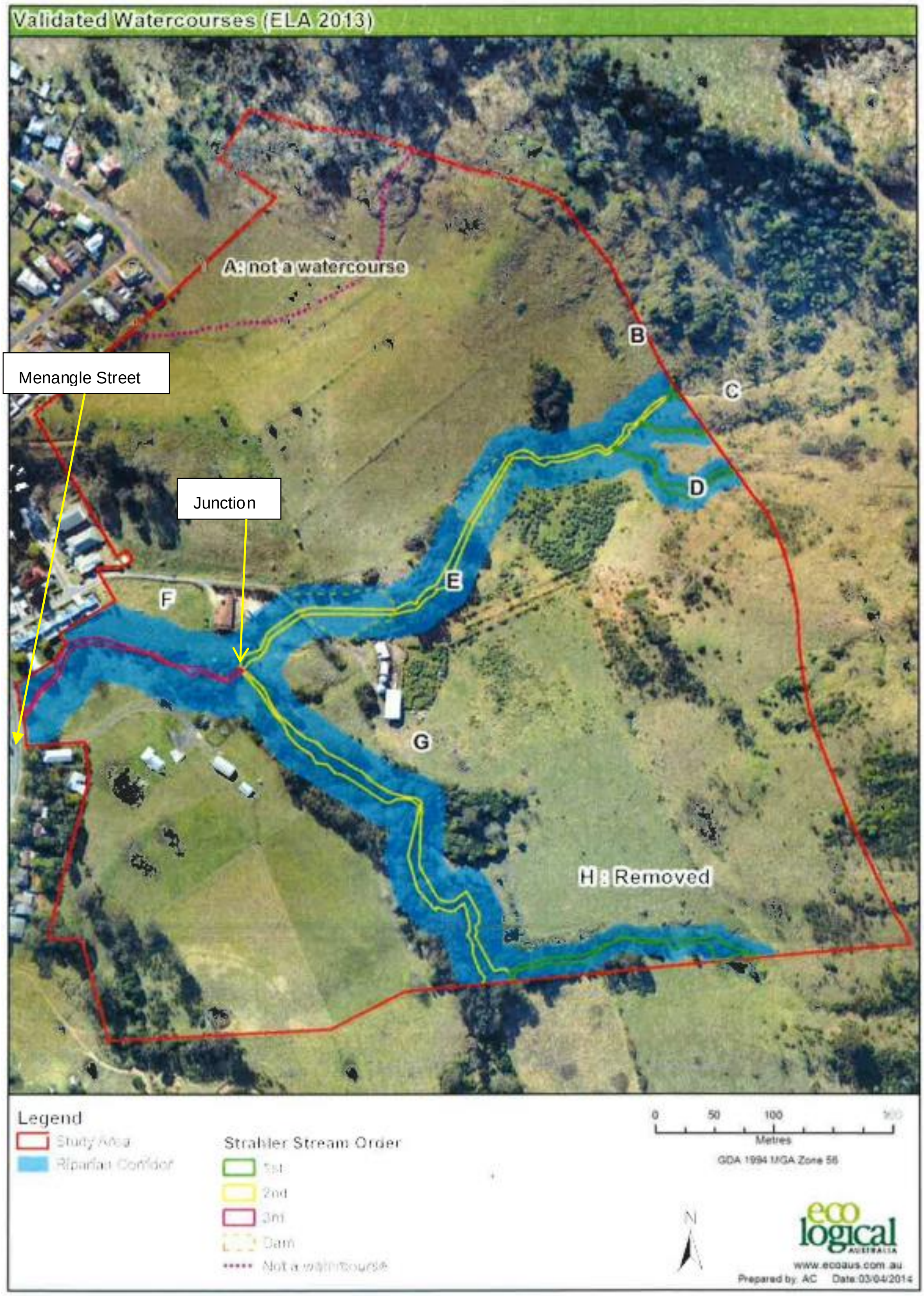

Figure 2-1 – Riparian Corridor classification

3 Water Quantity Assessment

3.1 General

Hydrological modelling for the Reeves Creek Development was undertaken using XP-RAFTS (version 2013) computer software to determine the pre and post-developed site runoff. XP-RAFTS is a robust runoff routing model used in determination of hydrologic and hydraulic analysis of stormwater drainage and conveyance systems. Runoff has been estimated for 1, 5, 20 and 100 year Average Recurrence Interval (ARI) storm events for both development scenarios.

3.2 Pre-development Condition Model

The XP RAFTS model was developed to estimate existing condition storm hydrographs for the 1, 5, 20 and 100 year ARIs. The resulting flows were used as the permissible site discharge (PSD) requirements for stormwater detention basin sizing to ensure pre-development flows are maintained in the post-developed condition. Figure 3-1 below shows the catchment plan with the existing catchments.

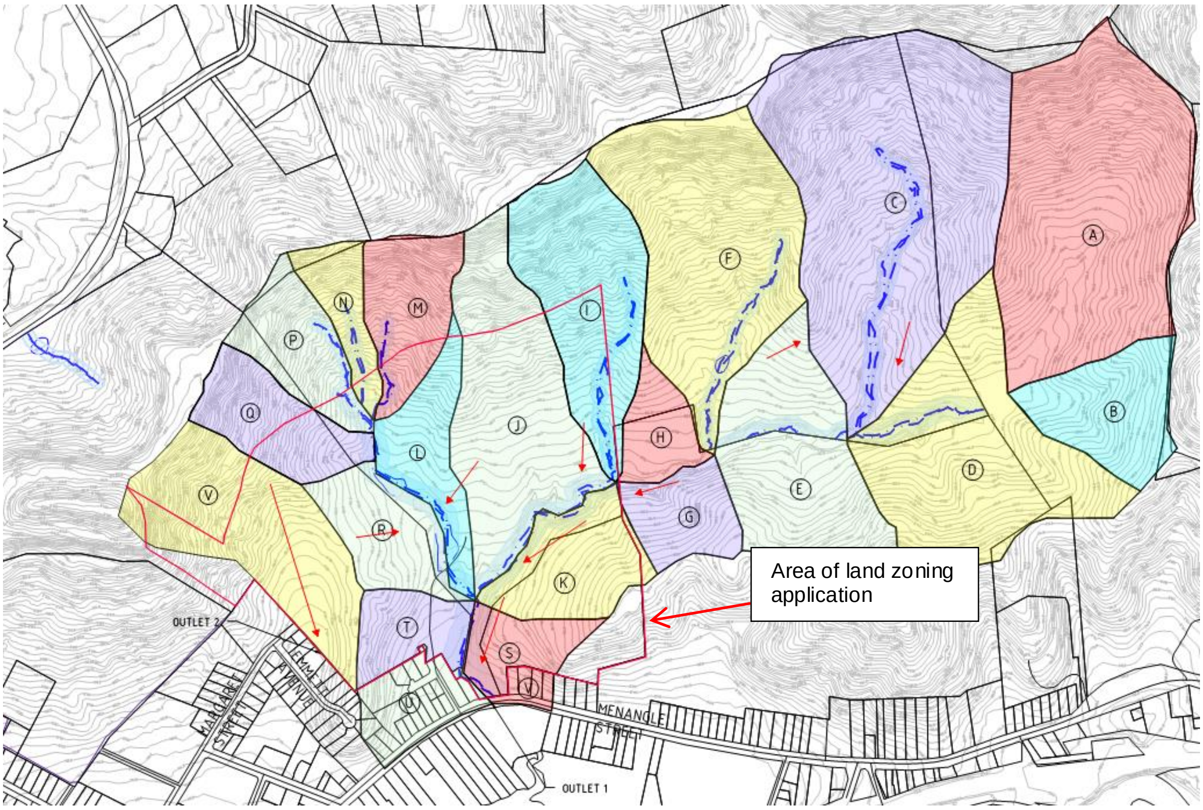

Figure 3-1 – Existing Catchments

Catchments were defined as 100% pervious. Slopes were calculated using the vectored slope method based on existing site survey and design rainfall IFD data was obtained from Wollondilly design specifications. Additional modelling parameters are presented in Table 3-1.

Table 3-1 - XP-RAFTS Existing Condition Parameters

PARAMETER	Pervious	Impervious
PERN (n)	0.06	0.015
Initial Loss (mm)	10	0
Continuing Loss (mm)	3	0

3.3 Post-Development Condition Model

Based on the results of the pre-development model, the post-development model was then used to determine preliminary sizing of basins to restrict post-developed peak flows to existing levels.

Under the post development condition model, the adopted impervious areas are summarised below:

- Residential area - 80% impervious; and
- External catchment and riparian corridor - 0% impervious;

The PERN (n) roughness adopted in the post development condition model are shown in Table 4-2 below.

Table 3-2 - XP-RAFTS Post Developed Condition Parameters

PARAMETER	Pervious	Impervious
PERN (n)	0.025 0.06 (External Catchment and Riparian Corridor)	0.015
Initial Loss (mm)	10	0
Continuing Loss (mm)	3	0

The slope for the proposed developed area was determined by the average grading of the roads, which would be approximately 5%.

The post developed catchment plan and the basin location is shown in Figure 3-2 below.

The proposed on site detention (OSD) basins have been designed in accordance with Wollondilly Shire Council's design specification with the following configurations:

- The base of the all OSD basins has a minimum 1% grade;
- Online OSD basins to be planted with native vegetation in accordance with Office of Water requirements;
- Make use of topography as far as possible to minimise earthwork;
- Minimum 500mm freeboard between floor level of dwellings and top water level;
- All basins to have maximum internal batter of 1(V):4(H) with child proof fence around the basins.

A combined WSUD/OSD basin has also been proposed to treat the stormwater runoff from Catchment W with similar a configuration to above with the addition of:

- A bio-retention area at the bottom of the basin with 300mm extended detention zone;
- A low flow control pit to control 100% and 20% AEP storm events; and
- A high flow control pit to control the storm events up to 1% AEP.

The basin outlet details are summarised in Table 3-3 below and the catchment plan for the post development scenario is shown in Figure 3-2.

Table 3-3 - Basin Outlet Details

Basin ID	Minor Storm Control	Major Storm Control
A1	2.4m x 1.8m Culvert	10m weir
A2	900mm diameter pipe	10m weir
A3	375mm diameter pipe for 20% AEP storm and 600mm diameter pipe for 5% AEP storm	5m weir
A4	750mm diameter pipe	10m weir
W	225mm diameter pipe at the low level control pit and a 450mm diameter pipe at a high level control pit	Inlet pit with 5m perimeter and a 750mm diameter pipe

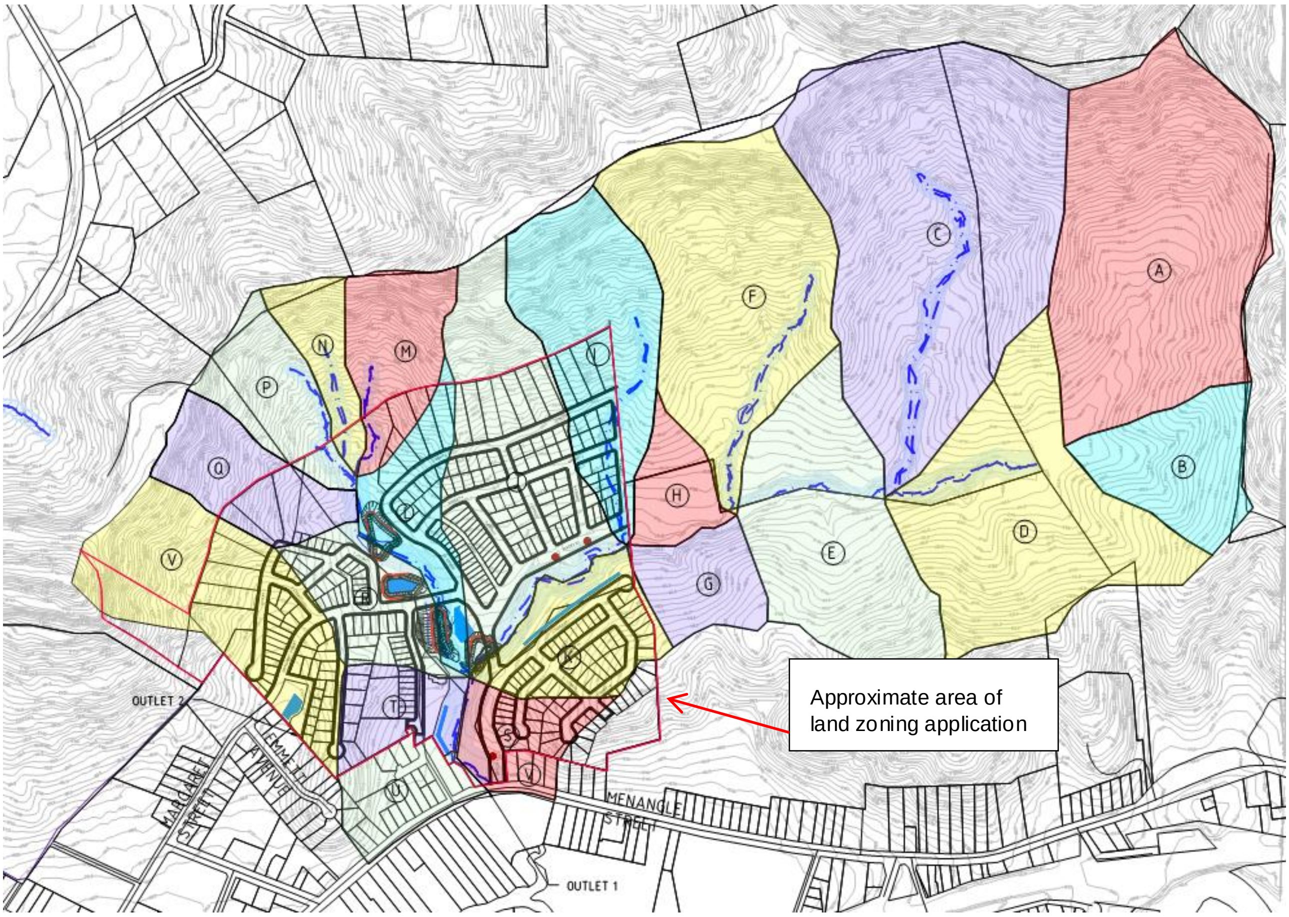

Figure 3-2 – Post development Catchments

The locations of the OSD basins are shown in Figure 3-3 below.

Figure 3-3 - Proposed OSD Basin Locations

3.4 Water Quantity Modelling Results

The modelling results demonstrate that the basins will limit the post development runoff to match existing peak flows for all storms up to and including 1% AEP events.

Table 3-4 below compares the pre-development and post development peak flows at the catchment outlets.

Table 3-4 - Discharges at Catchment Outlets

AEP (%)	PSD at the Menangle Street culvert (m^3/s)	Peak flows at the Menangle Street culvert (m^3/s)	PSD at the outlet of Basin W (m^3/s)	Peak flows at the outlet of Basin W (m^3/s)
100	6.60	6.56	0.52	0.44
20	15.40	14.21	1.38	1.23
5	23.40	21.51	2.14	1.99
1	32.22	29.74	2.88	2.83

The operation of each basin is shown in Table 3-5 below.

Table 3-5 - Basin Modelling Results

Basin	AEP (%)	Basin Outflows (m^3/s)	Storage (m3)	Depth (m)
A1	100	5.06	805	0.99
	20	10.99	1352	1.54
	5	16.82	1655	1.79
	1	23.51	1915	1.98
A2	100	1.44	705	1.17
	20	4.28	915	1.40
	5	6.28	1140	1.52
	1	8.14	1140	1.62
A3	100	0.22	240	0.42*
	20	0.38	355	0.59*
	5	0.62	430	0.69*
	1	0.79	505	0.79*
A4	100	1.23	985	0.91
	20	3.29	1210	1.08
	5	4.76	1345	1.17
	1	6.13	1460	1.25
W	100	0.15	455	0.48*
	20	0.35	860	0.82*
	5	0.63	1060	0.97*
	1	1.01	1305	1.14*

**Water depth excludes the 300mm extended detention depth*

Results from the basin modelling indicate depths are generally less than 1.5m except Basin A1 and A2, where they are located at the junction of two watercourses.

4 Stormwater Quality Analysis

4.1 Water Quality Objectives

The Water Sensitive Urban Design (WSUD) goal for the proposed development is to reduce the pollutants and nutrients from the stormwater runoff whilst the land transitions from its current rural usage into an urban development. The strategy is to utilise established and accepted treatment devices such as bio-retention basins and Gross Pollutant Traps (GPT) to improve the water quality.

The objectives of the WSUD strategy are outlined in Table 4-1.

Table 4-1 - Water Quality Objectives

Pollutants	Treatment Objective
Gross Pollutants	70%
Coarse sediments (sediment between 0.1mm and 5mm)	90%
Total Suspended Solids (sediments less than 0.1mm)	85%
Total Nitrogen (TN)	45%
Total Phosphorus (TP)	65%
Hydrocarbons, oil and grease	90%

The objectives in Table 4-1 above were obtained from “Wollondilly Shire Council’s Design Specification” and “Managing Urban Stormwater: Environmental Targets Consultation Draft” published by Department of Environment and Climate Change, Sydney Metropolitan Catchment Management Authority, October 2007.

4.2 Proposed WSUD Strategy

The gross pollutants and coarse sediments can be removed effectively by GPT. A vortex type GPT can remove up to 98% of gross pollutants and 95% of coarse sediment.

A number of studies have found that most hydrocarbons, oil and grease are attached to sediments. Based on CRCCH, up to 70% of oils are associated with solids in stormwater. Specification from a CDS unit shows the GPT has removal efficiency up to 94%.

Site Constraints, particularly topography, makes that it difficult to provide end of catchment measures such as wetlands or large bioretention basins. The following strategy has been proposed:

- For catchments K, L, R1, T and W, large end of catchments bio-retention basins are proposed in the treatment train to remove the suspended solids and nutrients from the stormwater runoff. Each bio-retention basin will have a 300mm extended detention zone and 500mm thick sand filter to treat the stormwater runoff.
- For catchments J and S, it is proposed to use a proprietary end-of-line device such as a Humes Jellyfish filter rather than a bio-retention basin.

4.3 Water Quality Modelling

The industry standard Water Quality Modelling package MUSIC (version 6) was used to analyse the performance of the proposed treatment train. Figure 4-1 shows the node and link diagram, which comprises GPTs and bio-retention basins. For the purposes of this report, the multiple bioretention measures proposed for catchments J and S have been modelled as a single node. The treatment train has been checked to ensure stormwater quality targets are met before stormwater runoff leaves the site.

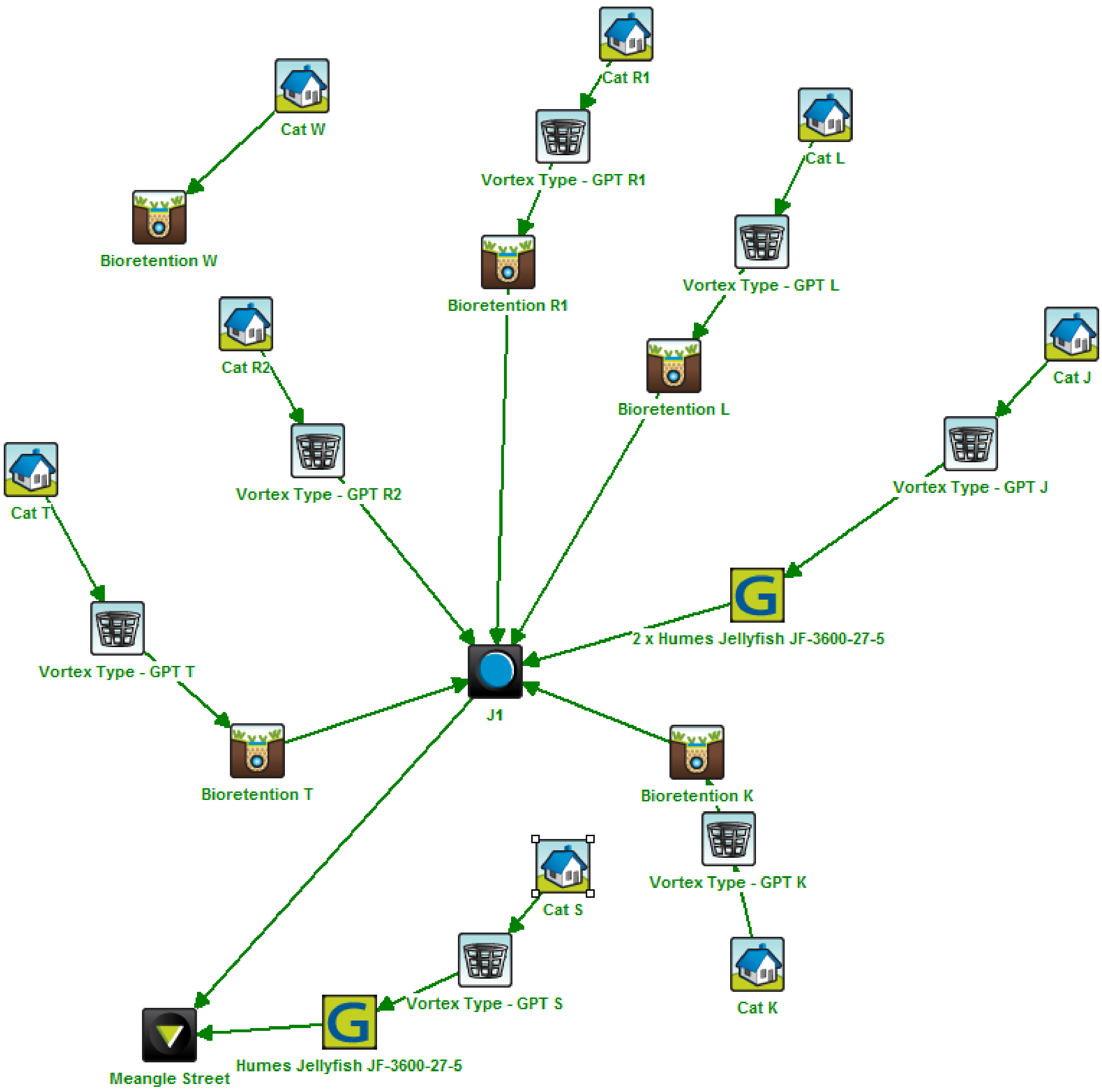

Figure 4-1 - MUSIC node and link diagram

Historical rainfall records have been obtained from the Bureau of Meteorology (BOM) to replicate the mean annual rainfall for the site. The closest station to Picton with reliable long term data is Station No. 67035 at Liverpool. Ten years of data, 1966 to 1977, has been extracted from this station data set to simulate Camden's mean annual rainfall. The adopted historical mean annual rainfall is 823mm compared to Camden's 800mm.

The data provided by BOM did not include evapotranspiration data and Parramatta monthly average aerial PET data has been used in lieu for the modelling.

A geotechnical assessment has been undertaken by Douglas Partners to investigate slope stability of the site. The borehole log indicated the soil is generally silty clay, therefore, the rainfall and runoff parameters shown on Table 4-2 were used.

Table 4-2 - Rainfall Runoff Parameters (DRAFT NSW MUSIC Modelling Guidelines)

Rainfall Threshold (mm/day)	1
Soil Storage Capacity (mm)	54
Initial Storage (% of Capacity)	30
Field Capacity (mm)	51
Infiltration Capacity Coefficient – a	180
Infiltration Capacity Exponent – b	3.0
Initial Depth (mm)	10
Daily Recharge Rate (%)	25
Daily Baseflow Rate (%)	25
Daily Deep Seepage Rate (%)	0

The pollutant concentration parameters used in the model are based on the findings from Fletcher et al, 2004 for residential and commercial areas. The parameters are listed in Table 4-3 below.

Table 4-3 - Base Flow and Storm Flow Concentration Parameters for NSW

	Concentration (mg/L – log10)					
	Total Suspended Solids		Total Phosphorus		Total Nitrogen	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Base Flow	1.20	0.17	-0.85	0.19	0.11	0.12
Storm Flow	2.15	0.32	-0.60	0.25	0.30	0.19

*Source: DRAFT MUSIC Modelling Guideline for New South Wales

GPT's were modelled as a vortex type unit with the efficiency outlined below:

- Total Suspended Solids (TSS) – 70% for inflow concentrations greater than 75mg/L;
- Total Nitrogen (TN) – 0%; and
- Total Phosphorus (TP) – 30% for inflow concentration greater than 0.5mg/L.

The locations of the bio-retention basins are shown in Figure 4-2 and the calculated filter areas only for each basin is summarised in Table 4-4 below. Figure 4-2 shows the basin filter areas only and does not consider the additional area required for batters, access ramps etc.

The properties adopted for the modelling of the bio-retention basin are:

- Extended detention depth – 300mm;
- Hydraulic conductivity – 120mm/h;
- TN Content of Filter Media – 400mg/kg; and
- Orthophosphate Content of Filter Media– 40mg/kg.

Table 4-4 - Bio-retention Basin Filter Area / Jellyfish Filter Model

Catchment	Bio-retention Filter Area (m^2)	Humes Jellyfish Filter
J	(550)*	2 x JF3600-27-5
K	650	-
L	1000	-
R1	450	-
R2	300	-
S	(200)*	1 x JF3600-27-5
W	600	-

** Humes Jellyfish Filters proposed in lieu of Bioretetention Basin.*

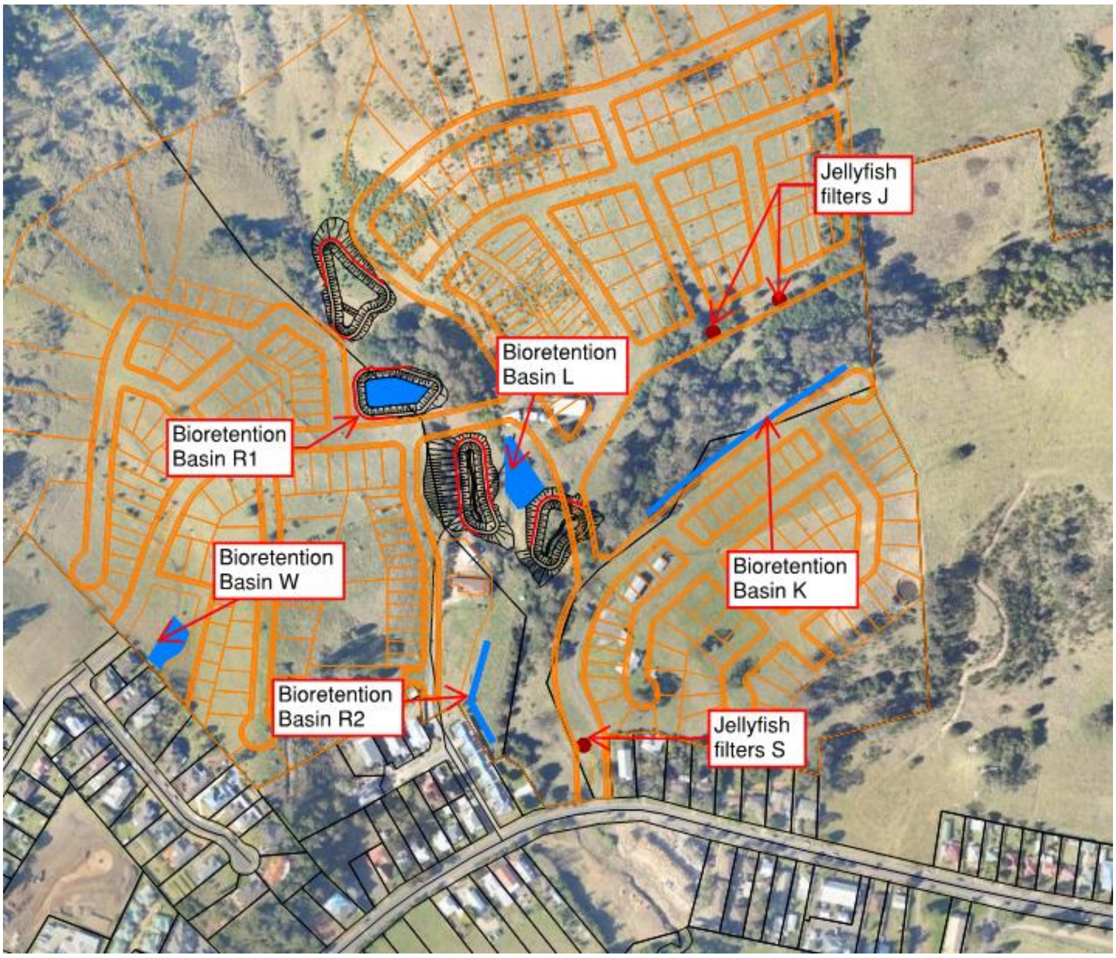

Figure 4-2 - WSUD Basin locations

Note: Basin bio-retention filter area shown only. Basin interface to be confirmed subject to detailed design.

4.4 Model Results

The water quality model shows the proposed treatment train achieves Council's Water Quality Targets as presented in Table 4-1. A summary of the pollutant removal achieved at each outlet location is presented below in Table 4-5, for outlet locations refer to Figure 4-2.

Table 4-5 - Post development WSUD Modelling Results

Outlet	Parameter	Before Treatment	After Treatment	% Reduction	% Objective
Menangle Street	Total Suspended Solids (kg/yr)	25400	2570	90	85
	Total Phosphorous (kg/yr)	41	14	65	65
	Total Nitrogen (kg/yr)	302	144	52	45
	Gross Pollutants (kg/yr)	3860	281	93	90
Basin W	Total Suspended Solids (kg/yr)	4700	612	87	85
	Total Phosphorous (kg/yr)	7	2	69	65
	Total Nitrogen (kg/yr)	55	22	59	45
	Gross Pollutants (kg/yr)	703	31	96	90

5 Conclusion

This stormwater management report investigated the performance of the proposed stormwater management strategy which includes on-site detention basins, gross pollutants traps and bio-retention basins to treat the stormwater runoff from the development.

The combination of the above measures and the modelling results has demonstrated the proposed stormwater management strategy has:

- Meets the water quality objectives in accordance with Wollondilly Shire Council Design Specification;
- Incorporated the WSUD principles and managing urban stormwater as outlined in the OEH General Guidelines for Strategic Planning;
- Controlled the post development peak runoff to match the pre development condition; and
- Identified the order of the existing watercourses and the associated requirements to protect and maintain them.