

NORTH BUNGENDORE PLANNING PROPOSAL ASSESSMENT STUDY 8: STORMWATER **REPORT**

PREPARED FOR QUEANBEYAN-PALERANG REGIONAL COUNCIL
20/12/2016
16-000862
ORIGINAL
WATER & ENVIRONMENT

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DOCUMENT CONTROL
16-000862

Issue	Date	Issue Details	Author	Checked	Approved
1	17/11/16	Draft	PM	APL	APL
2	20/12/16	Final with QPRC Comments	PM	AJL	APL

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1 INTRODUCTION

This report has been prepared on behalf of Queanbeyan-Palerang Regional Council (QPRC) for the North Bungendore Planning Proposal Assessment (Lot 1 DP798111, part) Study 8: Stormwater.

QPRC received a planning proposal for the rezoning of partial Lot DP 798111 (Figure 1-1) from RU1 Primary Production to R2 Low Density Residential, R5 Large Lot Residential and RE1 Public Recreation. The proposal states that the indicative lot yield is approximately 309 lots, with block sizes ranging between 800m² and 1200m².

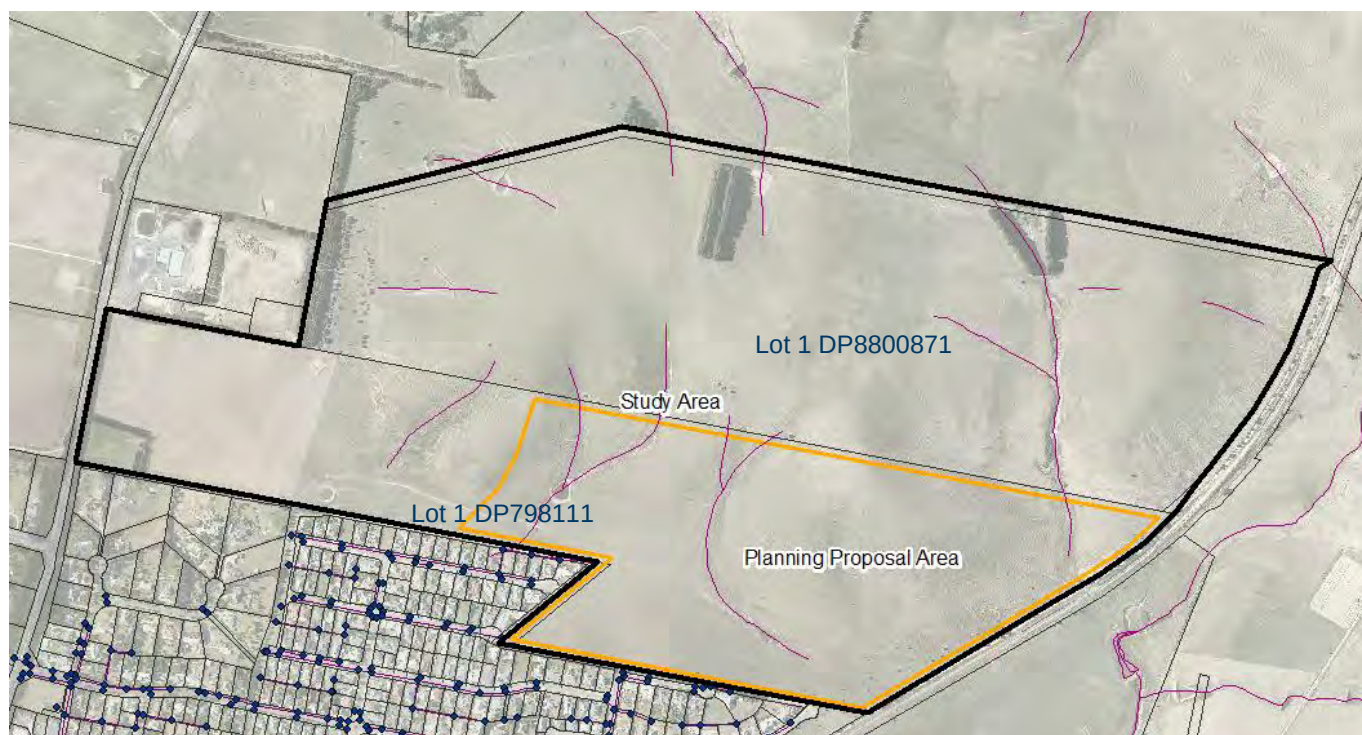


Figure 1-1: Study area and planning proposal area

On 27 April 2015, the NSW Department of Planning and Environment provided a gateway determination that the proposal may proceed, subject to a range of conditions, one of which is an assessment of Stormwater within the study area.

Appropriate strategies for the management of urban stormwater runoff and its effects on flows and water quality on receiving waters or properties has been investigated in this report, with Water Sensitive Urban Design (WSUD) principals utilised.

It is possible that the area to the north of Lot 1 DP798111, Lot 1 DP8800871, may also be developed in the future subject to a planning proposal being supported by Council and the NSW Department of Planning and Environment. This area has been considered in this study for possible future growth.

2 SCOPE OF SERVICES

The scope of services for this project is as follows:

- Undertake a review of the information provided by proponents within the submitted planning proposal as relevant to this study;
- Undertake a network assessment and report outlining options for the management of stormwater;
- Recommend strategies for the management of urban stormwater runoff and its effects on flows and water quality on receiving waters or properties, generally in line with the objectives and outcomes outlined in the Australian Runoff Quality, Australian Rainfall and Runoff and industry best practice;
- Undertake an assessment of the impacts of the proposal in terms of stormwater, having regard to:
 - Possible future growth; and
 - Local planning policies, strategies and development requirements, State Government planning policies and strategies, Section 117 Directions, and relevant state and federal legislative and regulatory requirements.
- Prepare a report including maps, areas requiring further assessment (if identified), and recommendations; and
- Include the methods used for the gathering of data.

3 PURPOSE OF THE REPORT

The purpose of this report is to support a planning proposal to rezone the subject land from RU1 Primary Production to a range of land use zones including R2 Low Density Residential, R5 Large Lot Residential and RE1 Public Recreation.

The Stormwater section of the planning proposal provided, offers only a paragraph on Stormwater Management stating that Water Sensitive Urban Design principals are to be considered, and reduction in potable water demands is desirable. This report aims to expand on these desired outcomes.

4 SITE CHARACTERISTICS

The planning proposal area is approximately 50.5 Ha, and the total study area is approximately 186.1 Ha (Figure 1-1).

The site is located to the north of the existing Elmslea Estate in Bungendore NSW. The analysis presented in this report focuses on the planning proposal area discharging runoff to surrounding areas, with consideration given to future growth in the total study area.

The planning proposal area is currently undeveloped primary production land with a number of overland flow paths which run through the site (Figure 4-1). The catchment has been cleared and is well grassed. As a result of farming activities there are two existing farm dams within the planning proposal area.

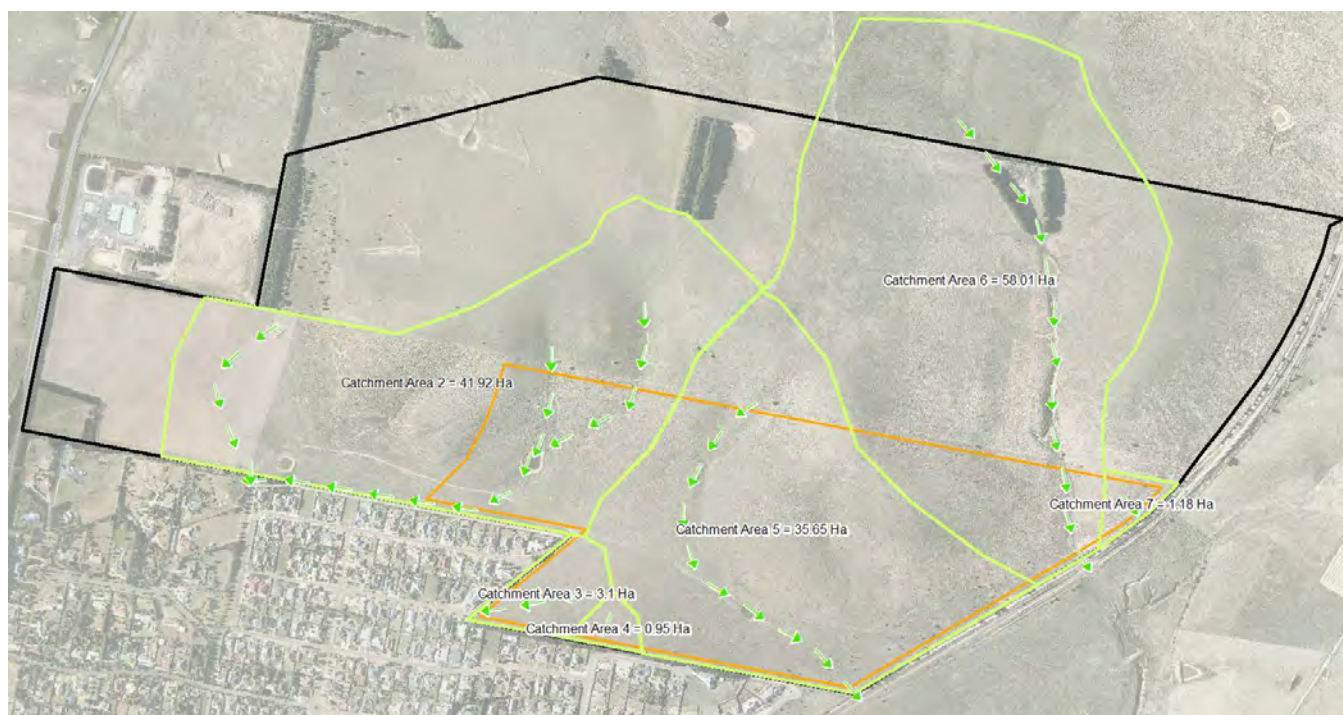


Figure 4-1: Planning proposal area catchments

5 DEPARTMENT OF PLANNING SECTION 117 REQUIREMENTS

Section 117 of the Environmental Planning and Assessment Act 1979, provides directions issued by the Minister for Planning to relevant planning authorities. These directions apply to planning proposals lodged with the Department of Planning

As the study area stormwater catchment is outside of the Sydney Drinking Water Catchment the requirements of Section 117 Local Planning Directions Section 5 do not apply. The water quality objectives identified in Palerang Development Control Plan (2015) are adequate for this site if they are achieved.

Section 117 Local Planning Directions Section 4.3 Flood Prone Land is also not applicable to this study, as the development of the study area is outside of any known flood prone lands and will have no implications on adjoining flood prone lands.

6 STORMWATER MANAGEMENT OPTIONS

6.1 DESCRIPTION OF MANAGEMENT OPTIONS

Stormwater management aims to protect human and ecological values by preventing or mitigating the adverse effects of stormwater quality and quantity on the human and aquatic environment.

Stormwater quality improvement devices (SQIDs) can be designed for the following two primary purposes:

‘Water quantity’ – designed to handle large flows and mitigate flooding effects

‘Water quality’ – designed to treat pollutants in stormwater to improve discharge quality.

The devices that have been evaluated are the following.

- Swales
- Raingardens
- Rainwater tanks
- Ponds / wetlands
- Gross Pollutant Traps (GPTs).

The descriptions below address the benefits the above five devices have in relation to both the water quality and quantity.

Swales:

Swales are stormwater quality devices while also providing stormwater conveyance. They also can temporarily hold small quantities of runoff and allow it to infiltrate into the soil and attenuate peak flows. A vegetated swale may also be known as a grassed channel, dry swale, wet swale or biofilter. Vegetated swales can serve as part of a stormwater drainage system and can replace kerbs, gutters and storm sewer systems. The passage of stormwater through vegetated swales utilises a number of physical, chemical and biological factors to reduce stormwater contaminants.

Swales can have significant environmental benefits but they do have limitations. Swales can reduce peak flows, remove pollutants, and promote runoff infiltration, and they tend to have lower capital costs. While swales are generally used as a stand-alone stormwater Best Management Practice (BMP), they are most effective when used in conjunction with other BMPs, such as ponds, infiltration strips, and wetlands.

Vegetated swales are generally suitable for sites with gradients below 5 percent (1:20). Should swales be constructed on sites with gradients more than 5 percent (1:20) the requirement for swale protection should be analysed. Vegetation cover of swales usually consists of a dense and continuous cover of relatively long grass (typically 50mm to 150mm) and therefore should not be mown too short, or too frequently.

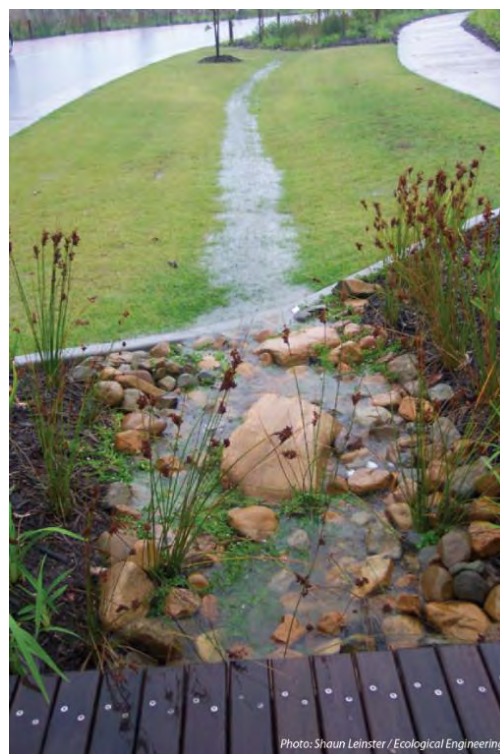


Figure 6-1: Typical Swale

Raingardens:

Raingardens are especially suited for small residential catchment areas and are primarily designed for stormwater quality treatment but can have stormwater quantity management benefits if designed with additional detention storage. Raingardens look and function like any other garden except they generally include a layer of 100mm of mulch, 600mm (minimum) to 1000mm of planting soil, and vegetation (grass and shrubs) to treat runoff. Raingardens utilise physical, biological and chemical mechanisms to treat stormwater and therefore tend to have high pollutant removal efficiencies compared to other practices such as ponds.

Rain gardens are a combination of an infiltration and filtration device. Water is directed to a local hollow where it soaks into an organic filter medium such as topsoil or compost. Some water soaks into the ground while the remainder is collected and piped to a stormwater drainage system.



Figure 6-2: Example of constructed raingarden

Rainwater tanks:

Rainwater tanks are primarily water quantity management devices and can be used for stormwater detention, rainwater use, or both. Rainwater tanks are increasingly being used in urban and suburban areas as a method to reduce stormwater runoff volumes and for water conservation purposes. Rainwater is collected from roof runoff and can be re-used for toilets, laundry and external uses.

Using rainwater:

- Reduces demand for mains water supply i.e. saving costs.
- Reduces flooding by providing temporary storage for rainwater.
- Reduces wet weather sewage overflows.
- Reduces pollution of waterways.

Rainwater tanks provide some treatment through the capture of first flush volume and redirecting stormwater into the non-potable water system for a house etc.

Ponds / wetlands:

Provide attenuation and effective water quality treatment (primarily via settling and sedimentation) depending on the specific design and whether or not the stormwater is held for extended detention periods. A pond generally requires a significant area of land to maintain a constant water depth and requires a variety of maintenance and safety issues.



Figure 6-3: Existing fringe wetland in Bungendore

‘Gross Pollutant Traps’ or equivalent:

The effectiveness of the system is highly depended on regular removal of contents collected by the trap. It is ideal as part of a ‘treatment train’ approach.

6.2 STORMWATER MANAGEMENT DEVICE EVALUATION

The table below summarises our evaluation of the stormwater options in relation to the site. Factors relating to treatment efficiency, capital and maintenance costs, site suitability and quantity control have been used.

Treatment Devices	Treatment Efficiency	Capital/ Maintenance Cost	Site Suitability (e.g. slope, space)	At-source treatment	Quantity Control	Total
Swales	●●●	●●	●●●	●●	●●	12
Raingardens	●●●	●	●●	●●●	●	10
Rainwater tanks (for lot water supply)	●●	●●	●●●	●●	●●●	12
Ponds / wetland	●●	●●	●●●	●	●●●	12
Gross Pollutant Traps	●●●	●	●●●	●●		9

●●●- excellent ●● - good ● - average

The table above illustrates that rainwater tanks, for lot water supply, and ponds/wetlands in conjunction with swales would be the most appropriate stormwater management devices for this site considering device treatment efficiency, capital and maintenance costs, site-suitability (excluding geology) and quantity control capabilities.

7 STORMWATER QUANTITY

7.1 UNDEVELOPED FLOW RATES

7.1.1 STUDY AREA

The study area has a number of main drainage outlet locations and are indicated in Figure F007 in Appendix B. Undeveloped flow rates at the study area discharge locations identified are displayed in Table 7-1.

These values have been obtained using XP-RAFTS. XP-RAFTS is a Laurensen non-linear runoff routing model used extensively throughout Australasia. XP-RAFTS has been an industry standard for modelling catchments ranging in size from a few square metres to thousands of square kilometres in both urban and rural nature and includes the ability to model attenuation basins.

Table 7-1: Study area undeveloped stormwater peak flow rates

Catchment Name (Outlet locations)	Undeveloped 5 Year ARI (m ³ /s)	Undeveloped 100 Year ARI (m ³ /s)
Catchment 1 (Tarago Road)	0.32	1.02
Catchment 2 (Larmer Street Open Channel) ¹	2.36	6.25
Catchment 3 (Eyre Street)	0.22	0.56
Catchment 4 (Simms Drive)	0.07	0.19
Catchment Area 5 (Rail Corridor) ²	1.85	5.05
Catchment Area 6 (Rail Corridor) ²	1.95	5.76
Catchment Area 7 (Rail Corridor)	0.16	0.38
Catchment Area 8 (Rail Corridor)	0.61	1.60
Catchment Area 9 (Rail Corridor)	0.40	1.17
Catchment Area 10	0.53	1.34
Catchment Area 11	0.26	0.68
Catchment Area 12	0.59	1.53
Catchment Area 13	0.95	2.55

¹ Catchment 2 is the sum of catchments 2.1, 2.2, 2.3, 2.4 and 2.5.

² Catchment 5 is the sum of catchments 5.1 and 5.2.

³ Catchment 6 is the sum of catchments 6.1 and 6.2.

7.1.2 PLANNING PROPOSAL AREA

The Planning proposal area has six main drainage outlet locations and are indicated in Figure 7-1 (and Figure F002 in Appendix B). Undeveloped flow rates at the site discharge locations identified are displayed in Table 7-2.

The existing downstream network capacity for each of the six outlet locations are discussed in the following sections.



Figure 7-1: Planning proposal area stormwater outlet locations

Table 7-2: Planning proposal area undeveloped stormwater peak flow rates

Catchment Name (Outlet locations)	Undeveloped 5 Year ARI (m ³ /s)	Undeveloped 100 Year ARI (m ³ /s)
Catchment 2 (Larmer Street Open Channel)	2.36	6.25
Catchment 3 (Eyre Street)	0.22	0.56
Catchment 4 (Simms Drive)	0.07	0.19
Catchment Area 5 (Rail Corridor)	1.85	5.05
Catchment Area 6 (Rail Corridor)	1.95	5.76
Catchment Area 7 (Rail Corridor)	0.16	0.38

7.2 CAPACITY ASSESSMENT OF EXISTING STORMWATER INFRASTRUCTURE

An assessment of the existing stormwater network downstream of the planning proposal area, has been undertaken and is discussed in the following sections.

7.2.1 ELMSLEA ESTATE STORMWATER NETWORK CAPACITY ASSESSMENT

The planning proposal area has three outlet locations which enter the existing Elmslea Estate, locations of which are shown in Figure 7-2.

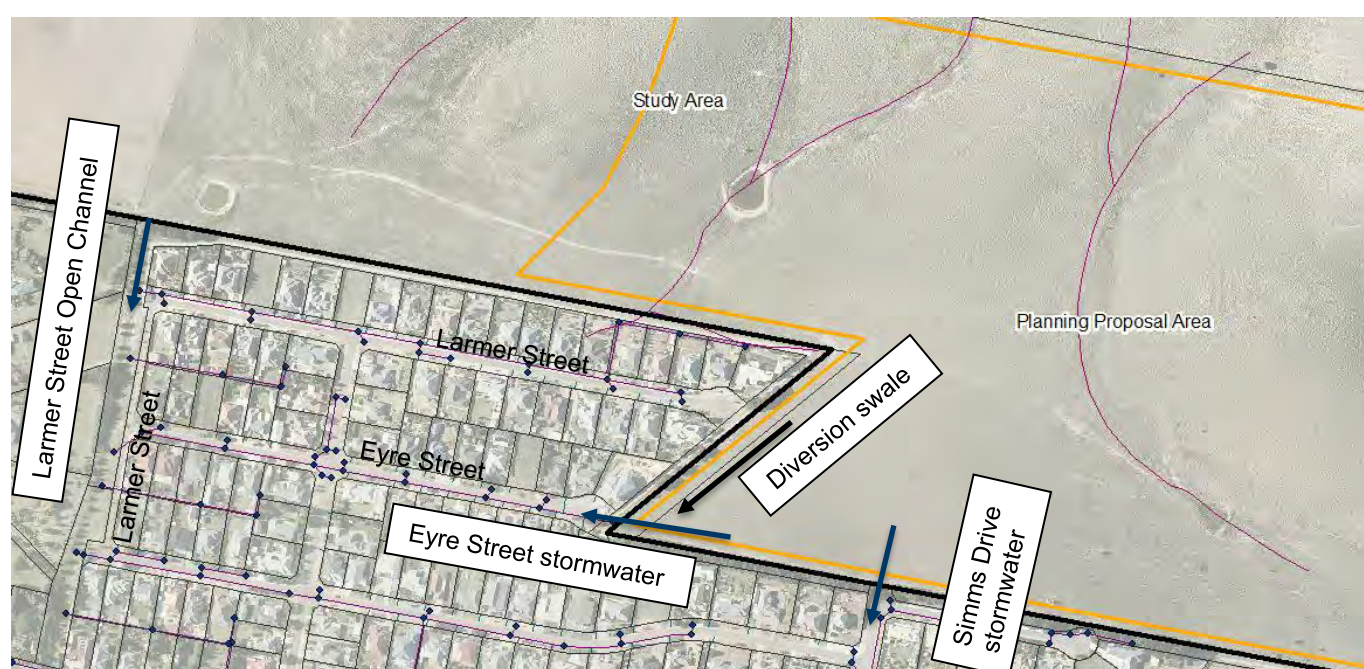


Figure 7-2: Planning proposal stormwater outlets to existing Elmslea Estate infrastructure

7.2.1.1 CATCHMENT 2 (LARMER STREET OPEN CHANNEL)

The Larmer Street open channel has been designed to convey a flow of $4.34 \text{ m}^3/\text{s}$ in a 100-year Average Recurrence Interval (ARI) rainfall event as noted in Drawing C01046-SW Stormwater Masterplan, Brown Consulting 2001, located in Appendix A.

As noted in Table 7-2, the provided contours produce a contributing catchment area of 41.92 Ha (Figure 7-3) and a resulting 100 year ARI flow rate of $6.25 \text{ m}^3/\text{s}$ in XP-Rafts. This is significantly larger than what the Larmer Street open channel has been designed for.

Any development in the study area / planning proposal area must detain the 100 year ARI developed flow rate to $4.34 \text{ m}^3/\text{s}$.

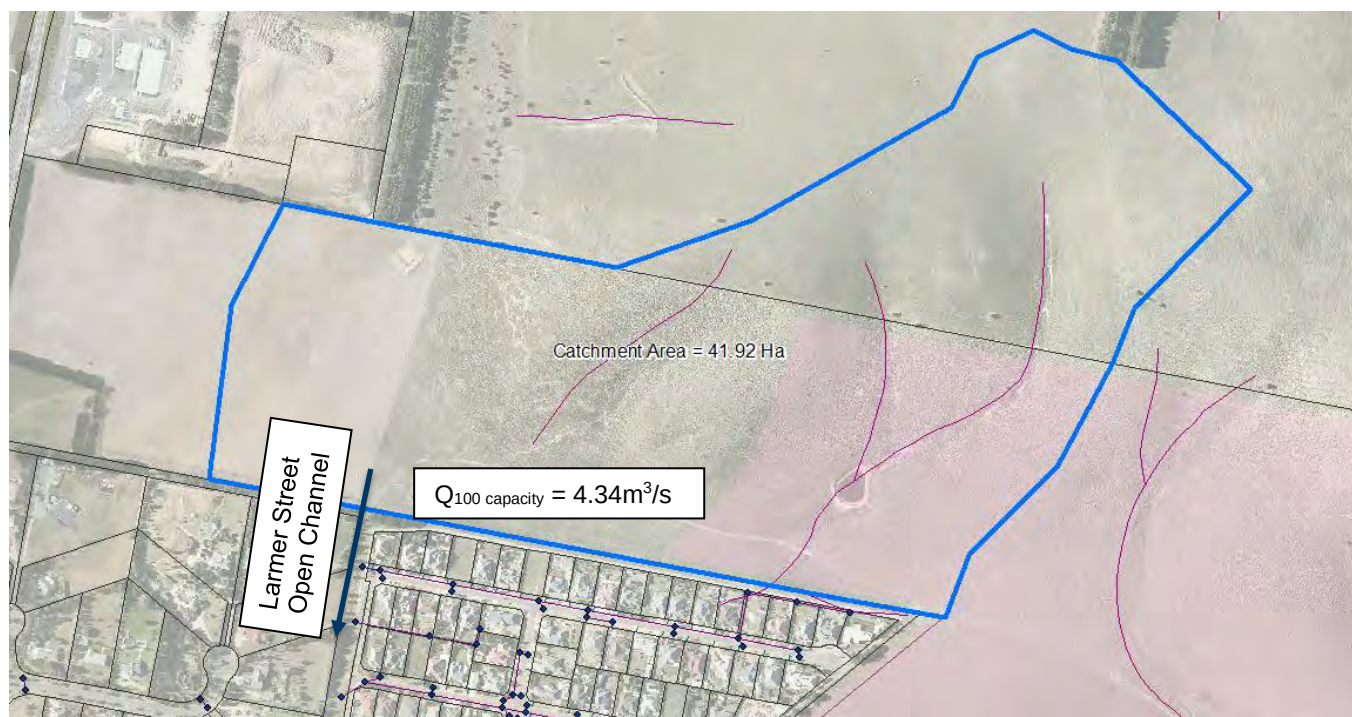


Figure 7-3: Larmer Street Contributing Catchment

7.2.1.2 EYRE STREET

The total catchment area contributing to the Eyre Street Stormwater network that discharges to the Larmer Street open channel is 7.72 Ha, as shown in Figure 7-4.

Surface flows from the upstream open space are diverted via a swale (Figure 7-4) and carried to a plantation sump at the top of Eyre Street. The plantation sump is connected to a 375mm diameter stormwater pipe, which continues down Eyre Street and increases to 675mm in diameter at its point of discharge.

The first section of the 375mm pipe down Eyre Street is graded at 5.8% and could convey approximately 0.45 m³/s of stormwater. As identified in Table 7-2, the 5 year ARI flow rates at the top of Eyre Street for the undeveloped scenario is 0.22 m³/s and has sufficient capacity of a 5 year ARI event.

At its discharge location into the Larmer Street open channel, the estimated flow rate has been determined as 0.72 m³/s. The capacity of a 675mm diameter stormwater pipe at approximately 1% grade is 0.94 m³/s.

No existing flooding issues have been identified along this network, verifying that the network has sufficient capacity in its existing condition.

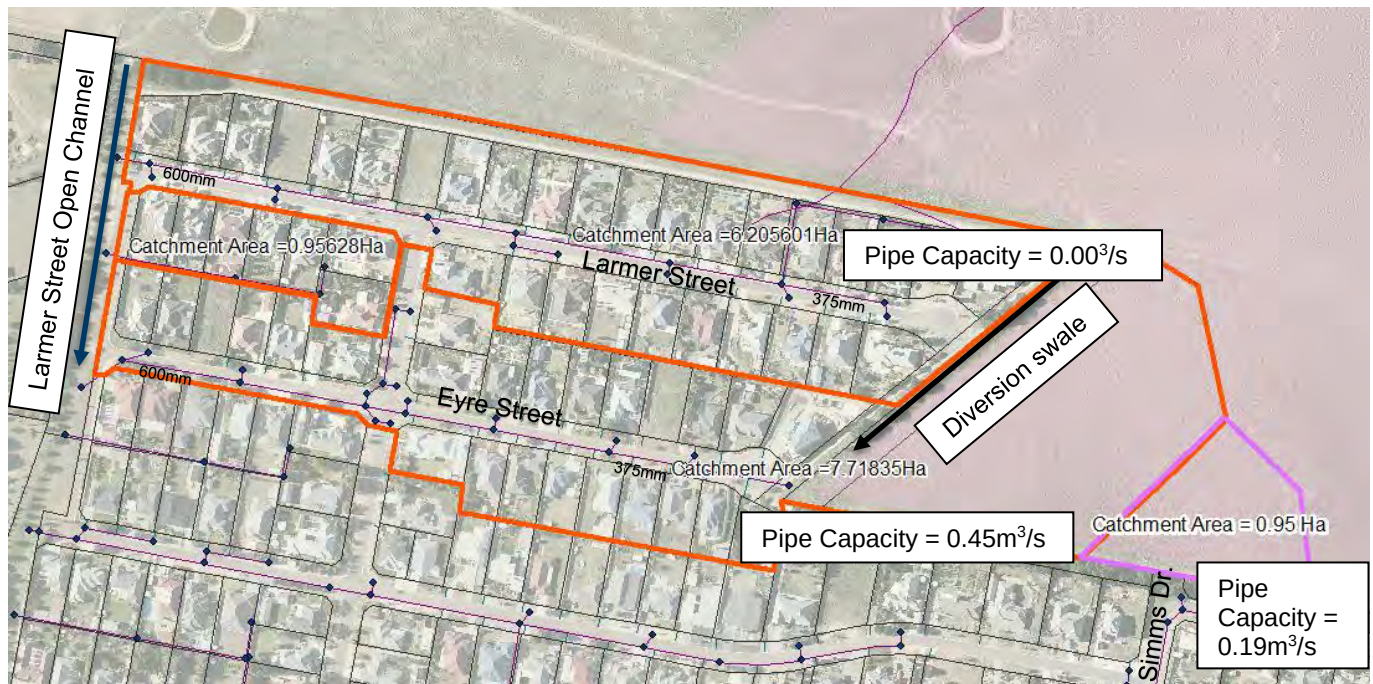


Figure 7-4: Existing Catchments, Eyre Street Larmer Street and Simms Drive

7.2.1.3 LARMER STREET

The total catchment area contributing to the Larmer Street stormwater network that discharges to the Larmer Street open channel is 6.21 Ha, as shown in Figure 7-4. The stormwater network starts with a 375mm diameter stormwater pipe from the cul-de-sac, continuing down Larmer Street and increasing to a 600mm pipe at its point of discharge. At its discharge location, a flow rate of 0.66 m³/s has been determined. The capacity of a 600mm diameter stormwater pipe at approximately 1% grade is 0.69 m³/s.

The open space to the East of the cul-de-sac does not contribute any stormwater to this street due to a diversion swale that has been constructed (Figure 7-4). There is very little remaining capacity within the existing stormwater network to receive any additional flows. Therefore, the capacity of this network at the top of Larmer Street is 0 m³/s.

No existing flooding issues have been identified along this network, verifying that the network has sufficient capacity in its existing condition.

7.2.1.4 SIMMS DRIVE

The total catchment area contributing to the Simms Street stormwater network is 0.95 Ha, as shown in Figure 7-4. The stormwater network starts with a 450mm diameter stormwater pipe at 8% grade from the planning proposal area catchment, continuing down Lithgow Place, increasing to a 600mm pipe at 1% grade at the bottom of the network and discharging into open space. The capacity of the network at the catchments discharge location is approximately 0.9 m³/s.

A total runoff of 0.07 m³/s will be produced from this catchment in a 100 year ARI event in its undeveloped condition. Simms Drive is deemed to have sufficient capacity for the upstream contributing catchment.

7.2.2 STORMWATER CAPACITY ASSESSMENT FOR OTHER PLANNING PROPOSAL DISCHARGE LOCATIONS

The planning proposal area has three catchment areas that discharge to the existing railway corridor south-east of the site (Figure 7-5 below). A site visit was conducted to inspect the railway corridor, and assess the adjoining stormwater.

7.2.2.1 CATCHMENT AREA 5

Catchment Area 5 has a total area of 35.65 Ha, 31.25 Ha of which, is located within the Planning proposal area (Figure 7-5). During the site inspection, it was noted that there is no defined channel to convey the stormwater to the nearby watercourse from Catchment 5. There is a culvert however it is not located at a low point. Any runoff produced from this catchment will travel parallel with the railway line. No adverse impact from rainfall runoff such as scouring was observed.

Therefore, any stormwater runoff from within catchment 5 from the proposed development must be detained to the undeveloped peak flows (Table 7-2). If this is done it is considered that no adverse effects will be observed downstream.

7.2.2.2 CATCHMENT AREA 6

Catchment Area 6 has a total area of 58.01 Ha, 8.42 Ha of which, is located within the planning proposal area (Figure 7-5). During the site inspection, it was noted that the main overland flow path of this channel leaves the planning proposal site, passes through a culvert below the neighbouring railway line and into the nearby water course. The size and capacity of this culvert is unknown. No adverse impact from rainfall runoff such as scouring was observed.

Any stormwater runoff from within catchment 6 from the proposed development must be detained to the undeveloped peak flows (Table 7-2). If this is done, it is considered that no adverse effects will be observed.

7.2.2.3 CATCHMENT AREA 7

Catchment Area 7 has a total area of 1.18 Ha (Figure 7-5). This is a small catchment with no defined channel. Stormwater from this area will sheet flow towards the neighbouring railway corridor.

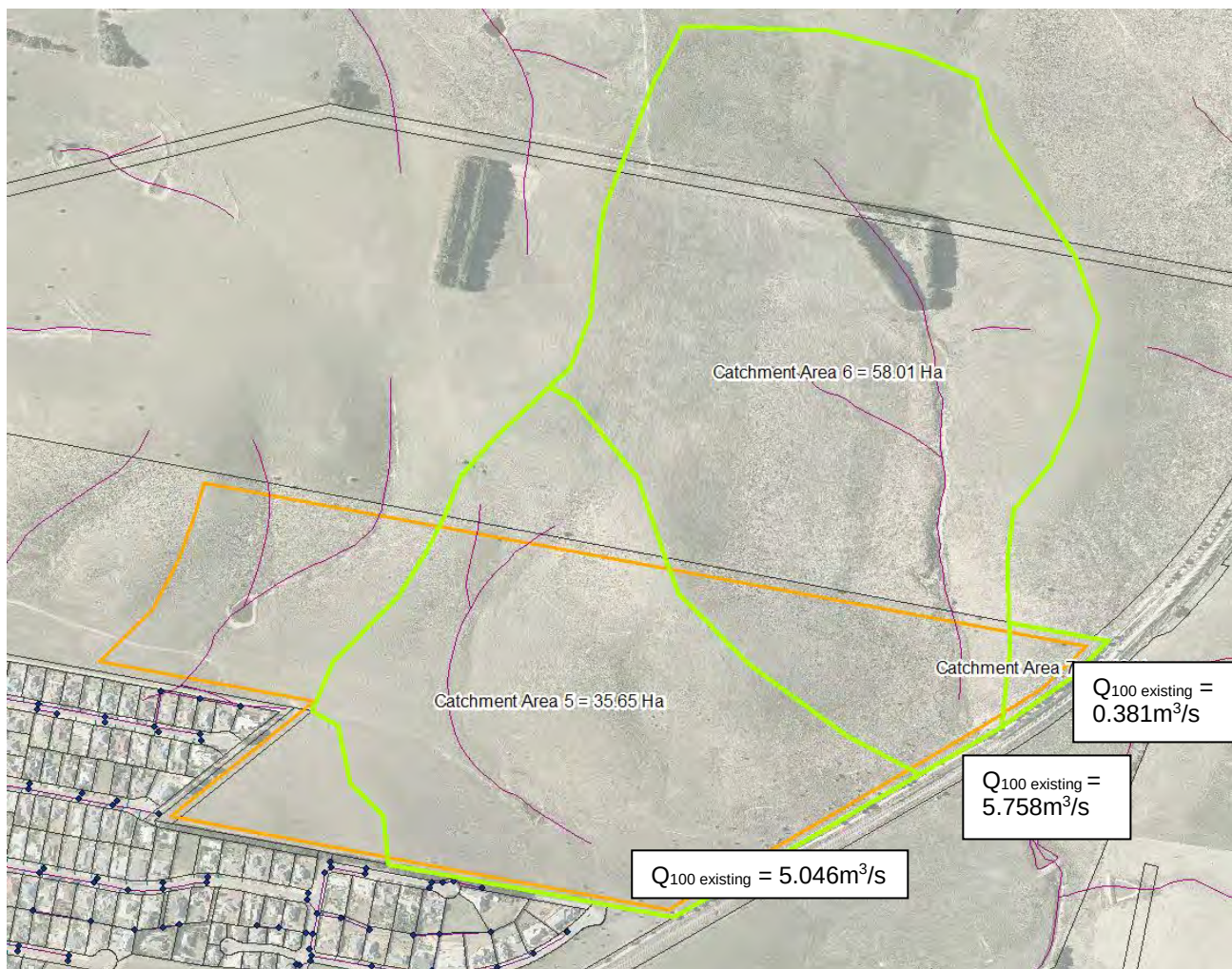


Figure 7-5: Undeveloped Catchments discharging to Railway Corridor

7.3 DEVELOPED UNMITIGATED FLOW RATES

Table 7-3 and Table 7-4 below, present the difference in flow rates at the site discharge locations if the planning proposal area only is developed without any stormwater mitigation measures in place.

XP-RAFTS has been used to determine the increase in stormwater runoff. The developed stormwater catchment plan is provided in Drawing F007 in Appendix B. The XP-RAFTS model layout is provided in Appendix C.

Each catchment, with the exception of Catchment 6, results in an increase to its site discharge. The result for catchment 6 is due to the increased impervious area being located at the downstream end of the catchment.

Table 7-3: 5 Year ARI Flow rates from a developed planning proposal area

Discharge Location	Undeveloped 5 year ARI Flow Rates (m ³ /s)	Developed 5 year ARI Flow Rates (m ³ /s)	Difference in Flow Rate (m ³ /s)
Catchment 2 (Larmer Street Open Channel)	2.36	2.53	0.17
Catchment 3 (Eyre Street)	0.22	0.42	0.20
Catchment 4 (Simms Drive)	0.07	0.13	0.06
Catchment Area 5 (Rail Corridor)	1.85	3.61	1.76
Catchment Area 6 (Rail Corridor)	1.95	1.94	-0.01
Catchment Area 7 (Rail Corridor)	0.16	0.23	0.07

Table 7-4: 100 Year ARI Flow rates from a developed planning proposal area

Discharge Location	Undeveloped 100 year ARI Flow Rates (m ³ /s)	Developed 100 year ARI Flow Rates (m ³ /s)	Difference in Flow Rate (m ³ /s)
Catchment 2 (Larmer Street Open Channel)	6.25	6.63	0.38
Catchment 3 (Eyre Street)	0.56	0.81	0.25
Catchment 4 (Simms Drive)	0.19	0.28	0.09
Catchment Area 5 (Rail Corridor)	5.05	7.11	2.07
Catchment Area 6 (Rail Corridor)	5.76	5.59	-0.17
Catchment Area 7 (Rail Corridor)	0.38	0.44	0.06

7.4 FLOW MITIGATION REQUIREMENTS

7.4.1 SUMMARY OF FLOW MITIGATION REQUIREMENTS

The previous sections summarise the undeveloped flow rates, developed flow rates and the existing stormwater network capacity for development of the planning proposal area only.

Our analysis of the existing stormwater network found that the existing stormwater network has capacity to convey the pre-development peak flows, with the exception of the Larmer Street Open Channel. This channel has been designed to convey a peak flow rate of 4.34 m³/s, which is less than the undeveloped 100 year ARI peak flow rate. Therefore, the flow mitigation requirement for the development within Catchment 2 in a 100 year ARI event is 4.34 m³/s.

For the remaining catchments the peak flows for the 5 year ARI and 100 year ARI are to be reduced to pre-development flows, in accordance with the Palerang Development Control Plans (2015) Table 5 Water Quality and Quantity Performance Targets.

Table 7-5 below provides a summary of the peak flow mitigation requirements for each stormwater catchment.

Table 7-5: Planning proposal area flow mitigation requirements

Discharge Location	5 Year ARI Peak Flow			100 Year ARI Peak Flow		
	Undeveloped (m ³ /s)	Developed (m ³ /s)	Peak Flow Attenuation (m ³ /s)	Undeveloped (m ³ /s)	Developed (m ³ /s)	Peak Flow Attenuation (m ³ /s)
Catchment 2 (Larmer Street Open Channel)	2.36	2.53	0.17	4.34 ¹	6.63	2.29
Catchment 3 (Eyre Street)	0.22	0.42	0.20	0.56	0.81	0.25
Catchment 4 (Simms Drive)	0.07	0.13	0.06	0.19	0.28	0.09
Catchment Area 5 (Rail Corridor)	1.85	3.61	1.76	5.05	7.11	2.07
Catchment Area 6 (Rail Corridor)	1.95	1.94	-0.01	5.76	5.59	-0.17
Catchment Area 7 (Rail Corridor)	0.16	0.23	0.07	0.38	0.44	0.06

¹ The Larmer Street Open Channel 100 Year ARI flow rate been extracted from Drawing C01046-SW Stormwater Masterplan, Brown Consulting 2001. This has been set as the downstream boundary condition for the Larmer Street open channel

The following sections address how the development peak flows can be attenuated to meet the requirements outlined in Table 7-5.

7.4.2 LARMER STREET OPEN CHANNEL FLOW MITIGATION

In section 7.2.1.1 it was identified that the Larmer Street Open Channel has been designed to convey a peak flow rate of 4.34 m³/s. As shown in Table 7-5, the Larmer Street Open Channel would require peak flow mitigation of 2.29 m³/s when developing the Planning proposal area. The planning proposal area is set due to the proximity of the waste depot. In order to maximise developable area and best integrate water quality and quantity devices for this catchment, the appropriate location for this basin is at the top of the Larmer Street Open Channel, as shown in Figure 7-6.

To achieve the flow mitigation required, a basin in this location will have a detention storage volume of 1890m³ in conjunction with 2x1050mm outlet pipes for a 5 Year ARI event, and a storage volume of 4,400m³ in conjunction with an 8m wide spillway and the aforementioned outlet pipes for a 100 Year ARI event.

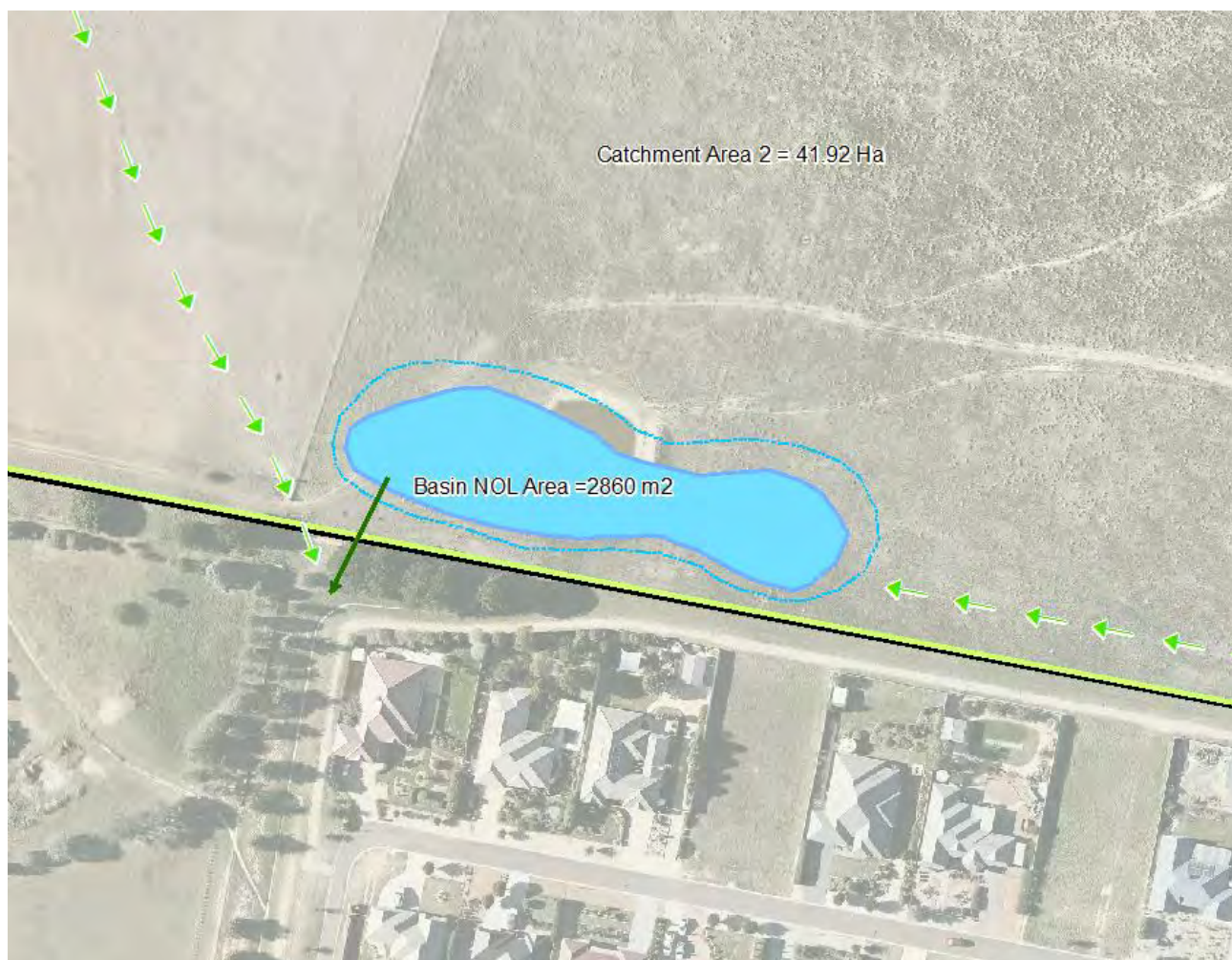


Figure 7-6: Larmer Street Basin

7.4.3 EYRE STREET AND LARMER STREET FLOW MITIGATION

As shown in Table 7-5, the Eyre Street stormwater network would see a 0.25 m³/s increase in flow due to developing the planning proposal area, if flow from the existing Catchment Area 3 is still discharged to the Eyre Street Stormwater Network.

As identified in section 7.2.1.3, the Larmer Street stormwater network has little additional capacity. The Eyre Street is estimated to have sufficient capacity for this additional flow, however not all of the developed flow may reach this network depending on the developments road layout. This will require consideration in the design of this development.

7.4.4 SIMMS DRIVE FLOW MITIGATION

As shown in Table 7-4, the Simms Drive stormwater network would see a 0.09 m³/s increase in flow due to developing the planning proposal area.

This increase is only minor and present no immediate issue for the downstream network. No detention is proposed; however, this area will need to be assessed with the proposed layout as this flow rate may vary significantly.

7.4.5 CATCHMENT AREA 5

As shown in Table 7-5, Catchment 5 would see a 2.07 m³/s increase in flow due to developing the Planning proposal area.

To achieve the flow mitigation required, a detention basin is required at the base of the catchment, as shown in Figure 7-7. This Basin will require a detention storage volume of 2450m³ in conjunction with 2x825mm outlet pipes for a 5 Year ARI event, and a storage volume of 4450m³ in conjunction with an 8m wide spillway and the aforementioned outlet pipes for a 100 Year ARI event.



Figure 7-7: Catchment 5 Basin

7.4.6 CATCHMENT AREA 6 AND CATCHMENT AREA 7

Due to the large size of Catchment 6 and the proposed development being located at the downstream end of the catchment, peak flow from the developed area does not influence the peak flow from the total catchment. As a result, no detention is required for this catchment if only the planning proposal area is used.

Catchment 7 is a minor catchment, with an increase of only 0.06 m³/s. As this is discharging to open space, no detention is proposed; however, this area will need to be assessed with the planned layout as this flow rate and direction may vary with grading.

7.5 PLANNING PROPOSAL AREA HYDRAULIC REQUIREMENTS

Catchment 2.5 (including 2.2, 2.3, and 2.4), Catchment 5 and Catchment 6 (Figure F007 in Appendix B) are large catchments and as such, may require an open channel or large stormwater pipes to carry water to downstream water quality and quantity devices. Estimated flow volumes and required pipe sizes for these catchments are provided in Table 7-6 below.

Table 7-6: Site Hydraulic requirements

Discharge Location	5 year ARI Flow Rates (m ³ /s)	100 year ARI Flow Rates (m ³ /s)	5 year Hydraulic Capacity 1	100 year Hydraulic Capacity
Catchment 2.5	2.91	6.22	1 x 1050mm pipe at 1%	2 x 1050mm pipe at 1%
Catchment 5	3.61	7.11	1 x 1200mm pipe at 1%	2 x 1200mm pipe at 1%
Catchment 6	1.542	4.672	1 x 850mm pipe at 1%	1 x 1350mm pipe at 1%

¹ Subdivision requirements state the 5 year ARI event shall be piped.

² Flow rates are for the upstream undeveloped catchment which is to be conveyed through the planning proposal area.

Table 7-6 assumes that all flow from these catchments converge into single or dual stormwater pipe/s. With a development layout these pipe sizes may vary. Pipe sizes are indicative only, and will require further analysis.

The planning proposal area which is at the base of catchment area 6 has a significant upstream catchment. The pipe size indicated should only be taken if the planning proposal area only is developed. If the total study area is developed further consideration will need to be given as a large detention basin is likely to be required upstream of the planning proposal area within this catchment. The future development of the study area is investigated in Section 9.

8 STORMWATER QUALITY

It is expected that if left unmitigated, the development will increase the stormwater pollutants that are exported to its surrounding areas. A treatment train comprised of suitable SQIDs is proposed to intercept and capture pollutants so that the potential impacts to receiving waters and other infrastructure will be adequately mitigated and the development will achieve the required Water Quality Objectives (WQOs).

This section discusses:

- The WQOs identified for the catchment;
- Proposed measures to mitigate the increase in pollutant export; and
- Modelling of the proposed measures to confirm their effectiveness in meeting the WQOs.

8.1 WATER QUALITY OBJECTIVES

The Palerang Development Control Plan (2015) outlines the minimum level of pollutant load reductions for the planning proposal area. These pollutant load reductions are outlined in Table 8-1 below.

Table 8-1: Water Quality Objectives

Pollutant	Load Target Reduction
Total Suspended Solids (TSS)	80%
Total Phosphorus (TP)	65%
Total Nitrogen (TN)	45%
Gross Pollutants	100%

8.2 WATER QUALITY MODELLING

Water quality modelling of the planning proposal area and its contributing catchments has been undertaken using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) Version 6.2.0, developed by the Cooperative Research Centre for Catchment Hydrology (CRCCH). MUSIC enables the user to conceptualise the transfer of pollutants through a stormwater drainage system and provides an aid in quantifying the effectiveness of the proposed stormwater quality treatment train. MUSIC only provides quantitative modelling for Total Suspended Solids (TSS), Total Phosphorous (TP), Total Nitrogen (TN) and Gross Pollutants (GP).

The subsequent sections discuss the model configurations adopted for the analysis.

8.2.1 METEOROLOGICAL DATA

Six-minute pluviographic data was sourced from the eWater website for Canberra Airport Rainfall Station (Station No. 70014) as this was the nearest rainfall station to the site with a range of rainfall data. The 10-year period from 1st January 1968 to 31st December 1977 was adopted for the rainfall duration. The six-minute time step mean annual rainfall for this period is 655mm.

8.2.2 SOURCE NODES

Source nodes represent sub-catchment areas within the MUSIC model. The site was divided into catchments as shown on Drawing F007 in Appendix B.

Table 8-2: MUSIC Catchments

Catchment	Total Area (ha)	Land Use	SQIDs
2.2, 2.3 and 2.5	18.82 ¹	Residential & Agricultural	• Rainwater Tanks for Residential • Gross Pollutant Trap; and • End-of-Line Fringe Wetland
3	3.10	Residential	• Rainwater Tanks
4	0.95	Residential	• Rainwater Tanks
5	35.65	Residential & Agricultural	• Rainwater Tanks for Residential • Gross Pollutant Trap; and • End-of-Line Fringe Wetland
6	8.42 ²	Residential	• Rainwater Tanks for Residential • Gross Pollutant Trap; and • End-of-Line Fringe Wetland (offline from main overland flow path)

Catchment	Total Area (ha)	Land Use	SQIDs
7	1.18	Residential	• Rainwater Tanks

¹The western area of Catchment 2.5 (18.82 Ha) will bypass the estate and has not been modelled as part of the water quality analysis.

²Catchment 6 has a large upstream catchment which runs through the site and should bypass the water quality treatment devices in the planning proposal area. The total area which will require bypassing is 49.59 Ha. This area has not been included as a part of the water quality analysis for the planning proposal area only.

8.2.3 TREATMENT NODES

8.2.3.1 RAINWATER TANKS

Rainwater tanks were adopted for all residential areas at a minimum of 22,500L/dwelling in accordance with Table 11 of the Palarang Development Control Plan (2015) for a 3-bedroom house. The average roof area has been taken as 350m², with 75% of the roof area reaching the rainwater tank. Re-use has been taken as 600L/day as per Table 9 of the Palarang Development Control Plan (2015) for a 3-bedroom house.

Table 8-3: Rainwater Tank Parameters

Parameters per Tank	Value
Rainwater Tank Volume below overflow pipe per tank (kL)	22.5
Depth above Overflow per tank (m)	0.2
Adopted Surface Area per tank (m ²) ¹	9.77
Initial volume per tank (kL) ²	18
Overflow Pipe Diameter per tank (mm)	90
Daily Re-use per tank (L/day) ³	600

¹Surface area based on tank diameter of 3.53m

²Rainwater tank at 80% Capacity.

8.2.3.2 SWALES

As outlined in Section 6, swales provide both stormwater conveyance and stormwater treatment. It has been assumed that stormwater for the planning proposal area will be conveyed through an underground hydraulic network and has therefore not been considered in this preliminary water quality assessment.

8.2.3.3 GROSS POLLUTANT TRAPS

GPTs have been modelled as Continuous Deflection Separation (CDS) Units with treatment nodes supplied by Rocla. CDS unit treatment nodes have a recommended treatment area capacity. These have been incorporated upstream of proposed wetlands, and sized based on the upstream catchment area. Alternate GPT devices could be used in the actual design of the development.

8.2.3.4 WETLANDS

Wetlands were modelled using MUSIC's Wetland Treatment node for Catchment 6 which requires no stormwater detention. Wetlands for catchments 2 and 5 have utilised the Pond Treatment Node with adjusted *k* and *C** to simulate a fringe wetland in accordance with the NSW *Using MUSIC in Sydney's Drinking Water Catchment* Guidelines. The configurations of these wetlands are outlined in Table 8-4.

Table 8-4: Fringe Wetlands for Catchments 2 and 5

Parameters	Fringe Wetland Parameters	Catchment 2 Wetland	Catchment 5 Wetland
Extended Detention Depth (mm)	300	300	300
Surface Area (m ²)	~2% of the total catchment area	2,860	7,000
Permanent Pool Volume (m ³)	1 x Surface Area	2,860	7,000
Notional Detention Time (hrs)	48	48	48

Table 8-5: Wetland for Catchment 6

Parameters	Standard Wetland Parameters	Catchment 6 Wetland
Inlet Pond (m ³)	5% of the Surface Area	62
Extended Detention Depth (mm)	500	500
Surface Area (m ²)	~1.5% of the total catchment area	1,240
Permanent Pool Volume (m ³)	1 x Surface Area	1,240
Notional Detention Time (hrs)	48	48

8.3 MUSIC MODELLING RESULTS

Results of the proposed stormwater quality management strategy is presented in Table 8-6 below. The results represent the pollutant reductions for the planning proposal.

The treatment train includes:

- Rainwater tanks for residential lots.
- Gross Pollutant Traps
- End of line wetlands;

Table 8-6: MUSIC Model Results

Description	Target Pollutant		
	TSS	TP	TN
WQO	80%	65%	45%
Load Reduction Achieved	86%	68%	53%
Load Reduction Achieved > WQO	YES	YES	YES

The above results indicate that the required water quality objectives can be achieved.

9 POSSIBLE FUTURE GROWTH IN PLANNING PROPOSAL AREA

The proponent may seek to develop the total study area in the future. This would be subject to a planning proposal being supported by Council and the NSW Department of Planning and Environment.

An approximate lot yield for the total study area has been taken as 1028 lots. This is based on an assumed 1800m² per block as directed by QPRC, with the total study area being approximately 186 Ha.

A high level investigation for the total study area has been conducted to identify if any additional stormwater treatment or detention is required for the devices proposed as part of the planning proposal area.

9.1 STORMWATER QUANTITY

As the existing stormwater network has been designed only for the upstream undeveloped condition, all water leaving the planning proposal area and study area should be detained and treated to match the undeveloped flow rates as provided in Section 7.4.

9.1.1 DEVELOPED STUDY AREA UNMITIGATED FLOW RATES

Table 9-1 and Table 9-2 below, present the difference in flow rates at the site discharge locations if the site is developed without any stormwater mitigation measures in place.

Table 9-1: 5 Year ARI Flow rates from a developed study area

Discharge Location	Undeveloped 5 year ARI Flow Rates (m ³ /s)	Developed 5 year ARI Flow Rates (m ³ /s)	Difference in Flow Rate (m ³ /s)
Catchment 2 (Larmer Street Open Channel)	2.36	3.746	2.646
Catchment 3 (Eyre Street)	0.22	0.42	0.200
Catchment 4 (Simms Drive)	0.07	0.13	0.06
Catchment Area 5 (Rail Corridor)	1.85	3.41	1.56
Catchment Area 6 (Rail Corridor)	1.95	3.72	1.78
Catchment Area 7 (Rail Corridor)	0.16	0.23	0.07

Table 9-2: 100 Year ARI Flow rates from a developed planning proposal area

Discharge Location	Undeveloped 100 year ARI Flow Rates (m ³ /s)	Developed 100 year ARI Flow Rates (m ³ /s)	Difference in Flow Rate (m ³ /s)
Catchment 2 (Larmer Street Open Channel)	6.25	7.731	3.391
Catchment 3 (Eyre Street)	0.56	0.81	0.24

Discharge Location	Undeveloped 100 year ARI Flow Rates (m ³ /s)	Developed 100 year ARI Flow Rates (m ³ /s)	Difference in Flow Rate (m ³ /s)
Catchment 4 (Simms Drive)	0.19	0.28	0.09
Catchment Area 5 (Rail Corridor)	5.05	6.83	1.79
Catchment Area 6 (Rail Corridor)	5.76	8.45	2.69
Catchment Area 7 (Rail Corridor)	0.38	0.44	0.06

9.1.2 FLOW MITIGATION REQUIREMENTS

From Table 9-1 and Table 9-2, it can be seen that flow mitigation is required at the Larmer Street Open Channel, Eyre Street, Catchment Area 5 and Catchment Area 6 if the study area outside of the planning proposal area is also developed.

However, in section 7.2.1.1 it was identified that the Larmer Street Open Channel has been designed to convey a peak flow rate of 4.34 m³/s. This is less than the undeveloped 100 year ARI peak flow rate and is therefore the flow mitigation requirement for the development within Catchment 2 in a 100 year ARI event. The 5 year ARI event is as per the Palerang Development Control Plan Requirements.

Table 9-3 provides estimated detention storage requirements if the entire study area is to be developed.

Table 9-3: Flow mitigation requirements considering future growth

Discharge Location	Study area 100 year ARI developed flow rate	Detention storage required (m ³)
Catchment 2 (Larmer Street Open Channel)	7.73	7,311
Catchment 3 (Eyre Street)	0.81	The Eyre Street is estimated to have sufficient capacity for this additional flow
Catchment Area 5 (Rail Corridor)	6.83	4,410
Catchment Area 6 (Rail Corridor)	8.45	6,630

9.1.3 COMPARISON OF FUTURE GROWTH REQUIREMENTS

Table 9-4 compares the detention storage requirements at the Larmer Street Open Channel, Catchment Area 5, and Catchment Area 6 if only the planning proposal area is developed, or if the whole study area is developed.

Table 9-4: Detention Basin Requirements for future growth

Discharge Location	Planning proposal detention storage required (m ³)	Study area detention storage required (m ³)
Larmer Street Open Channel	4,400	7,311
Catchment Area 5	4,450	4,410
Catchment Area 6	0	6,630

9.2 STORMWATER QUALITY

9.2.1 SOURCE NODES

Source nodes have been updated to account for the total study area being developed. These are summarised in Table 9-5. The MUSIC model layout is provided in Appendix D.

Table 9-5: MUSIC Catchments

Catchment	Total Area (ha)	Lot Yield	Land Use	SQIDs
2	41.92 ¹	232	Residential	- Rainwater Tanks for Residential - Gross Pollutant Trap; and - End-of-Line Fringe Wetland
3	3.10	17	Residential	Rainwater Tanks
4	0.95	6	Residential	Rainwater Tanks
5	35.65	197	Residential	- Rainwater Tanks for Residential - Gross Pollutant Trap; and - End-of-Line Fringe Wetland
6	58.01 ²	253	Residential & Agricultural	- Rainwater Tanks for Residential - Gross Pollutant Trap; and - Off-Line Fringe Wetland (offline from main overland flow path)
7	1.18	7	Residential	Rainwater Tanks

¹The total contributing catchment to the Larmer Street channel is modelled as developed.

²Catchment 6 is a large catchment which runs through the site. Approximately 12 Ha of Agricultural land is a contributing catchment outside of the total study area. This area has been included as a part of the water quality analysis for the total study area.

9.2.2 TREATMENT NODES

9.2.2.1 RAINWATER TANKS

Rainwater tanks have been modelled as per the planning proposal area, utilising 22,500L tanks.

9.2.2.2 GROSS POLLUTANT TRAPS

GPTs have been modelled as per the planning proposal area.

9.2.2.3 WETLANDS

Wetlands have been modelled as per the planning proposal area. Table 9-6, Table 9-7 and Table 9-8 summarise the additional treatment area that will be required for the wetlands specified as part of the planning proposal area, if the study area is developed.

Table 9-6: Fringe Wetlands for Catchments 2

Parameters	Fringe Wetland Parameters	Catchment 2 Planning Proposal Wetland Area	Catchment 2 Study Area Wetland Area
Extended Detention Depth (mm)	300	300	300
Surface Area (m ²)	~2% of the total catchment area	2,860	4,460
Permanent Pool Volume (m ³)	1 x Surface Area	2,860	4,460
Notional Detention Time (hrs)	48	48	48

Table 9-7: Fringe Wetlands for Catchments 5

Parameters	Fringe Wetland Parameters	Catchment 5 Planning Proposal Wetland Area	Catchment 5 Study Area Wetland Area
Extended Detention Depth (mm)	300	300	300
Surface Area (m ²)	~2% of the total catchment area	7,000	7,000
Permanent Pool Volume (m ³)	1 x Surface Area	7,000	7,000
Notional Detention Time (hrs)	48	48	48

Table 9-8: Wetland for Catchment 6

Parameters	Banded Wetland Parameters	Catchment 6 Planning Proposal Wetland Area	Catchment 6 Study Area Wetland Area
Inlet Pond (m ³)	5% of the Surface Area	62	432
Extended Detention Depth (mm)	500	500	500
Surface Area (m ²)	~1.5% of the total catchment area	1,240	8,690
Permanent Pool Volume (m ³)	1 x Surface Area	1,240	8,690
Notional Detention Time (hrs)	48	48	48

9.2.3 MUSIC MODELLING RESULTS

Results of the proposed stormwater quality management strategy is presented in Table 9-9 below. The results represent the pollutant reductions for the study area.

The treatment train includes:

- Rainwater tanks for residential lots.
- Gross Pollutant Traps; and
- Wetlands;

Table 9-9: MUSIC Model Results

Description	Target Pollutant		
	TSS	TP	TN
WQO	80%	65%	45%
Load Reduction Achieved	88%	66%	51%
Load Reduction Achieved > WQO	YES	YES	YES

The above results indicate that the required water quality objectives can be achieved.

10 RECOMMENDATIONS

10.1 PLANNED PROPOSAL AREA

The following stormwater quality and quantity devices are recommended if only the planning proposal area is developed:

- Assumed lot size of approximately 1800m². This includes the road and associated road reserve area.
- A 22,500 L rainwater tank is required for each residential block.
- Gross Pollutant Traps are required upstream of each wetland.
- Two detention basins are required for the planning proposal area. The detention basins are listed below and locations are shown on Drawings F003, F004, F005 and F006 in Appendix B
 - 4,400m³ detention for catchment 2 which discharge to the Larmer Street Open Channel, and;
 - 4,450m³ detention for catchment 5 which discharges to the neighbouring railway corridor.
- The planning proposal developed area in Catchment 6 does not require attenuation due to location of the developed area. If the upstream area is to be developed a detention basin is like to be required, as a result the major overland flow path through the catchment should remain clear from development.
- To meet the required WQOs, stormwater quality management will be provided via following:
 - Rainwater tanks for residential allotments in all the catchments;
 - End of line fringe wetlands with a surface area of 2,860 m² for catchment 2 and 7,000 m² for catchment 5;
 - Wetland for catchment 6 with a surface area of 1,240 m² which is outside the existing overland flow path.

10.2 ALLOWANCE FOR POSSIBLE FUTURE GROWTH

If future growth within the study area is to occur, the following impacts or adjustments will be expected for stormwater quality and quantity devices within the planning proposal area:

- Assumed lot size of approximately 1800m². This includes the road and associated road reserve area.
- A 22,500 L rainwater tank is required for each residential block.
- Gross Pollutant Traps are required upstream of each wetland.
- Three detention basins are required for the planning proposal area. The detention basins are listed below and locations are shown on Drawings F008, F009, and F010 in Appendix B
 - 7,311m³ detention for catchment 2 which discharge to the Larmer Street Open Channel;
 - 4,410m³ detention for catchment 5 which discharges to the neighbouring railway corridor; and

- 6,630m³ detention for catchment 6 which discharge to the neighbouring railway corridor.
- To meet the required WQOs, stormwater quality management will be provided via following:
 - Rainwater tanks for residential allotments in all the catchments;
 - End of line fringe wetlands with a surface area of 4,460 m² for catchment 2 and 7,000 m² for catchment 5;
 - One or multiple wetlands for catchment 6 with a surface area of 6,630 m² which may be online or offline with the existing overland flow path.

Lot yields for the above requirements are provided in Table 9-5.

11 CONCLUSION

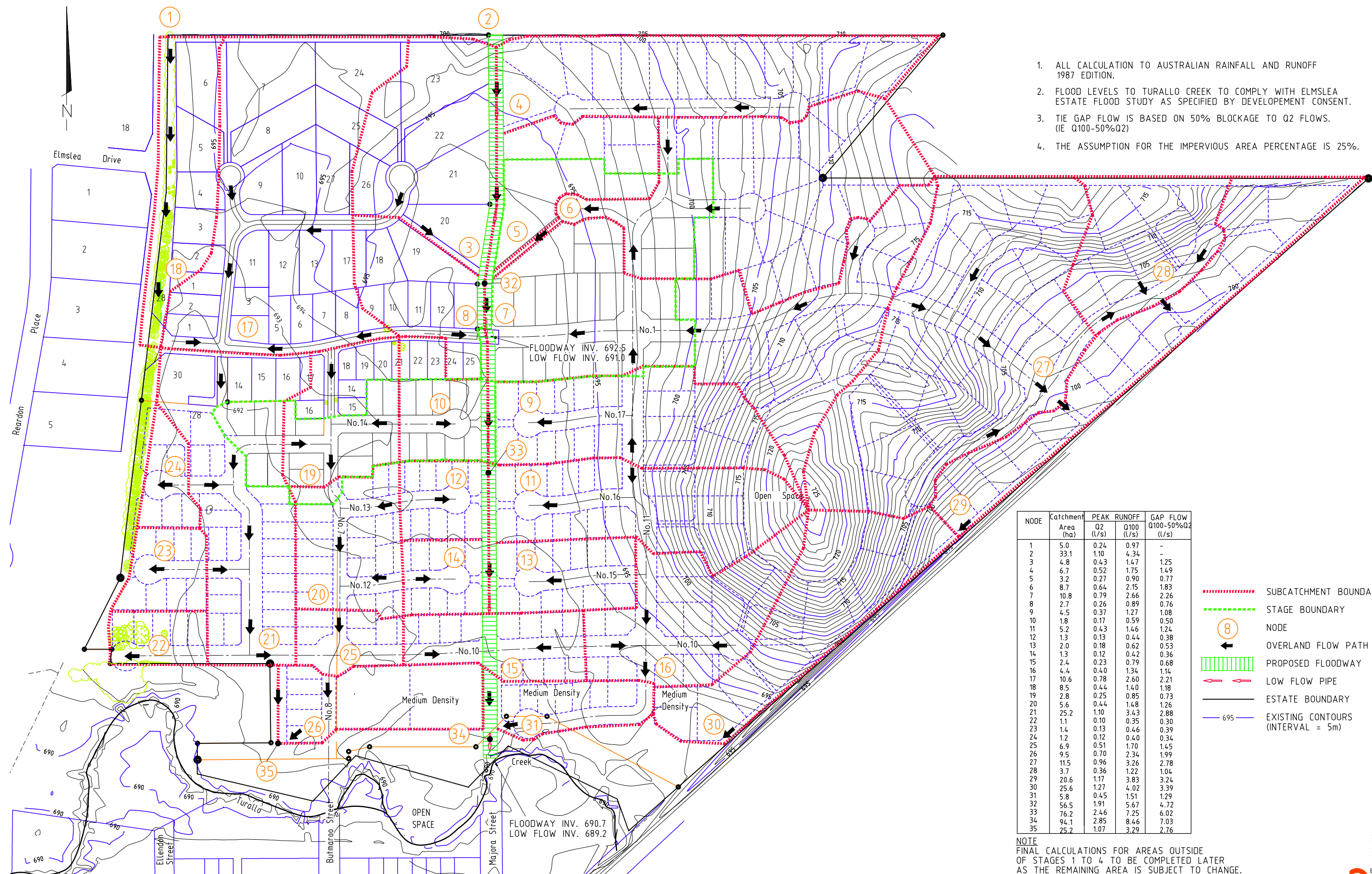
This stormwater investigation has found that if the above recommendations are adhered to, the proposed LEP Amendment (rezoning) may proceed. The site is capable of supporting development with respect to stormwater quantity and quality requirements.

12 REFERENCES

- Palerang Council Development Control Plan 2015
- NSW Using MUSIC in Sydney's Drinking Water Catchment Guidelines 2012
- ACT Planning & Land Authority (2008), Waterways: Water Sensitive Urban Design General Code.
- Healthy Waterways (2010), MUSIC Modelling Guidelines Version 1.0 – 2010.

APPENDICES

APPENDIX A PREVIOUS STORMWATER MASTERPLAN FOR ELMSLEA ESTATE



1. ALL CALCULATION TO AUSTRALIAN RAINFALL AND RUNOFF 1987 EDITION.
2. FLOOD LEVELS TO TURALLO CREEK TO COMPLY WITH ELSLEA ESTATE FLOOD STUDY AS SPECIFIED BY DEVELOPEMENT CONSENT.
3. TIE GAP FLOW IS BASED ON 50% BLOCKAGE TO Q2 FLOWS. (IE Q100-50%Q2)
4. THE ASSUMPTION FOR THE IMPERVIOUS AREA PERCENTAGE IS 25%.

NODE	Catchment Area (ha)	PEAK Q2 (L/s)	RUNOFF Q100 (L/s)	GAP FLOW Q100-50%Q2 (L/s)
1	5.0	0.24	0.97	-
2	33.1	1.10	4.34	-
3	4.8	0.43	1.47	1.25
4	6.7	0.52	1.75	1.49
5	3.2	0.27	0.90	0.77
6	8.7	0.64	2.15	1.83
7	10.8	0.79	2.66	2.26
8	2.7	0.26	0.89	0.76
9	4.5	0.37	1.27	1.08
10	1.8	0.17	0.59	0.50
11	5.2	0.43	1.46	1.24
12	1.3	0.13	0.44	0.38
13	2.0	0.18	0.62	0.53
14	1.3	0.12	0.42	0.36
15	2.4	0.23	0.79	0.68
16	4.4	0.40	1.34	1.14
17	10.6	0.78	2.60	2.21
18	8.5	0.44	1.40	1.18
19	2.8	0.25	0.85	0.73
20	5.6	0.44	1.48	1.26
21	25.2	1.10	3.43	2.88
22	1.1	0.10	0.35	0.30
23	1.4	0.13	0.46	0.39
24	1.2	0.12	0.40	0.34
25	6.9	0.51	1.70	1.45
26	9.5	0.70	2.34	1.99
27	11.5	0.96	3.26	2.78
28	3.7	0.36	1.22	1.04
29	20.6	1.17	3.83	3.24
30	25.6	1.27	4.02	3.39
31	5.8	0.45	1.51	1.29
32	56.5	1.91	5.67	4.72
33	76.2	2.46	7.25	6.02
34	94.1	2.85	8.46	7.03
35	25.2	1.07	3.29	2.76

- SUBCATCHMENT BOUNDARIES
- STAGE BOUNDARY
- 8 NODE
- ← OVERLAND FLOW PATH
- PROPOSED FLOODWAY
- ← LOW FLOW PIPE
- ESTATE BOUNDARY
- 695 EXISTING CONTOURS (INTERVAL = 5m)

NOTE
FINAL CALCULATIONS FOR AREAS OUTSIDE OF STAGES 1 TO 4 TO BE COMPLETED LATER AS THE REMAINING AREA IS SUBJECT TO CHANGE.

FILE:C01046-SW.dwg 8th-Aug-2001 11:00AM USR:veronique
Xref's: X-A1-C01046 X-BLK-C01046 X-CONT-C01046 X-TREES-C01046

FIRST ISSUE	CALCS	DRAWN	CHECK	APPROVED	DATE
A	VAO	VPP	3-6	4	30/07/01
B					
C					
D					
E					
F					

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A3 PLOT SCALE (METRES)
1:5000 50 0 50 100
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MICROFILM No.
PROJECT No.

CLIENT
ELMSLEA LAND DEVELOPMENT PTY LTD
PROJECT
ELMSLEA STAGES 3 AND 4
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DRAWING TITLE
STORMWATER MASTERPLAN
DRAWING NUMBER
C01046-SW
AMEND.



APPENDIX B DRAWINGS



Legend

- Planning Proposal Area
- Study Area

Notes:

Maps have been developed from information available at the time of this study.

Details

Issue	Amendment	Date
1	Final	19-Dec-2016

Project

**NORTH BUNGENDORE PLANNING
PROPOSAL ASSESSMENT - STUDY 8
STORMWATER**

Drawing Title

STUDY AREA

Scale 1:10,000 @ A3 - 1:5,000 @ A1

Drawn PM

Checked AL

Job No. 16-000862

Figure F001

Document Path: H:\16-000000\16-000862\05 Technical\01 Model\GIS\16-000862 F001 Planning Proposal Area.mxd

0 50 100 200 300 400
Meters



Legend

- Overland Flow Path
- Stormwater Catchment
- Planning Proposal Area
- Study Area

Notes:

Maps have been developed from information available at the time of this study.

Details

Issue	Amendment	Date
1	Final	19-Dec-2016

Project

NORTH BUNGENDORE PLANNING PROPOSAL ASSESSMENT - STUDY 8 STORMWATER

Drawing Title

PLANNING PORPOSAL AREA EXISTING STORMWATER CATCHMENTS

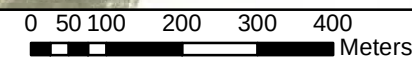
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Job No. 16-000862

Figure F002





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Legend

- Overland Flow Path
- Stormwater Catchment
- Planning Proposal Area
- Study Area
- Water Quality Basin
- Q100 Extents
- Basin Outlet
- Existing Stormwater
- Stormwater Manholes

Notes:
Maps have been developed from information available at the time of this study.

Details		
Issue	Amendment	Date
1	Final	19-Dec-2016

Project
NORTH BUNGENDORE PLANNING PROPOSAL ASSESSMENT - STUDY 8 STORMWATER

Drawing Title
PLANNING PROPOSAL AREA WSUD REQUIREMENTS

Scale 1:2,000 @ A3 - 1:1,000 @ A1
Drawn PM
Checked AL
Job No. 16-000862
Figure F003



Legend

- Overland Flow Path
- Stormwater Catchment
- Planning Proposal Area
- Study Area
- Water Quality Basin
- Q100 Extents
- Basin Outlet
- Existing Stormwater
- Stormwater Manholes

Notes:

Maps have been developed from information available at the time of this study.

Details

Issue	Amendment	Date
1	Final	19-Dec-2016

Project

**NORTH BUNGENDORE PLANNING
PROPOSAL ASSESSMENT - STUDY 8
STORMWATER**

Drawing Title

**PLANNING PROPOSAL AREA WSUD
REQUIREMENTS**

Scale 1:2,000 @ A3 - 1:1,000 @ A1

Drawn PM

Checked AL

Job No. 16-000862

Figure F004

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0 12.5 25 50 75 100
Meters



Legend

- Overland Flow Path
- Stormwater Catchment
- Planning Proposal Area
- Study Area
- Water Quality Basin
- Q100 Extents
- Basin Outlet
- Existing Stormwater
- Stormwater Manholes

Notes:

Maps have been developed from information available at the time of this study.

Details		
Issue	Amendment	Date
1	Final	19- Dec-2016

Project

NORTH BUNGENDORE PLANNING PROPOSAL ASSESSMENT - STUDY 8 STORMWATER

Drawing Title

PLANNING PROPOSAL AREA WSUD REQUIREMENTS

Scale 1:2,000 @ A3 - 1:1,000 @ A1

Drawn PM

Checked AL

Job No. 16-000862

Figure F005



Legend

- Overland Flow Path
- Stormwater Catchment
- Planning Proposal Area
- Study Area
- Water Quality Basin
- Q100 Extents
- Basin Outlet
- Existing Stormwater
- Stormwater Manholes

Notes:

Maps have been developed from information available at the time of this study.

Details

Issue	Amendment	Date
1	Final	19-Dec-2016

Project

**NORTH BUNGENDORE PLANNING
PROPOSAL ASSESSMENT - STUDY 8
STORMWATER**

Drawing Title

**PLANNING PROPOSAL AREA WSUD
REQUIREMENTS**

Scale 1:2,000 @ A3 - 1:1,000 @ A1

Drawn PM

Checked AL

Job No. 16-000862

Figure F006

Issue

1

Legend

-  Overland Flow Path
-  Study Area Catchments
-  Planning Proposal Area
-  Study Area

Notes:

Maps have been developed from information available at the time of this study.

Details

Issue	Amendment	Date
1	Final	19-Dec-2016

Project

NORTH BUNGENDORE PLANNING PROPOSAL ASSESSMENT - STUDY 8 STORMWATER

Drawing Title

STUDY AREA EXISTING STORMWATER CATCHMENTS

Scale 1:10,000 @ A3 - 1:5,000 @ A1

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Job No. 16-000862

Figure F007

Issue

1



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0 50 100 200 300 400 Meters



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Legend

- Overland Flow Path
- Stormwater Catchment
- Q100 Extent
- Study Area Water Quality Basin
- Planning Proposal Area
- Study Area
- Basin Outlet
- Existing Stormwater
- Stormwater Manholes

Notes:

Maps have been developed from information available at the time of this study.

Details

Issue	Amendment	Date
1	Final	19-Dec-2016

Project

NORTH BUNGENDORE PLANNING PROPOSAL ASSESSMENT - STUDY 8 STORMWATER

Drawing Title

STUDY AREA WSUD REQUIREMENTS

Scale 1:2,000 @ A3 - 1:1,000 @ A1

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Job No. 16-000862

Figure F008



Legend

-  Overland Flow Path
-  Stormwater Catchment
-  Q100 Extent
-  Study Area Water Quality Basin
-  Planning Proposal Area
-  Study Area
-  Basin Outlet
-  Existing Stormwater
-  Stormwater Manholes

Notes:

Maps have been developed from information available at the time of this study.

Details

Issue	Amendment	Date
1	Final	19-Dec-2016

Project

**NORTH BUNGENDORE PLANNING
PROPOSAL ASSESSMENT - STUDY 8
STORMWATER**

Drawing Title

STUDY AREA WSUD REQUIREMENTS

Scale 1:2,000 @ A3 - 1:1,000 @ A1

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Job No. 16-000862

Figure F009

Document Path: H:\16-000000\16-000862\05 Technical\01 Model\GIS\16-000862 F009 WSUD Study Area.mxd

0 12.5 25 50 75 100
Meters



Legend

- Overland Flow Path
- Basin Outlets
- Stormwater Catchment
- Q100 Extent
- Study Area Water Quality Basin
- Planning Proposal Area
- Study Area

Notes:

Maps have been developed from information available at the time of this study.

Details

Issue	Amendment	Date
1	Final	19-Dec-2016

Project

NORTH BUNGENDORE PLANNING PROPOSAL ASSESSMENT - STUDY 8 STORMWATER

Drawing Title

STUDY AREA WSUD REQUIREMENTS

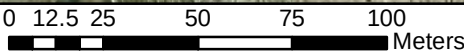
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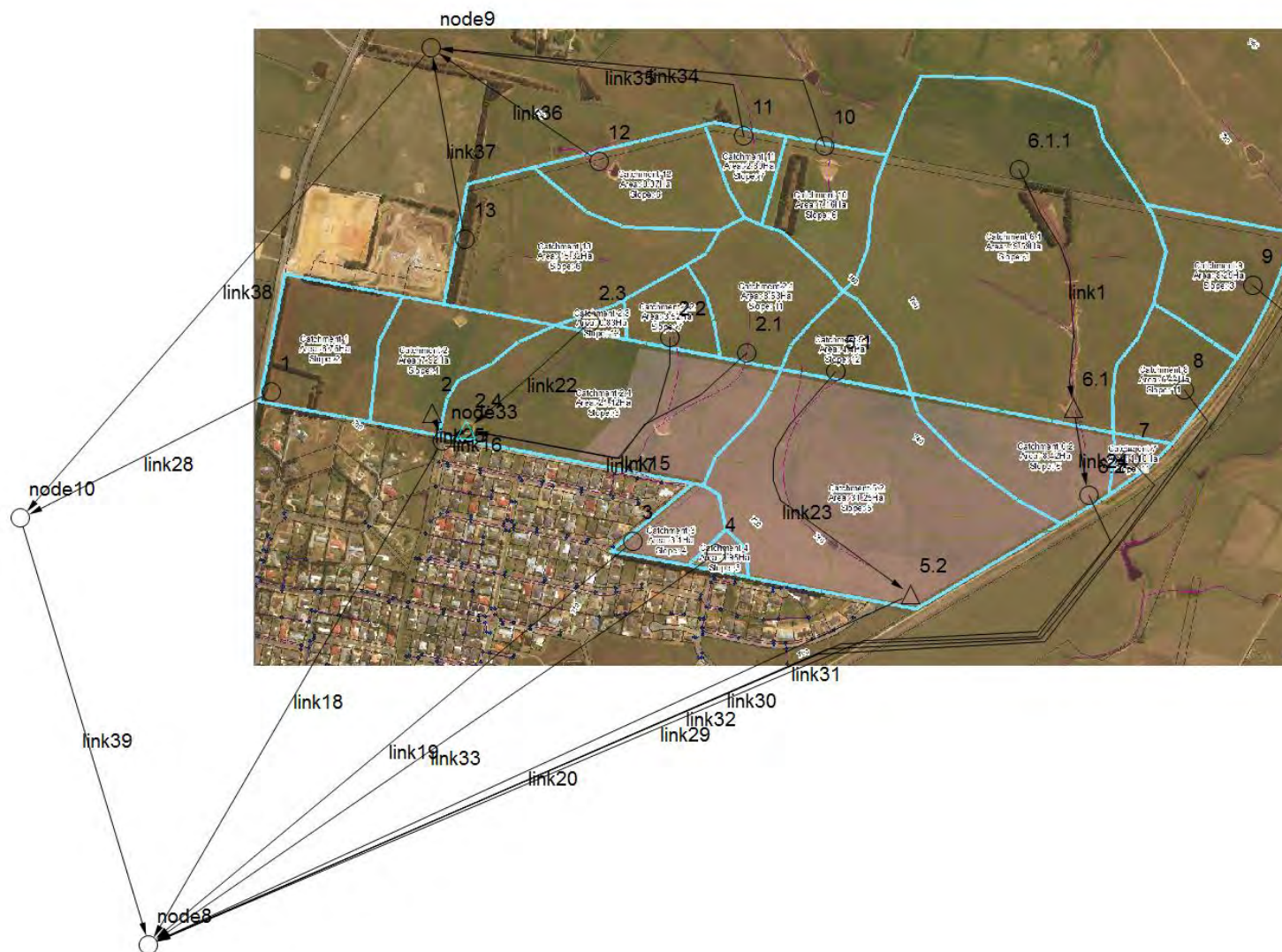
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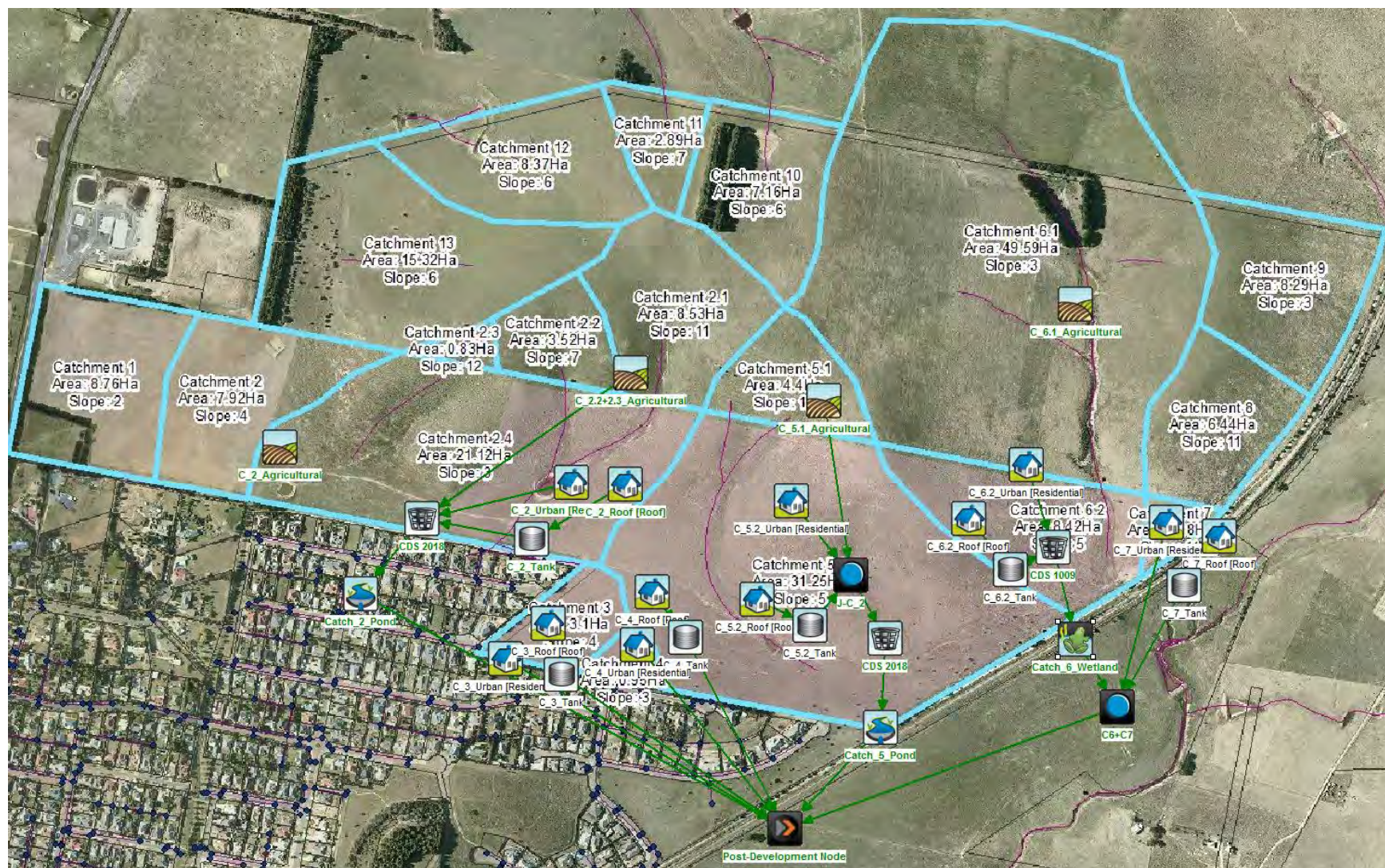
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Figure F010

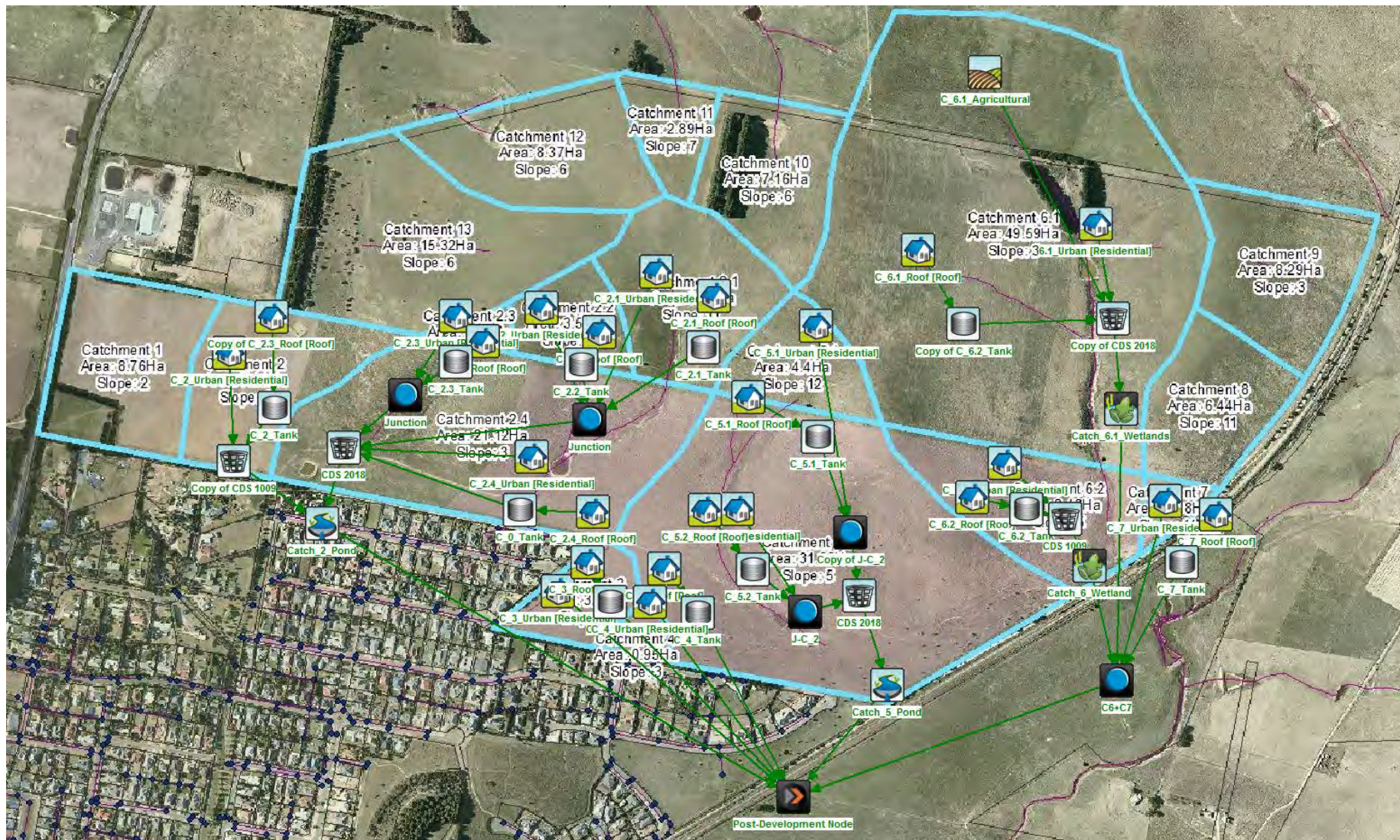




APPENDIX D MUSIC MODEL LAYOUT



Appendix D 1: Music model layout for planning proposal area only



Appendix D 2: Music model layout for study area