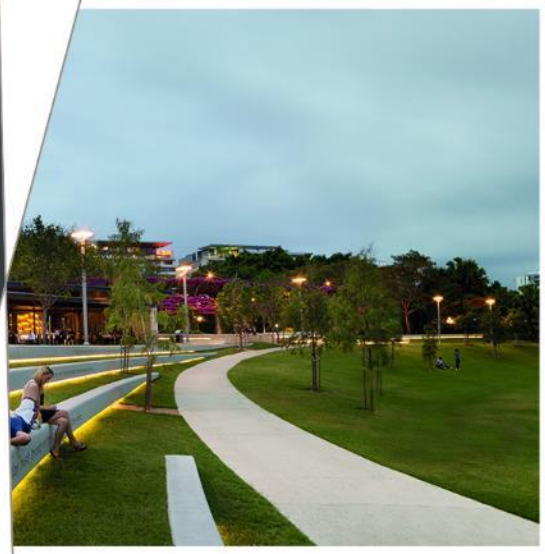
Stormwater Management Strategy

Jacaranda Ponds

80215086



Prepared for
Celestino

21 November 2018

Cardno

Contact Information

Cardno (NSW/ACT) Pty Ltd
ABN 95 001 145 035

Level 9 - The Forum
203 Pacific Highway
St Leonards NSW 2065
Australia

www.cardno.com
Phone +61 2 9496 7700
Fax +61 2 9496 7748

Document Information

Prepared for	Celestino
Project Name	Jacaranda Ponds
File Reference	17-0476 Stormwater Management Strategy v4 181121.docx
Job Reference	80215086
Date	21 November 2018
Version Number	04
Effective Date	21/11/2018

Author(s):

Tim Michel
Civil Engineer, Urban Infrastructure

Document History

Version	Effective Date	Description of Revision	Prepared by	Reviewed by
01	08/01/2018	Issue for client review	TIM	
02	09/02/2018	Final Issue	TIM	LMC
03	20/03/2018	Incorporating minor amendments	TIM	LMC
04	21/11/2018	Incorporating amendments	TIM/JHL	BRH

Table of Contents

Appendices

Tables

Figures

1 Introduction

This report outlines a Stormwater Management Strategy for a parcel of land referred to as Jacaranda Ponds, located within the Hawkesbury City Council local government area.

The Jacaranda Ponds site is generally bound by Spinks Road and existing rural residential lots to the north and west, rural residential / farmland to the east and Currency Creek to the south.

The extent of the site relative to key geographical features is presented in **Figure 1-1**.

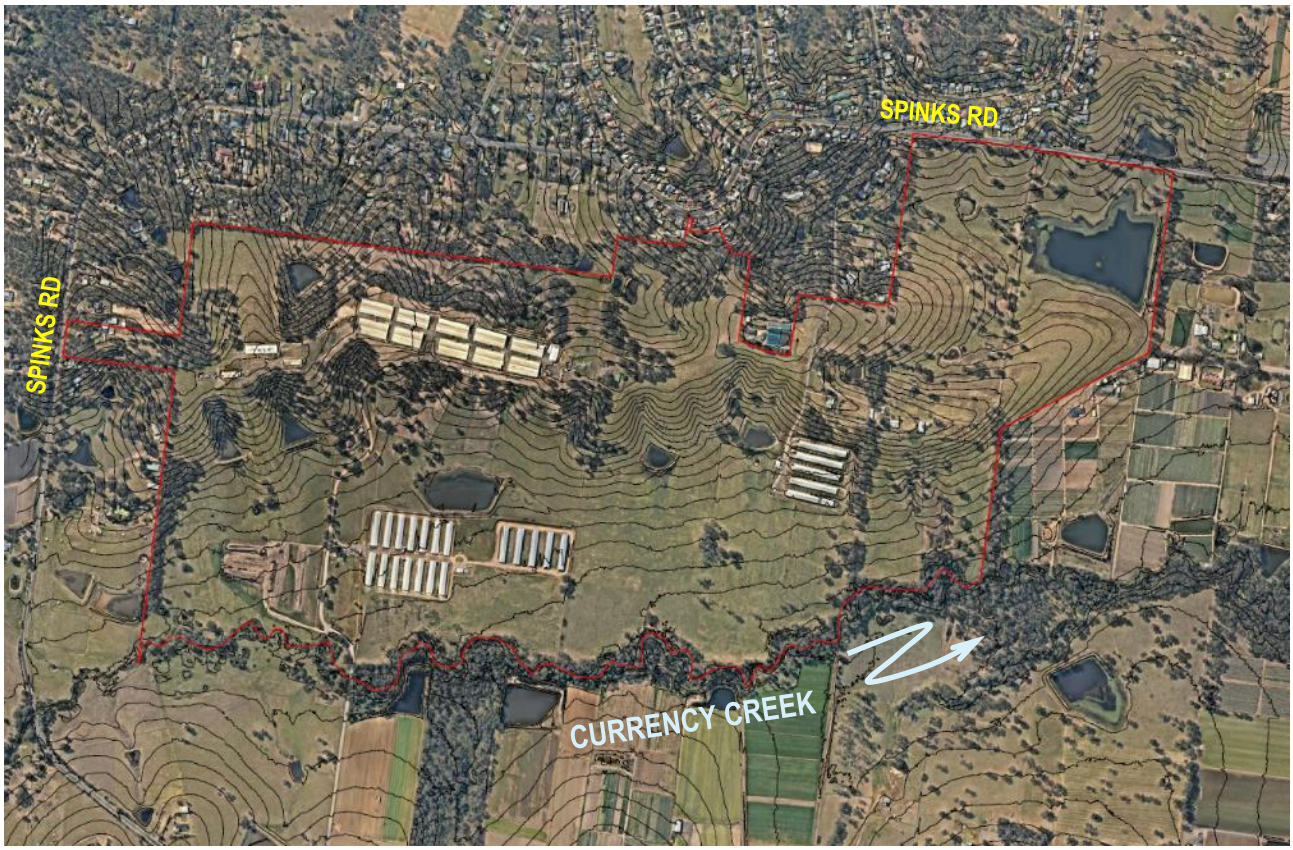


Figure 1-1 Jacaranda Ponds Locality Plan

Celestino are the project proponent for the proposed residential development of Jacaranda Ponds. Masterplanning and design development is currently being undertaken by Celestino and their consultant team. The current Site Masterplan, included as **Appendix A**, would result in a residential lot yield in the order of 580 lots, with other proposed land uses across the site including public open space and environmental conservation. The development would yield lots with a range of minimum lot sizes, ranging from 1000 m^2 to 4000 m^2.

This Strategy outlines stormwater management issues and requirements pertaining to the proposed development of the site, including:

- Stormwater Quality Management
- Stormwater Quantity Management
- Flood Risk Management

The intent of this report is to inform the revised planning proposal, in support of amendments to the land zoning of the subject site and to facilitate subdivision works through establishment of precedence for overall site water management objectives.

2 Site Conditions

2.1 General

The site generally consists of open pasture land and sheds that have been used for chicken farming. There are some scattered trees across much of the site, including stands of endangered ecological communities including Shale Plains Woodland and Alluvia Woodland.

A ridgeline runs generally west to east through the site, between the western portion of the site fronting Spinks Road and the large farm dam in the north-eastern corner of the site.

Approximately two-thirds of the site generally grades north to south towards Currency Creek, which discharges in an easterly direction and ultimately into the Hawkesbury River approximately 10 km north-east of the site. The topography of the southern portion of the site varies, with ground slopes of up to 12% in the upper portion adjacent to the ridgeline, and flatter sections of approximately 2-4% near Currency Creek.

The north-eastern portion of the site slopes towards a large farm dam and has ground slopes of approximately 4-6%.

The northern portion of the site discharges towards a number of low order ephemeral watercourses, which are characterised by a number of farm dams along their reaches.

2.2 Discharge Points

Based on the existing site conditions, there are eight main points of stormwater discharge across the site. These are presented below in **Figure 2-1** and described in further detail below.

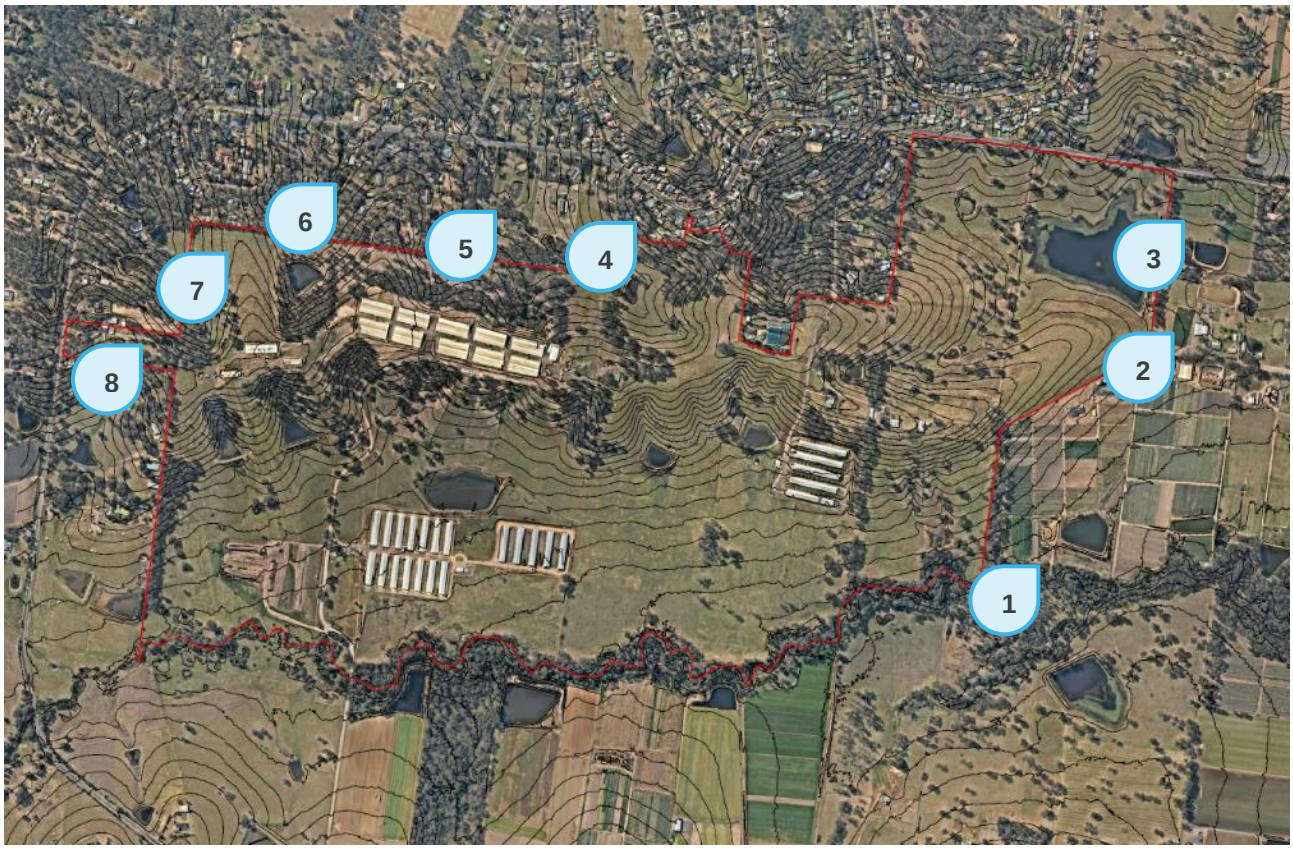


Figure 2-1 Existing surface water discharge points

> Discharge Point 1 – the downstream most point of Currency Creek adjacent to the site, at the south-eastern corner of the site.

- Discharge Point 2 – sheet flow across the boundary towards existing rural residential lots at the end of Jordan Avenue.
- Discharge Point 3 – overflow from the existing farm dam across the eastern site boundary.
- Discharge Point 4 – across the northern boundary and towards three existing farm dams located on an unnamed tributary of Howes Creek.
- Discharge Point 5 – across the northern boundary and towards an unnamed tributary of Howes Creek.
- Discharge Point 6 – across the northern boundary and towards an existing farm dam on an unnamed tributary of Howes Creek.
- Discharge Point 7 – across the western boundary and towards an existing farm dam on an unnamed tributary of Howes Creek.
- Discharge Point 8 – across the southern boundary of existing Lot 75 of DP214752 (361 Spinks Road), towards an existing farm dam and ultimately towards Currency Creek.

2.3 Catchment Delineation

Figure 2-2 presents a catchment plan that has been used as the basis for developing the stormwater management strategy and for sizing stormwater quality and quantity management measures. The catchment plan has been prepared based on the following data:

- Existing site contours (2 metre interval), sourced from the NSW Spatial Data Catalogue
- The current Site Masterplan (refer to **Appendix A**)
- A preliminary site grading plan that has been prepared based on the current Site Masterplan

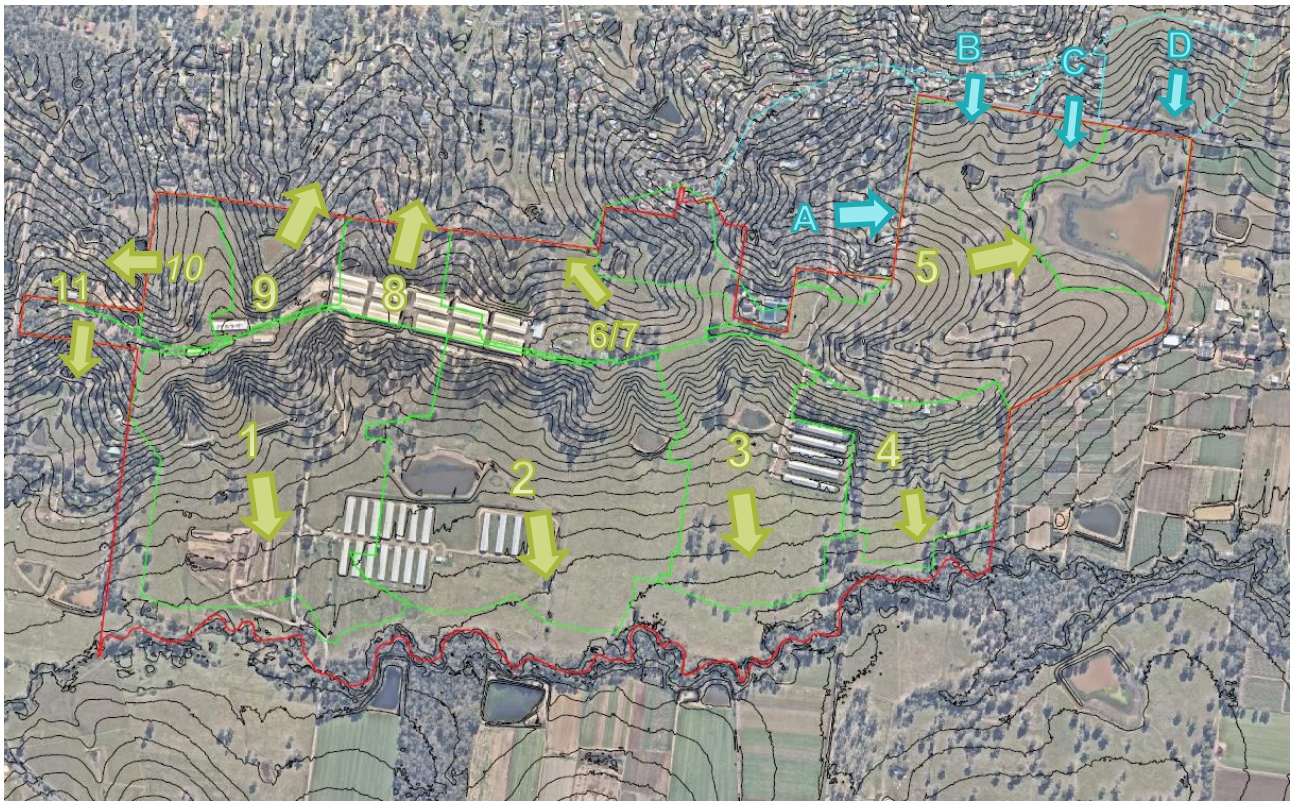


Figure 2-2 Catchment Plan

2.4 Watercourse Classification

Currency Creek, which forms the southern boundary of the site, has been mapped as a 4th order stream under the Strahler system for stream classification. It will therefore require a 40 metre wide vegetated riparian zone (VRZ), which is measured from the top of the northern bank of the creek.

There are two 1st order streams that cross the northern site boundary, and one 1st order stream that cross the western site boundary. These streams are all unnamed tributaries of Howes Creek. Due to their ephemeral nature, lack of riparian vegetation and undefined bed and banks, these three streams are likely to be declassified and replaced with an engineered form of drainage infrastructure (e.g. pit and pipe drainage or overland flow path).

3 Statutory and Development Control Requirements

3.1 Statutory Planning Controls

The land within the site is currently zoned for various uses, including:

- R2 – Low Density Residential
- R5 – Large Lot Residential
- RE1 – Public Recreation
- SP2 – Infrastructure

An extract from Hawkesbury Council's Land Zoning Map showing the current land zones within the site is presented in **Figure 3-1**.

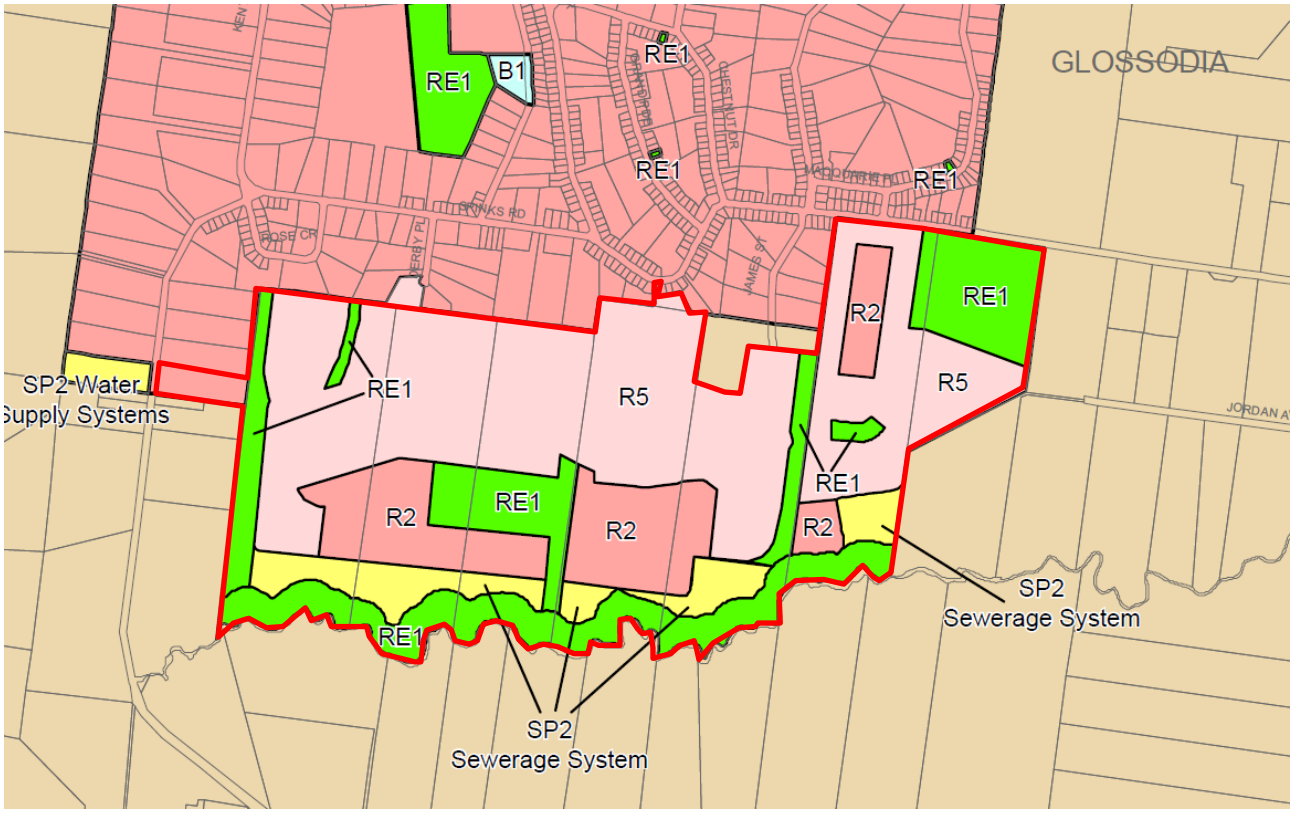


Figure 3-1 Current site zoning under *Hawkesbury Local Environmental Plan 2012* (extracted from Land Zoning Map Sheet LZN_008C)

This Strategy report will support a proposal to amend the site zoning and minimum lot sizes across the site to reflect a range of site constraints (e.g. ground slopes, endangered ecological communities). The proposed rezoning will be consistent with the current zoning in terms of potential residential lot yield.

3.2 Development Control Plans

Council's development control requirements are outlined in the *Hawkesbury Development Control Plan 2002* (DCP). The DCP outlines objectives and requirements for stormwater management that will need to be adopted at Jacaranda Ponds. The objectives outlined in the DCP are:

- *Drainage from subdivision sites should be consistent in both water quality and quantity terms with the predevelopment stormwater patterns.*
- *Drainage systems should be designed so as to ensure safety and minimise the likelihood of stormwater inundation of existing and future dwellings.*

> *Adequate provision should be made for measures during construction to ensure that the landform is stabilised and erosion controlled.*

3.3 BASIX

The NSW Building Sustainability Index (BASIX) aims to deliver equitable, effective water and greenhouse gas reductions across NSW. The Environmental Planning and Assessment Regulation 2000 (EP&A Regulation) and State Environmental Planning Policy (Building Sustainability Index) 2004 (BASIX SEPP) stipulate a requirement to achieve a 40% reduction in potable water use throughout the development.

4 Stormwater Quality Management

4.1 Strategy Objectives

The stormwater quality management objectives for the Jacaranda Ponds site are to preserve the existing state of watercourses within and adjacent to the site and to ensure that post-development pollutant loads are consistent with the requisite stormwater pollutant load reduction targets.

Section 8.24 of Council's Civil Works Specification states '*The minimum requirement shall be that the average annual pollutant load discharged from the developed site shall be no greater than for existing conditions.*'

Specific stormwater pollutant reduction targets are not stipulated in Council's DCP. However, a set of parameters have been adopted for the site that are consistent with the targets adopted for the Pitt Town Development within the Hawkesbury LGA (WorleyParsons, 2015), located approximately 10 km south-east of Jacaranda Ponds. These pollutant reduction targets are:

- Total Suspended Solids (TSS) 80% reduction in the average annual load
- Total Phosphorus (TP) 45% reduction in the average annual load
- Total Nitrogen (TSS) 45% reduction in the average annual load
- Gross Pollutants (GP) 90% reduction in the average annual load

The size and type of stormwater quality management measures will be determined based on their ability to satisfy both of the aforementioned objectives.

4.2 Strategy Overview

There is a general preference for achieving stormwater quality management objectives through the implementation of catchment-wide (end-of-line) stormwater treatment devices, rather than smaller devices within individual lots or road reserves.

The proposed stormwater quality management strategy for Jacaranda Ponds has been developed to incorporate gross pollutant traps (GPTs) and bio-retention systems within areas of public open space and in residential areas, as well as a constructed wetland generally within the extent of the large dam located in the north-eastern corner of the site.

There is also a requirement to achieve a 40% reduction in potable water use throughout the development, as stipulated by the NSW Government's *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) and *State Environmental Planning Policy (Building Sustainability Index)* 2004 (BASIX SEPP). This will be achieved by the provision of a reticulated recycled water system that will provide high quality recycled water from the proposed Glossodia Local Water Centre for domestic non-potable uses such as toilet flushing, washing machines, garden irrigation and car washing. On this basis, the proposed stormwater management strategy will not include the provision of rainwater tanks on individual lots.

4.3 Water Quality Model Setup

The MUSIC software package was used to develop a water quality model for each of the catchments that extend across the site. MUSIC is able to conceptually simulate the performance of a series of stormwater treatment measures (often referred to as the "treatment train") to assess whether a proposed water quality strategy is able to meet specified water quality objectives.

A MUSIC stormwater quality model was developed for the site to estimate the average annual pollutant loads that would be generated under existing and post-development conditions. The MUSIC model also incorporated end-of-line stormwater quality improvement devices to ensure that the stormwater pollutant reduction targets can be achieved.

The key model parameters adopted in the MUSIC model are summarised in the following sections.

4.3.1 Rainfall Data

Six-minute interval rainfall data used in the MUSIC model was sourced from the Bureau of Meteorology pluviometer gauge at Richmond RAAF (Station No. 067033), which is located approximately 7.5 km south of Jacaranda Ponds. The rainfall data adopted was recorded over a 16 year period between 1978 and 1993 inclusive, over which time the average annual rainfall was approximately 784mm. This period also includes years of relatively low rainfall and high rainfall, with a minimum and maximum annual totals of 397mm and 1352mm respectively. This period is generally representative of the long term annual average recorded at Richmond RAAF (approximately 815mm).

4.3.2 Evaporation Data

Monthly areal potential evapotranspiration (PET) values were obtained for the site from the online Bureau of Meteorology average monthly evapotranspiration maps, which are based on climatology data from over 750 weather stations across Australia for the period 1961 to 1990.

The adopted monthly areal PET values are presented in **Table 4-1**.

Table 4-1 Monthly Areal Evapotranspiration

Month	Areal Potential Evapotranspiration (mm/month)
January	170
February	135
March	135
April	90
May	60
June	45
July	45
August	60
September	90
October	130
November	150
December	160

4.3.3 Soil Parameters and Groundwater Properties

The soil profile parameters adopted in the MUSIC model affect the amount of stormwater runoff generated from pervious areas. A Geotechnical and Salinity Assessment was undertaken for the site by Geotechnique in 2015. This investigation established that the site is anticipated to comprise topsoil and natural souls underlain by siltstone / shale bedrock. The majority of the test pits taken on the site encountered topsoil to depths between 100mm and 200mm above silty clay or clay soils.

On the basis of the reported soil type at the site, pervious area soil storage and field capacities have been adopted based on the values for Silty Clay presented in Table 5-5 of the *NSW MUSIC Modelling Guidelines*.

The groundwater properties that were adopted in the MUSIC model are the values presented in Table 5-5 of the *NSW MUSIC Modelling Guidelines* for Silty Clay soils.

A summary of the pervious area soil parameters and groundwater properties adopted in the MUSIC modelling are presented in **Table 4-2**.

Table 4-2 Adopted Soil and Groundwater Parameters in MUSIC

Parameter	Value
Pervious Area	
Soil Storage Capacity	54mm
Initial Storage	25%
Field Capacity	51mm
Coefficient – a	180
Coefficient – b	3.0
Groundwater Properties	
Initial Depth	10
Recharge Rate	25%
Baseflow Rate	25%
Deep Seepage Rate	0%

4.3.4 Pollutant Event Mean Concentrations

Pollutant Event Mean Concentrations (EMCs) for base flow and storm flow scenarios were adopted from Table 5-6 and Table 5-7 of the *NSW MUSIC Modelling Guidelines*.

A summary of adopted EMC values for each of the nominated land uses in the MUSIC models is presented in **Table 4-3**. These values are applied to source nodes within the MUSIC model to estimate mean annual pollutant loads exported from the site under pre-development and post-development scenarios.

Table 4-3 Adopted EMC Values in MUSIC

Land Use	Mean Pollutant Concentration (mg/L)					
	TSS		TP		TN	
	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow
Pre-Development Scenario						
Forest	6.0	39.8	0.06	0.08	0.30	0.89
Agricultural	20.0	141	0.09	0.60	1.10	3.02
Rural	14.1	89.1	0.06	0.22	0.89	2.00
Unsealed Road	15.8	141	0.14	0.50	1.29	2.19
Post-Development Scenario						
Residential / Open Space	15.8	141	0.14	0.25	1.29	2.00

4.3.5 Land Uses

Various land use types were adopted for the existing scenario. The proportion of each land use type was estimated based on analysis of aerial photography of the site and is summarised below:

- Forest: 5% of total site area
- Agricultural: 6% of total site area
- Rural: 87% of total site area
- Unsealed Road: 2% of total site area

The post-development modelling scenario was based on land uses defined in the Site Masterplan (refer to **Appendix 1**) and broke these land uses down according to residential and open space areas. The percentage impervious for each of the adopted land uses is summarised in **Table 4-4**.

Table 4-4 Impervious percentages for various land use types

Land Use	Percentage Impervious
Forest	0%
Rural	5%
Unsealed Road	100%
Residential (including road reserve)	65%
Open Space	5%

4.3.6 Catchment Delineation

The site has been delineated into 11 overall catchments based on the location of discharge points from the site and proposed locations of stormwater quality control structures.

The extent of internal and external catchments has been determined based on existing ground contours and proposed site grading based on a preliminary grading strategy.

4.4 Proposed Water Quality Control Measures

A series of water quality control measures are proposed to be adopted within the Jacaranda Ponds site to satisfy the objectives outlined in **Section 4.1**. These measures are intended to be co-located with stormwater quantity management measures (detention basins) across the catchment. The indicative location and extent of these measures is presented in **Figure 4-1**. A general description of the proposed stormwater treatment train components is outlined in the following sections.

Figure 4-1 Indicative location and extent of proposed water quality management measures

4.4.1 Gross Pollutant Traps (GPTs)

The proposed stormwater treatment train would consist of GPTs as a means of primary stormwater treatment. GPTs are designed to capture litter, debris, coarse sediment, as well as some oils and greases. A range of proprietary GPTs are available and the most appropriate GPT would be selected at the subdivision design stage.

Pollutant capture efficiency differs between various proprietary GPTs. As prescribed in the *NSW MUSIC Modelling Guidelines*, the pollutant removal rates adopted for the GPT treatment nodes in MUSIC are presented in **Table 4-5**.

Table 4-5 GPT treatment node inputs in MUSIC

Pollutant	Input (mg/L)	Output (mg/L)	% Reduction
TSS	0	0	0
	75	75	0
	1000	350	65%
TP	0	0	0
	0.5	0.5	0
	1.00	0.85	15%
TN	0	0	0
	0.5	0.5	0
	5.0	4.3	14%
Gross Pollutants	0	0	0
	15	1.5	90%

High-flow by-passes for the GPTs have been adopted as half of the 1 EY post-development peak flow rate.

4.4.2 Bio-Retention Systems

The objective of bio-retention systems is to provide a filtering effect when stormwater runoff flows through a vegetation layer and sand and/or gravel filer media in order to remove pollutants from the runoff. Bio-retention systems generally consist of an open space containing landscaping of native grasses, shrubs and trees with an underlying filter media.

A number of bio-retention basins are proposed to be located in open space areas adjacent to riparian corridors within the site. These would be constructed to collect surface runoff from roads and general urban areas.

The proposed bio-retention systems would generally be constructed outside riparian corridors. However it is noted that under the NSW Office of Water's *Guidelines for riparian corridors on waterfront land*, water quality management measures (e.g. bio-retention basins) can be placed in the outer 50% of the VRZ on 1st and 2nd order streams, as long as the average VRZ width can be achieved over the length of the watercourse within the development site (refer to **Figure 4-2)**.

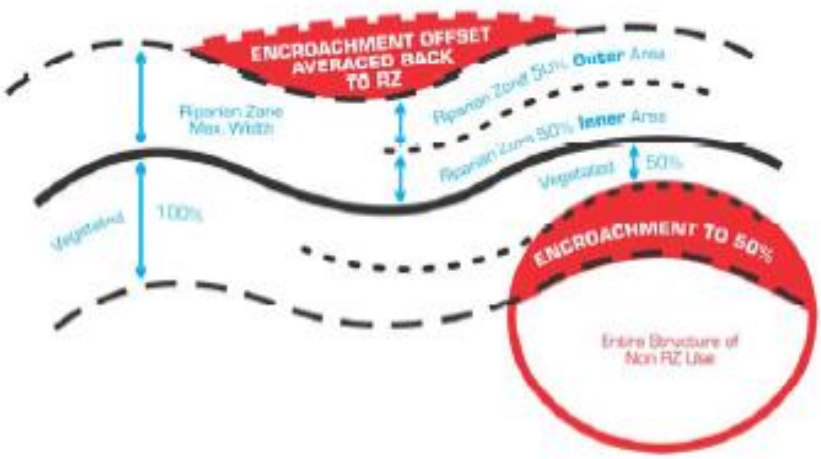


Figure 4-2 NSW Office of Water 'averaging rule' for riparian corridors

(Source: NSW Office of Water, 2012)

The following general parameters have been adopted for the proposed bio-retention systems:

- High flow by-pass: half of 1 year ARI peak flow
- Extended Detention Depth: 300mm
- Saturated Hydraulic Conductivity: 90mm/hr
- Filter Depth: 400mm
- TN Content of Filter Media: 400mg/kg
- Orthophosphate content: 40mg/kg
- Exfiltration rate: 0mm/hr
- Assumed to be vegetated with effective nutrient removing plants

4.4.3 Constructed Wetlands

A constructed wetland generally has two components – an upstream pond with relatively deep water and littoral macrophytes, and a downstream wetland with a comparatively shallow water body and extensive macrophyte vegetation.

The pond component traps 'readily settleable' solids (generally down to coarse-medium silt) while the wetland component traps dissolved pollutants by adsorption and bio-film growth on macrophytes. The pond component manages the hydrology and hydraulics of the wetland and the primary function of the littoral macrophytes are to aerate the sediments in order to manage the flow characteristics to enhance sedimentation and to minimise bank erosion.

It is proposed to incorporate a constructed wetland within the footprint of the existing farm dam at the downstream end of Catchment 5 in the north-eastern corner of the site. The dam would be modified to incorporate typical wetland vegetation and suitable low flow and high flow outlets to satisfy design criteria and operating requirements of the wetland.

4.5 Model Scenarios

Two model scenarios have been prepared and analysed:

1. A pre-development model to simulate existing site conditions, and
2. A post-development model to estimate the change in pollutant loads and the effectiveness of the proposed stormwater treatment train.

The pre-development scenario MUSIC model was prepared to reflect the existing catchment / site conditions and incorporated the parameters outlined in the preceding sections (*i.e., rainfall, evapotranspiration,*

percentage impervious, land use and EMC values). The model was developed to estimate the mean annual pollutants load discharged at each of the site's discharge points under existing conditions.

A post-development MUSIC model was developed based upon the land uses depicted in the Site Masterplan prepared by onecollective (refer to **Appendix A**). The layout of the pre-development and post-development models (included in one model file) is presented in **Figure 4-3**.

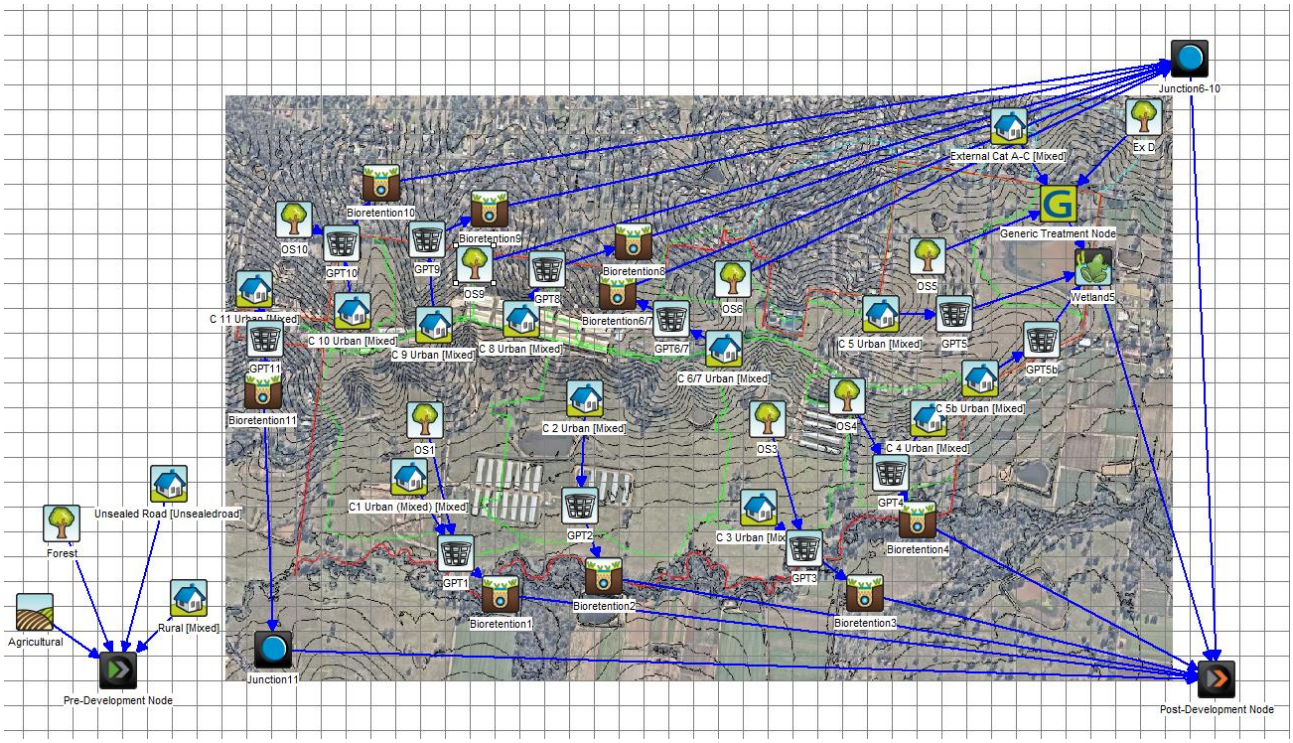


Figure 4-3 Layout of pre-development and post-development MUSIC models

The land use breakdown for each of the catchments under the post-development scenario is included in **Table 4-6**.

Table 4-6 Post-development scenario – land use breakdown

Catchment No.	Total Area (ha)	General Urban (ha)	Open Space (ha)
1	29.80	20.50	9.30
2	30.17	30.17	-
3	16.68	15.40	1.28
4	9.32	6.80	2.52
5	38.26	28.93	9.33
6/7	16.01	10.30	5.71
8	5.17	5.17	-
9	5.63	0.67	4.96
10	5.54	3.56	1.98
11	1.87	1.87	-

GPTs and bio-retention systems or constructed wetlands were included in the post-development scenario model to demonstrate the capacity of the proposed development to satisfy the objectives of the stormwater quality management strategy.

Key attributes of the proposed bio-retention systems within each of the catchments are summarised in **Table 4-7**. These attributes have been determined such that they will satisfy the pollutant reduction targets outlined in **Section 4.1**.

Table 4-7 Proposed bio-retention system properties

Catchment	Surface area at base (Filter Area) (m^2)	Surface area at crest of spillway (m^2)
1	6300	9000
2	9790	12790
3	4690	7000
4	3000	3950
6/7	2690	4290
8	1560	2520
9	600	900
10	820	1590
11	500	1060

The key design parameters for the proposed wetland in the north-eastern corner of the site are as follows:

- Surface Area = 20,900 m^2
- Extended Detention Depth = 750mm
- Permanent Pool Volume = 20,900 m^3 (assuming average 1 metre depth across area of wetland)

4.6 Model Results

The estimated mean annual pollutant loads from the site under pre-development and post-development conditions are listed in **Table 4-8**. For the post-development conditions scenario, pollutant loads are presented for scenarios both with and without treatment. The capacity of the proposed stormwater quality improvement structures to meet the strategic objectives of the strategy is demonstrated by the percentage reductions relative to both existing and proposed (no treatment) conditions.

Table 4-8 Summary of stormwater quality modelling results

Pollutant	Pre-Development (kg/yr)	Post-Development – NO treatment (kg/yr)	Post-Development – with treatment (kg/yr)	% Reduction (from Pre-Development)	% Reduction (from Post-Development – NO treatment)
TSS	57700	13900	13300	73%	90%
TP	95.2	225	59.9	37%	73%
TN	666	1660	589	12%	65%
GP	4330	21000	190	96%	99%

5 Stormwater Quantity Management

5.1 Strategy Objectives

Council's DCP outlines general requirements for on-site stormwater detention within the Hawkesbury LGA.

In areas where urban development is proposed, it is customary for measures to be implemented to reduce peak discharges to pre-development levels to minimise potential impacts on adjoining land owners that may arise due to an increase in peak flows. In addition, OSD measures can minimise impacts on watercourses such as stream bank erosion.

The objective of the stormwater quantity management strategy for Jacaranda Ponds is to restrict post-development peak flow rates to less than or equal to pre-development peak flow rates at each outlet point for a range of storm events from the 1 EY (1 year ARI) to the 1% AEP (100 year ARI).

At this point in the rezoning / masterplanning stage, no design of the internal drainage network has been undertaken due to the very preliminary nature of design. The focus of the strategy at this point is to demonstrate that stormwater runoff under post-development conditions can be managed to ensure that post-development peak flow rates do not exceed pre-development peak flow rates at each of the site's discharge points.

5.2 Strategy Overview

The proposed development will require the provision of stormwater detention to ensure that peak discharges generated for the post-development scenario match existing peak discharges from the site for events up to the 1% AEP event.

The required stormwater detention storage will be incorporated within a basin adjacent to each of the proposed bio-retention systems that are to be incorporated into the development. Each of the proposed detention basins will be designed with multi-stage outlets, to provide the required stormwater detention volume and to limit discharges such that post-development peak discharge rates do not exceed pre-development peak discharge rates for a range of storm events up to the 1% AEP event.

As a minimum, the proposed detention basins will need to comply with the requirements outlined in Section 8.21 of the *Hawkesbury Development Control Plan*.

5.3 Proposed Detention Basin Locations and Configuration

The proposed locations and configuration of each of the detention basins required throughout the development are summarised below in **Table 5-1**.

Table 5-1 Summary of proposed detention basin locations and configuration

Basin ID	Location	Configuration
1, 2, 3, 4	Offline, adjacent to Currency Creek riparian corridor	Dry basin, with outlet configured to achieve required stormwater attenuation rates, including low flow pipe outlet(s) and multi-staged weir
5	Online, around the footprint of existing farm dam	Wet basin, with a permanent pond below the required stormwater detention volume to be re-designed as a wetland. The detention basin outlet will be configured above the permanent pond volume and will include low flow pipe outlets and multi-staged weirs as required.

Basin ID	Location	Configuration
6/7, 8, 9, 10	Offline, adjacent to northern site boundary	Dry basin, with outlet configured to achieve required stormwater attenuation rates, including low flow pipe outlet and multi-staged weir
11	Offline, adjacent to main east/west spine road	Dry basin, with outlet configured to achieve required stormwater attenuation rates, including low flow pipe outlet and multi-staged weir

5.4 Hydrologic Model Setup

The DRAINS software package Version 2017.11 (incorporating the ARR2016 procedures) was used to develop a hydrologic model of the catchments that drain through the site. The hydrologic model was then used to simulate a range of design storms and estimate peak flow rates from the development site under existing and post-development scenarios.

The detention basin modelling capability within DRAINS was used to calculate the stormwater detention storage volumes required to ensure that post-development peak flow rates are less than or equal to pre-development peak flow rates at each of the site's outlet points.

Design rainfall based on the *Australian Rainfall and Runoff 2016* Intensity Frequency Durations (IFDs) was sourced from the Bureau of Meteorology.

The following model assumptions were adopted the DRAINS model:

- Impervious area depression storage = 1mm
- Pervious area depression storage = 5mm
- Soil Type = 3 (slow infiltration rates)
- Antecedent Moisture Condition = 3

5.5 Design Event Simulations

The DRAINS model was used to simulate the following design storm events under pre-development and post-development conditions:

- 1 EY (equivalent to the 1 year ARI under the ARR 1987 procedures)
- 0.2 EY (equivalent to the 5 year ARI under the ARR 1987 procedures)
- 5% AEP (equivalent to the 20 year ARI under the ARR 1987 procedures)
- 1% AEP (equivalent to the 100 year ARI under the ARR 1987 procedures)

A post-development model incorporating preliminary stormwater detention basin design parameters was developed and run to simulate the outlet configuration and basin volume that would be required to achieve the necessary level of attenuation to meet the strategy objective.

5.6 Results

Preliminary stormwater detention volumes that would be required based on the current Masterplan are summarised in **Table 5-1**.

Table 5-2 Preliminary stormwater detention volumes

Sub-Catchment	PSD Peak Flow Rate (m^3/s)	1% AEP Peak Flow Rate (m^3/s)	Preliminary Estimate of Required Detention Volume (m^3)	Volume per unit area (m^3/ha)
1	4.69	4.59	8640	290
2	5.10	3.94	13300	441
3	4.14	3.36	6158	370
4	3.57	3.10	3473	373
5	15.1	0.59*	40769	1066
6/7	4.03	2	3413	214
8	1.40	1.09	1905	369
9	2.62	1.8	384	69
10	1.60	0.90	600	109
11	0.52	0.52	516	276

* Wetland OSD to be designed in detail in the future.

NB: Peak flow rates presented above are for the median storm in the ensemble of design storm events that represent the critical duration for a particular catchment.

6 Flooding and Watercourse Assessment

6.1 Flood Assessment

6.1.1 Flood Extents

A Flood Study for the site has been undertaken by Cardno (May 2016) to define flood behaviour within and adjacent to the site under both the 1% AEP and Probable Maximum Flood (PMF) events (refer to **Appendix B**).

A two-dimensional model was setup and run using the TUFLOW software package. The model was developed using both an XP-RAFTS hydrology model for the extent of the Currency Creek catchment upstream of the site (approximately 15 km^2) and a 'rainfall on grid' approach for hydrology within the site.

The extents of the 1% AEP and PMF events under existing site conditions, as presented in the 2016 Flood Study, are reproduced below as **Figure 6-1** and **Figure 6-2** respectively.

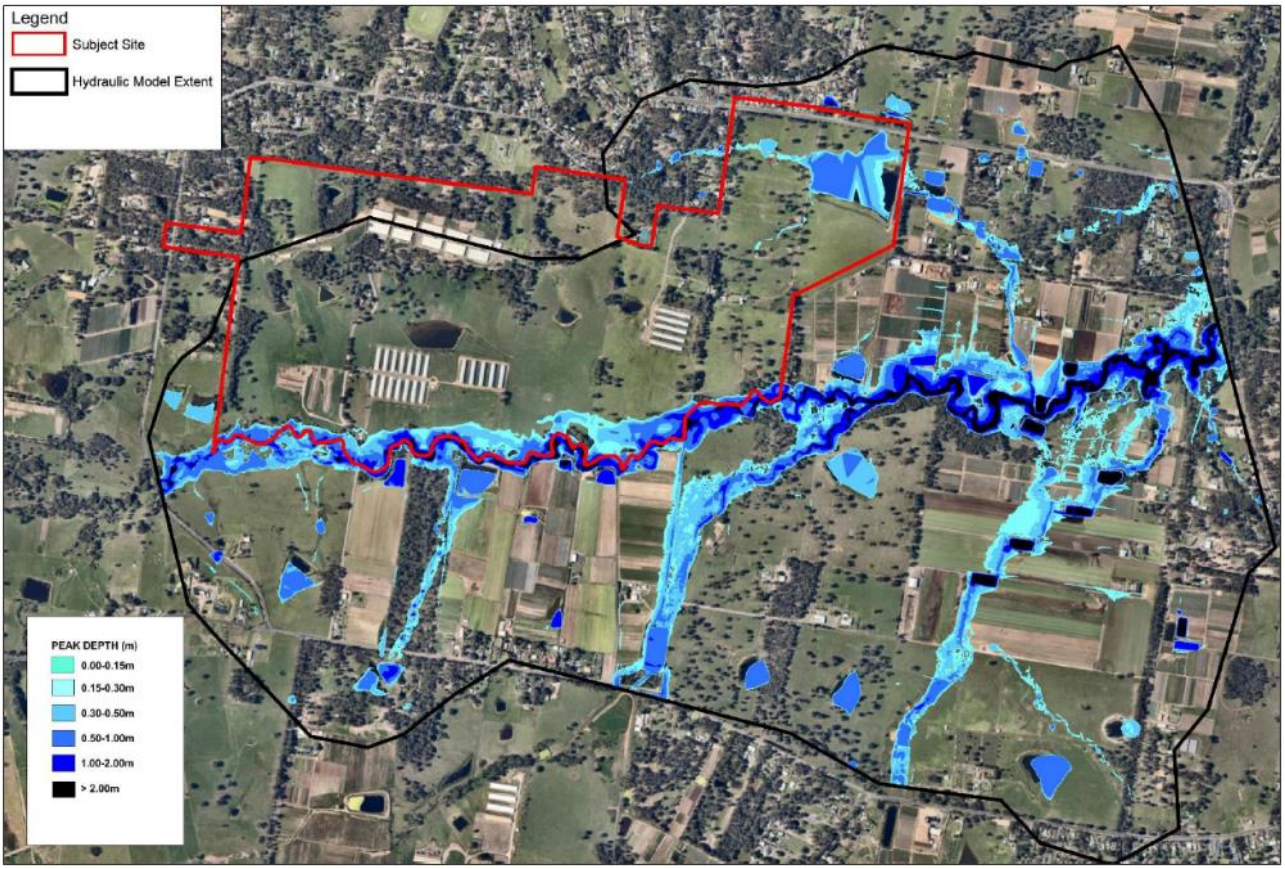


Figure 6-1 1% AEP Flood Extent and Depth under existing conditions

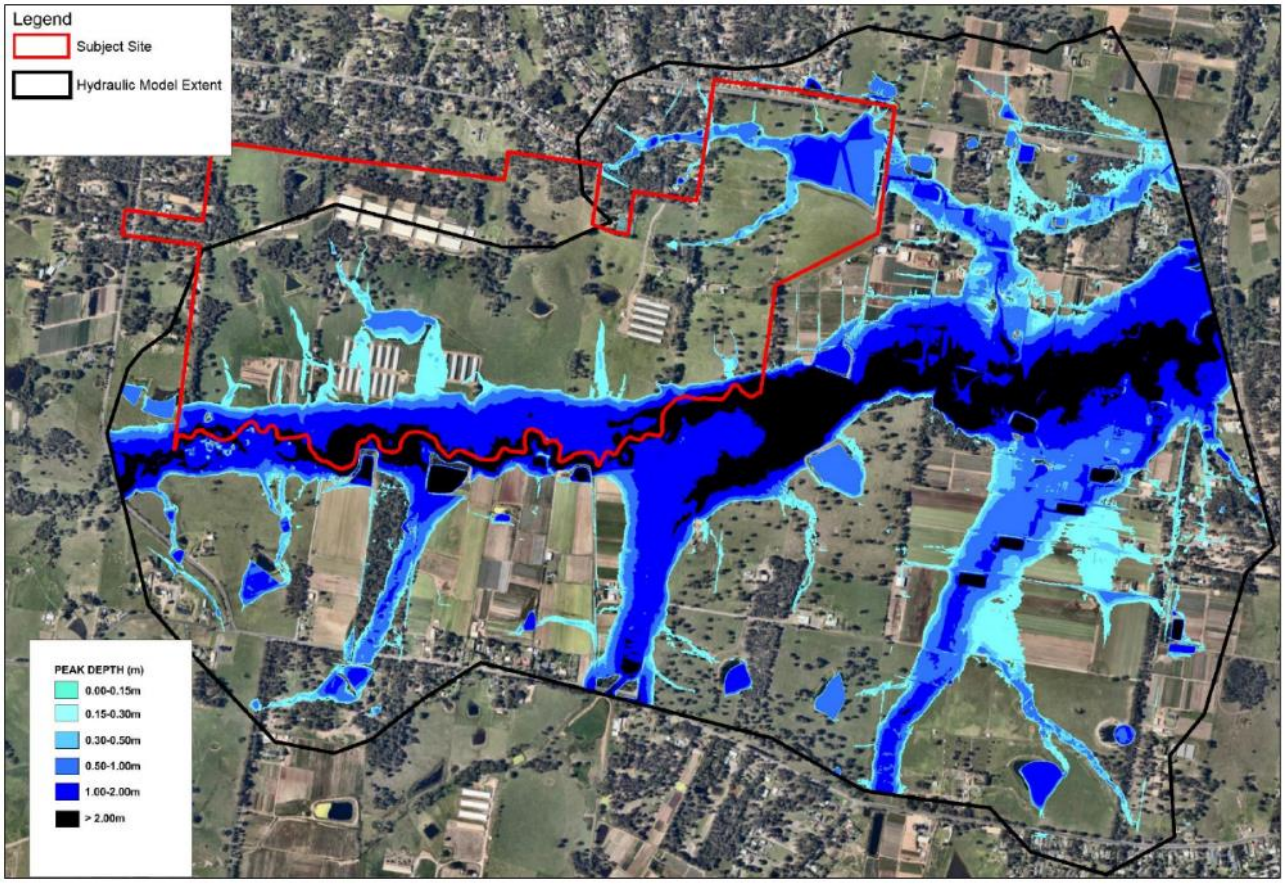


Figure 6-2 PMF Flood Extent and Depth under existing conditions

The extent of the 1% AEP flood is generally contained within the extent of riparian corridors adjacent to Currency Creek, which will not be subject to residential development and therefore will not pose a constraint to the development.

There is a minor area of flood affectation in the PMF event in the south of the site adjacent to Currency Creek. The flood risk for these properties is negligible due to the proximity to flood free land and the suitability of evacuation routes.

6.2 Design Considerations

6.2.1 Major and Minor Drainage Systems

In accordance with Council's DCP (2012), a pit and pipe drainage network will be required to adequately convey flows up to at least the 5 year ARI (0.2 EY) design storm event, with flows up to the 1% AEP event to be contained within roadways and dedicated overland flow paths.

In some instances, particularly at the bottom of individual catchments, it may be prudent to consider designing the pit and pipe drainage network to convey flows greater than the 5 year ARI. Doing so would minimise overland flow in order to demonstrate that it can be conveyed within road reserves or nominated flow paths at an acceptable flood hazard (*typically velocity x depth product less than 0.4*).

A preliminary assessment of major and minor drainage system requirements suggests that Council's DCP requirements can be achieved on the basis of the following:

- Overland flows can be safely contained within road reserves, assuming a nominal carriageway width of 8 metres and a standard 150 mm high kerb and gutter.
- The minor drainage system could be designed to cater for flows up to the 5% AEP (if and where required) in order to minimise overland flows.

Final design of the minor and major drainage systems within Jacaranda Ponds will need to consider the criteria outlined in Sections 8.13 and 8.14 of Council's DCP.

6.2.2 Minimum Habitable Floor Levels

The estimated 1% AEP and PMF flood extents are generally located outside of areas designated for future development under the Site Masterplan. Where and if residential development is proposed in flood affected areas, Council's DCP (2012) requires a minimum 500mm freeboard above the predicted 1% AEP peak flood level adjacent to the property.

6.2.3 Flood Evacuation

The proposed development must consider the risks associated with flooding generated in storms greater than the 1% AEP event and up to the PMF. This assessment needs to consider flood emergency response management issues, including the potential need for evacuation.

It is likely that some areas of future residential development could be affected by the PMF. However, the provisional road layout shown on the Site Masterplan provides sufficient capacity for flood free evacuation of any areas affected by the PMF.

Once development layouts are confirmed at subsequent stages of the development, it is recommended that detailed Flood Evacuation Plans be prepared for any flood affected properties in order to confirm the following:

- Available flood free evacuation routes from any flood affected properties.
- Appropriate points of assembly for events greater than the 1% AEP flood.
- The time between the onset of rainfall in the catchment and initial inundation of the property, to determine the time available to initiate flood evacuation procedures.

Further information is available in the report prepared by Molino Stewart, *Jacaranda Ponds Flood Evacuation*, which is attached to the planning proposal.

7 Conclusion

This Stormwater Management Strategy has been prepared to outline the overarching principles for the proposed development of the Jacaranda Ponds site at Glossodia. It demonstrates the proposed stormwater management requirements and features that would satisfy relevant statutory and development controls.

The proposed strategy for the management of stormwater within the site will involve the implementation of a treatment train including catchment wide primary treatment measures (GPTs) and secondary / tertiary treatment measures (bio-retention systems or constructed wetlands). Each of these measures would be sized to satisfy the objective of ensuring post-development pollutant loads are no greater than pre-developed pollutant loads for suspended solids and nutrients.

Peak flow attenuation would be achieved by the implementation of stormwater detention basins, which would be located at the downstream extents of the development to satisfy the objective of limiting post-development peak flow rates to less than or equal to pre-developed peak flow rates.

The intent of this report is to guide the preparation of further detailed design at DA and CC phases for each development stage. It is acknowledged that the Strategy and proposed water management measures are likely to evolve over the development lifecycle.

8 References

- BMT WBM, *NSW Music Modelling Guidelines*, Revision 1, August 2015
- Ball, J et al, 2016, *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia
- Australian Government Bureau of Meteorology, 2016 Rainfall IFD Data System, sourced at http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016
- EcoLogical Australia, *Flora and Fauna Assessment, Rezoning Planning Proposal (Version 1)*, 22 September 2017
- Geotechnique Pty Ltd, *Geotechnical and Salinity Assessment (Report No. 13429/1-AA)*, 23 September 2015
- Hawkesbury City Council, *Development Control Plan 2002*
- WorleyParsons, *Pitt Town Development, Updated Stormwater Management Strategy* (Rev 0), 9 November 2015

APPENDIX

A

CURRENT SITE MASTERPLAN

JACARANDA PONDS | MASTER PLAN

onecollective URBANDESIGNSTUDIO

19TH NOV 2018

0 50 100m

www.onecollective.com.au

APPENDIX

B

FLOOD STUDY (CARDNO, 2016)

Our Ref 80215086
Contact Martin Griffin

23 May 2016

Celestino
642 Great Western Highway
Pendle Hill NSW 2145

Attention: Lloyd Gomez

Via Email: lloyd.gomez@celestino.net.au

Cardno (NSW/ACT) Pty Ltd
ABN 95 001 145 035

Level 9
The Forum
203 Pacific Highway
St. Leonards NSW 2065

P.O. Box 19
St Leonards NSW 1590
Australia

Phone: +61 2 9496 7700
Fax: +61 2 9439 5170

www.cardno.com.au

Dear Lloyd,

FLOOD STUDY FOR JACARANDA PONDS DEVELOPMENT, GLOSSODIA

The landowner is proposing to develop the Jacaranda Ponds site located in Glossodia, within the Hawkesbury Council Local Government Area (LGA). The development of the site is currently at a preliminary master planning phase and will be developed into an amended planning proposal to be submitted to Hawkesbury Council.

The objective of this study is to define the flood behaviour in the 100 year ARI and PMF flood events for Currency Creek which forms the southern boundary of the property. Once the existing flood behaviour has been defined it will be possible to assess the preliminary master plan based on Councils current flood related development controls.

1. BACKGROUND

1.1 Existing Site

The Jacaranda Ponds site is located in the suburb of Glossodia, north-west Sydney within the Hawkesbury LGA. The site is located north of Richmond and north-west of Windsor. The site lies north of the Hawkesbury River, elevated above the river floodplain, adjacent to Currency Creek. The creek is a tributary which converges with Chain of Ponds Creek downstream to the east of the site, eventually discharging to the Hawkesbury River at the township of Ebenezer to the north-east. The location of the site is shown in **Figure 1**.

The site comprises a total of seven large existing cadastral lots with predominantly rural land use and is approximately 185 hectares in size. The site is bounded by Spinks Road to the north and Currency Creek to the south, with a number of existing minor local roads traversing the site. The majority of the site is clear and undeveloped with a steep middle section with grades in the order of 25 to 35%. There are two large existing irrigation dams on the site as well as a number of smaller farm dams. The existing subject site is shown in **Figure 2**.

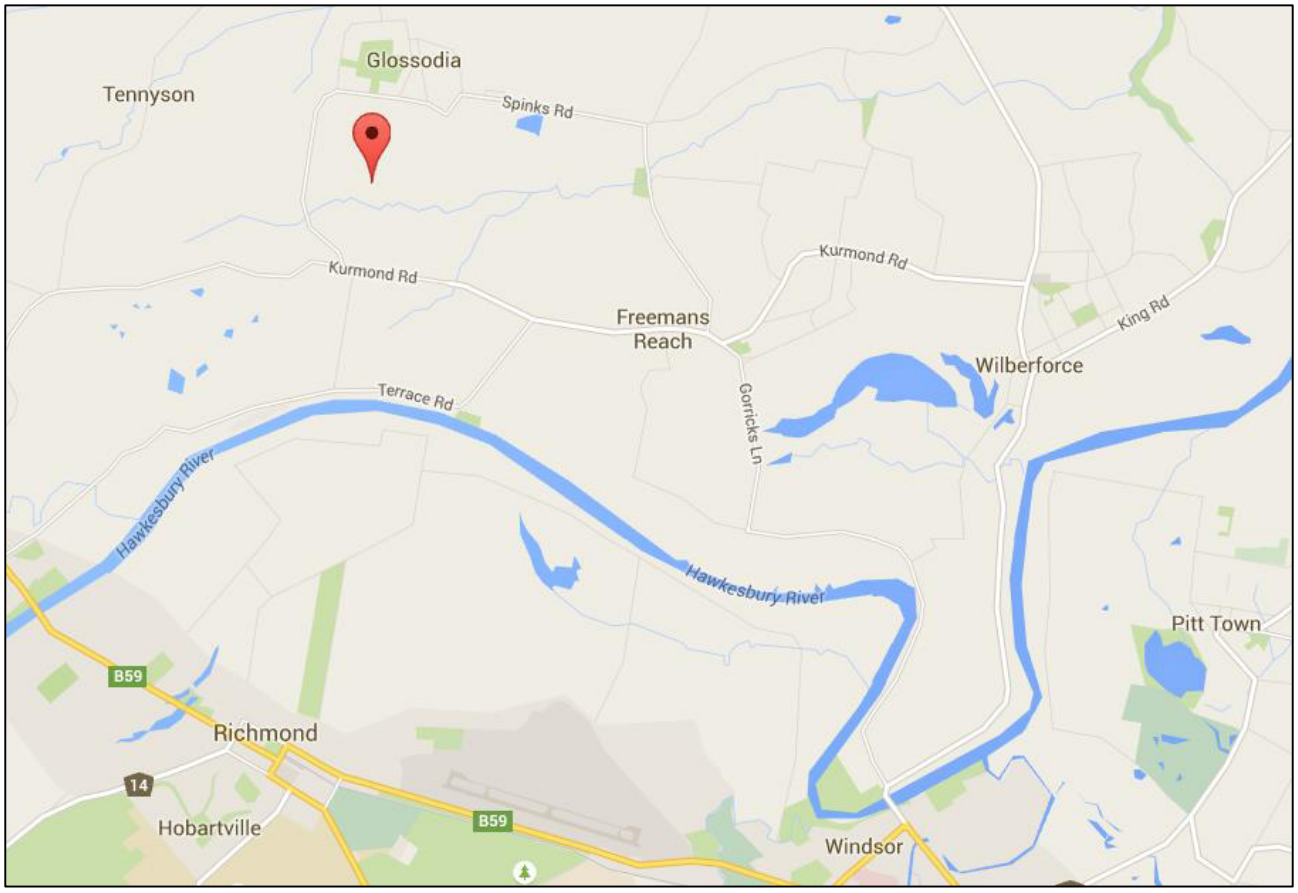


Figure 1 – Location of Jacaranda Ponds Site (Source: Google Maps, 2016)

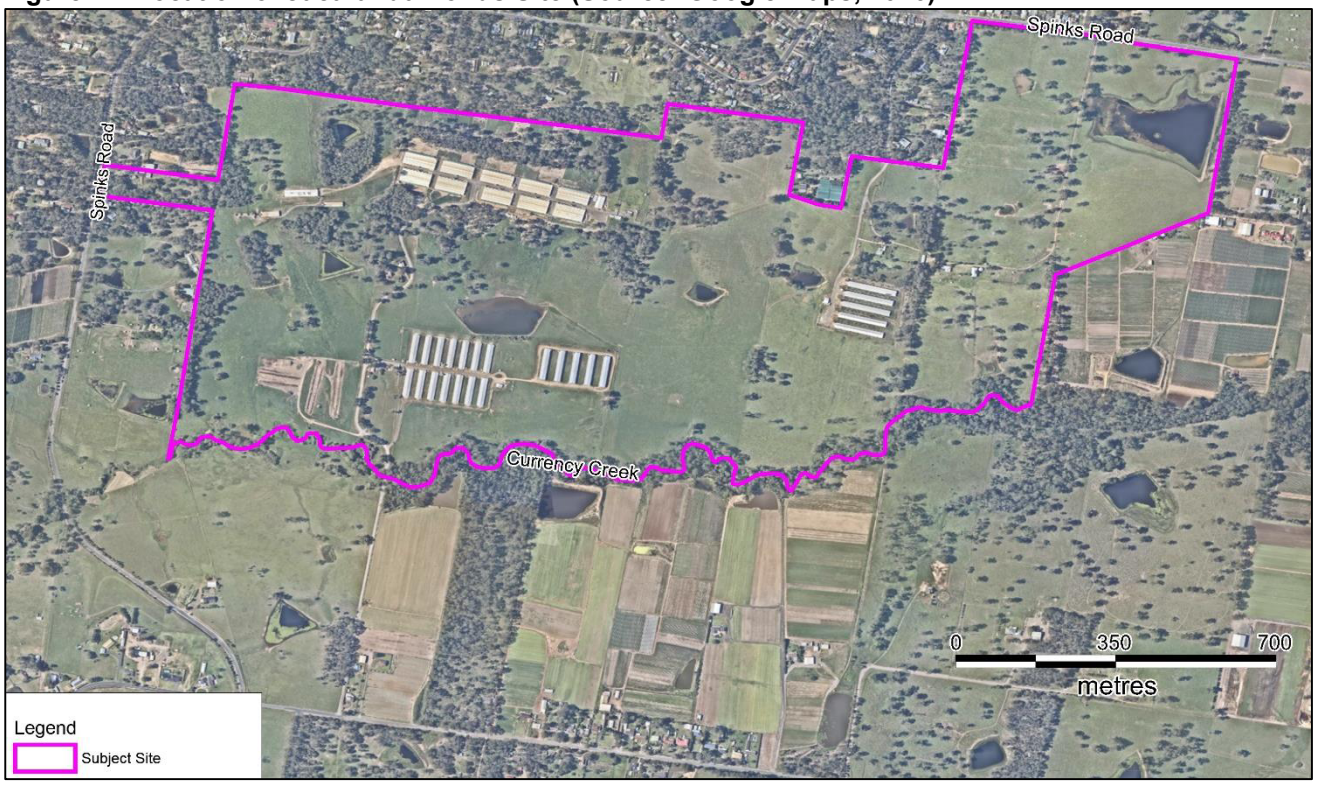


Figure 2 – Existing Subject Site

1.2 Proposed Development

The site has recently been rezoned for Large Lot Residential (R5) and Low Density Residential (R2) with associated infrastructure (SP2) and recreation zones (RE1). The zoning for the site extracted from the Hawkesbury Council Local Environment Plan (LEP) mapping is shown in **Figure 3**.

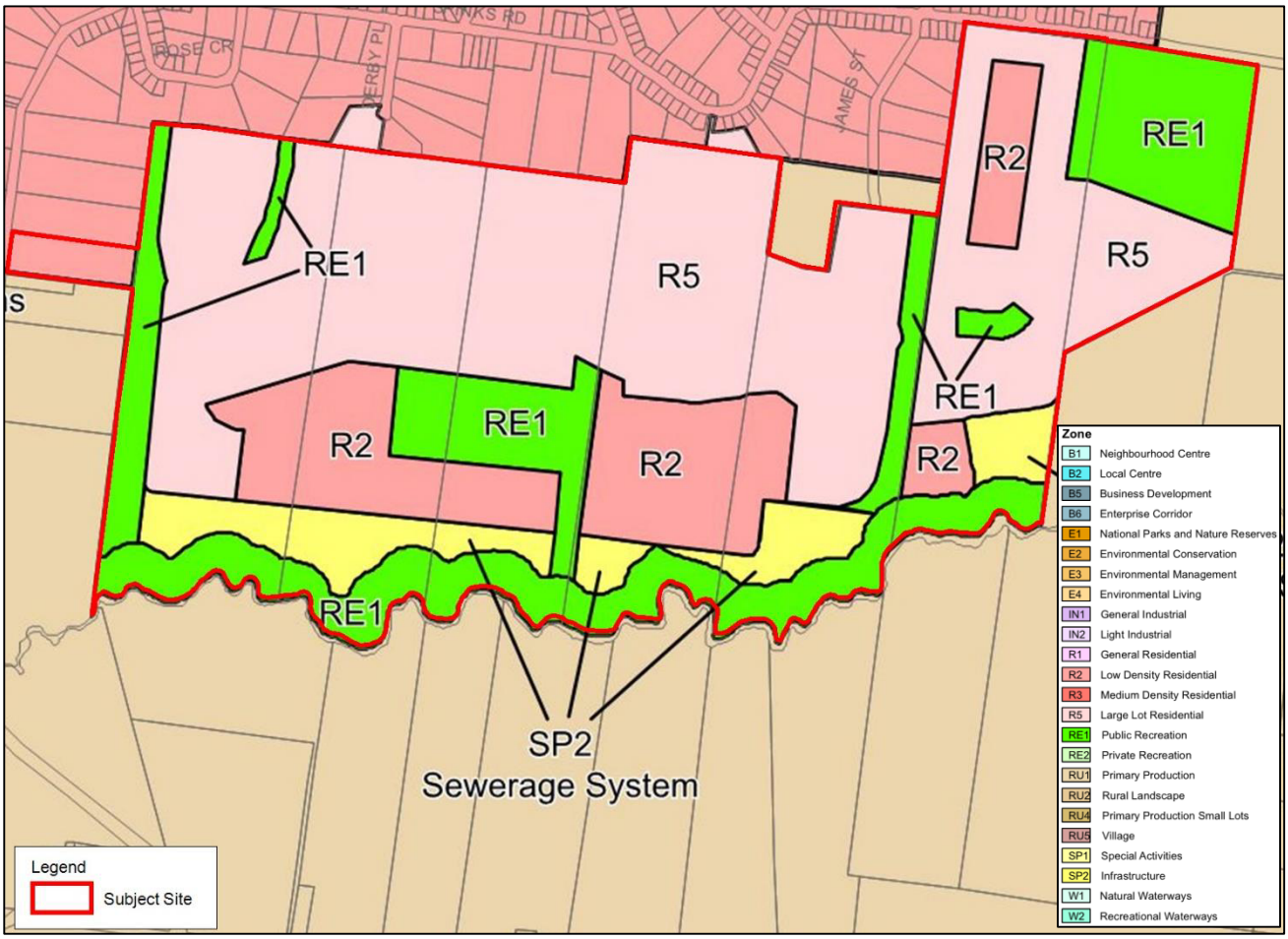


Figure 3 - Current Land Use Zoning of Subject Site (Source: Hawkesbury LEP, 2012)

It is understood that following the release of this zoning in the LEP 2012, the master planning for the site has been further developed and the final master plan layout for the site is likely to vary to the current land use zoning shown in **Figure 3**. Nevertheless it is understood that the current zoning provides a reasonable representation of the likely extent of development with respect to the Currency Creek riparian corridor

1.3 Relevant Council Flood Information

Hawkesbury Council provide on their website flood extent mapping for the Hawkesbury LGA based on flood information extracted from the *Hawkesbury Floodplain Risk Management Study and Plan* (Bewsher Consulting, 2012). Council's flood extent maps for the floodplain around the site are shown in **Figure 4**.

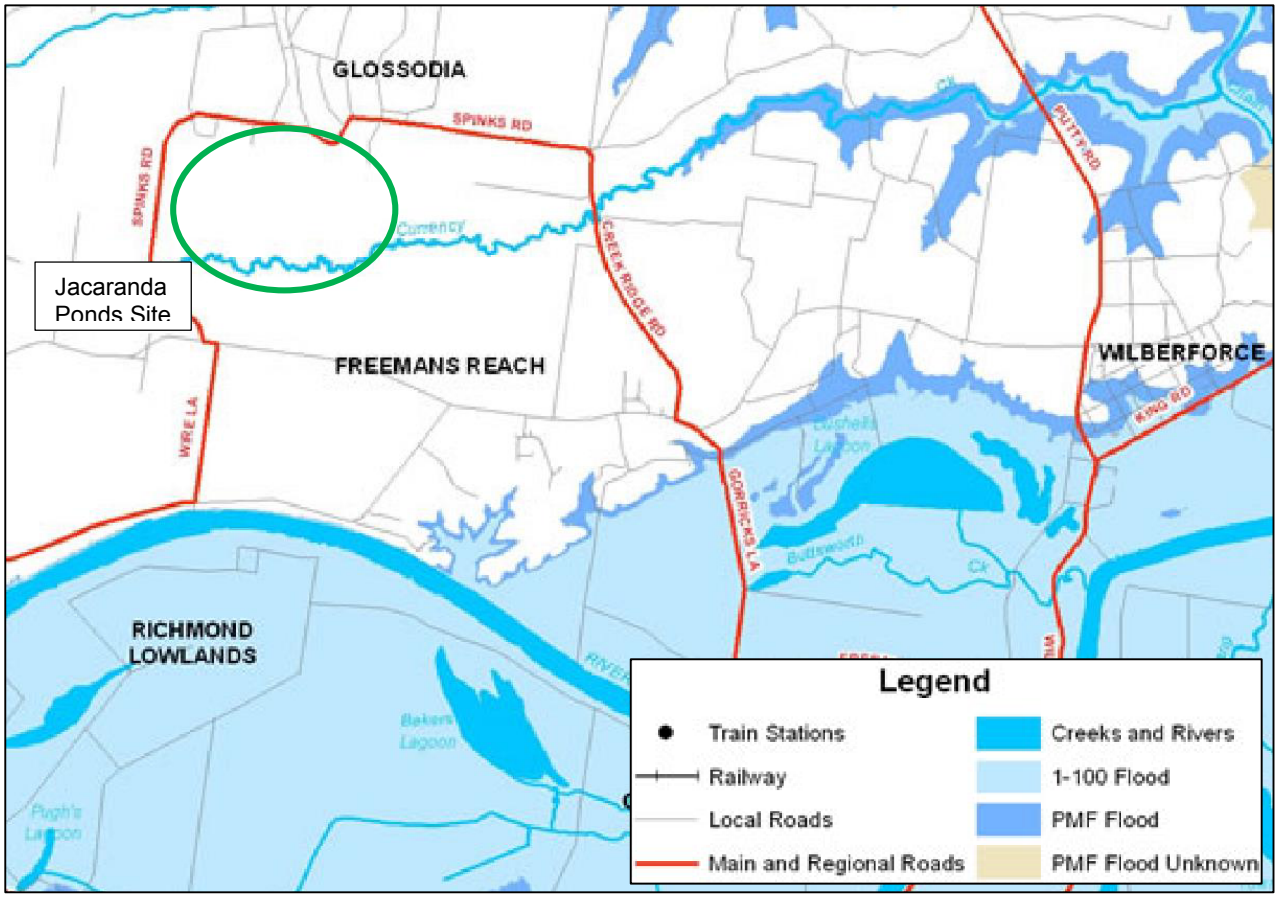


Figure 4 – Hawkesbury Council Flood Extent Mapping

The flood extents shown in **Figure 4** indicate that the study commissioned by Hawkesbury Council does not cover the upper Currency Creek catchment area as no flood extents are shown for the area. This does not indicate that the area is flood free, but rather that Council does not possess flood information for this area.

Therefore in order to inform this Flood Study for the Jacaranda Ponds site, a hydrology and hydraulic model was required to be established to define flood behaviour for the area as no flood information is currently available. Once the flood behaviour for the area has been established through modelling it will be possible to assess the master plan compared to Hawkesbury Councils flood related development controls.

2. HYDROLOGICAL AND HYDRAULIC MODELLING

2.1 Available Data

The following data was used to inform the modelling:

- Ground survey for the existing subject site, including triangulated surfaces recorded by Watson Buchan Pty Ltd, dated 17/09/2009.
- 2 metre interval contour information based on LiDAR data sourced by Cardno through the NSW Department of Land and Property Information (LPI) for the entire Currency Creek catchment.
- 1m x 1m Digital Elevation Model (DEM) based on LiDAR data from the NSW Department of Land and Property Information (LPI) for the portion of Currency Creek closest to the Jacaranda Ponds site;
- Aerial photography of the site and surrounds recorded by NearMap in 2014.

2.2 Modelling Approach

In order to assess the flood behaviour of the site, a TUFLOW 2D model was assembled and run using the "rainfall on grid" approach. As the total area for the entire Currency Creek catchment upstream is quite large, approximately 15 km^2, in order to minimise model run times an XP-RAFTS hydrology model was established for the upper catchment. This allowed for a reduced TUFLOW hydraulic model extent for the site with an area of approximately 681 ha, is shown in **Figure 5**.

Topography

The model terrain grid was developed from two main sources:

- For the Jacaranda Ponds site, terrain was based on available ground survey;
- All other areas within the catchment were defined by the data extracted from LiDAR supplied by LPI.

The civil and surveying package, 12D, was used to generate a detailed 3D surface (digital terrain model) of the study area combining these two data sources. A grid size of 3m x 3m was adopted for the study area. The terrain for the Currency Creek catchment upstream of the site is shown in **Figure 5**. As noted in **Section 2.1** the DEM data did not extend across the entire catchment as shown in the figure below.

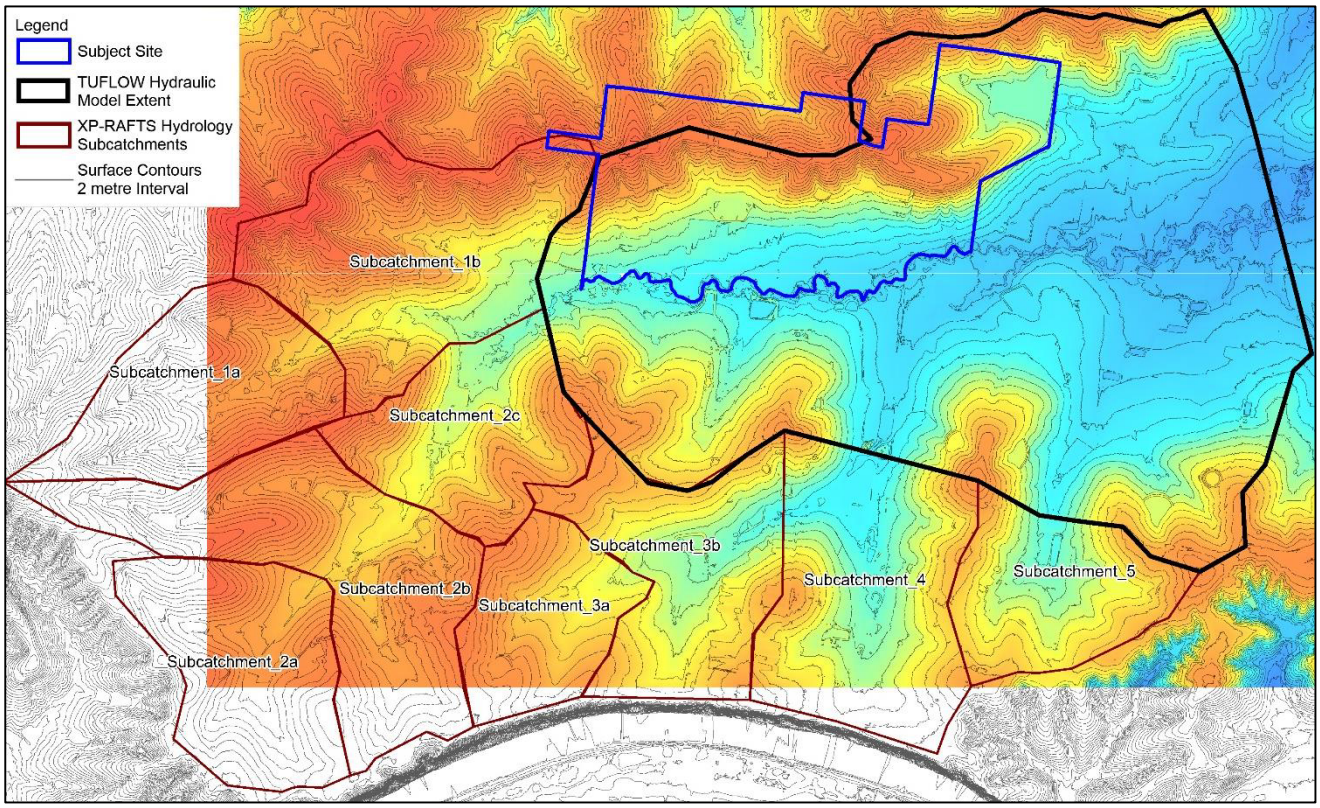


Figure 5 – Surface Topography of Currency Creek Catchment

Hydrology

A hydrologic model of the upstream catchments was developed using XP-RAFTS software. The primary purpose of this hydrological model is to generate input hydrographs to the 2D hydraulic model from the

upstream catchments. The delineation of the sub-catchments is shown in **Figure 5**, with catchment details adopted within the XP-RAFTS model summarised in **Table 1**.

Table 1 – XP-RAFTS Hydrology Catchment Data

Subcatchment	Area (ha)	Impervious %	Vectored Slope (%)
1a	91	5	3.52
1b	135	5	0.88
2a	90.6	5	1.34
2b	137	5	0.71
2c	82	5	0.70
3a	61	5	1.86
3b	96	5	0.90
4	122.4	5	1.05
5	71	5	0.19

For the TUFLOW 2D model extent, runoff from the study area was estimated using the "rainfall on grid" approach where rainfall is applied to the 2D domain and runoff responds to the local terrain.

Rainfall

The 100 Year ARI and PMF design storm was modelled using design temporal patterns and IFD data obtained from the current edition of Australian Rainfall and Runoff (ARR1998). The full range of storm durations from 30 minute to 12 hour were assessed, with the 9 hour found to be the critical duration for the 100yr ARI flood event. The 90 minute duration was found critical for the PMF flood event.

Rainfall Losses and Surface Roughness

Initial loss of 10mm/hr and continuing rainfall loss of 2.5mm/hr were applied in the XP-RAFTS model based on characteristics of the area. Similarly hydraulic surface roughness have been modelled in the 2D TUFLOW model using spatially distributed roughness ("n") values based on the land use and vegetation cover adopted from the aerial topography.

Boundary Conditions

The subject site is located in an upper tributary of the Hawkesbury River catchment. It was assumed that the tailwater effects from Hawkesbury River are negligible and free outfall conditions were adopted. This assumption is supported by Hawkesbury Council mapping included in **Figure 4** which shows that the Hawkesbury River flood extents do not extend this far upstream, even in the PMF event.

2.3 Results

The estimated 100 year ARI and PMF flood levels and depths under Existing Conditions are plotted in **Figures 6 to 9** respectively.

An overlay of the land zoning for the site with the 100 year ARI and PMF extents is shown in **Figure 10**.

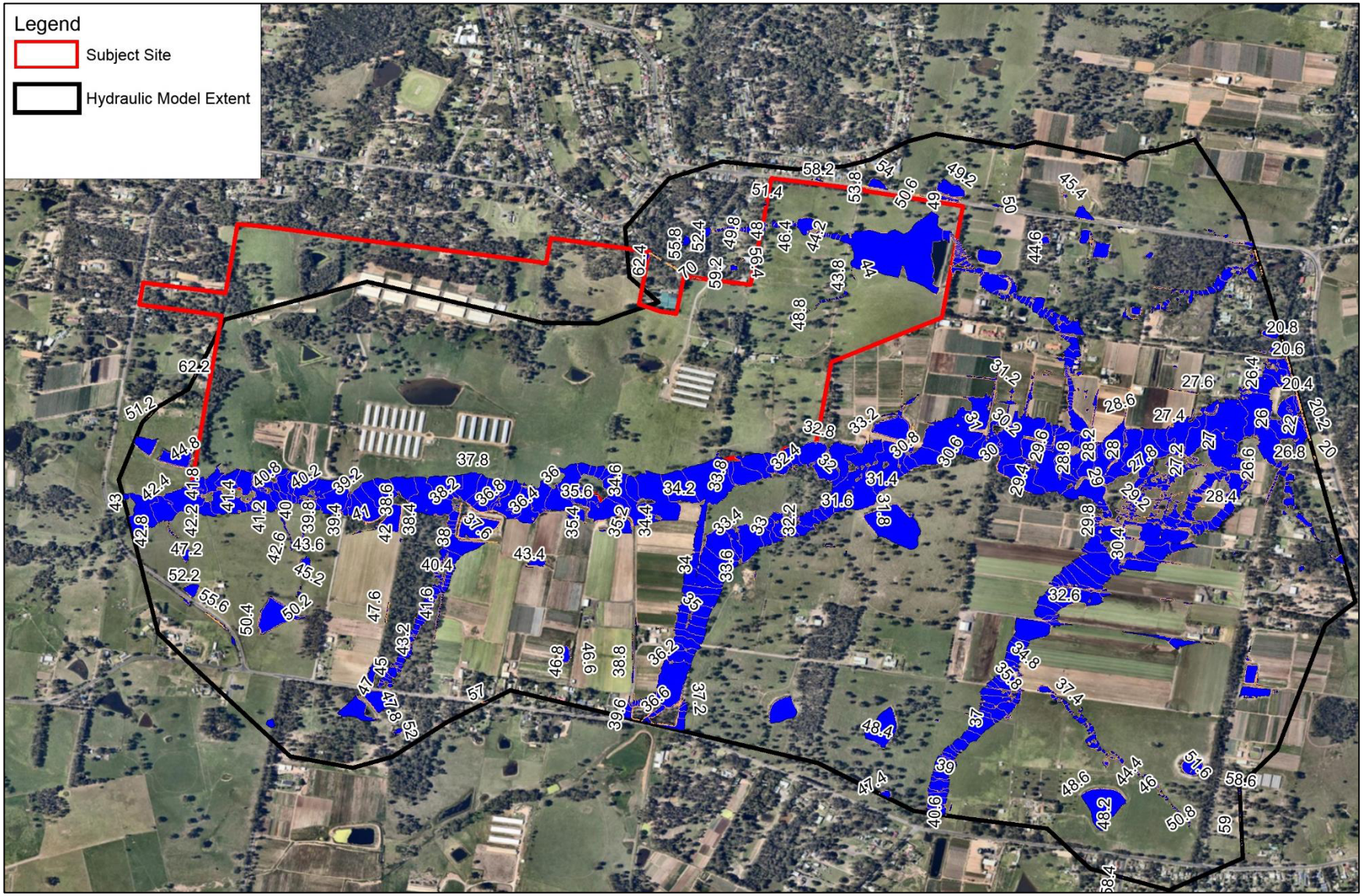


Figure 6 – 100 year ARI Peak Water Level - Existing Conditions

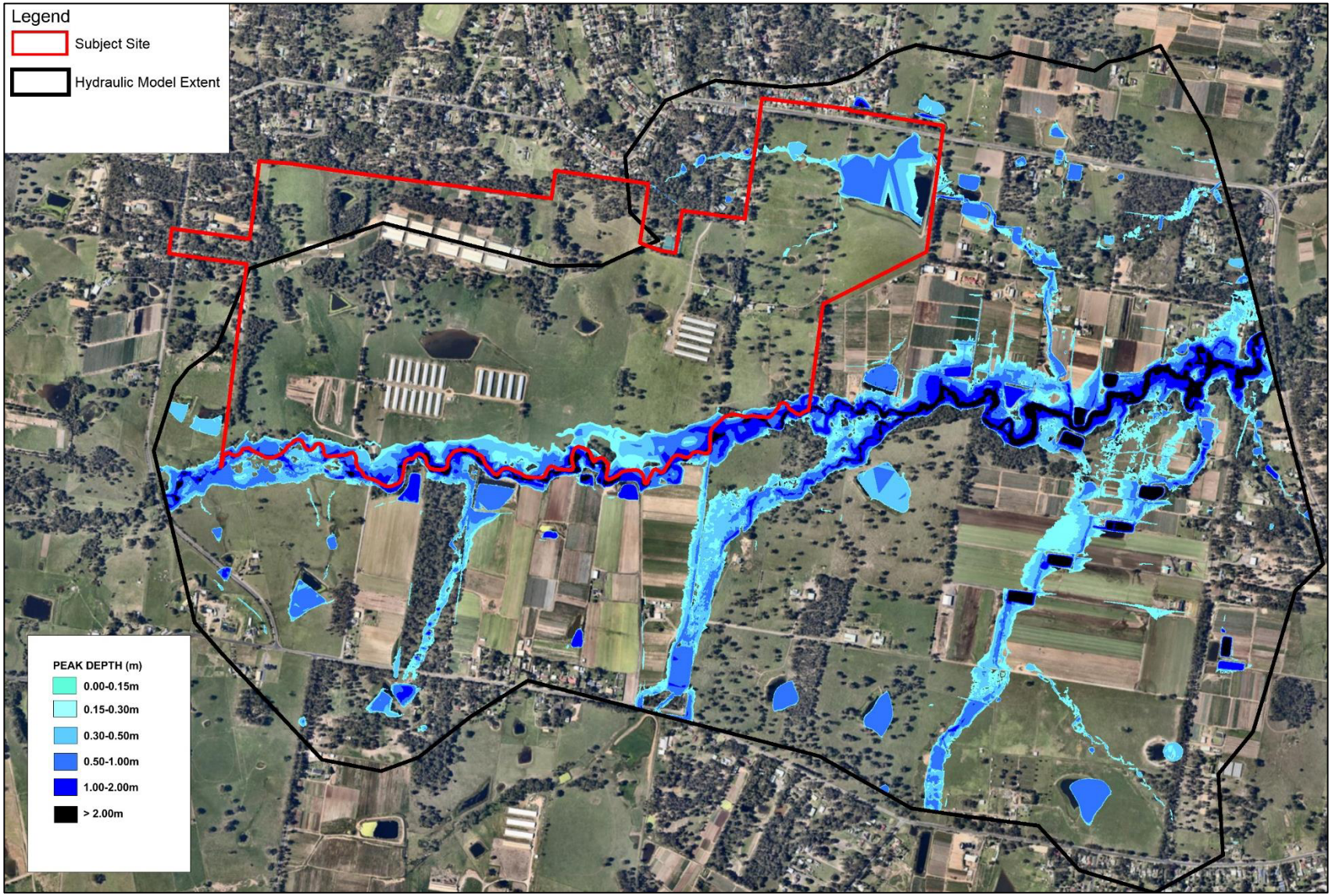


Figure 7 – 100 year ARI Peak Depth - Existing Conditions

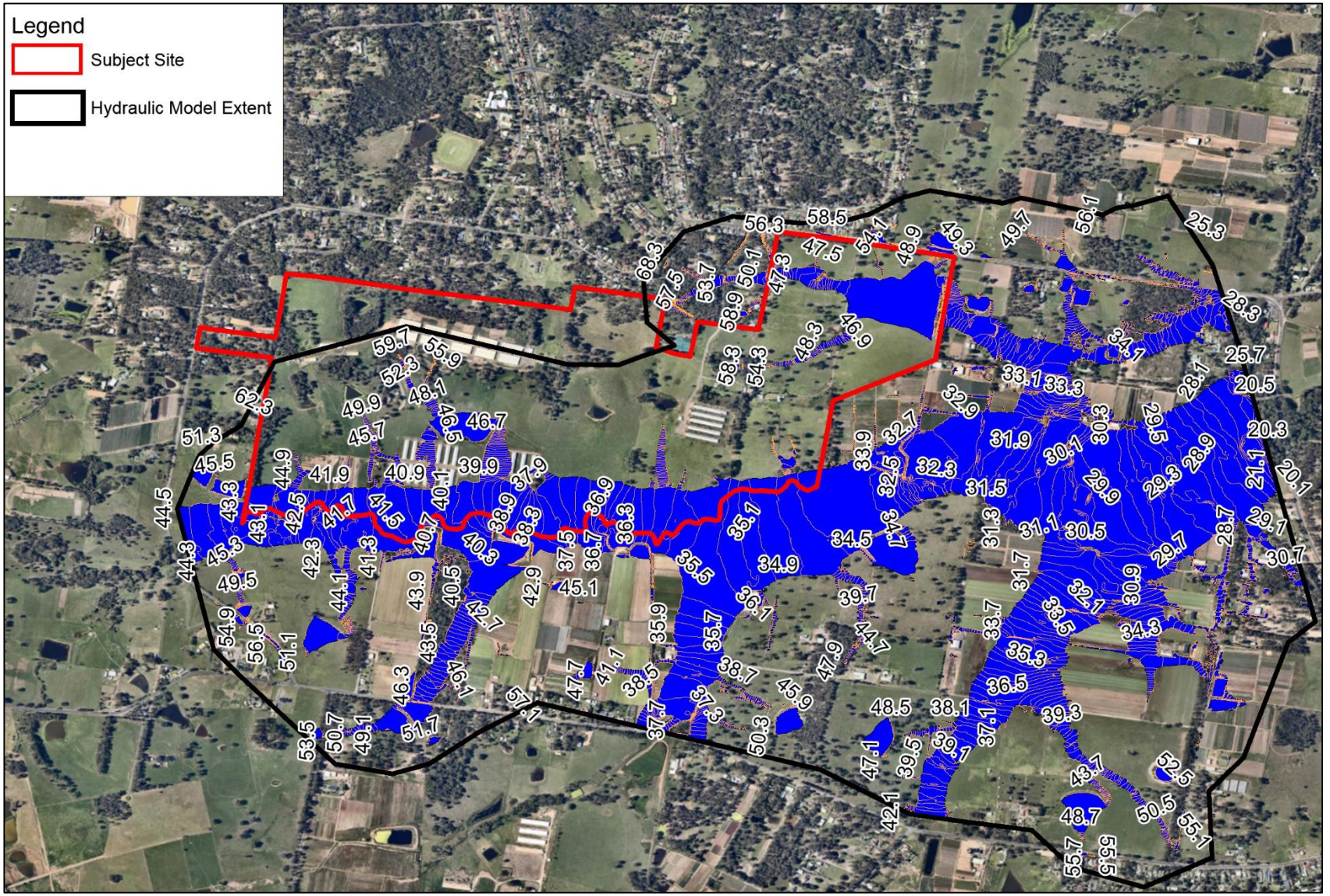


Figure 8– PMF Event Peak Depth - Existing Conditions

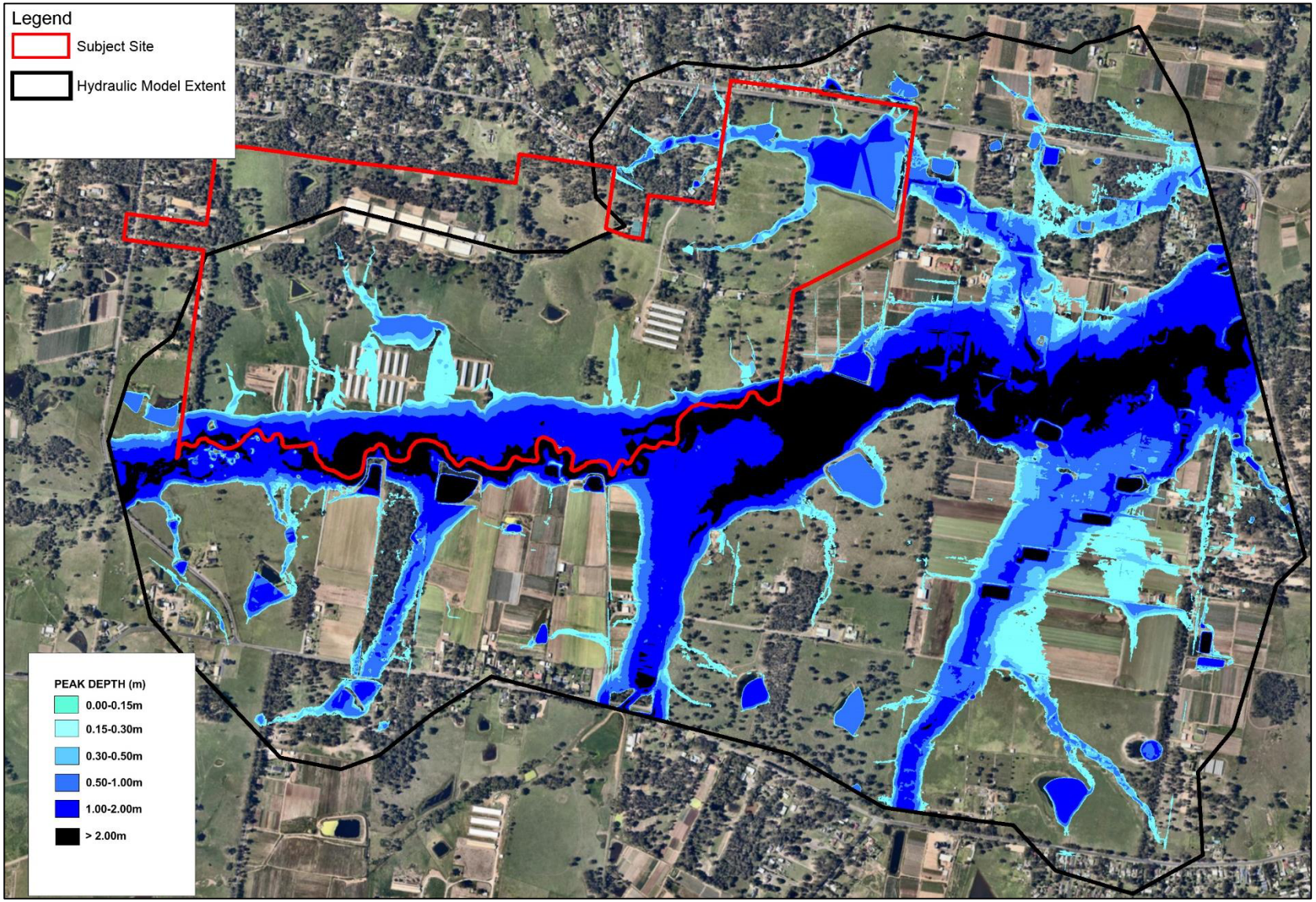


Figure 9 – PMF Event Peak Water Level - Existing Conditions

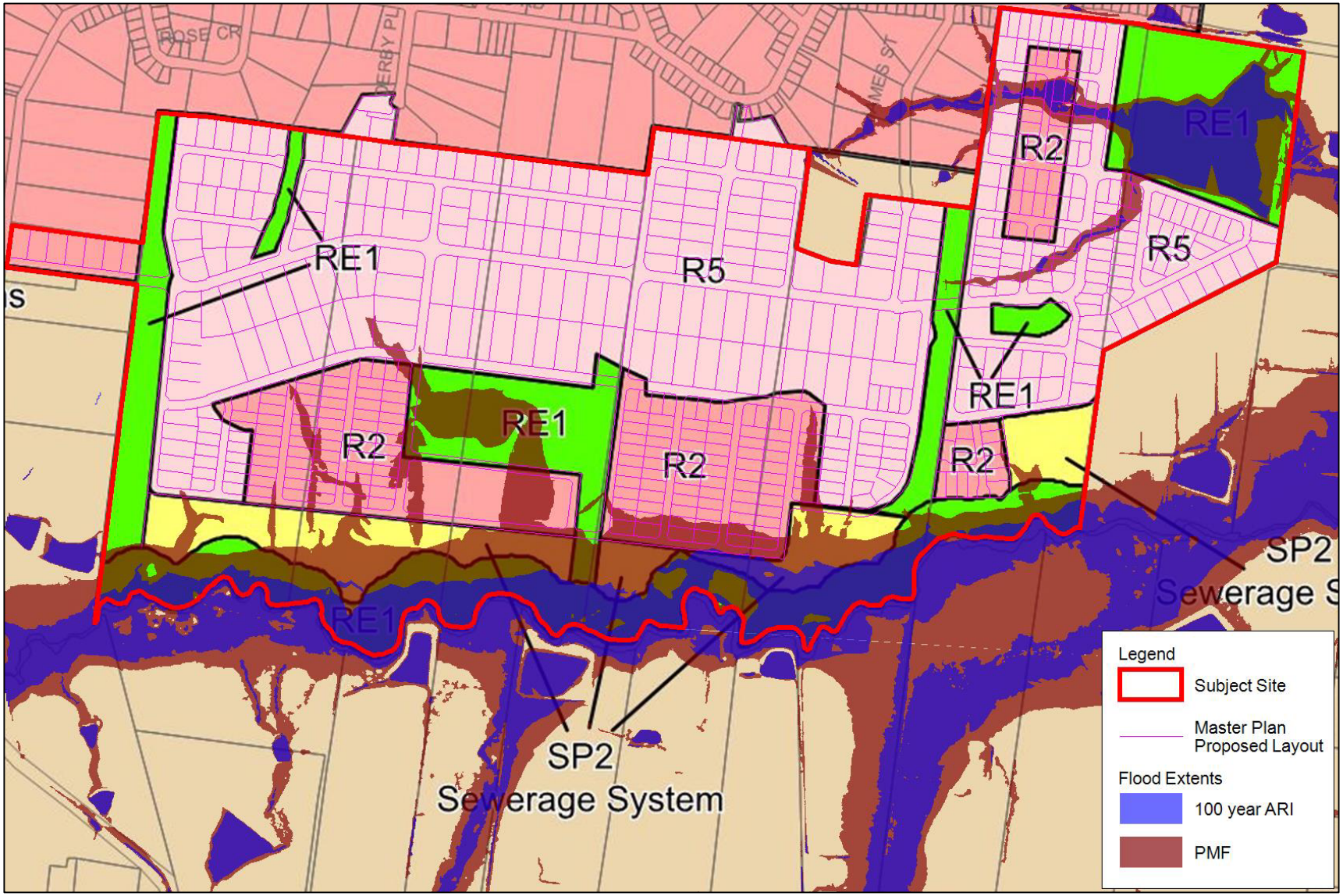


Figure 10 – Land Use Zoning with Flood Extents

3. DISCUSSION

The following assesses the development of the Jacaranda Ponds site compared to the flood policies relevant to the area. Hawkesbury City Council uses three key documents to control development on flood prone land:

- *Hawkesbury Local Environment Plan 2012* (HLEP 2012);
- *Hawkesbury Development Control Plan 2002* (HDCP 2002); and
- *Development of Flood Liable Land Policy* (2012).

In addition, there are other state-wide policies and guidelines that may influence development potential for the site. The main development considerations for flood affected land are discussed in the following sections based on the above documents.

3.1 Minimum Fill Level

For Hawkesbury LGA, the *Development of Flood Liable Land Policy* states:

> *"A dwelling must not be erected on land lying below the 100 ARI (average recurrent interval) flood event level if the allotment of land on which it is to be erected was created by a subdivision approved under clause 11 of Hawkesbury Local Environmental Plan 1989 on or after the commencement day (22 January 1999)."*

As shown in **Figure 10**, the entire Jacaranda Ponds development area lies outside the Currency Creek 100 year ARI flood extents, with flooding from the creek contained within land zoned as either SP2 – Sewerage System, or RE1 – Recreation Zones.

The north eastern portion of the Jacaranda Ponds site is affected by an overland flowpath sourced from the local catchment to the west bounded by Spinks Road. The peak 100 year ARI flows entering the site from this minor external catchment was calculated to be approximately 4.1 m^3/s. It is proposed that this overland flow be collected by a trunk drainage line to divert flows underground away from the future developed residential lots. The potential layout of the diversion pipe is shown in **Figure 11** below. It is assumed the diversion of this overland flow will be addressed in future design stages of the development and therefore the entire site can be flood free up to the 100 year ARI event.

3.2 Flood Planning Level - Minimum Floor Levels

The Hawkesbury LEP 2012 states that the flood planning level is equal to the 100 year ARI flood level. The Hawkesbury *Development of Flood Liable Land Policy* states:

- Habitable floor levels must be above the 100 year ARI flood level;
- Minor (Non-Habitable) structures such as farm buildings, outbuildings, sheds, garages and other ancillary structures may be erected on land below the 100 year ARI flood level, provided that flooding frequency, potential damages and evacuation are considered; and,

- Any part of a building below the 100 year ARI flood level are to be constructed of flood compatible materials.

As stated above, the future subdivided land level will be flood free for the 100yr ARI level and the above controls will then not come into effect.

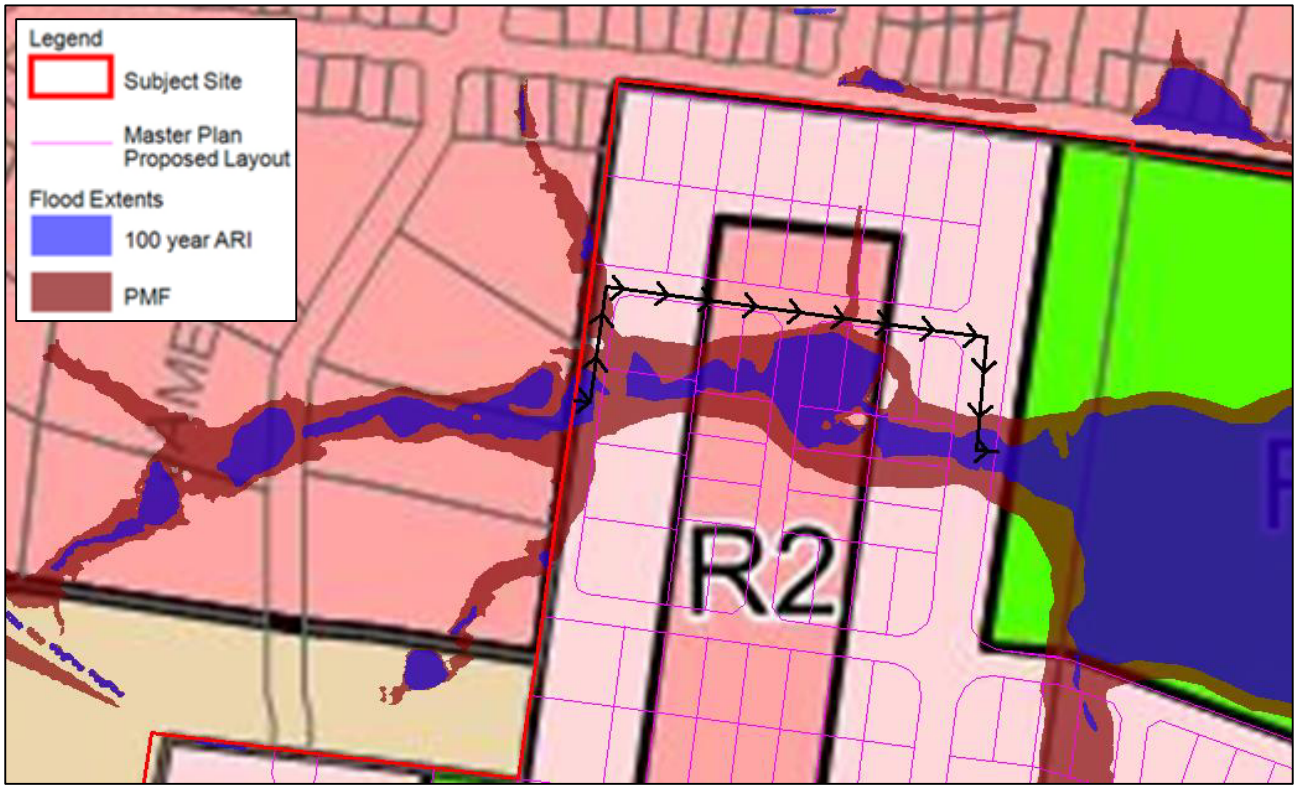


Figure 11 – Proposed Diversion of Overland Flow

3.3 Extent of Filling

Filling within the floodplain is permitted within Hawkesbury Councils policies, however, the extent of filling has limitations. Central to this is the requirement stated in the LEP:

> *"Development consent must not be granted for flood affected land unless Council is satisfied that the development is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties."*

It is assumed that the amount of filling or riparian corridor treatments that may influence flood behaviour within the Currency Creek floodplain will be negligible. Therefore the proposed development of the Jacaranda Ponds site will have negligible impact on flood behaviour.

3.4 Evacuation

The LEP states that development within flood liable land must be compatible with the flood hazard of the land, and incorporates appropriate measures to manage risk to life from flood. For a floodplain such as this, evacuation to flood free land is recommended.

For Hawkesbury the *Development of Flood Liable Land Policy* states:

> *"Suitable access and egress during flood events must be provided, and should not require travel through areas of higher flood risk. The development should not result in occupants becoming isolated in flood events."*

Only one portion of the Jacaranda Ponds site is affected by PMF affectation from Currency Creek, which is located in the southern portion of the site, as shown in **Figure 12**. The distance to flood free land from these locations is less than 120 metres, and it is assumed to be rising road access. This means the flood risk for these properties affected by PMF is negligible due to the proximity to flood free land and the suitability of the evacuation routes.

All other areas of PMF affectation within developable areas are classed as minor overland flow as they are sourced by the local catchment within the site and are not related to flooding from Currency Creek. It is assumed that overland affectation in the PMF event poses negligible risk and does not need to be addressed.

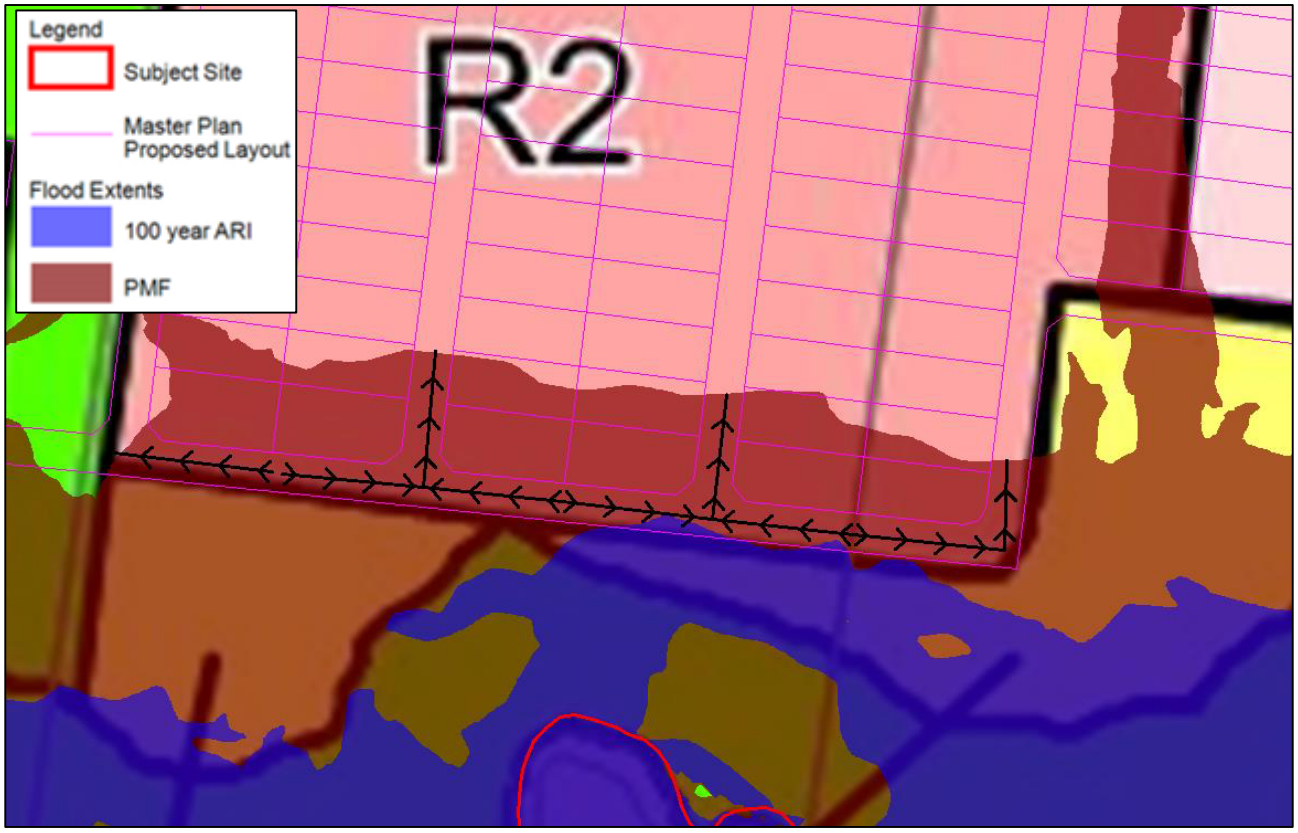


Figure 12 – Local Evacuation Routes for PMF Affected Properties from Currency Creek

4. CONCLUSION

The outcomes of this flood study show that in relation to the proposed rezoning of the Jacaranda Ponds site located in Glossodia:

- As an existing flood study was not available for the area, a local hydrology / hydraulic model was established for the Currency Creek floodplain;
- A detailed hydrology / hydraulic model of the catchment has now been established which may be used by future developers to assess flood impacts as part of any future DA submissions for the site;
- The master plan that this flood study supports does not propose any alterations to the site terrain within existing 100 year ARI flood extents of Currency Creek;
- There is one area of proposed development in the north-east of the site with minor overland flow affectation in the 100 year ARI event however this may be addressed through design of diversion / trunk drainage design during later stages of development;
- There is a minor area of flood affectation in the PMF event in the south of the site however the flood risk for these properties is negligible due to the proximity to flood free land and the suitability of the evacuation routes.

In summary the master plan for the Jacaranda Ponds site lies above the 100 year ARI flood level and provides suitable evacuation routes for those properties affected by PMF, and is therefore in accordance with flood requirements of Hawkesbury Council.

Should you have any questions, please don't hesitate to give the undersigned a call on 9496 7700 or the numbers listed below.

Yours faithfully,

Martin Griffin
Engineer
for **Cardno**
(02) 9496 7859
martin.griffin@cardno.com.au

About Cardno

Cardno is an ASX200 professional infrastructure and environmental services company, with expertise in the development and improvement of physical and social infrastructure for communities around the world. Cardno's team includes leading professionals who plan, design, manage and deliver sustainable projects and community programs. Cardno is an international company listed on the Australian Securities Exchange [ASX:CDD].

Contact

Level 9 - The Forum
203 Pacific Highway
St Leonards NSW 2065
Australia

Phone +61 2 9496 7700
Fax +61 2 9496 7748

Web Address
www.cardno.com