Premise

MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD

Arcadia Estate

STORMWATER MANAGEMENT STRATEGY

Report No: 223064_SMS_001

Rev: A

6 July 2023

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Prepared By		**Reviewed By**		**Authorised By**	
Ian Watts		Peter Oste		Peter Oste	

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1. INTRODUCTION

1.1 Background

Premise has been commissioned by Maximum Yield Pty Ltd & Burkes Gull Investments Pty Ltd to prepare a Stormwater Management Strategy (SMS) for Arcadia Estate East Subdivision. The extent of the site covered by this report is shown on **Drawing No. 223064_01A _C002** included in **Appendix A**. Note the site is part of the larger Acadia Estate that extends to the west of Burkes Gully.

1.2 Site Location and Description

The site is located in the larger Arcadia Estate that is part of the South Tamworth Rural Lands Master Plan Area (STRLMPA), approximately 6 kilometres southwest of the Tamworth Central Business District. The site has a total combined area of approximately 120 hectares. The site is bounded by Burkes Gully to its west, Burgmanns Lane to its south, large-lot residential development to its north and Longyard Golf Course, Rodeo Drive and residential and rural land to its east.

The site is largely cleared of native vegetation, featuring open grazing land and gentle slopes with Burkes Gully flowing adjacent to the western boundary of the proposed development.

The overall layout of the proposed development is indicated on **Drawing No. 223064_01A_C002** included in **Appendix A**. The proposed development includes a mixture of residential lots ranging in size from 500sq.m. to over 1100sq.m, dedicated open space areas and drainage reserves.

An aerial image of the site and surrounding arears as of the 30 January 2022 is included on **Drawing No. 223064_01A _C003** included in **Appendix A**.

2. SCOPE OF REPORT

The scope of this report is to:

- outline the proposed SMS for the proposed development area.
- present preliminary design and sizing information for key components of the SMS.

The entirety of the site slopes gently to the west and drains to Burkes Gully running along the western boundary of the site. Burkes Gully runs to the north west and drains to a culvert under Werris Creek Road labelled BG1.

The extent of the catchment area assessed in this report is indicated on **Drawing No. 223064_01A _C003** included in **Appendix A**.

3. SYSTEM MODELLING

3.1 Existing Studies

Lyall & Associates (L&A) prepared the *Arcadia Estate Subdivision Integrated Stormwater and Floodplain Management Strategy* report in November 2015 for Tamworth Regional Council (TRC) and a copy of this report can be found in **Appendix B**.

The L&A report contains details and results of their investigation to develop an integrated stormwater and floodplain management strategy (ISFMS) for the entire Arcadia Estate. The ISFMS was prepared to broadly determine the key components which need to be incorporated in the Arcadia Estate development in order to mitigate its runoff related impacts on the receiving drainage lines.

L&A developed a hydrologic model to assess peak flows in Burkes Gully and the drainage lines downstream of Arcadia Estate. Figure 4.2 in the report shows the layout of the hydrologic model along with the location of the major reporting nodes. Table 6.2 in the report lists the modelled peak flows at each of these locations for the pre development and post development (with and without mitigation measures) cases.

As previously advised by TRC, the L&A modelled pre-development peak flowrates (as contained in Table 6.2 of their report) are to be adopted as the limiting peak post-development flows for all final stormwater mitigation measures adopted at the site. Furthermore, the strategy for stormwater management at the site will generally be in accordance with the strategy outlined in the L&A report.

3.2 Hydrological Modelling

The performance of the proposed stormwater management system was assessed using the DRAINS stormwater modelling package.

This model is able to:

- Model spatial and temporal variations in storm rainfall across the catchment.
- Model variations in catchment characteristics.
- Model storage routing effects in drainage lines and detention basins, and
- Calculate discharge hydrographs (included peak discharge rates) at any required location in the catchment.

The analytical technique used in DRAINS involves the division of the catchment into a number of sub-catchments. Sub-catchment outlets are located at the junction of drainage lines, at the site of dams or retarding basins, at points corresponding to significant changes in catchment characteristics, or at any other point of interest.

Data is required on the area and connection sequence of the sub-catchments, together with average catchment slopes, the impervious percentage, and the rainfall data for the design storm being modelled. Additional data is required to model rainfall losses and channel or pipe flow. This information is entered in several different forms depending on the data availability and the degree of refinement desired for the analysis. For this assessment, the rainfall losses were modelled as initial and continuing losses.

3.2.1 MODEL SCENARIOS

Two catchment models were developed:

- Pre-development- 0-40% impervious areas in accordance with the L&A pre-development modelling.
- Post-development – % impervious set in accordance with the fraction impervious for various land-use types as adopted in the L&A report. 80% impervious was adopted for all areas of residential lots and associated roads whilst 10% impervious was adopted for open space and drainage areas (as opposed to 0% as adopted by L&A). On-site detention basins were added to control flows through the site and retard final flows exiting the site to pre-development peak flows.

3.2.2 SUB-CATCHMENT DEFINITION

The site lies within the larger Arcadia Estate catchment and slopes to the west to Burkes Gully draining under Werris Creek Road and ultimately into Timbumburi Creek west of the site.

For each scenario, the site was split into the sub-catchments shown in **Drawing No. 223064_01A _C003&C004** included in **Appendix A**. Catchment parameters for the site were determined from the detail survey of the site combined with a site inspection and aerial imagery. For catchment parameters outside of the proposed development the parameters adopted in the L&A modelling were adopted.

3.2.3 RAINFALL LOSSES

The following DRAINS model parameters for rainfall losses (as adopted in the 2015 L&A report) were used in the model:

Paved Area Initial loss	6.0 mm
Grassed Area Initial loss	2.0 mm
Antecedent Moisture Condition (AMC)	3.0
Soil Type	3.0

Reduced values were adopted for the 1 year ARI event in line with the L&A report:

> *Based on initial model runs it was found that the above model parameters provided a reasonable match to PRM peak flow estimates for storms with ARI's of between 2 and 100 years ARI. However, it was found that peak 1 year ARI discharges generated by the hydrologic model were significantly lower than the PRM peak flow estimates. In order to improve the fit, initial loss for grassed areas was reduced to 5 mm, while the AMC value was increased to 3.25 when deriving peak discharges for the 1 year ARI event.*

3.2.4 DESIGN STORMS

The catchment was modelled for the 1, 2, 20 & 100 years average recurrence interval (ARI) design storms to cover both the minor and major events and match the design storms in the L&A report. Design rainfall intensity/frequency/duration (IFD) data and storm temporal patterns were derived using the procedures set out in Australia Rainfall and Runoff (Institution of Engineers Australia, 1998), in line with the L&A report and TRC's *Engineering Design Minimum Standards for Subdivisions & Developments*.

Design storm durations from 5 minutes to 4.5 hours were modelled to determine the critical storm duration. (i.e., the storm that produced the highest peak flow) for both undeveloped and developed cases.

4. CONCEPTUAL STORMWATER MANAGEMENT STRATEGY

4.1 Stormwater Management Objectives

The proposed stormwater management strategy adopted at the site will be generally in accordance with the strategy outlined in the L&A report.

In accordance with the L&A report the main objectives adopted for stormwater management at the site are to:

- provide safe and efficient stormwater conveyance through the Arcadia Estate East subdivision.
- limit peak post development flows to pre-development flows.
- protect downstream drainage systems against construction and long-term impacts.

4.2 Conceptual Layout

The conceptual stormwater management system for the site is generally in accordance with the strategy proposed by L&A with the three proposed large basins on the eastern side of Burkes Gully replaced with seven (7) smaller basins as shown on **Drawing No. 223064_01A _C005** included in **Appendix A**. Preliminary sizing of the main system components has been undertaken to demonstrate that it can meet the proposed stormwater management objectives. The final system is subject to further detailed assessment during the detailed design stage to ensure it complements the proposed development layout.

The conceptual stormwater management system includes the following major components.

4.2.1 PIPE AND OPEN DRAIN SYSTEM

The stormwater conveyance system would comprise of pipes, roadways with kerb & guttering and open drains. Generally, pipes would be used for the interallotment drainage system and road drainage network. Discharge from the pipe system would generally be directly into the proposed detention basins that would then discharge into Burkes Gully for the eastern catchments or the into existing drainage lines and associated culverts under Werris Creek Road for the western catchments.

Pipes would be used as required to convey flow beneath roads. The interallotment and roadway pipe systems would be designed to convey the peak discharge for a 5 year ARI storm event for all residential areas while all commercial areas would be designed for the 10 year ARI storm event in accordance with Council requirements. Overland flow paths would be designed to convey overland flow during a 100yr ARI storm event at a safe depth and velocity. The preliminary reticulation layout is shown on drawing **223064_01A_C007-C010.**

4.2.2 ON-SITE DETENTION

To keep post-development peak flows discharging from the site at or below pre-development levels, seven (7) proposed detention basins have been sized and modelled.

The location of each proposed basin is shown on **Drawing No. 223064_01A _C005** included in **Appendix A**.

The following criteria was adopted in the preliminary design of the basins:

- Low flow pipe sized for the minor storm events down to the 1 year ARI storm event.
- Conventional broad crested weirs adopted for all basins (Basins 1, 2, 3, 4, 5, 6 and 7) and sized for the 100 yr ARI storm event.

- 1:6 internal and external batter slopes.
- Top of embankment set minimum 500mm above the 100 year ARI top water level.
- 3m wide top of embankment.
- Basin layouts shaped to integrate with existing landform and minimise depth of cut

Whilst subject to detailed design preliminary details of the basins are shown on **Drawing No. 223064_01A _C011-C017** included in **Appendix A**.

A summary of the proposed detention basin details is provided below in **Table 1.**

Table 1 – Proposed Detention Basins Details

Basin Name	Volume @ 100yr ARI TWL (ML)	Spillway Width (m)	Depth @Spill (m)	Low Level Outlet
Basin 1	6.37	70	1.75	375mm dia RCP fitted with 225mm orifice plate
Basin 2	1.52	50	1.20	375mm dia RCP
Basin 3	3.41	45	1.90	375mm dia RCP fitted with 225mm orifice plate
Basin 4	2.79	62	1.89	3 x 525mm dia RCP
Basin 5	4.30	30	1.75	375mm dia RCP fitted with 225mm orifice plate
Basin 6	3.20	32	1.90	375mm dia RCP fitted with 225mm orifice plate
Basin 7	1.07	38	0.90	375mm dia RCP fitted with 225mm orifice plate

5. STORMWATER MODELLING RESULTS

5.1 Hydrological Modelling Results

5.1.1 PRE-DEVELOPMENT

TRC supplied a copy of the L&A DRAINS model, and this was used for the pre-development case. The model was run to confirm the model results matched the tabled results in the L&A report pre-development peak flows from the site. A summary of the pre-development peak flows is provided in **Table 2** below and shows a near perfect match between the supplied DRAINS model output results and the L&A report.

Table 2 – Scenario 1 – Pre-Development Modelled Peak Flow Rates

Flow Location	Source of Results	1 year ARI Peak Flow (m^3/s)	2 year ARI Peak Flow (m^3/s)	20 year ARI Peak Flow (m^3/s)	100 year ARI Peak Flow (m^3/s)
BG1	L&A Report	5.0	6.6	26.7	47.8
	DRAINS Model	5.0	6.5	26.7	47.6

POST DEVELOPMENT INCLUDING DETENTION

The post development model was run to assess the performance of the proposed stormwater management strategy including the proposed detention basins within the site. A summary of the performance of each proposed basin is provided in **Table 3** below.

Table 3 – Scenario 2 – Proposed Detention Basins Results

Basin Name	Peak Inflow to Basin (m^3/s)		Peak Outflow from Basin (m^3/s)		Maximum Depth of Ponding (m)		Maximum Spill Depth (m)	
	1yr ARI	100yr ARI	1yr ARI	100yr ARI	1yr ARI	100yr ARI	1yr ARI	100yr ARI
Basin 1	1.24	5.55	0.08	3.92	1.41	1.85	N/A	0.10
Basin 2	0.79	3.29	0.28	3.04	1.11	1.30	N/A	0.10
Basin 3	0.81	3.40	0.07	2.33	1.59	2.00	N/A	0.10
Basin 4	1.57	5.89	1.30	5.84	0.83	2.00	N/A	0.11
Basin 5	1.07	4.40	0.08	1.65	1.28	1.85	N/A	0.10
Basin 6	0.56	2.46	0.06	1.69	1.12	2.00	N/A	0.10
Basin 7	0.67	2.66	0.08	2.09	0.88	1.00	N/A	0.10

A summary of the post development peak flows versus the pre-development peak flows are provided in **Table 4** below.

Table 4 – Scenario 2 – Post Development versus Pre Development Modelled Peak Flows

Flow Location	Pre/Post Development	1 year ARI Peak Flow (m^3/s)	2 year ARI Peak Flow (m^3/s)	20 year ARI Peak Flow (m^3/s)	100 year ARI Peak Flow (m^3/s)
BG1	Pre-Development	5.0	6.6	26.7	47.8
	Post-Development	4.9	6.5	20.9	35.2

The modelling results contained **Table 4** demonstrate that with the provision of the proposed onsite detention basins, the post development peak flows discharging from the site are at or below pre-development levels.

The final configuration of the proposed stormwater management system is subject to detailed design at which stage some adjustment to the design levels may occur. The design objectives would however remain unchanged.

6. CONCLUSION

This report presents an assessment of the proposed stormwater management strategy for the proposed Arcadia Estate residential subdivision proposed by Maximum Yield Pty Ltd & Burkes Gull Investments Pty Ltd.

It is proposed to construct a minor/major drainage system with the minor system consisting of stormwater pits and pipes that would convey minor flows to Burkes Gully and the existing culverts under Werris Creek Road via a number of pipe outlets. Major flows would be conveyed along road reserves and drainage easements.

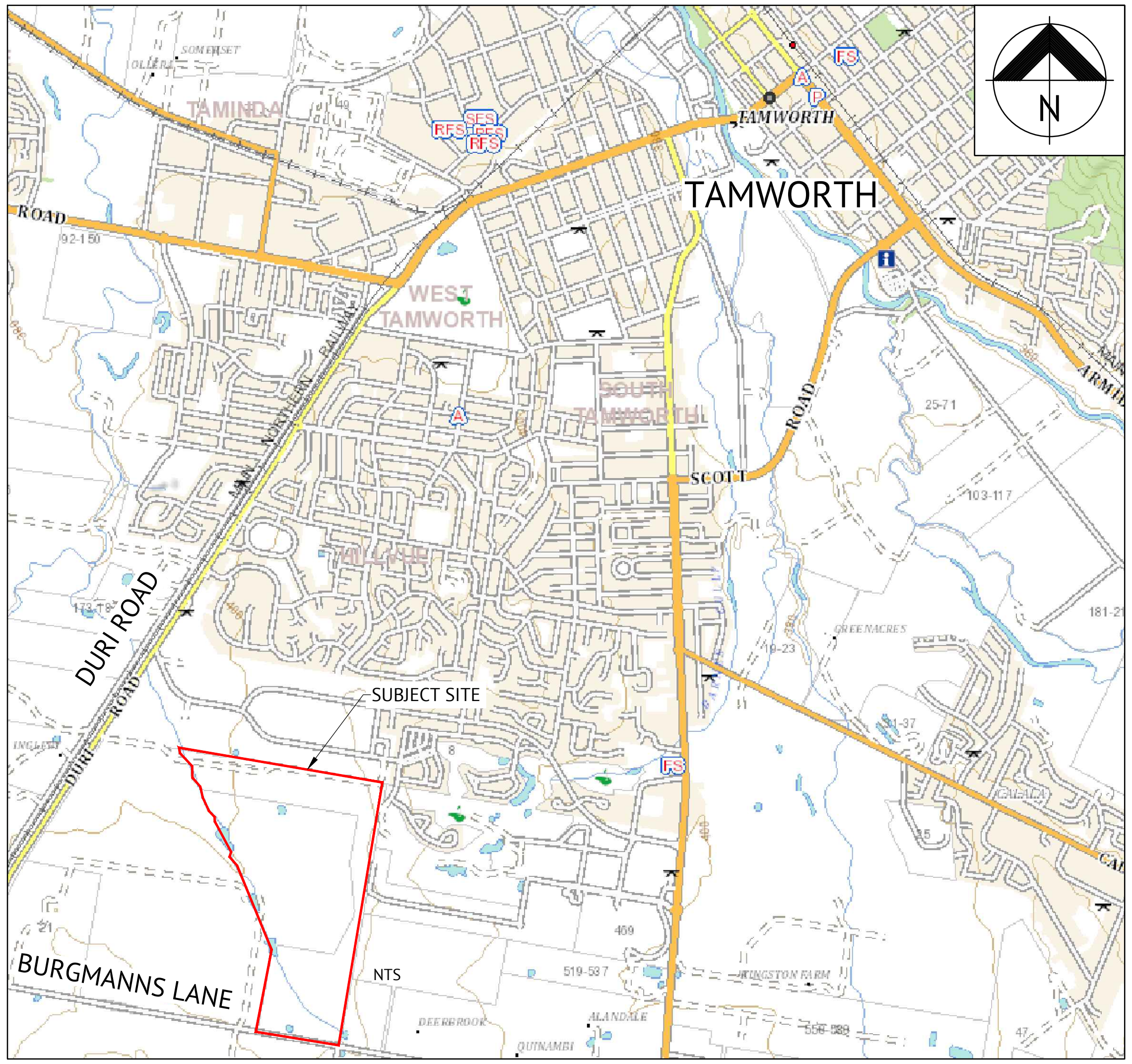
In accordance with the overall stormwater strategy for the catchment, on-site detention is proposed throughout the site to control peak flows through the site and to limit the final peak flows exiting the site to pre-development levels. All system components would be subject to further detailed assessment and design during the engineering design phase, based on the principles outlined in this assessment.

The results show that the proposed stormwater management system results in peak discharges from the site that are less than pre-development levels for both the 1yr ARI (minor event) and 100yr ARI (major event) storm events.

APPENDIX A

DRAWINGS

ARCADIA ESTATE EAST - STORMWATER STRATEGY
BURGMANS LANE, TAMWORTH
MAXIMUM YIELD PTY LTD & BOURKES GULL INVESTMENTS PTY LTD
CONCEPT STORMWATER SERVICING PLANS



LOCALITY PLAN

NTS

Sheet List Table

Sheet Number	Sheet Title
C001	TITLE SHEET & SCHEDULE OF DRAWINGS
C002	ARCADIA ESTATE EAST LAYOUT PLAN
C003	OVERALL STORMWATER CATCHMENT PLAN
C004	ARCADIA ESTATE EAST CATCHMENT PLAN
C005	PROPOSED CONCEPT STORMWATER MANAGEMENT PLAN
C006	OVERALL STORMWATER RETICULATION LAYOUT PLAN
C007	STORMWATER RETICULATION LAYOUT PLAN 1 OF 4
C008	STORMWATER RETICULATION LAYOUT PLAN 2 OF 4
C009	STORMWATER RETICULATION LAYOUT PLAN 3 OF 4
C010	STORMWATER RETICULATION LAYOUT PLAN 4 OF 4
C011	PROPOSED DETENTION BASIN 1 CONCEPT LAYOUT PLAN AND SECTIONS
C012	PROPOSED DETENTION BASIN 2 CONCEPT LAYOUT PLAN AND SECTIONS
C013	PROPOSED DETENTION BASIN 3 CONCEPT LAYOUT PLAN AND SECTIONS
C014	PROPOSED DETENTION BASIN 4 CONCEPT LAYOUT PLAN AND SECTIONS
C015	PROPOSED DETENTION BASIN 5 CONCEPT LAYOUT PLAN AND SECTIONS
C016	PROPOSED DETENTION BASIN 6 CONCEPT LAYOUT PLAN AND SECTIONS
C017	PROPOSED DETENTION BASIN 7 CONCEPT LAYOUT PLAN AND SECTIONS

ISSUED FOR REVIEW

DATE	REV	DESCRIPTION	REC	APP
05/07/2023	B	ISSUED FOR REVIEW	IW	PPO
30/06/2023	A	ISSUED FOR REVIEW	IW	PPO

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DESIGNED IW
CHECKED PPO
PROJECT MANAGER PPO
ENGINEERING CERTIFICATION
ENTER CERTIFIER DETAILS

SCALE

ORIGINAL SHEET SIZE A1

CLIENT MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION BURGMANS LANE, TAMWORTH
SHEET TITLE TITLE SHEET & SHEDULE OF DRAWINGS

JOB CODE 223064_02
SHEET NUMBER C001
REV B

NOTES

1. THIS PLAN IS FOR DEVELOPMENT APPLICATION PURPOSES ONLY.
2. ALL PROPOSED WORKS SHOWN ARE SUBJECT TO DETAILED CIVIL DESIGN & THE APPROVAL OF TAMWORTH REGIONAL COUNCIL.

LEGEND

CONTOURS (0.5m INTERVAL)
BURKES GULLY LINE
SITE BOUNDARY
LOT BOUNDARY

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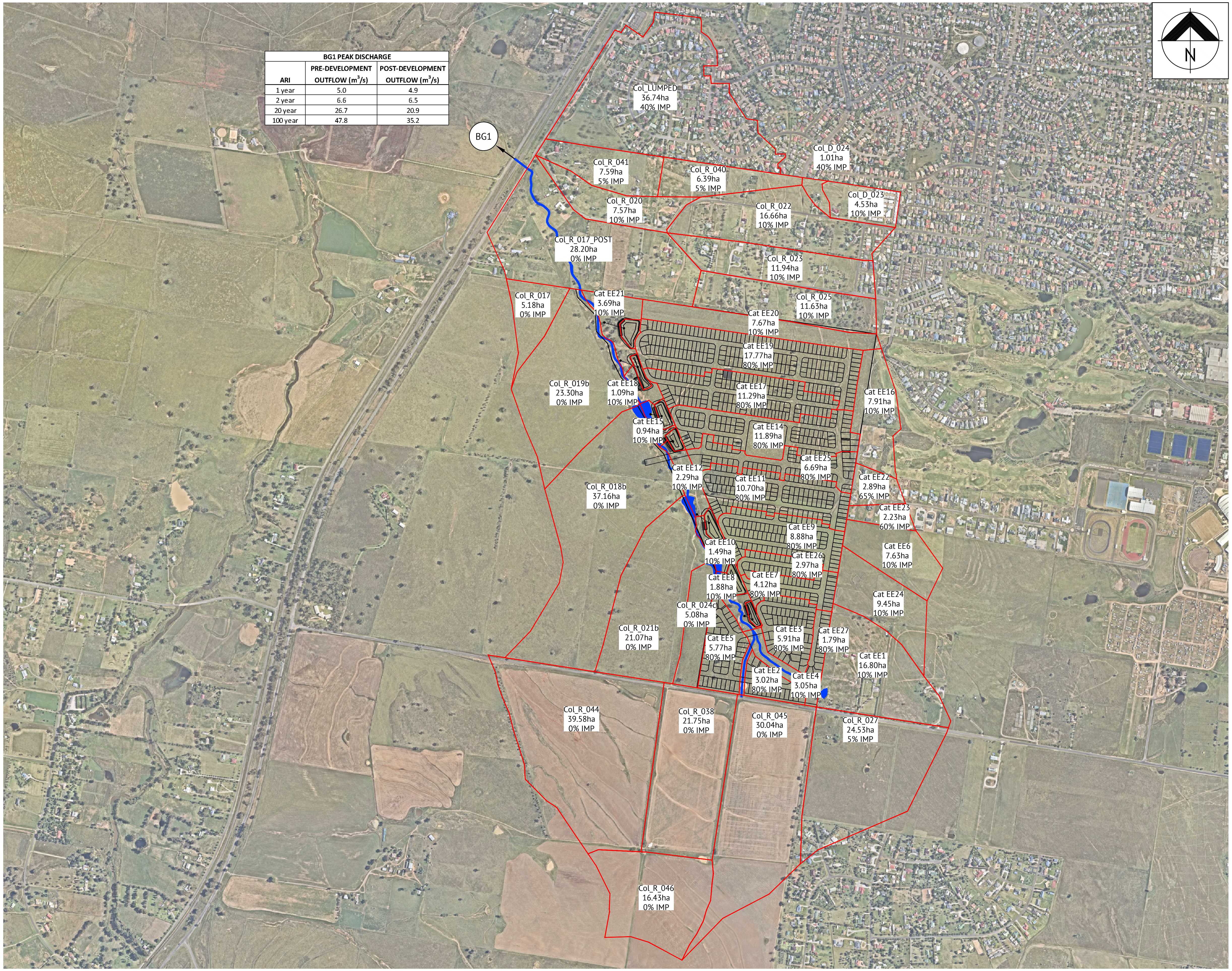
SCALE: 0 80 160 240m
SCALE 1:4000 (A1)
ORIGINAL SHEET SIZE A1

CLIENT: MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT: ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION: BURGMANS LANE, TAMWORTH
SHEET TITLE: ARCADIA ESTATE EAST SITE LAYOUT PLAN

JOB CODE: 223064_02
SHEET NUMBER: C002
REV: B

BG1 PEAK DISCHARGE		
ARI	PRE-DEVELOPMENT OUTFLOW (m^3/s)	POST-DEVELOPMENT OUTFLOW (m^3/s)
1 year	5.0	4.9
2 year	6.6	6.5
20 year	26.7	20.9
100 year	47.8	35.2



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LEGEND:

- STORMWATER CATCHMENT BOUNDARY
- 0.5m CONTOUR INTERVAL
- BURKES GULLY LINE
- SITE BOUNDARY
- BG1 PEAK FLOW NODE LOCATION

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SCALE 1:8000 (A1)
ORIGINAL SHEET SIZE A1

CLIENT: MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT: ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION: BURGMANS LANE, TAMWORTH
SHEET TITLE: OVERALL STORMWATER CATCHMENT PLAN

JOB CODE: 223064_02
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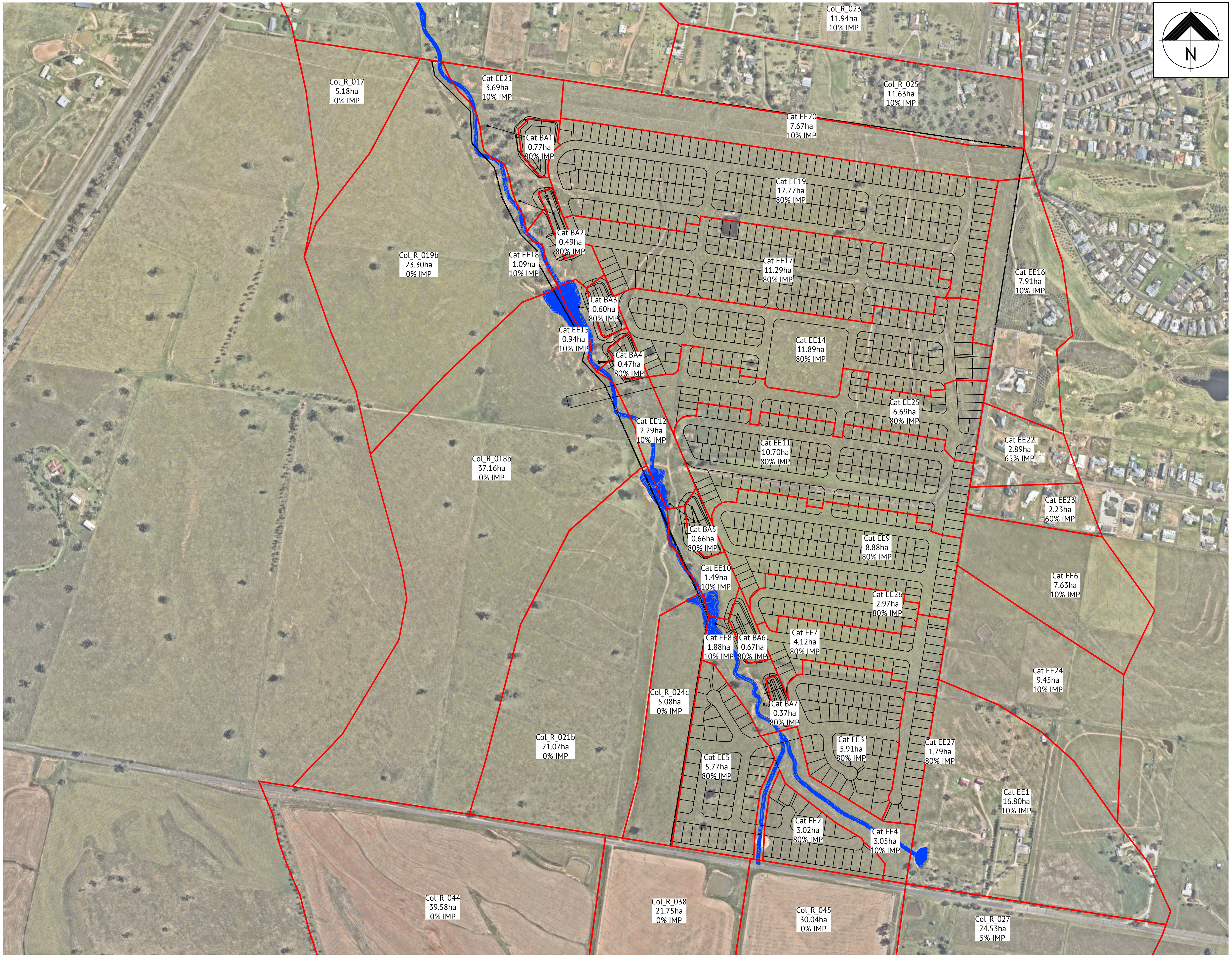
REV: B



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LEGEND:

- STORMWATER CATCHMENT BOUNDARY
- 0.5m CONTOUR INTERVAL
- BURKES GULLY LINE
- SITE BOUNDARY

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SCALE: 0 80 160 240m
SCALE 1:4000 (A1)
ORIGINAL SHEET SIZE A1

CLIENT: MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT: ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION: BURGMANS LANE, TAMWORTH
SHEET TITLE: ARCADIA ESTATE EAST STORMWATER CATCHMENT PLAN

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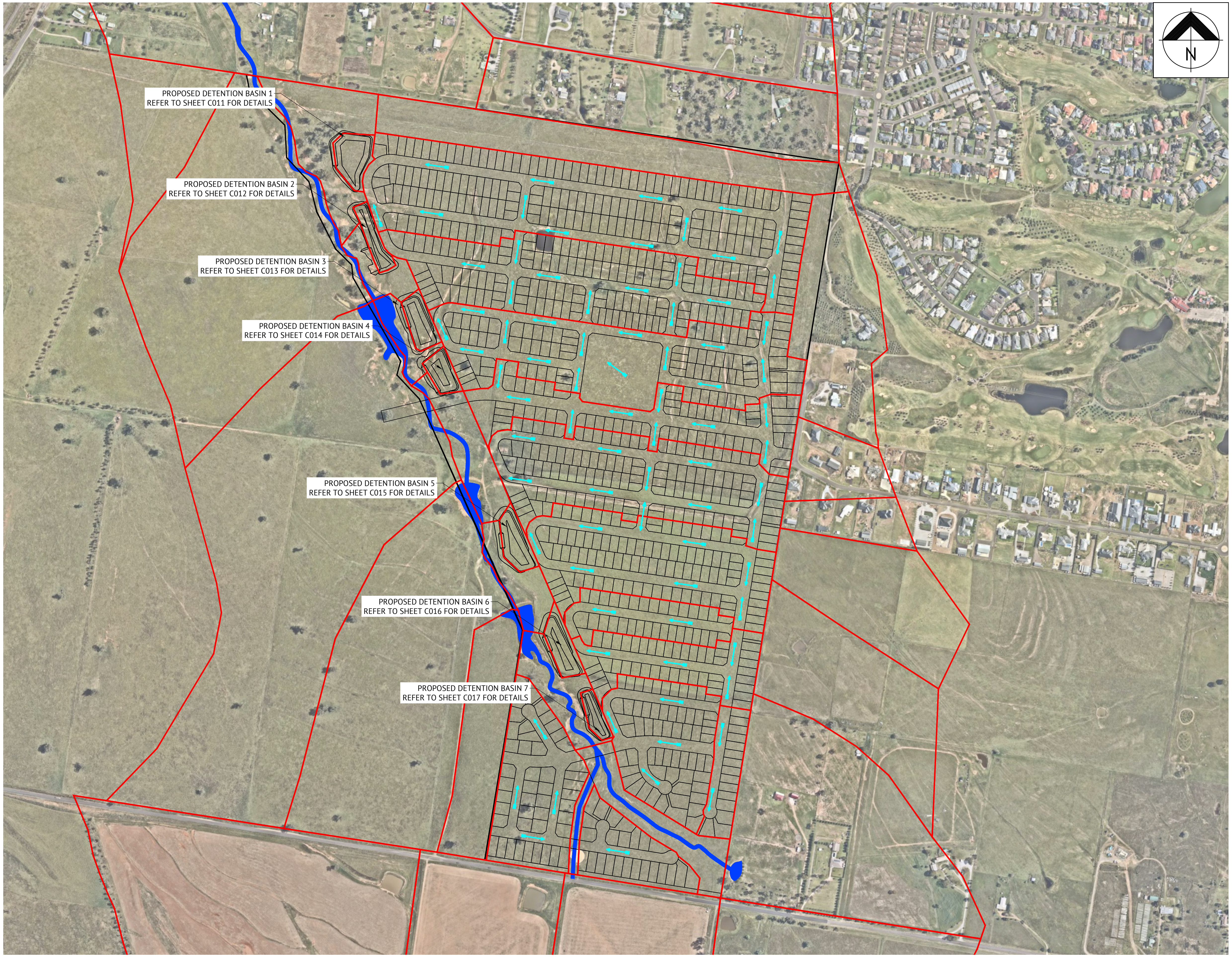
SHEET NUMBER: C004
REV: B



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LEGEND:

- STORMWATER CATCHMENT BOUNDARY
- 0.5m CONTOUR INTERVALS
- FLOW DIRECTION
- BURKES GULLY LINE
- SITE BOUNDARY

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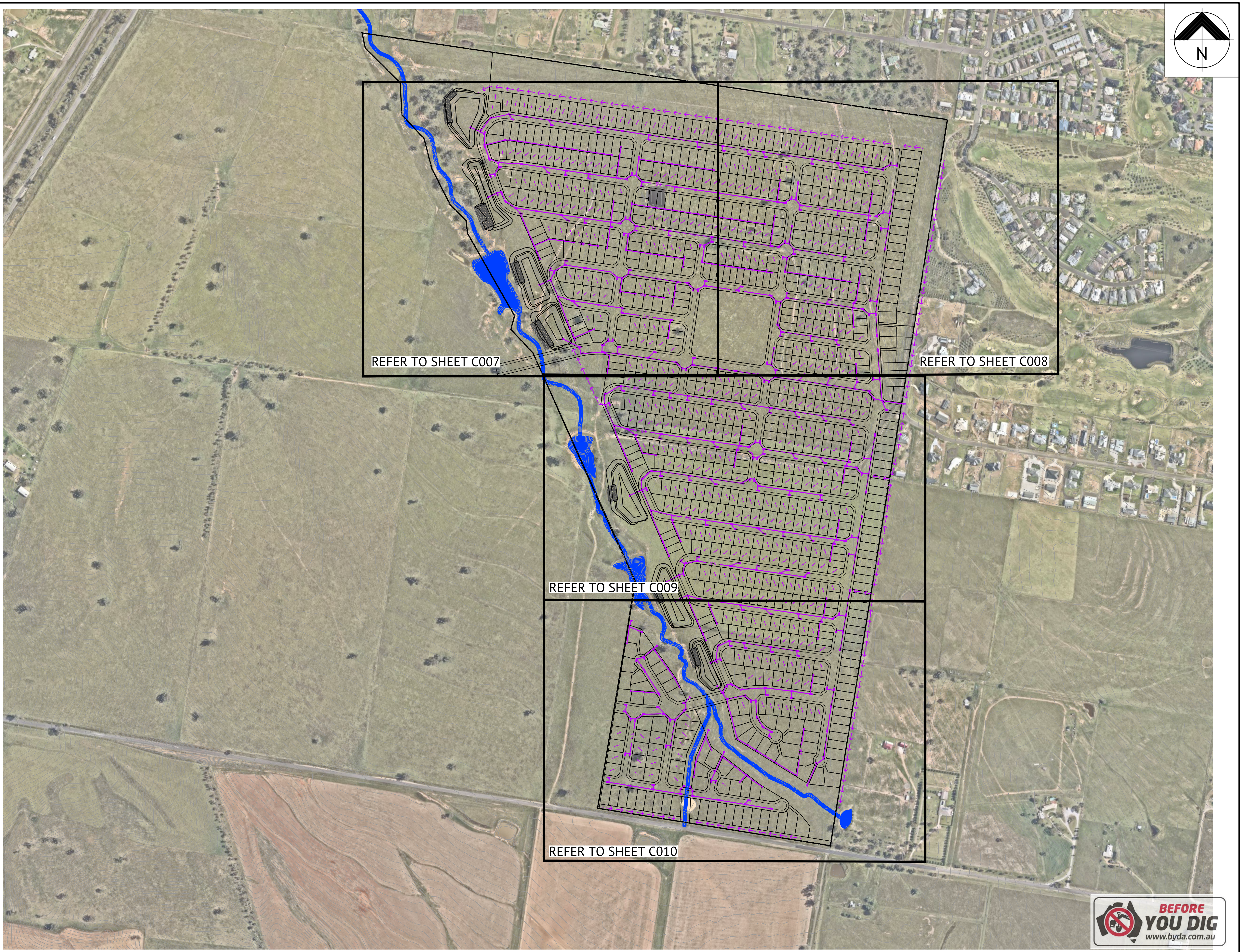
SCALE 1:4000 (A1)
ORIGINAL SHEET SIZE A1

CLIENT: MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT: ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION: BURGMANS LANE, TAMWORTH
SHEET TITLE: PROPOSED CONCEPT STORMWATER MANAGMENT PLAN

JOB CODE: 223064_02
SHEET NUMBER: C005
REV: B



LEGEND:

	EXISTING AND DESIGN CONTOUR (0.5m INTERVAL)
	PROPOSED LOT BOUNDARY
	PROPOSED KERB LINE
	PROPOSED SITE BOUNDARY
SW	PROPOSED STORMWATER DRAINAGE
	PROPOSED OPEN DRAIN
	PROPOSED KERB INLET PIT
	PROPOSED GRATED INLET PIT
	PROPOSED HEADWALL
	PROPOSED LOT REGRADING

NOTES:

1. THE LAYOUT SHOWN HEREON IS CONCEPTUAL ONLY AND SHALL NOT BE USED FOR CONSTRUCTION.
2. THIS PLAN IS PREPARED FROM A COMBINATION OF FIELD SURVEY AND COUNCIL RECORDS FOR THE PURPOSE OF DESIGNING NEW CONSTRUCTIONS ON THE LAND AND SHOULD NOT BE USED FOR ANY OTHER PURPOSE.
3. ALL UNDERGROUND SERVICES SHOWN ARE BASED ON A COMBINATION OF PREVIOUS COUNCIL RECORDS, VERBAL INSTRUCTIONS AND SURFACE INDICATORS LOCATED AT TIME OF SURVEY.
4. CONTOUR INTERVAL 0.5m.
5. THESE NOTES ARE AN INTEGRAL PART OF THIS PLAN.
6. SURVEY DATUM IS MGA 2020 AND AHD.

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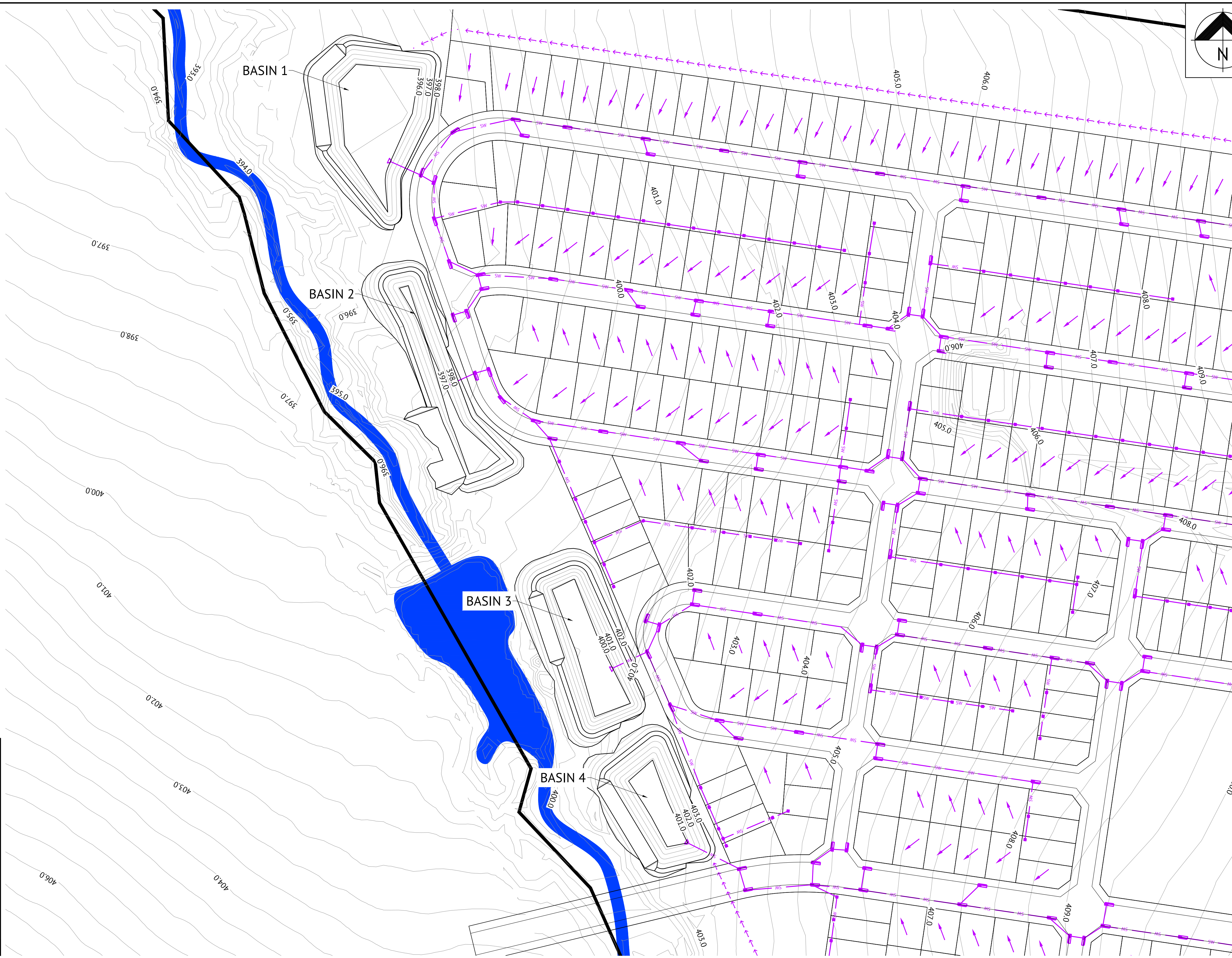
PROJECT: ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION: BURGMANS LANE, TAMWORTH
SHEET TITLE: OVERALL STORMWATER RETICULATION LAYOUT PLAN

JOB CODE: 223064_02
SHEET NUMBER: C006
REV: B



LEGEND:

- EXISTING AND DESIGN CONTOUR (0.5m INTERVAL)
- PROPOSED LOT BOUNDARY
- PROPOSED KERB LINE
- PROPOSED SITE BOUNDARY
- SW PROPOSED STORMWATER DRAINAGE
- PROPOSED OPEN DRAIN
- PROPOSED KERB INLET PIT
- PROPOSED GRATED INLET PIT
- PROPOSED HEADWALL
- PROPOSED LOT REGRADING

NOTES:

1. THE LAYOUT SHOWN HEREON IS CONCEPTUAL ONLY AND SHALL NOT BE USED FOR CONSTRUCTION.
2. THIS PLAN IS PREPARED FROM A COMBINATION OF FIELD SURVEY AND COUNCIL RECORDS FOR THE PURPOSE OF DESIGNING NEW CONSTRUCTIONS ON THE LAND AND SHOULD NOT BE USED FOR ANY OTHER PURPOSE.
3. ALL UNDERGROUND SERVICES SHOWN ARE BASED ON A COMBINATION OF PREVIOUS COUNCIL RECORDS, VERBAL INSTRUCTIONS AND SURFACE INDICATORS LOCATED AT TIME OF SURVEY.
4. CONTOUR INTERVAL 0.5m.
5. THESE NOTES ARE AN INTEGRAL PART OF THIS PLAN.
6. SURVEY DATUM IS MGA 2020 AND AHD.

ISSUED FOR REVIEW

DATE	REV	DESCRIPTION	REC	APP
05/07/2023	B	ISSUED FOR REVIEW	IW	PPO
30/06/2023	A	ISSUED FOR REVIEW	IW	PPO

REVISIONS

Premise

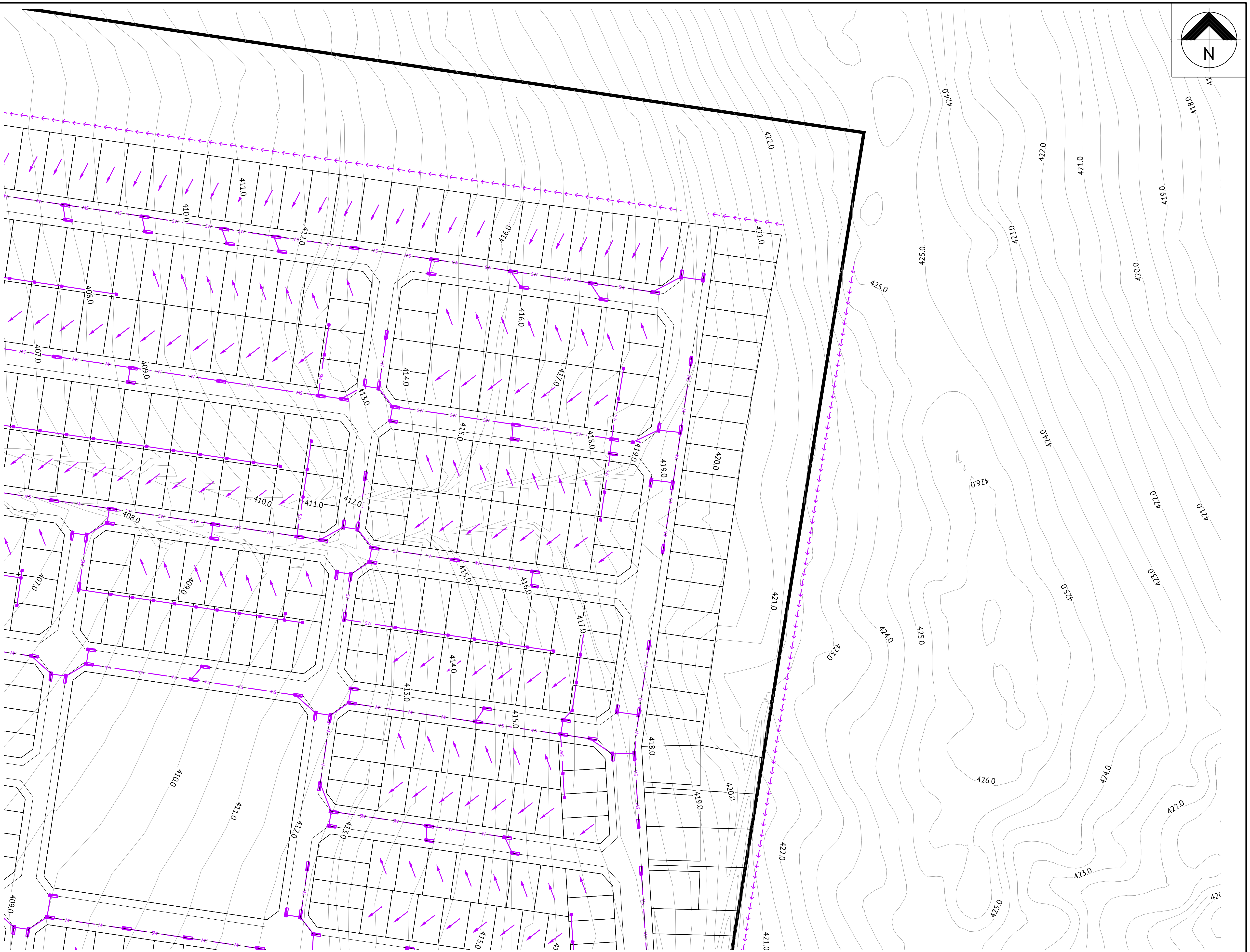
ORANGE OFFICE
154 PEISLEY STREET
ORANGE, NSW 2800
PH: (02) 6393 5000
WEB: www.premise.com.au

DESIGNED: IW
CHECKED: PPO
PROJECT MANAGER: PPO
ENGINEERING CERTIFICATION

SCALE: AS SHOWN
0 20 40 60m
SCALE 1:1250 (A1)
ORIGINAL SHEET SIZE A1

CLIENT: MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT: ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION: BURGMANS LANE, TAMWORTH
SHEET TITLE: STORMWATER RETICULATION LAYOUT PLAN SHEET 1 OF 4

JOB CODE: 223064_02
SHEET NUMBER: C007
REV: B



LEGEND:

- EXISTING AND DESIGN CONTOUR (0.5m INTERVAL)
- PROPOSED LOT BOUNDARY
- PROPOSED KERB LINE
- PROPOSED SITE BOUNDARY
- SW PROPOSED STORMWATER DRAINAGE
- PROPOSED OPEN DRAIN
- PROPOSED KERB INLET PIT
- PROPOSED GRATED INLET PIT
- PROPOSED HEADWALL
- PROPOSED LOT REGRADING

NOTES:

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3. ALL UNDERGROUND SERVICES SHOWN ARE BASED ON A COMBINATION OF PREVIOUS COUNCIL RECORDS, VERBAL INSTRUCTIONS AND SURFACE INDICATORS LOCATED AT TIME OF SURVEY.
4. CONTOUR INTERVAL 0.5m.
5. THESE NOTES ARE AN INTEGRAL PART OF THIS PLAN.
6. SURVEY DATUM IS MGA 2020 AND AHD.

ISSUED FOR REVIEW

DATE	REV	DESCRIPTION	REC	APP
05/07/2023	B	ISSUED FOR REVIEW	IW	PPO
30/06/2023	A	ISSUED FOR REVIEW	IW	PPO

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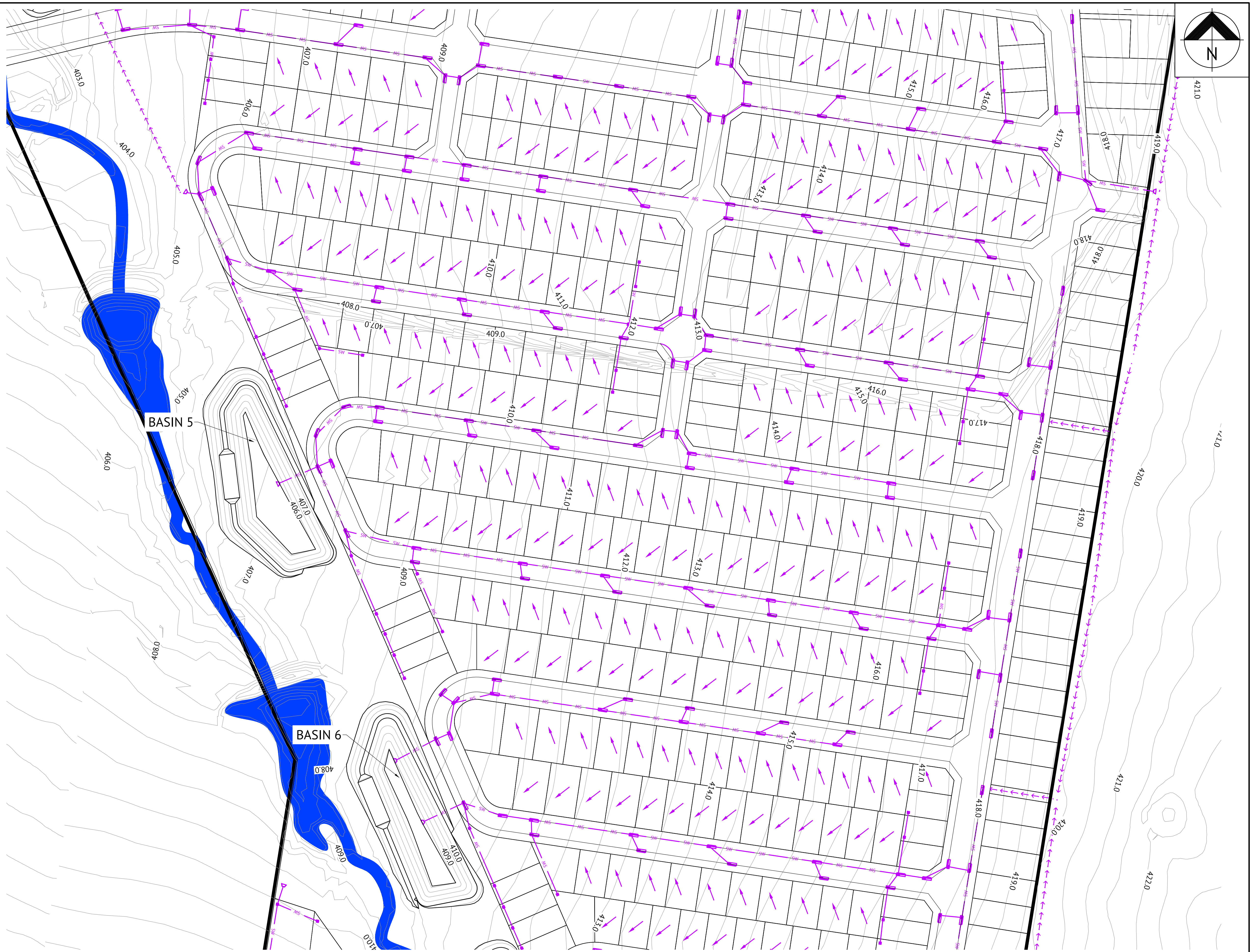
PROJECT MANAGER: PPO
ENGINEERING CERTIFICATION

SCALE: AS SHOWN
0 20 40 60m
SCALE 1:1250 (A1)
ORIGINAL SHEET SIZE A1

CLIENT: MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT: ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION: BURGMANS LANE, TAMWORTH
SHEET TITLE: STORMWATER RETICULATION LAYOUT PLAN SHEET 1 OF 4

JOB CODE: 223064_02
SHEET NUMBER: C008
REV: B



LEGEND:

- EXISTING AND DESIGN CONTOUR (0.5m INTERVAL)
- PROPOSED LOT BOUNDARY
- PROPOSED KERB LINE
- PROPOSED SITE BOUNDARY
- SW — PROPOSED STORMWATER DRAINAGE
- PROPOSED OPEN DRAIN
- PROPOSED KERB INLET PIT
- PROPOSED GRATED INLET PIT
- PROPOSED HEADWALL
- PROPOSED LOT REGRADING

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DATE	REV	DESCRIPTION	REC	APP
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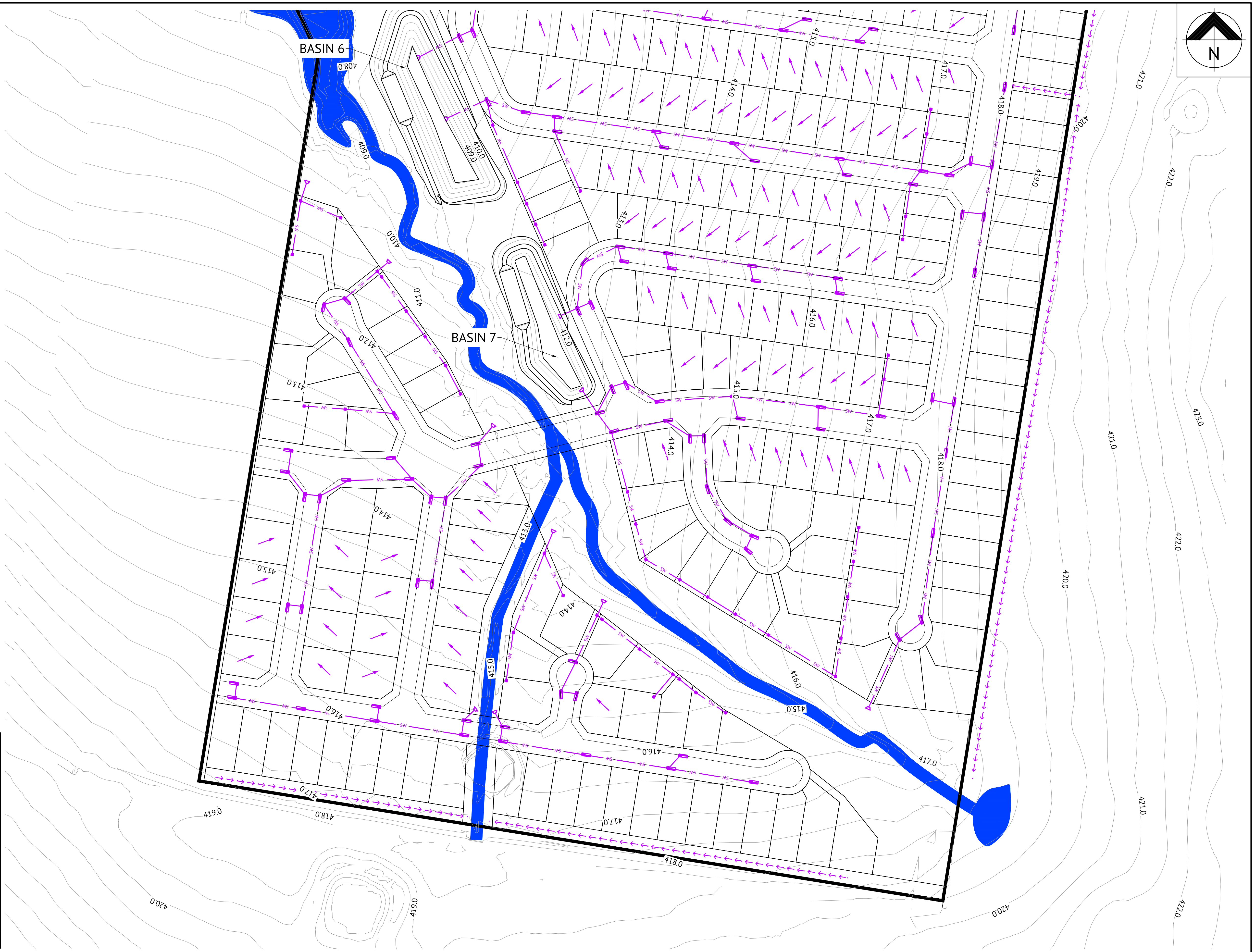
ENGINEERING CERTIFICATION

SCALE: AS SHOWN
0 20 40 60m
SCALE 1:1250 (A1)
ORIGINAL SHEET SIZE A1

CLIENT: MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT: ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION: BURGMANS LANE, TAMWORTH
SHEET TITLE: STORMWATER RETICULATION LAYOUT PLAN SHEET 1 OF 4

JOB CODE: 223064_02
SHEET NUMBER: C009
REV: B



LEGEND:

- EXISTING AND DESIGN CONTOUR (0.5m INTERVAL)
- PROPOSED LOT BOUNDARY
- PROPOSED KERB LINE
- PROPOSED SITE BOUNDARY
- SW — PROPOSED STORMWATER DRAINAGE
- PROPOSED OPEN DRAIN
- PROPOSED KERB INLET PIT
- PROPOSED GRATED INLET PIT
- PROPOSED HEADWALL
- PROPOSED LOT REGRADING

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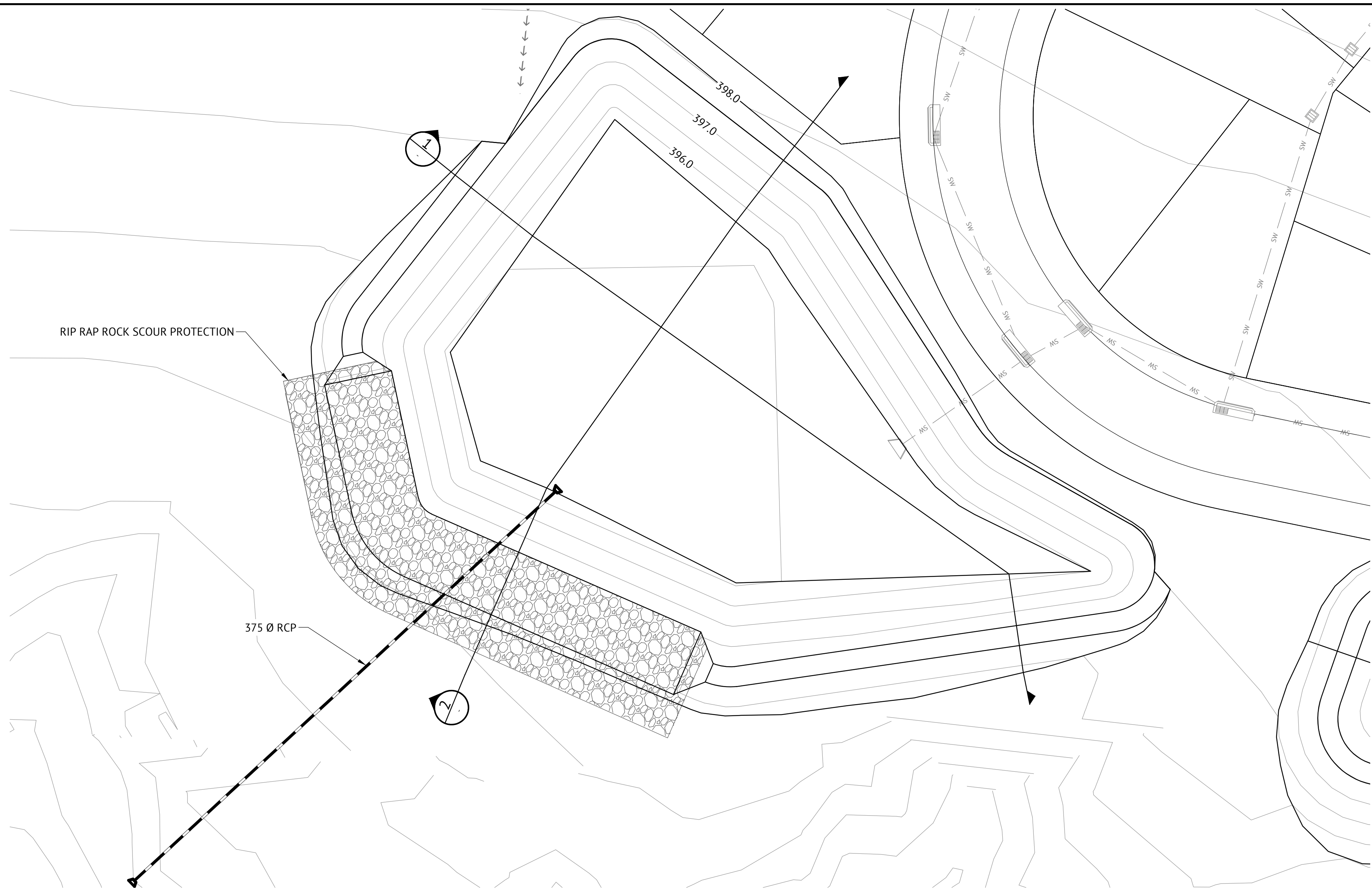
ENGINEERING CERTIFICATION

SCALE: AS SHOWN
0 20 40 60m
SCALE 1:1250 (A1)
ORIGINAL SHEET SIZE A1

CLIENT: MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT: ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION: BURGMANS LANE, TAMWORTH
SHEET TITLE: STORMWATER RETICULATION LAYOUT PLAN SHEET 1 OF 4

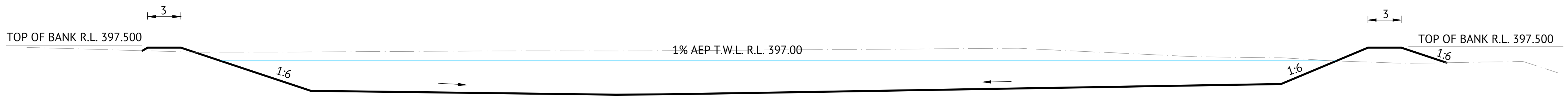
JOB CODE: 223064_02
SHEET NUMBER: C010
REV: B



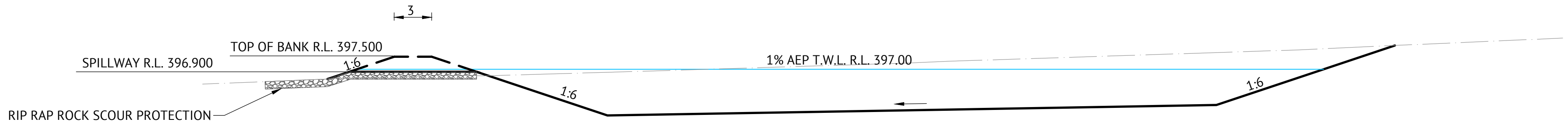
PROPOSED DETENTION BASIN 1

BASE/FLOOR R.L. 395.150
TOP OF BANK R.L. 397.500
PRIMARY OUTLET 1x375mm Ø FITTED WITH 225 ORIFICE PLATE
SPILLWAY 70m WIDE @ R.L. 396.90
VOLUME @ TOP WATER LEVEL 6.37ML
1EY PEAK DISCHARGE = 0.08m³/s
1EY PEAK WATER LEVEL R.L. 396.56
1% AEP PEAK DISCHARGE = 3.92m³/s
1% AEP PEAK WATER LEVEL R.L. 397.00

PROPOSED DETENTION BASIN
SCALE 1:400



1 SECTION
SCALE 1:250 H 1:125 V



2 SECTION
SCALE 1:250 H 1:125 V

LEGEND:

- DESIGN SURFACE
- EXISTING SURFACE
- 1% AEP TOP WATER LEVEL

NOTES

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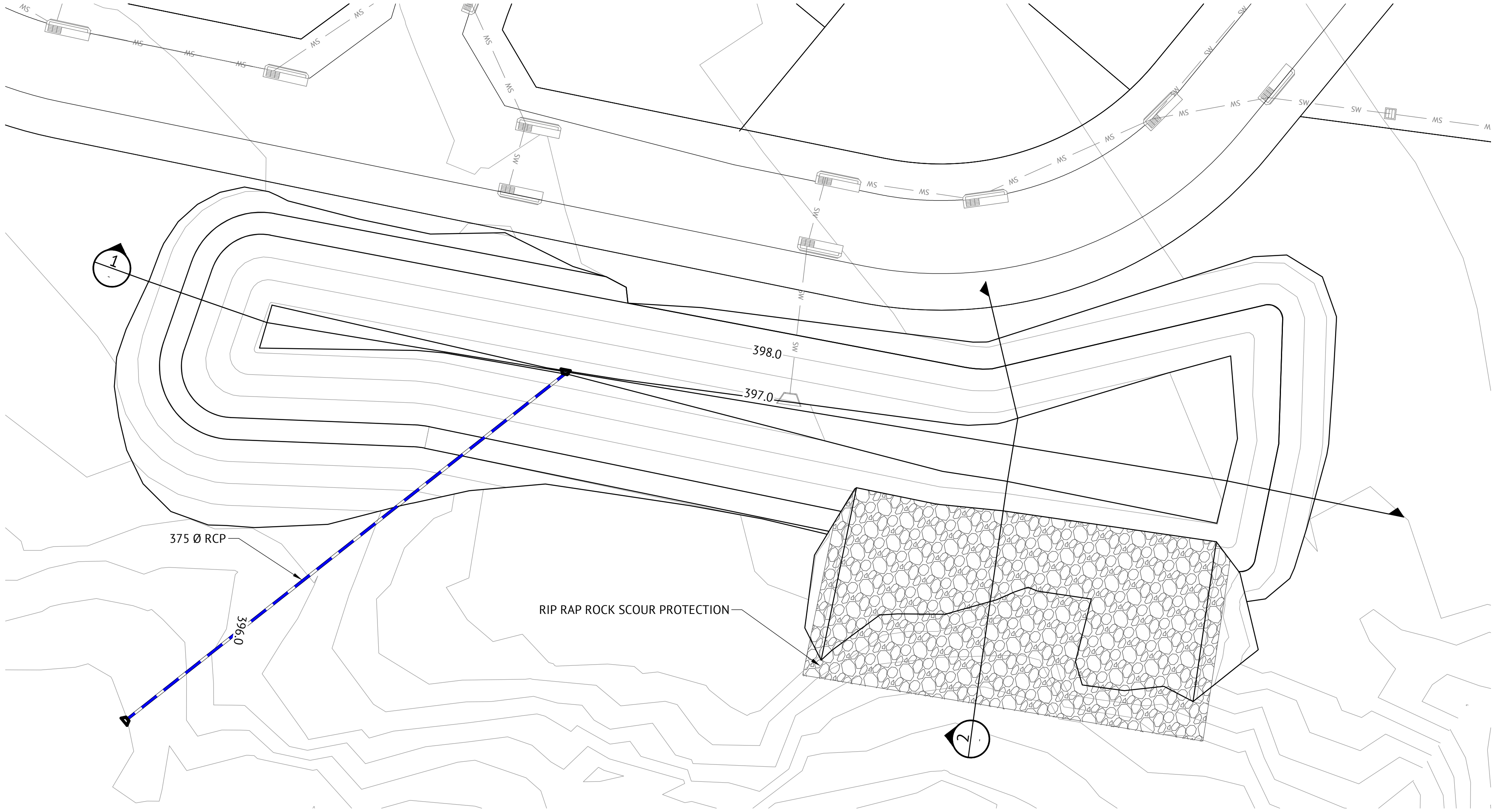
CHECKED PPO
PROJECT MANAGER PPO
ENGINEERING CERTIFICATION
ENTER CERTIFIER DETAILS
SCALE
ORIGINAL SHEET SIZE A1

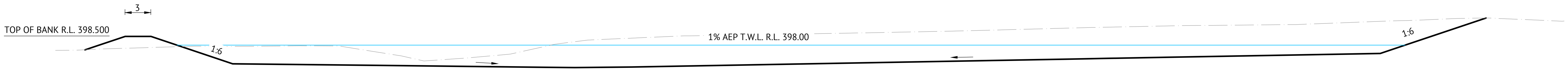
CLIENT MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION BURGMANS LANE, TAMWORTH
SHEET TITLE PROPOSED DETENTION BASIN 1 CONCEPT LAYOUT PLAN AND SECTIONS
JOB CODE 223064_02
SHEET NUMBER C011
REV B



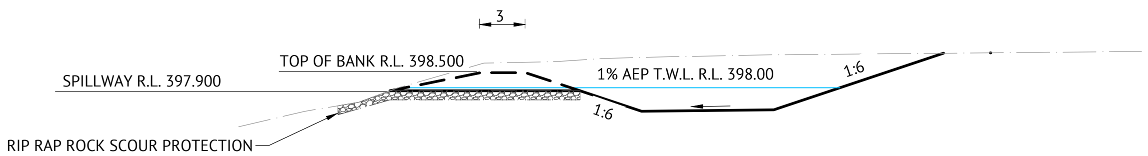
PROPOSED DETENTION BASIN 2

BASE/FLOOR R.L. 396.700
TOP OF BANK R.L. 398.500
PRIMARY OUTLET 1x375mm Ø
SPILLWAY 50m WIDE @ R.L. 397.900
VOLUME @ TOP WATER LEVEL 1.52ML
1EY PEAK DISCHARGE = 0.28m³/s
1EY PEAK WATER LEVEL R.L. 397.81
1% AEP PEAK DISCHARGE = 3.04m³/s
1% AEP PEAK WATER LEVEL R.L. 398.00

PROPOSED DETENTION BASIN
SCALE 1:400



1 SECTION
SCALE 1:250 H 1:125 V



2 SECTION
SCALE 1:250 H 1:125 V

LEGEND:
- DESIGN SURFACE
- EXISTING SURFACE
- 1% AEP TOP WATER LEVEL

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REVISIONS

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154 PEISLEY STREET
ORANGE, NSW 2800
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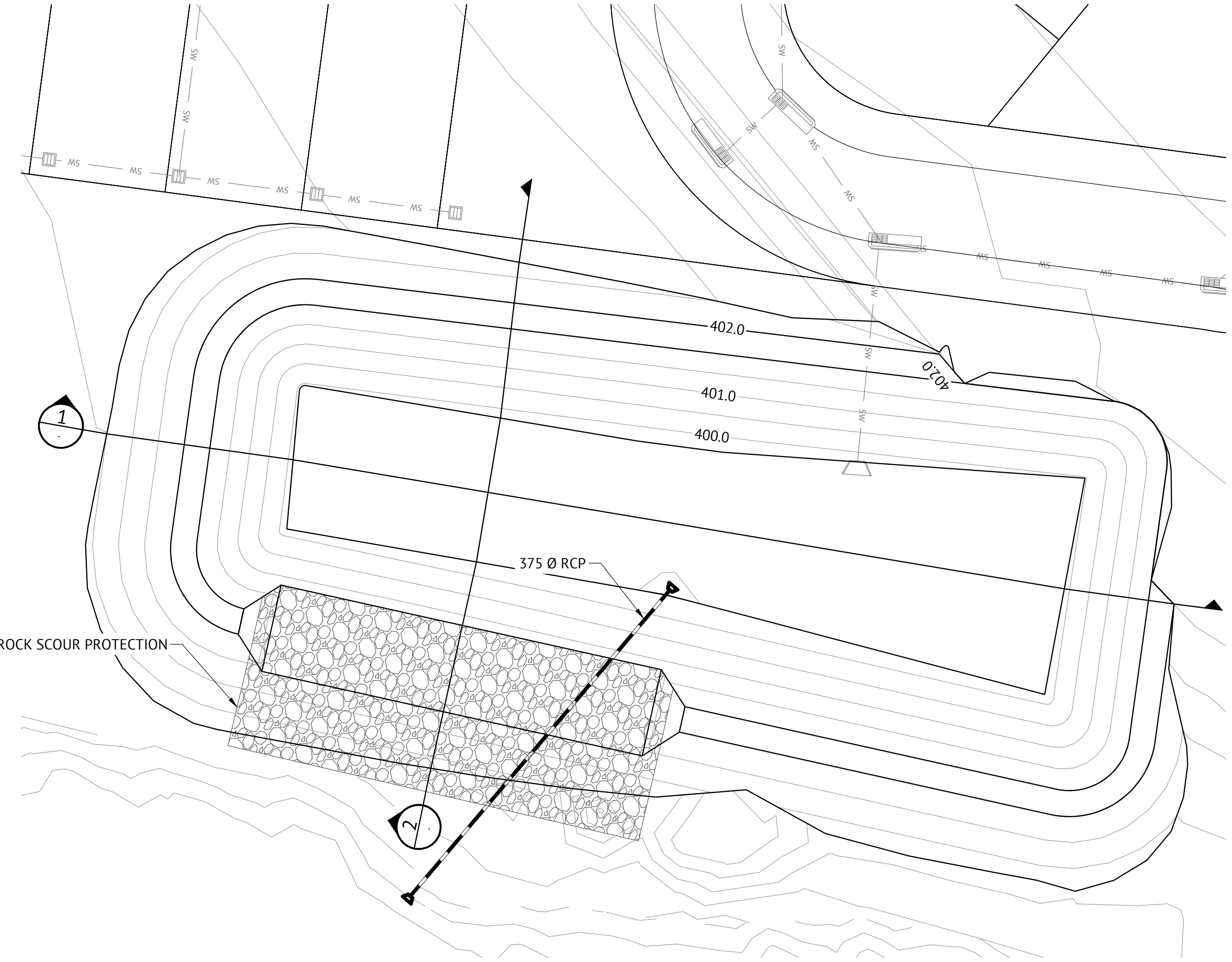
DESIGNED IW
CHECKED PPO
PROJECT MANAGER PPO
ENGINEERING CERTIFICATION
ENTER CERTIFIER DETAILS
SCALE
ORIGINAL SHEET SIZE A1

CLIENT MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION BURGMANS LANE, TAMWORTH
SHEET TITLE PROPOSED DETENTION BASIN 2 CONCEPT LAYOUT PLAN AND SECTIONS

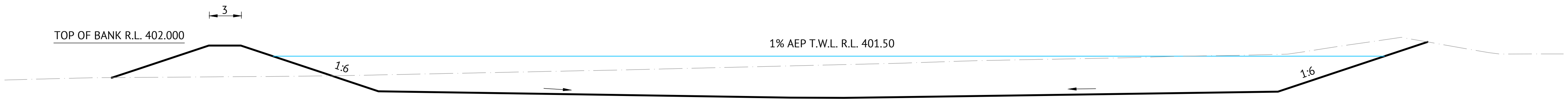
JOB CODE 223064_02
SHEET NUMBER C012
REV B



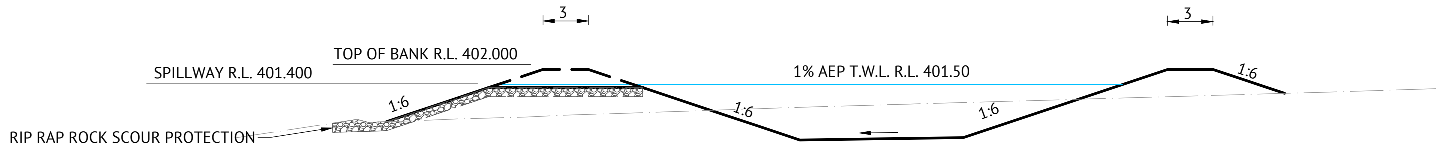
PROPOSED DETENTION BASIN 3

BASE/FLOOR R.L. 399.5
TOP OF BANK R.L. 402.000
PRIMARY OUTLET 1x375mm Ø FITTED WITH 225 ORIFICE PLATE
SPILLWAY 45m WIDE @ R.L. 401.400
VOLUME @ TOP WATER LEVEL 3.41ML
1EY PEAK DISCHARGE = 0.07m³/s
1EY PEAK WATER LEVEL R.L. 401.09
1% AEP PEAK DISCHARGE = 2.33m³/s
1% AEP PEAK WATER LEVEL R.L. 401.50

PROPOSED DETENTION BASIN
SCALE 1:400



1 SECTION
SCALE 1:250 H 1:125 V



2 SECTION
SCALE 1:250 H 1:125 V

LEGEND:

- DESIGN SURFACE
- EXISTING SURFACE
- 1% AEP TOP WATER LEVEL

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REVISIONS

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154 PEISLEY STREET
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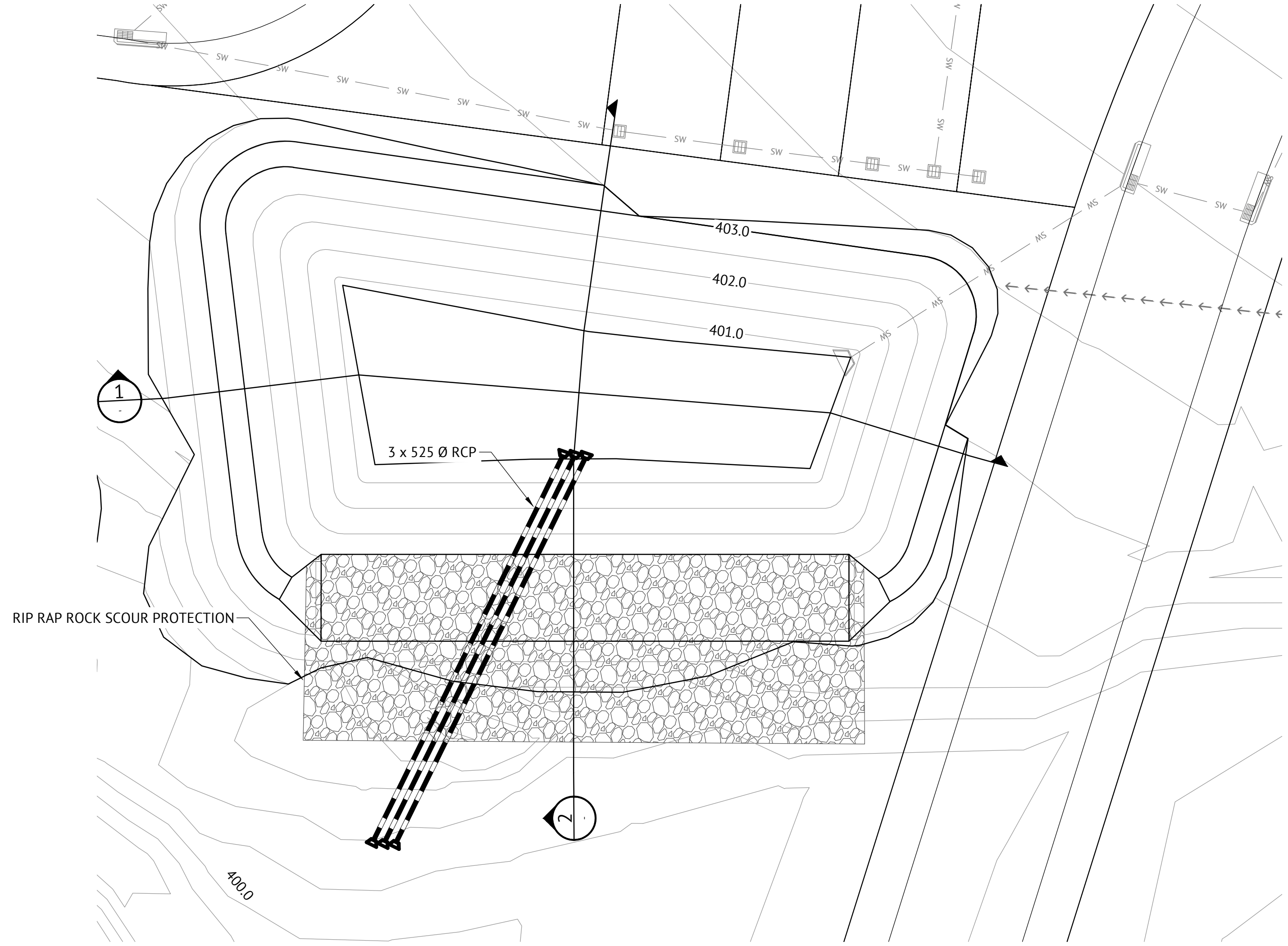
DESIGNED IW
CHECKED PPO
PROJECT MANAGER PPO
ENGINEERING CERTIFICATION
ENTER CERTIFIER DETAILS
SCALE
ORIGINAL SHEET SIZE A1

CLIENT: MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT: ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION: BURGMANS LANE, TAMWORTH
SHEET TITLE: PROPOSED DETENTION BASIN 3 CONCEPT LAYOUT PLAN AND SECTIONS

JOB CODE: 223064_02
SHEET NUMBER: C013
REV: B

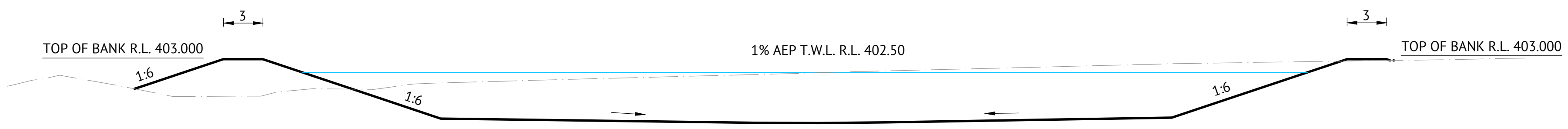


PROPOSED DETENTION BASIN 4

BASE/FLOOR R.L. 400.500
TOP OF BANK R.L. 403.000
PRIMARY OUTLET 3x525mm Ø
SPILLWAY 62m WIDE @ R.L. 402.390
VOLUME @ TOP WATER LEVEL 2.79ML
1EY PEAK DISCHARGE = 1.30m³/s
1EY PEAK WATER LEVEL R.L. 401.33
1% AEP PEAK DISCHARGE = 5.84m³/s
1% AEP PEAK WATER LEVEL R.L. 402.50

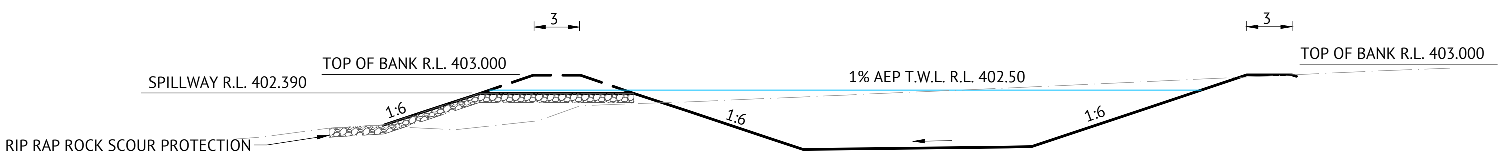
PROPOSED DETENTION BASIN

SCALE 1:400



1 SECTION

SCALE 1:250 H 1:125 V



2 SECTION

SCALE 1:250 H 1:125 V

LEGEND:

- DESIGN SURFACE
- EXISTING SURFACE
- 1% AEP TOP WATER LEVEL

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DATE	REV	DESCRIPTION	REC	APP
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30/06/2023	A	ISSUED FOR REVIEW	IW	PPO

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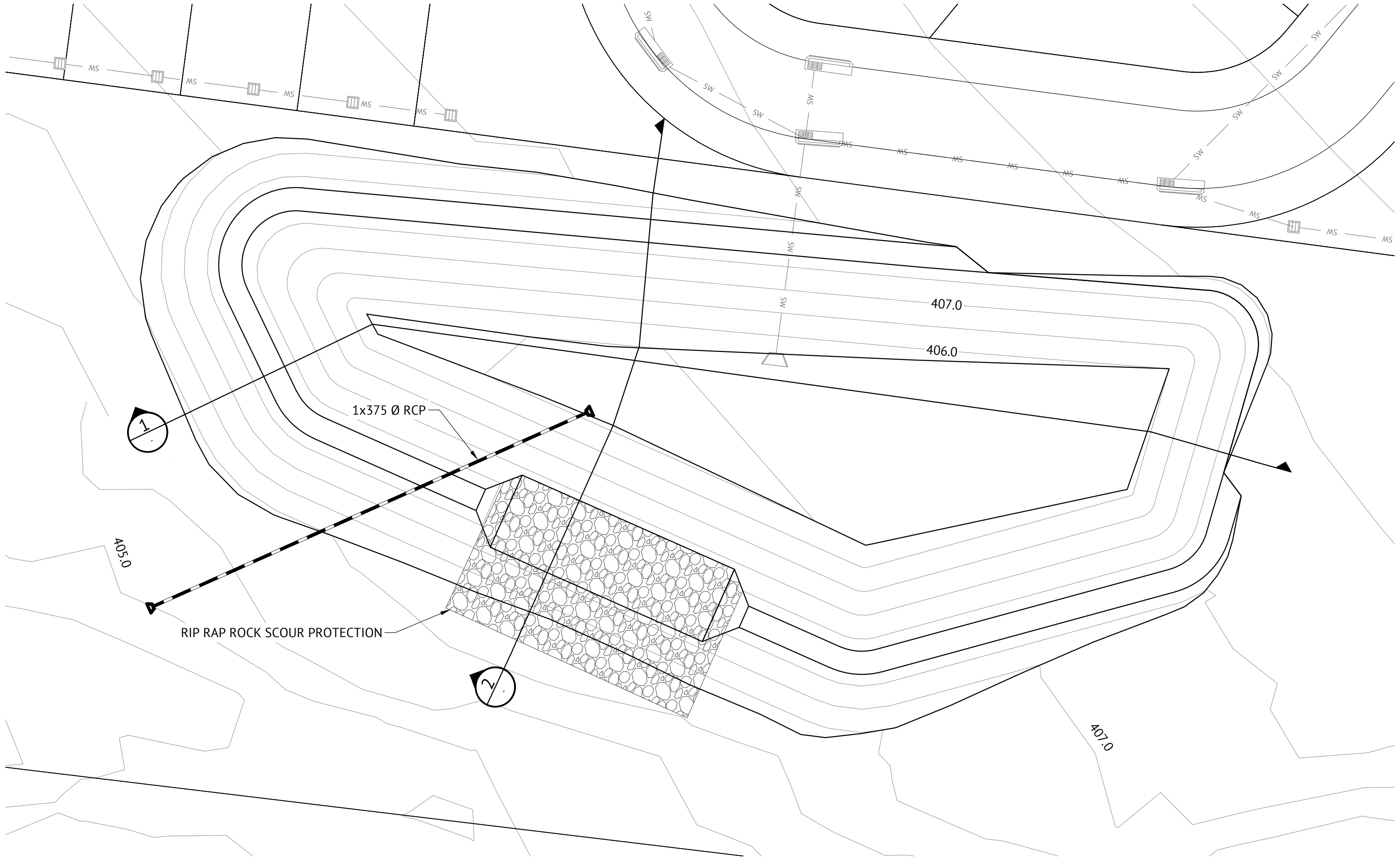
DESIGNED IW
CHECKED PPO
PROJECT MANAGER PPO
ENGINEERING CERTIFICATION
ENTER CERTIFIER DETAILS

SCALE

ORIGINAL SHEET SIZE A1

CLIENT: MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT: ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION: BURGMANS LANE, TAMWORTH
SHEET TITLE: PROPOSED DETENTION BASIN 4 CONCEPT LAYOUT PLAN AND SECTIONS

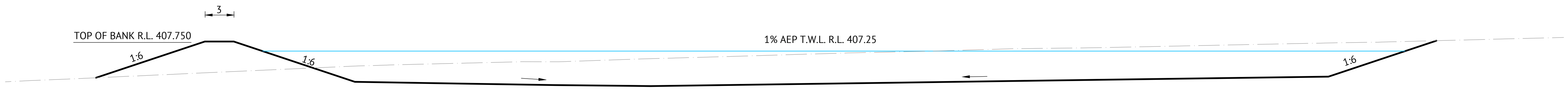
JOB CODE 223064_02
SHEET NUMBER C014
REV B



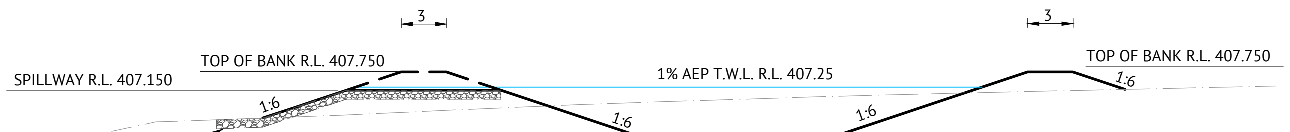
PROPOSED DETENTION BASIN 5

BASE/FLOOR R.L. 405.400
TOP OF BANK R.L. 407.750
PRIMARY OUTLET 1x375mm Ø FITTED WITH 225 ORIFICE PLATE
SPILLWAY 30m WIDE @ R.L. 407.150
VOLUME @ TOP WATER LEVEL 4.30ML
1EY PEAK DISCHARGE = 0.08m³/s
1EY PEAK WATER LEVEL R.L. 406.68
1% AEP PEAK DISCHARGE = 1.65m³/s
1% AEP PEAK WATER LEVEL R.L. 407.25

PROPOSED DETENTION BASIN
SCALE 1:400



1 SECTION
SCALE 1:250 H 1:125 V



2 SECTION
SCALE 1:250 H 1:125 V

LEGEND:

- DESIGN SURFACE
- EXISTING SURFACE
- 1% AEP TOP WATER LEVEL

NOTES

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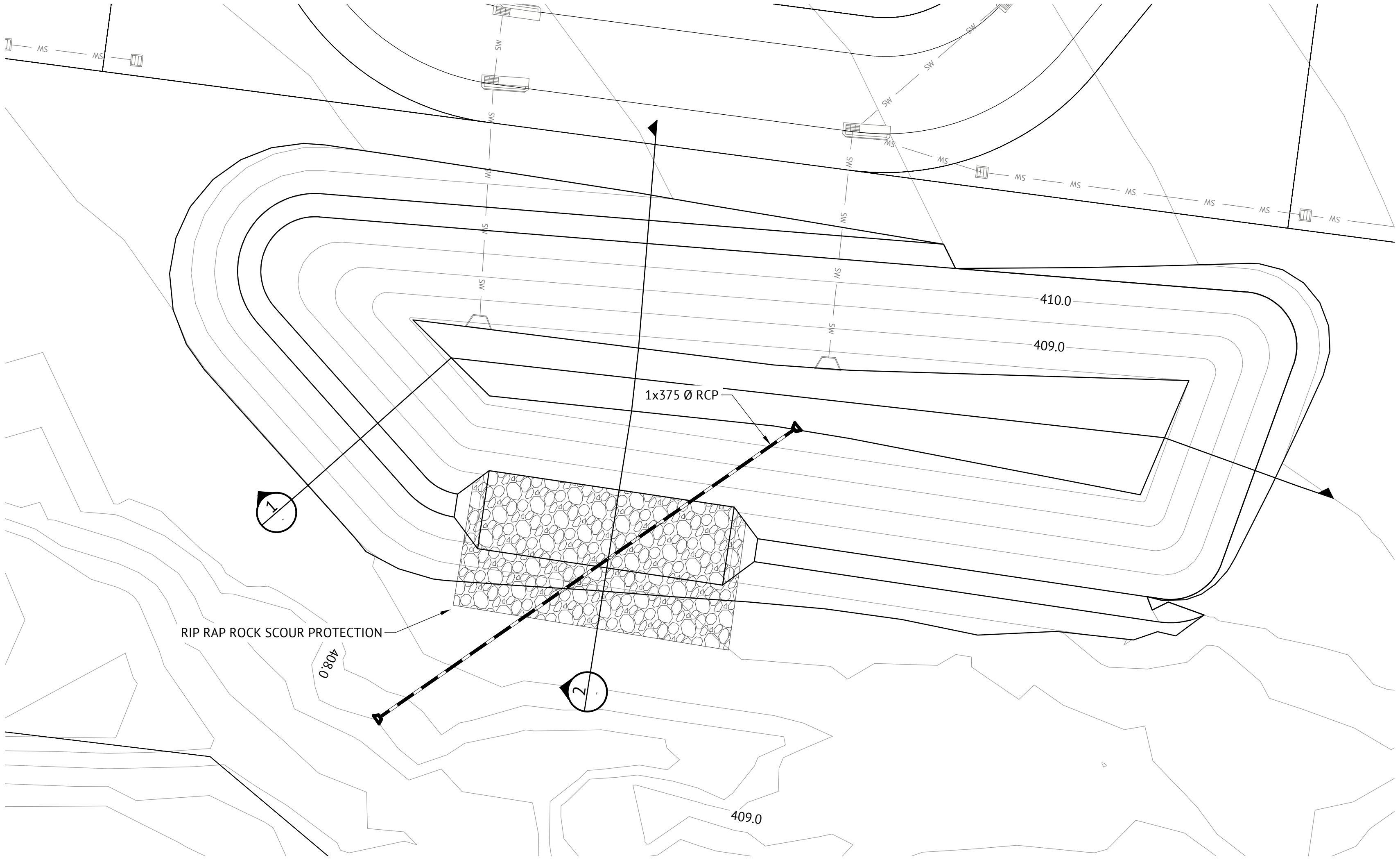
PROJECT MANAGER PPO
ENGINEERING CERTIFICATION
ENTER CERTIFIER DETAILS
SCALE
ORIGINAL SHEET SIZE A1

CLIENT MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION BURGMANS LANE, TAMWORTH
SHEET TITLE PROPOSED DETENTION BASIN 5 CONCEPT LAYOUT PLAN AND SECTIONS

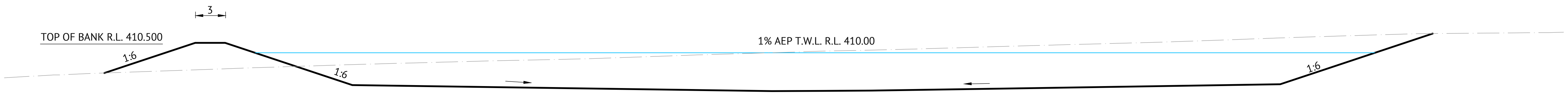
JOB CODE 223064_02
SHEET NUMBER C015
REV B



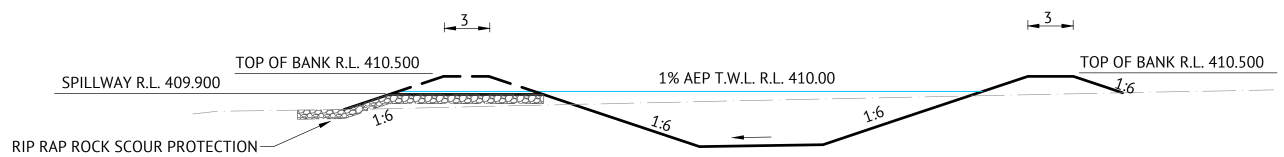
PROPOSED DETENTION BASIN 6

BASE/FLOOR R.L. 408.000
TOP OF BANK R.L. 410.500
PRIMARY OUTLET 1x375mm Ø FITTED WITH 225 ORIFICE PLATE
SPILLWAY 32m WIDE @ R.L. 409.900
VOLUME @ TOP WATER LEVEL 3.20ML
1EY PEAK DISCHARGE = 0.06m³/s
1EY PEAK WATER LEVEL R.L. 409.12
1% AEP PEAK DISCHARGE = 1.69m³/s
1% AEP PEAK WATER LEVEL R.L. 410.00

PROPOSED DETENTION BASIN
SCALE 1:400



1 SECTION
SCALE 1:250 H 1:125 V



2 SECTION
SCALE 1:250 H 1:125 V

LEGEND:

DESIGN SURFACE
EXISTING SURFACE
1% AEP TOP WATER LEVEL

NOTES
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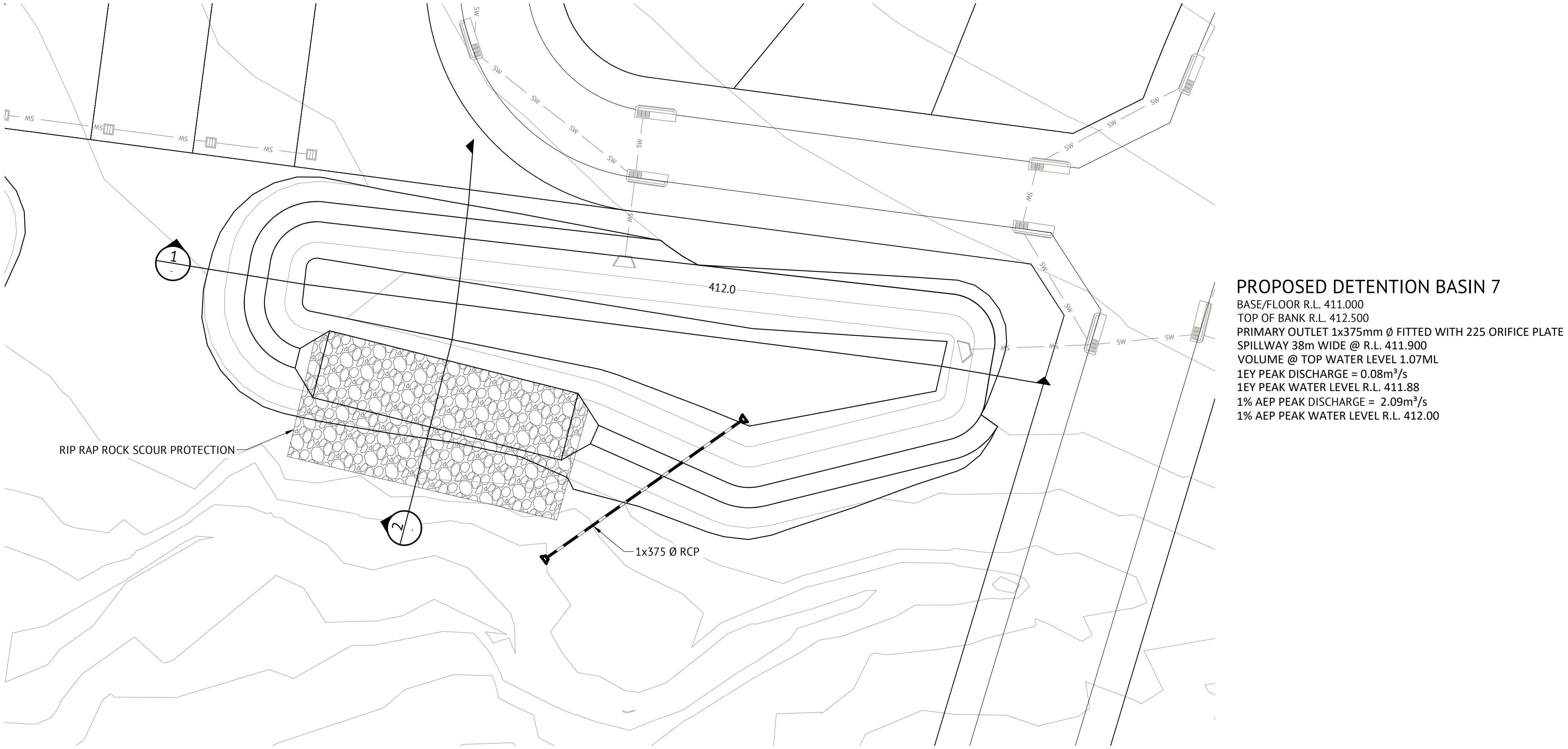
PROJECT MANAGER PPO
ENGINEERING CERTIFICATION
ENTER CERTIFIER DETAILS
SCALE
ORIGINAL SHEET SIZE A1

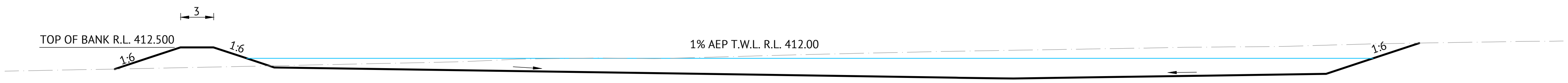
CLIENT	MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD
PROJECT	ARCADIA ESTATE EAST - STORMWATER STRATEGY
LOCATION	BURGMANS LANE, TAMWORTH
SHEET TITLE	PROPOSED DETENTION BASIN 6 CONCEPT LAYOUT PLAN AND SECTIONS

JOB CODE 223064_02
SHEET NUMBER C016
REV B



PROPOSED DETENTION BASIN

SCALE 1:400



1 SECTION

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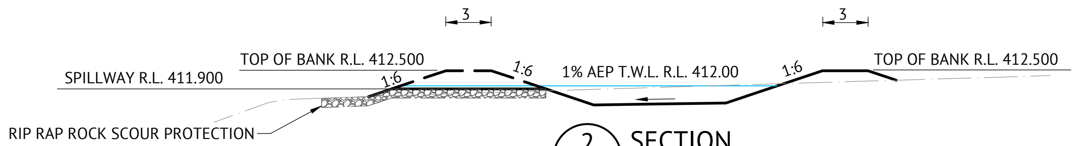

2 SECTION

SCALE 1:250 H 1:125 V

LEGEND:

DESIGN SURFACE

EXISTING SURFACE

1% AEP TOP WATER LEVEL

NOTES

1. THIS PLAN IS FOR DEVELOPMENT APPLICATION PURPOSES ONLY.
2. ALL PROPOSED WORKS SHOWN ARE SUBJECT TO DETAILED CIVIL DESIGN & THE APPROVAL OF TAMWORTH REGIONAL COUNCIL.

ISSUED FOR REVIEW

DATE	REV	DESCRIPTION	REC	APP
05/07/2023	B	ISSUED FOR REVIEW	IW	PPO
30/06/2023	A	ISSUED FOR REVIEW	IW	PPO

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SCALE

ORIGINAL SHEET SIZE A1

CLIENT: MAXIMUM YIELD PTY LTD & BURKES GULL INVESTMENTS PTY LTD

PROJECT: ARCADIA ESTATE EAST - STORMWATER STRATEGY

LOCATION: BURGMANS LANE, TAMWORTH

SHEET TITLE: PROPOSED DETENTION BASIN 7 CONCEPT LAYOUT PLAN AND SECTIONS

JOB CODE: 223064_02

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REV: B

APPENDIX B

LYALL & ASSOCIATES ISFMS REPORT AND FIGURES

ARCADIA ESTATE SUBDIVISION INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

VOLUME 1 - REPORT

November 2015

DRAFT REPORT

Job No: BZ336 File: AE-V1-Report [Rev 2.0].doc	Date: November 2015 Rev No: 2.0	Principal: SAB Authors: BJN/SAB

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NOTE ON FLOOD FREQUENCY

The frequency of floods may be referred to in terms of their Average Recurrence Interval (ARI) or Annual Exceedance Probability (AEP). For example, for a flood having a 100 year ARI there will be a flood of equal or greater magnitude once in 100 years on the average. For a flood having a 1% AEP magnitude, there is a 1% probability that there will be floods of equal or greater magnitude each year. The approximate correspondence between these two systems is:

ANNUAL EXCEEDANCE PROBABILITY (AEP) %	AVERAGE RECURRENCE INTERVAL (ARI) YEARS
0.5	200
1	100
5	20
20	5
50	2

In this report floods are referred to in terms of their ARI. Reference is also made in the report to the Probable Maximum Flood (PMF). This flood occurs as a result of the Probable Maximum Precipitation (PMP). The PMP is the result of the optimum combination of the available moisture in the atmosphere and the efficiency of the storm mechanism as regards rainfall production. The PMP is used to estimate PMF discharges using a model which simulates the conversion of rainfall to runoff. The PMF is defined as the limiting value of floods that could reasonably be expected to occur.

ABBREVIATIONS

AEP	Annual Exceedance Probability (%)
AHD	Australian Height Datum
ALS	Airborne Laser Scanning
AMC	Antecedent Moisture Condition
ARI	Average Recurrence Interval (years)
BoM	Bureau of Meteorology
FPA	Flood Planning Area
FPL	Flood Planning Level
NoW	New South Wales Office of Water
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PRM	Probabilistic Rational Method
RCBC	Reinforced Concrete Box Culvert
RCP	Reinforced Concrete Pipe
RL	Reduced Level
SEI	Stream Erosion Index
STRLMPA	South Tamworth Rural Lands Master Plan Area
TAI	Tamworth Agriculture Institute
TN	Total Nitrogen
TP	Total Phosphorus
TRC	Tamworth Regional Council
TSS	Total Suspended Solids

S1 SUMMARY

S1.1 Background

An investigation was carried out by Lyall and Associates (**L&A**) to develop an integrated stormwater and floodplain management strategy (**ISFMS**) for a planned residential and commercial subdivision which lies in the South Tamworth Rural Lands Master Plan Area (**STRLMPA**). **Figure 1.1** bound in **Volume 2** of this report shows the location of the proposed subdivision development, which has been named "*Arcadia Estate"* by Tamworth Regional Council (**TRC**). **Figures 2.1** and **2.2** respectively show proposed land use within the STRLMPA and more specifically Arcadia Estate.

This ISFMS has been prepared to support the rezoning application for Arcadia Estate and to broadly determine the key components which will need to be incorporated in the subdivision development in order to mitigate its runoff related impacts on the receiving drainage lines.

S1.2 Catchment Description

Arcadia Estate is located within the catchment of Timbumburi Creek, a minor tributary of the Peel River (**Figure 3.1**). Burkes Gully, a tributary to Timbumburi Creek runs in a north-west direction through the centre of Arcadia Estate, as shown in **Figure 3.2**. Burkes Gully controls a catchment area of about 400 ha where it crosses the northern boundary of Arcadia Estate, increasing to 520 ha at Werris Creek Road.

Two smaller catchments drain the western portion of Arcadia Estate and contribute to flow in two minor drainage lines which cross Werris Creek Road, the Main Northern Railway and Warral Road to the west of the proposed subdivision (refer **Drainage Lines 1** and **2** shown on **Figure 3.2**). Drainage Line 1 controls a catchment area of about 80 ha, and Drainage Line 2 a catchment area of about 70 ha where they cross Werris Creek Road.

Further discussion on existing catchment conditions, including an overview of the soil landscape and climate of the area is contained in **Chapter 2** of this report.

S1.3 Surface Water Hydrology and Flooding Behaviour – Present Day Conditions

A hydrologic model which was developed as part of a city-wide flooding investigation that L&A is presently undertaking on behalf of Tamworth Regional Council (**TRC**) was used to assess peak flows in Burkes Gully and the drainage lines downstream of Arcadia Estate (denoted in the city-wide study as the "**Coledale Hydrologic Model**"). **Figure 4.1** shows the layout of the Coledale Hydrologic Model which incorporates the sub-catchment arrangement shown on **Figure 4.2**. A summary of peak flows in Burkes Gully and also Drainage Lines 1 and 2 generated by the Coledale Hydrologic Model are contained in **Table 4.1** in **Chapter 4**.

A continuous rainfall-runoff and pollutant load generating model was developed as part of the present study. The MUSIC software was used for this purpose. The model was used to estimate runoff volumes and the average annual pollutant loads which are presently being generated within the Burkes Gully catchment and also those draining to Drainage Lines 1 and 2. **Table 4.2** in **Chapter 4** summarises the results of the MUSIC modelling for present day conditions.

Hydrographs generated by the Coledale Hydrologic Model were used as inflow boundary conditions to the hydraulic model that was originally developed as part of the aforementioned city-wide flooding investigation. **Figure 5.1** shows the layout of the hydraulic model which is denoted in the city-wide study as the "**Coledale TUFLOW Model**".

Design water surface profiles along Burkes Gully for storms with average recurrence intervals (**ARI's**) of 2 and 100 years are shown on **Figure 5.2**, Sheets 1 and 2, while **Figure 5.2** shows design stage and discharge hydrographs at the location where Burkes Gully and also Drainage Lines 1 and 2 cross Werris Creek Road. **Figure 5.4** shows indicative depths and extents of inundation in the vicinity of Arcadia Estate; and **Figure 5.5** maximum flow velocities in the various drainage lines for a 2 year ARI event. Indicative extents and depths of inundation for a 100 year ARI event are shown in **Figure 5.6**. Further discussion on flooding patterns in the vicinity of Arcadia Estate is contained in **Section 5.3** of this report.

S1.4 Impact of Uncontrolled Flows on Receiving Drainage Lines

Adjustments were made to the structure of the flood models to reflect the changes which will occur as a result of urbanisation within Arcadia Estate. **Figure 6.1** shows the sub-catchment arrangement which was adopted for assessing post-subdivision conditions.

An increase in imperious area associated with the proposed subdivision will increase peak flows along Burkes Gully and also Drainage Lines 1 and 2 (refer **Table 6.2** in **Chapter 6** for comparison of peak flows under pre- and post-subdivision conditions). The resulting increase in peak flows has the potential to exacerbate flooding conditions in existing development and to cause scour and bank instability in the receiving drainage lines. **Figures 6.2** to **6.6** show the impact the proposed development will have on flooding behaviour for design storms with ARI's of 2 and 100 years if appropriate mitigation measures are not incorporated into the subdivision.

Increases in pollutant loads attributed to the proposed subdivision development also have the potential to impact existing ecological systems located along the receiving drainage lines. The investigation found that unless appropriate controls are incorporated into the subdivision development, total suspended solids will increase by between 3 and 10 times the average annual load under present day conditions. The exception to this is in Drainage Line 2 (Location WN1), where the average annual load of TSS is predicted to increase by a factor of 30. Significant increases in gross pollutants are also predicted due to the urbanisation of what is presently a rural catchment. **Table 6.3** in **Chapter 6** provides a comparison of estimated average annual pollutant loads within Burkes Gully and also Drainage Lines 1 and 2 under pre- and post-subdivision conditions.

The increase in impervious area will also increase the volume of runoff discharging to the receiving drainage lines, which in combination with an increase in the rate of flow has the potential to impact on stream geomorphology. **Table 6.4** in **Chapter 6** provides a comparison of the Stream Erosion Index (**SEI**) which was computed for the receiving drainage lines under pre- and post-subdivision conditions.

S1.5 Arcadia Estate Integrated Stormwater and Floodplain Management Strategy

The Arcadia Estate ISFMS has been developed to manage adverse impacts of the proposed subdivision development on flooding, stream erosion and water quality. **Table S1** at the end of the **Summary** summarises the objectives that formed the basis of the ISFMS along with the recommended mitigation measures to manage the stormwater and flooding related impacts of the proposed development.

Figure S1 shows the key elements of the ISFMS, while **Figure S2** shows the indicative extent of land required for flooding and drainage, comprising the Flood Planning Area (**FPA**), riparian and drainage corridors and the footprints of eight detention basins which are required to control the rate of flow discharging to the receiving drainage lines. Note that these extents would be subject to further design development and integration of basin layouts and drainage corridors within the subdivision layout.

Figures 7.1 to **7.5** show the impact the proposed subdivision development will have on flooding behaviour for design storms with ARI's of 2 and 100 years following the implementation of the flow control strategy forming part of the ISFMS.

TABLE S1
SUMMARY OF STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY OBJECTIVES AND RECOMMENDED MITIGATION MEASURES FOR PROPOSED ARCADIA ESTATE SUBDVISION DEVELOPMENT SOUTH TAMWORTH RURAL LANDS MASTER PLAN AREA

Objective		Impact	Recommended Mitigation Measure
1	To minimise increases in peak flows in the receiving drainage lines during storms with ARI's of 2, 20 and 100 years.(1)	Increases in peak flows leading to adverse flood impacts on existing development and increased scour in receiving drainage lines.	**Figure S1** shows the layout of the stormwater detention basins that have been developed to offset the impact of increased flows in Burkes Gully and also Drainage Lines 1 and 2. The extents shown in **Figure S1** include provision for basin batters, top of embankment and maintenance access tracks. Refer to **Section 7.2.1** in **Chapter 7** of this report for further details of the design criteria used to develop the concept basin layouts. A summary of the detention basin sizes is provided in **Table 7.1** in **Chapter 7** of this report. The resulting peak flows in Burkes Gully and Drainage Lines 1 and 2 are summarised in **Table 6.2**, which shows that peak flows will be the same or slightly less than present day conditions for design storms with ARI's between 2 and 100 years. There will be a minor increase in peak 1 year ARI discharges of up to 10 per cent. Impacts during a 1 year ARI storm could be managed through a combination of detention basin controls and water sensitive urban design measures to control increases in runoff volumes (refer to **Objective 5** for recommended mitigation measures to manage the impact of increased runoff volumes).
2	To define the extent of FPA in accordance with the *"NSW Floodplain Development Manual"* (NSWG, 2005) and the *Tamworth Regional Local Environment Plan* (TRC, 2010).	Impacts of flooding on the proposed development.	The FPA is shown on **Figure S1** and defines the area of land that lies at or below the 100 year ARI flood level plus 0.5 m freeboard (referred to as the Flood Planning Level (**FPL**)). The 100 year ARI flood levels used to define the FPA are based on the assumption that the recommended flow control measures will be incorporated in the subdivision development. The FPA defines the extent of land that would be subject to the flood planning controls set out in Clause 7.2 of TRC, 2010, noting that its extent could be adjusted by raising ground levels within Arcadia Estate.
3	To identify the extent of drainage reserves to control overland flow entering or leaving the development in accordance with the *Engineering Guidelines for Subdivisions and Developments* (TRC, 2013).	Impacts of overland flow on existing and proposed development.	The indicative extent of drainage corridors required to control flows within Arcadia Estate during a 100 year ARI storm is shown in **Figure S1**. Note that the layout and extent of drainage corridors would be subject to further design development and integration with the subdivision layout. Further design development is also required to manage peak 100 year ARI flows internal to the subdivision.
4	To provide recommendations for the retention of stormwater pollutants in accordance with *"Managing Urban Stormwater: Council Handbook (Revised Draft)"* (EPA, 2007).(2)	Impacts on water quality due to an increase in pollutant loads in stormwater runoff.	The proposed water quality strategy involves a treatment train of measures incorporated into each detention basin controlling runoff from the proposed subdivision. The treatment train of measures would comprise: ➢ In-Line Gross Pollutant Control Devices at the outlets to piped drainage systems collecting runoff from the urbanised areas. The devices would be sized for the 3 month ARI design flow, which is approximately equivalent to 50 per cent of the 1 year ARI design flow. ➢ Grassed bio-retention swales to convey runoff from the pipe outlets along the base of the detention basin. The grassed swales would be underlain with a 0.6 m deep layer of sand filter media containing a slotted pipe to convey filtered runoff to the outlet of the detention basin. ➢ A bio-retention system at the outlet to the detention basin. The bio-retention system would comprise a 0.6 m deep water retention zone vegetated with nutrient absorbing plants, overlying a 0.6 m deep sand filter media zone with slotted pipes to convey filtered runoff to the outlet. The surface area required for the bio-retention systems constitutes approximately 10 per cent of the base area of the detention basins. A summary of the dimensions of the proposed water quality arrangements is provided in the **Table 7.5** in **Chapter 7** of this report. The resulting pollutant removal efficiencies are presented in **Table 7.6** which shows that the proposed arrangements meet the EPA, 2007 pollutant reduction targets for gross pollutants, TSS, TP and TN. While not measured within the MUSIC model, the proposed treatment train would be expected to provide retention of oils and grease in accordance with the EPA, 2007 targets.

Refer over for Footnotes to **Table S1**.

Cont'd Over

TABLE S1 (cont'd)
SUMMARY OF STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY OBJECTIVES AND RECOMMENDED MITIGATION MEASURES FOR PROPOSED ARCADIA ESTATE SUBDVISION DEVELOPMENT SOUTH TAMWORTH RURAL LANDS MASTER PLAN AREA

Objective		Impact	Recommended Mitigation Measure
5	To manage the impact of increased urbanisation on stream stability in accordance with *"Water Sensitive Urban Design – Book 1 – Policy (Draft)"* (Landcom, 2009), which recommends the following best practice guidelines: ➢ Manage increases in peak flows by limiting peak 1.5 year ARI peak discharges to present day conditions. ➢ Manage increases in runoff volume by limiting the **SEI**(3,4) to 2.0.	Increased stream erosion due to an increase in the rate and volume of runoff	Refer **Objective 1** for the recommended detention basin strategy to minimise increases in peak discharges for a range of design storms with ARI's between 1 year and 100 years. The proposed treatment train of water quality measures to address **Objective 4** will reduce the SEI under post-subdivision conditions by approximately 50 per cent. However, the resulting SEI values range from 2.6 to 7.6 and therefore still exceed the target value of 2.0 recommended in Landcom, 2009. Options to further reduce the SEI to achieve the target value of 2.0 will need to be investigated further during the next stage of the project. Measures to reduce runoff volumes that involve storage and reuse are recommended over measures involving infiltration due to the potential impacts of infiltration measures on salinity
6	To define the extent of riparian corridors that will need to be preserved in accordance with *"Guidelines for Riparian Corridors on Waterfront Land"* (NoW, 2012).	Impact on the environmental function of the riparian corridor	**Figure S1** shows the riparian corridor extent along Burkes Gully that would be subject to controls in accordance with NoW, 2012. The methodology used to define the riparian corridor extent is described in **Section 8.2** of this report.

Footnotes to **Table S1**.

1) The *Engineering Guidelines for Subdivisions and Developments* (TRC, 2013) also requires that peak discharges under post-subdivision conditions are no greater than present day conditions during a 1 year ARI event. Discharges during a 1 year ARI storm would be managed through a combination of detention basin controls and water sensitive urban design measures.
2) The *Tamworth Regional Development Control Plan* (TRC, 2010) requires that all new subdivisions include measures to control stormwater flow and water quality but does not provide any prescriptive guidelines for the management of increased pollutant loads. Pollution reduction targets recommended in "*Managing Urban Stormwater: Council Handbook (Revised Draft)"* (EPA, 2007) are commonly adopted for new development across NSW in the absence of local guidelines and have therefore been adopted for the assessment of water quality management measures for Arcadia Estate.
3) The SEI is defined as the ratio of the post-subdivision duration of flows greater than the "stream-forming flow" to the duration of flows greater than the "stream forming flow" under present day conditions. The stream-forming flow is the flow rate at which flow velocities will cause sediment movement for a particular creek or watercourse and is a function of the nature of bed sediment and how susceptible it is to erosion. Definition of the stream forming flow for a particular watercourse requires a site specific stream geomorphology study and is typically 10 to 50 per cent of the 2 year ARI peak discharge. In the absence of site specific data the 1 year ARI has been adopted as the stream forming flow, which is approximately 50 per cent of the 2 year ARI design flow rate.
4) An SEI target of 3 to 5 has been recommended for the growth centres in Western Sydney. However, subsequent research into stream erosion in urban areas presented in Landcom, 2009 suggests that these values may not be adequate in protecting the geomorphic stability of streams. Hence, Landcom, 2009 recommends an SEI target of 2.0, with a stretch target of 1.0.

1 INTRODUCTION

1.1 Background and Study Purpose

Arcadia Estate is located in the STRLMPA, which provides a framework for the future development of the rural lands in South Tamworth. The aim of the STRLMPA is to provide a logical framework for future development that is integrated with the natural environment and existing land uses, is aligned with regional strategies and encourages forward planning and the implementation of infrastructure such as roads, services and community facilities.

The location of Arcadia Estate within the STRLMPA is shown in **Figure 1.1** and will involve the rezoning of a 320 ha parcel of rural land for residential and commercial purposes.

Unless appropriate controls are incorporated into the proposed subdivision, future development within Arcadia Estate will increase the rate and duration of flow discharging to the receiving drainage lines, which in turn will:

a. increase the extent and depth of inundation on both the Burkes Gully and Timbumburi Creek floodplains in the vicinity of existing development; and
b. cause bed and bank erosion along the semi-natural reaches of the drainage system.

Future development within Arcadia Estate also has the potential to:

- increase the pollutant load discharging to the receiving drainage lines; and
- cause a rise in the saline groundwater table due to recharge.

The purpose of this study was therefore to develop a strategy which is aimed at mitigating the runoff related impacts of future development within Arcadia Estate. The strategy developed as part of the present study will form the basis of a site specific Development Control Plan (**DCP**) for Arcadia Estate.

1.2 Study Objectives

The ISFMS for Arcadia Estate has been developed giving consideration to relevant TRC and State Government policies and guidelines. The objectives of the study were:

i. To develop a detention basin strategy which limits peak flows in the receiving drainage lines to no larger than those under present day conditions for storms with ARI's of 1, 2, 20 and 100 years.[1]
ii. To define the extent of the FPA in accordance with the *"NSW Floodplain Development Manual"* (NSWG, 2005).
iii. To identify the extent of drainage reserves that will be required to control runoff entering or leaving Arcadia Estate in accordance with the *Engineering Guidelines for Subdivisions and Developments* (TRC, 2013).
iv. To provide recommendations for the retention of stormwater pollutants in accordance with *"Managing Urban Stormwater: Council Handbook (Revised Draft)"* (EPA, 2007)[2].

[1] The *Engineering Guidelines for Subdivisions and Developments* (TRC, 2013) also requires that peak flows under post-development conditions are no greater than present day conditions during a 1 year ARI event. It is envisaged that discharges during a 1 year ARI storm would be managed through a combination of detention basin controls and water sensitive urban design measures.

v. To manage the impact of increased urbanisation on stream stability in accordance with *"Water Sensitive Urban Design – Book 1 – Policy (Draft)"* (Landcom, 2009).

vi. To define the extent of riparian corridors that will need to be preserved in accordance with *"Guidelines for Riparian Corridors on Waterfront Land"* (NoW, 2012).

1.3 Scope of Work and Study Methodology

A scope of work was adopted for the present study that is commensurate with the level of detail required for the rezoning stage of the planning process, noting that further, more detailed studies will need to be undertaken during the preparation of the DCP for the subdivision.

The scope of the present study was broadly as follows:

- **Assessment of Water Quantity Related Impacts of Future Development**. The hydrologic (DRAINS/RAFTS) and hydraulic (TUFLOW) models which have been developed by L&A on behalf of TRC as part of a city-wide flooding investigation were used as the basis for defining flooding behaviour within the vicinity of Arcadia Estate under present day and post-subdivision conditions.

  The assessment included the impact future development within Arcadia Estate will have on flooding behaviour along Burkes Gully and on the larger Timbumburi Creek floodplain.

- **Assessment of Water Quality Related Impacts of Future Development**. A continuous rainfall-runoff and pollutant load generation model (MUSIC) was developed as part of the present study. The model was used to estimate the average annual weight of pollutants discharging to the receiving drainage lines under pre- and post-development conditions.

- **Assessment of Potential Mitigation Measures**. The results of the aforementioned modelling were used as the basis for developing a strategy which is aimed at mitigating the runoff related impacts of future development within Arcadia Estate. The strategy includes a combination of both online and offline measures which are aimed at reducing peak flows and pollutant loads in the receiving drainage lines. Measures which are aimed at reducing the impact future development will have on the morphology of the receiving drainage lines were also assessed as part of the study.

1.4 Overview of Report

Chapter 2 contains a brief description of the STRLMPA and Arcadia Estate.

Chapter 3 contains a brief description of the Timbumburi Creek catchment and more specifically the Burkes Gully catchment in which a large portion of Arcadia Estate is located. Also contained in this section of the report is a brief description of the soil landscape and climate of the region.

Chapter 4 deals with the investigation that was carried out to assess the quantity and quality of surface water runoff which presently discharges to Burkes Gully and the receiving drainage lines downstream of Arcadia Estate.

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[2] The *Tamworth Regional Development Control Plan* (TRC, 2010) requires that all new subdivisions include measures to control stormwater flow and water quality but does not provide any prescriptive guidelines for the management of increased pollutant loads. Pollution reduction targets recommended in "*Managing Urban Stormwater: Council Handbook (Revised Draft)"* (EPA, 2007) are commonly adopted for new development across NSW in the absence of local guidelines and have therefore been adopted for the assessment of water quality mitigation measures for Arcadia Estate.

Chapter 5 deals with the development of the TUFLOW hydraulic model and details the results of the hydraulic modelling of the design floods under present day climatic conditions. Results are presented as plans showing peak water surface elevation contours and indicative extents of inundation for the 2 and 100 year ARI events. Design water surface profiles along Burkes Gully, as well as stage and discharge hydrographs at the existing transverse drainage structures downstream of Arcadia Estate are also presented in this section of the report.

Chapter 6 presents the findings of an assessment into the impact future development in accordance with the proposed rezoning for Arcadia Estate will have on the receiving drainage lines. Also presented in this chapter are the findings of an investigation into the impact the proposed subdivision development will have on flooding behaviour should appropriate controls not be implemented to control the rate of flow discharging to the receiving drainage lines.

Chapter 7 sets out the recommended measures for mitigating the impacts of the proposed subdivision development on surface water hydrology and the condition of the receiving drainage lines.

Chapter 8 deals with the drainage and riparian corridor requirements for the proposed subdivision. The findings of an investigation into the extent of riparian corridors that will need to be preserved in accordance with *"Guidelines for Riparian Corridors on Waterfront Land"* (NoW, 2012) are also presented.

Chapter 9 contains a list of documents referred to in this report.

Appendix A presents the findings of an assessment into the storage requirements for the control of stormwater runoff discharging to Burkes Gully as part of either an online or offline detention basin strategy.

Figures referred to in the report are bound separately in **Volume 2** of the report.

1.5 Available Data

The following data were made available by TRC for this present investigation:

- Airborne Laser Scanning (**ALS**) survey data and aerial photography captured in September 2012. The ALS survey data were captured at an altitude of 700 m to the International Committee on Surveying and Mapping (ICSM) Level 3 standard with a 95% confidence interval on horizontal accuracy of ±800 mm and a 95% confidence interval on vertical accuracy of ±300 mm.
- GIS based data sets including cadastral information and stormwater pit and pipe data.
- GIS based data sets showing the extent and indicative layout of the Arcadia Estate subdivision.
- Detailed structure survey of several major drainage structures along Werris Creek Road, the Main Northern Railway and Warral Road.

2 SOUTH TAMWORTH RURAL LANDS MASTER PLAN AREA

2.1 General

As mentioned previously, Arcadia Estate is located within the STRLMPA, the extent of which is shown on **Figure 2.1**. The STRLMPA is bounded by existing development to its north, Werris Creek Road to its west, the floodplain of Goonoo Goonoo Creek to its east and Spins Lane to its south.

The STRLMPA consists of tourism, equine related industry, business development and residential development of varying densities. The extent of the various land-use types excluding that which is proposed within Arcadia Estate is shown on **Figure 2.1**.

2.2 Arcadia Estate

Arcadia Estate is located in the north-west corner of the STRLMPA and spans the suburbs of Hillvue and Warral. It is bounded by Werris Creek Road to its west, Burgmanns Lane to its south, rural land to its east and large-lot residential development to its north. The proposed subdivision site covers an area of about 320 ha which comprises mainly grazing land.

An indicative layout of the Arcadia Estate subdivision is shown in **Figure 2.2**. Development within Arcadia Estate will comprise a mix of residential development of varying density, as well as commercial development along its western boundary where it borders Werris Creek Road. The subdivision layout also includes areas set aside for recreation and drainage purposes.[3]

Natural surface levels across the central and eastern portion of Arcadia Estate fall at an average slope of about 2 to 3 per cent toward a naturally formed depression named Burkes Gully, while the western portion of the estate falls at similar grades toward the floodplain of a much larger watercourse named Timbumburi Creek. The highest point in Arcadia Estate is located along Burgmanns Lane at an elevation of about 432 m AHD, while the lowest point is located in its north-west corner at an elevation of about 387 m AHD.

[3] Note that the subdivision layout is indicative only and may be subject to change.

3 CATCHMENT DESCRIPTION

3.1 Catchments and Waterways

The western portion of the STRLMPA and the whole of Arcadia Estate are located in the catchment of Timbumburi Creek, a minor tributary of the Peel River. **Figure 3.1** shows the extent of the Timbumburi Creek catchment relative to the STRLMPA.

The headwaters of the Timbumburi Creek catchment lie about 22 km to the south of the STRLMPA near Mount Heath and Mount Cobla. Timbumburi Creek has a catchment area of about 131 km^2 where it crosses the southern boundary of the STRLMPA, about 164 km^2 at its confluence with Burkes Gully and about 175 km^2 at its confluence with the Peel River. The reach of Timbumburi Creek in the vicinity of the STRLMPA is characterised by a meandering channel of limited hydraulic capacity and a wide flat floodplain.

Burkes Gully, a tributary to Timbumburi Creek, runs in a north-west direction roughly through the centre of Arcadia Estate. Burkes Gully controls a catchment area of about 400 ha where it crosses the northern boundary of Arcadia Estate, increasing to 520 ha at Werris Creek Road. Burkes Gully discharges across Werris Creek Road, the Main Northern Railway and Warral Road via a series of box culverts as shown on **Figure 3.2**. Three farm dams are also located along Burkes Gully where it runs through Arcadia Estate (refer **Figure 3.2** for their location).

The invert level of Burkes Gully falls about 26 m over a distance of about 2.15 km where it runs through Arcadia Estate, from an elevation of about 417.5 m AHD to an elevation of about 391.5 m AHD. This equates to an average bed slope of about 1.2 per cent.

Based on the Strahler System of ordering watercourses, Burkes Gully is classified as a 1st Order Stream where it runs through most of Arcadia Estate, only changing to a 2nd Order Stream near its northern boundary (**Figure 3.2**).

Two smaller catchments drain the western portion of Arcadia Estate, as shown on **Figure 3.2.** Runoff from these two catchments discharges to two minor drainage lines which cross Werris Creek Road, the Main Northern Railway and Warral Road before discharging to the main arm of Timbumburi Creek (**Drainage Lines 1** and **2**). The catchments contributing runoff to Drainage Lines 1 and 2 where they cross Werris Creek Road are respectively 80 ha and 70 ha in area.

3.2 Soil Landscape

The soil landscape of Arcadia Estate comprises principally residual soils (**Duri**) with a small outcrop of erosional soils (**Fullwoods Hill**) located in its south-west corner (refer **Figure 3.2**). The qualities and limitations of the Duri soil landscape are defined in the publication "*Soil Landscapes of the Tamworth*" (DLWC, 2001) as follows:

> *"Complex soils; localised dieback; localised poor drainage; localised engineering hazard; gully erosion risk; inherent erosion risk; localised permanent high water tables; localised known discharge and recharge areas; localised high run-on; localised dry land salinity; localised seasonal waterlogging; localised shallow soils; sheet erosion risk; localised wind erosion risk (under traditional cultivation)."*

The presence of dry land salinity will need to be considered in the design of water sensitive urban design features to minimise the risk of groundwater mounding leading to saline groundwater flowing into waterways. Further discussion on measures which are aimed at mitigating the impact of future development on the groundwater table is contained in **Section 7.3** of this report.

3.3 Climate

Rainfall and evaporation are the two main 'drivers' of runoff in the catchment. The rainfall and evaporation characteristics of the catchment are therefore important to characterising and understanding the rainfall runoff processes in the catchment.

A review of operational weather stations indicates that two stations are located within close proximity of Arcadia Estate. The Bureau of Meteorology (**BoM**) operates a weather station which is located about 5 km to the west of Arcadia Estate (Tamworth Airport - Station No. 055325), while the Tamworth Agriculture Institute (**TAI**) operates a weather station at Marsden Park Road, Calala which is approximately 7 km to its east. The weather station installed by TAI conforms to the standards of BoM but has not yet been incorporated into their network.

The BoM operated weather station was installed in 1993, while the TAI operated weather station was installed in 1987. A comparison of annual totals indicates that the BoM operated weather station has very similar rainfall and temperature totals to the TAI operated weather station. In addition, the TAI operated weather station contains evaporation data based on 20 years of record. Monthly average rainfall, temperature and evaporation for the TAI operated weather station are summarised in **Table 3.1**.

TABLE 3.1
MONTHLY AVERAGE CLIMATE SUMMARY [(1)]

Characteristic	Month												Average/ Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Maximum Temperature (°C)	32.1	30.7	28.9	24.8	20.5	16.7	15.6	17.7	21.0	24.8	27.6	30.2	24.2
Minimum Temperature (°C)	17.8	17.8	15.1	11.2	8.0	5.3	4.1	3.7	7.6	10.7	13.8	16.2	11
Rainfall (mm)	90	64	46	35	44	41	46	42	48	63	75	86	680
Evaporation (mm)	242	192	177	122	76	51	53	77	107	153	184	226	1664

(1) Source: Data recorded by the TAI operated weather station located at Marsden Park Road, Calala.

The climate summary in **Table 3.1** shows that the region is typified by hot summers and cool winters. Monthly rainfalls are greater in the summer months. The annual evaporation exceeds the annual rainfall by a factor of almost three.

4 SURFACE WATER HYDROLOGY – PRESENT DAY CONDITIONS

4.1 Water Quantity

4.1.1. General

The following sections of the report contain a brief description of the adopted catchment modelling approach, as well as a summary of key model results for present day catchment conditions. Further discussion on the impact future development within Arcadia Estate will have on peak flow rates in the receiving drainage lines and proposed mitigation measures is presented in **Section 6**.

4.1.2. Background to Development of Event-Based Hydrologic Model

As mentioned in the **Summary**, the Coledale Hydrologic Model developed as part of the city-wide flooding investigation that L&A is presently undertaking on behalf of TRC formed the basis of the current assessment.

The Coledale Hydrologic Model, the layout of which is shown on **Figure 4.1** originally contained a combination of DRAINS and RAFTS modelling approaches for urban and rural areas respectively. However, the following adjustments were made to its structure to address the particular requirements of the present investigation:

- The sub-catchment delineation was refined to allow for a more detailed assessment of peak flows along the drainage lines that receive runoff from Arcadia Estate, particularly along Burkes Gully. **Figure 4.2** shows the extent of the catchments which were refined for the purpose of the present investigation.
- Sub-catchments within Arcadia Estate were converted from RAFTS to the DRAINS modelling approach to provide consistency between the assessment of present day and post-subdivision conditions.
- The DRAINS model parameters for sub-catchments within Arcadia Estate were revised to provide a better match to peak flow estimates derived using the probabilistic rational method (PRM)[4] across the range of design storms.

Rainfall intensities for design storms ranging between 1 and 100 year ARI, and for storm durations ranging between 25 minutes and 2 hours, were derived using procedures outlined in Australian Rainfall and Runoff (**ARR**) (IEAust, 1998). Adopted DRAINS model parameters comprised initial losses of 2 and 6 mm for paved and grassed areas, respectively. An antecedent moisture condition (**AMC**) of 3 was adopted, reflecting rather wet conditions prior to the occurrence of storm events and the soil type was set equal to 3, which corresponds with a soil of comparatively high runoff potential.

Based on initial model runs it was found that the above model parameters provided a reasonable match to PRM peak flow estimates for storms with ARI's of between 2 and 100 years ARI. However, it was found that peak 1 year ARI discharges generated by the hydrologic model were significantly lower than the PRM peak flow estimates. In order to improve the fit, initial loss for grassed areas was reduced to 5 mm, while the AMC value was increased to 3.25 when deriving peak discharges for the 1 year ARI event.

[4] Procedures for deriving peak flow estimates using the PRM are set out _Australian Rainfall and Runoff_ (IEAust, 1998).

4.1.3. Peak Flow Estimates

Table 4.1 over page gives peak flows generated by the Coledale Hydrologic Model for design storms with ARI's of 1, 2, 20 and 100 years. For comparative purposes, **Table 4.1** also includes peak flow estimates derived using the PRM.

Comparison of the peak flow estimates with the PRM estimates shows a reasonable match across the full range of modelled design storm events.

4.2 Water Quality

4.2.1. General

A continuous rainfall-runoff and pollutant load generation model was developed as part of the present study in order to assess the impact future development within Arcadia Estate will have on the quality of stormwater runoff discharging to the receiving drainage lines. The MUSIC software was used for this purpose.

4.2.2. Background to Development of Pollutant Load Generation Model

To estimate the average annual runoff volumes and pollutant loads which presently discharge to the receiving drainage lines which will be impacted by the Arcadia Estate development, a MUSIC model was established to reflect the land-use characteristics of the contributing catchments under present day conditions (**Arcadia Estate MUSIC Model**). The sub-catchments comprising the Arcadia Estate Music Model matched those incorporated in the Coledale Hydrologic Model (refer **Figure 4.2**).

Rainfall records from the pluviographic recorder at Oxley Lane, Tamworth (Bureau of Meteorology Station No. 555327) for the period 1993 to 2006 were selected for use in the investigation. These data were available within the MUSIC software in a six minute time step, which was considered suitable for the response time of the catchment, residence time of the proposed treatment measures and model run times. To provide a consistent comparison between present day and post-subdivision conditions, mean pollutant concentrations were adopted in lieu of stochastically generated pollutant concentrations. Evapotranspiration rates were defined based on the average monthly evapotranspiration data for Tamworth which is included in the MUSIC software.

4.2.3. Runoff Volumes and Pollutant Load Estimates

Table 4.2 over page gives the estimated average annual runoff volumes and loads of gross pollutants, total suspended solids (**TSS**), total phosphorus (**TP**) and total nitrogen (**TN**) discharging to Burkes Gully and also Drainage Lines 1 and 2 under present day conditions.

TABLE 4.1
SUMMARY OF PEAK FLOWS – PRESENT DAY CONDITIONS
(m^3/s)

Catchment	Location Identifier(1)	Catchment Area (ha)	1 year ARI		2 year ARI		20 year ARI		100 year ARI	
			DRAINS	PRM	DRAINS	PRM	DRAINS	PRM	DRAINS	PRM
Burkes Gully	BG1	520.9	5.0	3.6 *[2.3]*	6.6	6.6 *[4.2]*	26.7	24.0 *[15.4]*	47.8	53.0 *[34.0]*
Drainage Line 1	WN1	79.8	0.8	0.9 *[0.6]*	1.2	1.6 *[1.0]*	5.8	6.0 *[3.7]*	9.9	13.3 *[8.3]*
Drainage Line 2	WS1	70.2	1.0	0.8 *[0.5]*	1.3	1.4 *[0.9]*	6.2	5.4 *[3.4]*	10.3	12.1 *[7.5]*

(1) Refer **Figure 4.2** for reference to Location Identifier.

(2) The runoff coefficient used to estimate peak flows based on the PRM procedures set out in IEAust, 1998 is adjusted depending on whether the site lies east or west of the line joining Ashford, Tamworth, Bathurst, Yass, Tumut and Jingellic. As Arcadia Estate is located within Tamworth and therefore lies on this divide, the more conservative peak flow estimates derived based on the western zone runoff coefficient have been adopted for the purpose of the present study. For comparative purposes, peak flow estimates derived based on the eastern zone runoff coefficient are shown in [ ].

TABLE 4.2
ESTIMATED AVERAGE ANNUAL RUNOFF VOLUMES AND POLLUTANT LOADS
PRESENT DAY CONDITIONS

Catchment	Location Identifier[(1)]	Catchment Area (ha)	Impervious Area (%)	Runoff Volume (ML/year)	Gross Pollutants (kg/year)	TSS (kg/year)	TP (kg/year)	TN (kg/year)
Burkes Gully	BG1	520.7	5	263	5,830	30,800	84	643
	BG2	394.5	1	122	573	9,760	32	248
	BG3	329.9	1	98	241	7,370	24	192
	BG4	187.0	6	58	241	4,700	15	119
Drainage Line 1	WN_W1	79.7	0	22.2	0	1490	5.09	40.8
Drainage Line 2	WS_W1	34.9	0	19.6	0	1310	4.47	35.9

(1) Refer **Figures 4.2** for reference to Location Identifier.

5 FLOODING BEHAVIOUR – PRESENT DAY CONDITIONS

5.1 General

Detailed two-dimensional hydraulic modelling was undertaken using the TUFLOW software to define flooding behaviour along the main drainage lines that convey runoff generated from within Arcadia Estate. The following sections of the report contain a brief description of the hydraulic modelling approach, as well as a summary of key model results for present day conditions.

5.2 TUFLOW Model Setup

The hydraulic model that was originally developed as part of the city-wide flooding investigation that L&A is presently undertaking on behalf of TRC formed the basis of the current assessment (**Coledale TUFLOW Model**). The Coledale TUFLOW Model was developed to define mainstream flood behaviour along Timbumburi Creek and its tributaries, including Burkes Gully, as well overland flow behaviour along local drainage paths within rural and urban areas of the catchment.

The Coledale TUFLOW Model was based on a 2.5 m grid developed from ALS survey data captured in September 2012. TRC's pit and pipe database was used to obtain details of the existing piped drainage system, while an assumed cover of 700 mm was adopted for those drainage elements where invert levels were not available. Details of major cross drainage structures, including those located along Werris Creek Road, the Main Northern Railway and Warral Road west of Arcadia Estate are built into the Coledale TUFLOW Model.

Hydraulic roughness values adopted in the Coledale TUFLOW Model are summarised in **Table 5.1**.

TABLE 5.1
"BEST ESTIMATE" OF HYDRAULIC ROUGHNESS VALUES
ADOPTED FOR TUFLOW MODELLING

Surface Treatment	Manning's n Value
Asphalt or concrete road surface	0.02
Burkes Gully Channel	0.045
Lightly treed areas	0.05
Pastureland	0.045
Allotments where fences and outbuildings are present	0.1
Buildings	10

To address the particular requirements of the present study, the following adjustments were made to the structure of the Coledale TUFLOW Model:

- Details of cross drainage structures along Burkes Gully at Burgmanns Lane, south of Arcadia Estate, were built into the Coledale TUFLOW Model.
- Inflow hydrographs and the locations of inflow boundaries were updated to reflect the revisions made to the DRAINS hydrologic model described in **Section 4.1.2**.

The layout of the Coledale TUFLOW Model is shown on **Figure 5.1**.

5.3 TUFLOW Model Results

Figure 5.2 shows design 2 year and 100 year ARI water surface profiles along Burkes Gully. Note that the three farm dams which are located in Arcadia Estate influence depths of flow along the channel under present day conditions. The water surface profile also shows that Werris Creek Road and the Main Northern Railway are overtopped during a 100 year ARI flood. Stage and discharge hydrographs for the waterway crossings at Werris Creek Road are shown in **Figure 5.3**.

Figures 5.4 and **5.5** show design 2 year ARI flood depths and velocities, respectively. **Figure 5.5** shows peak 2 year ARI velocities along Burkes Gully of up to 1.5 m/s, but typically 1.0 m/s or less.

Figure 5.6 shows that flooding along Burkes Gully is relatively well confined during a 100 year ARI flood, apart from minor breakouts of flow which occur at the location of the three farm dams. **Figure 5.6** also shows a number of overland flow paths within Arcadia Estate that will need to be considered in the design of the subdivision and associated drainage arrangements.

6 IMPACTS OF PROPOSED DEVELOPMENT - UNCONTROLLED FLOW SCENARIO

6.1 General

This chapter deals with the impact the subdivision development would have on both the quantity (rate and volume) and quality of stormwater runoff discharging to the receiving drainage lines in the absence of appropriate mitigation measures. The impact uncontrolled development will have on flooding behaviour and the stability of the receiving drainage lines is also presented.

6.2 Peak Flow Rates

The structure of the Timbumburi Creek Hydrologic Model was altered to reflect changes which will occur to land-use within the catchments which drain to Burkes Gully, as well as Drainage Lines 1 and 2 as a result of the proposed development. Adjustments were made to the fractions impervious and sub-catchment boundaries to reflect the layout of the proposed subdivision. **Figure 6.1** shows the layout of future land-use zones proposed for Arcadia Estate, as well as the sub-catchment layout for post-subdivision conditions. **Table 6.1** gives the adopted fractions impervious for each land-use zone, which were based on TRC, 2013 and advice provided by TRC.

TABLE 6.1
ADOPTED FRACTION IMPERVIOUS FOR VARIOUS LAND-USE TYPES

Land Use Type	Adopted Fraction Impervious (%)
4,000 m^2 Residential Lots	60
2,000 m^2 Residential Lots	70
700 m^2 Residential Lots	75
700 m^2 Medium Density Residential Lots	80
700 m^2 Commercial Lots	95
Recreation / Drainage	0

Note that the fractions impervious recommended in TRC, 2013 for residential development are higher than would typically be expected for the allotment sizes listed in **Table 6.1**. While this provides an allowance for future infill development within the catchment it also means that stormwater infrastructure such as detention basins may be oversized for the ultimate development configuration. An investigation was therefore carried out on the sensitivity of peak flows to the adopted fractions impervious to assess the implications on the proposed detention basin strategy. The findings of this investigation are presented in **Section 7.2.2** in **Chapter 7** of this report.

For the purpose of the present investigation, it has been assumed that future development upslope of Arcadia Estate would incorporate measures to reduce the rate of flow in the receiving drainage lines to pre-developed conditions. Therefore, no changes were made to the catchments upstream of Arcadia Estate to reflect future development in these areas.

Table 6.2 over page shows the impact the proposed rezoning will have on peak flows at selected locations along Burkes Gully and also in Drainage Lines 1 and 2 for storms with ARI's of 1, 2, 20 and 100 years (refer **Columns C** to **J**). Note that the locations referred to in **Table 6.2** are shown on **Figure 6.1**.

The increase in urbanisation associated with the proposed rezoning would result in an increase in peak 1 and 2 year ARI discharges of between three and six times when compared to present day conditions. Peak 20 year ARI discharges would experience an increase of between 40 and 130 per cent, while 100 year ARI discharges would experience an increase of between 10 and 80 per cent.

6.3 Water Quality

The proposed development will impact the quality of stormwater runoff discharging to Burkes Gully, as well as Drainage Lines 1 and 2 due to an increase in the build-up and subsequent transport during rainfall events of contaminants such as suspended sediments, heavy metals, litter, nutrients such as nitrogen and phosphorus, oils and greases.

To demonstrate the level of impact that the proposed development will have on the pollutant load discharging to the receiving drainage lines, the Arcadia Estate MUSIC Model established for present day conditions was adjusted to reflect post-subdivision conditions by modifying catchment boundaries, per cent impervious and land-use types. **Figure 6.1** shows the layout of future land-use zones proposed for Arcadia Estate, as well as the sub-catchment layout for post-subdivision conditions.

The changes in pollutant loads which will result from the proposed development are summarised in **Table 6.3** over page. Under post-subdivision conditions, it is predicted that TSS will increase by between 3 and 10 times the average annual load under present day conditions. The exception to this is in Drainage Line 2 (Location WN1), where the average annual load of TSS is predicted to increase by a factor of 30. Significant increases in gross pollutants are predicted due to the urbanisation of what is presently a rural catchment.

6.4 Flooding Behaviour

Hydraulic modelling was undertaken to assess the impacts of the proposed subdivision development on flood behaviour. For this purpose, the TUFLOW model which was used to define flood behaviour under present day conditions was modified to reflect the proposed subdivision layout. The following changes were made to the structure of the TUFLOW model representing present day conditions:

- A flow diversion channel was included along the northern side of Burgmanns Lane to control overland flow that surcharges the road.
- Removal of farm dams along Burkes Gully (refer Farm Dams 1, 2 and 3 on **Figure 3.2**).
- The hydraulic roughness along Burkes Gully was increased from 0.045 to 0.08 to reflect the increased vegetation density following rehabilitation of the riparian corridor.
- Inflow hydrographs were updated to reflect the post-subdivision DRAINS model.

Figure 5.1 shows 2 year and 100 year ARI water surface profiles along Burkes Gully under post-subdivision conditions. Stage and discharge hydrographs for the waterway crossings at Werris Creek Road are shown in **Figure 5.2**.

TABLE 6.2
IMPACT OF PROPOSED SUBDIVISION DEVELOPMENT ON PEAK FLOWS
(m^3/s)

Catchment	Location Identifier(1)	Present Day Conditions				Post-Subdivision Conditions (Uncontrolled Flow Scenario)				Post-Subdivision Conditions (Controlled Flow Scenario)			
		1 year ARI	2 year ARI	20 year ARI	100 year ARI	1 year ARI	2 year ARI	20 year ARI	100 year ARI	1 year ARI	2 year ARI	20 year ARI	100 year ARI
[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]	[I]	[J]	[K]	[L]	[M]	[N]
Burkes Gully	BG1	5.0	6.6	26.7	47.8	14.5 *[120%]*	19.3 *[192%]*	46.1 *[73%]*	67.3 *[41%]*	5.3 *[6%]*	6.6 *[0%]*	24.9 *[-7%]*	45.8 *[-4%]*
	BG2	3.1	4.3	22.1	39.4	12.0 *[179%]*	15.8 *[267%]*	37 *[67%]*	52.9 *[34%]*	3.3 *[6%]*	4.0 *[-7%]*	19.4 *[-12%]*	36.2 *[-8%]*
	BG3	2.8	3.8	19.2	34.6	10.8 *[184%]*	14.4 *[279%]*	34.2 *[78%]*	48.7 *[41%]*	2.7 *[-4%]*	3.3 *[-13%]*	17.7 *[-8%]*	33.2 *[-4%]*
	BG4	1.9	2.5	12.1	21.3	6.9 *[176%]*	9.2 *[268%]*	25.6 *[112%]*	32.2 *[51%]*	1.9 *[0%]*	2.5 *[0%]*	12.3 *[2%]*	23.5 *[10%]*
Drainage Line 1	WN1	0.9	1.2	5.8	9.9	5.2 *[333%]*	6.9 *[475%]*	13.6 *[134%]*	17.6 *[78%]*	1.0 *[10%]*	1.1 *[-8%]*	5.4 *[-7%]*	9.7 *[-2%]*
Drainage Line 2	WS1	1.0	1.3	6.2	10.3	2.7 *[108%]*	3.5 *[169%]*	8.9 *[44%]*	11.4 *[11%]*	1.1 *[9%]*	1.3 *[0%]*	6.2 *[0%]*	10.3 *[0%]*

(1) Refer **Figure 6.1** for reference to Location Identifier.

(2) Value in [ ] relates to percentage change relative to present day conditions. A positive value represents an increase in peak flow compared to existing conditions.

TABLE 6.3
IMPACT OF PROPOSED SUBDIVISION DEVELOPMENT ON WATER QUALITY

Catchment	Location Identifier[(1)]	Scenario	Catchment Area (ha)	Impervious Area (%)	Runoff Volume (ML/year)	Gross Pollutants (kg/year)	TSS (kg/year)	TP (kg/year)	TN (kg/year)
Burkes Gully	BG1	Present Day Conditions	520.7	5	263	5,830	30,800	84	643
		Post-Subdivision Conditions (Uncontrolled Flow Scenario)	525.5	27	823 *[213%]*	29,400 *[404%]*	121,000 *[293%]*	285 *[239%]*	2,150 *[234%]*
		Post-Subdivision Conditions (Controlled Flow Scenario)	525.5	27	606 *[130%]*	5,830 *[0%]*	40,300 *[31%]*	141 *[68%]*	1,330 *[107%]*
	BG2	Present Day Conditions	394.5	1	122	573	9,760	32	248
		Post-Subdivision Conditions (Uncontrolled Flow Scenario)	402.6	29	683 *[460%]*	24,100 *[4106%]*	101,000 *[935%]*	233 *[637%]*	1,750 *[606%]*
		Post-Subdivision Conditions (Controlled Flow Scenario)	402.6	29	466 *[282%]*	571 *[0%]*	19,300 *[98%]*	89 *[181%]*	938 *[278%]*
	BG3	Present Day Conditions	329.9	1	98	241	7,370	24	192
		Post-Subdivision Conditions (Uncontrolled Flow Scenario)	359.7	29	597 *[510%]*	21,000 *[8614%]*	87,600 *[1089%]*	203 *[735%]*	1,530 *[697%]*
		Post-Subdivision Conditions (Controlled Flow Scenario)	359.7	29	414 *[323%]*	241 *[0%]*	16,200 *[120%]*	76 *[214%]*	819 *[327%]*

(1) Refer **Figure 6.1** for Location Identifier.

(2) Value in [ ] relates to percentage change relative to present day conditions. A positive value represents an increase in run off volume or pollutant load compared to present day conditions.

TABLE 6.3 (cont'd)
IMPACT OF PROPOSED SUBDIVISION DEVELOPMENT ON WATER QUALITY

Catchment	Location Identifier (1)	Scenario	Catchment Area (ha)	Impervious Area (%)	Runoff Volume (ML/year)	Gross Pollutants (kg/year)	TSS (kg/year)	TP (kg/year)	TN (kg/year)
Burkes Gully	BG4	Present Day Conditions	187.0	6	58	241	4,700	15	119
		Post-Subdivision Conditions (Uncontrolled Flow Scenario)	242.3	21	313 *[440%]*	9,980 *[4041%]*	44,600 *[849%]*	105 *[591%]*	790 *[564%]*
		Post-Subdivision Conditions (Controlled Flow Scenario)	242.3	21	223 *[284%]*	241 *[0%]*	9,940 *[111%]*	43 *[185%]*	444 *[273%]*
Drainage Line 1	WN1	Present Day Conditions	79.7	0	22.2	0	1490	5.09	40.8
		Post-Subdivision Conditions (Uncontrolled Flow Scenario)	72.7	67	262 *[1080%]*	9340 *[-]*	40800 *[2638%]*	92 *[1707%]*	687 *[1584%]*
		Post-Subdivision Conditions (Controlled Flow Scenario)	72.7	67	211 *[850%]*	0 *0%*	5240 *[252%]*	30.9 *[507%]*	378 *[826%]*
Drainage Line 2	WS1	Present Day Conditions	34.9	0	19.6	0	1310	4.47	35.9
		Post-Subdivision Conditions (Uncontrolled Flow Scenario)	37.1	51	114 *[482%]*	3980 *[-]*	16600 *[1167%]*	38.5 *[761%]*	290 *[708%]*
		Post-Subdivision Conditions (Controlled Flow Scenario)	37.1	51	86.4 *[341%]*	0 *0%*	2920 *[123%]*	15 *[236%]*	165 *[360%]*

(1) Refer **Figure 6.1** for Location Identifier.

(2) Value in [ ] relates to percentage change relative to present day conditions. A positive value represents an increase in run off volume or pollutant load compared to present day conditions

By inspection of **Figure 5.3,** uncontrolled development will result in a 25 per cent increase in the peak 100 year ARI flow in Burkes Gully at Werris Creek Road from 37.8 m^3/s to 47.1 m^3/s. Similar increases will be experienced in Drainage Lines 1 and 2.[5]

The effect uncontrolled development will have on peak flows is more pronounced for the more frequent storm events. For example, the peak 2 year ARI flow in Burkes Gully at Werris Creek Road will be increased 20 fold, while on Drainage Lines 1 and 2 it will be increased about 5 fold. The impact is greatest in the lower reaches of Burkes Gully as presently runoff generated by the upstream catchment is attenuated due to ponding behind the road embankment. Based on the findings of the present study, uncontrolled development will generally increase peak flows for the more frequent events between 3 and 5 fold when compared to present day conditions.

Figure 6.2 shows indicative depths and extents of inundation during the 2 year ARI flood. The impact of the proposed development on 2 year ARI peak flood levels and flow velocities is presented in **Figures 6.3** and **6.4**, respectively.

By inspection of **Figure 6.4**, the proposed development will result in an increase in 2 year ARI flow velocities in Burkes Gully downstream of Arcadia Estate of up to 1.0 m/s. Increases in flow velocity would be experienced over a distance of approximately 700 m downstream of Werris Creek Road to the confluence with Timbumburi Creek. Within Arcadia Estate there will be an increase in 2 year ARI flow velocities as a result of the increased discharges, as well as the removal of the existing farm dams.

Figure 6.5 shows indicative depths and extents of inundation for the 100 year ARI flood. The impact of the proposed development on design 100 year ARI flood levels is presented in **Figure 6.6**.

By inspection of **Figure 6.6**, the proposed development will result in an increase in peak 100 year ARI flood levels in Burkes Gully downstream of Arcadia Estate of up to 0.15 m, but typically less than 0.1 m. Increases in peak flood levels would be experienced over a distance of approximately 700 m downstream of Werris Creek Road to the confluence with Timbumburi Creek.

Increases in peak 100 year ARI flood levels of up to 0.12 m would be experienced at Werris Creek Road on Drainage Line 1, reducing to about 0.1 m west of the road corridor.

Increases in peak flood 100 year ARI flood levels of up to 0.17 m would be experienced along Werris Creek Road near its intersection with Burgmanns Lane. West of the road corridor, localised increases in peak 100 year ARI flood levels of up to 0.05 m would be experienced along Drainage Line 2.

[5] Note that the peak flows in **Figure 5.3** are slightly lower than those generated by the Timbumburi Creek Hydrologic Model (refer **Table 6.2**). This is due to the TUFLOW model incorporating temporary floodplain storage along the various reaches of the drainage system (e.g. temporary ponding areas behind road embankments), which has the effect of attenuating the flow when compared to the hydrologic model which incorporates a simple lag type approach to routing the flood wave through the drainage system.

6.5 Stream Stability

A change in the hydrologic regime of the receiving drainage lines due to increased impervious within the catchments has the potential to impact stream geomorphology. To manage these impacts, Landcom, 2009 recommends the following best practice management measures be implemented as part of subdivision developments:

- Limit post-developed peak 1.5 year ARI flows to no greater than present day conditions.
- Limit increases in runoff volume so that the computed SEI is no greater than 2.0.[6,7]

An assessment of the SEI for the receiving drainage lines was undertaken using the MUSIC models that were developed for present day and post-subdivision conditions. The SEI was calculated using the methodology set out in the Draft NSW MUSIC Modelling Guidelines (BMT WBM, 2010) and involved the following steps:

- The stream forming flow was estimated based on the 1 year ARI peak flow. The PRM was used to derive the 1 year ARI peak flow rate along Burkes Gully and also Drainage Lines 1 and 2.
- The mean annual volume of runoff exceeding the stream forming flow rate was calculated for present day and post-subdivision conditions based on results of the MUSIC modelling.
- The SEI was then calculated by dividing the mean annual runoff volume exceeding the stream forming flow under post-subdivision conditions by the mean annual runoff volume exceeding the stream forming flow under present day conditions.

The analysis showed that without appropriate controls, development within Arcadia Estate has the potential to significantly increase scour along the receiving drainage lines as indicated by the relatively high SEI values given in **Column F** of **Table 6.4**.

[6] The SEI is defined as the ratio of the post-subdivision duration of flows greater than the "stream-forming flow" to the duration of flows greater than the "stream forming flow" under present day conditions. The stream-forming flow is the flow rate at which flow velocities will cause sediment movement for a particular creek or watercourse and is a function of the nature of bed sediment and how susceptible it is to erosion. Definition of the stream forming flow for a particular watercourse requires a site specific stream geomorphology study and is typically 10 to 50 per cent of the 2 year ARI peak discharge. In the absence of site specific data the 1 year ARI has been adopted as the stream forming flow, which is approximately 50 per cent of the 2 year ARI design flow rate.

[7] An SEI target of 3 to 5 has been recommended for the growth centres in Western Sydney. However, subsequent research into stream erosion in urban areas suggests that these values may not be adequate in protecting the geomorphic stability of streams. Hence, Landcom, 2009 recommends an SEI target of 2.0, with a stretch target of 1.0.

TABLE 6.4
ASSESSMENT OF STREAM EROSION INDEX

Catchment	Location Identifier (1)	Stream Forming Flow (2) (m^3/s)	Present Day Conditions	Post-Subdivision Conditions (Uncontrolled Flow Scenario)		Post-Subdivision Conditions (Controlled Flow Scenario)	
			Runoff Volume Exceeding Stream Forming Flow (ML/year)	Runoff Volume Exceeding Stream Forming Flow (ML/year)	Stream Erosion Index	Runoff Volume Exceeding Stream Forming Flow (ML/year)	Stream Erosion Index
[A]	[B]	[C]	[D]	[E]	[F] = [E] / [D]	[G]	[H] = [G] / [D]
Burkes Gully	BG1	3.6	21.9	112	5.1	57	2.6
	BG2	3.0	15.7	103	6.6	49.4	3.2
	BG3	2.6	13.2	98.2	7.4	46.8	3.6
	BG4	1.7	7.1	45.1	6.3	21.7	3.1
Drainage Line 1	WN1	0.9	2.8	50.8	18.4	20.9	7.6
Drainage Line 2	WS1	0.8	2.4	11.7	4.9	6.31	2.6

(1) Refer **Figure 6.1** for Location Identifiers.

(2) Based on the 1 year ARI peak design flow rate.

(3) Recommended water quality management measures are outlined in **Section 7.3**.

7 RECOMMENDED MITIGATION MEASURES

7.1 General

This chapter presents the recommended approach to mitigating the impacts of the proposed subdivision on surface water hydrology and the condition of the receiving drainage lines.

7.2 Recommended Flow Control Measures

7.2.1. Overview

A strategy was developed to mitigate the impact of the proposed subdivision development on the rate of flow discharging to Burkes Gully and also Drainage Lines 1 and 2. Based on the findings of an assessment of several online and offline detention basin strategies (refer Appendix A for findings), it was concluded that the preferred strategy should comprise the construction of eight stormwater detention basins (six adjacent to Burkes Gully and two adjacent to Werris Creek Road on Drainage Lines 1 and 2) which have been sized to limit peak flows in the receiving drainage lines to no greater than present day conditions for design storms with ARI's of 2 and 100 years.

Figure S1 in the **Summary** shows the footprint of the eight basins which have been sized to control the rate of flow discharging to the receiving drainage lines. A summary of the detention basin sizes is provided in the **Table 7.1** over page. It should be noted that the basin footprints are subject to further design development and integration with the subdivision layout and also the findings of geotechnical and groundwater investigations that will be required during the next stage of the project.

In developing the proposed basin arrangements it was assumed that runoff from areas upslope of Arcadia Estate to the east would be conveyed by the stormwater drainage system within the subdivision and discharged into **Basins B4** and **B6**. The alternative arrangement would be to provide separate stormwater systems to convey external catchment runoff directly to Burkes Gully. While this may lead to a reduction in basin size, it would require additional stormwater infrastructure.

Figures B1 and **B2** in **Appendix B** show a concept detention basin layout illustrating the following criteria that have been considered in developing the concept layouts:

- Low flow outlet pipe designed to control peak discharges from the development up to a 2 year ARI storm.
- High flow culvert structure designed to control peak discharges from the subdivision up to a 100 year ARI storm to be no greater than pre-developed conditions. Spillway provisions are integrated with the high flow outlet.
- Top of basin embankment set 0.5 m above the 100 year ARI top water level.
- Basin batter slopes – 1 (vertical) to 6 (horizontal).
- Top of basin embankment width – 3 m.
- Width access maintenance path – 5 m.
- Basin layouts shaped to integrate with existing landform and minimise depth of cut. Depth of cut typically varies between 1.5 to 2 m.

TABLE 7.1
DETENTION BASIN SUMMARY

Basin Identifier(1) [A]	Catchment Area(2) (ha) [B]	Basin Area at Base (m^2) [C]	Basin Area at Top Water Level(3) (m^2) [D]	Basin Volume (m^3) [E]	2 year ARI Depth (m) [F]	100 year ARI Depth (m) [G]	Basin Area / Catchment Area (%) [H] = [C]/[A]	Basin Volume / Catchment Area (m^3/ha) [I] = [D]/[A]
B1	16.5	2,580	3,835	2,800	0.7	1.1	2.1%	170
B2	14.9	1,630	2,775	2,045	0.7	1.0	1.6%	137
B3	34.2	5,100	7,895	8,320	1.1	1.5	2.2%	243
B4	83.2	9,850	13,725	16,400	1.1	1.7	1.5%	197
B5	61.9	11,000	15,140	19,050	1.3	1.8	2.4%	308
B6	36.6	6,020	8,950	10,120	1.0	1.6	2.3%	277
W1	72.8	12,075	16,500	19,940	1.1	1.6	2.2%	274
W2	37.1	4,860	7,605	8,350	0.9	1.5	1.9%	225
Totals	**357.2**	**53,115**	**76,425**	**87,025**			**2.1%**	**244**

(1) Refer to **Figure S1** in the **Summary** for basin locations.

(2) Catchment areas draining to detention **Basins B4** and **B6** also include the area upstream (east) of Arcadia Estate.

(3) Basin Area at Top Water Level is measured to the 100 year ARI peak water level.

Figures B1 and **B2** also show a bio-filtration zone at the basin outlet and bio-retention swales which have been provided to convey runoff from piped drainage outlets controlling runoff from the subdivision. Water quality measures are discussed further in **Section 7.3**.

The resulting peak flows in Burkes Gully and also Drainage Lines 1 and 2 are summarised in **Table 6.2** (refer **Columns K** to **N**). By inspection of the values given in **Table 6.2**, peak flows will be the same or slightly less than present day conditions for design storms with ARI's between 2 and 100 years. While there will be a minor increase in peak 1 year ARI discharges of up to 10 per cent, this increase could be mitigated by incorporating at-source WSUD measures such as rainwater tanks into the subdivision development.

Note that further refinement would be required of the low level outlet arrangements in order to reduce the duration over which stormwater ponds within the offline basins, as prolonged inundation of the grassed area would cause die-off and also saturation of the basin invert.

7.2.2. Impact of Adopted Fraction Impervious Values on Storage Volumes

As noted previously, the fractions impervious recommended in TRC, 2013 for residential development are higher than would typically be expected for the allotment sizes listed in **Table 6.1**. An investigation was therefore carried out on the sensitivity of peak flows to the adopted fractions impervious to assess the implications on the recommended detention basin strategy.

Figure C1 in **Appendix C** shows the location of seven sites within the broader Tamworth area that were selected as being representative of the residential allotment sizes given in **Table 6.1**. Within each sample site the extent of impervious area was measured to determine an average fraction impervious. The extent of impervious area within each site is shown in **Figures C2** to **C5** in **Appendix C** and includes roofs, roads, footpaths, driveways and sheds. A summary of the calculations is provided in **Table 7.2** over page, while a comparison of the calculated fractions impervious with Council's adopted values is shown in **Table 7.3** over page.

Table 7.3 shows that Council's adopted fractions impervious are approximately double the average calculated values for 2,000 to 4,000 m^2 lots, and 50% greater than the average calculated value for 700 m^2 lots.

The sensitivity of the recommended detention basin sizes to the adopted fractions impervious was assessed using the Timbumburi Creek Hydrologic Model. Fractions impervious within each sub-catchment were updated to reflect the average calculated fractions impervious shown in **Table 7.3**. The analysis showed that with the lower fraction impervious values the basin volumes could be reduced by approximately 20%. Further investigations would be required to determine how these reduced basin volumes could be incorporated into the existing landform and the overall reduction in basin footprint that could be achieved.

7.2.3. Impact of Flow Control Strategy on Flooding Behaviour

Figures 7.1 shows indicative depths and extents of inundation for the 2 year ARI flood following the implementation of the recommended flow control measures. The impact the proposed subdivision will have on peak 2 year ARI flood levels and flow velocities following implementation of the recommended flow control measures is presented in **Figures 7.2** and **7.3**, respectively.

By inspection of **Figure 7.3**, the provision of temporary flood storage within Arcadia Estate will result in a maximum increase in 2 year ARI flow velocities of 0.5 m/s downstream of northern boundary, with increases typically limited to 0.2 m/s or less.

TABLE 7.2
SUMMARY OF FRACTION IMPERVIOUS CALCULATIONS FOR SAMPLE RESIDENTIAL AREAS

Sample Site	Typical Lot Size (m^2)	Total Area (m^2)	Impervious Area (m^2)	Fraction Impervious (%)
1	700 – 1,000	236,200	117,310	50
2	350 - 450	21,820	14,030	64
3	700 - 800	130,900	57,400	44
4	14,000 - 16,000	211,700	23,160	11
5	4,500 - 5,000	102,300	21,620	21
6	700 - 900	74,230	38,580	52
7	2,000 - 4,000	118,600	31,360	26

(1) Refer **Figure C1 in Appendix C** for reference to Sample Site locations. Refer **Figures C2** to **C5** in **Appendix C** for measured regions of impervious area.

TABLE 7.3
COMPARISON OF FRACTION IMPERVIOUS VALUES FOR VARIOUS RESIDENTIAL DENSITIES

	TRC Adopted Fraction Impervious (%)(1)	Average Calculated Fraction Impervious (%)(2)
700 m^2 Residential Lots	75	50
700 m^2 Medium Density Residential Lots	80	65
2,000 m^2 Residential Lots	70	35
4,000 m^2 Residential Lots	60	25

(1) Based on TRC, 2013.

(2) Based on calculations of the seven sample sites presented in **Table 7.2**.

Figure 7.4 shows indicative depths and extents of inundation for the 100 year ARI flood following the implementation of the recommended flow control measures. The impact the proposed development will have on peak 100 year ARI flood levels velocities following implementation of the recommended flow control measures is presented in **Figure 7.5**.

From inspection of **Figure 7.4**, flooding along Burkes Gully is relatively well confined during a 100 year ARI flood. **Figure 7.5** shows that the provision of temporary flood storage along Burkes Gully will mitigate the impacts of the subdivision development on flood levels in Burkes Gully downstream of northern boundary.[8]

[8] Note that peak flood levels are shown to increase along Burkes Gully where it runs through Arcadia Estate when compared to present day conditions. The reason for this is due to the adoption of a higher Manning's n hydraulic roughness value within the proposed riparian corridor.

The provision of temporary flood storage within Basin W1 will mitigate the impacts of development on peak flood levels along Drainage Line 1.

There would be a minor increase in peak flood levels along Werris Creek Road near its intersection with Burgmanns Lane of up to 0.05 m. Localised increases of 0.02 m or less will also occur in the property which is located on the western (downstream) side of Warrel Road adjacent to Drainage Line 2.

7.3 Recommended Water Quality Management Measures

A strategy was developed to manage the impact the subdivision development will have on pollutant loads in stormwater runoff discharging to Burkes Gully and also Drainage Lines 1 and 2. The water quality arrangements have been sized to meet the pollution reduction targets set out in EPA, 2007, which are reproduced in **Table 7.4**.

TABLE 7.4
POLLUTION REDUCTION TARGETS

Stormwater Pollutant	Target(1)
Gross Pollutants	100% retention of litter and coarse sediment up to 0.25 times the 1 year ARI peak flow
Total Suspended Solids (TSS)	85%
Total Phosphorus (TP)	65%
Total Nitrogen (TN)	45%
Oil and Grease	No visible oils up to 0.25 times the 1 year ARI peak flow

(1) Based on EPA, 2007.

The proposed water quality strategy involves a treatment train of water quality measures incorporated into each detention basin controlling runoff from the proposed subdivision as shown in **Figures B1** and **B2** in **Appendix B**. The treatment train of measures would include:

- In-Line Gross Pollutant Control Devices at the outlets to piped drainage systems collecting runoff from urbanised areas. The devices would be sized for the 3 month ARI design flow in accordance with *Australian Runoff Quality* (EA, 2006).
- Grassed bio-retention swales to convey runoff from the pipe outlets along the base of the detention basins. The grassed swales would be underlain with a 0.6 m deep layer of sand filter media containing a slotted pipe to convey filtered runoff to the outlet of the detention basin.
- Bio-retention systems at the outlet to the detention basin. The bio-retention system would comprise a 0.6 m deep water retention zone vegetated with nutrient absorbing plants, overlying a 0.6 m deep sand filter media zone with slotted pipes to convey filtered runoff to the outlet.

As noted in **Section 3.2**, Arcadia Estate is located in an area where there are known salinity problems. Measures that locally increase infiltration of runoff have the potential to result in a local rise in the groundwater table, which can cause saline groundwater to flow into waterways. Lining of the bio-filtration basins is therefore recommended to reduce the risk of groundwater mounding in the vicinity of the WSUD measures.

A summary of the water quality treatment sizes is provided in **Table 7.5** over page. The surface area required for the bio-retention systems constitutes approximately 10 per cent of the base area of each detention basin.

Table 7.6 over page shows that the proposed arrangements meet the EPA, 2007 pollutant reduction targets for gross pollutants, TSS, TP and TN. While not measured within the MUSIC model, the proposed treatment train would also be expected to provide retention of oils and grease in accordance with the EPA, 2007 targets.

Table 6.3 in **Chapter 6** provides a comparison of the average annual pollutant loads under pre- and post-subdivision conditions. By inspection of **Table 6.3**, the proposed water quality treatment measures will offset increases in gross pollutants. However, there will still be an increase in TSS, TN and TP. It should be noted that the EPA, 2007 target reductions are based on achieving the 'point of diminishing returns' in the performance of treatment techniques and therefore reflect what can practically be incorporated into new developments and minimise impacts on the downstream waterways, rather than result in no nett increase in pollutant loads.

7.4 Recommended Approach to Mitigating Scour Potential in Receiving Drainage Lines

As discussed **Section 7.2.1**, the implementation of the recommended flow control measures will reduce peak flows for events between 2 and 100 year ARI to no greater than present day conditions, while the implementation of at-source WSUD measures such as rainwater tanks would ensure that peak flows for the 1 year ARI event are not increased when compared to existing.

The recommended water quality measures would also reduce the SEI along Burkes Gully by approximately 50 per cent when compared to values for uncontrolled development, as shown in **Table 6.4** (comparison of values given in **Columns F** and **H**). Similar reductions are expected in Drainage Lines 1 and 2.

However, the resulting SEI values range from 2.6 to 7.6 and therefore still exceed the target value of 2.0 recommended in Landcom, 2009. Options to further reduce the SEI for the proposed subdivision would include:

- Infiltration measures such as rain gardens, absorption trenches and infiltration basins. However, infiltration measures are not suitable at sites where salinity problems would otherwise, as is the case for Arcadia Estate.
- Storage and re-use of runoff through the implementation of lot scale rainwater tanks or large scale stormwater storage and re-use systems.

It is recommended that measures involving the storage and re-use of stormwater runoff be further investigated during the next stage of the project.

TABLE 7.5
SUMMARY OF WATER QUALITY TREATMENT TRAINS

Detention Basin	Gross Pollutant Control Device	Grassed Swale		Bio-retention System
	Design Flowrate (1) (m^3/s)	Total Length (m)	Width (m)	Surface Area (m^2)
B1	0.5	100	2	160
B2	0.4	75	2	95
B3	1.1	150	2	570
B4	1.8	220	2	945
B5	1.6	225	2	975
B6	1.0	165	2	400
W1	2.6	170	2	2100
W2	1.3	100	2	690

(1) Based on the 3 month ARI design flow rate, which has been estimated based on 50 per cent of the 1 year ARI design flow rate.

TABLE 7.6
WATER QUALITY TREATMENT TRAIN PERFORMANCE

Detention Basin	Inflow					Outflow				
	Runoff Volume (ML/year)	Gross Pollutants (kg/year)	TSS (kg/year)	TP (kg/year)	TN (kg/year)	Runoff Volume (ML/year)	Gross Pollutants (kg/year)	TSS (kg/year)	TP (kg/year)	TN (kg/year)
B1	46.3	1,650	7,210	16.3	121	26.7 *[42%]*	0 *[100%]*	1,090 *[85%]*	5.41 *[67%]*	57.4 *[53%]*
B2	28.3	1,190	4,260	9.72	73.5	14.2 *[50%]*	0 *[100%]*	588 *[86%]*	3 *[69%]*	31.6 *[57%]*
B3	113	3,970	17,600	39.6	296	78 *[31%]*	0 *[100%]*	2,680 *[85%]*	14 *[65%]*	157 *[47%]*
B4	170	7,010	25,300	58.1	441	111 *[35%]*	0 *[100%]*	3,530 *[86%]*	19 *[67%]*	217 *[51%]*
B5	178	6,330	27,600	62.3	465	124 *[30%]*	0 *[100%]*	4,160 *[85%]*	21.4 *[66%]*	243 *[48%]*
B6	84.8	3,420	12,900	29.3	221	49.2 *[42%]*	0 *[100%]*	1,660 *[87%]*	8.8 *[70%]*	98.5 *[55%]*
W1	262	9,340	40,800	92.0	687	211 *[20%]*	0 *[100%]*	5,240 *[87%]*	30.9 *[66%]*	378 *[45%]*
W2	104	3,980	16,000	36.2	272	76.6 *[26%]*	0 *[100%]*	2,270 *[86%]*	12.8 *[65%]*	147 *[46%]*

(1) Refer **Figure 6.1** for water quality location identifiers.

(2) Value in [ ] relates to percentage change in runoff volume and pollutant loads discharging from the water quality treatment train. A positive value represents an increase in runoff volume or pollutant load compared to present day conditions.

8 DRAINAGE AND RIPARIAN CORRIDOR REQUIREMENTS

8.1 Drainage Corridor Requirements

It will be necessary to incorporate a series of drainage corridors in the subdivision development to control runoff entering and leaving the development in accordance with TRC, 2013. An indicative extent of drainage corridor reserves is shown on **Figure S1** in the **Summary**.

Note that the layout and extent of drainage corridors would be subject to further design development and integration with the subdivision layout. Further design development is also required to incorporate measures into the subdivision layout to manage flows internal to Arcadia Estate

The extent of the FPA is also shown on **Figure S1** of the **Summary**. The flood levels used to define the FPA are based on post-subdivision conditions following implementation of the recommended flow control measures. The FPA defines the extent of land that would be subject to flood planning controls in accordance with Clause 7.2 of TRC, 2010. It is noted that the extent of the FPA within Arcadia Estate could be modified by raising ground levels, although the impact this would have on flood behaviour would first need to be assessed.

8.2 Riparian Corridor Requirements

Riparian corridors form an important transition zone between a watercourse and the surrounding terrestrial environment that provide a range of environmental functions that include:

- Providing bed and bank stability and reducing bank and channel erosion.
- Protecting water quality by providing a buffer for the retention of sediment, nutrients and other contaminants.
- Providing diversity and connectivity of habitat for flora and fauna
- Managing flood flows, and
- Providing a buffer between development and waterways and areas for passive recreational use in urban development.

Protecting and rehabilitating vegetated riparian corridors is important for maintaining or improving the environmental values of a watercourse. The NSW Office of Water has therefore developed the *Guidelines for Riparian Corridors on Waterfront Land* (NoW, 2012) that sets out requirements for carrying out controlled activities within riparian corridors.

NoW, 2012 defines the extent of riparian corridor as:

- the channel which comprises the bed and banks of the watercourse (to the highest bank); and
- the vegetated riparian zone (VRZ) adjoining the channel.

Table 1 in NoW, 2012 entitled ‘Recommended riparian corridor (RC) widths’ (reproduced as **Table 8.1** over page) sets out the four categories of watercourse and the width of VRZ which apply to each.

TABLE 8.1
RECOMMENDED RIPARIAN CORRIDOR (RC) WIDTHS

Watercourse Type	VRZ Width (each side of watercourse)	Total RC Width
1st order	10 m	20 m + channel width
2nd order	20 m	40 m + channel width
3rd order	30 m	60 m + channel width
4th order	40 m	80 m + channel width

Source: NoW, 2012

As described in **Section 3.1**, Burkes Gully is classified as a 1st Order Stream where it runs through most of Arcadia Estate, only changing to a 2nd Order Stream near its northern boundary (**Figure 3.2**). In accordance with **Table 8.1**, a 10 m vegetated riparian zone would need to be offset either side of the main channel, increasing to 20 m over the section that is classified a 2nd Order Stream.

Figure S1 in the **Summary** shows the extent of riparian corridor that has been delineated along Burkes Gully based on the procedures set out in NoW, 2012.

Note that in accordance with Table 2 of NoW, 2012, land-use within the vegetated riparian zone along Burkes Gully can include cycleways and paths, detention basins and road crossings. However, water quality treatment measures must be located external to the riparian corridor.

NoW, 2012 also permits the outer 50 percent of the VRZ to be adjusted providing the average width of the VRZ can be achieved over the length of the watercourse within the subdivision. This provides an opportunity to adjust the riparian corridor extent to better integrate with the overall subdivision layout.

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APPENDIX A

ASSESSMENT OF ONLINE VERSUS OFFLINE DETENTION BASIN STRATEGIES

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A1.3 Detention Basin Strategy Scenario 2
A1.4 Detention Basin Strategy Scenario 3
A1.5 Detention Basin Strategy Scenario 4

A3.1 Design Discharge Hydrographs Along Burkes Gully – Pre- versus Post-Developed Conditions

A1. INTRODUCTION

A2.1 Background

This Appendix deals with the findings of an assessment into the storage requirements for the control of stormwater runoff discharging to Burkes Gully as part of either an online or offline detention basin strategy. While not documented in this appendix, the assessment included requirements for the control of stormwater runoff from future development located downstream of the Arcadia Estate in the vicinity of Bylong Road (denoted herein as the Bylong Road Subdivision). **Figure A1.1** (bound in **Volume 2**) shows the future land-use and associated fraction impervious values which were adopted for the purpose of the assessment.

A2.2 Assessed Detention Basin Strategy Scenarios

The following detention basin scenarios were assessed as part of the present investigation:

- **Detention Basin Strategy Scenario 1** – This scenario would involve the construction of a single online detention basin within Arcadia Estate adjacent to its northern boundary in combination with a single offline detention basin in the Bylong Road Subdivision. **Figure A1.2** shows the layout of the basin arrangement comprising this scenario.
- **Detention Basin Strategy Scenario 2** - This scenario would involve the construction of a single online detention basin in the Bylong Road Subdivision on the upstream side of Werris Creek Road. **Figure A1.3** shows the layout of the basin arrangement comprising this scenario.
- **Detention Basin Strategy Scenario 3** - This scenario would involve the construction of five online detention basins within Arcadia Estate, three of which correspond with the location of existing farm dams. **Figure A1.4** shows the layout of the basin arrangement comprising this scenario.
- **Detention Basin Strategy Scenario 4** – This scenario would involve the construction of six offline detention basins within Arcadia Estate and a single offline detention basin within the Bylong Road Subdivision. **Figure A1.5** shows the layout of the basin arrangement comprising this scenario.

Note that unless otherwise stated, it was assumed that the catchment contributing flow to Burkes Gully upstream of Arcadia Estate is in its pre-developed state (i.e. present day condition).

A2.3 Key Findings

Table A3.1 in **Chapter A3** summarises the key features of each detention basin, including pre- and post-developed peak flows in Burkes Gully. The key findings of the assessment were as follows:

<u>**Detention Basin Strategy Scenarios 1 and 2**</u>

i. Peak flows in Burkes Gully upstream of the single online basin options (i.e. Scenarios 1 and 2) will be increased 4-5 fold as a result on uncontrolled flows discharging to the watercourse. For example, the peak 2 year ARI flow discharging to the single online detention basin in Arcadia Estate will increase from about 4.3 m^3/s to about 14.7 m^3/s and in the case of the single online detention basin in the Bylong Road Subdivision from about 5.4 m^3/s to about 19.3 m^3/s. **Figure A3.1**, 2 sheets provides a comparison of pre- and post-developed 2 and 100 year ARI design discharge hydrographs at select locations along Burkes Gully.

ii. Large-scale stream stabilisation and scour protection measures would need to be incorporated in the invert of Burkes Gully along its length to prevent major damage from occurring to the watercourse under post-developed conditions.

iii. Depths of ponding in the basin would exceed 5 m in the case of the single online basin in Arcadia Estate and over 4.5 m in the case of the of the single online basin in the Bylong Road Subdivision in a 100 year ARI event.

iv. Major scour protection works would be required immediately downstream of the high level outlet on each basin given the rate of flow discharging from the structures. For example, in a 100 year ARI event, a peak flow of about 30 m^3/s would discharge from the 8 off 2400 x 750 RCBC's in the case of the single online basin in Arcadia Estate and about 40 m^3/s from the 8 off 2700 x 750 RCBC's in the case of the single online basin in the Bylong Road Subdivision.

v. The depth of ponding in the online basins would increase as a result of future development upstream of Arcadia Estate (refer values in [ ] in **Table A3.1**). In order to cater for future increases in the volume of stormwater runoff from upstream development , larger detention basins would need to be constructed as part of the Arcadia Estate development, or alternatively, be able to be augmented in the future (for example, designed so as to allow the crest height of the embankment to be raised).

<u>Detention Basin Strategy 3</u>

i. Peak flows in Burkes Gully upstream of online basins AE2 and AE4 will be increased 2-3 fold as a result of uncontrolled flows discharging to the watercourse. For example, the peak 2 year ARI flow discharging to basin AE2 will increase from about 3.8 m^3/s to about 9.0 m^3/s and in the case of basin AE4 from about 2.5 m^3/s to about 8.0 m^3/s.

ii. The strategy will increase the period over which elevated flows will be experienced in Burkes Gully, as shown on **Figure A3.1**, 2 sheets. While the rate of flow in the watercourse would generally not be greater than occurs under pre-developed conditions, the increase in the duration bank-full type flows will be experienced in the watercourse will cause scour. This phenomena is common in watercourses where on-site detention has been introduced into a catchment.

iii. While of a lesser scale than for Detention Basin Strategy Scenarios 1 and 2, relatively large-scale stream stabilisation and scour protection measures would need to be incorporated in the invert of Burkes Gully in order to prevent major damage to the watercourse from occurring under post-developed conditions. This is because of the impact the basin arrangement will have on the duration elevated flows are experienced in the watercourse.

iv. Depths of ponding would equal or exceed 2 m in all five basins, and reach a maximum of about 4.2 m in basin AE2 in a 100 year ARI event.

v. Major scour protection works would be required immediately downstream of the high level outlets given the rate of flow discharging from each structure. For example, in a 100 year ARI event, a peak flow of between about 15-20 m^3/s would discharge from each of the basins in a 100 year ARI event.

vi. While not assessed as part of this investigation, the size of the basins would be affected by future development upstream of Arcadia Estate which would increase the volume of runoff discharging to Burkes Gully. This would have similar implications as described above for Detention Basin Strategy Strategies 1 and 2 in terms of basin sizing.

Detention Basin Strategy 4

i. Peak flows in Burkes Gully will generally not be increased along its full length for storms with ARI's up to 100 years, with the shape of the post-developed discharge hydrographs closely matching those for pre-developed conditions (refer **Figure A3.1**, 2 sheets).

ii. The strategy will increase the duration over which minor flows are experienced in the invert of Burkes Gully, as shown on **Figure A3.1**, 2 sheets. Similar flow characteristics resulting from the construction of basins with small diameter low flow outlets in Tamworth have been found to be beneficial for stream health, as the wetter invert has promoted plant growth within the receiving drainage lines.

iii. Depths of ponding within the offline basins will not exceed about 1.2 m in a 2 year ARI event and about 1.7 m in a 100 year ARI event.

iv. Major scour is not expected to occur in Burkes Gully due to the shape of the post-developed hydrographs closely matching pre-developed conditions (refer **Figure A3.1**, 2 sheets).

A2.4 Concluding Remarks

Based on the above findings, the offline detention basin strategy is considered to be the preferred approach to managing stormwater runoff from the Arcadia Estate development. The key reasons for this are:

- The sizes of the basins are not affected by future development upstream of Arcadia Estate.
- The depths of ponding (and hence the height of the basin embankments) are relatively shallow compared to the online basin options.
- The strategy matches as close as is practicable the shape of the pre-developed discharge hydrograph in Burkes Gully, thereby reducing the risk of scour in the watercourse.
- Large-scale bank stabilisation and scour protection measures would not be required in Burkes Gully.
- The use of offline basins provides the opportunity to incorporate water quality control measures into the invert of the basins, noting that NoW, 2012 requires measures to be located external to the riparian corridor.

Note that further refinement would be required of the low level outlet arrangements in order to reduce the duration over which stormwater ponds within the offline basins, as prolonged inundation of the grassed area would cause die-off and also saturation of the basin invert.

While not assessed as part of this investigation, TRC may wish to consider a hybrid online-offline detention basin strategy which comprises the following:

- Construction of a single online basin in the headwaters of Burkes Gully within Arcadia Estate. The basin could be designed to over-throttle flows in Burkes Gully when compared to pre-developed conditions, thereby allowing a number of smaller offline basins to be constructed along the watercourse (refer below for further details). The basin could be designed and built to accommodate future development upstream of the estate, with TRC offering a reduction in developer contributions to offset the additional costs associated with future proofing the basin.

- Construction of a number of smaller offline basins along Burkes Gully within the estate. The size of the basins could be reduced as they wouldn't need to throttle the incoming flow to the extent to which is required under Detention Basin Strategy Scenario 4 conditions. This is because the upstream online basin would reduce peak flows in the watercourse and allow less attenuated flow to discharge to the watercourse downstream of its location.
- Incorporating a requirement to install larger rainwater tanks within individual properties than is required by BASIX in the Development Control Plan (DCP) for Arcadia Estate. The larger rainwater tanks would assist in reducing the volume of stormwater discharging to Burkes Gully during relatively frequent storm events. While a detailed investigation would need to be undertaken to quantify the benefits the larger rainwater tanks would provide in terms of a reduction in the volume of stormwater runoff, it may be feasible to further reduce the size of the offline basins given the additional storage within the contributing catchments.

A2. DESCRIPTION OF APPROACH

The structure of the hydrologic model described in **Section 4.1.2** was adjusted to incorporate temporary flood storage at the locations corresponding to the four assessed detention basin scenarios.

In the case of the assessed online detention basin options, the volume of temporary flood storage was computed based on the available LiDAR survey data. For sizing purposes it was assumed that natural surface levels would not be lowered upstream of the basin embankment (i.e. it was assumed that the valley would simply be back flooded upstream of the basin outlet). In the case of the three online detention basins that correspond with the location of the existing farm dams within Arcadia Estate (refer Scenario 3), it was necessary to estimate natural surface levels beneath the footprint of each dam as the ground levels within the LiDAR survey data represented the existing earth embankment and also the standing water level in each dam at the time the data were captured.

In the case of the assessed offline detention basin options, the volume of temporary flood storage was computed based on concept designs which included the lowering of natural surface levels to generate the required flood storage. A series of sketches showing the key features of the adopted offline detention basin arrangement are contained in **Appendix B** of this report.

The elevations of the low level outlets were set equal to the invert of the watercourse in the case of the online basin options and at the invert of the wet area in the case of the offline basin option. The elevation of the high level outlets were set at or above the maximum 2 year ARI ponding level in the basin for both the online and offline basin options.

The sensitivity of the embankment height to increases in the volume of flow discharging to Burkes Gully as a result of future development upstream of Arcadia Estate was also assessed for Detention Basin Strategy Scenarios 1 and 2.

A3. DETENTION BASIN SIZING

Table A3.1 summarises the key features of each basin arrangement, including pre- and post-developed peak flows in Burkes Gully.

Figures A1.2, **A1.3** and **A1.4** show the extent of ponding upstream of the online basin arrangements for the 2 and 100 year ARI events. Also shown on the figures is the extent of the Flood Planning Area (FPA) associated with each basin. Note that the extent of the FPA shown on **Figures A1.2** and **A1.3** is based on the maximum 100 year ARI ponding level in the two basins assuming 40 per cent fraction impervious in the catchment which drains to Burkes Gully upstream of Arcadia Estate.

Figure A1.5 shows the extent of the six offline basins which would border Burkes Gully within Arcadia Estate. The footprint of each basin includes an allowance for basin batters, a 3 m wide crest width and a maintenance track around its perimeter. Sketches showing the key features of the offline basin arrangements are contained in **Appendix B**.

Figure A1.6, 2 sheets provides a comparison of pre- and post-developed design 2 and 100 year ARI discharge hydrographs.

TABLE A3.1
DETENTION BASIN DETAILS

Scenario	Basin ID	Upstream Catchment Area (ha)	Peak Flows (m^3/s)								Maximum Depth of Ponding (m)		Active Storage Volume (m^3)		Outlet Arrangement	
			Present Day Conditions		Post-Development Conditions											
					Inflow to Basin		Outflow From Basin		In Burkes Gully Immediately Downstream of Basin Outlet							
			2 year ARI	100 year ARI	2 year ARI	100 year ARI	2 year ARI	100 year ARI	2 year ARI	100 year ARI	2 year ARI	100 year ARI	2 year ARI	100 year ARI	Low Level	High Level
[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]	[I]	[J]	[K]	[L]	[M]	[N]	[O]	[P]	[Q]
1(1)	AE1	395	4.28	39.4	14.7 [20.2]	52.4 [61.6]	4.23 [3.99]	35.2 [33.1]	Refer Values in Column H	Refer Values in Column I	4.21 [4.87]	5.24 [5.83]	23,400 [41,975]	56,575 [88,300]	1 off 1500 x 600 RCBC [1 off 1500 x 450 RCBC]	8 off 2400 x 750 RCBC's [8 off 2400 x 750 RCBC's]
2(1)	BR1	488	5.36	46.2	19.3 [23.3]	62.3 [71.0]	5.29 [5.42]	44.3 [44.9]			4.06 [5.16]	4.58 [5.56]	37,175 [55,400]	83,150 [107,175]	1 off 1500 x 750 RCBC [1 off 1500 x 600 RCBC]	8 off 2700 x 750 RCBC's [8 off 2700 x 750 RCBC's]
3(1,2)	AE5	162	2.2	18.0	2.83	18.3	2.20	17.4			1.27	2.24	740	6,030	2 off 750 RCP's	10 wide Armoured Spillway
	AE4	243	2.54	21.3	8.03	28.7	2.36	19.2			2.76	3.83	8,500	29,750	2 off 600 RCP's	10 wide Armoured Spillway
	AE3	256	3.04	26.5	2.97	19.2	2.83	19.1			1.00	2.00	400	4,565	3 of 750 RCP's	10 wide Armoured Spillway
	AE2	352	3.83	34.6	8.97	26.3	3.87	22.5			3.11	4.24	9,670	27,750	2 off 750 RCP's	10 wide Armoured Spillway
	AE1	395	4.3	39.3	5.26	23.9	4.32	23.6			1.95	3.07	2,150	11,260	3 off 750 RCP's	10 wide Armoured Spillway
4(3)	B6	36.6	2.54	21.3	2.91	12.0	0.24	3.60	2.37	23.3	1.01	1.59	5,750	10,300	1 off 225 RCP	3 off 1500 x 450 RCBC's
	B5	61.9			3.96	15.7	0.10	2.61			1.16	1.71	9,550	17,250	1 off 225 RCP	3 off 1500 x 300 RCBC's
	B4	83.2	3.81	34.6	4.44	15.0	0.61	6.75	3.29	32.6	1.12	1.64	9,350	15,300	1 of 450 RCP	3 off 2400 x 450 RCBC's
	B3	34.2			2.98	9.29	0.57	4.57			1.08	1.49	5,650	8,150	1 off 375 RCP	3 off 2400 x 300 RCBC's
	B2	14.9	4.28	39.4	0.82	2.90	0.20	1.50	3.97	35.9	0.60	1.0	975	1,750	1 off 300 RCP	3 off 1800 x 300 RCBC's
	B1	16.5			1.22	3.81	0.39	1.78			0.69	1.13	1,575	2,650	1 off 375 RCP	3 off 1800 x 300 RCBC's

1. Values in [ ] assume 40 per cent fraction impervious in catchment draining to Burkes Gully upstream of Arcadia Estate. A similar assessment was not undertaken for Scenario 3.
2. High level culvert arrangement similar to Scenarios 1 and 2 was not assessed for Scenario 3. Rather, a simple spillway arrangement was incorporated into the DRAINS model for assessment purposes.
3. Maximum depth of ponding is measured above the proposed wet area (refer sketches in **Appendix B** for details).

APPENDIX B

SKETCHES SHOWING CONCEPT LAYOUT OF PROPOSED DETENTION BASINS (REFER VOLUME 2)

APPENDIX C

FIGURES SHOWING SAMPLE SITES ADOPTED FOR FRACTION IMPERVIOUS CALCULATIONS
(REFER VOLUME 2)

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

VOLUME 2 – FIGURES AND APPENDICES

November 2015

DRAFT REPORT

Job No: BZ336 File:/Reports/AE-V2-Figures[Rev 2.0].doc	Date: November 2015 Rev No: 2.0	Principal: SAB Authors: BJN/SAB

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S2 Indicative Extent of Land Required For Flooding and Drainage

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3.2 Extent of Catchments Draining Arcadia Estate

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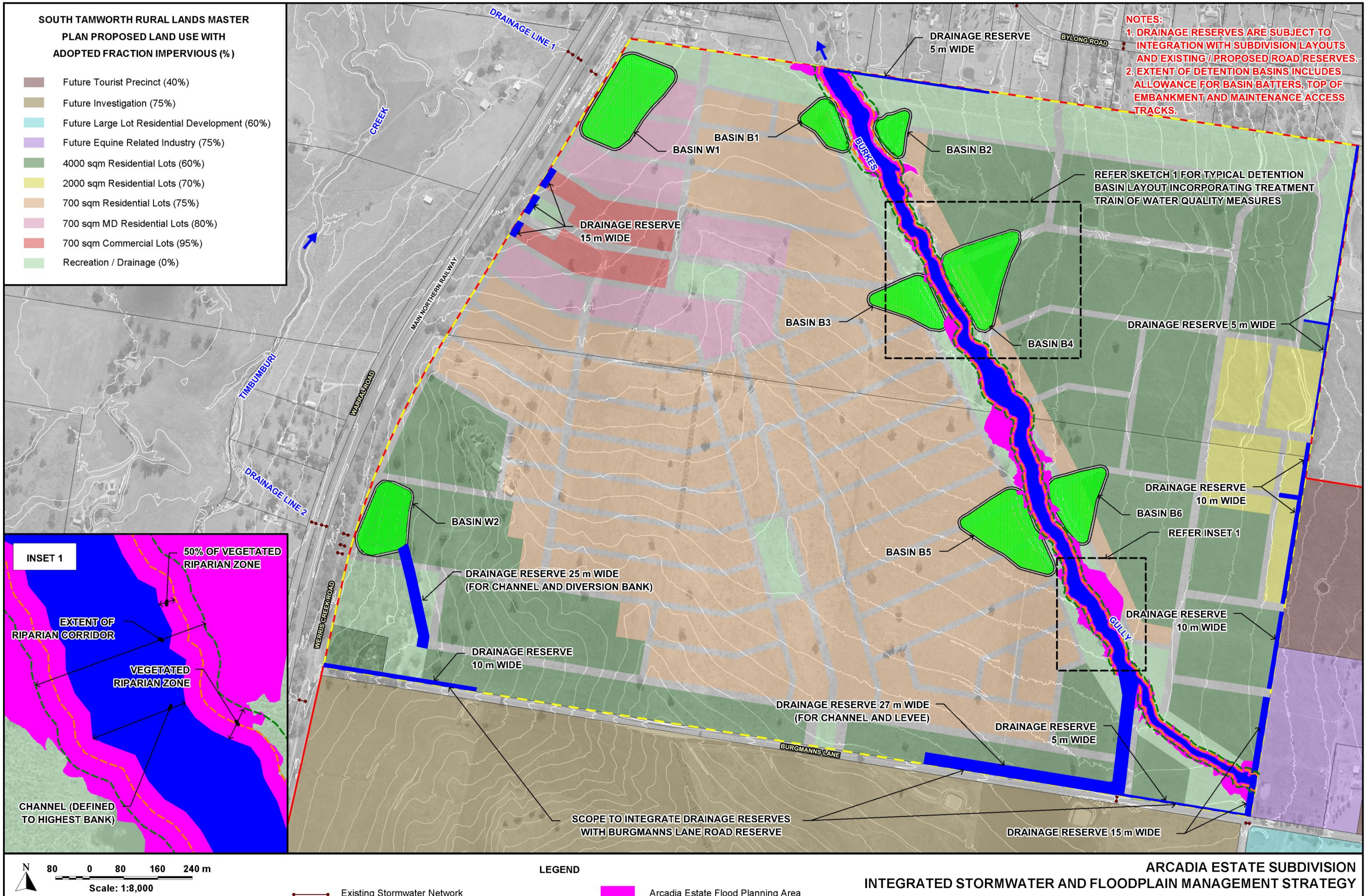
7.5 Impact of Proposed Subdivision Development on Flooding Behaviour (Controlled Flow Scenario) – 100 year ARI



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LEGEND

- Existing Stormwater Network
- Extent of Arcadia Estate Subdivision
- South Tamworth Rural Lands Master Plan Area
- Arcadia Estate Flood Planning Area
- Riparian Corridor Extents (Refer Inset 1)
- Detention Basin Incorporating Water Quality Measures

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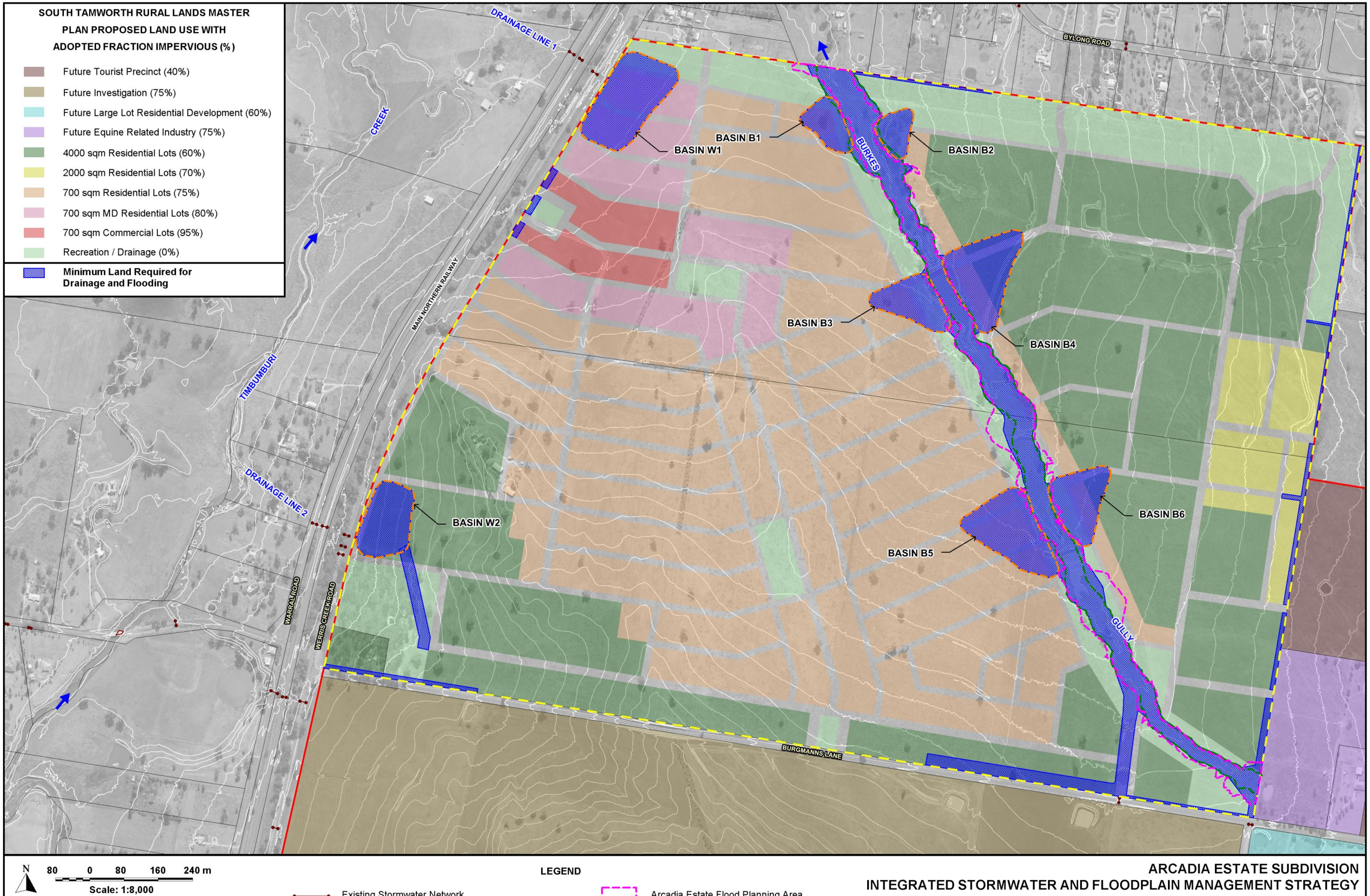
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure S1

RECOMMENDED MITIGATION MEASURES



LEGEND

- Existing Stormwater Network
- Extent of Arcadia Estate Subdivision
- South Tamworth Rural Lands Master Plan Area
- Arcadia Estate Flood Planning Area
- Riparian Corridor Extent
- Detention Basin

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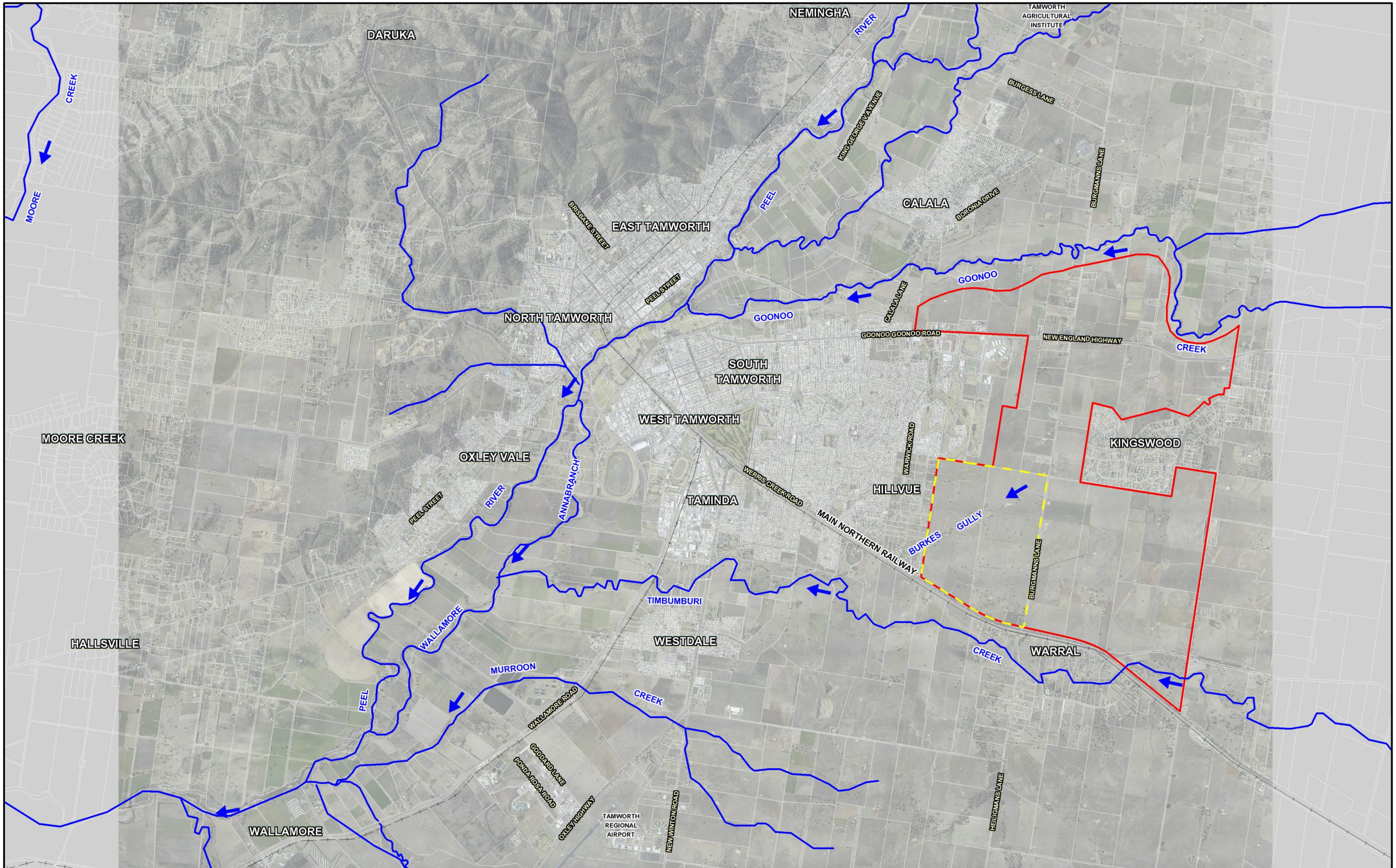
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure S2

INDICATIVE EXTENT OF LAND REQUIRED FOR FLOODING AND DRAINAGE



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500 0 500 1000 1500 m

Scale: 1:50,000

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LEGEND

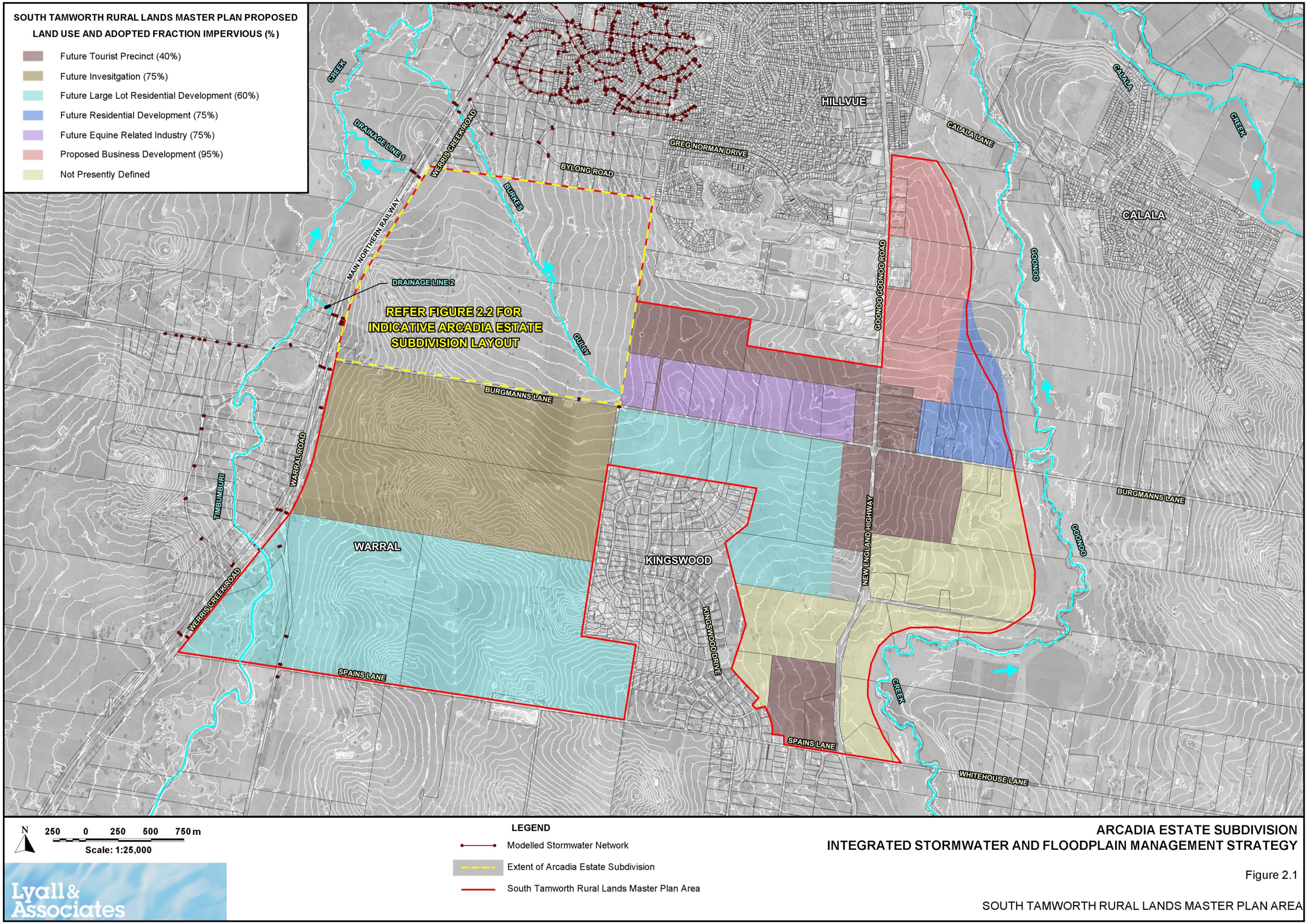
Extent of Arcadia Estate Subdivision

South Tamworth Rural Lands Master Plan Area

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 1.1

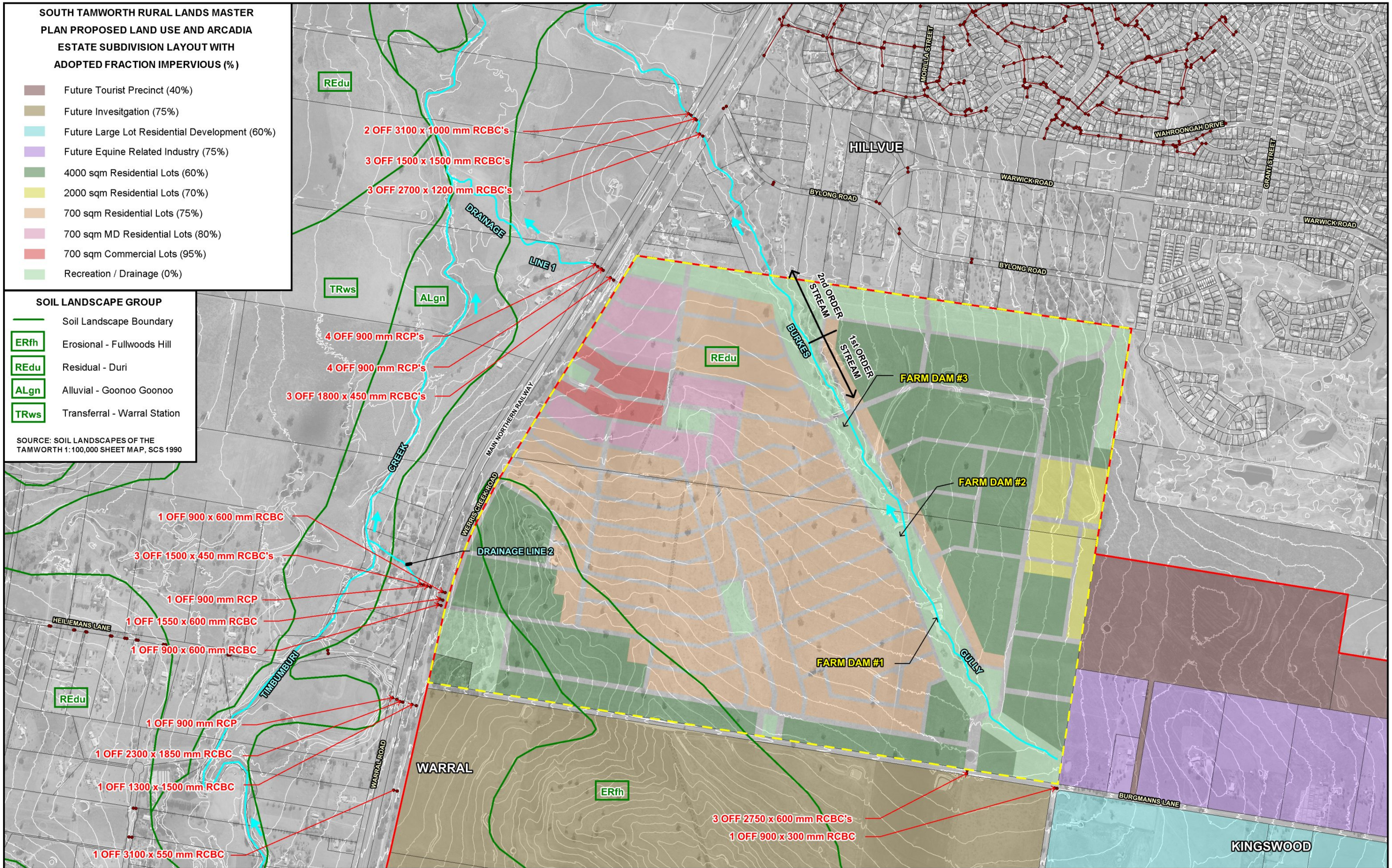
LOCATION PLAN



ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 2.1

SOUTH TAMWORTH RURAL LANDS MASTER PLAN AREA



N
120 0 120 240 360 m
Scale: 1:12,000

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LEGEND

Modelled Stormwater Network

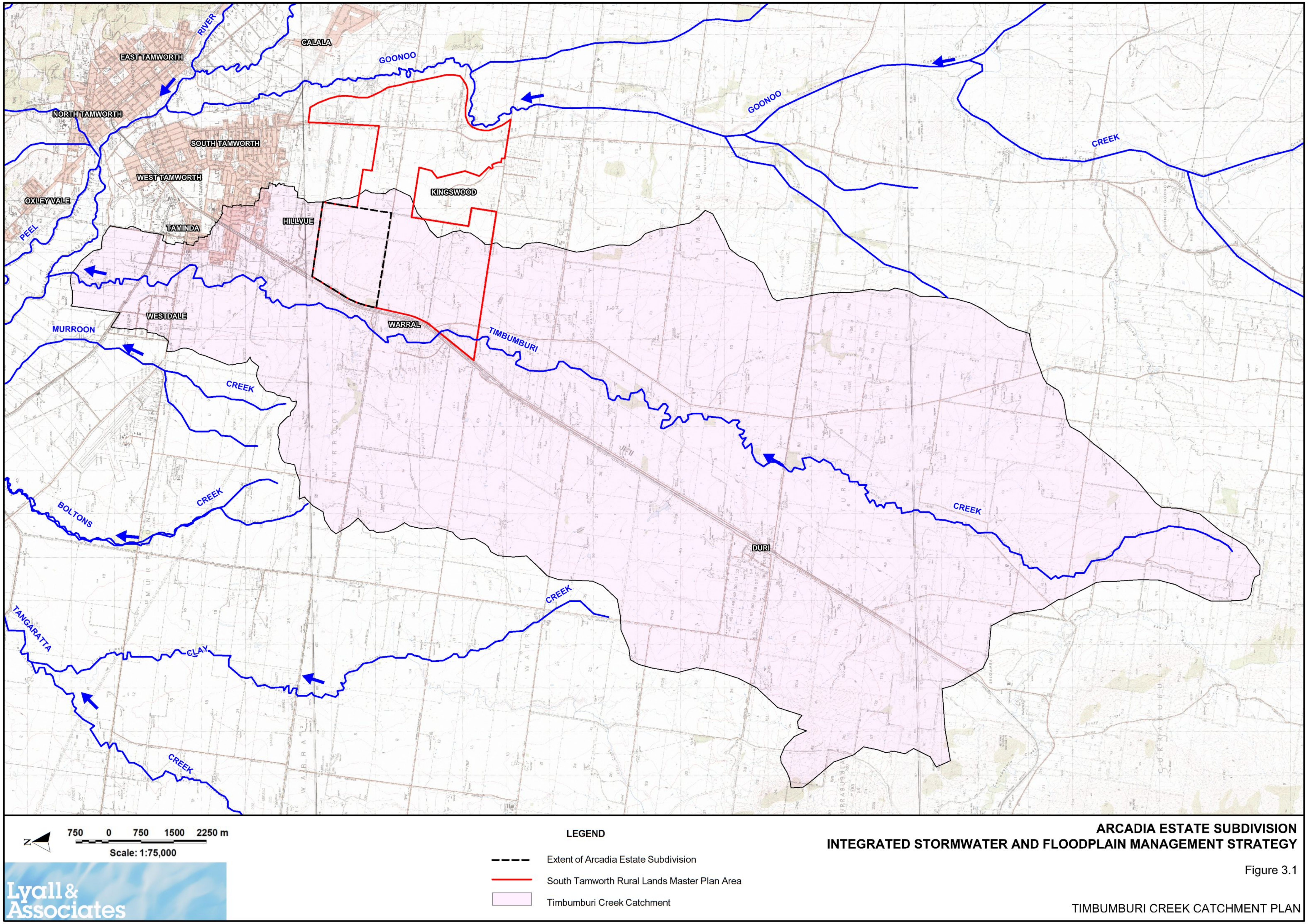
Extent of Arcadia Estate Subdivision

South Tamworth Rural Lands Master Plan Area

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 2.2

INDICATIVE ARCADIA ESTATE SUBDIVISION LAYOUT



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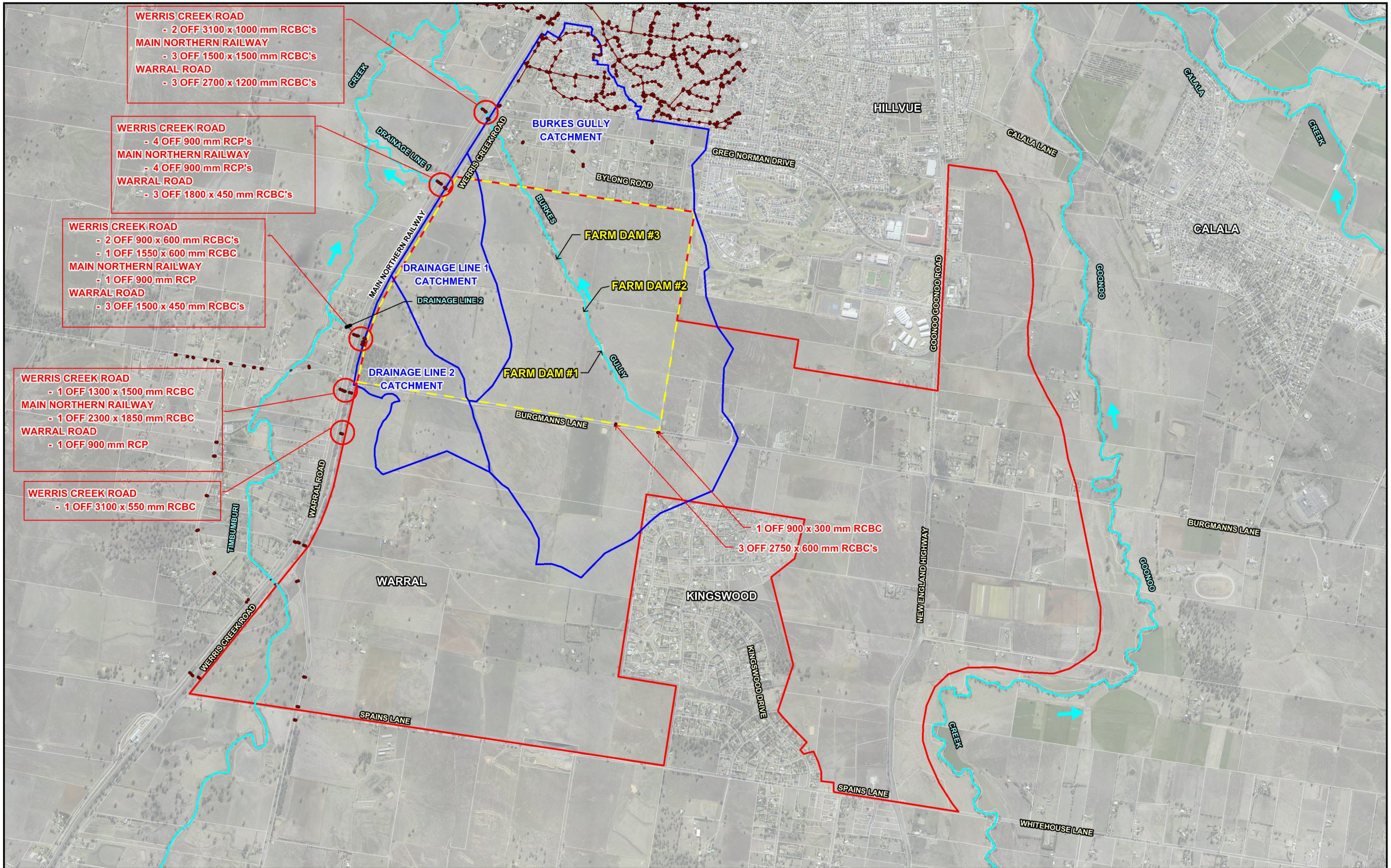
ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 3.1

TIMBUMBURI CREEK CATCHMENT PLAN



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Scale: 1:25,000

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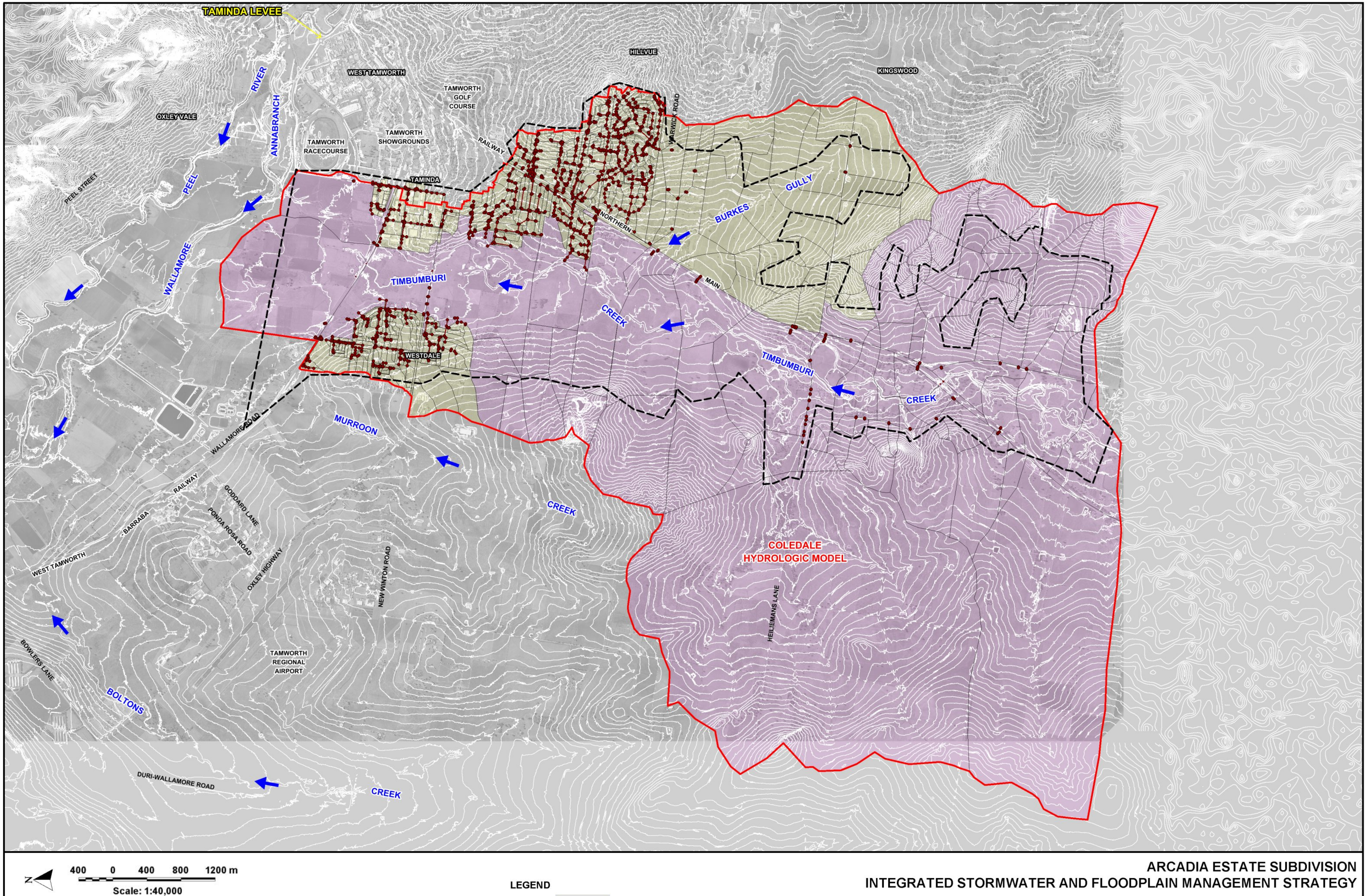
LEGEND

- Extent of Arcadia Estate Subdivision
- South Tamworth Rural Lands Master Plan Area
- Modelled Stormwater Network
- Catchments Contributing Runoff to Transverse Drainage Structures West of Arcadia Estate Subdivision

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 3.2

EXTENT OF CATCHMENTS DRAINING ARCADIA ESTATE



LEGEND

Two-Dimensional Model Boundary	DRAINS Sub-Catchment
Modelled Stormwater Network	RAFTS Sub-Catchment
	Hydrologic Model Boundary and Identifier

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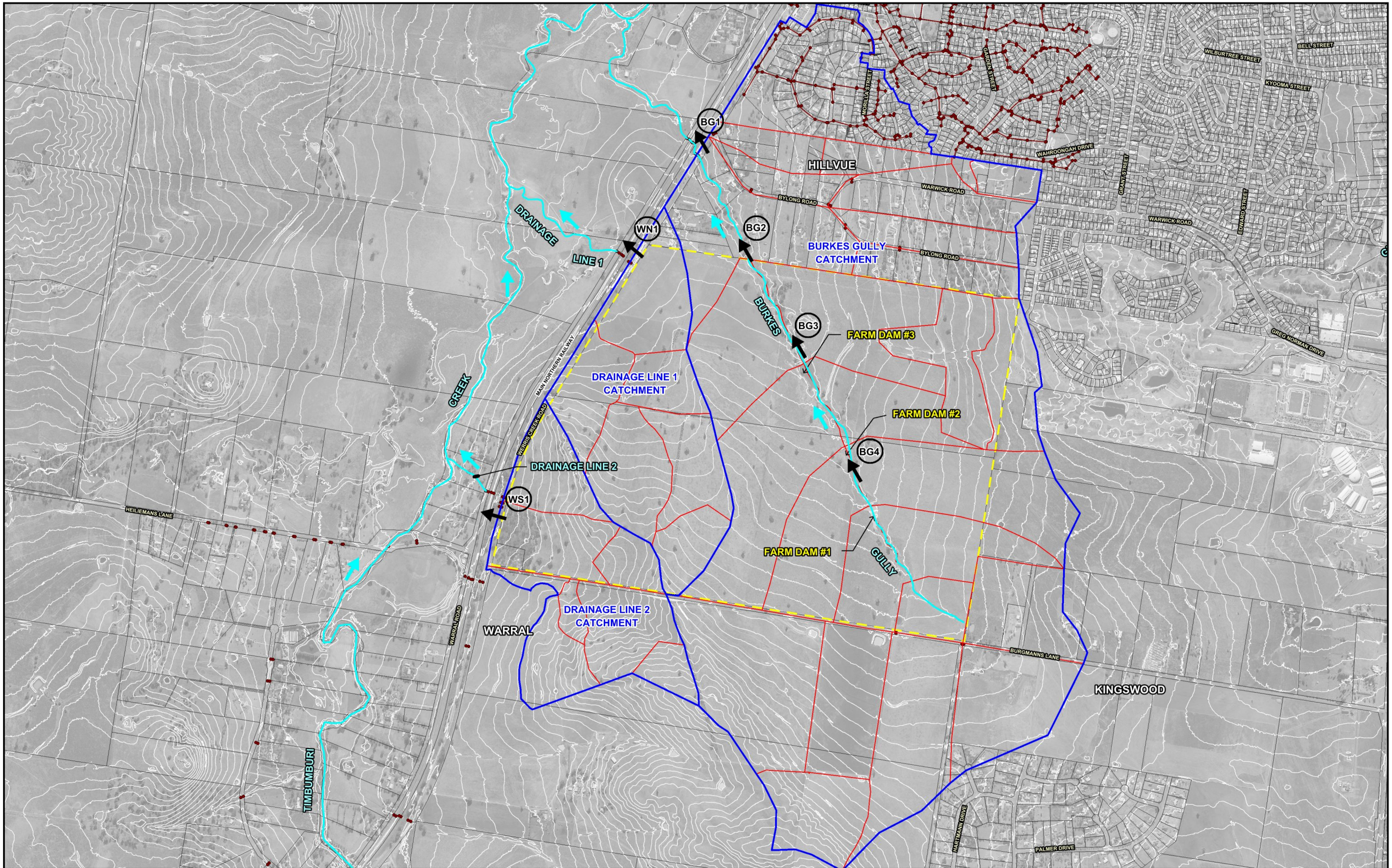
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 4.1

COLEDALE HYDROLOGIC MODEL LAYOUT



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160 0 160 320 480 m

Scale: 1:16,000

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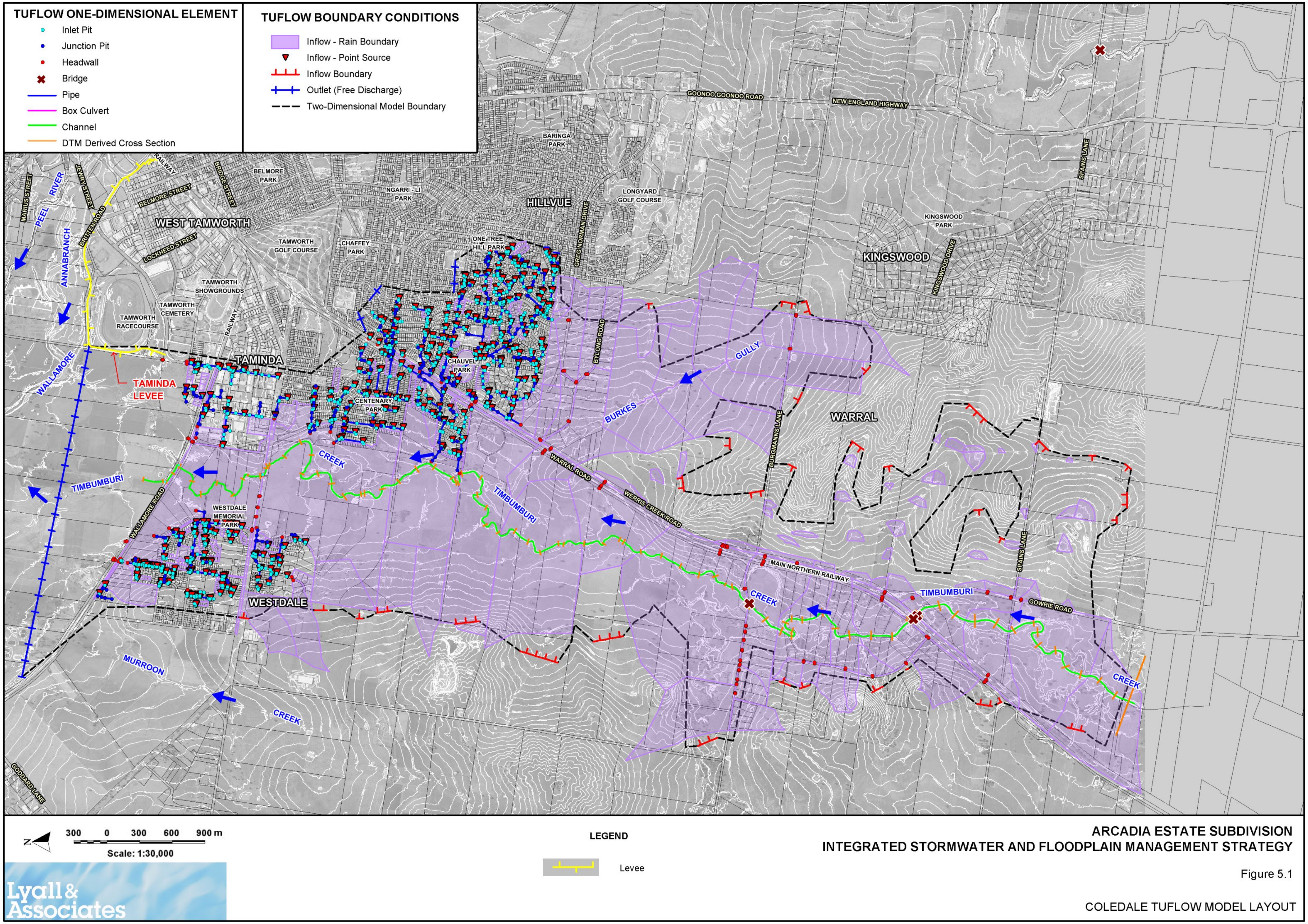
LEGEND

- Modelled Stormwater Network
- Extent of Arcadia Estate Subdivision
- Sub-Catchment Boundary
- BG3 Peak Flow and Water Quality Location and Identifier
- Catchments Contributing Runoff to Transverse Drainage Structures West of Arcadia Estate Subdivision

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 4.2

ARCADIA ESTATE SUB-CATCHMENT PLAN
PRESENT DAY CONDITIONS



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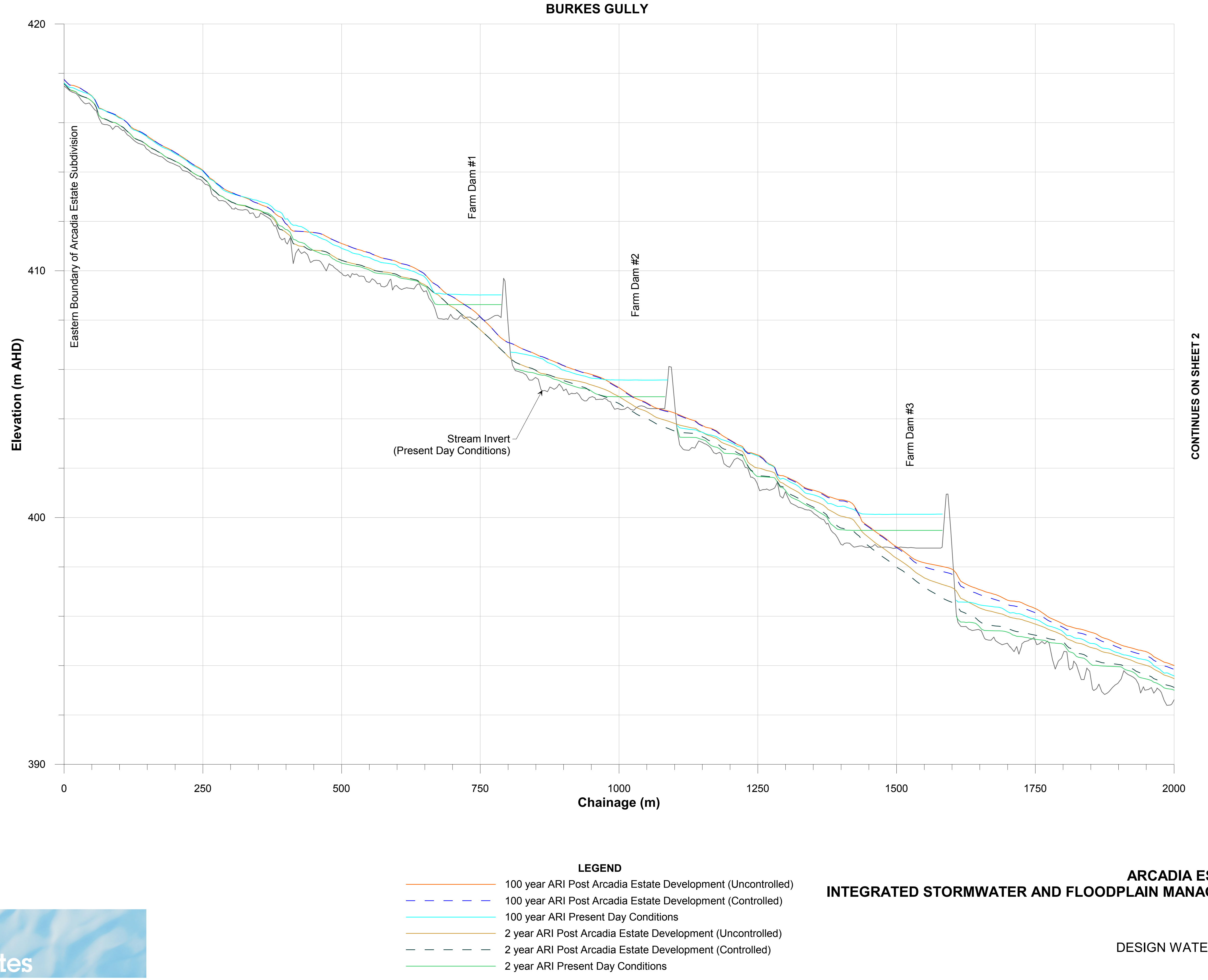
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 5.1

COLEDALE TUFLOW MODEL LAYOUT



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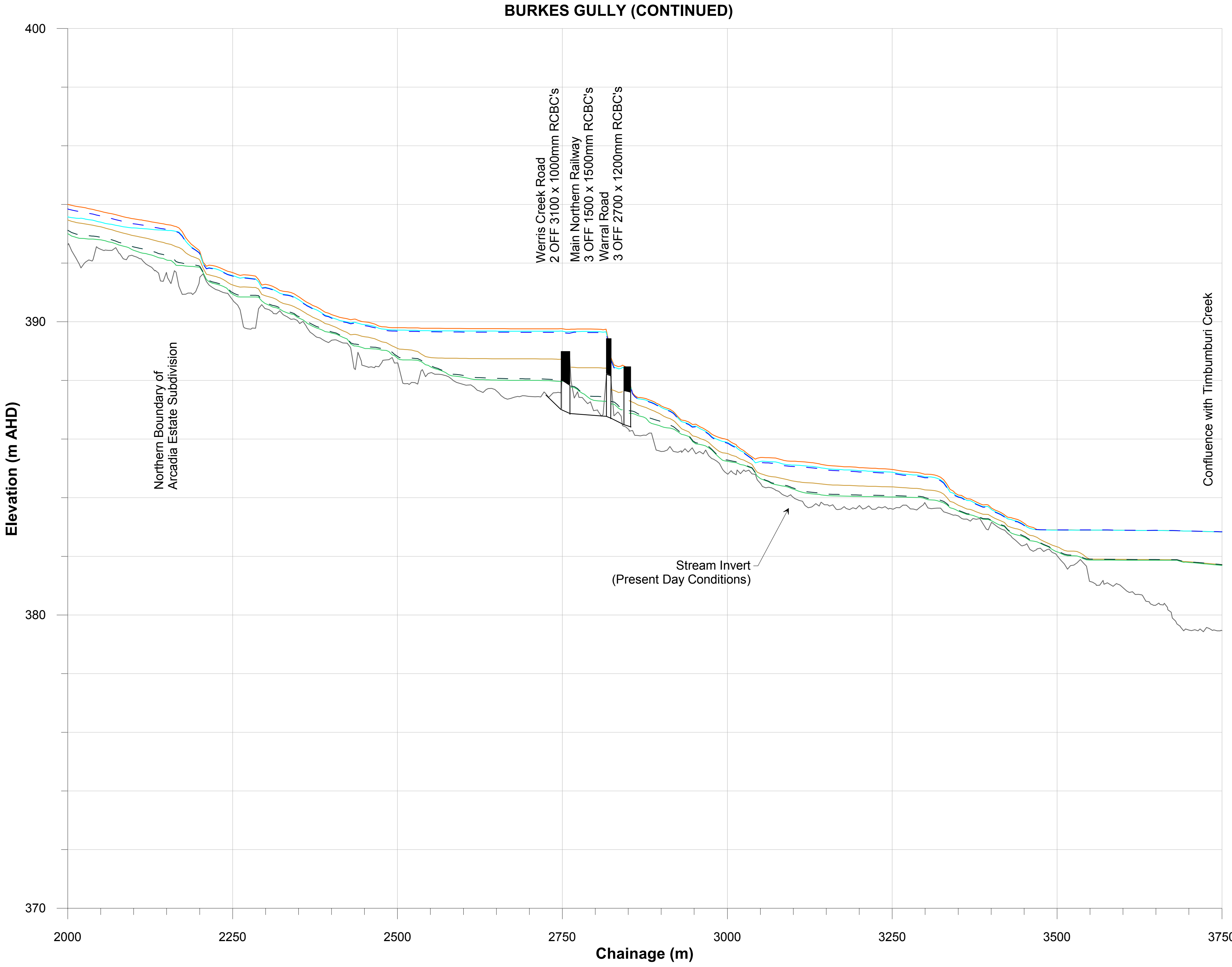
ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 5.2
Sheet 1 of 2

DESIGN WATER SURFACE PROFILES
BURKES GULLY



LEGEND

- 100 year ARI Post Arcadia Estate Development (Uncontrolled)
- 100 year ARI Post Arcadia Estate Development (Controlled)
- 100 year ARI Present Day Conditions
- 2 year ARI Post Arcadia Estate Development (Uncontrolled)
- 2 year ARI Post Arcadia Estate Development (Controlled)
- 2 year ARI Present Day Conditions

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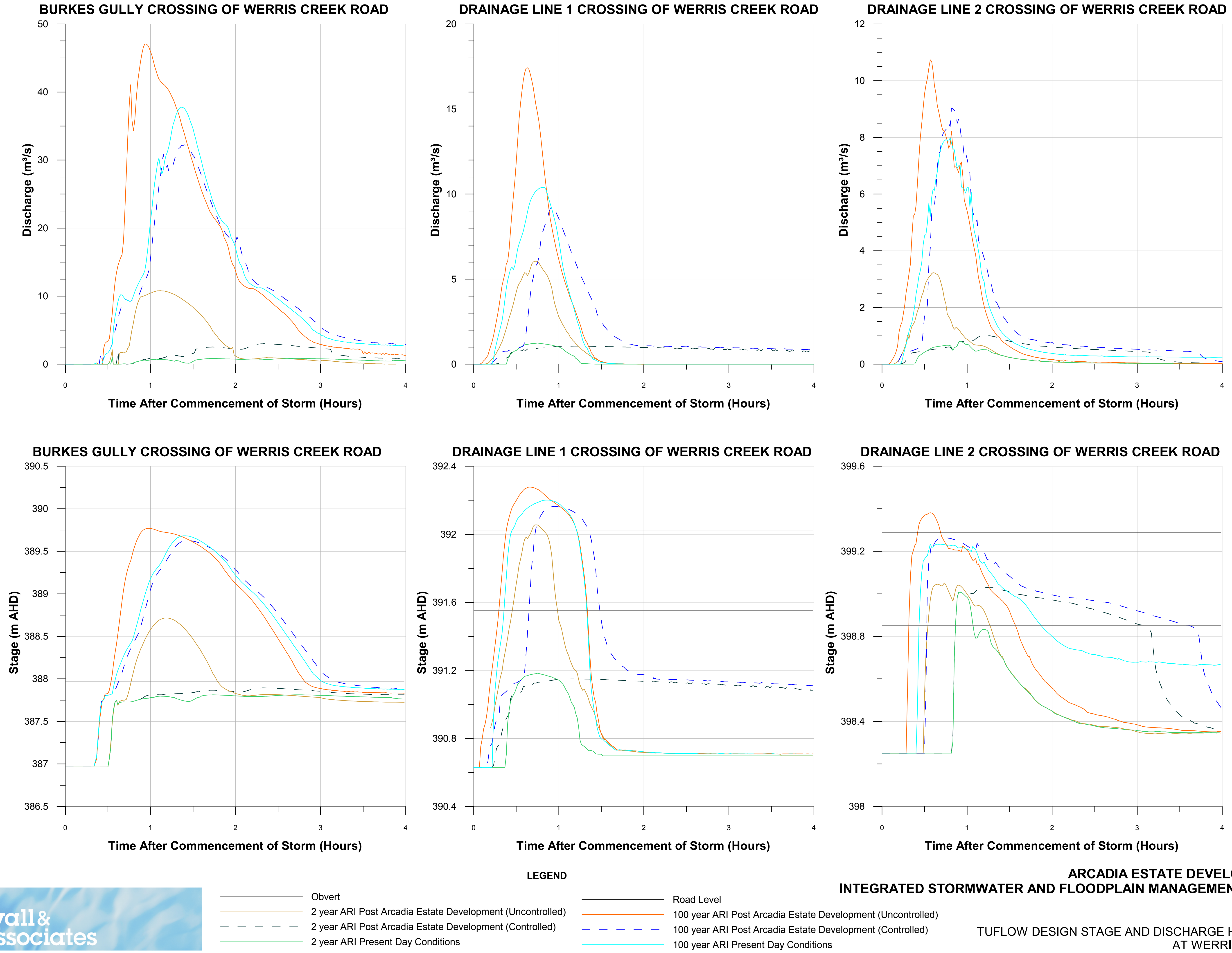
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 5.2
Sheet 2 of 2

DESIGN WATER SURFACE PROFILES
BURKES GULLY



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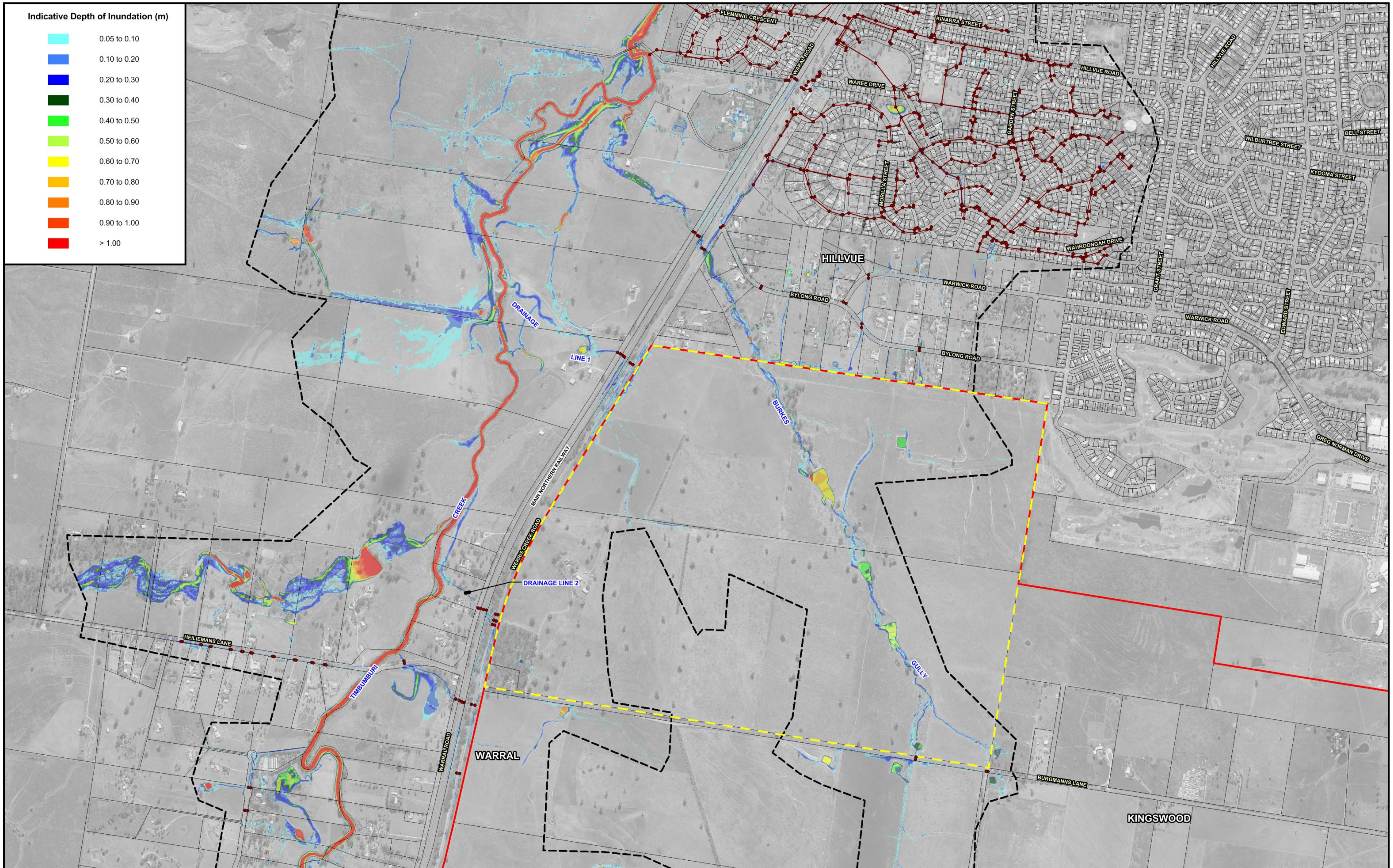
ARCADIA ESTATE DEVELOPMENT SITE
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 5.3

TUFLOW DESIGN STAGE AND DISCHARGE HYDROGRAPHS
AT WERRIS CREEK ROAD



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150 0 150 300 450 m

Scale: 1:15,000

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LEGEND

TUFLOW Model Extent

South Tamworth Rural Lands Master Plan Area

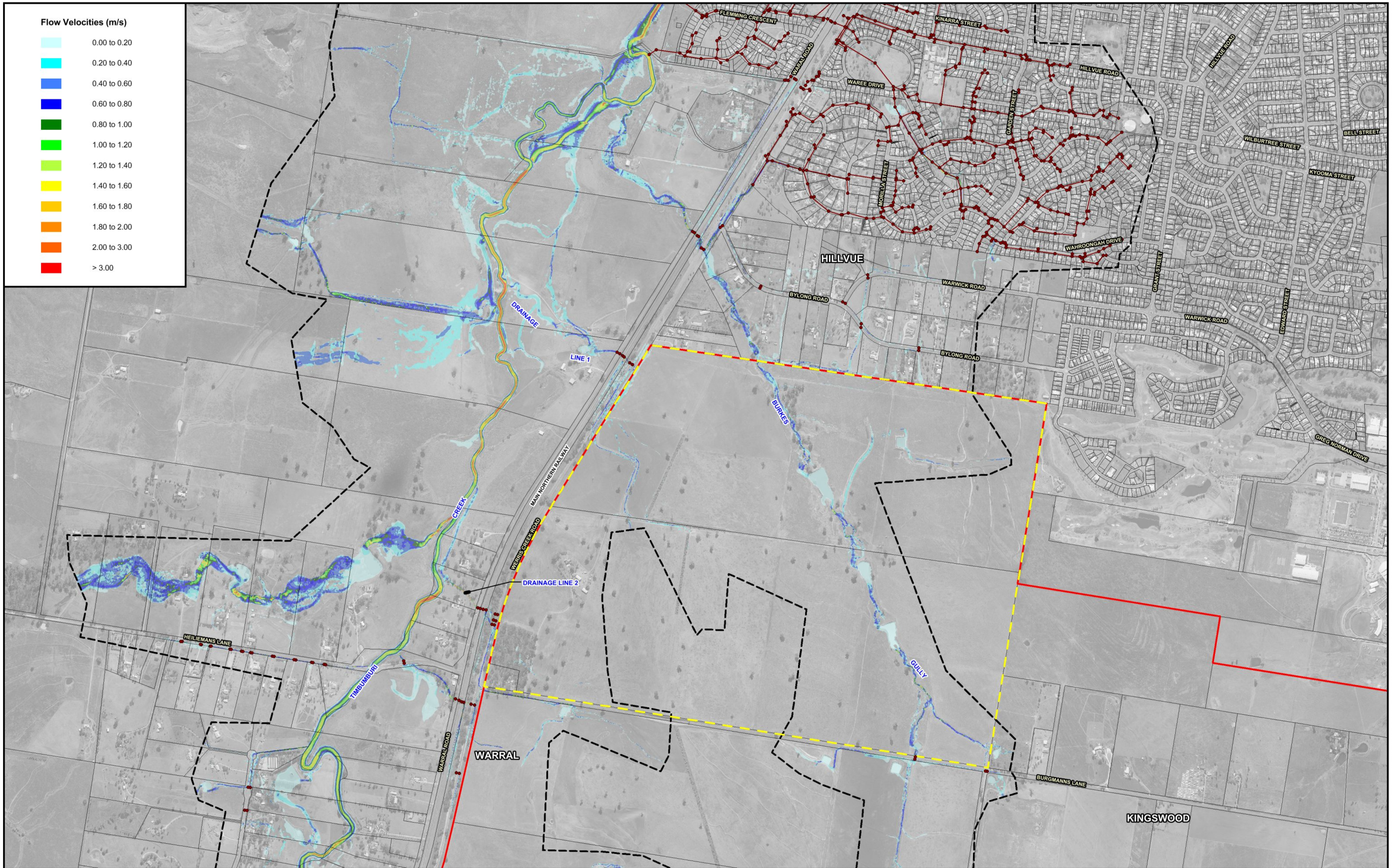
Modelled Stormwater Network

Extent of Arcadia Estate Subdivision

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 5.4

INDICATIVE EXTENTS AND DEPTHS OF INUNDATION
PRESENT DAY CONDITIONS - 2 YEAR ARI



N

150 0 150 300 450 m

Scale: 1:15,000

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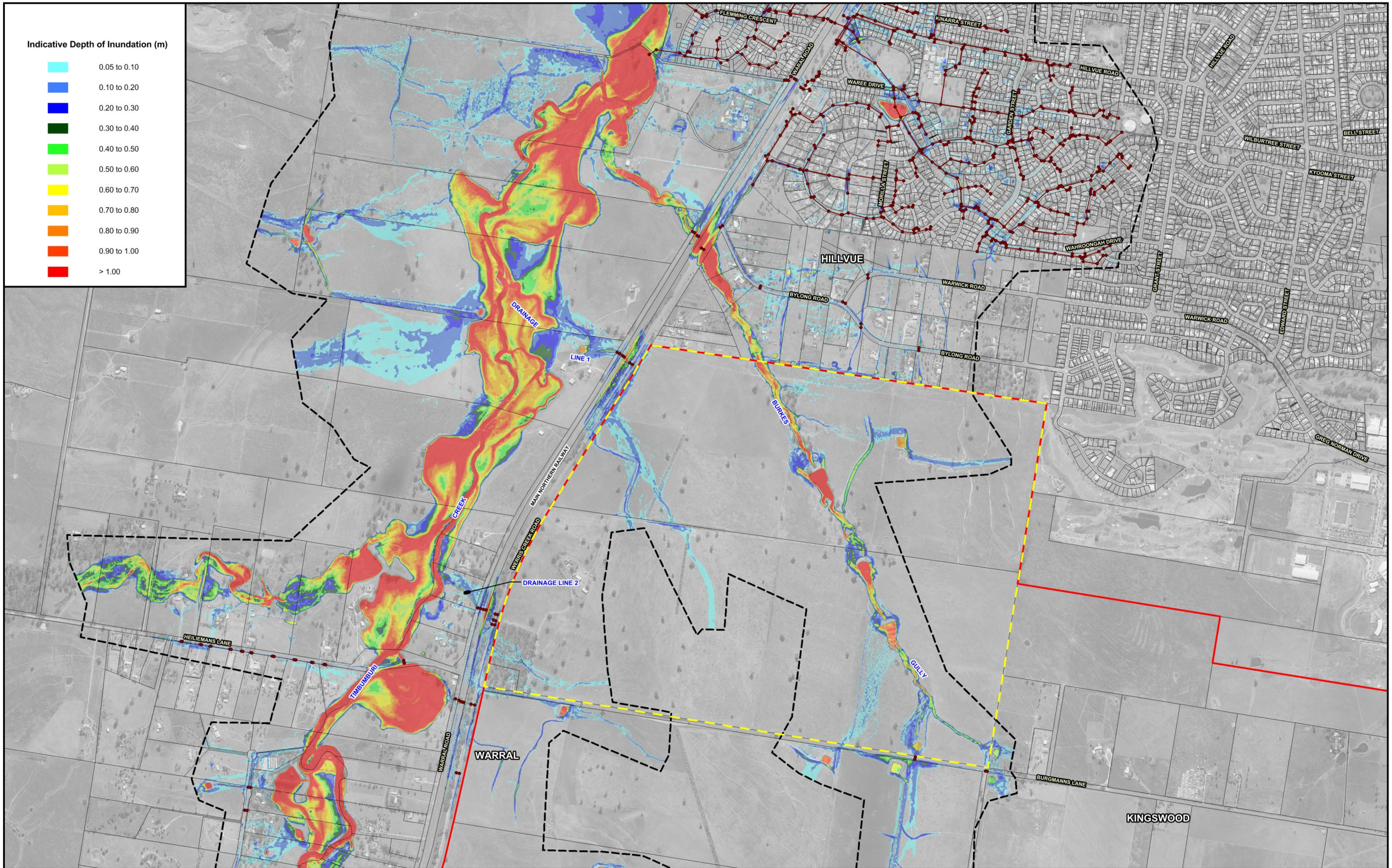
LEGEND

- TUFLOW Model Extent
- South Tamworth Rural Lands Master Plan Area
- Modelled Stormwater Network
- Extent of Arcadia Estate Subdivision

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 5.5

INDICATIVE FLOW VELOCITIES
PRESENT DAY CONDITIONS - 2 YEAR ARI



N

150 0 150 300 450 m

Scale: 1:15,000

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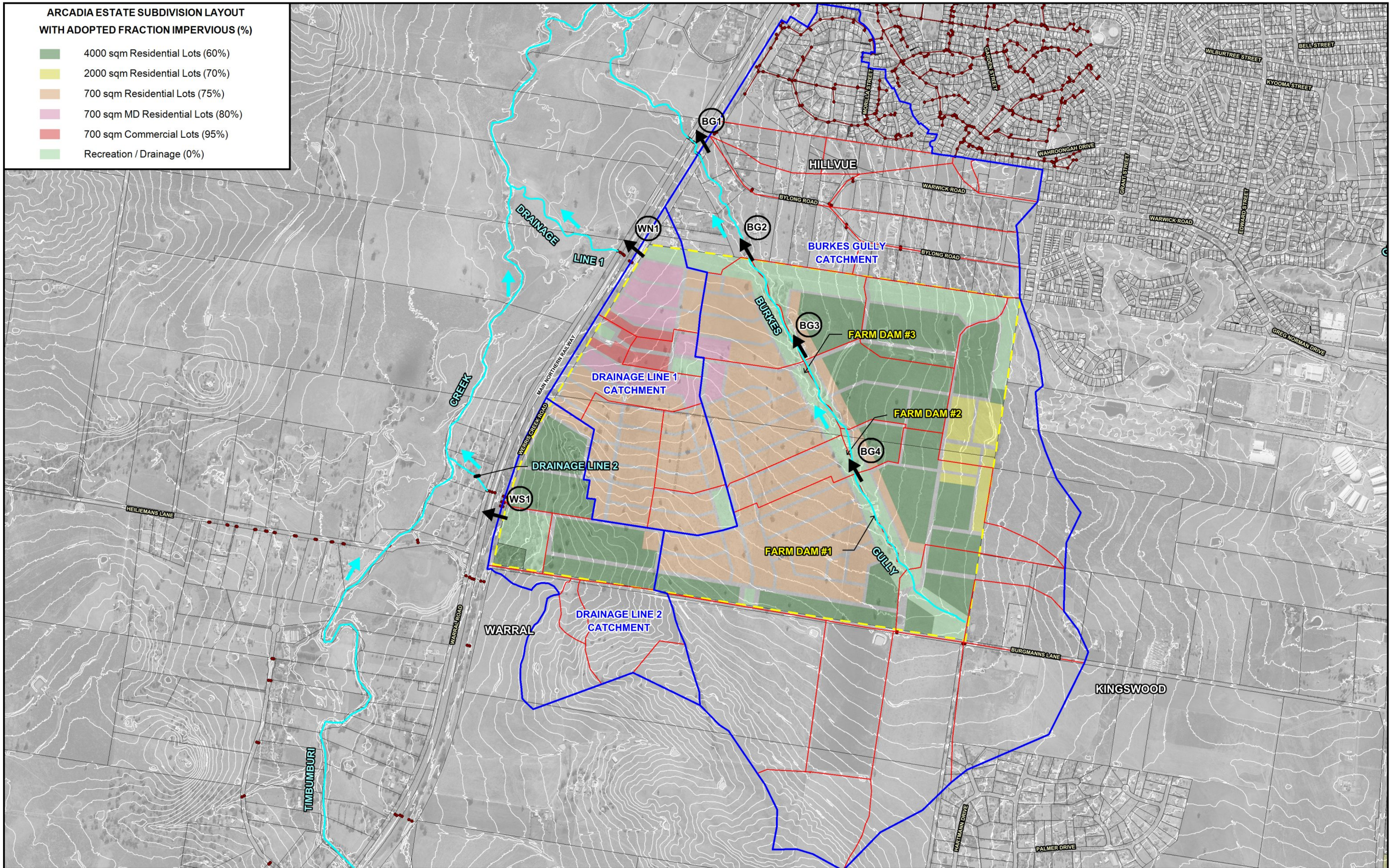
LEGEND

- TUFLOW Model Extent
- South Tamworth Rural Lands Master Plan Area
- Modelled Stormwater Network
- Extent of Arcadia Estate Subdivision

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 5.6

INDICATIVE EXTENTS AND DEPTHS OF INUNDATION
PRESENT DAY CONDITIONS - 100 YEAR ARI



N

160 0 160 320 480 m

Scale: 1:16,000

LEGEND

- Modelled Stormwater Network
- Extent of Arcadia Estate Subdivision
- Sub-Catchment Boundary
- BG3 → Peak Flow and Water Quality Location and Identifier
- Catchments Contributing Runoff to Transverse Drainage Structures West of Arcadia Estate Subdivision

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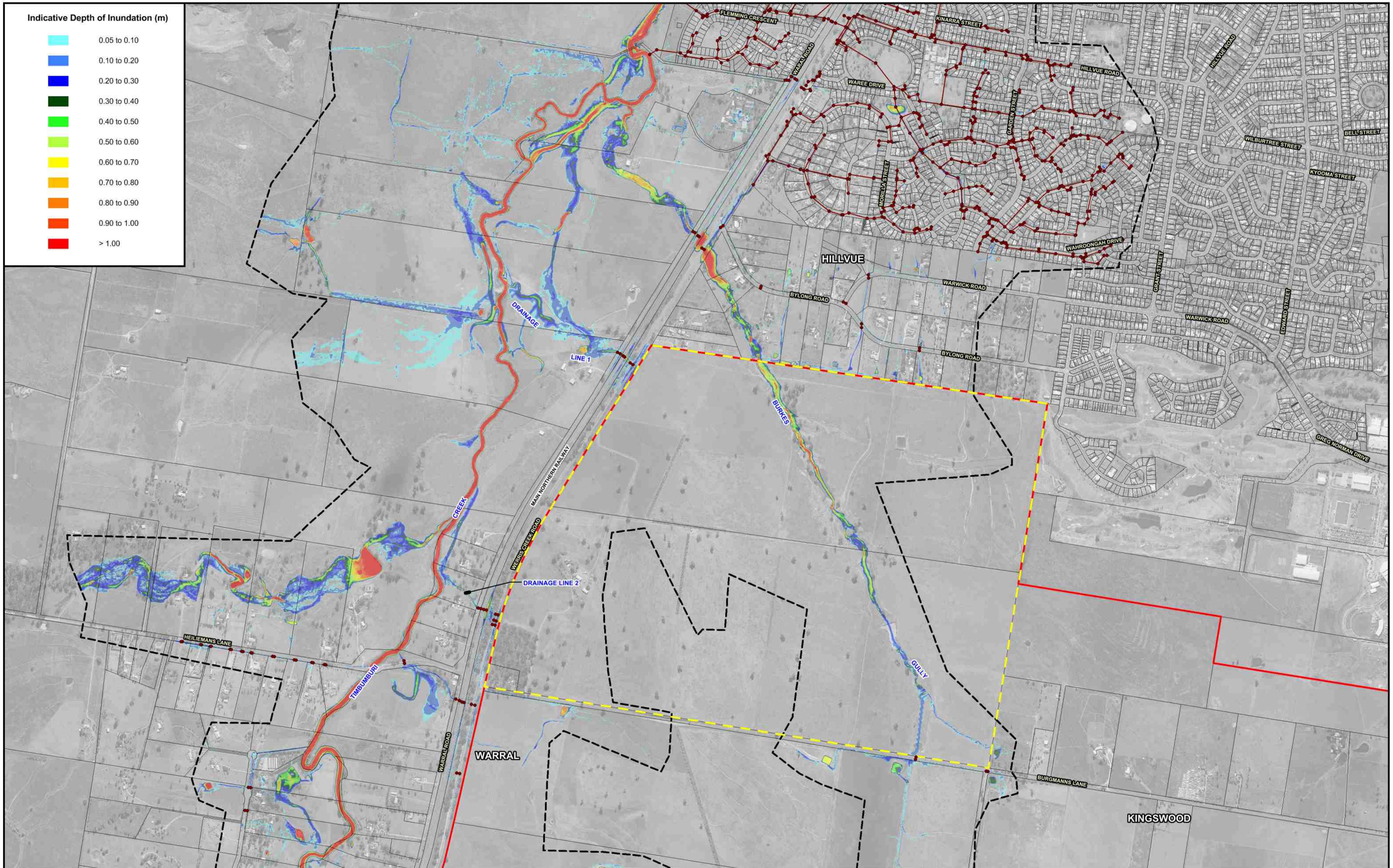
ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 6.1

ARCADIA ESTATE SUB-CATCHMENT PLAN
POST-SUBDIVISION CONDITIONS



N 150 0 150 300 450 m

Scale: 1:15,000

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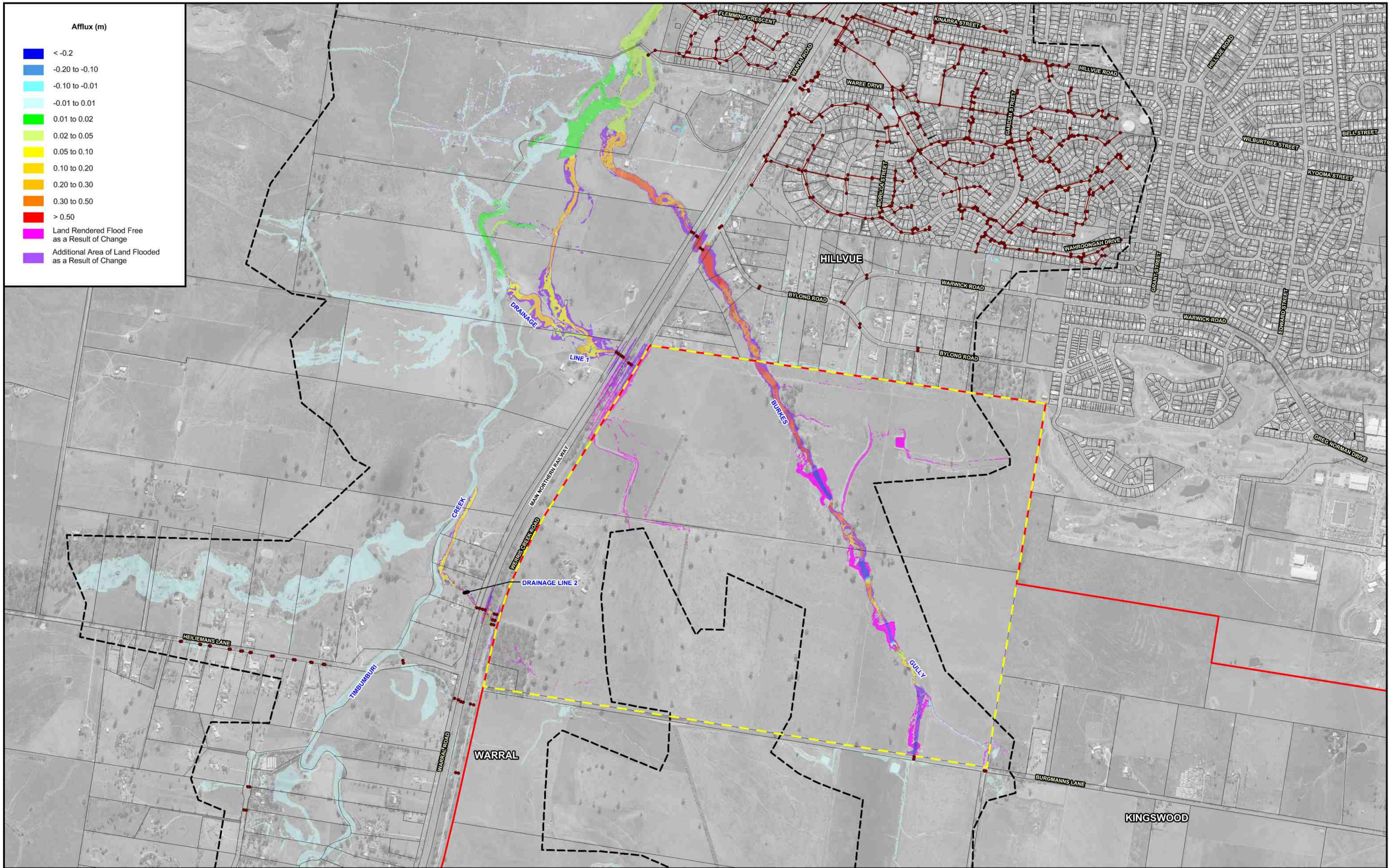
LEGEND

- TUFLOW Model Extent
- South Tamworth Rural Lands Master Plan Area
- Modelled Stormwater Network
- Extent of Arcadia Estate Subdivision

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 6.2

INDICATIVE EXTENTS AND DEPTHS OF INUNDATION
POST-SUBDIVISION CONDITIONS (UNCONTROLLED FLOW SCENARIO - 2 YEAR ARI



N

150 0 150 300 450 m

Scale: 1:15,000

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LEGEND

TUFLOW Model Extent

South Tamworth Rural Lands Master Plan Area

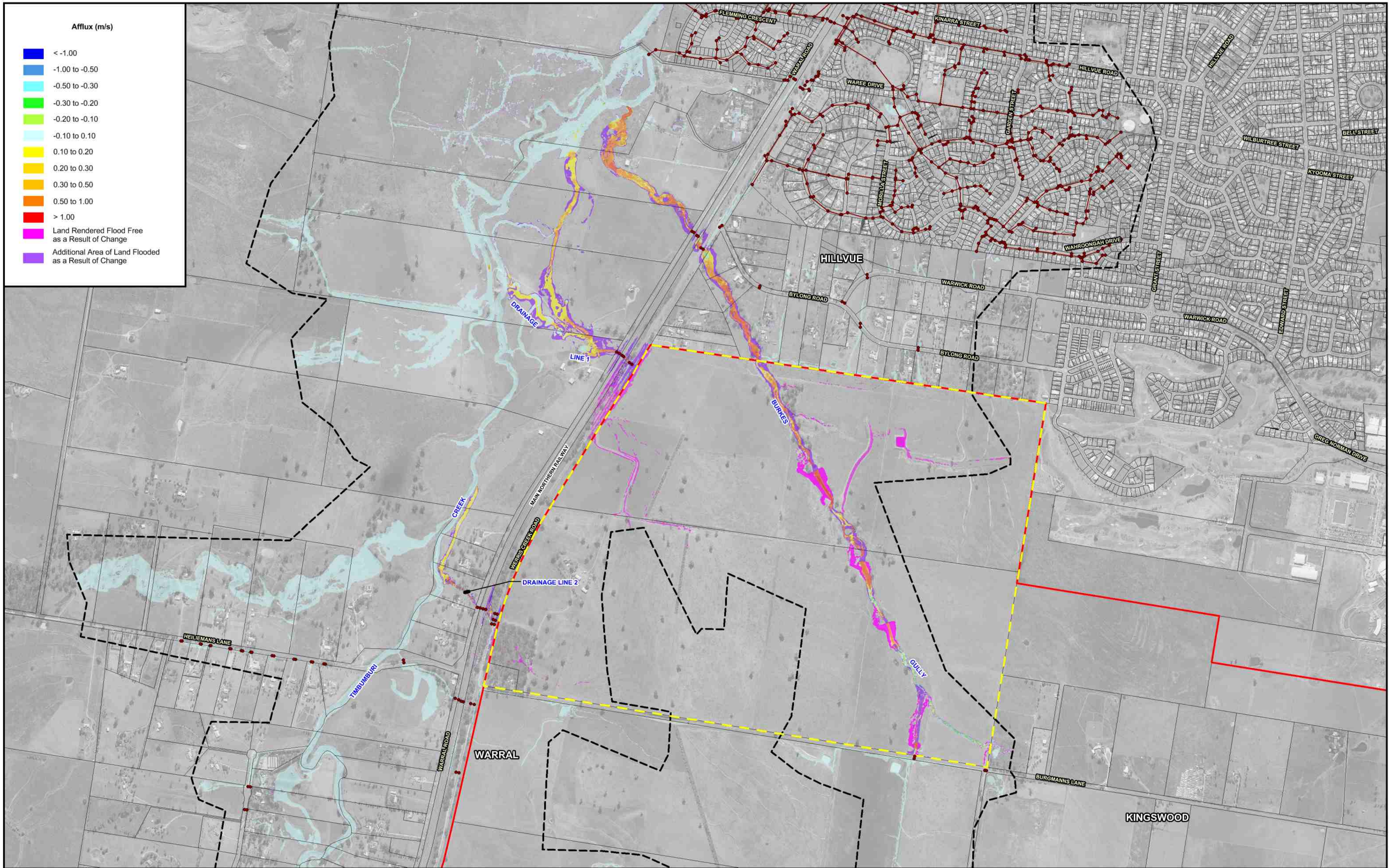
Modelled Stormwater Network

Extent of Arcadia Estate Subdivision

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 6.3

IMPACT OF PROPOSED SUBDIVISION DEVELOPMENT ON FLOODING BEHAVIOUR
(UNCONTROLLED FLOW SCENARIO) - 2 YEAR ARI



N

120 0 120 240 360 m

Scale: 1:12,000

LEGEND

- TUFLOW Model Extent
- South Tamworth Rural Lands Master Plan Area
- Modelled Stormwater Network
- Extent of Arcadia Estate Subdivision

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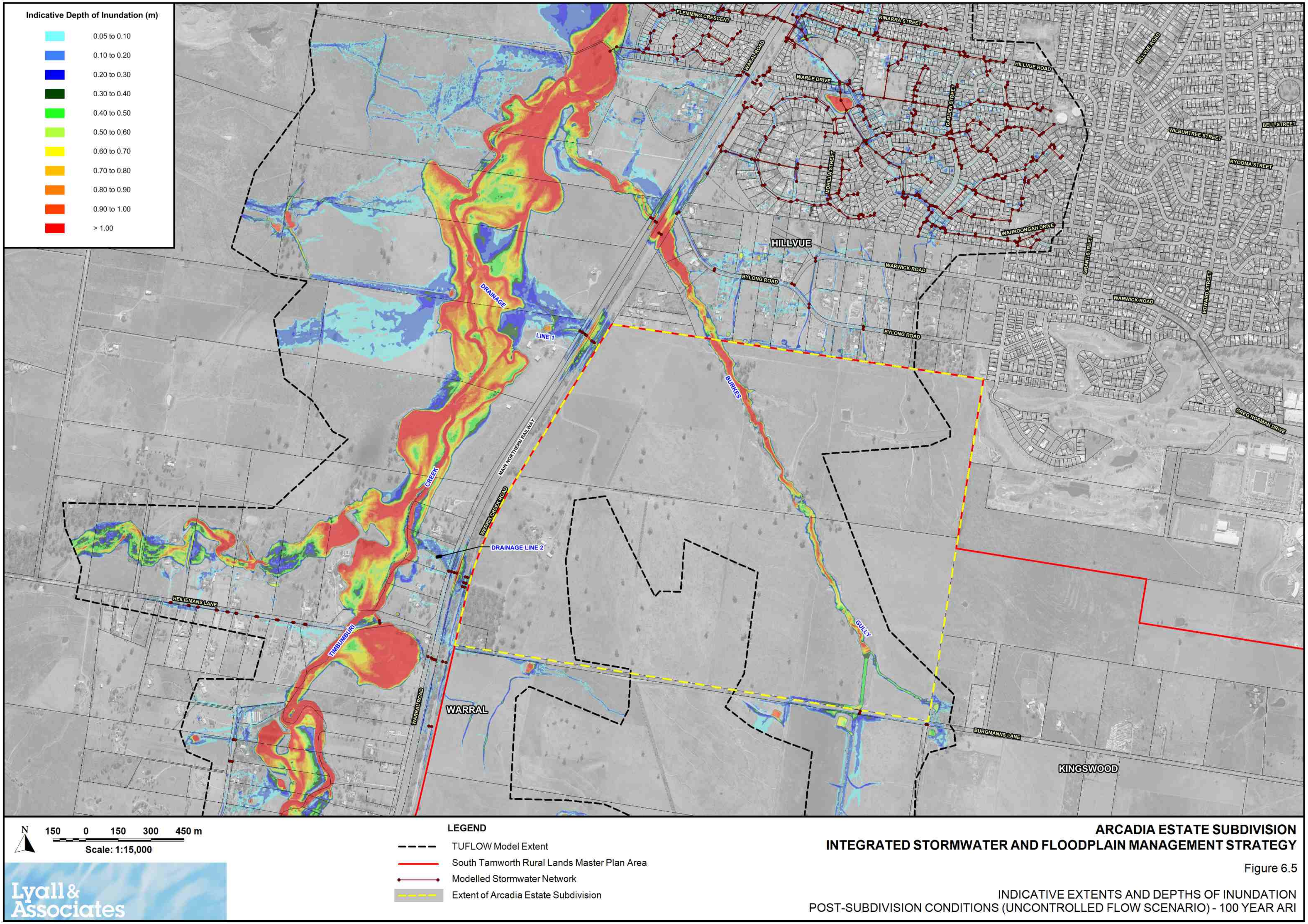
ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 6.4

IMPACT OF PROPOSED SUBDIVISION DEVELOPMENT ON FLOW VELOCITIES
(UNCONTROLLED FLOW SCENARIO) - 2 YEAR ARI



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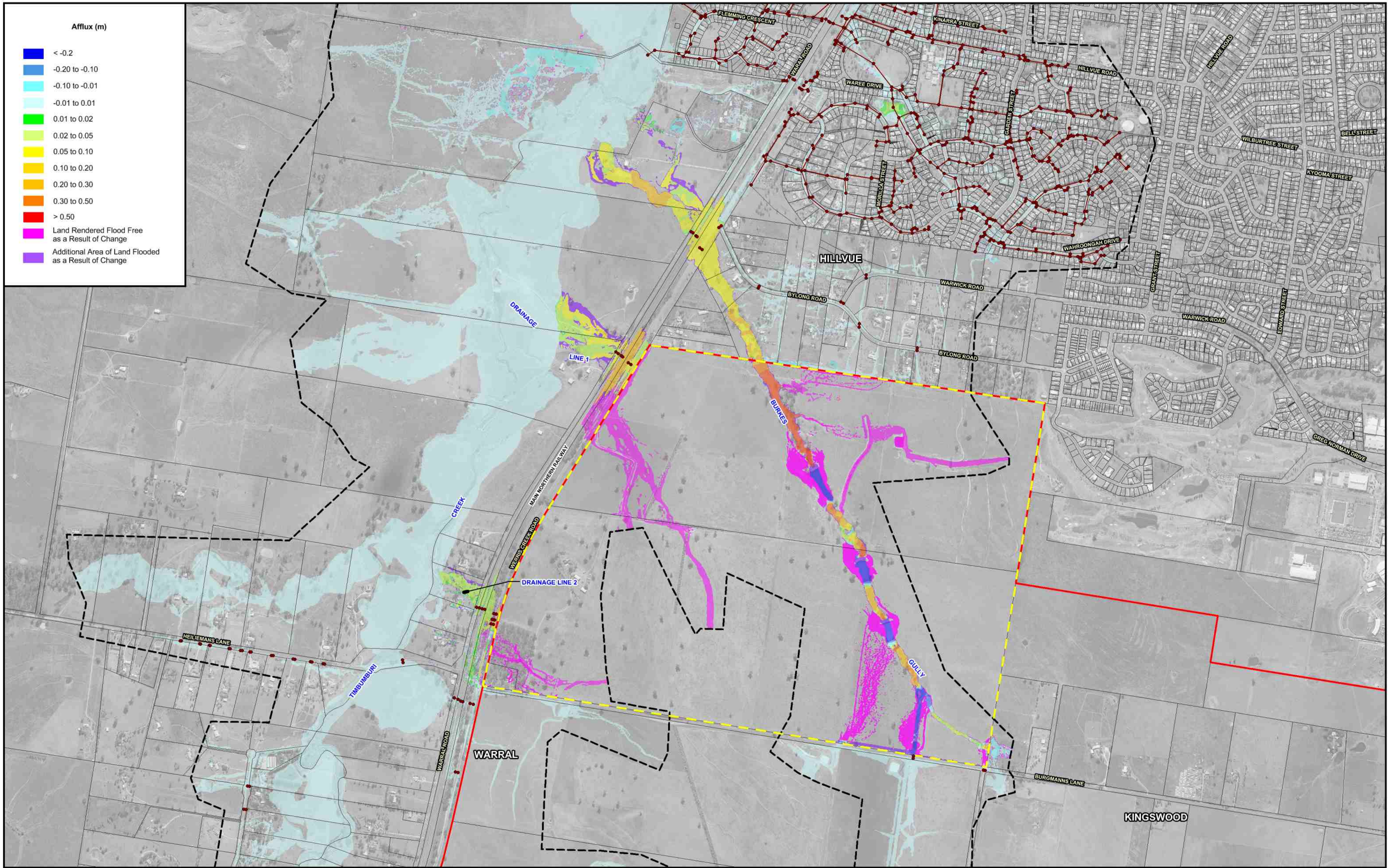
ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 6.5

INDICATIVE EXTENTS AND DEPTHS OF INUNDATION
POST-SUBDIVISION CONDITIONS (UNCONTROLLED FLOW SCENARIO) - 100 YEAR ARI



N

150 0 150 300 450 m

Scale: 1:15,000

LEGEND

- TUFLOW Model Extent
- South Tamworth Rural Lands Master Plan Area
- Modelled Stormwater Network
- Extent of Arcadia Estate Subdivision

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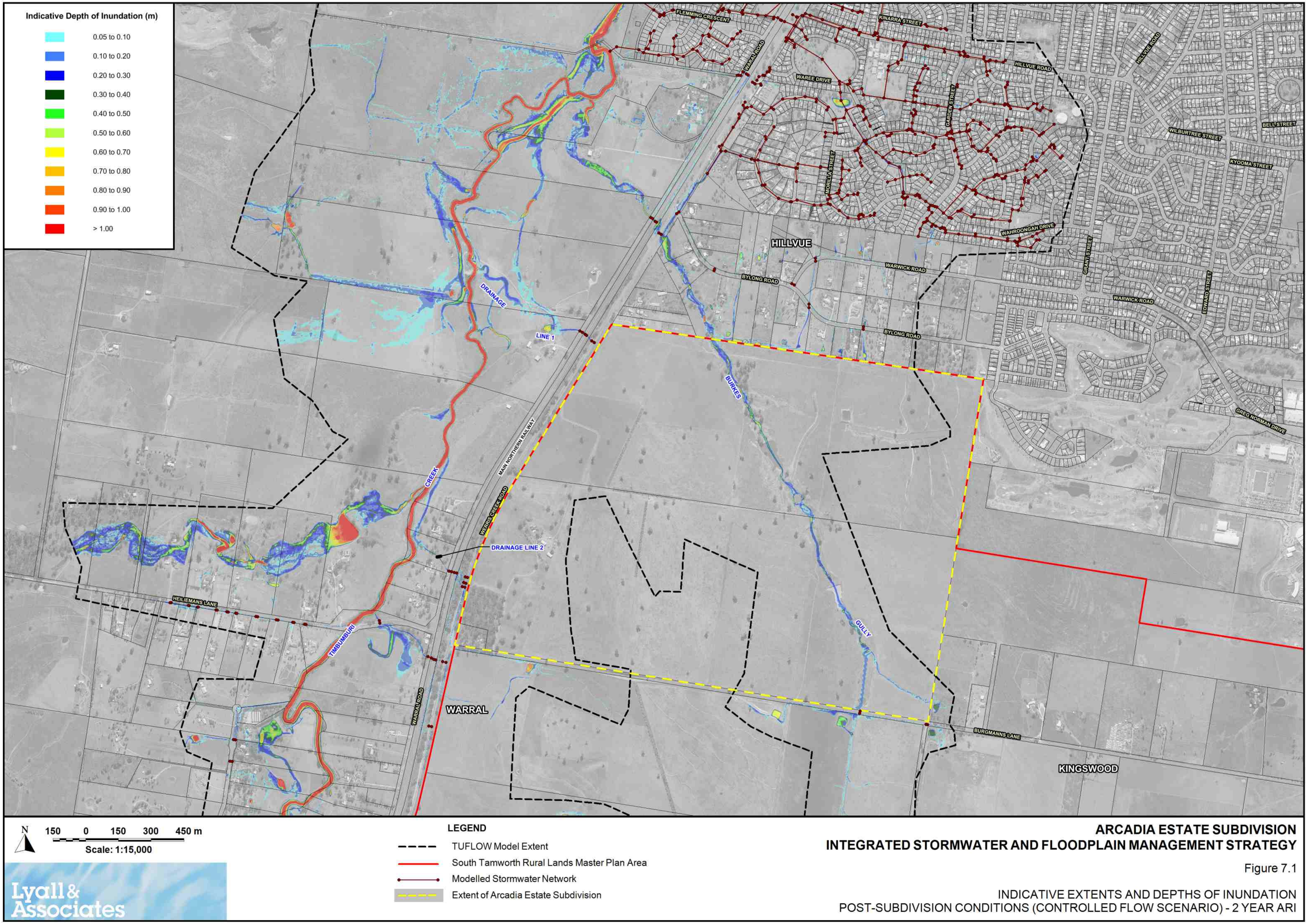
ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 6.6

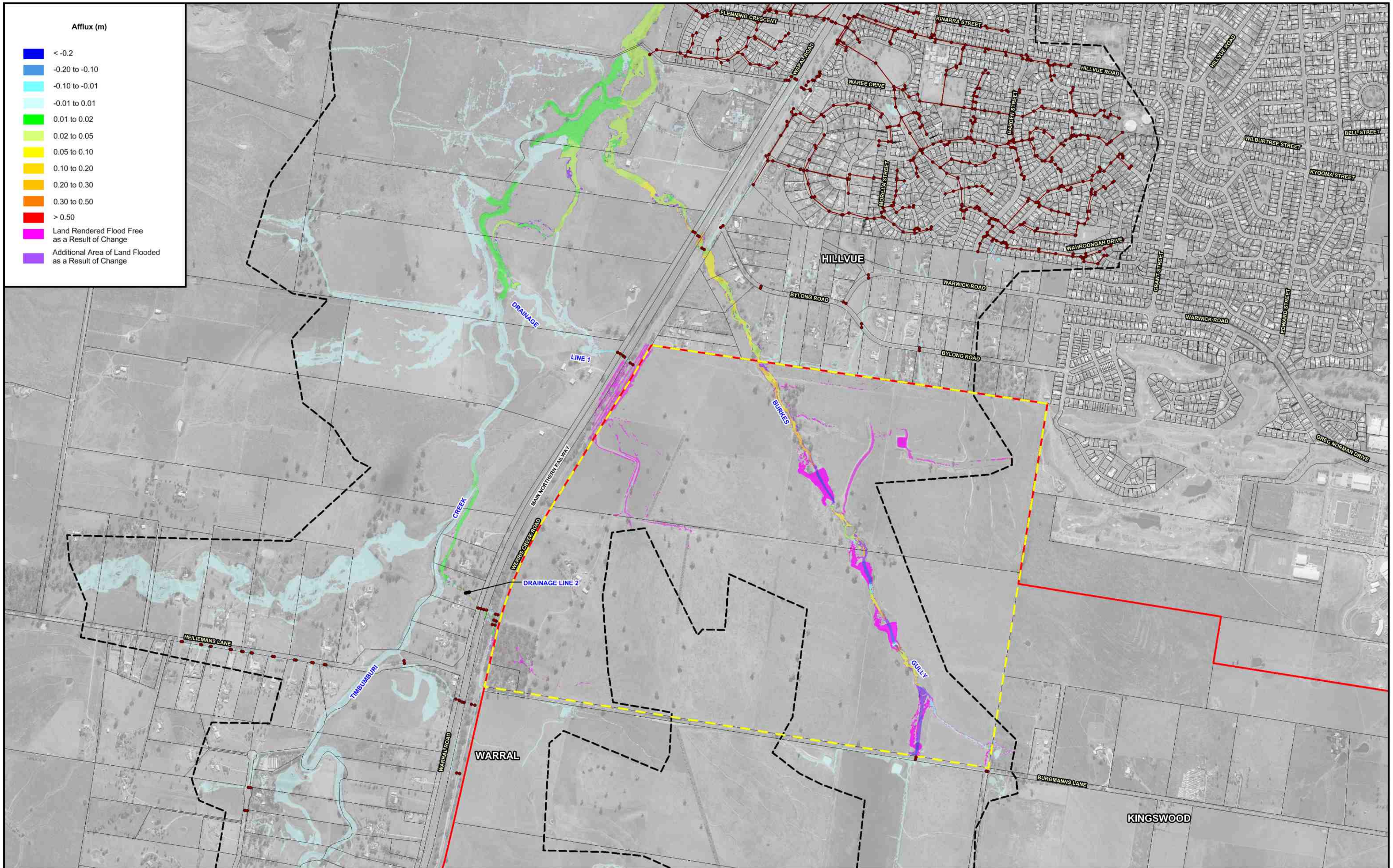
IMPACT OF PROPOSED SUBDIVISION DEVELOPMENT ON FLOODING BEHAVIOUR (UNCONTROLLED FLOW SCENARIO) - 100 YEAR ARI



ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 7.1

INDICATIVE EXTENTS AND DEPTHS OF INUNDATION
POST-SUBDIVISION CONDITIONS (CONTROLLED FLOW SCENARIO) - 2 YEAR ARI



N

150 0 150 150 450 m

Scale: 1:15,000

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LEGEND

TUFLOW Model Extent

South Tamworth Rural Lands Master Plan Area

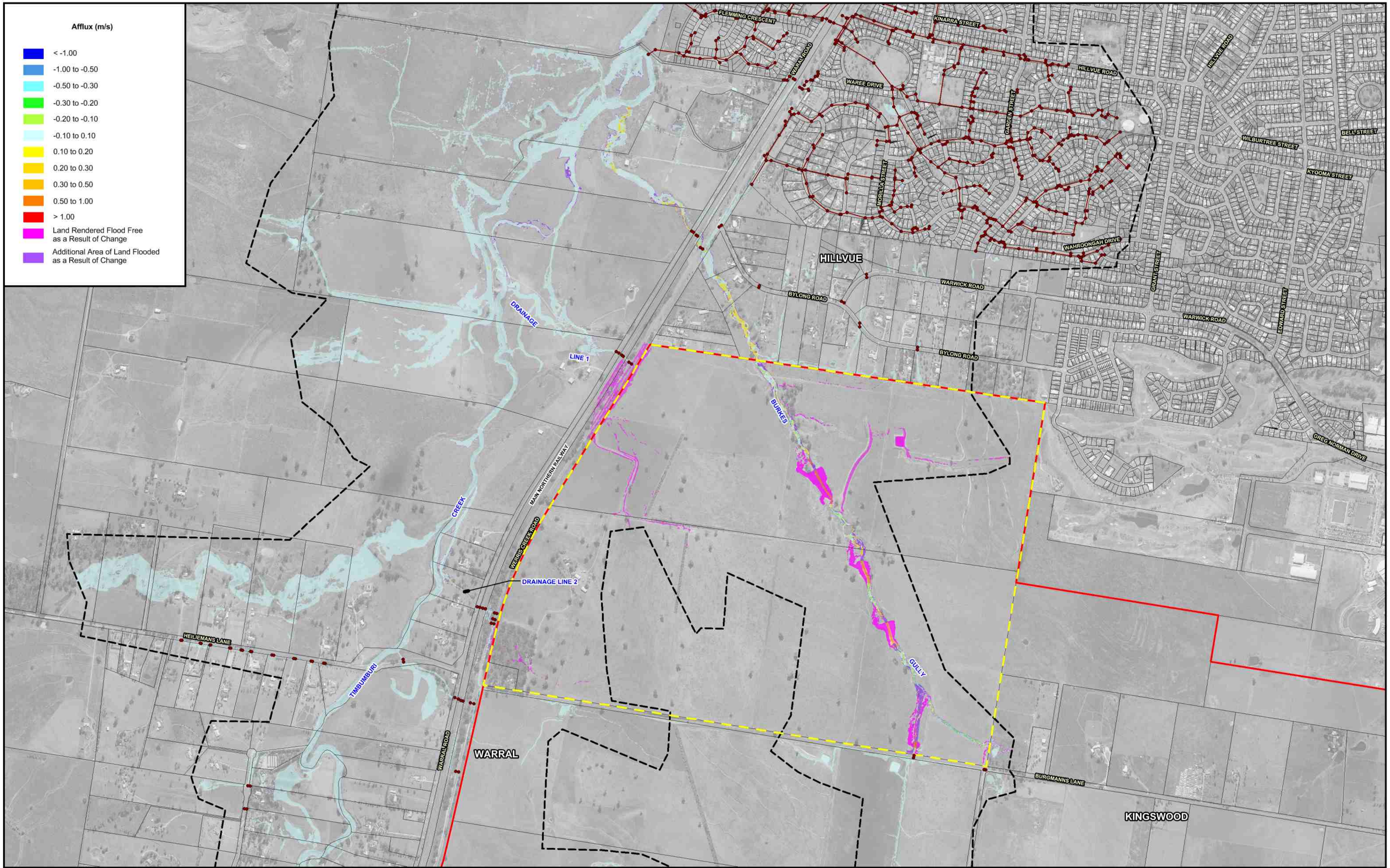
Modelled Stormwater Network

Extent of Arcadia Estate Subdivision

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 7.2

IMPACT OF PROPOSED SUBDIVISION DEVELOPMENT ON FLOODING BEHAVIOUR (CONTROLLED FLOW SCENARIO) - 2 YEAR ARI



120 0 120 240 360 m

Scale: 1:12,000

LEGEND

- TUFLOW Model Extent
- South Tamworth Rural Lands Master Plan Area
- Modelled Stormwater Network
- Extent of Arcadia Estate Subdivision

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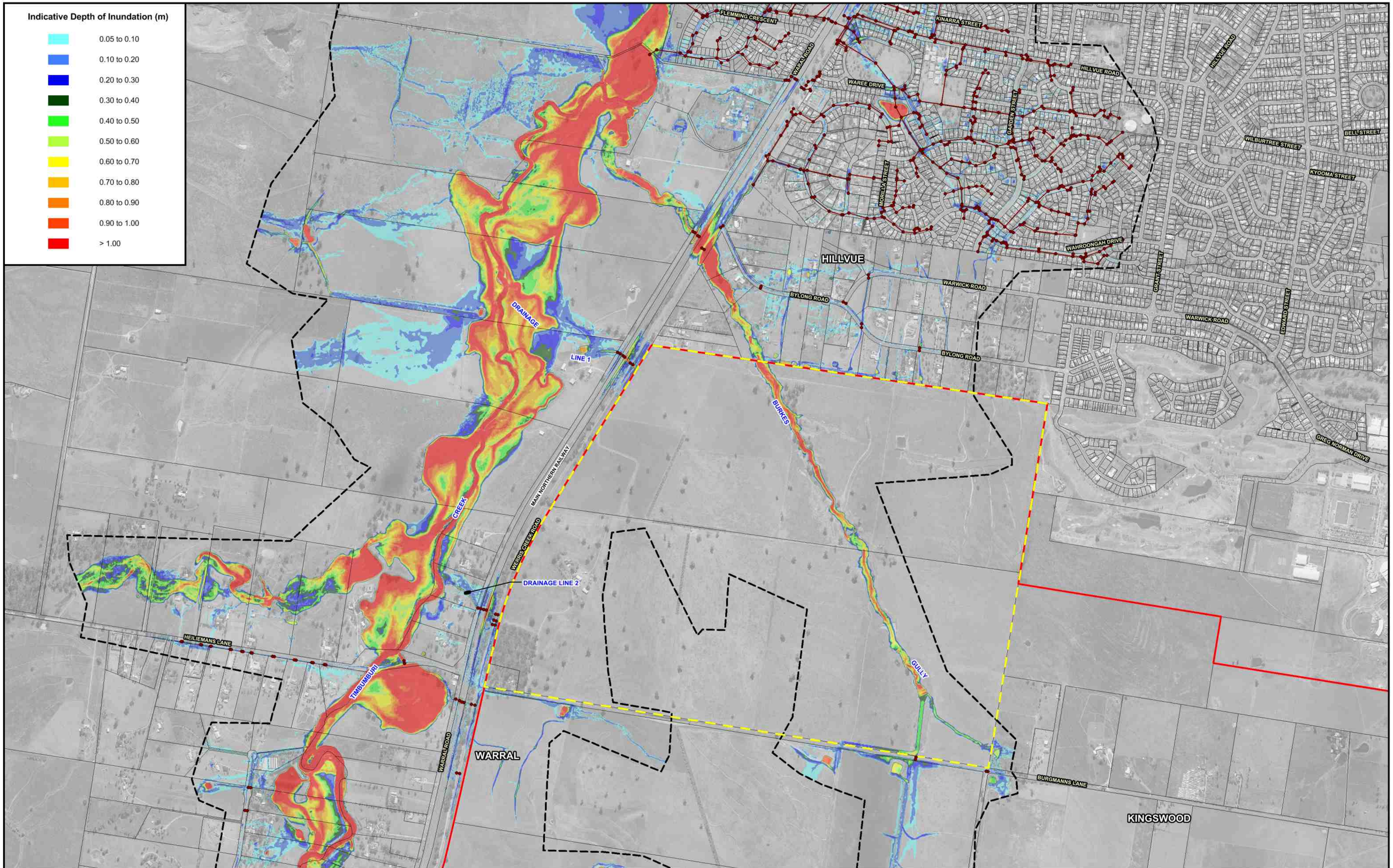
ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 7.3

IMPACT OF PROPOSED SUBDIVISION DEVELOPMENT ON FLOW VELOCITIES
(CONTROLLED FLOW SCENARIO) - 2 YEAR ARI



N

150 0 150 300 450 m

Scale: 1:15,000

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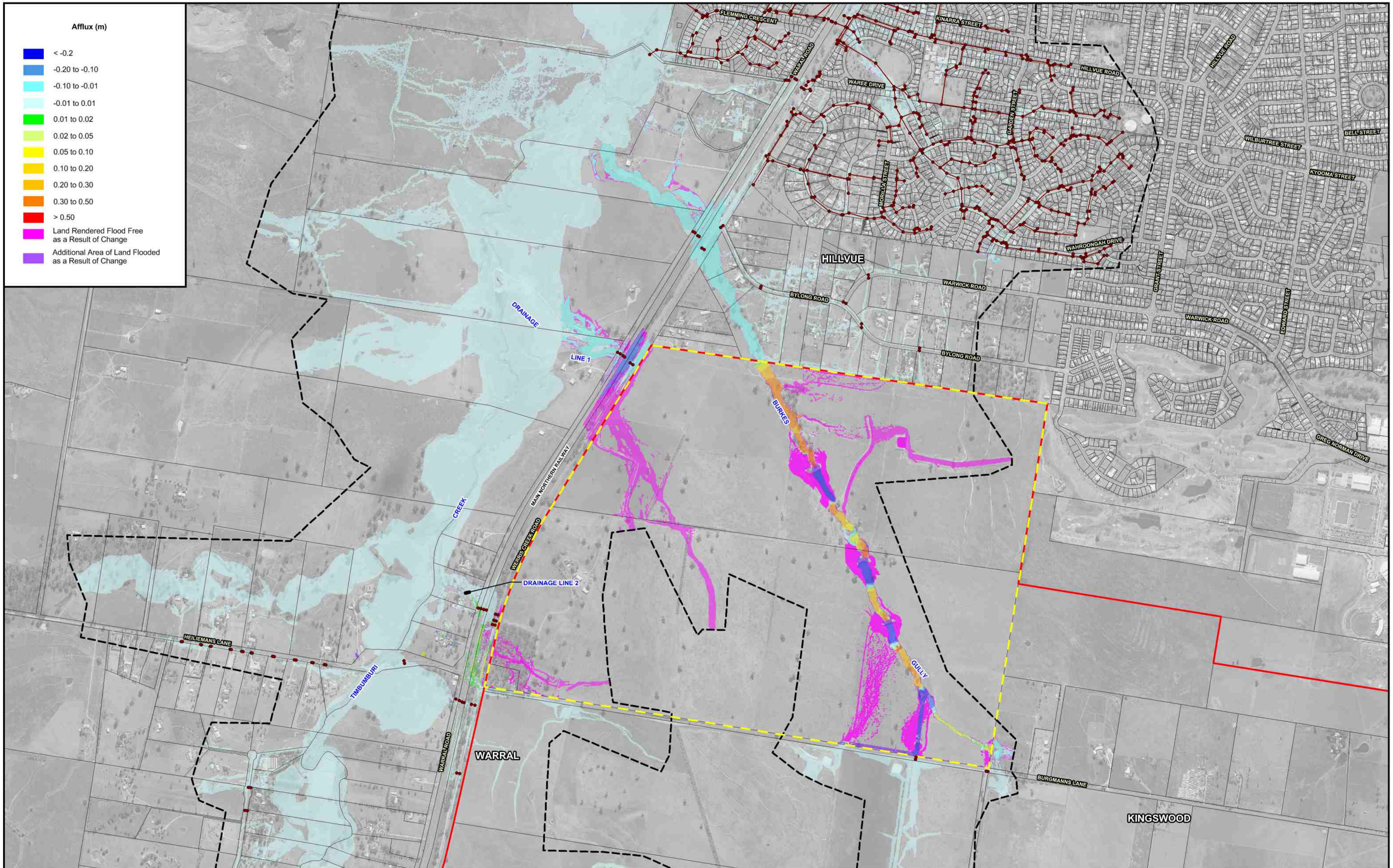
LEGEND

- TUFLOW Model Extent
- South Tamworth Rural Lands Master Plan Area
- Modelled Stormwater Network
- Extent of Arcadia Estate Subdivision

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 7.4

INDICATIVE EXTENTS AND DEPTHS OF INUNDATION
POST-SUBDIVISION CONDITIONS (CONTROLLED FLOW SCENARIO) - 100 YEAR ARI



N

150 0 150 150 450 m

Scale: 1:15,000

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LEGEND

TUFLOW Model Extent

South Tamworth Rural Lands Master Plan Area

Modelled Stormwater Network

Extent of Arcadia Estate Subdivision

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure 7.5

IMPACT OF PROPOSED SUBDIVISION DEVELOPMENT ON FLOODING BEHAVIOUR (CONTROLLED FLOW SCENARIO) - 100 YEAR ARI

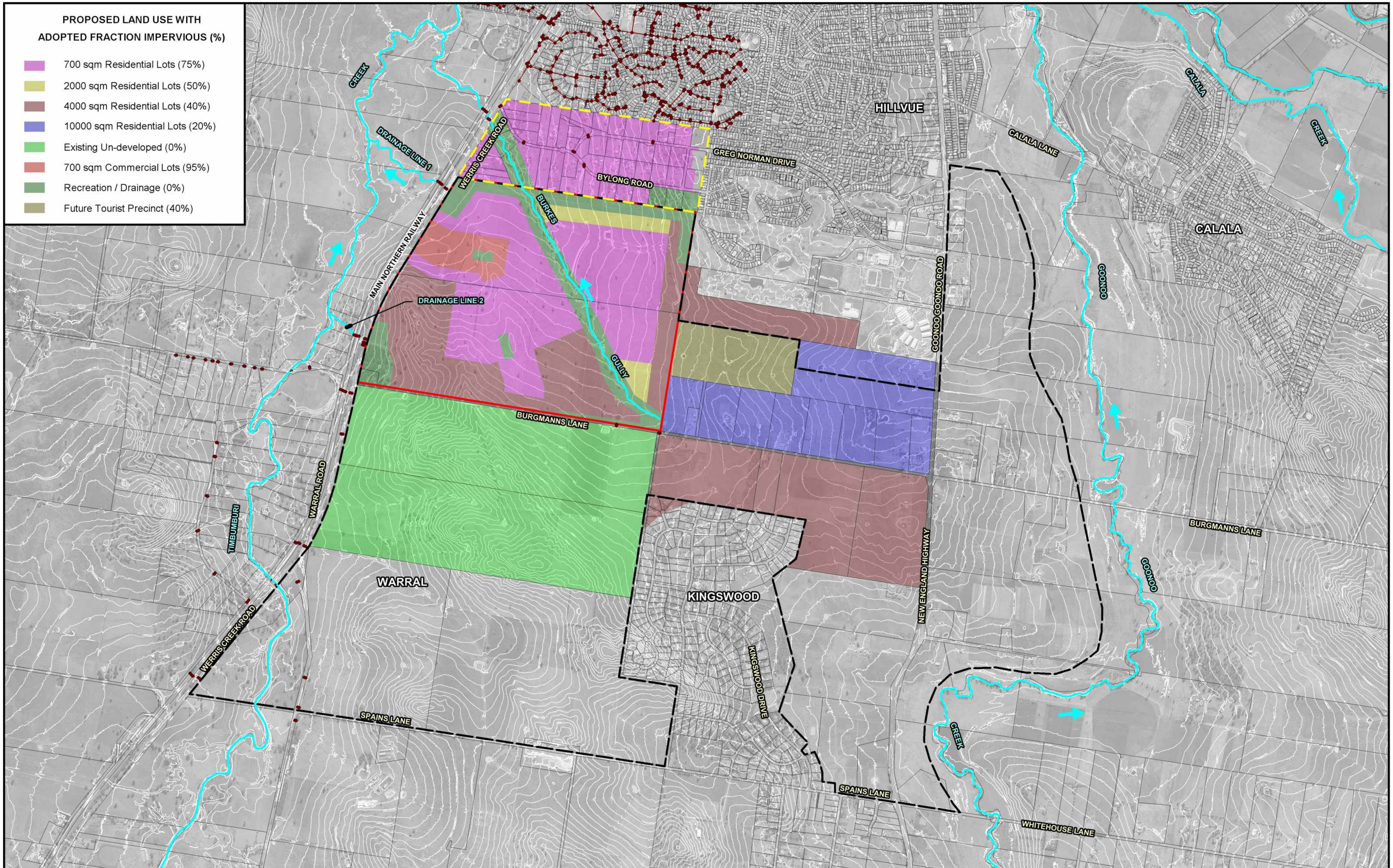
APPENDIX A

ASSESSMENT OF ONLINE VERSUS OFFLINE DETENTION BASIN STRATEGIES

LIST OF FIGURES

A1.1 Adopted Future Land-Use and Fraction Impervious Values
A1.2 Detention Basin Strategy Scenario 1
A1.3 Detention Basin Strategy Scenario 2
A1.4 Detention Basin Strategy Scenario 3
A1.5 Detention Basin Strategy Scenario 4

A3.1 Design Discharge Hydrographs Along Burkes Gully – Pre- versus Post-Developed Conditions



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LEGEND

Modelled Stormwater Network

Extent of Bylong Road Subdivision

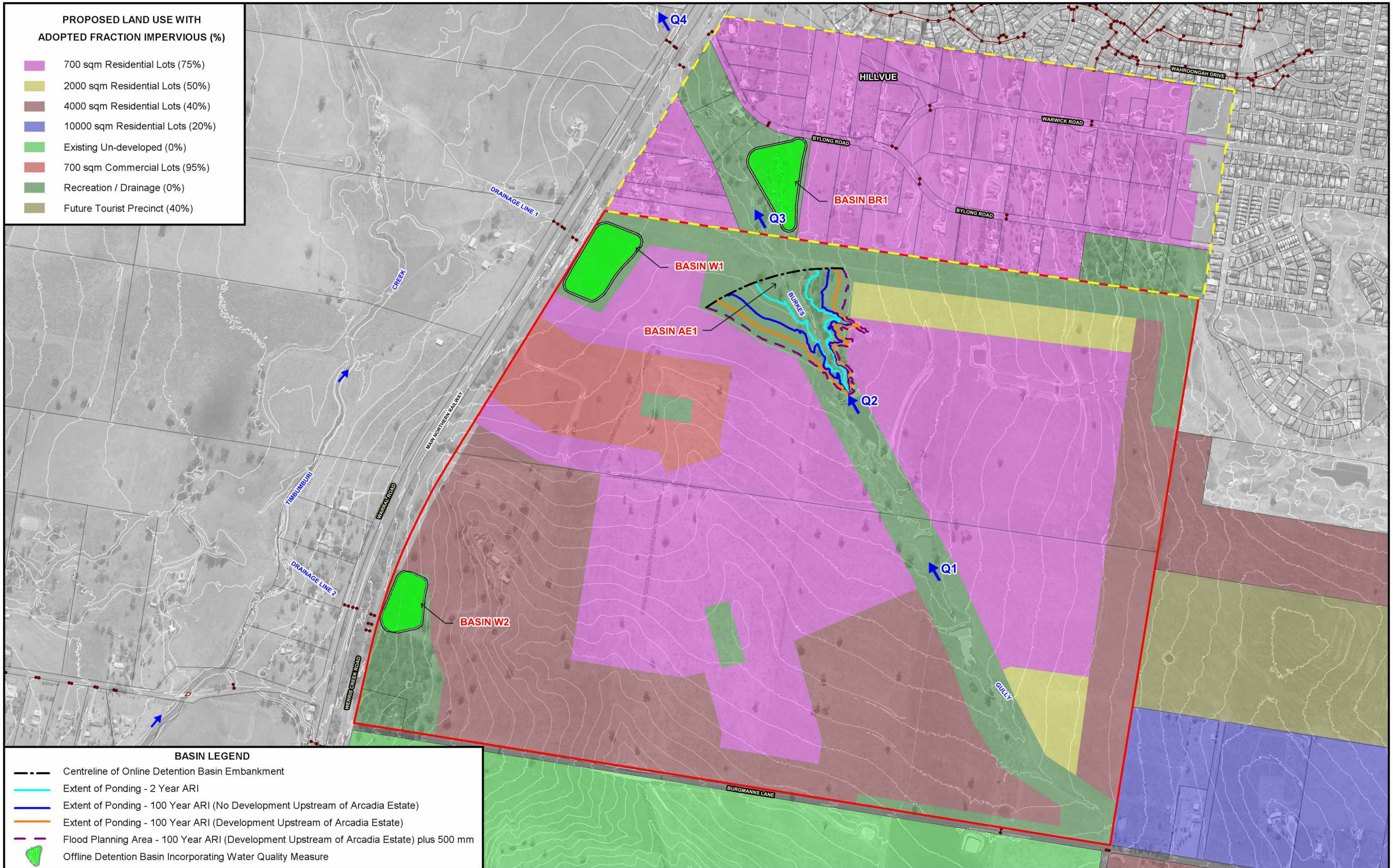
Extent of Arcadia Estate Subdivision

South Tamworth Rural Lands Master Plan Area

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure A1.1

ADOPTED FUTURE LAND-USE AND FRACTION IMPERVIOUS VALUES



N 100 0 100 200 300 m

Scale: 1:10,000

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LEGEND

Existing Stormwater Network

Extent of Bylong Road Subdivision

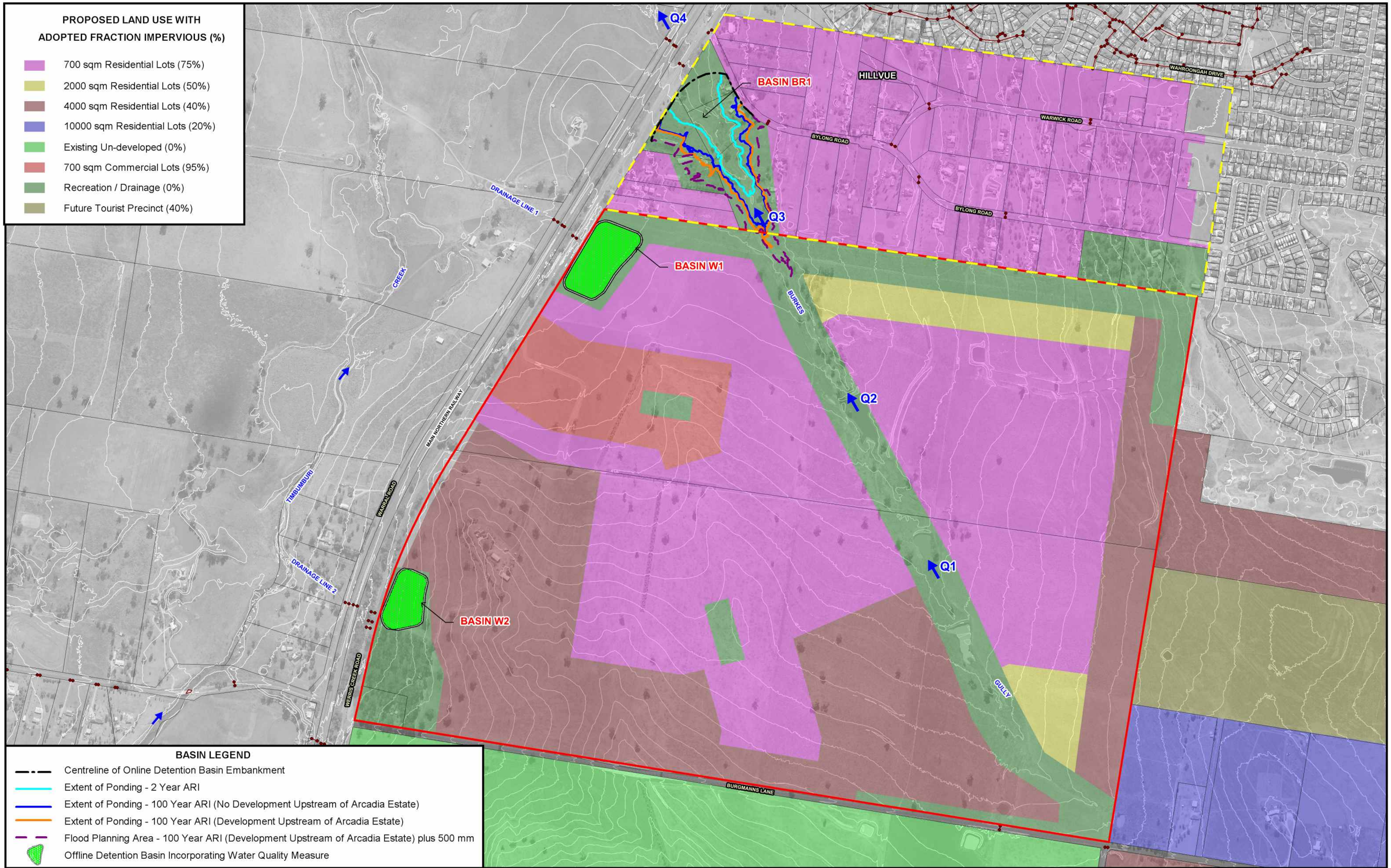
Extent of Arcadia Estate Subdivision

Q1 Peak Flow Location and Identifier
(Refer Table A3.1 in Appendix A for Values)

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure A1.2

DETENTION BASIN STRATEGY SCENARIO 1



N 100 0 100 200 300 m

Scale: 1:10,000

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LEGEND

Existing Stormwater Network

Extent of Bylong Road Subdivision

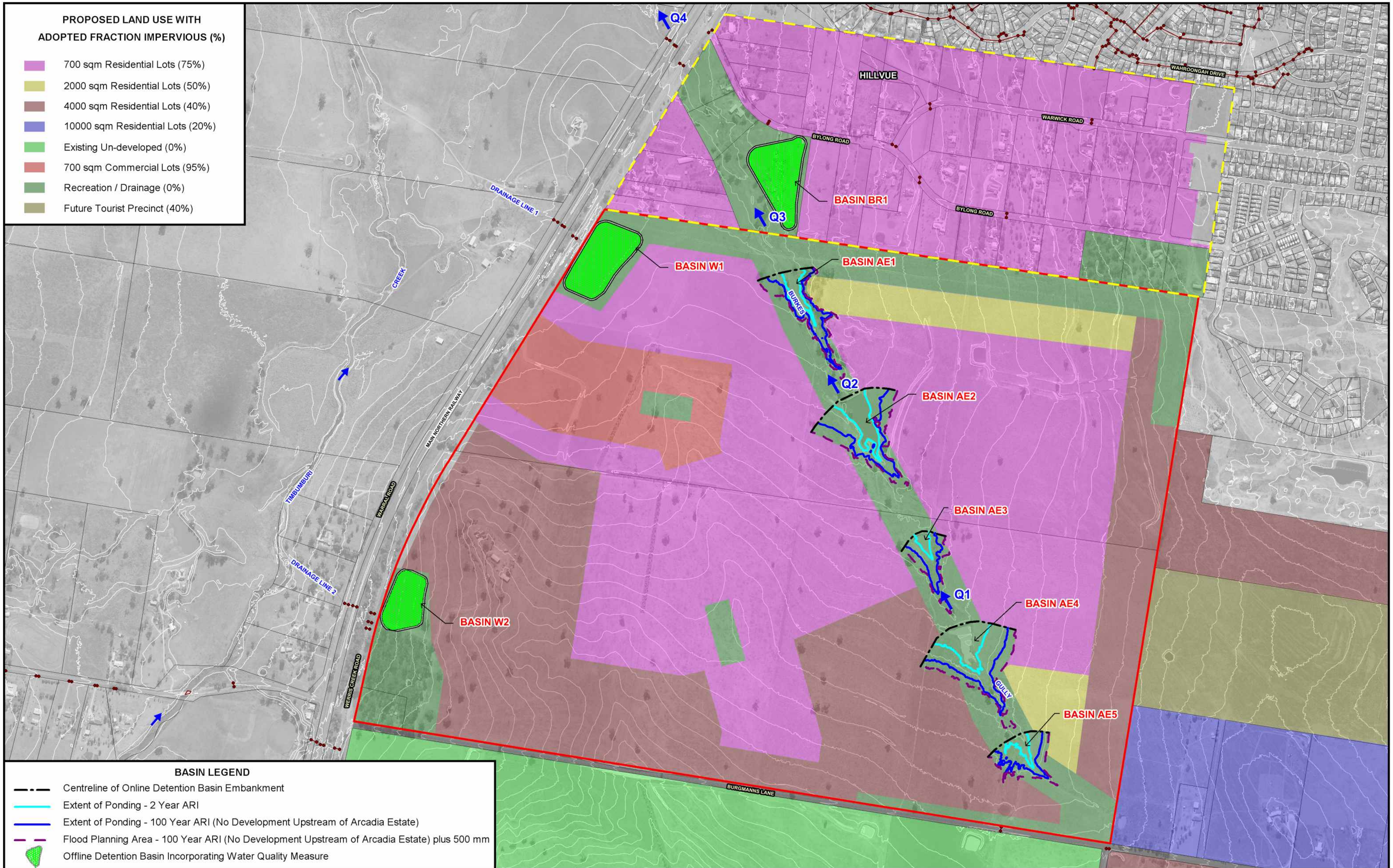
Extent of Arcadia Estate Subdivision

Q1 Peak Flow Location and Identifier
(Refer Table A3.1 in Appendix A for Values)

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure A1.3

DETENTION BASIN STRATEGY SCENARIO 2



N
100 0 100 200 300 m
Scale: 1:10,000

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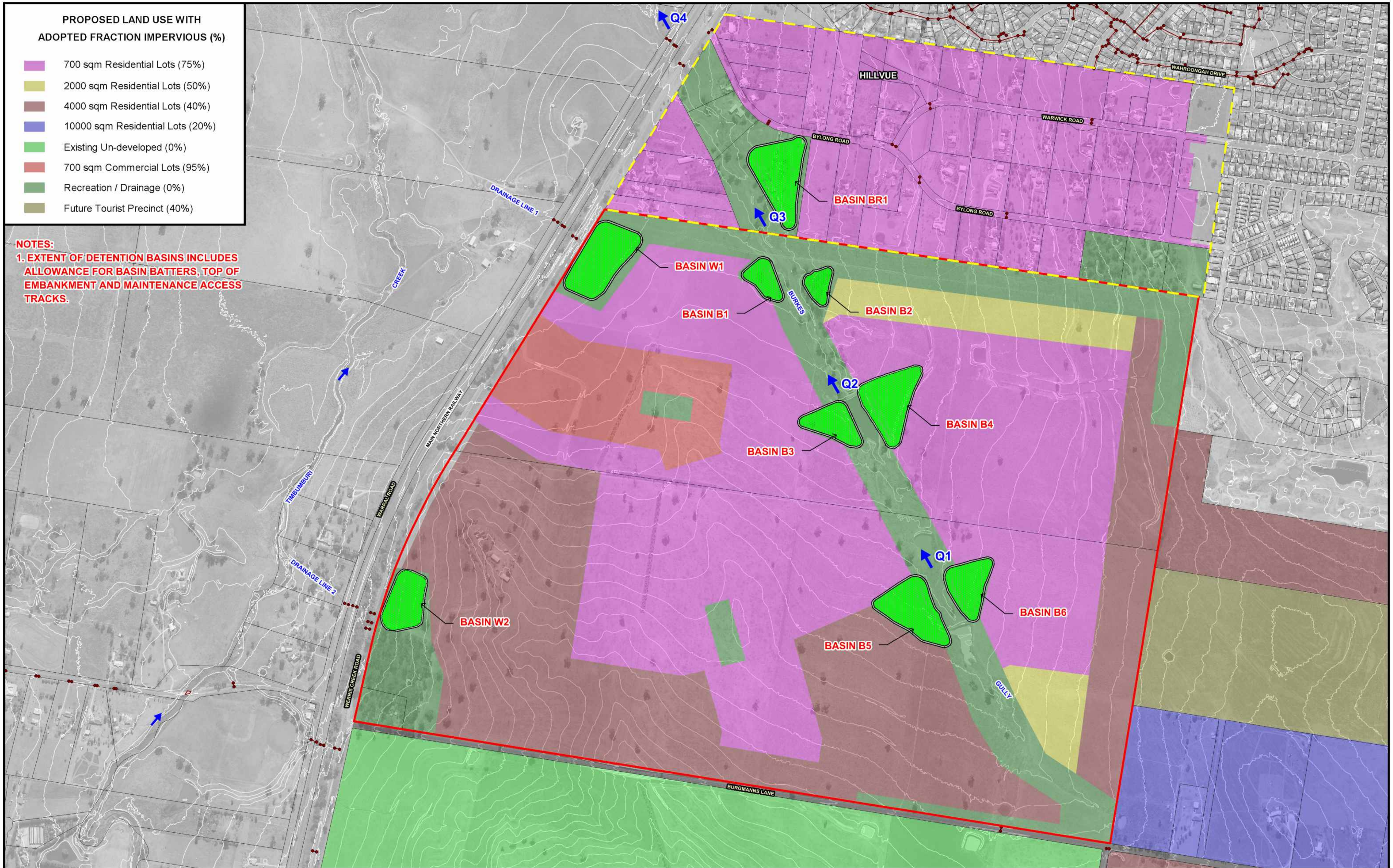
LEGEND
- Existing Stormwater Network
- Extent of Bylong Road Subdivision
- Extent of Arcadia Estate Subdivision
- Q1 Peak Flow Location and Identifier (Refer Table A3.1 in Appendix A for Values)

ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure A1.4

DETENTION BASIN STRATEGY SCENARIO 3



N
100 0 100 200 300 m
Scale: 1:10,000

LEGEND

- Existing Stormwater Network
- Extent of Bylong Road Subdivision
- Extent of Arcadia Estate Subdivision
- Offline Detention Basin Incorporating Water Quality Measures
- Q1 Peak Flow Location and Identifier (Refer Table A3.1 in Appendix A for Values)

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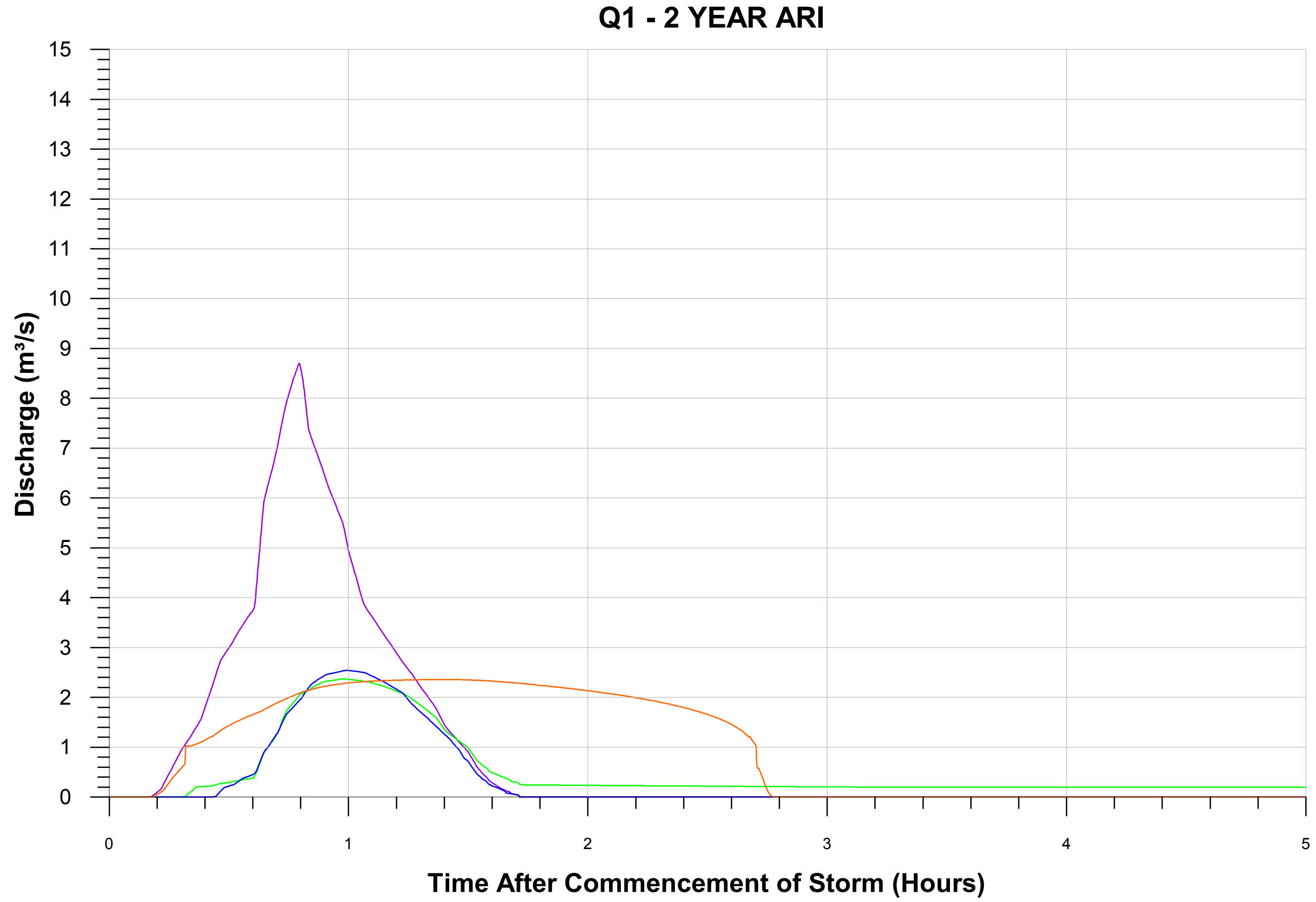
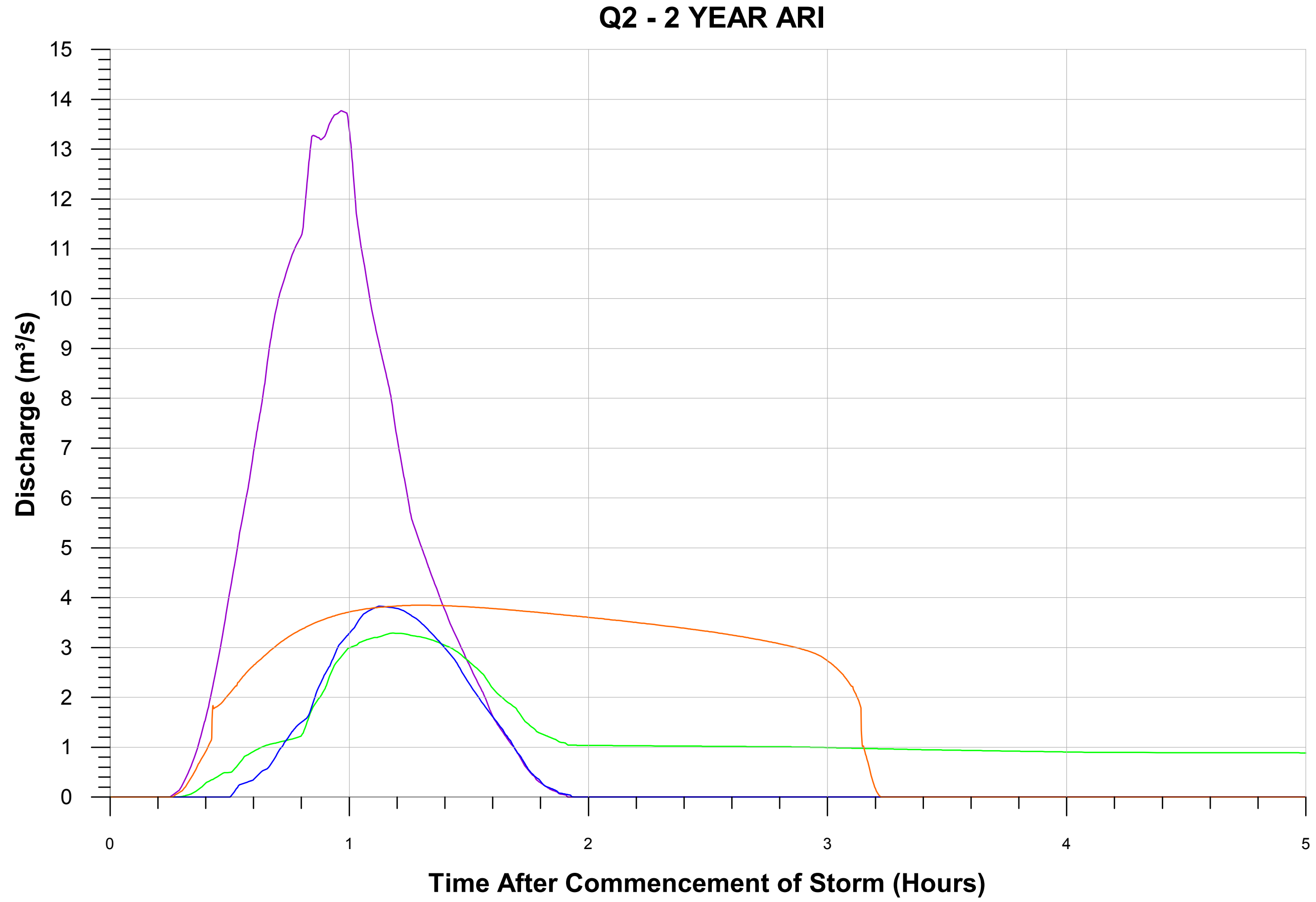
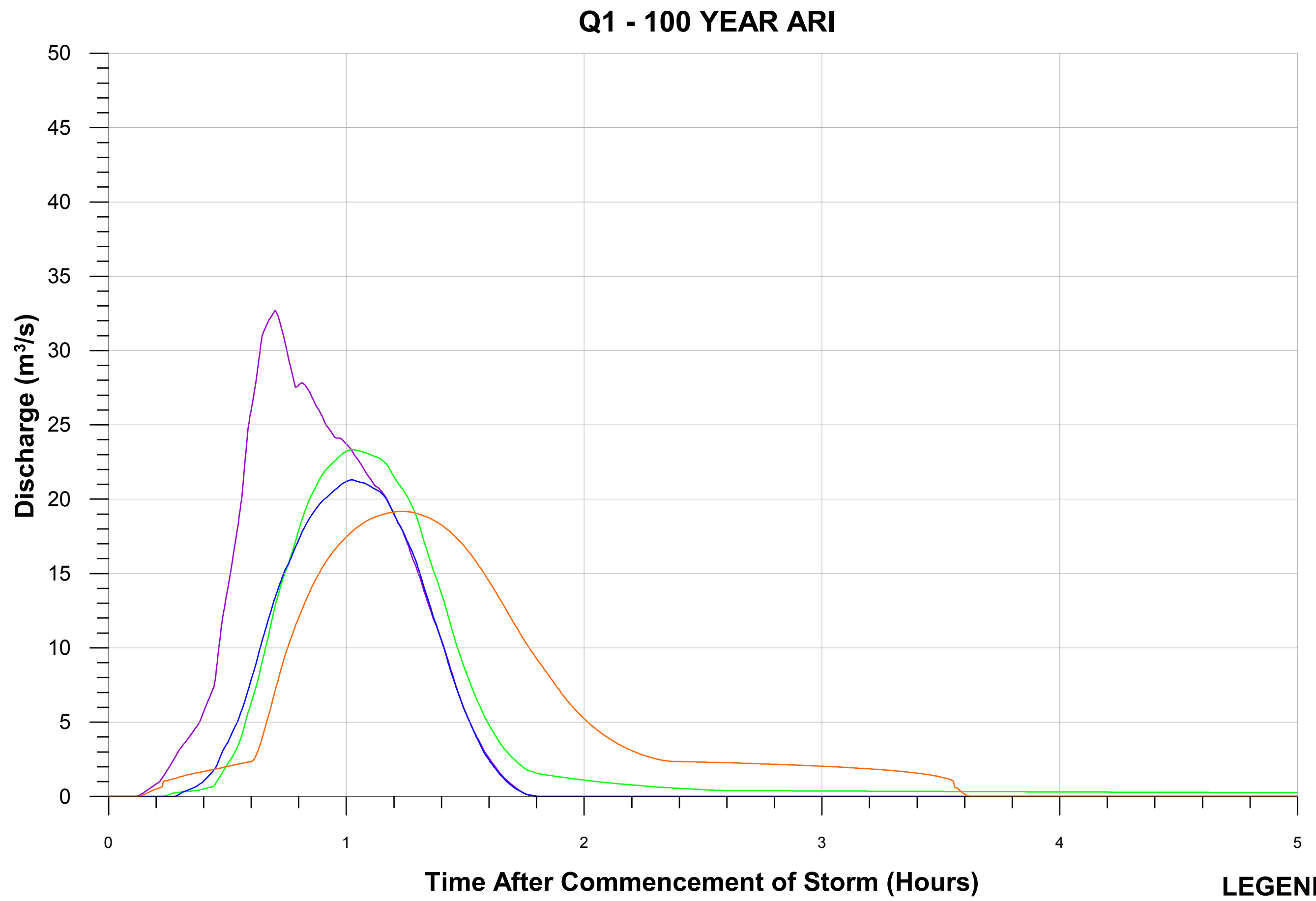
ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

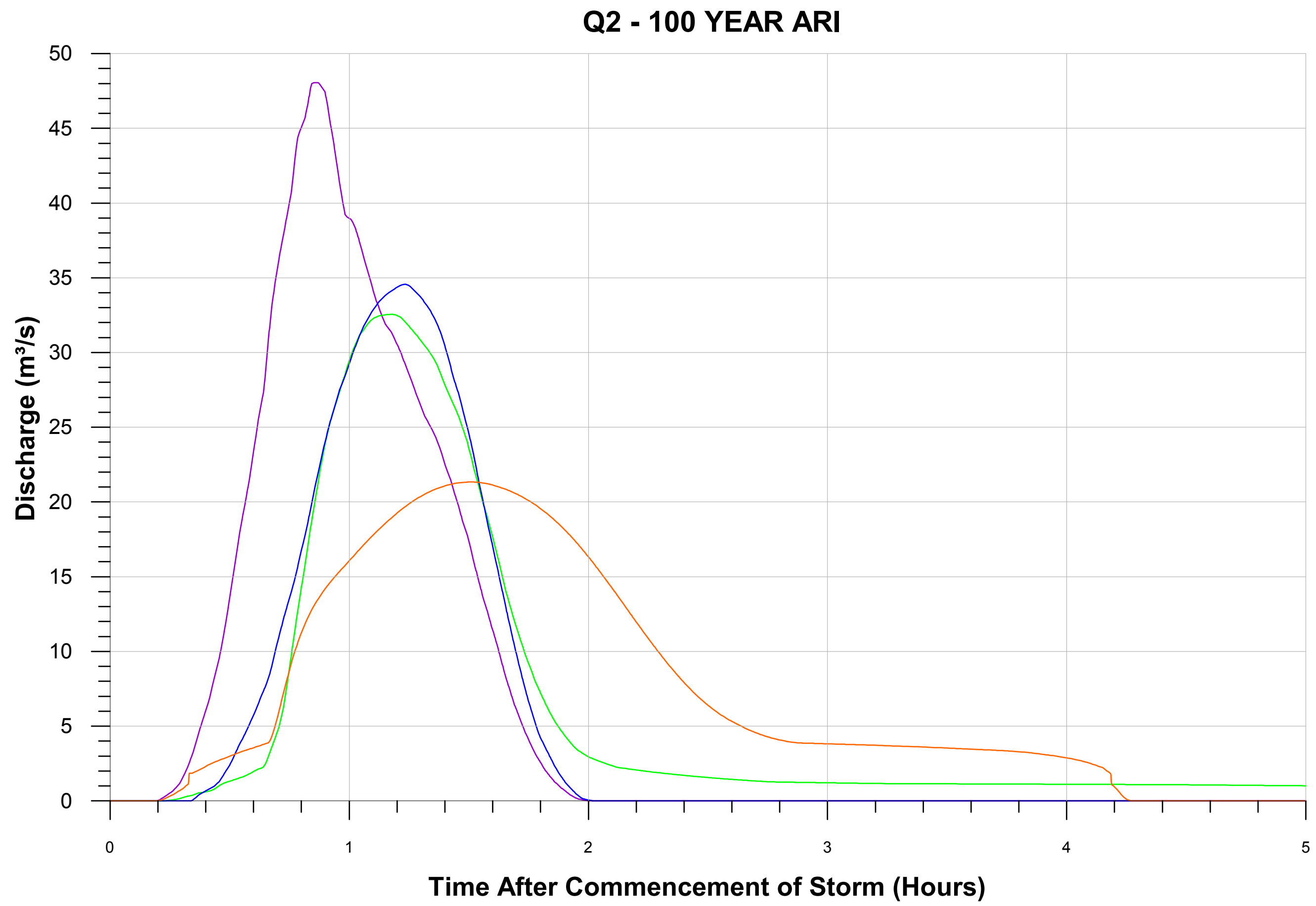
Figure A1.5

DETENTION BASIN STRATEGY SCENARIO 4









LEGEND

- Present Day Conditions
- Detention Basin Strategy Scenario 1
- Detention Basin Strategy Scenario 3
- Detention Basin Strategy Scenario 4

NOTE: Discharge hydrographs for Scenarios 1 and 2 are identical at locations Q1 and Q2.

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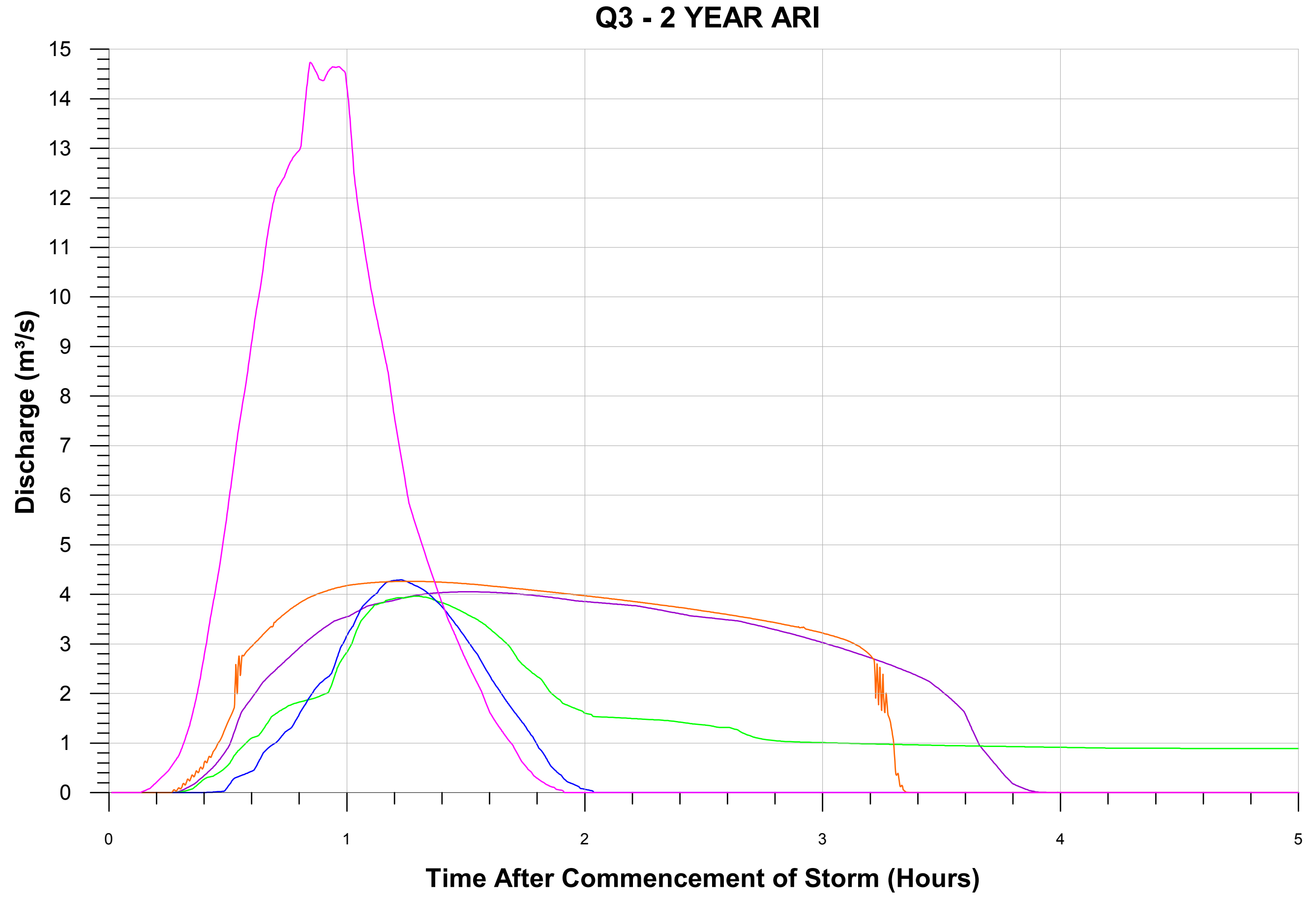
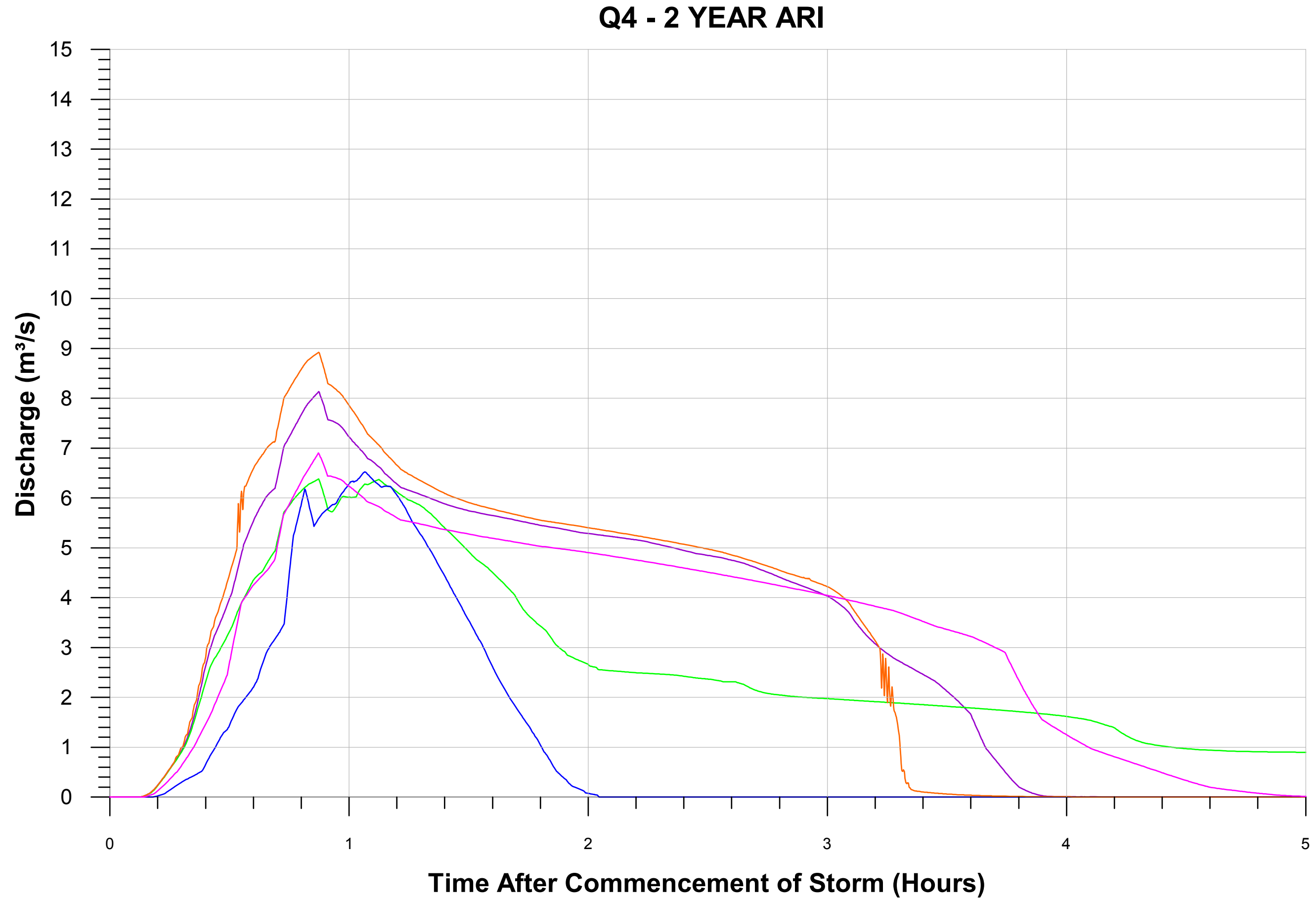
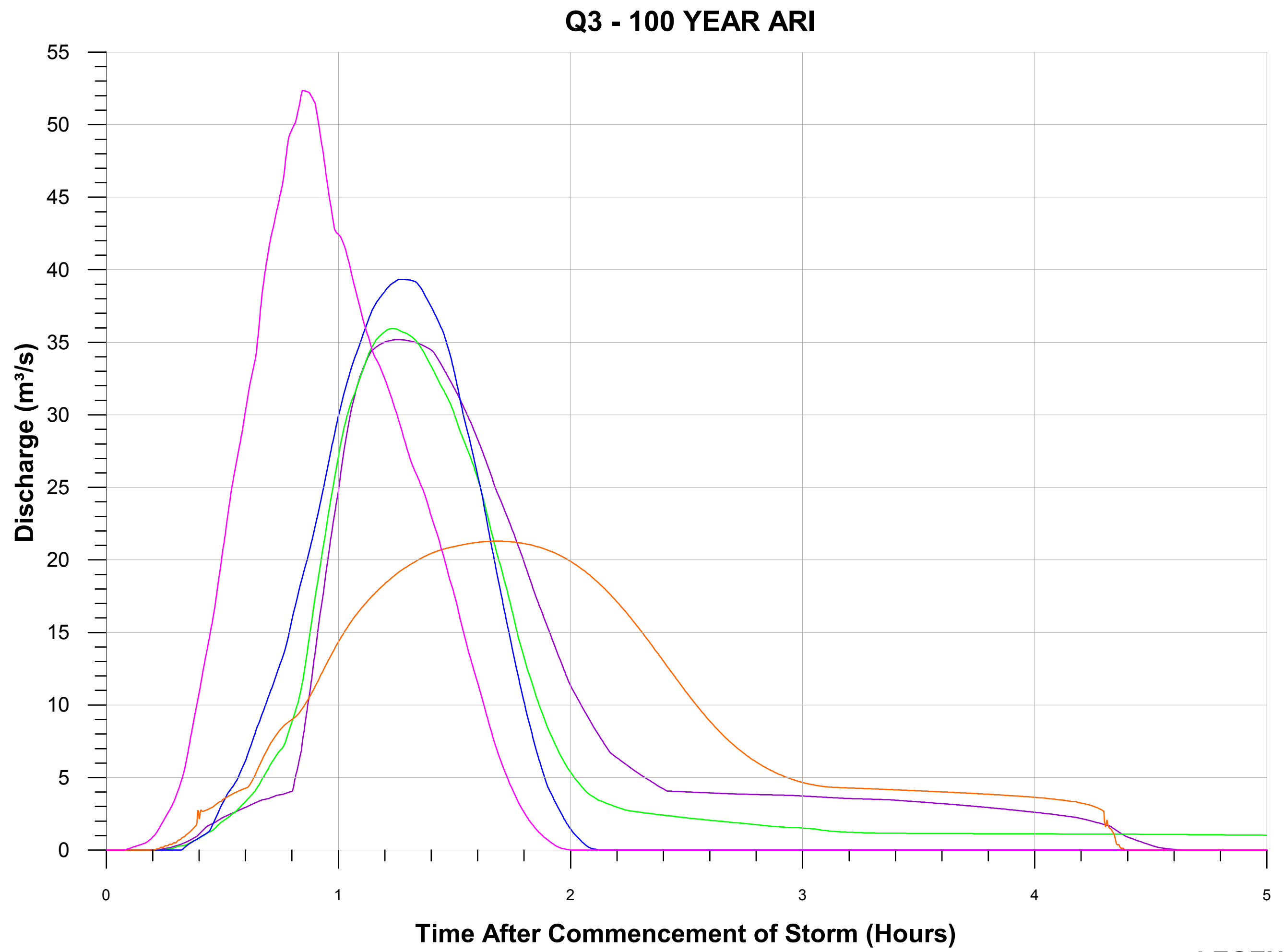
ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

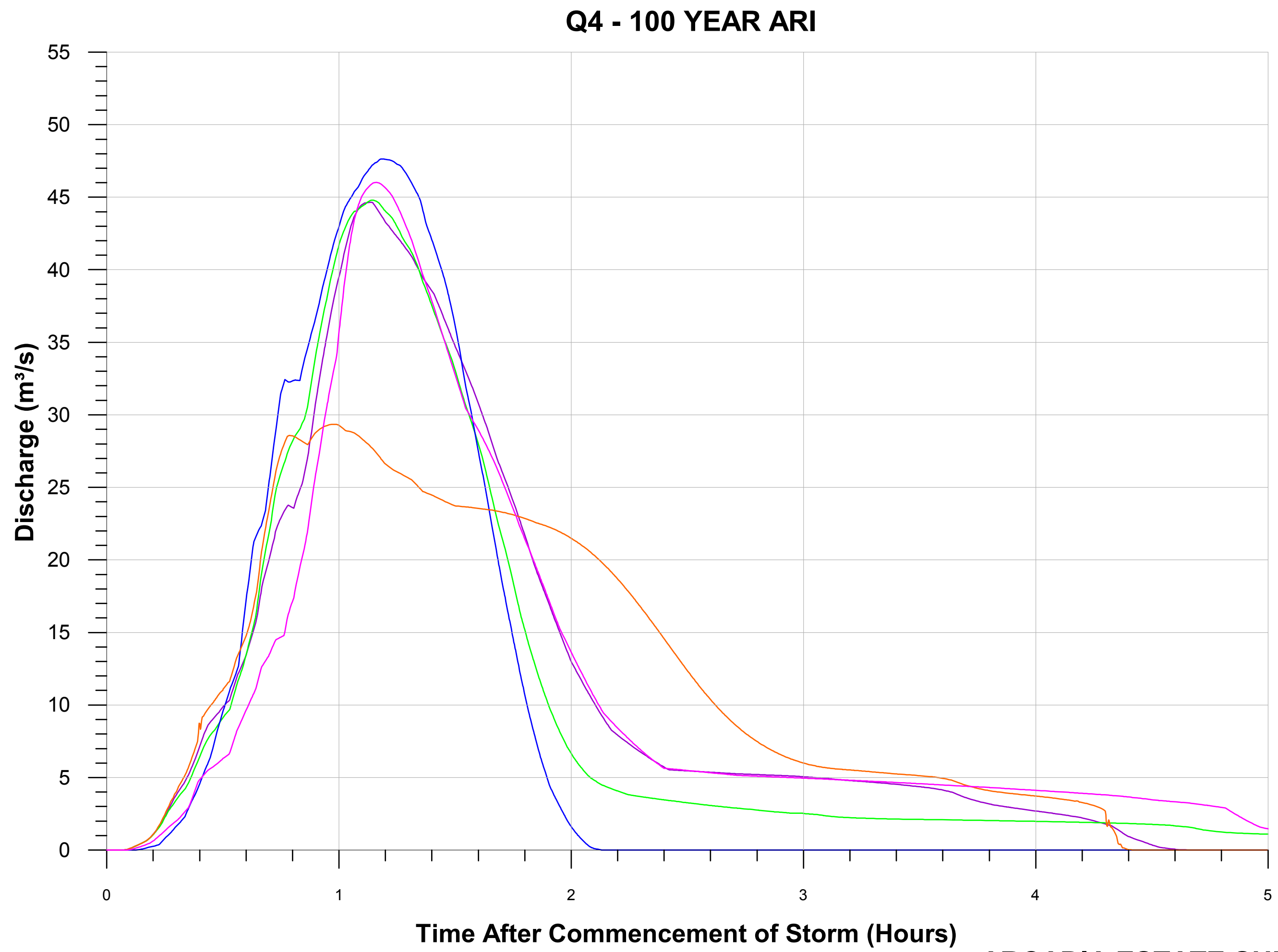
Figure A3.1
(Sheet 1 of 2)

DESIGN DISCHARGE HYDROGRAPHS ALONG BURKES GULLY
PRE- VERSUS POST-DEVELOPED CONDITIONS









LEGEND

- Present Day Conditions
- Detention Basin Strategy Scenario 1
- Detention Basin Strategy Scenario 2
- Detention Basin Strategy Scenario 3
- Detention Basin Strategy Scenario 4

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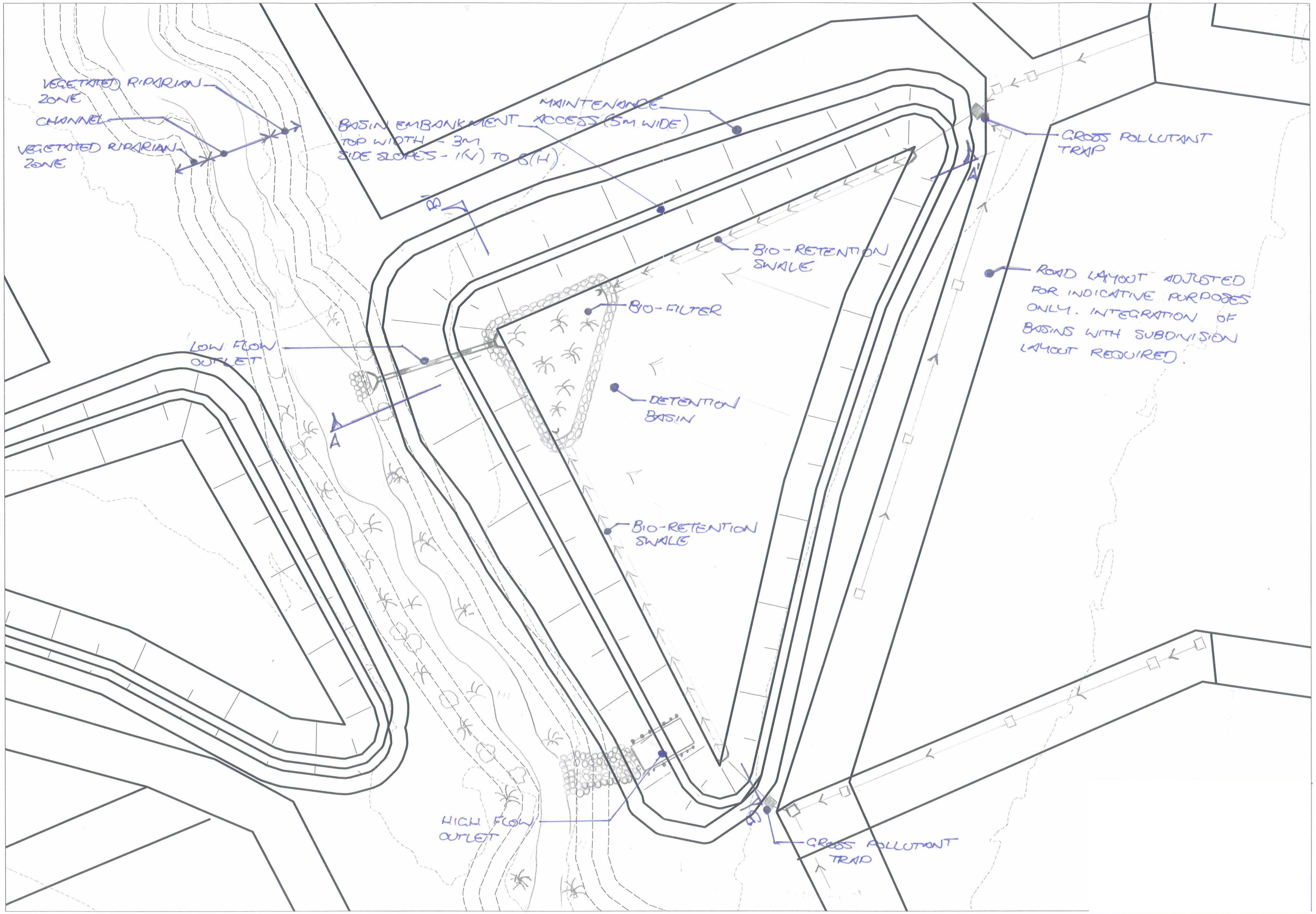
ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure A3.1
(Sheet 2 of 2)

DESIGN DISCHARGE HYDROGRAPHS ALONG BURKES GULLY
PRE- VERSUS POST-DEVELOPED CONDITIONS

APPENDIX B

SKETCHES SHOWING CONCEPT LAYOUT OF PROPOSED DETENTION BASINS



ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

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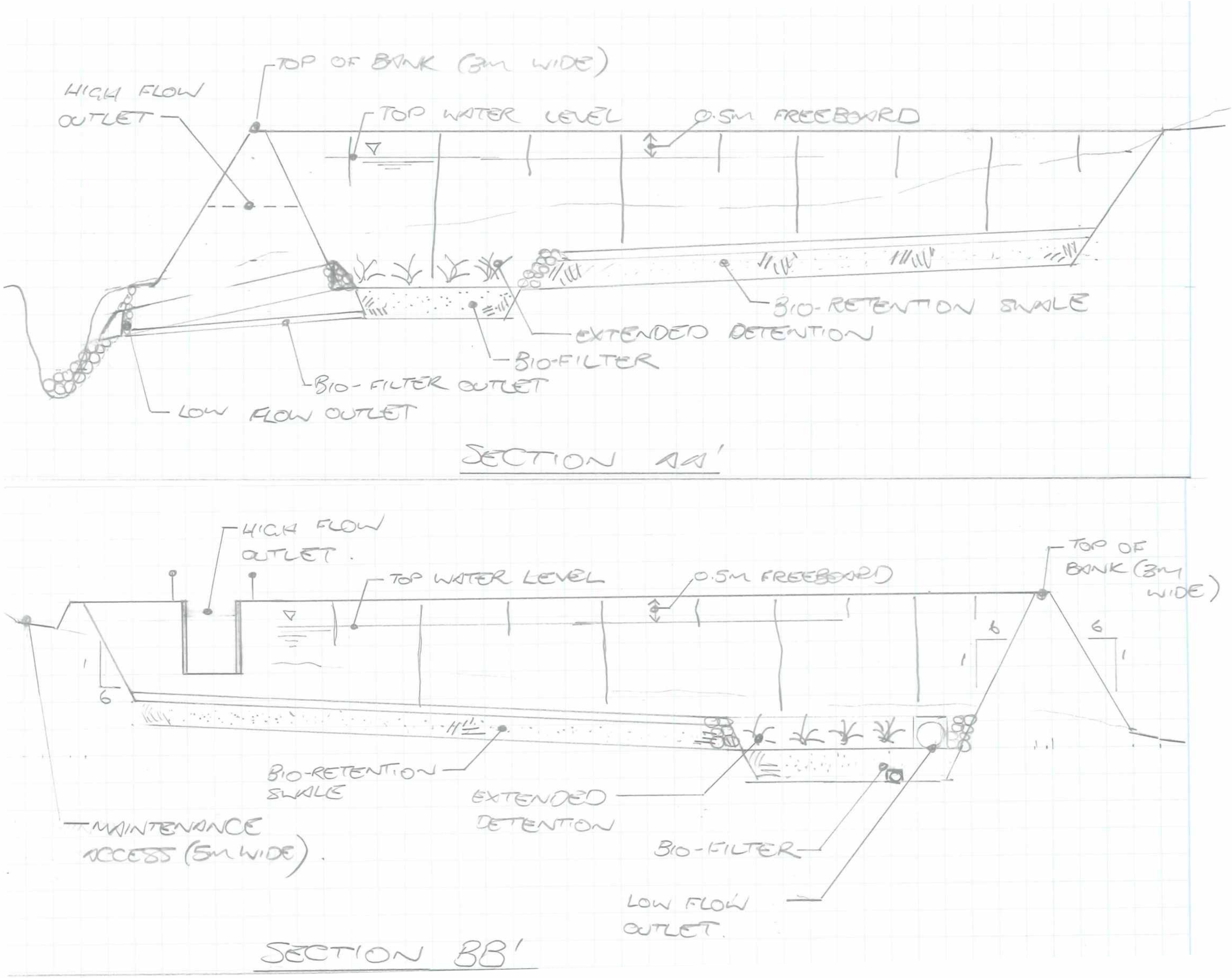
Figure B1

TYPICAL DETENTION BASIN LAYOUT



ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

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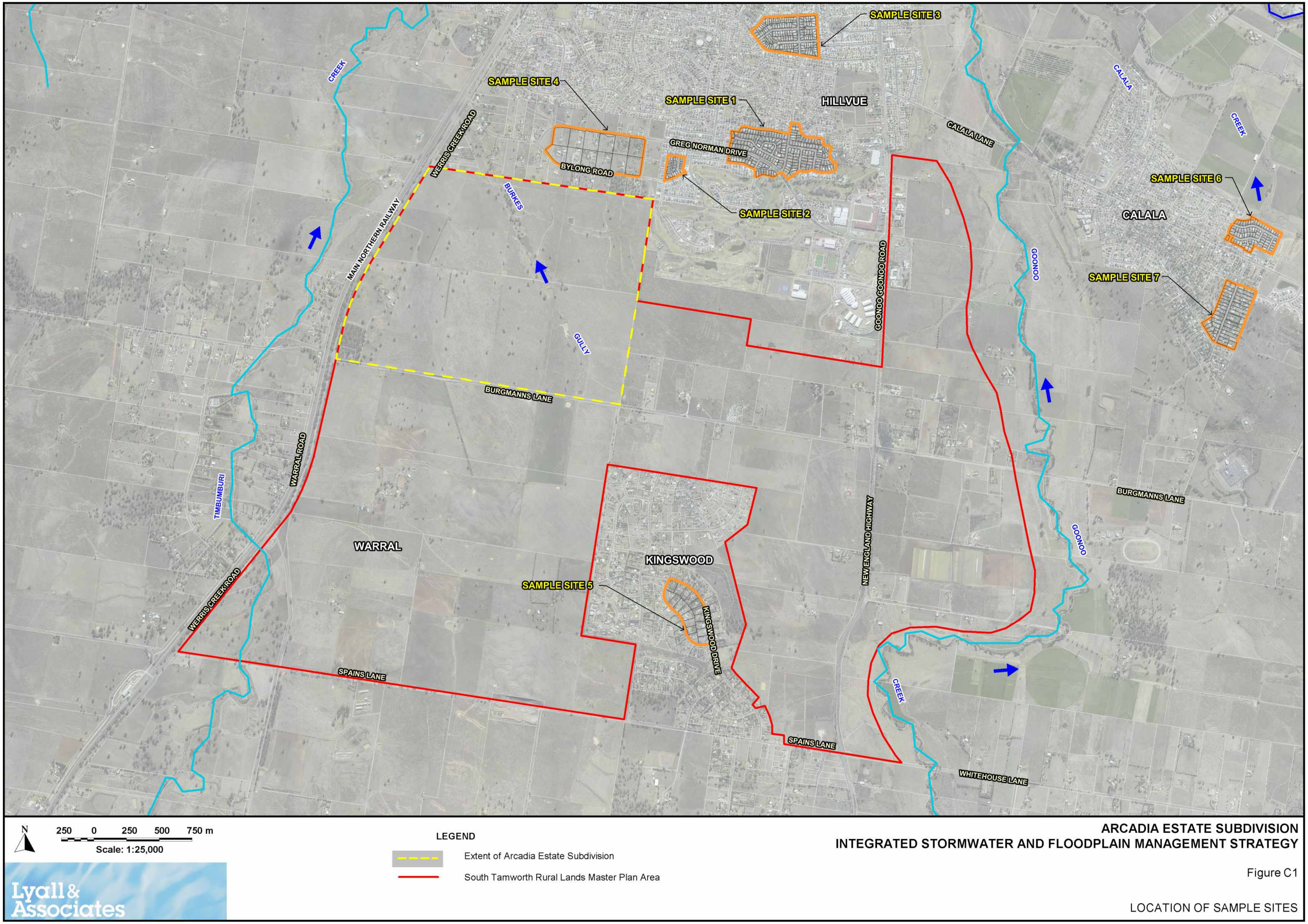
Figure B2

TYPICAL DETENTION BASIN SECTIONS

APPENDIX C

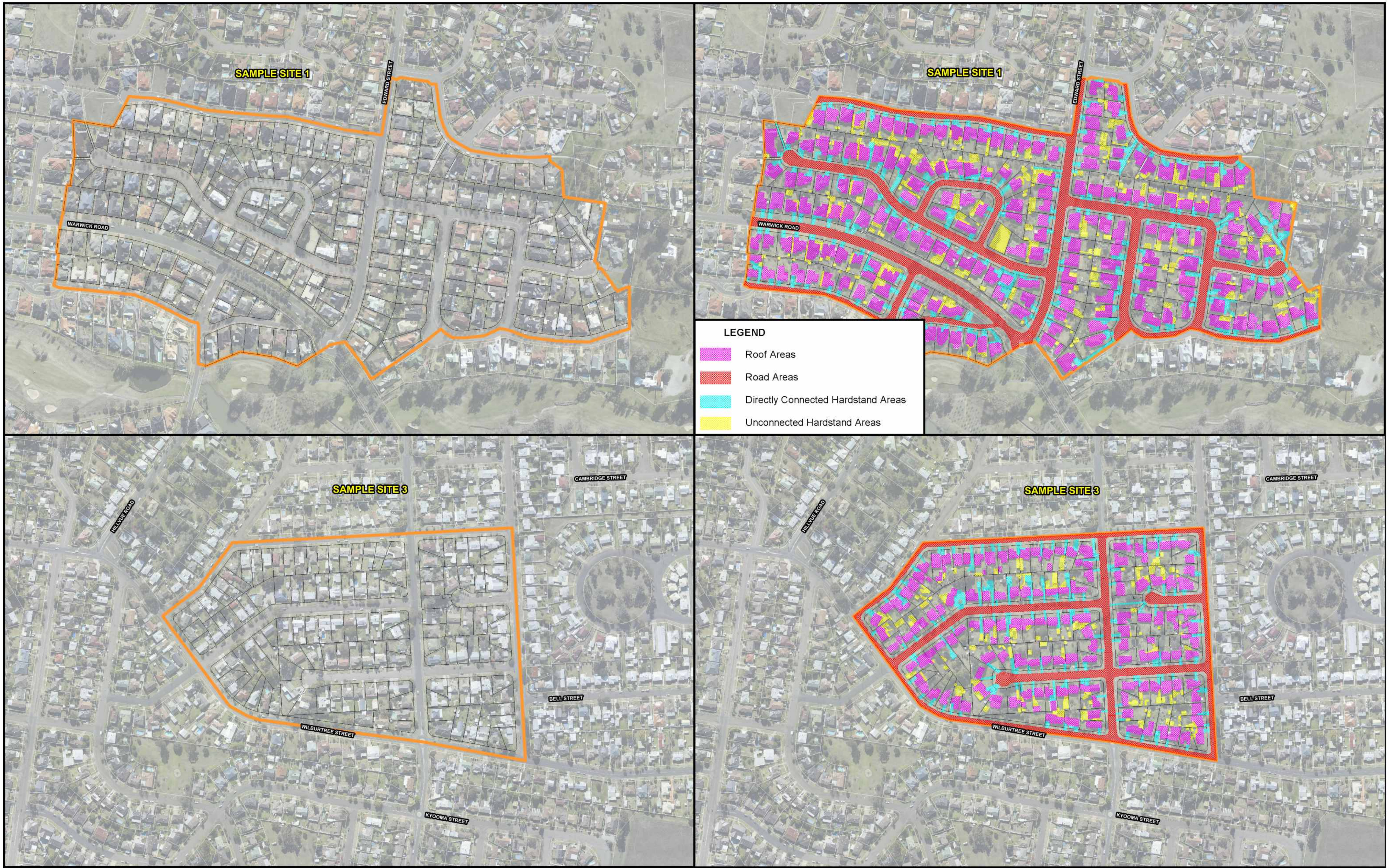
FIGURES SHOWING SAMPLE SITES ADOPTED FOR FRACTION IMPERVIOUS CALCULATIONS



ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure C1

LOCATION OF SAMPLE SITES



N
50 0 50 100 150 m
Scale: 1:5,000

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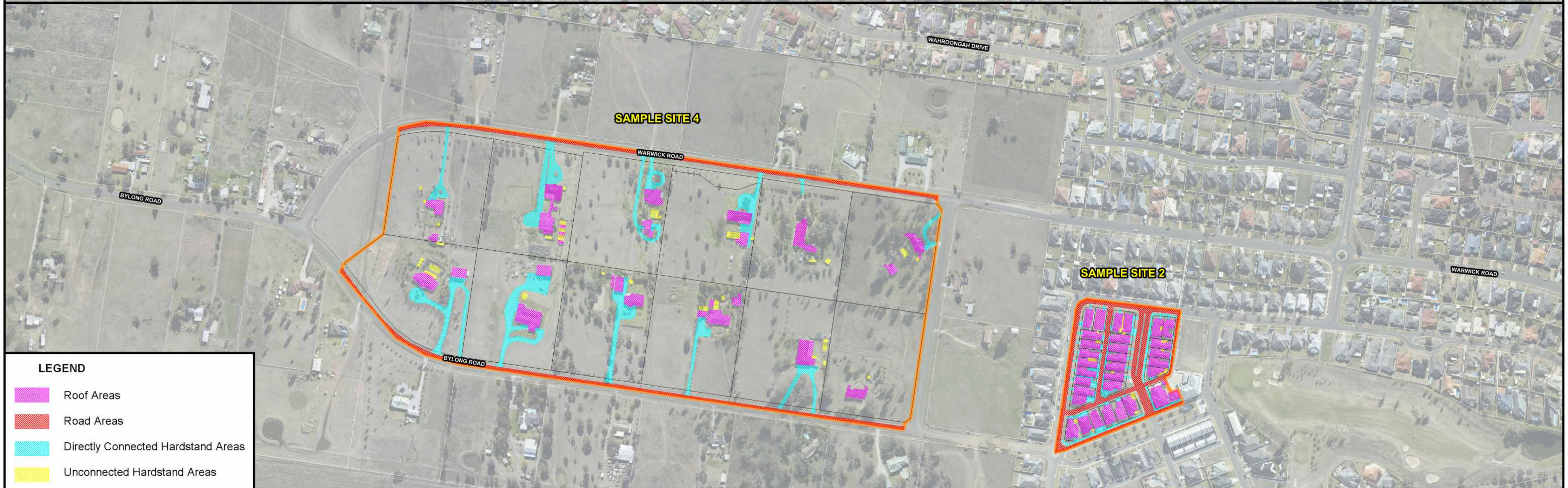
Figure C2

SAMPLE SITE Nos. 1 AND 3



N
50 0 50 100 150 m
Scale: 1:5,000

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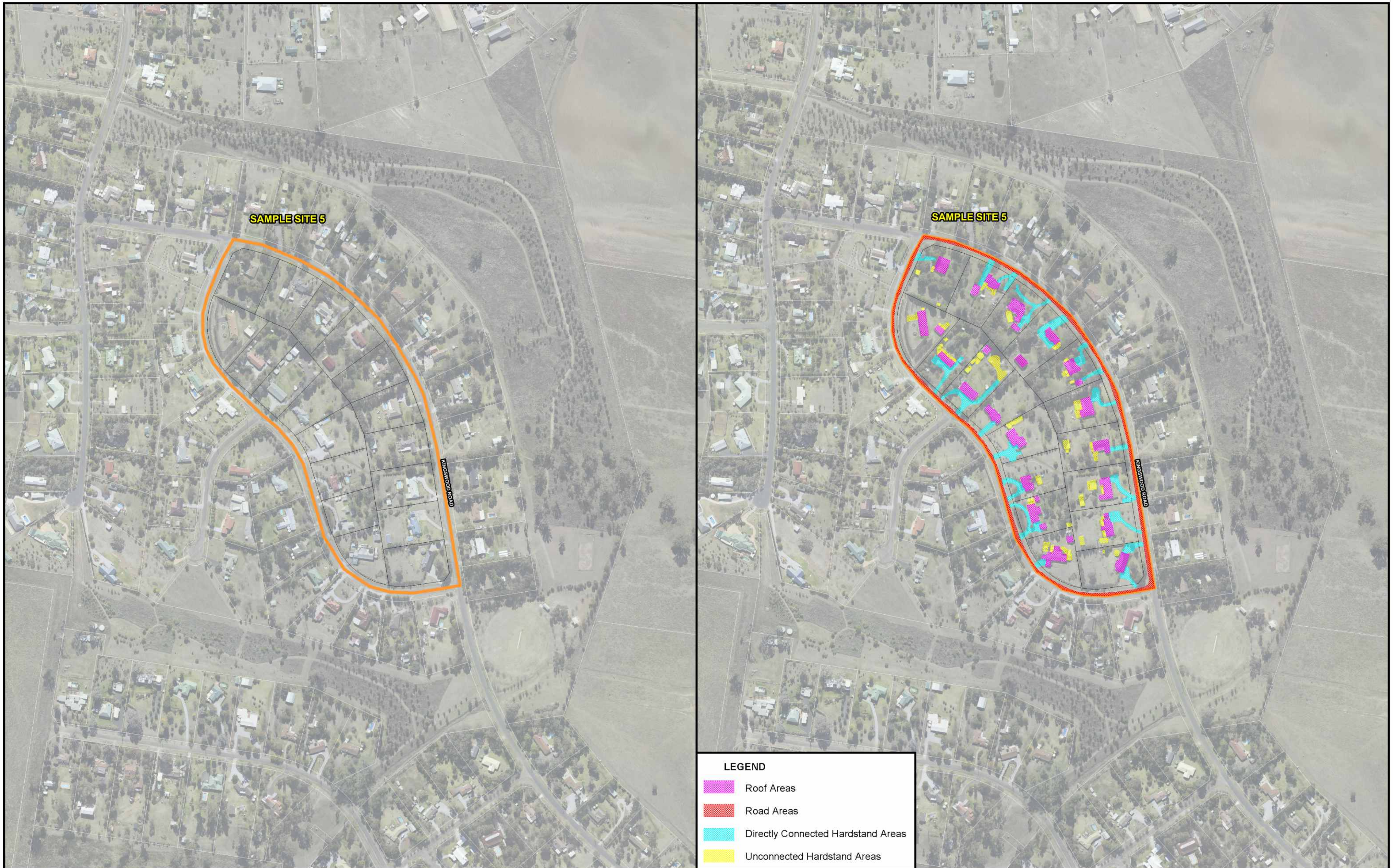
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure C3

SAMPLE SITE Nos. 2 AND 4



N

50 0 50 100 150 m

Scale: 1:5,000

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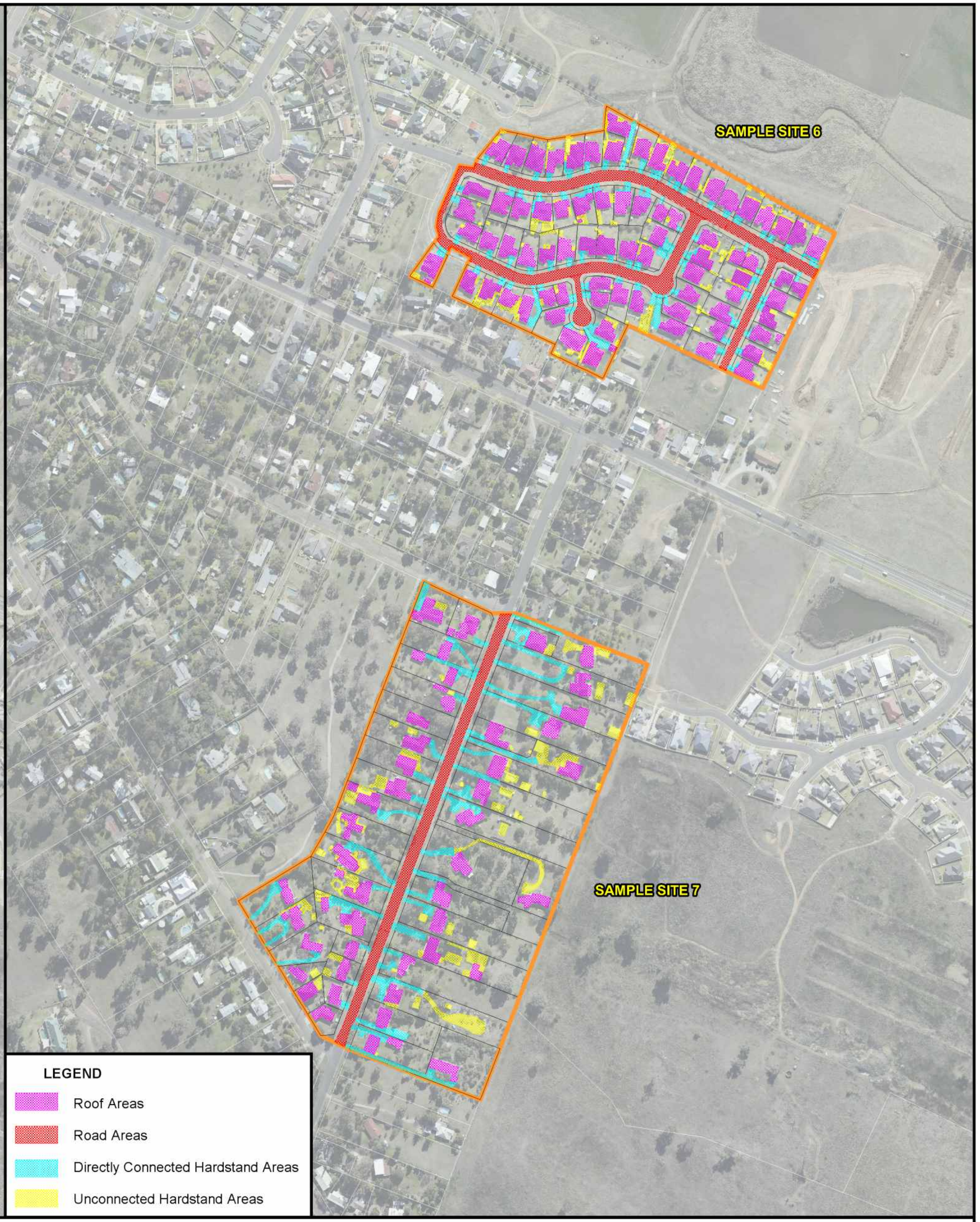
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure C4

SAMPLE SITE No.5



N
50 0 50 100 150 m
Scale: 1:5,000

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ARCADIA ESTATE SUBDIVISION
INTEGRATED STORMWATER AND FLOODPLAIN MANAGEMENT STRATEGY

Figure C5

SAMPLE SITE Nos. 6 AND 7

Premise

premise.com.au