Lot 282 Bottlebrush Crescent, Suffolk Park

Stormwater management plan

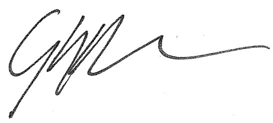
Tain Investments Pty Ltd ATF the Tain Investment Trust

1384-02-C3, 12 November 2020

Report Title	Lot 282 Bottlebrush Crescent, Suffolk Park
Client	Tain Investments Pty Ltd ATF the Tain Investment Trust 112 Fowlers Lane Bangalow 2479
Report Number	1384-02-C3

Revision Number	Report Date	Report Author	Reviewer
0	21 October 2019	DM	GR
1	22 October 2019		GR
2	25 June 2020	MB	GR
3	12 November 2020	MB	GR

For and on behalf of WRM Water & Environment Pty Ltd
Level 9, 135 Wickham Tce, Spring Hill
PO Box 10703 Brisbane Adelaide St Qld 4000
Tel 07 3225 0200



Greg Roads
Director

Contents

List of Figures

List of Tables

1 Introduction

Tricend Design & Engineering on behalf of Tain Investments Pty Ltd have requested WRM Water & Environment prepare a stormwater management plan for a proposed development located at Bottlebrush Crescent, Suffolk Park.

This report addresses clause 6.3 of the Byron Local Environment Plan (BSC, 2014c). The objectives of this clause include:

a. Minimise the flood risk to life and property associated with the use of land;
b. Development is compatible with the land's flood hazard, taking into account project changes as a result of climate changes; and
c. Avoid significant adverse impacts on flood behaviour and the environment.

The requirements from the relevant chapters of the Byron Development Control Plan (BSC, 2014b) (B3 Services, C2 Areas Affected by Flood and D6 Subdivision) have also been addressed.

This report supersedes an approved stormwater management plan for a previous site layout (WRM, 2008) containing 13 Community Title lots and one Community lot. This new site layout increases the number of lots to 17 Community Title lots including one Community lot and proposed no changes to the existing on-site detention basin. It also addresses the request for further information with regard to the Stormwater Management Plan from Byron Shire Council dated 9 December 2019 and a request for further information dated 22 October 2020.

2 Previous reports

There have been numerous flood assessment reports in relation to the subject site:

1. Tallow Creek Flood Study" Report prepared for Byron Shire Council by Water Studies Pty Ltd, November 2002.
2. "Flood Study for Proposed Development, Bottlebrush Crescent, Byron Hills" Report prepared for SAE Properties Pty Ltd by Water Studies Pty Ltd, August 2003.
3. "Flood Study for Proposed Development, Bottlebrush Crescent, Byron Hills" Report prepared for SAE Properties by WRM Water & Environment Pty Ltd, June 2004.
4. "Flood Study for Proposed Development, Bottlebrush Crescent, Byron Hills" Report prepared for SAE Properties Pty Ltd by Water Studies Pty Ltd, December 2005.
5. "Flood Mitigation Study for Byron Hills and the Bottlebrush Crescent Development" Report prepared for David Abramovich (Tain Investments) by WRM Water & Environment Pty Ltd 31 January 2008.
6. "Statement of evidence stormwater and flood issues – Bryon Shire Council -ATS-Kennedy Lot 282 Bottlebrush Crescent, Suffolk Park", Report prepared for David Abramovich (Tain Investments) by WRM Water & Environment Pty Ltd 2 February 2010.
7. "Lot 282 Bottlebrush Crescent, Suffolk Park, Stormwater management plan" Report prepared for Tricend Design & Engineering by WRM Water & Environment Pty Ltd 30 November 2017

A discussion of these reports is given below.

- The Tallow Creek Flood Study (Report 1) was prepared over an 18 month period in conjunction with a community steering committee, DLWC and Byron Shire Council. The report defined the peak discharges and flood levels throughout the Tallow Creek catchment. The subject site is in the upper headwaters of the Tallow Creek catchment. This report was prepared when I was employed at Water Studies Pty Ltd. A XP-RAFTS rainfall runoff routing hydrological model that predicts flood flows and a TUFLOW two dimensional hydraulic model that predicts flood levels were developed for this study. The two subsequent reports on the subject site are based on the hydrologic and hydraulic models developed for the Tallow Creek Flood Study.

- The August 2003 report (Report 2) was prepared by Dr Richard Walton for a 21 lot subdivision on the same development site. The report focussed on the impact on downstream discharges of increasing the impervious areas on the subject site using the XP-RAFTS model.

- The June 2004 report (Report 3) was prepared for a 10 lot subdivision on the subject site, of which 9 were proposed to be used as residential lots. This report also focussed on the impact on downstream discharges of the proposed development using the XP RAFTS model.

- The December 2005 (Report 4) was prepared for an 8 lot subdivision on the subject site. This report focussed on constructing a new spillway in the Coogera Circuit Detention basin adjacent to Bottlebrush Crescent to mitigate any additional flooding downstream of the existing spillway that may have been caused by the additional inflows from increasing the impervious areas on the subject site.

- The January 2008 report (Report 5) was prepared following discussions with BSC staff (John Samuels and James Flockton) to assess an option of completely removing the existing detention basin on the site and to determine downstream measures required to mitigate the flood impacts.

- The February 2010 report (Report 6) was prepared for an 8 lot subdivision on the subject site. This report focussed on the resizing the existing detention basin on the site and determining downstream measures required to mitigate the flood impacts.

- The November 2017 report (Report 7) was prepared for a 16 lot subdivision on the subject site, of which 15 were proposed to be used as residential lots. This report focussed on removing the existing Coogera Circuit Detention Basin on the site and identifying downstream measures required to mitigate the flood impacts.

The January 2008 (Report 5) is the approved stormwater management plan superseded by this current application.

This proposed SMP is similar to the configuration assessed in the December 2005 report (Report 4) with the exception that the Jabiru Circuit flows were diverted back to the Coogera Circuit basin. This plan was not approved by council at that time.

WRM have undertaken extensive investigations to develop strategies to mitigate the existing flooding problems associated with the Coogera Circuit Detention Basin and at Jabiru Terrace by undertaking works both on and downstream of the subject site including a scenario of an upgrade to the Byron Hills Stormwater Management System. This scenario was rejected as an option by council staff due to the significant ecological impacts, prohibitive associated costs on the subject development & the extensive construction periods involved impacting on Suffolk Park residents.

The previous development application for a CT subdivision DA 10.2017.703 for the same number of lots was withdrawn once this was decided to enable a detailed assessment by the project ecologists and an additional study by WRM to include arrangements for keeping the existing detention basin and finding alternative means of minimising the impacts from the proposed development

These studies found that it is practically impossible to undertake works on the subject site to mitigate the existing problems in Coogera Circuit and Jabiru Terrace without impacting on properties elsewhere in the catchment. Note that these are existing problems, not problems associated with the proposed development.

As a result, this SMP aims for ‘no worsening’ of the existing problems, rather than fix the existing problems. To do this, a local flood model of the development site has been developed rather than using the regional model.

3 Site description

3.1 EXISTING CONDITIONS

The Bottlebrush Crescent development site (hereafter referred to as the subject site) is located on the western side of Bottlebrush Crescent in Suffolk Park. The subject site has an area of approximately 6.9 ha, and presently supports stands of rainforest scrub and Melaleuca swamp.

Figure 3.1 shows the existing site drainage characteristics. The site slopes steeply from west to east, with elevations ranging from 79 mAHD at the western boundary to 11 mAHD at the site's frontage onto Bottlebrush Crescent. An existing 2nd order watercourse drains across the site from west to east (Subcatchment B) and is joined by a 1st order watercourse entering the site from the north (Subcatchment A). A small portion of the site drains along the southern boundary (Subcatchment C) (not via a defined watercourse), adjacent to Jabiru Terraces. Under existing conditions some flows drain through an existing townhouse development (Jabiru Terraces) to Bottlebrush Crescent and the remainder drain to the existing detention basin on the subject site. At the rear of the Jabiru Terraces there is a stormwater pit and pipe network which discharges to the existing detention basin via a 225 mm diameter pipe.

An existing detention basin (hereafter referred to as the Coogera Circuit detention basin) has been constructed in the sites north-eastern corner. Table 3.1 shows the existing basin characteristics. The watercourses traversing the site drain into the detention basin. The detention basin's low flow pipe passes beneath Bottlebrush Crescent and discharges into the nearby Beech Drive detention basin. The basin spills to the north, with all spills draining through properties fronting Coogera Circuit. The basin presently spills for events equal to or greater than the 2 Year average recurrence interval (ARI).

According to the Tallow Creek Flood Risk Management Study and Plan (SKM, 2009), the Coogera Circuit detention basin is a high flood hazard due to having a depth of greater than 1.0 m.

Table 3.1 - Existing Coogera Circuit detention basin characteristics

Basin characteristics	
Invert	9.47 mAHD
Minimum wall elevation	12.50 mAHD
Detention volume	5,312 m^3 (at 12.47 mAHD)
Outlet pipe (to Beech Drive basin)	0.75 m diameter IL at 9.47 mAHD
Spillway	
Width	15 m
Invert	12.01 m
Volume below spillway	3782 m^3

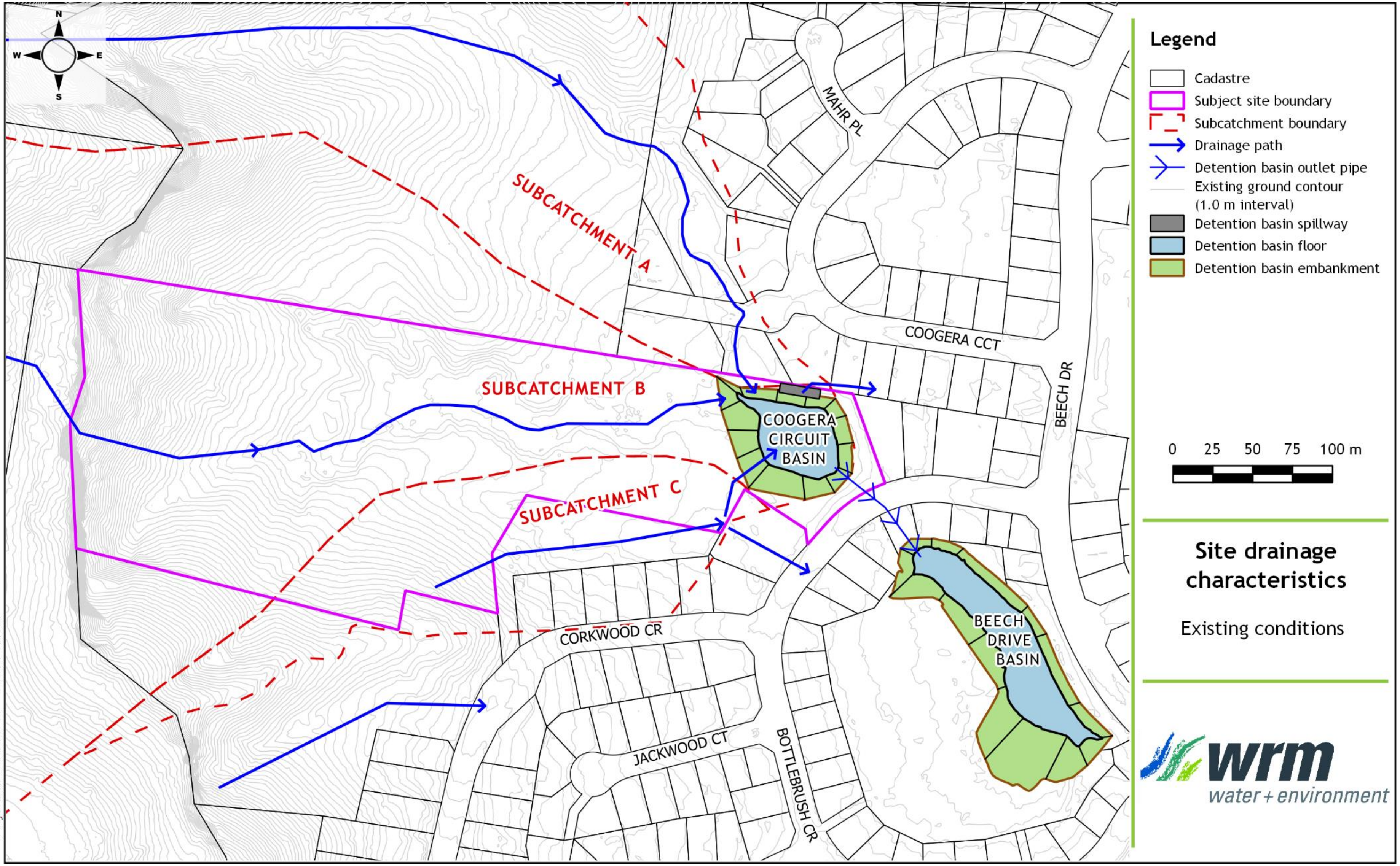


Figure 3.1 – Existing site drainage characteristics

3.2 DEVELOPED CONDITIONS

3.2.1 Proposed drainage

Figure 3.2 shows the proposed site drainage configuration for developed conditions. There are no proposed changes to the existing Coogera Basin detention basin on the subject site or its downstream drainage network under the developed conditions.

Culverts will be constructed beneath the subject site access road at two locations across the Subcatchment C flowpath. Table 3.2 shows the configuration of the proposed culverts beneath the access road for the subject site. The existing 225 mm pipe draining the rear of Jabiru Terraces will be directed into Culvert 1. The access road at culvert 1 will include a 5 m wide overflow weir to take the Subcatchment C flows in excess of the pipe culvert.

A proposed bund and drain behind Lot 11 along the property boundary will redirect flow from the Subcatchment C flowpath to the Subcatchment B flowpath. This bund is to prevent upstream catchment flows from draining through the proposed development. The upstream catchment to be diverted is 0.8 ha.

Table 3.2 - Proposed subject site culvert configuration

Design parameter	Culvert 1	Culvert 2
Upstream invert level (mAHD)	13.00	17.05
Downstream invert level (mAHD)	12.60	17.00
Road deck level (mAHD)	13.90	17.95
Length (m)	8.2	13.0
Culvert dimensions (m)	0.375 RCP	2.1 W x 0.6 H RCBC
Number of barrels	1	2

3.2.2 Proposed stormwater treatment

Figure 3.2 also shows the indicative locations of the stormwater management devices for the proposed development. The following is of note:

- A 5 kL rainwater tank is proposed for each residential house on the subject property collecting roof runoff from each house. Water stored in the tank will be used internally for toilet flushing and externally for landscaping irrigation as a minimum.
- Overflows from the rainwater tanks will be piped to the access road for all lots except for Lot 8, 9 and 10.
- Yard runoff from Lots 2 and 3 will be treated by a buffer strip and then discharge to the Subcatchment B flow path;
- Yard runoff from Lots 4 to 6 will be treated by a buffer strip and then discharge to the Subcatchment C flow path;
- Yard runoff from Lot 11 to 16 will be treated by a buffer strip and then discharge to the access road.
- Yard runoff from Lot 7,8,9,10 and 17 will be treated by a buffer strip and then discharge to the overland flow path draining to the Subcatchment C flow path. A drainage easement will be required within these lots.
- Runoff draining to the access road will be piped to a proprietary GPT (Jellyfish Filter) before discharging to the Coogera Circuit detention basin.

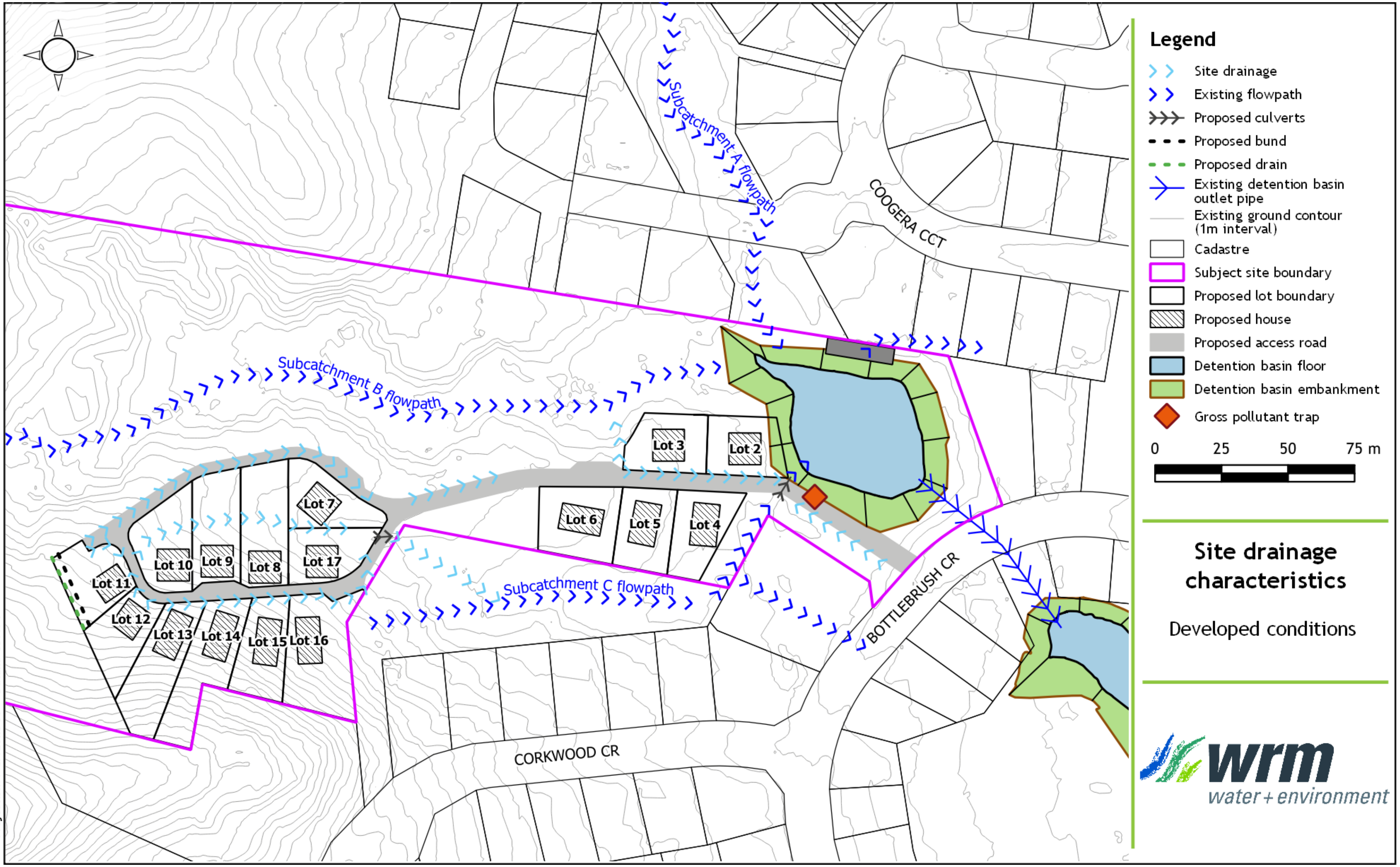


Figure 3.2 – Developed site drainage characteristics

4 Estimation of discharge

4.1 OVERVIEW

The RAFTS runoff-routing model (Innovyze, 2018) developed as part of the Tallow Creek Flood Study (Water Studies, 2002) was used to estimate design flood discharges in the area of interest. Design discharges were estimated for the 5, 20 and 100 Year average recurrence interval (ARI) storm events for existing conditions.

4.2 RAFTS MODEL MODIFICATIONS

Development and calibration of the Tallow Creek RAFTS model is described in the Tallow Creek Flood Study report (Water Studies, 2002). Minor modifications to the Tallow Creek RAFTS model were made to investigate the drainage characteristics of the site in greater detail. These modifications include:

- RAFTS catchments 25 and 26 were split into 25A, 25B, 26A and 26B based on existing ground contours in order to estimate flows across the subject site in Subcatchments A and B.
- RAFTS catchment 29 was also split into 29A, 29B and 29C to more accurately reflect the portion of this catchment that drains to the subject site (Subcatchment C). Examination of catchment boundaries indicated that the upper portion of the catchment drained onto Corkwood Crescent rather than towards the subject site.
- Catchment roughness parameters were revised in order to produce discharge estimates consistent with the Rational Method for the modified catchments.
- The revised configuration of the existing conditions RAFTS model catchments is shown in Figure 4.1.
- The adopted RAFTS model parameters for the existing conditions at the subject site are shown in Table 4.1.

All other parameters of the RAFTS model were identical to the values adopted in the Tallow Creek Flood Study (Water Studies, 2002). Note that for existing conditions, the RAFTS model assumes 50% of flow from RAFTS catchment 29 discharges via Jabiru Terraces to the Beech Drive basin with the remaining flow discharging to the Coogera Circuit Detention Basin. This flow split has now been determined by the hydraulic model (see Section 5).

4.3 RATIONAL METHOD DISCHARGES

Design flood discharges for the sub-catchments draining the proposed subject site were estimated using the Rational Method as described in Northern Rivers Development and Design Manual (AUS-PEC, 2013) and IEAust (1998). Details of the Rational Method calculations for the site are provided in Table 4.2.

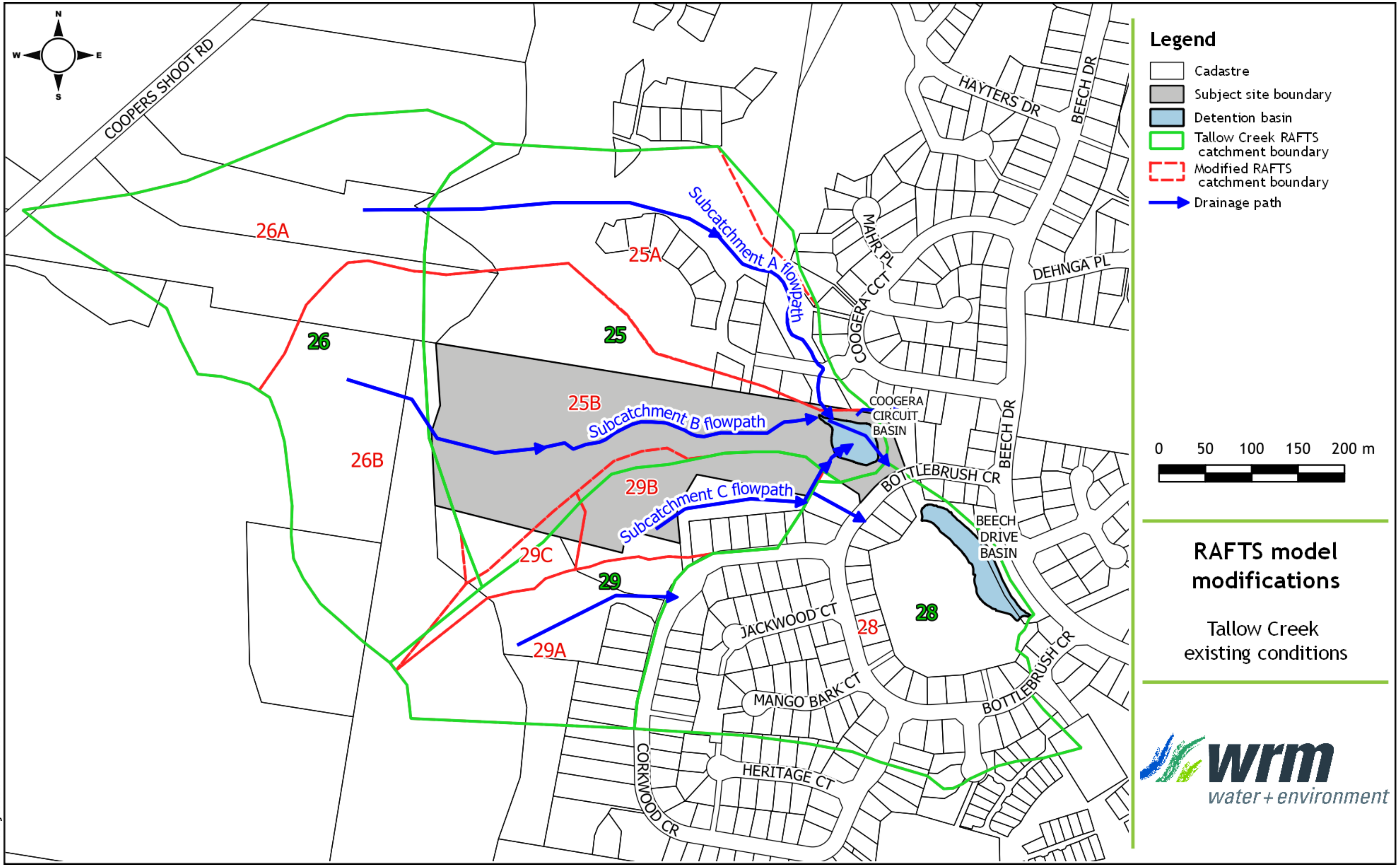


Figure 4.1 – Modifications to existing conditions Tallow Creek RAFTS model

Table 4.1 - Adopted RAFTS model parameters at the subject site, existing conditions

Catchment	Catchment Area (ha)	Catchment slope (m/m)	Manning's 'n' value	Initial loss (mm)	Continuing loss (mm/hr)
RAFTS catchment 25A					
Pervious	6.59	9.1	0.06	10	2.5
Impervious	0.85	9.1	0.035	0	0.5
RAFTS catchment 25B					
Pervious	8.02	9.1	0.06	10	2.5
RAFTS catchment 26A					
Pervious	6.84	8.4	0.06	10	2.5
RAFTS catchment 26B					
Pervious	6.32	8.4	0.06	10	2.5
RAFTS catchment 29B&C					
Pervious	2.76	14.0	0.035	10	2.5
Impervious	0.14	14.0	0.015	0	0.5

Table 4.2 - Subject site Rational Method calculations

Parameters	Subcatchment A (RAFTS catchments 25A & 26A)	Subcatchment B (RAFTS catchments 25B & 26B)	Subcatchment C (RAFTS catchment 29B&C)
Area (ha)	14.28	14.34	2.9
Time of Concentration (min)	22	22	12
Runoff coefficient			
C_5	0.83	0.83	0.83
C_{20}	0.96	0.96	0.96
C_{100}	1.18	1.18	1.18
Rainfall intensity (mm/hr)			
I_5	106	106	139
I_{20}	131	131	172
I_{100}	164	164	214
Design discharge (m^3/s)			
5 Year ARI	3.48	3.50	0.93
20 Year ARI	5.01	5.03	1.34
100 Year ARI	7.67	7.71	2.03

4.4 COMPARISON OF RATIONAL METHOD AND RAFTS MODEL DISCHARGES

Table 4.3 shows a comparison of Rational Method discharges with values calculated by the RAFTS model. The RAFTS model values are generally consistent with values calculated using the Rational Method, although are slightly lower than Rational Method estimates for the 100 Year ARI event. However, the RAFTS model discharges are consistent with Tallow Creek Flood Study (Water Studies 2002) RAFTS model discharges for this catchment. As such the RAFTS model discharges have been adopted for this study.

Table 4.3 – Comparison of Rational Method and RAFTS model discharges

Event ARI	Design discharge (m^3/s)					
	Subcatchment A (RAFTS catchments 25A & 26A)		Subcatchment B (RAFTS catchments 25B & 26B)		Subcatchment C (RAFTS catchment 29B)	
	Rational Method	RAFTS	Rational Method	RAFTS	Rational Method	RAFTS
5 Years	3.48	3.10	3.50	3.25	0.93	1.16
20 Years	5.01	4.29	5.03	4.46	1.34	1.59
100 Years	7.67	5.62	7.71	5.81	2.03	1.93

4.5 DESIGN DISCHARGES

The RAFTS model outflows for Subcatchments 26A, 26B, 29C and 28 have been adopted as inflows into the hydraulic model. Subcatchments 25A, 25B and 29B&C, which represents the local runoff draining in the hydraulic model area, were modelled as a direct rainfall (see Section 5.2.5). Note the changed runoff characteristics of the subject site, have been assessed by the hydraulic model.

5 Hydraulic model configuration

5.1 OVERVIEW

The TUFLOW two-dimensional model (BMT, 2020) was used to estimate the 5, 10, 20 and 100 Year ARI design flood levels in the vicinity of the subject site and to assess the impacts of the proposed development on flood levels surrounding the subject site.

The model was run using the rain on grid methodology, which applies rainfall to each grid within the model area, supplemented by direct inflows from the adjoining sub-catchments (Subcatchment 26A, 26B, 29A and 28 in Figure 2.1) at the model boundary. The rain-on-grid methodology was considered the most appropriate to represent the local drainage characteristics including the overland flow split between Jabiru Terrace and the Coogera Circuit detention basin under existing conditions. It was also considered the best approach to assess the impact of the change in impervious areas on the subject site together with the drainage strategies given in Section 3.2.1.

The TUFLOW model was run for local catchment inflows for design storm durations of 30, 60 and 90 minutes.

5.2 MODEL CONFIGURATION

5.2.1 Model configuration

The extent and configuration of the TUFLOW model is shown in Figure 5.1. The hydraulic model area covers approximately 30.2 hectares. A 1 metre grid size was adopted for the model.

5.2.2 Topographic data

Topographic data for the model was taken from New South Water Government LIDAR data for the area (2010). This LiDAR data was captured on the 28 August 2010 and has a vertical accuracy of 0.3 m (95% confidence Interval) and a horizontal accuracy of 0.8 m (95% confidence Interval).

The TUFLOW model was supplemented with detailed survey data of the site provided by Nigel White dated 2 June 2020 and additional survey of the Subcatchment A and C flowpaths provided by Scott Thompson Surveying Pty Ltd trading as Canty's Surveyors.

5.2.3 Hydraulic structures

Details of the existing stormwater pit and pipe network located are the rear of Jabiru Terrace and the Coogera Circuit detention basin outlet pipe was obtained from the survey data and modelled as 1D structures embedded within the 2D model domain.

The bridge across Subcatchment A flowpath at Tea Tree Court was modelled as a layered flow constriction within the 2D model domain.

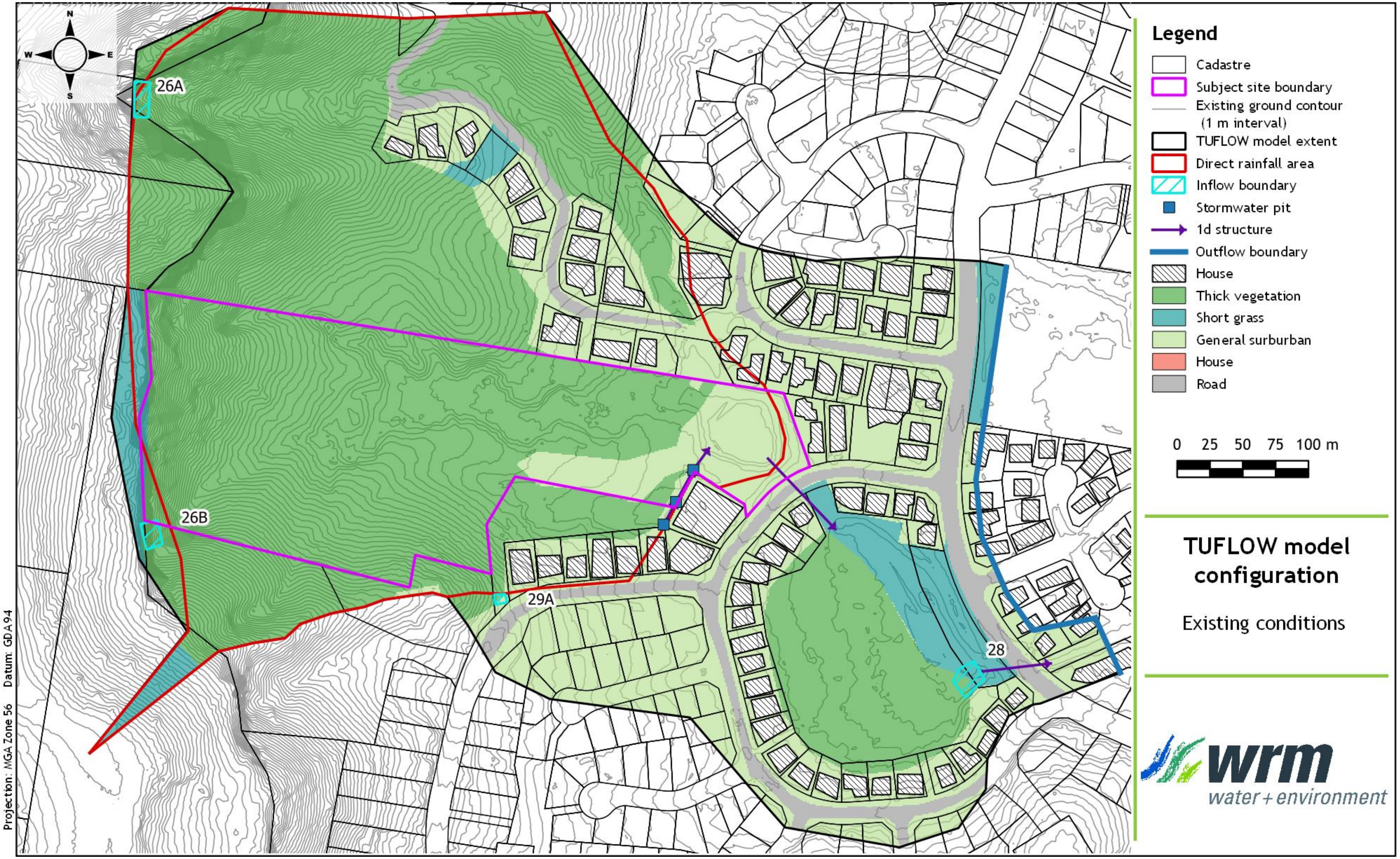


Figure 5.1 – TUFLOW model configuration, existing conditions

5.2.4 Adopted Manning's 'n' values

The adopted Manning's 'n' values for area of thick vegetation and roads is consistent with the values adopted in the Tallow Creek Flood Study (Water Studies 2002). A depth varying Manning's 'n' value was used for the other areas with the Manning's 'n' value for deeper flow consistent with the Tallow Creek Flood Study (Water Studies 2002).

An additional material was used to represent the fence line between the existing Subcatchment C flowpath and Jabiru Terrace.

The adopted Manning's 'n' values are shown in Table 5.1.

Table 5.1 – Adopted Manning's 'n' values

Material	Manning's 'n' value	Comment
Thick vegetation	0.100	• Value adopted from Tallow Creek Flood Study (Water Studies 2002).
Short grass	0.100 (below 0.05 m)	• A higher roughness value at shallow depths to represent the rougher surface.
	0.040 (above 0.06 m)	• Value adopted from Tallow Creek Flood Study (Water Studies 2002).
Suburban areas	0.100 (below 0.03 m)	• A higher roughness value at shallow depths to represent the rougher surface.
	0.050 (above 0.04 m)	• Value adopted from Tallow Creek Flood Study (Water Studies 2002).
Houses blockage	0.020 (below 0.05 m)	• A low roughness value at shallow depths, representing the rapid run-off response associated with rainfall on building roofs.
	0.200 (above 0.06 m)	• Higher roughness for deeper flows when the building structure impedes overland flow. • Value adopted from Tallow Creek Flood Study (Water Studies 2002).
Roads	0.025	• Value adopted from Tallow Creek Flood Study (Water Studies 2002)
Jabiru Terrace fence	0.050 (below 0.03 m)	• Lower roughness at shallow flows when the overland flow flows under the fence.
	0.150 (above 0.05 m)	• Higher roughness for deeper flows when the fence impedes overland flow.

5.2.5 Model inflows

The inflow boundaries representing the runoff from the upper catchments of subcatchments A and B were modelled as 2D surface area (SA) polygons. The inflow boundaries representing runoff from catchments downstream of the site were also modelled as SA polygons. The design discharges for RAFTS catchment 26A, 26B, 29A and 28 were used as inflows into the TUFLOW model.

The runoff from within the hydraulic model area is represented using the direct rainfall component within TUFLOW. The direct rainfall was applied to approximately 18.3 ha over the TUFLOW model extent. The roof runoff from the existing buildings and residential houses was included in the overland flow in the modelling.

The adopted rainfall losses for each land use are shown in Table 5.2 and are consistent with the losses applied in the RAFTS model taken from the Tallow Creek Flood Study (Water Studies 2002).

Table 5.2 – Adopted rainfall losses for each land use in the hydraulic model

Land use	Initial loss (mm)	Continuing loss (mm/hr)
Pervious areas (thick vegetation, short grass, suburban areas and Jabiru Terrace fence)	10	2.5
Impervious areas (houses blockage and roads)	0	0.5

5.2.6 Outflow boundary conditions

A normal depth outflow boundary was adopted downstream of Beech Drive. The adopted tailwater slope was 0.01 m/m for the outflow, consistent with the ground level slope.

5.3 DEVELOPED CONDITIONS MODIFICATIONS

Figure 5.2 shows the configuration of the TUFLOW model for developed conditions. The modifications to existing conditions TUFLOW model to represent developed conditions are as follows:

- The proposed access road configuration and levels were provided by Tai Lonergan dated 11 June 2020. The road level at the Culvert 1 was reduced from the Lonergan design to incorporate the 5 m wide weir flow.
- The road land use and impervious area losses were applied.
- The building footprints/roof areas were raised by a minimum of 0.5 m above the surrounding ground levels and the building land use and impervious area losses were applied.
- The land use for the remaining lots areas was changed to suburban areas with the pervious area losses.
- The proposed access road culverts (detailed in Table 3.2) were modelled as 1D structures embedded within the 2D model domain.
- A bund behind Lot 11 was raised 1.0 m above the surrounding ground level and the drain was lowered 0.5 m below the surrounding ground level to divert Subcatchment 29C to the Subcatchment B flow path.
- The remainder of the model is as for existing conditions.

Figure 5.2 – TUFLOW model configuration, developed conditions

6 Flood assessment

6.1 EXISTING CONDITIONS FLOODING

Figure 6.1 to Figure 6.4 shows the 5, 10, 20 and 100 year ARI flood depths and extent under existing conditions respectively. The results are shown using a map cut-off depth of 0.02 m to differentiate between shallow, sheet flow from the rain-on-grid modelling and depths that would be classed as 'flooded'. The following is of note with respect to the existing conditions flooding:

- The proposed lots are not within the existing Subcatchment B flowpath.
- Through the subject site, Subcatchment C flowpath is generally confined to a 14 m wide corridor.
- The peak water levels in the Coogera Circuit Detention Basin are 12.63 mAHD, 12.66 mAHD, 12.72 mAHD and 12.83 mAHD for the 5, 10, 20 and 100 year ARI events, respectively.

6.2 DEVELOPED CONDITIONS FLOODING

Figure 6.5 to Figure 6.8 shows the 5, 10, 20 and 100 year ARI flood depths and extent under developed conditions respectively. The following is of note with respect to the developed conditions flooding:

- The proposed house footprints have 100 year ARI flood immunity
- The Lot 11 bund successfully diverts the upstream catchment to Subcatchment B removing upper catchment flows from draining through Lots 7 to 10 and Lot 17.
- The access road is trafficable during all events, with a peak depth of less than 0.10 m for the 1% AEP event.
- The peak water levels in the Coogera Circuit Detention Basin are 12.63 mAHD, 12.66 mAHD, 12.71 mAHD and 12.83 mAHD for the 5, 10, 20 and 100 year ARI events, respectively

6.3 FLOOD IMPACTS

Afflux maps comparing peak water levels for the developed and existing conditions are provided in Figure 6.9, Figure 6.10, Figure 6.11 and Figure 6.12. The change in water levels due to the development does not impact any properties outside of the subject site boundary for all events.

6.4 DEVELOPED CONDITIONS FLOOD HAZARD

Hazard maps comparing depth x velocity product for the developed conditions are provided in Figure 6.13, Figure 6.14, Figure 6.15 and Figure 6.16. The hazard mapping shows the depth x velocity product is less than 0.4 m^2/s for all events throughout the development.

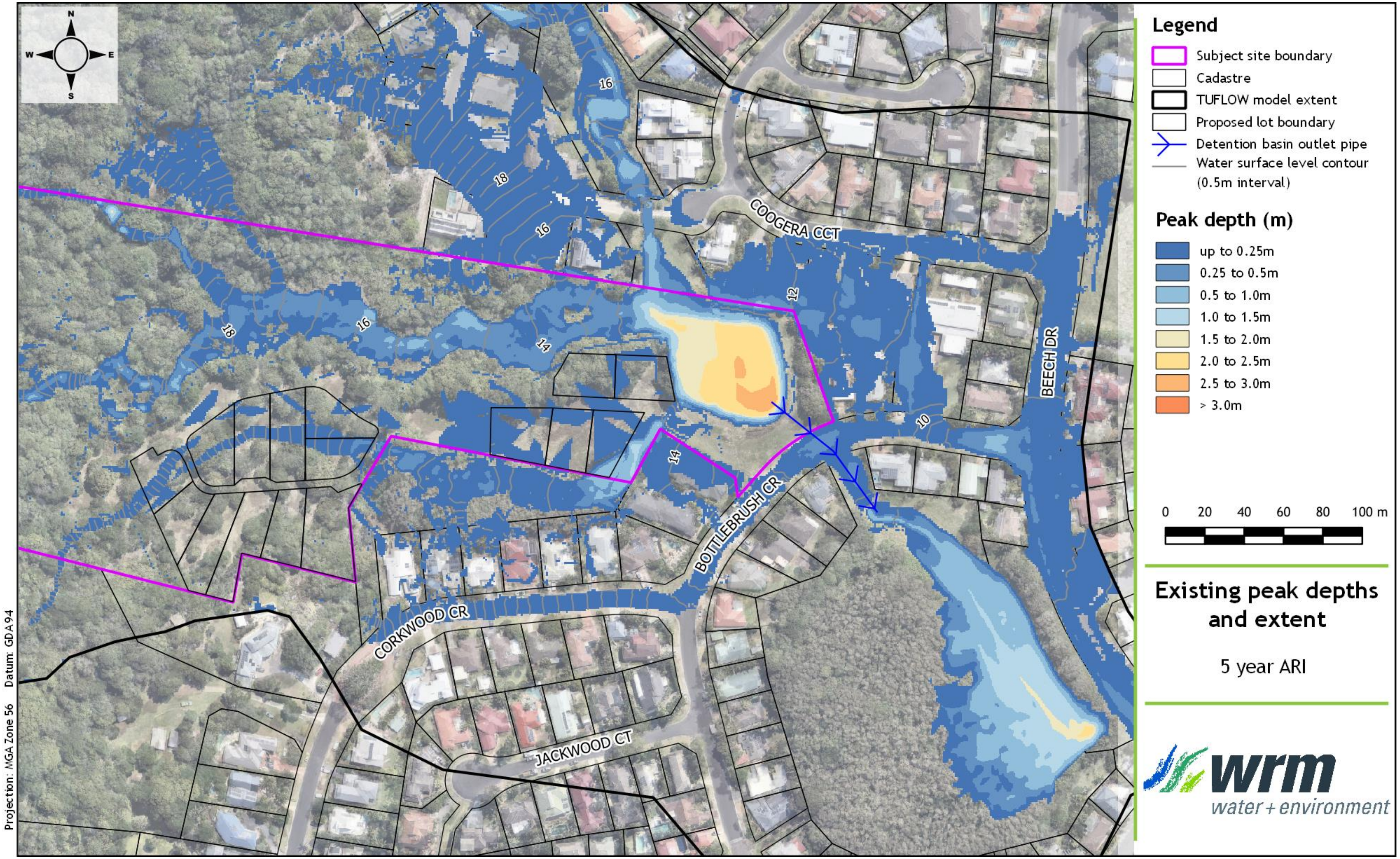


Figure 6.1 – Peak depths and extent, 5 year ARI existing conditions

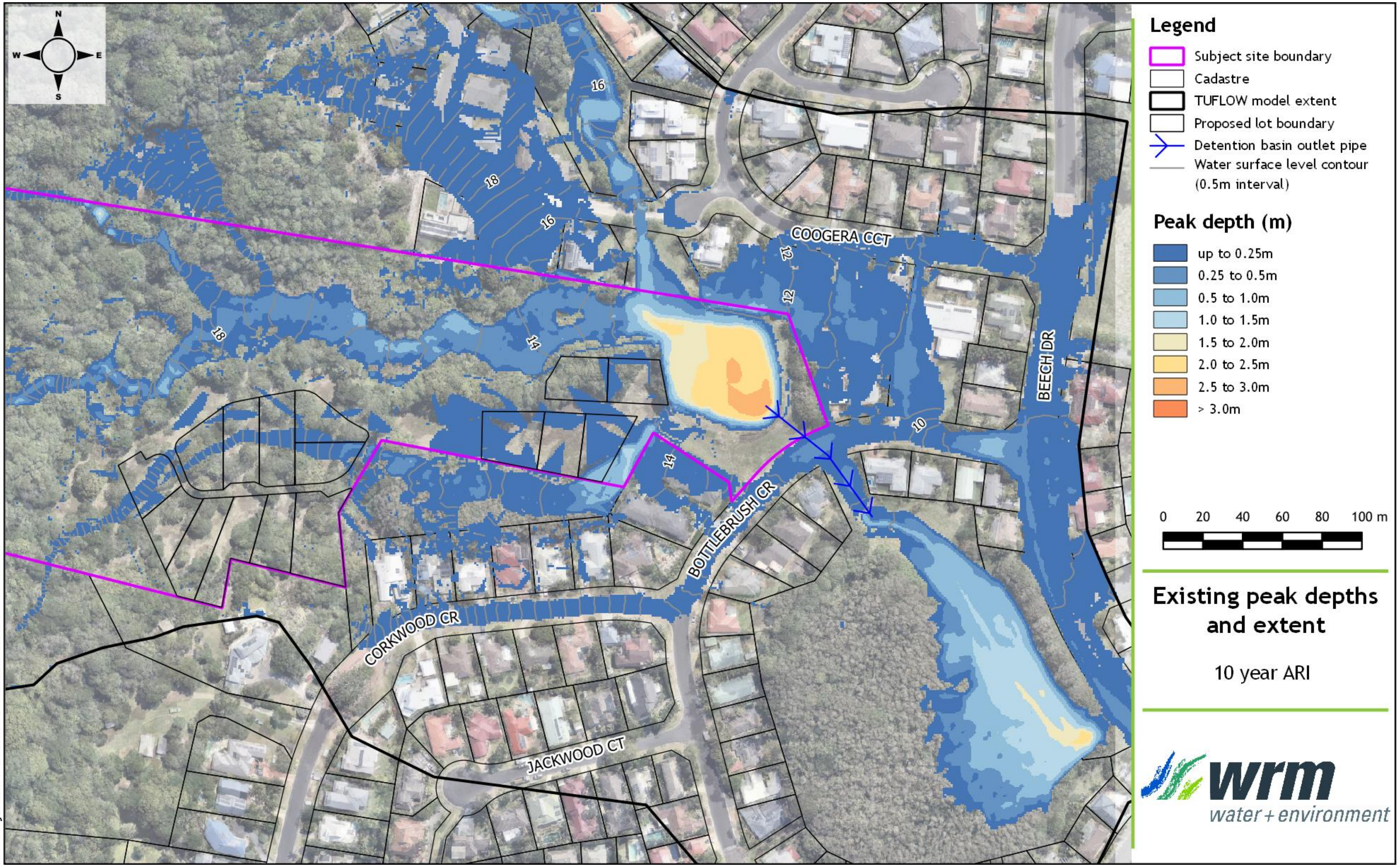


Figure 6.2 – Peak depths and extent, 10 year ARI existing conditions

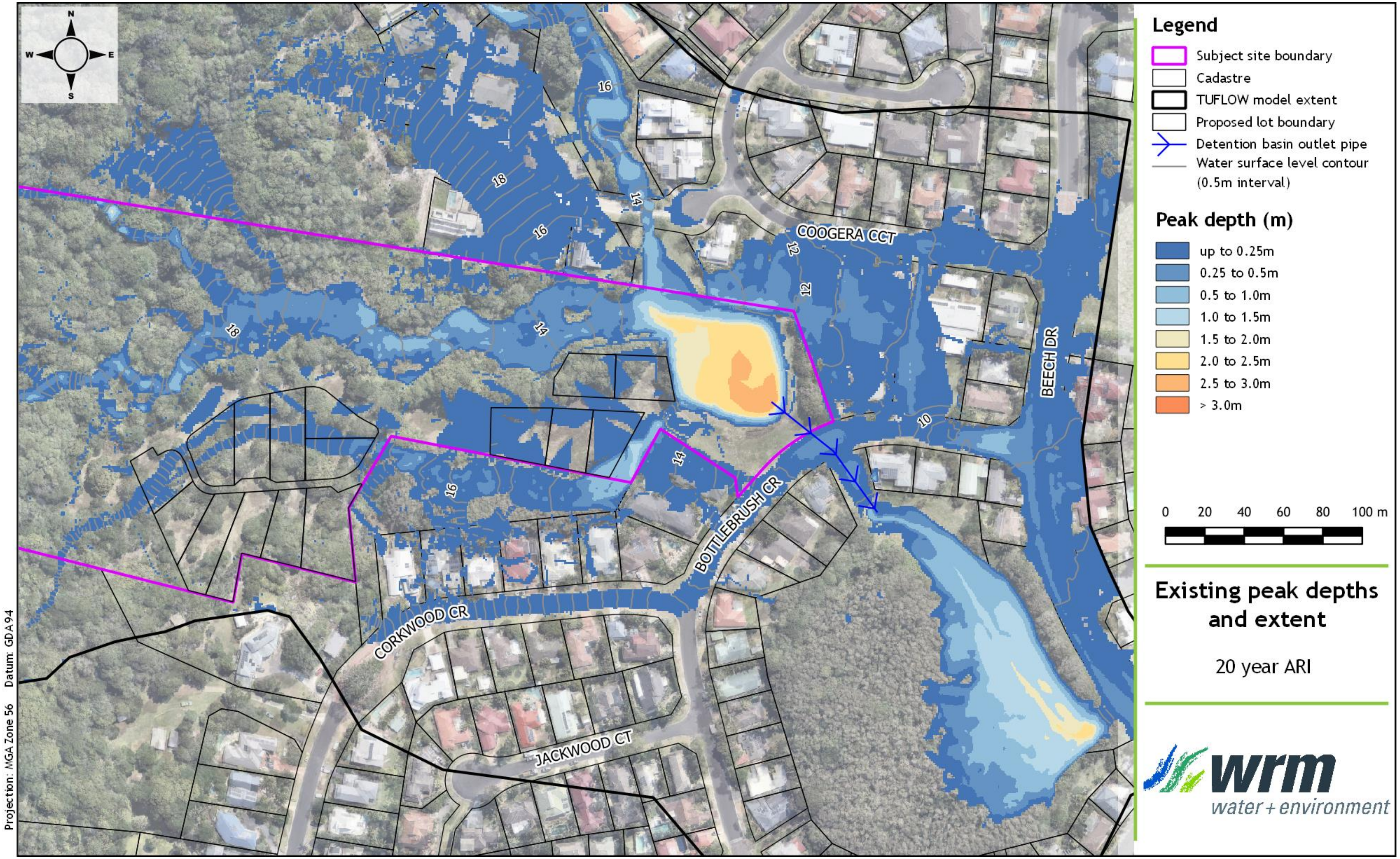


Figure 6.3 – Peak depths and extent, 20 year ARI existing conditions

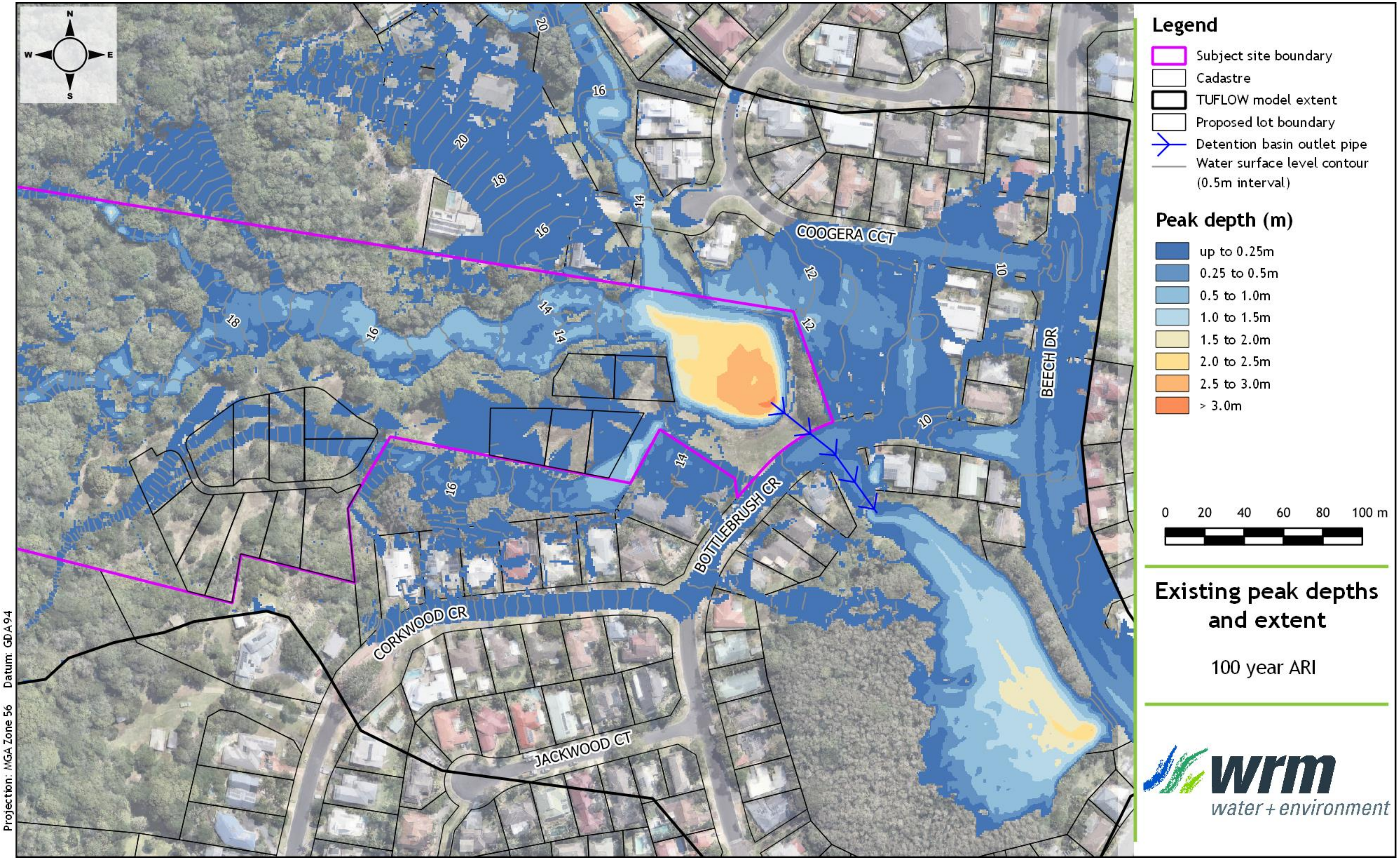


Figure 6.4 – Peak depths and extent, 100 year ARI existing conditions

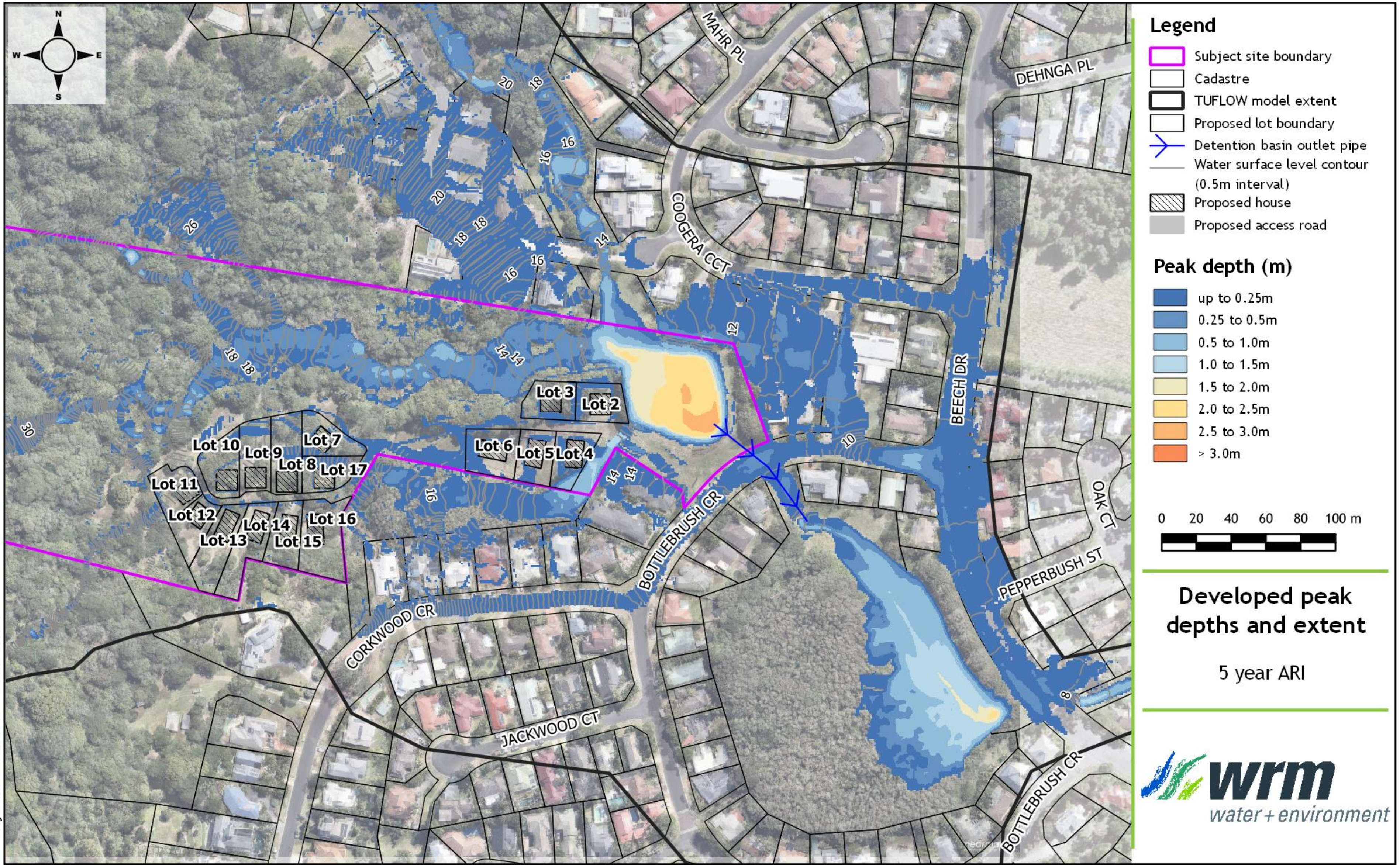


Figure 6.5 – Peak depths and extent, 5 year ARI developed conditions

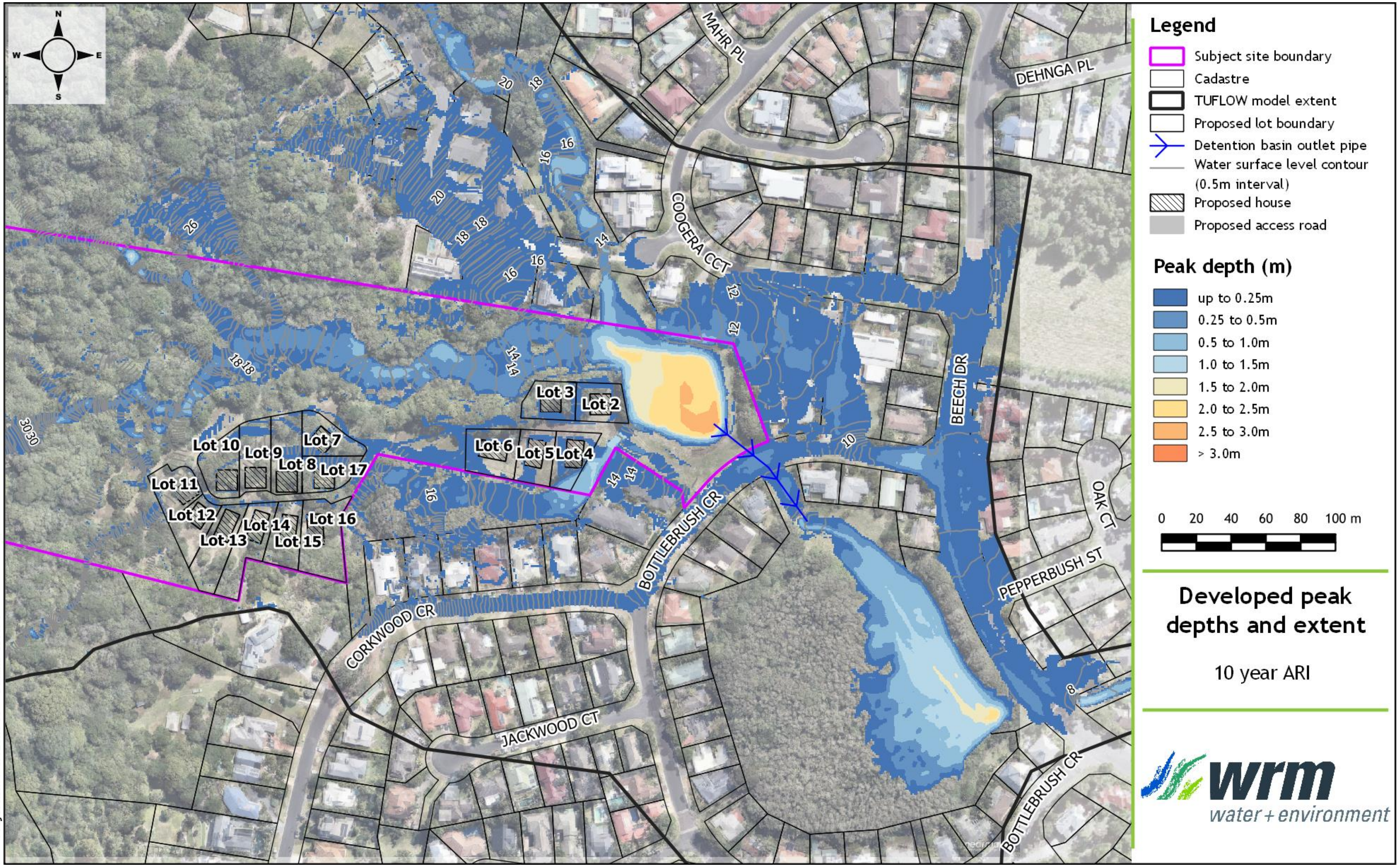


Figure 6.6 – Peak depths and extent, 10 year ARI developed conditions

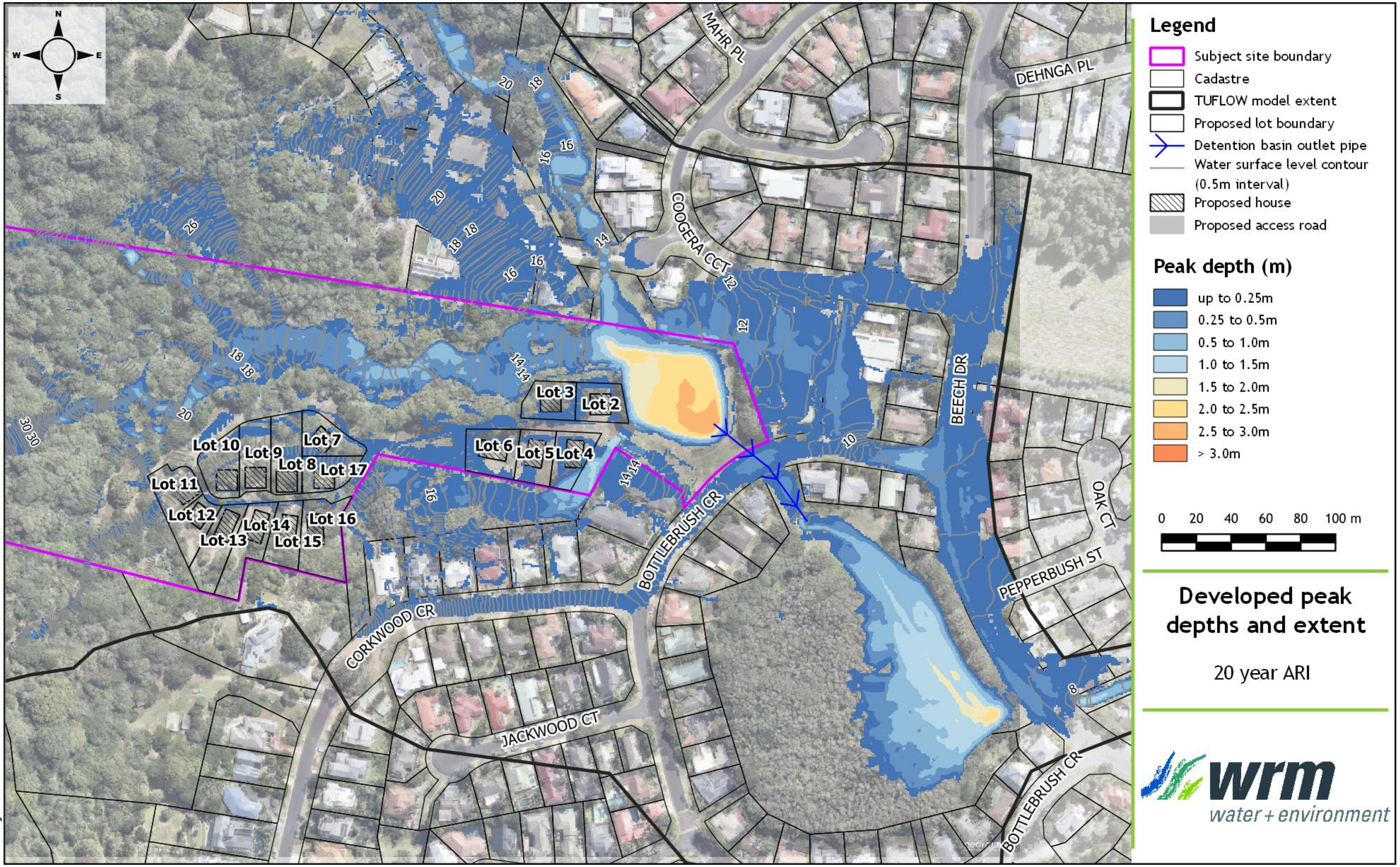


Figure 6.7 – Peak depths and extent, 20 year ARI developed conditions

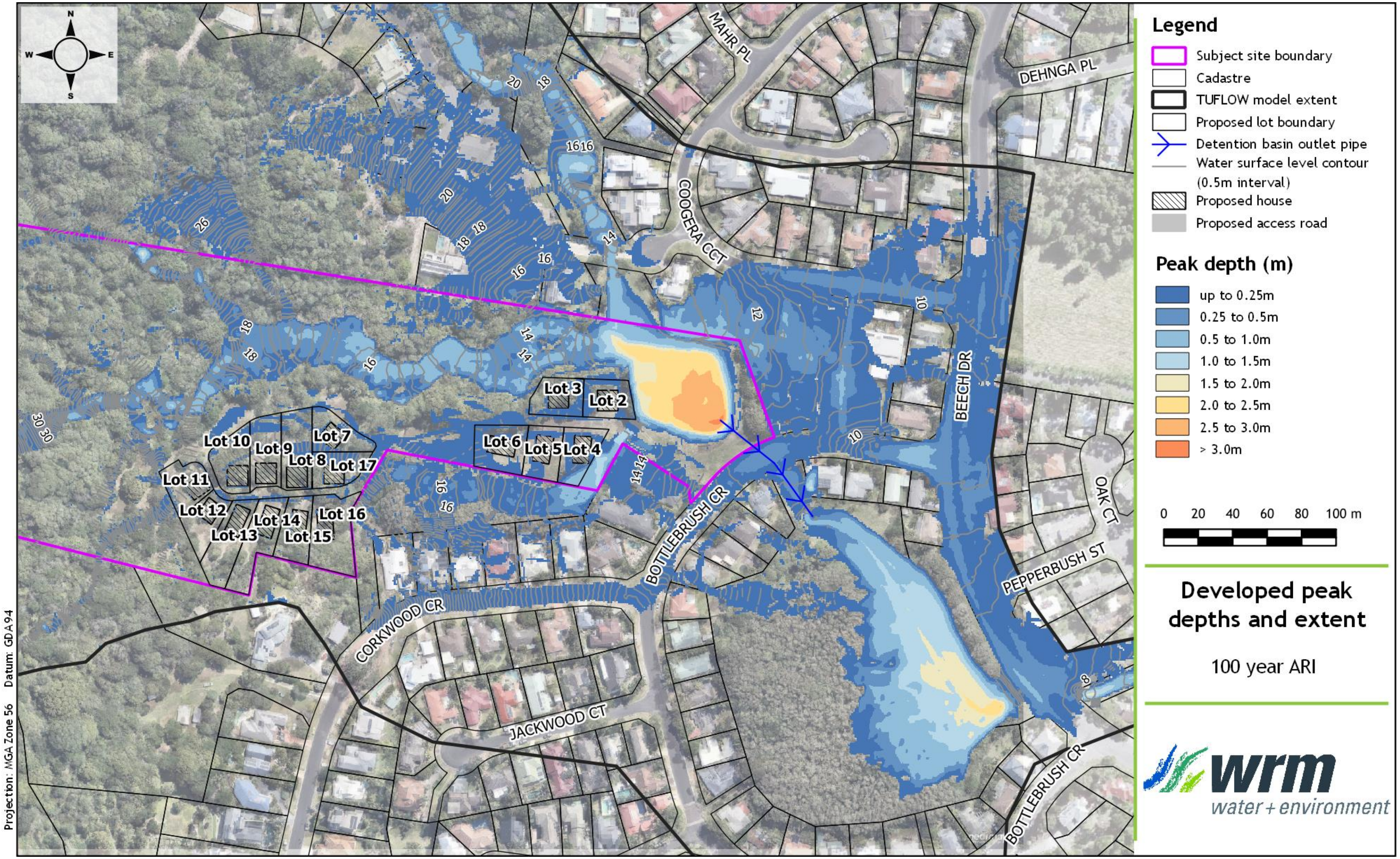


Figure 6.8 – Peak depths and extent, 100 year ARI developed conditions

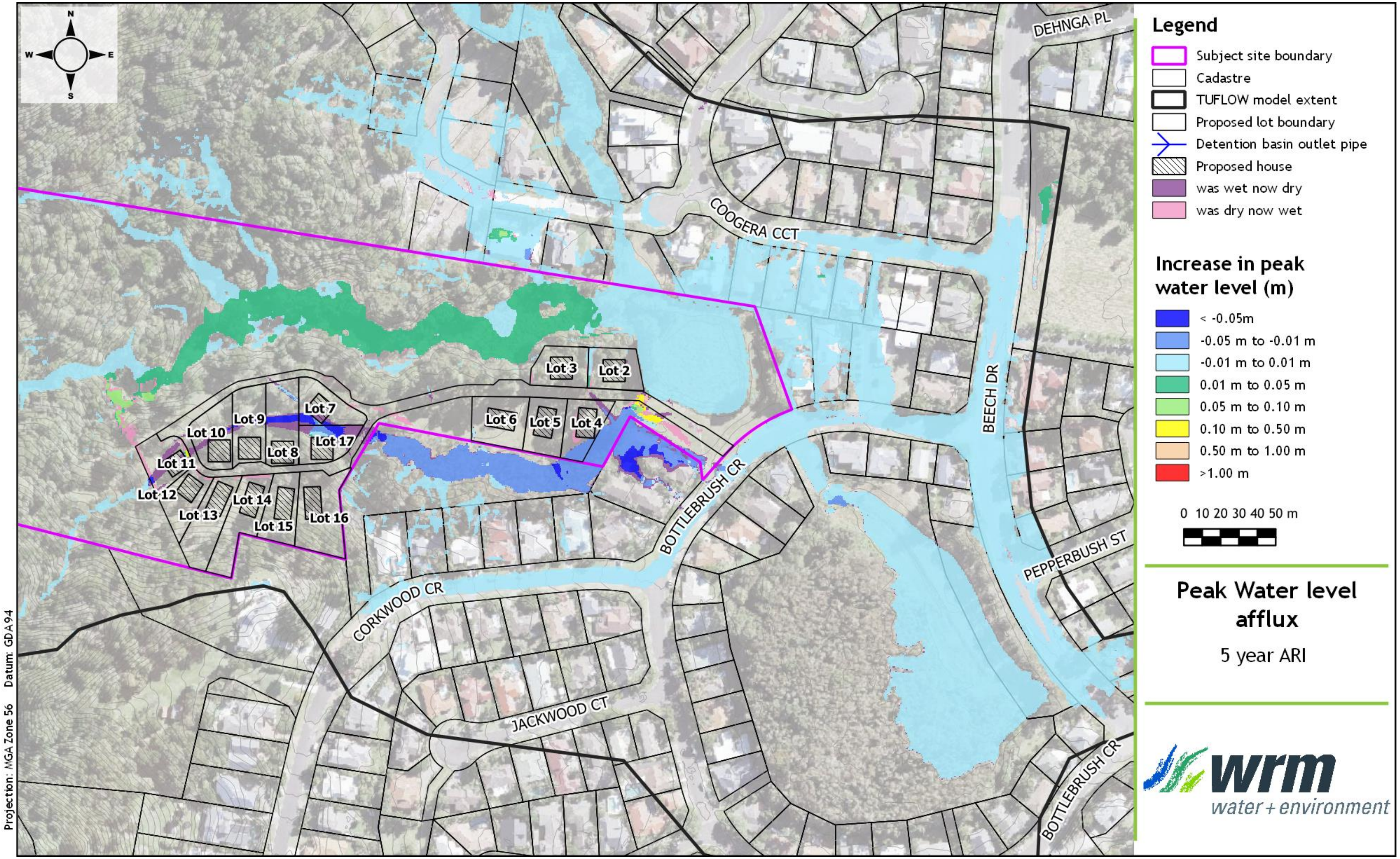


Figure 6.9 – Peak water level afflux, 5 year ARI

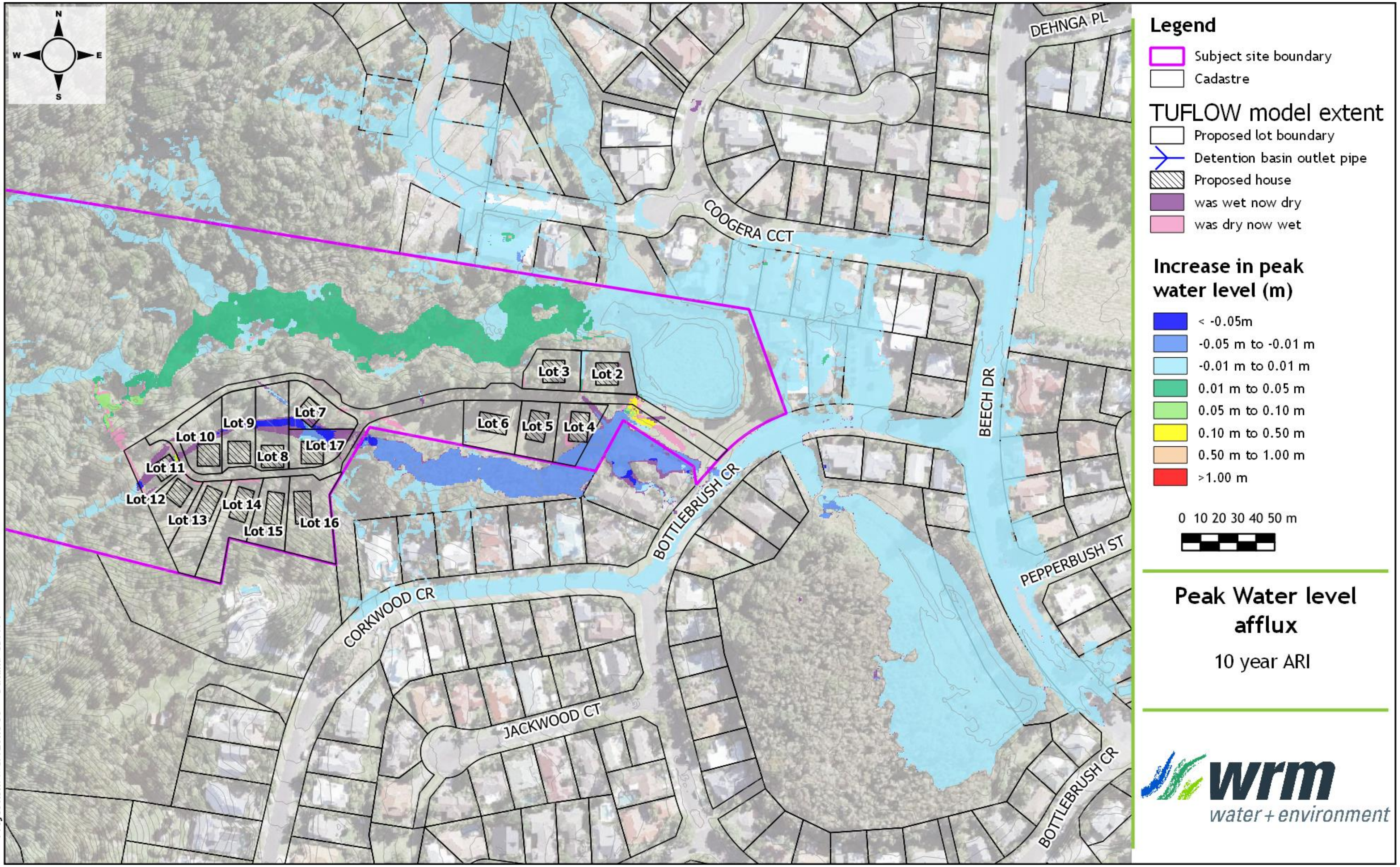


Figure 6.10 – Peak water level afflux, 10 year ARI

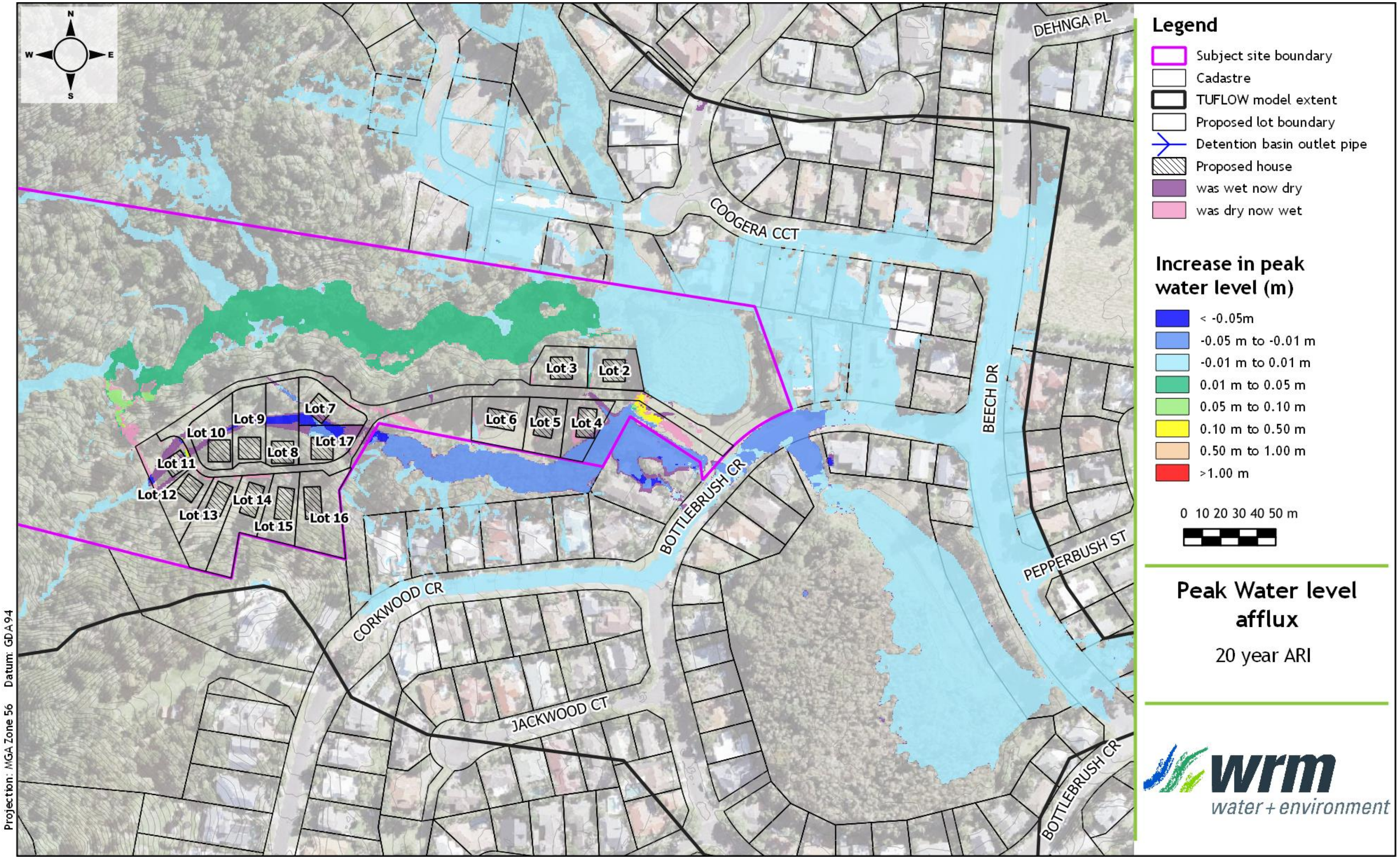


Figure 6.11 – Peak water level afflux, 20 year ARI

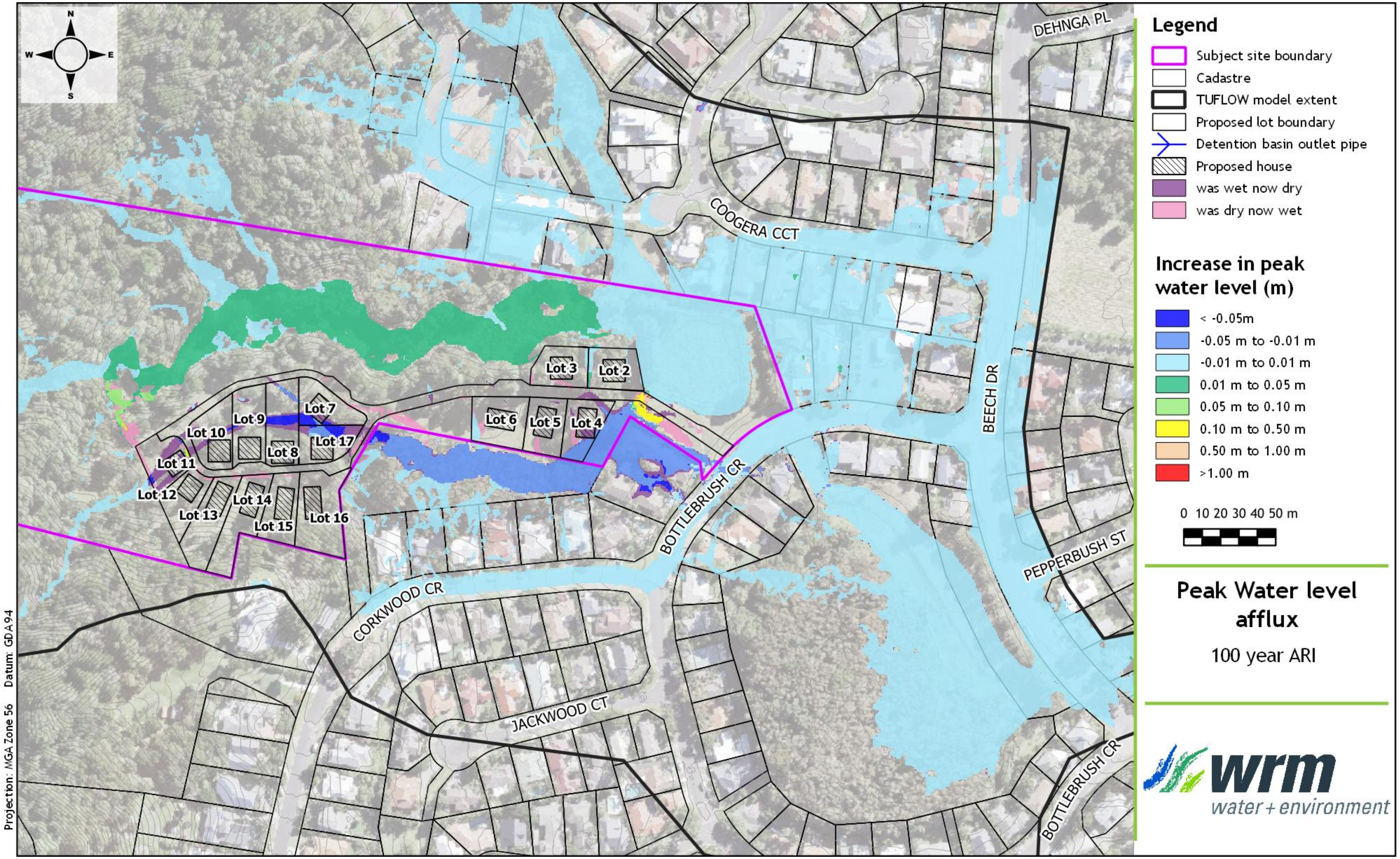


Figure 6.12 – Peak water level afflux, 100 year ARI

Figure 6.13 – Hazard (v x d), 5 year ARI

Figure 6.14 – Hazard (v x d), 10 year ARI

Figure 6.15 – Hazard (v x d), 20 year ARI

Figure 6.16 – Hazard (v x d), 100 year ARI

6.5 HOUSE PAD FLOOD LEVELS

Table 6.1 shows design flood levels adjacent to the house pads for the 10 and 100 year ARI events.

Table 6.1 - Design flood levels adjacent to house pads

Lot	Q10 Level (mAHD)	Q100 Level (mAHD)
Lot 2	14.18	14.19
Lot 3	-	-
Lot 4	14.04	14.11
Lot 5	-	15.04
Lot 6	-	16.05
Lot 7	19.07	19.08
Lot 8	-	-
Lot 9	-	-
Lot 10	-	-
Lot 11	26.40	26.42
Lot 12	-	-
Lot 13	-	-
Lot 14	26.07	26.08
Lot 15	-	-
Lot 16	-	-
Lot 17	18.95	18.96

6.6 FLOW IMPACTS

Figure 6.17 shows the locations of flood discharge impact reporting lines for comparison of peak flows for existing and developed conditions. The maximum flows for the reporting lines for the 5 year, 10 year, 20 year and 100 year ARI events for existing and developed conditions are presented in Table 6.2. The flow through reporting line three includes any flow through the existing 0.225m culvert and the 0.375m culvert in the developed case.

- The peak discharge overflowing from the Coogera Circuit detention basin increases by between 1% and 3% (Reporting line 1). These increases are very small and within the order of accuracy of the modelling. More importantly, the change does not increase peak flood levels downstream of the basin as described in Section 6.3.
- The peak discharge in Subcatchment B (Reporting line 2) increases due to the diversion of subcatchment 29C.
- The peak discharge into the Coogera Circuit Detention Basin from the Subcatchment C (Reporting line 3) reduces for all design events.
- The peak discharge through Jabiru Terrace (Reporting line 4) and further downstream (Reporting line 5) reduces for all design events.

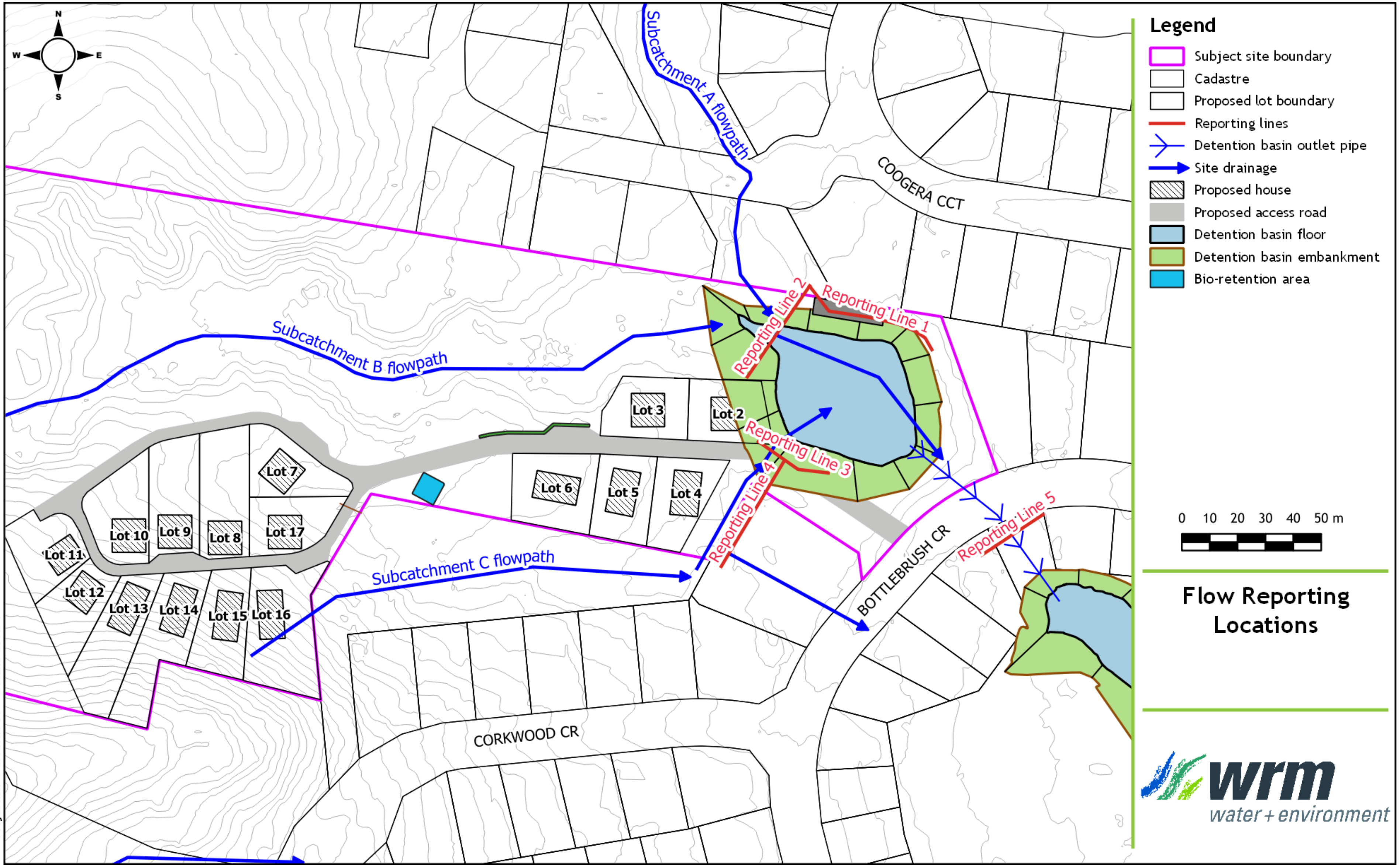


Figure 6.17 – Location of flow reporting lines

Table 6.2 - Reporting line peak discharges, existing and developed conditions

Event	Peak discharge (m^3/s)				
	Reporting Line 1	Reporting Line 2	Reporting Line 3	Reporting Line 4	Reporting Line 5
100 year ARI					
Existing	11.60	12.80	1.20	0.95	2.50
Developed	11.75	13.10	1.05	0.60	2.40
Difference	0.15	0.30	-0.15	-0.35	-0.10
20 year ARI					
Existing	5.90	8.70	1.15	0.75	1.60
Developed	6.00	9.00	0.85	0.50	1.40
Difference	0.10	0.30	-0.15	-0.25	-0.20
10 year ARI					
Existing	4.20	7.30	0.85	0.55	1.30
Developed	4.30	7.50	0.70	0.30	1.20
Difference	0.10	0.20	-0.15	-0.25	-0.10
5 year ARI					
Existing	3.00	6.80	0.80	0.50	1.10
Developed	3.10	7.00	0.60	0.30	1.10
Difference	0.10	0.20	-0.20	-0.20	0.00

6.7 ACCESS ROAD TRAFFICABILITY

It was necessary to construct an overflow weir across the access road at culvert 1 to maintain the existing conditions distribution of flow between the Coogera Circuit detention basin and Jabiru Terraces. Peak depths, velocities and hazard (measured as the depth and velocity product [DV]) across the road at Culvert 1 are shown in Table 6.3. The access road remains trafficable for all design events.

Table 6.3 - Peak depths, velocities and hazard on access road

Event (ARI)	Depth (m)	Velocity (m/s)	Hazard (DV)
5	0.08	0.50	0.05
10	0.10	0.55	0.06
20	0.12	0.60	0.07
100	0.14	0.70	0.10

7 Climate change

7.1 OVERVIEW

The proposed development was assessed for the 100 year ARI climate change scenario based on the Climate Change Strategic Planning Policy Scenario 2100 (BSC 2014a). The minimum elevation at the subject site is 11.0 mAHD at the site's frontage onto Bottlebrush Crescent. Therefore, the subject site is not affected by rising sea levels or storm surge increases. The climate change scenario used in the flood modelling was an increase in rainfall intensity of 30%.

7.2 ESTIMATION OF DISCHARGE

The XP-RAFTS rainfall runoff routing model described in Section 3 was used to estimate the peak discharges for the 100 year ARI climate change design discharge for upper catchments of Subcatchment A and B (RAFTS catchments 26A and 26B) and the catchments downstream of the site (RAFTS catchments 29A and 28). The direct rainfall applied to the TUFLOW model domain was increased by 30%.

7.3 BOTTLEBRUSH CRESENT DEVELOPMENT

The TUFLOW model was rerun using the 100 year ARI climate change rainfall.

The impact of the proposed development on 100 year ARI climate change flood event is shown in Figure 7.1. Under this climate change scenario the impact from the proposed development is similar to the impact from the 100 year ARI event.

The proposed house footprints all have 100 year ARI climate change flood immunity, while the peak depth of water over the access road under climate change conditions is 0.10 m.

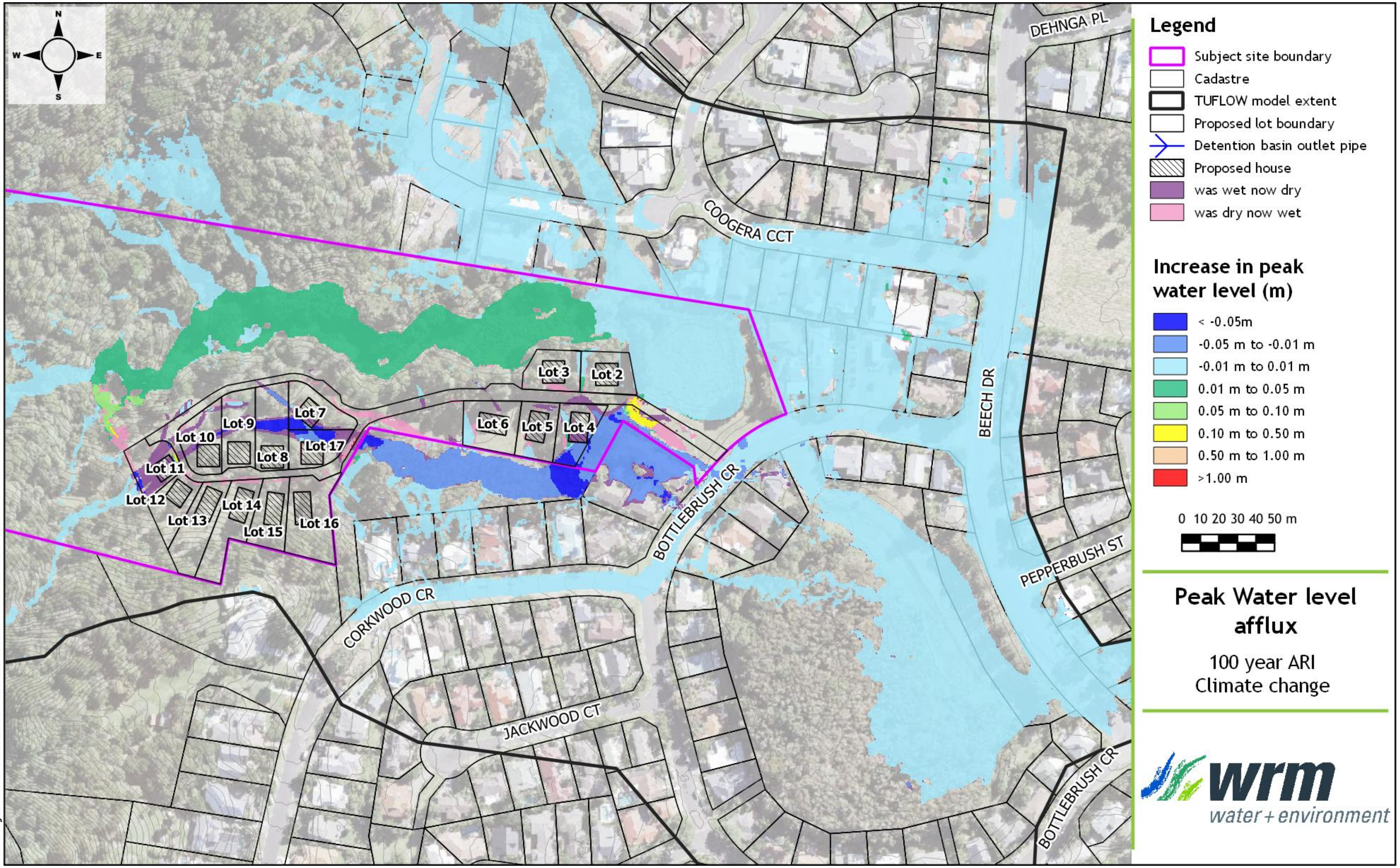


Figure 7.1 – Peak water level afflux, 100 year ARI climate change

8 Water quality modelling

8.1 MODELLING OVERVIEW

Assessment of mitigated and unmitigated post-development site runoff water quality was undertaken using the 'MUSIC' water quality model (CRCCH, 2014). The Healthy Waterways Water by Design MUSIC Modelling Guidelines (HW, 2010) were used to develop the MUSIC model parameters. Total nitrogen, total phosphorus and litter concentrations were estimated with the MUSIC model runoff generation parameters.

8.2 WATER QUALITY OBJECTIVES

Table 8.1 gives the load-based stormwater management design objectives (SWMDOs) set out by the DCP (BSC, 2014b) for site runoff in the operational phase of a development. The design objectives have been adopted as the SWMDOs for the proposed development. The percent reductions given in Table 8.1 are target reductions for low density residential comparing mitigated with unmitigated site annual pollutant loads.

Table 8.1 – Operational phase stormwater management design objectives

Parameter	Percent Reduction (%)
Total Nitrogen	45
Total Phosphorous	45
Litter	70

8.3 AVAILABLE DATA

8.3.1 Evaporation

Monthly average areal evapotranspiration estimates were obtained from DSITIA Data Drill service for the Federal Post Office during the adopted period of analysis. Table 8.2 shows the adopted monthly evapotranspiration rates.

8.3.2 Rainfall

Six minute rainfall data for Federal Post Office (station no. 58072) from the Bureau of Meteorology (BOM). A rainfall period of ten years was used for all MUSIC modelling, recommended by Healthy Waterways (HW, 2010). The adopted period of analysis was 1 January, 1988 to 31 December, 1997.

8.3.3 Source node parameters

Source nodes in the MUSIC model were split into roof, yard and road areas. Table 3.8 in HW (2010) provides mean base flow and storm flow pollutant concentrations and standard deviations for residential road, ground level and roof areas.

The HW (2010) pollutant generation parameters were applied in the MUSIC model of the subject site. Table 8.3 and Table 8.4 show the adopted MUSIC rainfall-runoff and pollutant generation parameters, respectively. Routing was not used in any drainage links.

Table 8.2 - Adopted average monthly evapotranspiration rates

Month	Monthly evapotranspiration (mm/day)	Monthly evapotranspiration (mm/month)
January	5.04	156
February	4.40	123
March	3.83	119
April	3.08	92
May	2.07	64
June	2.00	60
July	2.24	69
August	3.06	95
September	4.14	124
October	4.85	150
November	5.19	156
December	5.32	165

Table 8.3 - Adopted MUSIC runoff generation parameters

Parameter	Urban Residential
Rainfall Threshold (mm)	1
Soil Capacity (mm)	500
Initial Storage (%)	10
Field Capacity (mm)	200
Infiltration Capacity Coefficient a	211
Infiltration Capacity Coefficient b	5
Initial Depth (mm)	50
Daily Recharge Rate (%)	28
Daily Drainage Rate (%)	27
Daily Deep Seepage Rate (%)	0

Table 8.4 - Adopted base and stormflow concentration parameters

Land Use Type for MUSIC Source Nodes	Parameter	Total Suspended Solids (Log_{10} mg/L)		Total Phosphorus (Log_{10} mg/L)		Total Nitrogen (Log_{10} mg/L)	
		Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow
Urban Res Roof Areas	Mean	N/A	1.30	N/A	-0.89	N/A	0.26
	Std Dev	N/A	0.39	N/A	0.31	N/A	0.23
Urban Res Road Areas	Mean	1.00	2.43	-0.97	-0.30	0.20	0.26
	Std Dev	0.34	0.39	0.31	0.31	0.20	0.23
Urban Res Ground Area	Mean	1.00	2.18	-0.97	-0.47	0.20	0.26
	Std Dev	0.34	0.39	0.31	0.31	0.20	0.23

8.4 MODEL CONFIGURATION

Figure 8.1 shows the MUSIC model configuration used to assess the developed site runoff quality for the development. The adopted source node areas and percentage impervious are given in Table 8.5. The estimated roof areas were based on an assumed roof area of 200 m^2 per lot.

Table 8.5 - Source node area and percent impervious

Lots	Source Node ID	Adopted MUSIC Source Node Parameters	Area (ha)	Percent Impervious (%)
Lot 2-3	Yards	Urban Residential Ground Area	0.09	15%
Lot 4-6	Yards	Urban Residential Ground Area	0.15	15%
Lot 7-10, 17	Yards	Urban Residential Ground Area	0.27	15%
Lot 11-16	Yards	Urban Residential Ground Area	0.38	15%
Lot 7-10 & 17	Roof	Urban Residential Roof Areas	0.07	100%
Lot 2-6,11-16	Roof	Urban Residential Roof Areas	0.20	100%
Lot 2-17 road	Road/Reserve	Urban Residential Road Areas	0.26	60%
		TOTAL	1.42	36%

8.4.1 Rainwater tank

Toilet flushing reuse demand of 0.042 kL/day was adopted for each 5 kL rainwater tank. This demand was adopted from the permanent residential (with full water saving devices) rainwater tank demands recommended by HW (2010).

Rainwater tank reuse for landscaping was calculated in accordance with the guidelines in HW (2010) with the annual irrigation application of 548 mm on the residential lots.

The total adopted tank volume for the development was 80 kL.

8.4.2 Jellyfish filter

Table 8.6 shows the adopted MUSIC modelling parameters for the Jellyfish filter. These parameters were provided by Ocean Protect, the proprietor, of the jellyfish filter. A JF1200-2-1 filter was found to be suitable for the site.

Table 8.6 - Adopted Jellyfish filter design parameters, JF1200-2-1

Parameter	Jellyfish Filter
High flow Bypass (L/s)	12.5
Gross pollutant capture (%)	99
Total suspended solids capture (%)	93
Total phosphorus capture (%)	57
Total nitrogen capture (%)	50

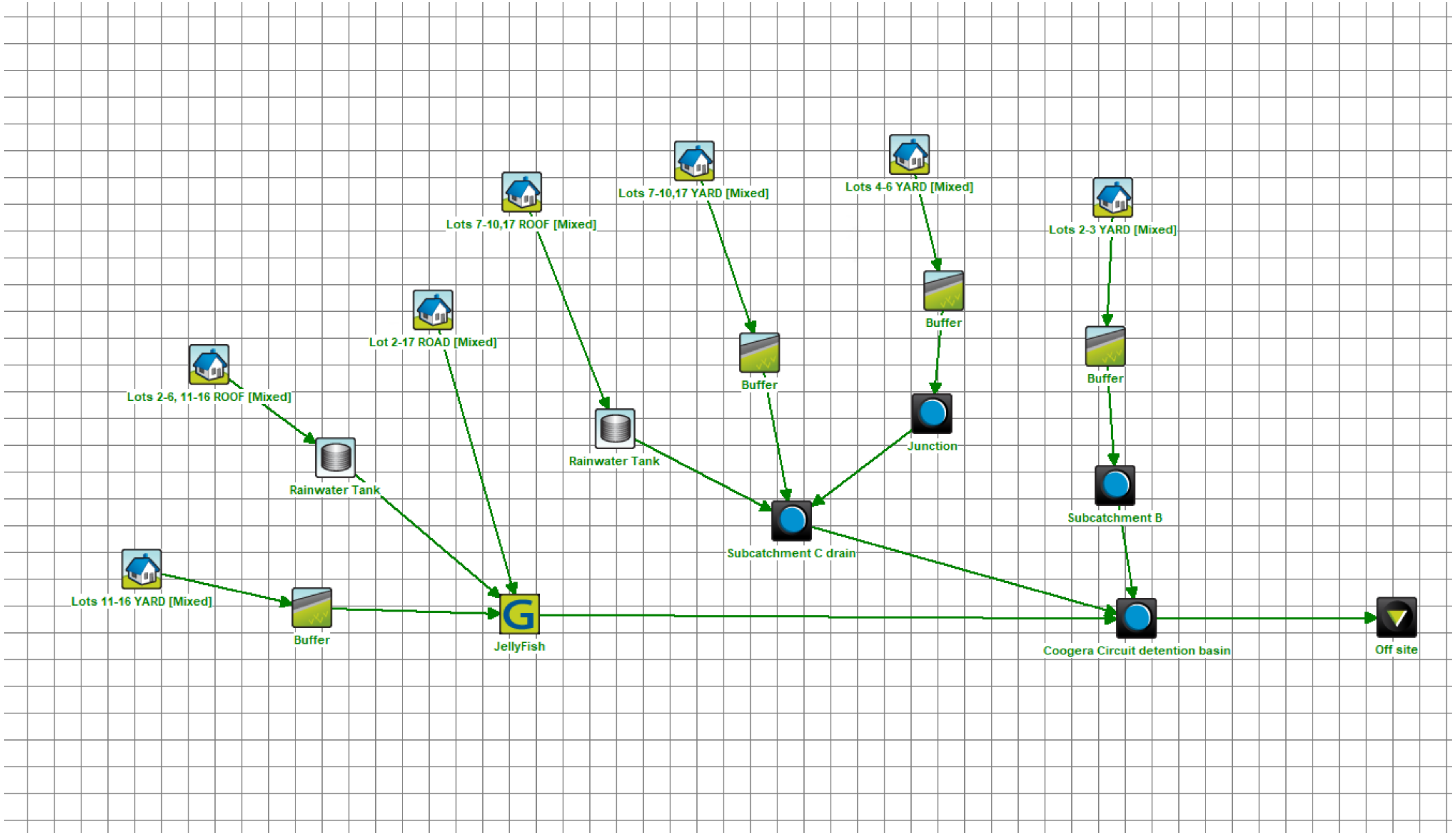


Figure 8.1 - Post-development MUSIC model configuration

8.5 WATER QUALITY RESULTS

Table 8.7 shows the mean annual pollutant loads for total nitrogen, total phosphorous and litter for mitigated and unmitigated developed conditions. WQOs are met for total P, total N and litter for these catchments.

Table 8.7 - Modelled pollutant export

Treatment Train Effectiveness - Off site

	Sources	Residual Load	% Reduction
Flow (ML/yr)	9.46	8.67	8.4
Total Suspended Solids (kg/yr)	1550	180	88.4
Total Phosphorus (kg/yr)	3.25	1.36	58.2
Total Nitrogen (kg/yr)	19.2	10.4	45.7
Gross Pollutants (kg/yr)	161	32.1	80.1

9 Conclusions

This report provides a stormwater management plan for a proposed development located at Bottlebrush Crescent, Suffolk Park.

This report has satisfied the objectives of clause 6.3 of the Byron Local Environment Plan (BSC, 2014c). The proposed development at the subject site will be above the flood planning level (100 year ARI), minimising the flood risk to life and property at the subject site including during climate changes.

The report shows that proposed developed will not cause significant adverse impacts on flood behaviour downstream of the developed including in the properties adjacent to the existing Coogera Circuit affected by spills from the existing Coogera Circuit detention basin or from the catchment to the west of Bottlebrush Crescent which passes through Jabiru Terraces.

In addition, the proposed stormwater management system for the proposed development will meet the load-based stormwater management design objectives.

The stormwater runoff from the subject site discharges to existing that are lawful points of discharge and retains the existing riparian vegetation through the subject site.

According to the BSC Comprehensive Guidelines for Stormwater Management (BSC, 2014d), an on-site stormwater detention is not required where the site is located within a catchment within which a regional detention structure has been provided for the ultimate development of the catchment. The subject site is located within a catchment within which a regional detention structure (Beech Drive detention basin) contains the increase in discharges from the developed site. Therefore, an on-site stormwater detention structure is not required for the subject site. Furthermore the modelling shows that the development does not impact on downstream flood levels or flows.

10 References

AUS-PAC, 2013	*'Northern Rivers Development and Design Manual'* AUS-PEC, August 2013
BSC, 2014a	*'Policy – Climate Change Strategic Planning',* Byron Shire Council, June 2014
BSC, 2014b	*'Bryon Shire Development Control Plan 2014',* Byron Shire Council, July 2014
BSC, 2014c	*'Byron Local Environmental Plan 2014',* Byron Shire Council, July 2014
BSC, 2014d	*'Comprehensive Guidelines for Stormwater Management',* Byron Shire Council, June 2014
BMT, 2018	TUFLOW (software), BMT, version 2018-03-AD, 2018.
IEAust, 1998	*'Australian Rainfall and Runoff: A Guide to Flood Estimation',* Revised edition, Institution of Engineers, Australia, 1998.
Innoyvze, 2019	*XP-RAFTS* (software), Innoyvze, Version 2018.1.2, 2019
HW, 2010	*Water By Design MUSIC Modelling Guidelines Version 1.0 - 2010, Healthy Waterways, Brisbane.*
Water Studies, 2002	'Tallow Creek Flood Study' for Byron Shire Council, 00421-S, Water Studies Pty Ltd, November 2002
Water Studies, 2003	"Flood Study for Proposed Development, Bottlebrush Crescent, Byron Hills", B17680/01-B, Report prepared for SAE Properties Pty Ltd by Water Studies Pty Ltd, August 2003.
WRM, 2004	"Flood Study for Proposed Development, Bottlebrush Crescent, Byron Hills", 00421-B, Report prepared for SAE Properties by WRM Water & Environment Pty Ltd, June 2004.
WRM, 2005	"Flood Study for Proposed Development, Bottlebrush Crescent, Byron Hills", 00421-B(rev2), Report prepared for SAE Properties by WRM Water & Environment Pty Ltd, December 2005.
WRM, 2008	"Flood Mitigation Study for Byron Hills and the Bottlebrush Crescent Development", 00421-S, Report prepared for David Abramovich (Tain Investments) by WRM Water & Environment Pty Ltd 31 January 2008.
WRM, 2010	"Statement of evidence stormwater and flood issues – Bryon Shire Coucil -ATS- Kennedy Lot 282 Bottlebrush Crescent, Suffolk Park", 00421-V, Report prepared for David Abramovich (Tain Investments) by WRM Water & Environment Pty Ltd 2 February 2010.
WRM, 2017	"Lot 282 Bottlebrush Crescent, Suffolk Park Stormwater management plan", 1384-01-B3, Report prepared for Tricend Design & Engineering by WRM Water & Environment Pty Ltd 30 November 2017.