WESTERN DOWNS REGIONAL COUNCIL

Jandowae, Wandoan and Tara Flood Study
Volume I
Detailed Technical Report

April 2014

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PROJECT DETAILS

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Client	Western Downs Regional Council
Client Project Manager	Allen Christensen
Water Technology Project Manager	Richard Walton
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93 Boundary Street
West End QLD 4101
Telephone (07) 3105 1460
Fax (07) 3846 5144

ABN No. 60 093 377 283
ACN No. 093 377 283

Executive Summary

Background

The Jandowae, Wandoan and Tara Flood Study is a Western Downs Regional Council (WDRC) initiative aimed at understanding the risks associated with flooding in these towns. Once the flood risks posed to the residents and businesses of these towns are understood, ways to manage these risks may be developed.

The Jandowae, Wandoan and Tara Flood Study is being undertaken as part of the full WDRC Planning Scheme review currently being undertaken to create one Planning Scheme for the Western Downs Region.

The Flood Study

A flood study is a comprehensive technical investigation of flooding behaviour that defines the extent, depth and velocity of floodwaters for floods of various magnitudes. This information is the principal technical information from which flood overlays for the Planning Scheme are formulated.

There are two principal components to a flood study:

- **Hydrologic analysis** or the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and hydrographs for a range of floods.
- **Hydraulic analysis** refers to the detailed description of flow down a watercourse or through a rural or urban floodplain or a combination of both to determine the extent, depths and velocities of flooding.

It is usual to undertake hydrologic and hydraulic analyses using computer modelling systems. Data about the catchments, floodplains, rivers, structures (e.g. bridges and culverts), land use (e.g. rural or urban) are all fed into the models. Once all the data is in the models, the models are "calibrated" to historic events to ensure that rainfall and floodplain processes can be accurately reproduced.

Following model calibration a series of theoretical "design" events are applied to the models with the aim of determining the flood hazard for flood events ranging from common (floods that could be expected to occur, on average every few years) to extreme (floods that could be expected to occur, on average once in a generation or even less frequently).

Flood Hazard

Flood hazard refers to the potential loss of life, injury and economic loss caused by future floods events. The degree of hazard varies with the severity of flooding and is affected by flood behaviour (extent, depth, velocity, duration and rate of rise of floodwaters), topography, population at risk and emergency management. Flood hazard is typically defined in the following terms:

- **Low** – there are no significant evacuation problems. If necessary, children and elderly people could wade to safety with little difficulty; maximum flood depths and velocities along evacuation routes are low; evacuation distances are short. Evacuation is possible by a sedan-type motor vehicle, even a small vehicle. There is ample time for flood forecasting, flood warning and evacuation.
- **Medium** – fit adults can wade to safety, but children and the elderly may have difficulty; evacuation routes are longer; maximum flood depths and velocities are greater. Evacuation by

sedan-type vehicles is possible in the early stages of flooding, after which 4WD vehicles or trucks are required.

- **High** – fit adults have difficulty in wading to safety; wading evacuation routes are long again; Motor vehicle evacuation is possible only by 4WD vehicles or trucks and only in the early stage of flooding. Boats or helicopters may be required.
- **Extreme** – boats or helicopters are required for evacuation; wading is not an option because of the rate of rise and depth and velocity of floodwaters. Extreme hazard is produced when flood depths exceed 1.0m, velocities exceed 1.5m/s or the combination of depth and velocity exceeds $0.6m^2/s$.

Work undertaken for the Jandowae, Wandoan and Tara Flood Study

As this is the first substantial flood study for Jandowae, Wandoan and Tara, WDRC and the project team undertook a significant amount of research and data gathering. This was in the form of:

- Community consultation,
- Research by the Dalby Family Historical Society, the Chinchilla Museum and the Miles Museum,
- Research by Council officers, and
- Interviews with residents.

Data gathered included:

- Official records (e.g. Bureau of Meteorology).
- Previous flood study reports.
- Newspaper articles.
- Photos.
- Recorded flood height records by long-term town residents.
- Flood marks on buildings and other structures.
- Anecdotal evidence/family histories of flood heights on structures (e.g. for floods that occurred over 80 years ago where there is a family history of how high the flood occurred on the house; which is still standing).

WDRC also commissioned highly accurate, aerial survey over Jandowae, Wandoan and Tara, which has been a vital component of this study and will continue to be a valuable resource for the Jandowae, Wandoan and Tara communities into the future.

Based on the historic flood information gathered by WDRC and the community, a significant amount of technical analysis was undertaken. This is discussed in detail in this document.

Study Update

The initial Jandowae, Wandoan and Tara Flood Study report was submitted in November 2012. Since then a significant amount of additional community consultation and technical analysis has been undertaken which has resulted in significantly confidence in the flow estimates for Dalby, Chinchilla and Miles.

While there has not been a significant increase in the amount of data available for Jandowae, Wandoan and Tara, as discussed in this report, the flood estimates for Jandowae, Wandoan and Tara use regional scaling techniques and as such, revised design discharges are presented in this report.

Through this revised analysis, there has been a general decrease in design flows with a corresponding decrease in design levels.

Jandowae, Wandoan and Tara Flood Studies – Lessons Learned

The Jandowae, Wandoan and Tara Flood Study has provided an increased understanding of floods and flood hazard for these towns. Specific lessons learned include:

- There is substantial flood hazard in and around Jandowae and Tara, due to the flat terrain.
- There is limited flood hazard in Wandoan as large floods are for the most part confined to the creek.
- There has only been a small amount of development in and around the towns over recent decades. This development has not had a substantial impact on (and is not significantly exposed to) flood risk.
- While there is limited ongoing development pressure in the towns, WDRC need to ensure appropriate management (through the Planning Scheme) of stormwater flooding.

Outcomes of the Jandowae, Wandoan and Tara Flood Studies

Outcomes of the Jandowae, Wandoan and Tara Flood Studies that will have direct benefit to the town communities include a series of maps detailing flood hazard for:

- Creek floods, and
- Local stormwater floods.

The maps will be an invaluable tool to ensure appropriate development that provides a suitable level of safety while not adversely impacting on existing properties or residents (e.g. by blocking of overland flowpaths and/or redirecting stormwater onto nearby properties).

Report Format

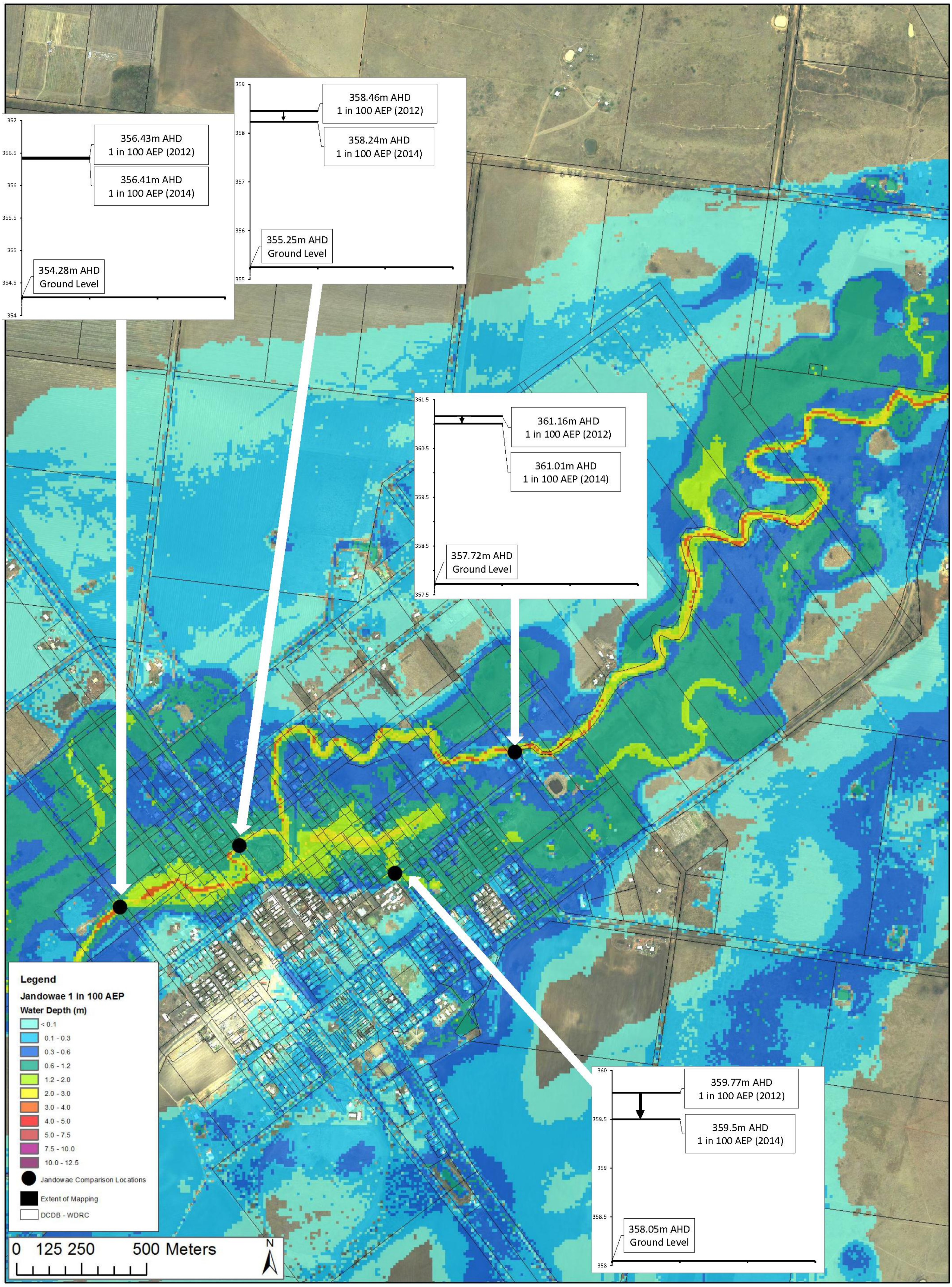
For convenience, this report consists of four volumes:

Volume I: Jandowae, Wandoan and Tara Flood Study Detailed Technical Report (this document).

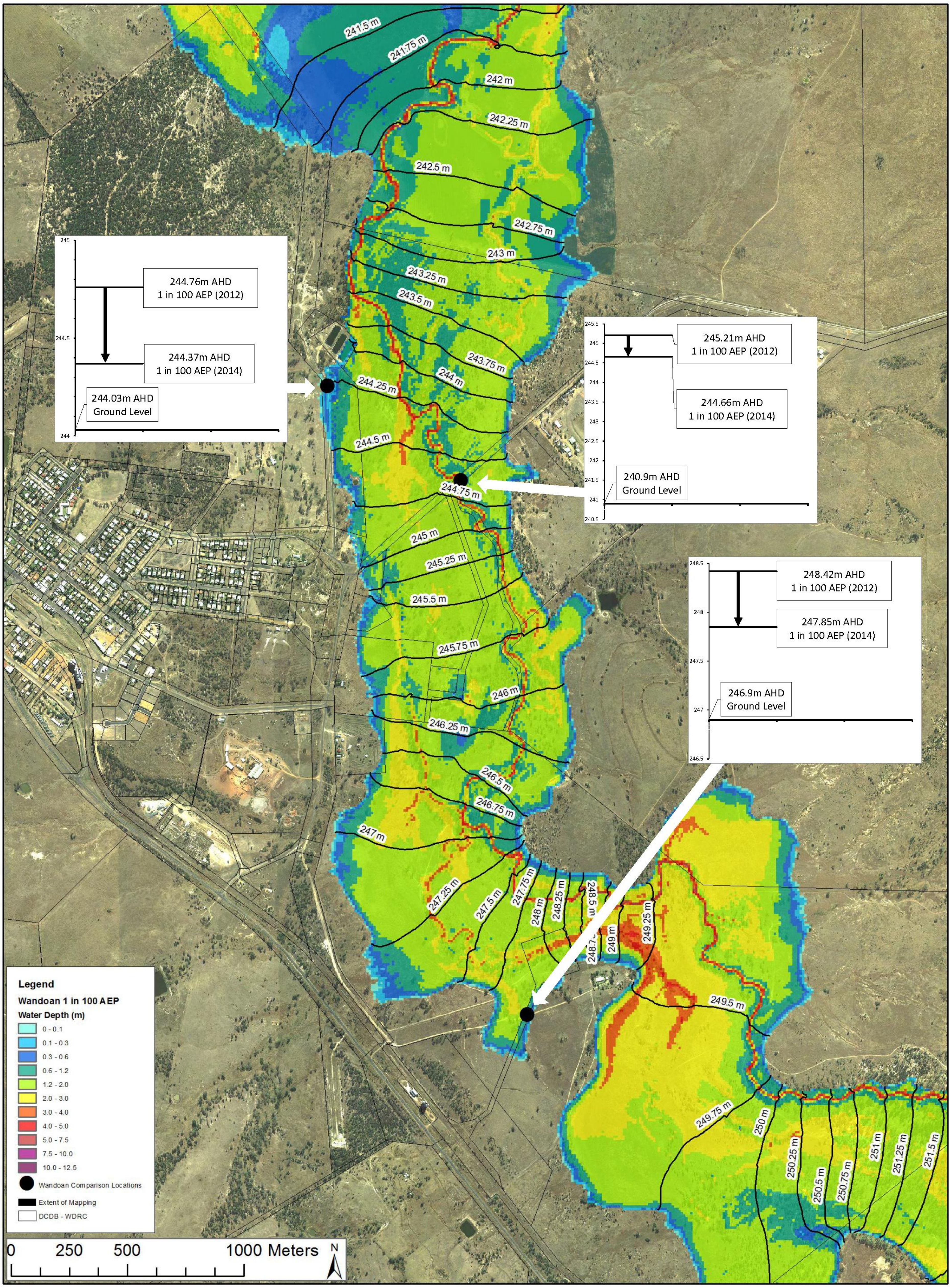
Volume II: Jandowae Flood Study Maps.

Volume III: Wandoan Flood Study Maps.

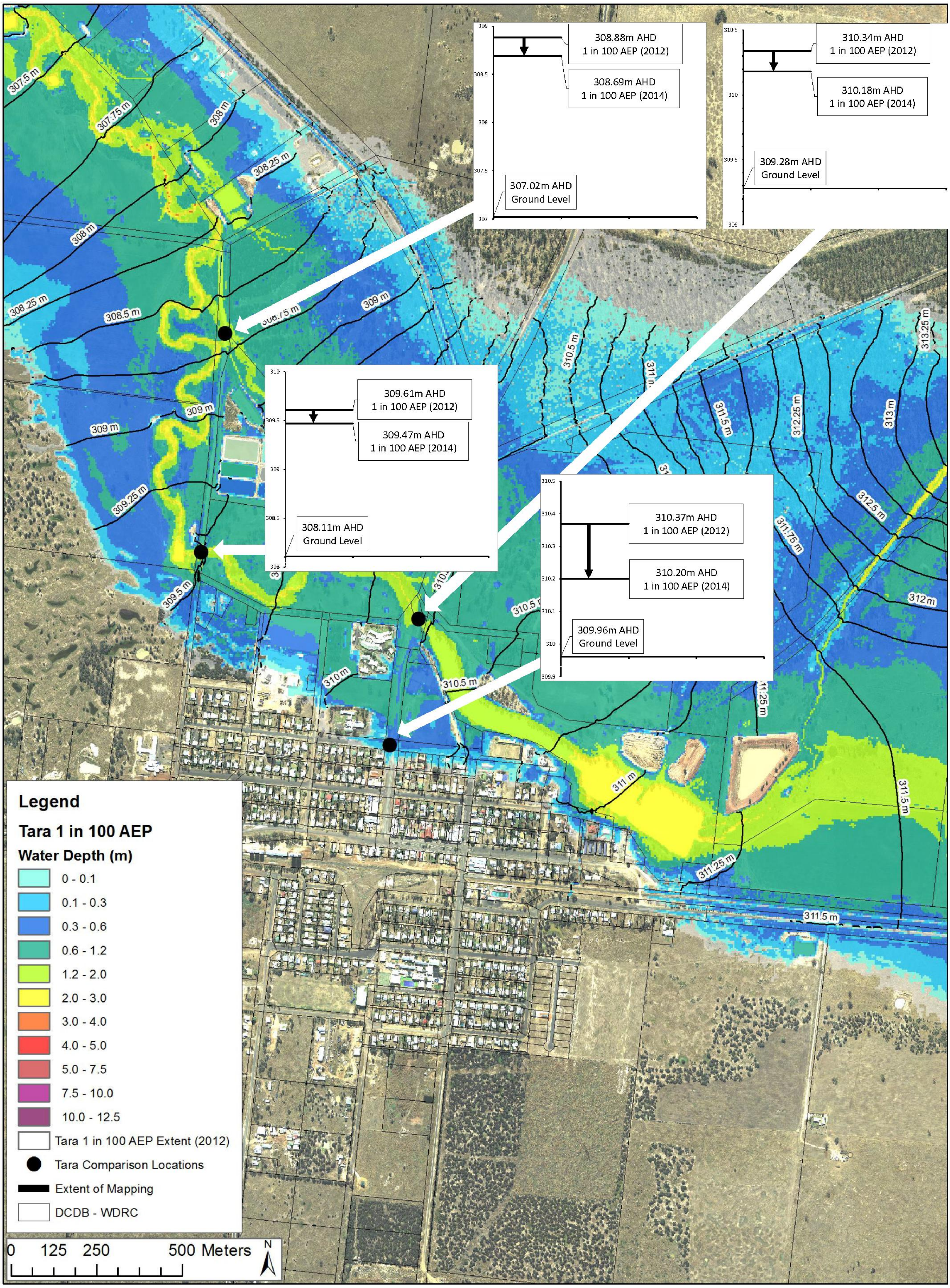
Volume IV: Tara Flood Study Maps.



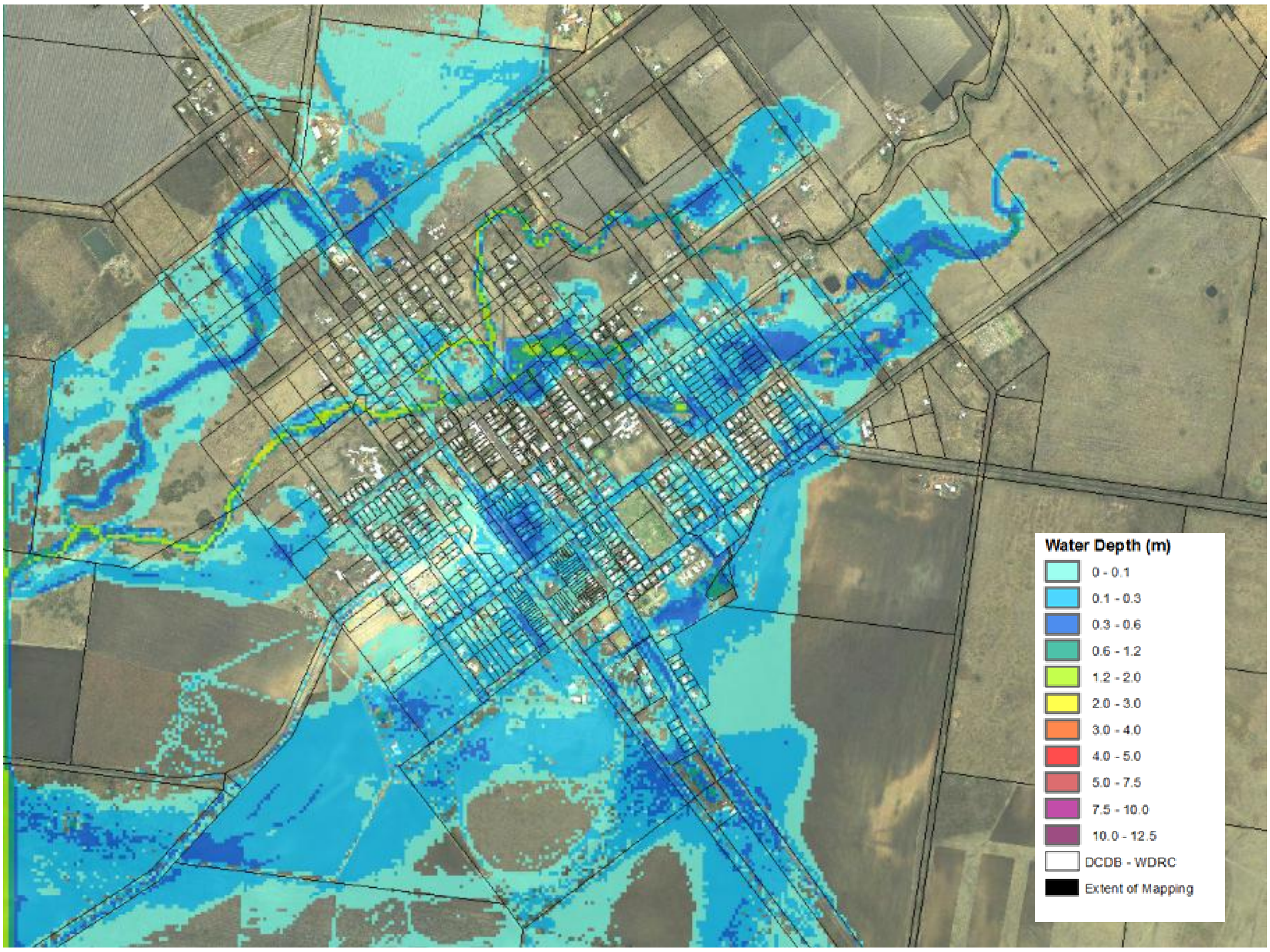
Jandowae 1 in 100 AEP Riverine Flood Depth



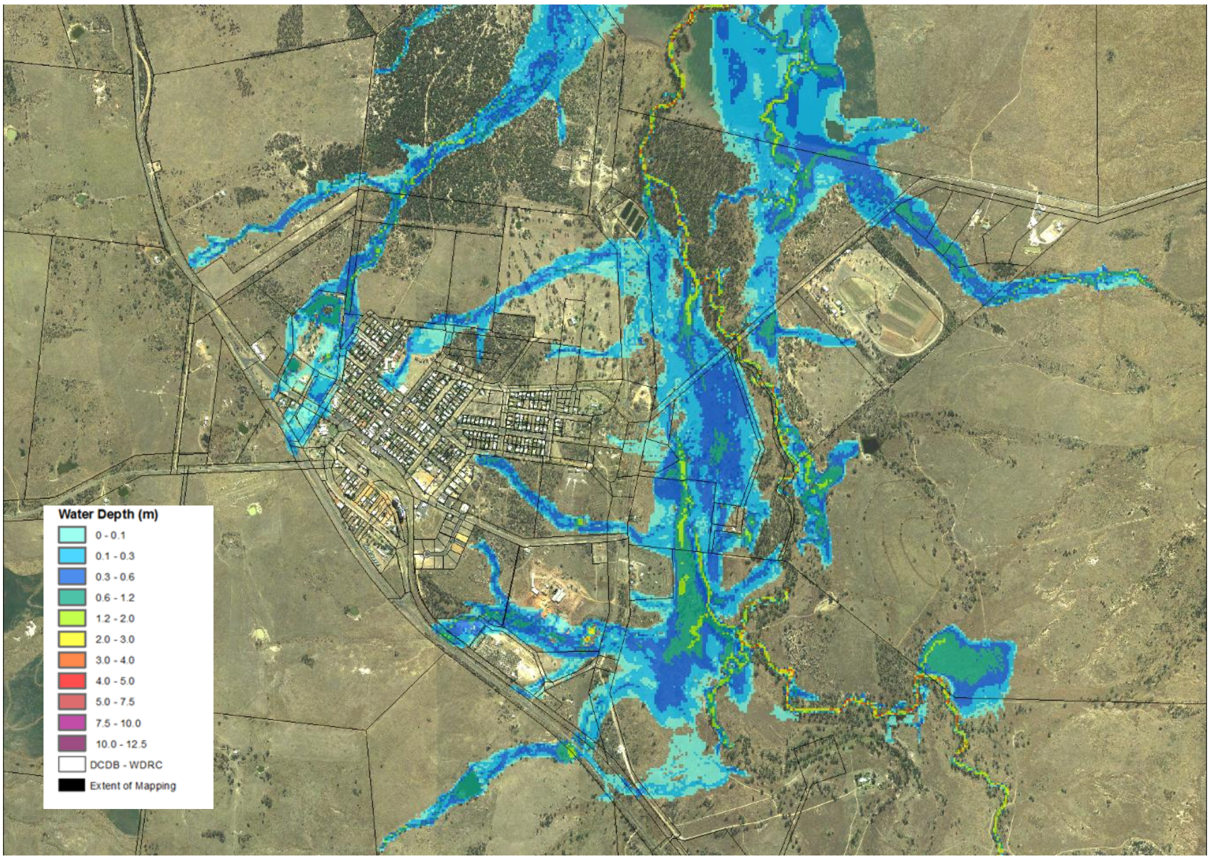
Wandoan 1 in 100 AEP Riverine Flood Depth



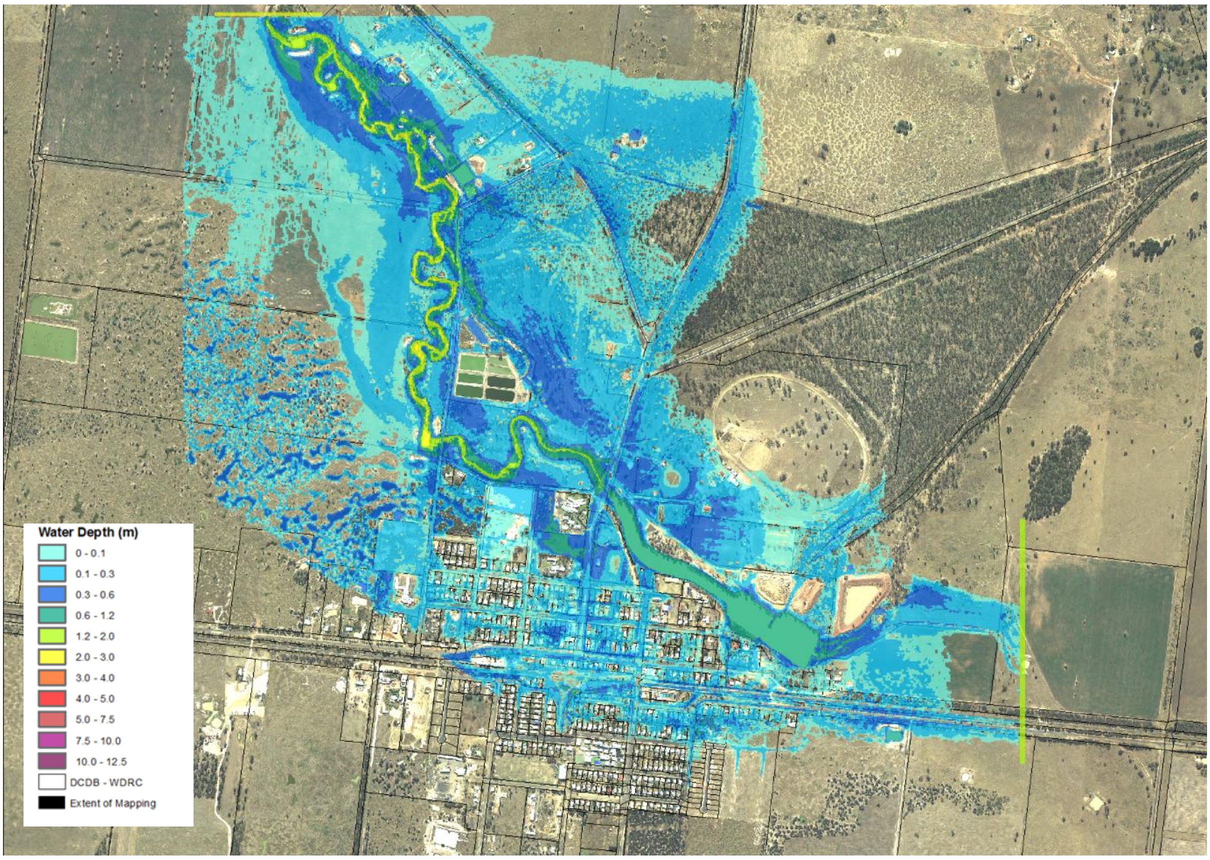
Tara 1 in 100 AEP Riverine Flood Depth



Jandowae 1 in 100 AEP Stormwater Flood Depth



Wandoan 1 in 100 AEP Stormwater Flood Depth



Tara 1 in 100 AEP Stormwater Flood Depth

Acknowledgements

This study would not have been possible without the support of the following people and organisations:

- The residents of Jandowae, Wandoan and Tara (past and present).
- The Dalby Family Historical Society.
- The Chinchilla Museum.
- The Miles Museum.
- WDRC Councillors.
- WDRC Officers.

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Abbreviations

AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
AR&R	Australian Rainfall and Runoff
BoM	Bureau of Meteorology
DNRM	Department of Natural Resources and Mines
DFE	Defined Flood Event
DTM	Digital Terrain Model
DTMR	Department of Transport and Main Roads
EWS	Energy and Water Supply, Queensland Government
GIS	Geographic Information System
LIDAR	Light Detection and Ranging
NFRAG	National Flood Risk Advisory Group
NHMA	Natural Hazard Management Areas
NRW	Natural Resources and Water (Queensland Government)
QR	Queensland Rail
QRA	Queensland Reconstruction Authority
QFCI	Queensland Flood Commission of Inquiry
SPP 1/03	State Planning Policy 1/03

Glossary

Annual Exceedance Probability (AEP) means the chance of a flood of a given or large size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (1 in 20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Bureau of Meteorology (the Bureau) is Australia's national weather, climate and water agency.
Australian Height Datum (AHD) means a common national surface level datum approximately corresponding to mean sea level.
Average Recurrence Interval (ARI) means the long-term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event (see AEP).
Catchment is the land area drained by a waterway and its tributaries.
Climate change a change in the state of the global climate induced by anthropogenic change to the atmospheric content of greenhouse gases and that persists for an extended period, typically decades or longer (Note 2)
Culvert is a short passageway under a road, railway or embankment designed to allow stormwater to allow from one side to the other without being dammed.
Defined flood event (DFE) is the flood event adopted by a local government for the management of development in a particular locality.
Defined flood level (DFL) is the level of a flood that would occur during a defined flood event (DFE).
Discharge is the rate of flow of water measured in terms of volume per unit of time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving.
Essential services encompass electrical power, the provision of drinking water, sewerage, stormwater drainage, telecommunications and roads and rail.
Flood relatively high water levels caused by excessive rainfall, storm surge, dam break or a tsunami that overtop the natural or artificial banks of a stream, creek, river, estuary, lake or dam (Note 4)
Flood damage the tangible (direct and indirect) and intangible costs (financial, opportunity cost, clean-up) of flooding. Tangible costs are qualified in monetary terms (e.g. damage to goods and possessions, loss of income or services in the flood aftermath). Intangible damages are difficult to quantify in monetary terms and include the increased levels of physical, emotional and psychological health problems suffered by flood-affected people and attributed to a flooding episode (Note 4)
Flood hazard potential loss of life, injury and economic loss caused by future floods events. The degree of hazard varies with the severity of flooding and is affected by flood behaviour (extent, depth, velocity, duration and rate of rise of floodwaters), topography, population at risk and emergency management (Note 4)

Glossary cont.

Flood hazard area, for the purposes of Queensland Development Code, proposed new part 3.5: 'Construction of buildings in flood hazard areas', 21 November 2011 , means an area, whether or not mapped, designated by a local government as a natural hazard management area (flood) under section 13 of the *Building Regulation 2006.*
Flood map is a map which depicts the extent of a particular flood or floods, for example the 1 in 100 AEP flood or a historical flood.
Flood overlay map is a map used in land planning to depict the land constrained by planning controls imposed by a council because of the flood risk associated with the land.
Floodplain is an area of land adjacent to a creek, river, estuary, lake, dam or artificial channel, which is subject to inundation by floodwater.
Flood risk is a term that usually embodies both likelihood of flooding and the consequences of flood.
Flow velocity means the speed and direction of flow, measured in metres per second (m/s). (Note 6)
Hydrodynamic (hydraulic) model uses data about the flow in streams and the terrain of a particular area to estimate flood heights, velocities and flow over time. In order to do this the hydrodynamic model solves the equations for the conservation of mass and momentum/energy.
Hydrograph a graph that shows for a particular location, the variation with time of discharge (discharge hydrograph) or water level (stage hydrograph) during the course of a flood (Note 4)
Hydrologic model (runoff routing model) uses rainfall data and estimates of the proportion of the rainfall which turns into runoff and the time which the runoff from each part of the catchment rakes to flow into the stream to estimate flow in the stream over time.
Hydrology is the term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
Major flooding is a term used by the Bureau of Meteorology to depict extensive flooding of rural areas and/or urban areas. Properties and towns are likely to be isolated and major traffic routes likely to be closed. Evacuation of people from flood affected areas may be required.
Major Overland Flow Path an overland flow path that drains water from more than one property, has no suitable flow bypass, and has a water depth in excess of 75mm during the major design storms, or is an overland flow path recognized as "significant" by the local government (Note 3).
Major Road a road whose primary function is to serve through traffic. These roads include Collector Roads, Sub-Arterial and Arterial Roads. Refer to Department of Main Roads or AustRoads for further definition (Note 3)
Minor flooding is a term used by the Bureau of Meteorology to depict flooding that occurs in low-lying areas next to watercourses where inundation may require the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged.
Planning scheme is a local planning instrument for regulating development in Queensland. Planning schemes regulate what development must be assessed before it can be undertaken, the type of assessment required and the criteria used in an assessment in each council region. They also contain codes with which self-assessable development must comply.
Probable maximum flood is an estimate of the largest possible flood that could occur at a particular location, under the most severe meteorological and hydrological conditions.

Glossary cont.

Q100 is a probability-based design flood event discharge, aimed to reflect typical combinations of flood producing and flood modifying factors which act together to produce a flood event at a specific location of interest that has a I in 100 chance of being equalled or exceeded in any one year (1% annual exceedance probability - AEP): it is described as having an average recurrence interval (ARI) of 100 years. It is a theoretical flood model used to inform planning and policy (see AEP and ARI).
Stormwater is the rain water that has not yet entered a river system or soaked into the ground.
Stormwater flooding inundation by local runoff caused by heavier than usual rainfall. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing urban stormwater drainage systems to overflow (Note 4).
Stream /river gauging station (gauge) a manual or automated gauge that measures the height of the water in a river at a particular location.
Watercourse as defined in the Sustainable Planning Regulation 2009 (Note 2): (1) Generally, watercourse means a watercourse as defined under the *Water Act 2000,* schedule 4. (2) Watercourse, for schedule 3, part 1, table 4, item 5(b)(iv), means a river, creek or stream in which water flows permanently or intermittently – (a) in a natural channel, whether artificially improved or not; or (b) in an artificial channel that has changed the course of the watercourse (3) Watercourse, for schedule 24, part 1, section 1(2) – (a) Means a river, creek or stream in which water flows permanently or intermittently – i) in a natural channel, whether artificially improved or note; or ii) in an artificial channel that has changed the course of the watercourse; and iii) Includes the bed and banks and any other element of a river, creek or stream confining or containing water.
Waterway as defined under the *Environmental Protection Act 1994* means any of the following (Note 5): • a creek, river, stream or watercourse • an inlet of the sea into which a creek, river, stream or watercourse flows • a dam or weir

Notes

(1) Unless otherwise noted, definitions have been taken from the QFCI Final Report.
(2) Definitions taken from SPP1/03.
(3) Definitions taken from the Queensland Urban Drainage Manual.
(4) Definitions taken from Floodplain Management in Australia, Best Practice Principles and Guidelines.
(5) Definitions taken from SPP4/10.

1 INTRODUCTION

Western Downs Regional Council (WDRC) was created in March 2008 after the amalgamations of local government areas throughout Queensland. WDRC contains six former local government areas and six different Planning Schemes. The former local government areas include Dalby Town Council, Wambo Shire Council, part of Taroom Shire Council, Chinchilla Shire Council, Murilla Shire Council and Tara Shire Council. A full Planning Scheme review is currently being undertaken to create one Planning Scheme for the Western Downs Region to resolve conflicts between the six different Planning Schemes within the Western Downs Regional Council.

WDRC proposed to undertake flood studies of six towns in the region in conjunction with the Planning Scheme review. There are two components to the flood studies; riverine flooding and stormwater flooding. The purpose of the riverine flood studies are to identify areas of risk of flood inundation, their impact upon current and future development and to identify flood hazard categories for the inundation areas for the defined flood event (DFE). The purpose of the stormwater flood analysis is to define and map stormwater corridors within current and future development areas. The six towns included in the study were Dalby, Chinchilla, Miles, Wandoan, Jandowae and Tara.
Figure 1.1 shows the WDRC area and the location of the six towns where flood studies have been undertaken as part of the current planning scheme review.

This report presents the technical analysis undertaken in support of the flood study for Jandowae, Wandoan and Tara.

This report consists of four volumes:

Volume I: Jandowae, Wandoan and Tara Flood Study Detailed Technical Report (this document).

Volume II: Jandowae Flood Study Maps.

Volume III: Wandoan Flood Study Maps.

Volume IV: Tara Flood Study Maps.

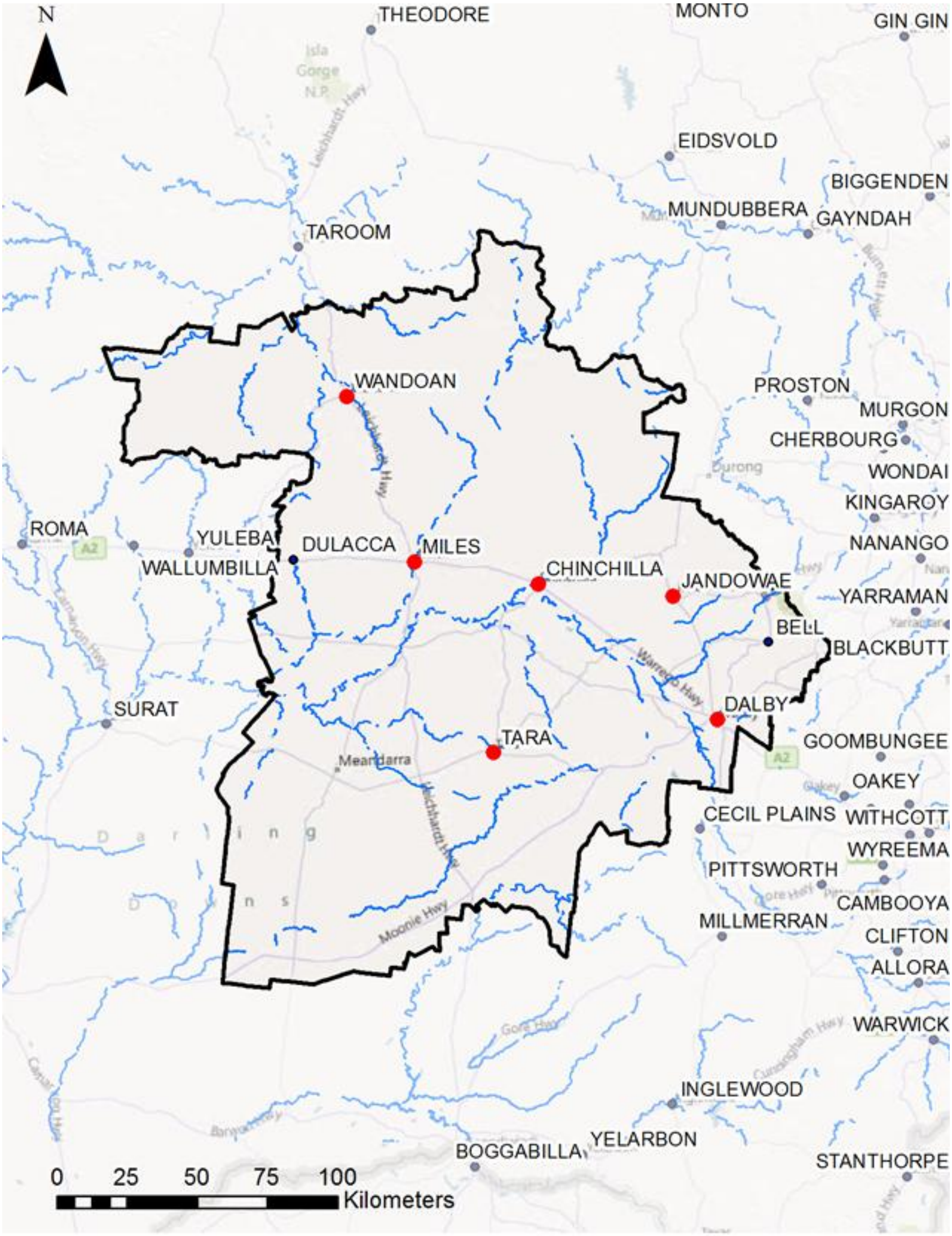

Figure 1.1 Western Downs Regional Council Area

(Red dots represent towns where a flood study has been undertaken as part of the planning scheme revision)

2 AVAILABLE DATA

2.1 Previous Investigations

Unfortunately no previous investigations (in the form of formal flood studies) were available for Jandowae, Wandoan or Tara.

2.2 Topographical Survey

The survey data adopted for this study are:

- A LIDAR survey of the six study towns undertaken by WDRC in 2010 was adopted for:
  - Hydraulic modelling of both riverine and stormwater flooding
  - Catchment delineation for stormwater modelling.
- Topographic data with a resolution of 3 arc seconds was used to estimate the catchments for the riverine flood studies.

2.3 Hydrometerological Data

2.3.1 Rainfall

Table 2.1 lists and Figure 2.1 shows the location of the available rainfall stations throughout the study area.

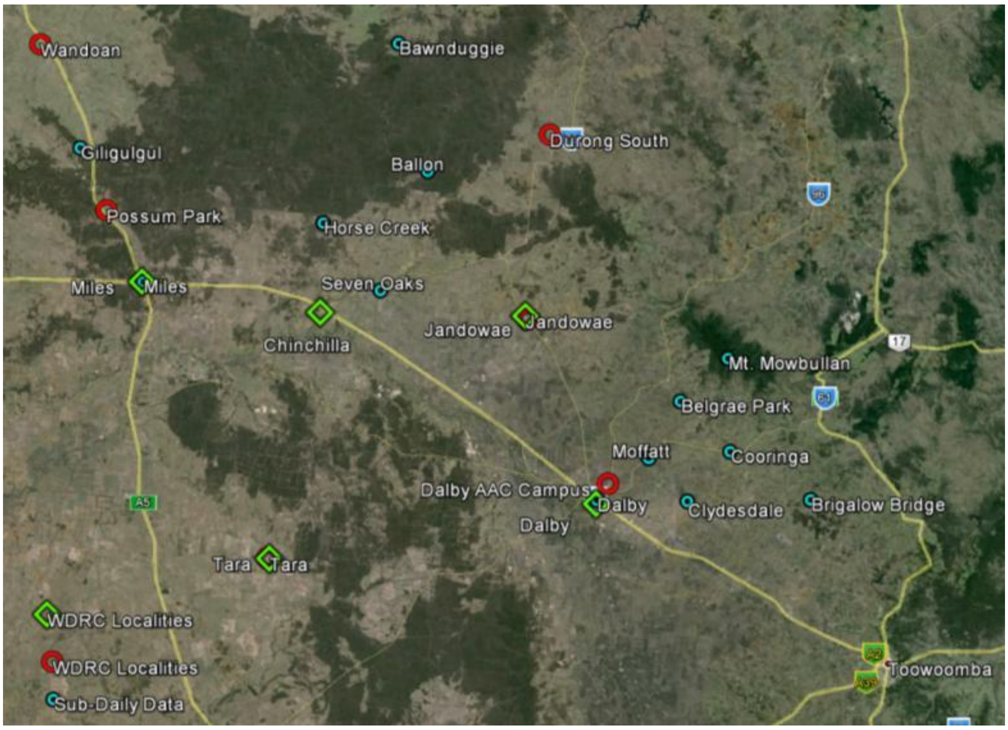

Figure 2.1 Available Rainfall Gauging Stations

(Red markers represent daily stations and blue markers represent sub-daily stations)

Table 2.1 Available Rainfall Stations

Station		
Name	**Number**	**Type** [1]
Miles	042112	AWS
Possum Park	042004	Daily
Seven Oaks	041020	TM
Ballon	041092	TM
Bawnduggie	042036	TM
Durong South	040071	Daily
Horse Creek	042025	TM
Giligulgul	035039	TM
Wandoan	035014	Daily
Jandowae	041050	Daily
Dalby	541041	Alert
Moffatt	541042	Alert
Clydesdale	541043	Alert
Tara	041009	Daily
Belgrae Park	041551	Alert
Cooringa	541044	Alert
Mt Mowbullan	541046	Alert
Brigalow Bridge	041490	TM
Dalby AAC Campus	041497	Daily

Note 1
Daily – Rainfall Stations report rainfall amount received in the 24 hours prior to 9am each day.
Alert – Rainfall and/or stream gauging stations that communicate every one millimetre of rainfall over radio network to Flood Warning Centre
AWS – Automatic Weather Station. Sub hourly data
TM – Rainfall station connected to the public phone network, polled regularly during periods of heavy rain

2.3.2 Stream Gauges

Unfortunately there are no stream gauges on watercourses that run through Jandowae, Wandoan and Tara.

2.4 Hydraulic Structures

Details for all major hydraulic structures were provided by WDRC. Minor structures, for example culverts under private driveways, were not included in the hydraulic analysis.

2.5 Additional Flood Data Collection

Extensive research was undertaken as part of the study to identify and list historical floods for Jandowae, Wandoan and Tara. Full details are provided in the following sections.

2.6 Available Historical Flood Data Sets

No flood level data is available for historical floods in the study towns. Table 2.2 shows the dates of the most recent floods.

Table 2.2 Historical Floods – Wandoan, Jandowae and Tara

Town (gauge location)	Date [1]	Height [2]		Comments
		Gauge (m)	AHD (m)	
Wandoan	unknown	n/a	n/a	
Jandowae	11 January 2011	n/a	n/a	Anecdotally the largest in living memory.
Tara	27 December 2010	n/a	n/a	

Notes:
1) Date of flood peak.
2) n/a denotes no gauging station present

2.7 Historical and Ultimate Hydraulic Roughness and Topography Maps

A historic hydraulic roughness and topography map was developed for Jandowae to model the 2011 flood. The map was based upon the 2010 level of development. Ultimate development maps in accordance with planning scheme zones, were developed for all three towns.

2.8 Regional Flood Frequency Estimates

Software supporting the Australian Regional Flood Frequency (ARFF) estimates was released in November 2012 (Engineers Australia, 2012). This software was developed as part of the review of the Australian Rainfall and Runoff (ARR) guide to flood estimation. ARFF provides a regional estimate of discharge anywhere in Australia. The ARFF estimates were used as an additional piece of information in the determination of flood discharge magnitude for the six towns in the current study. The ARFF estimates for Jandowae, Wandoan and Tara are presented and discussed further in Section 0.

3 FLOOD ANALYSIS APPROACH

3.1 Overview

The flood analysis of Jandowae, Wandoan and Tara was undertaken using a combination of hydrologic and hydraulic modelling techniques.

3.2 Hydrologic (Rainfall/Runoff) Analysis

3.2.1 Overview

Hydrology is the term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.

A **Hydrologic model (runoff routing model)** uses rainfall data and estimates of the proportion of the rainfall which turns into runoff and the time which the runoff from each part of the catchment takes to enter into the stream or watercourse over time. The 'RAFTS' runoff-routing model (XP Software, 2001) was used to model hydrologic processes in Jandowae, Wandoan and Tara.

3.3 Hydraulic (Flow) Analysis

Hydraulics (in this context) refers to the detailed description of flow down a watercourse or through a rural or urban floodplain or a combination of both.

A hydraulic (or hydrodynamic) model uses data about the flow in streams and the terrain of a particular area to estimate flood heights, velocities and flow over time.

Hydraulic modelling of the Dogwood Creek floodplain through Miles has been undertaken utilising DHI Software's MIKE FLOOD modelling system.

MIKE FLOOD combines via dynamic coupling the one-dimensional MIKE 11 river model and MIKE 21 fully two-dimensional model systems. Through coupling of these two systems it is possible to accurately represent in and over-bank floodplain flood behaviour as well as sub-surface drainage flow behaviour through the application of a comprehensive range of hydraulic structures (including culverts, bridges, weirs, control gates etc.).

4 FLOOD HYDROLOGY

4.1 Overview

There is very limited historical flood data for Jandowae, Wandoan and Tara. The only data of note is flood level data for Jandowae for the January 2011 flood. There are no stream gauges or rainfall gauges in any of the catchments.

Given the paucity of data, it is not possible to estimate discharges using either a flood frequency analysis or the design rainfall technique for any of the three towns. The best option available is estimation of discharges using area scaling against a nearby catchment. For this study, the three catchments to choose from are Dalby, Chinchilla or Miles. The Australian Regional Flood Estimation (ARFF) discharge estimates were also used to assist in flood magnitude selection.

In consultation with WDRC staff, it was considered that the following catchments were most similar:

- Jandowae – Dalby.
- Wandoan – Miles.
- Tara – Chinchilla soil characteristics and Dalby Terrain.

4.2 Historical Data

There is very limited historical flood data for Jandowae, Wandoan and Tara. The only data of note is flood level data for Jandowae for the January 2011 flood. There are no stream gauges or rainfall gauges in any of the catchments.

4.3 Joint Hydrologic/Hydraulic Calibration

Joint hydrologic/hydraulic model calibration was not undertaken due to insufficient and inadequate rainfall data. There are no stream gauges or rainfall gauges in any of the catchments.

- The hydrology models used design rainfall.
- The hydraulic models used roughness consistent with the Chinchilla and Dalby calibrations.

4.4 Design Discharge Estimation Techniques

Given the paucity of data, it is not possible to estimate discharges using either a flood frequency analysis or the design rainfall technique for any of the three towns. The best option available is estimation of discharges using area scaling against a nearby catchment. For this study, the three catchments to choose from are Dalby, Chinchilla or Miles. The Australian Regional Flood Estimation (ARFF) discharge estimates were also used to assist in flood magnitude selection.

4.5 Area Scaling

Transposing discharge estimates from gauged to ungauged catchments needs to account for the following processes:

- Spatial variation in catchment characteristics and climate.
- Variation in catchment areas.
- Spatial variation of rainfall.

That is, assuming that catchment characteristics and climate are similar:

- Larger catchments will produce larger discharges (for a given AEP) than smaller catchments, due to the larger catchment area.
- There will be greater spatial variation in rainfall across larger catchments; this effect is often represented by use of an "areal reduction factor". That is, for a small catchment, a given rainfall event is likely to fall over the entire catchment area with the percentage of the catchment receiving rainfall decreasing with increasing catchment area. This tends to introduce non-linearity in the catchment area – discharge relationship.

There is very little available methodology for transposing discharges between catchments in Queensland. The only applicable method is that reported in Grayson et al. (1996):

$$\frac{Q_C}{Q_G} = \left(\frac{A_C}{A_G}\right)^b \qquad \textbf{(4.1)}$$

Where:

Q = Discharge (m^3/s)
A = Area
C = ungauged catchment (km^2)
G = gauged catchment (km^2)
b = exponent

Studies show that the exponent b ranges from 0.5 to 0.85. If no data is available Grayson et al. (1996) recommend a value of b=0.7. There appears to be no clear basis for the adoption of b=0.7 other than (if no data is available) it is approximately the average of the range of published values.

Area-scaling discharge estimates for all three towns based upon Dalby, Chinchilla and Miles flood quantiles was undertaken. An exponent of 0.7 was adopted for all scaling. The results for each town are provided in Table 4.1 to Table 4.3

4.6 Australian Regional Flood Frequency

The Australian Regional Flood Frequency (ARFF) Model (Engineers Australia, 2012) was used to estimate flood magnitudes for each town. The ARFF flood magnitude estimates for each town are provided in Table 4.1 to Table 4.3

Table 4.1 Discharge Estimates for Jandowae

AEP (1 in x)	Scaled Discharge (m^3/s) (Direct Area Scaling) from Reference Catchment			ARFF (m^3/s)	Adopted (based on Dalby scaled discharge) (m^3/s)
	Miles Dogwood Ck @ Warrego Hwy (042107) (2,875 km^2)	Chinchilla Charleys Ck @ Weir (041409) (WT Catchment Area) (3,458 km^2)	Dalby Myall Ck @ Dalby (WT Catchment Area) (1,464 km^2)		
2				50	
5				140	
10	160	50	60	220	60
20	240	140	120	320	120
50	380	240	290	475	290
100	490	330	500	600	500

Jandowae Creek @ Jandowae = 241 km^2

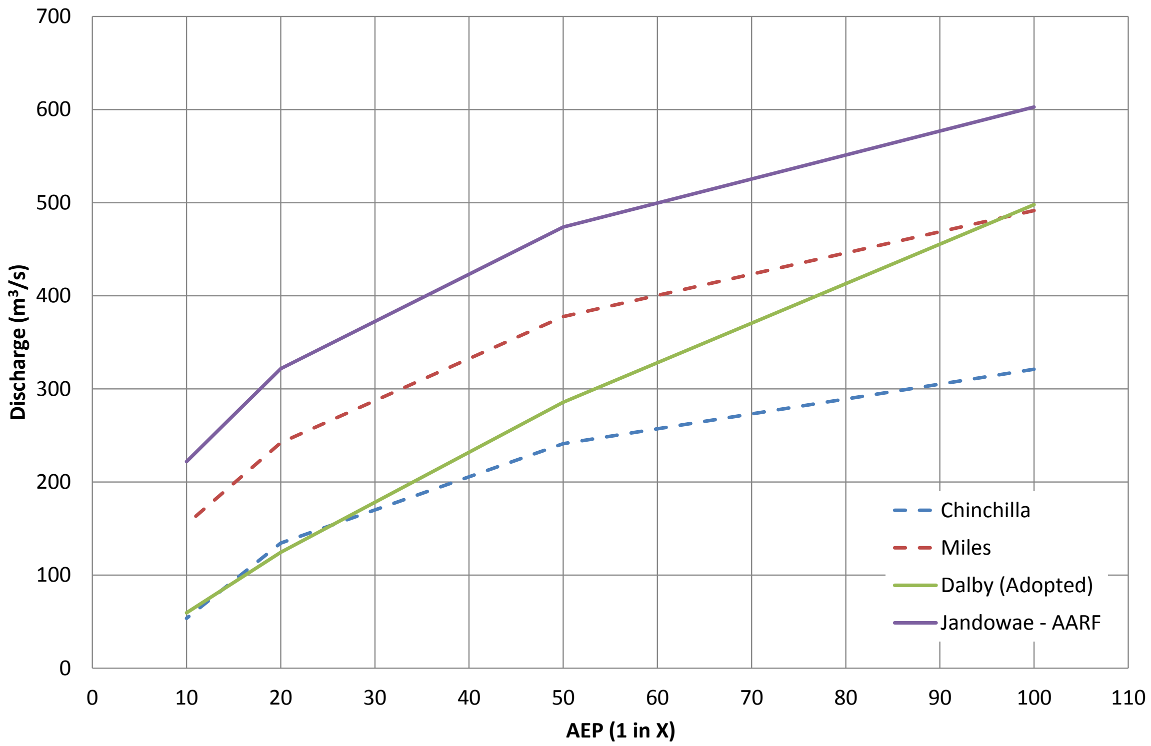

Figure 4.1 Comparison of Discharge Estimates for Jandowae

Table 4.2 Discharge Estimates for Wandoan

AEP (1 in x)	Scaled Discharge (m^3/s) (Direct Area Scaling) from Reference Catchment			ARFF (m^3/s)	Adopted (based on Miles scaled discharge) (m^3/s)
	Miles Dogwood Ck @ Warrego Hwy (042107) (2,875 km^2)	Chinchilla Charleys Ck @ Weir (041409) (WT Catchment Area) (3,458 km^2)	Dalby Myall Ck @ Dalby (WT Catchment Area) (1,464 km^2)		
2				110	
5				330	
10	300	110	120	550	300
20	470	260	240	800	470
50	730	470	550	1180	730
100	950	630	960	1500	950

Juandah Ck @ Wandoan Area = 618 km^2

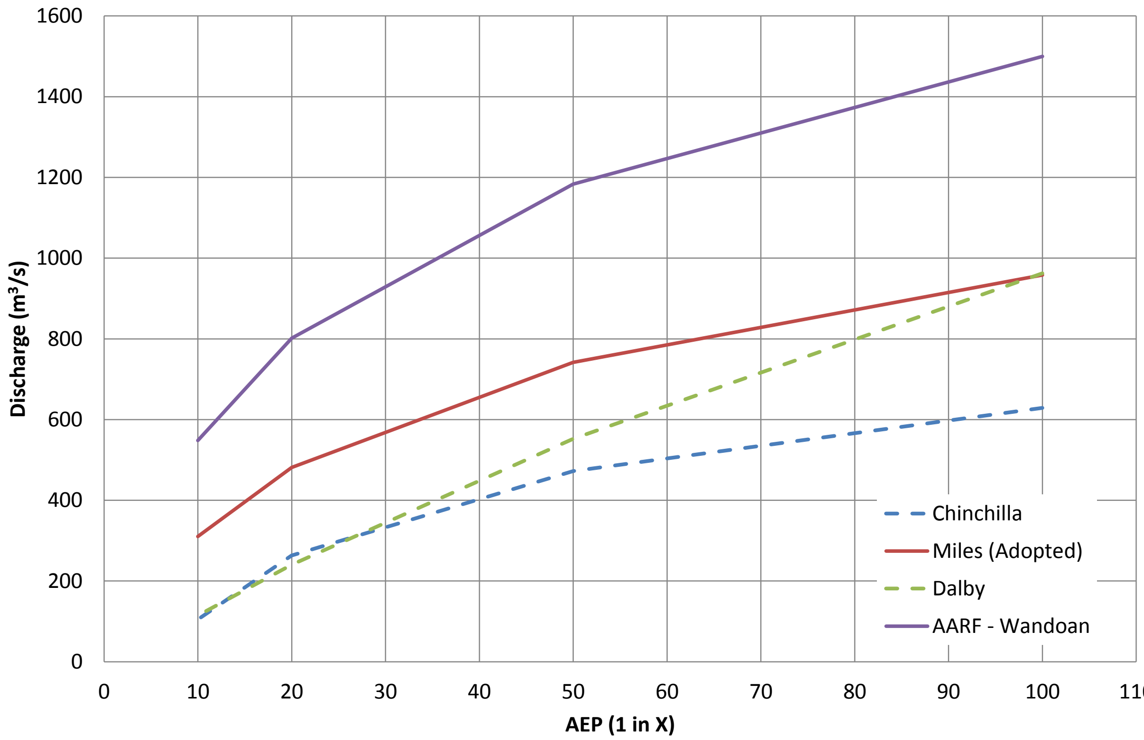

Figure 4.2 Comparison of Discharge Estimates for Wandoan.

Table 4.3 Discharge Estimates for Tara

AEP (1 in x)	Scaled Discharge (m^3/s) (Direct Area Scaling) from Reference Catchment			ARFF (m^3/s)	Adopted (based on Dalby scaled discharge) (m^3/s)
	Miles Dogwood Ck @ Warrego Hwy (042107) (2,875 km^2)	Chinchilla Charleys Ck @ Weir (041409) (WT Catchment Area) (3,458 km^2)	Dalby Myall Ck @ Dalby (WT Catchment Area) (1,464 km^2)		
2				30	
5				90	
10	120	40	40	140	40
20	180	100	90	210	90
50	270	180	200	300	200
100	350	230	360	380	360

Undulla Ck @ Tara Area = 149 km^2

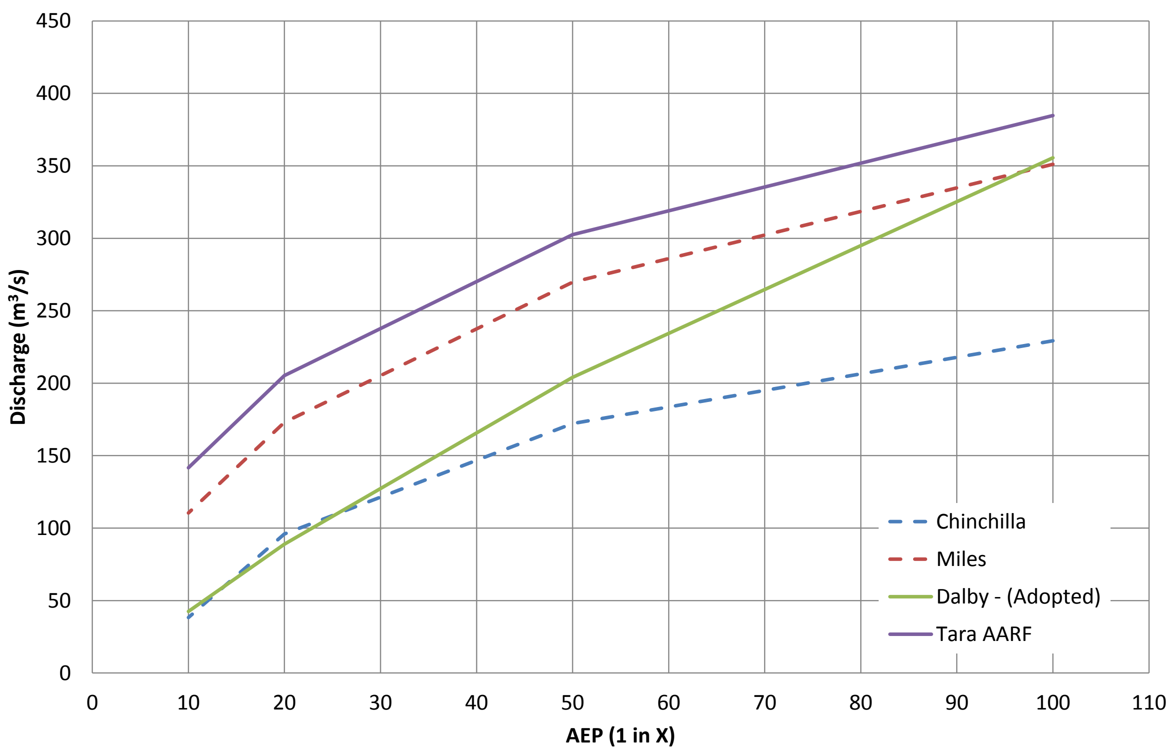

Figure 4.3 Comparison of Discharge Estimates for Tara.

4.7 Discharge Selection

A summary of the area scaling, ARFF and adopted flood magnitude estimates for each town are provided in Table 4.1 to Table 4.3 and Figure 4.1 to Figure 4.3. In consultation with WDRC staff, it was considered that the following catchments were most similar:

- Jandowae – Dalby.
- Wandoan – Miles.
- Tara – Dalby.

In the absence of additional data, professional judgement was used to decide upon the appropriate flood quantiles for each catchment.

As a check, the RAFTS model for each catchment was calibrated to the adopted flood quantiles by adjusting the rainfall loss parameters. The details of this check are discussed further in the following section.

4.8 Adopted Discharges

Table 4.4 shows the adopted flood magnitude estimates for each town

Table 4.4 Adopted Flood Discharges - Jandowae, Wandoan and Tara

AEP (1 in x)	Jandowae (m^3/s)	Wandoan (m^3/s)	Tara (m^3/s)
10	60	300	40
20	120	470	90
50	290	730	200
100	500	950	360

5 HYDROLOGIC MODELLING

The 'RAFTS' runoff-routing model (XP Software, 2001) was used to model hydrologic processes for the creeks draining to Jandowae, Wandoan and Tara.

5.1 RAFTS Model Configuration

RAFTS requires several key parameters to accurately model hydrologic processes. Many of these have been derived through a joint calibration process which will be described in detail in the following section. A summary of the general RAFTS modelling approach adopted for this study includes:

- Use of the “one-subcatchment” model for all catchments,
- A catchment Manning’s n of 0.055 (based on calibration of the 2011 event through Chinchilla) was used for all catchments,
- A catchment percent imperviousness of 0% was adopted for all catchments at all locations. It was considered that the slight increase in imperviousness in the catchments that contained the towns would have an insignificant impact on discharges (due to the location in the catchment and the small area relative to the total catchment) and was therefore not included.
- The RAFTS Muskingum routing routine was used to model channel routing as follows:
  - The relationship between average stream velocity and stream slope was determined on a sample of representative streams in the study catchments. These relationships were then applied consistently across all catchments. Table 5.1 shows the adopted channel slope – velocity relationships.
- A value of Muskingum x=0.2 was adopted for all streams.
- The RAFTS default storage coefficient ‘Bx’ = 1 was adopted.
- The initial loss (IL) and (CL) were used as calibration parameters.

Table 5.1 Average Stream Velocities Adopted to Estimate Muskingum K (Jandowae, Wandoan and Tara)

Channel Slope (m/m)	Velocity (m/s)
<= 0.0003	0.8
0.0007	1
>= 0.0012	1.5

Figure 5.1, Figure 5.2 and Figure 5.3 present an overview of the RAFTS model layouts for Jandowae, Wandoan and Tara respectively.

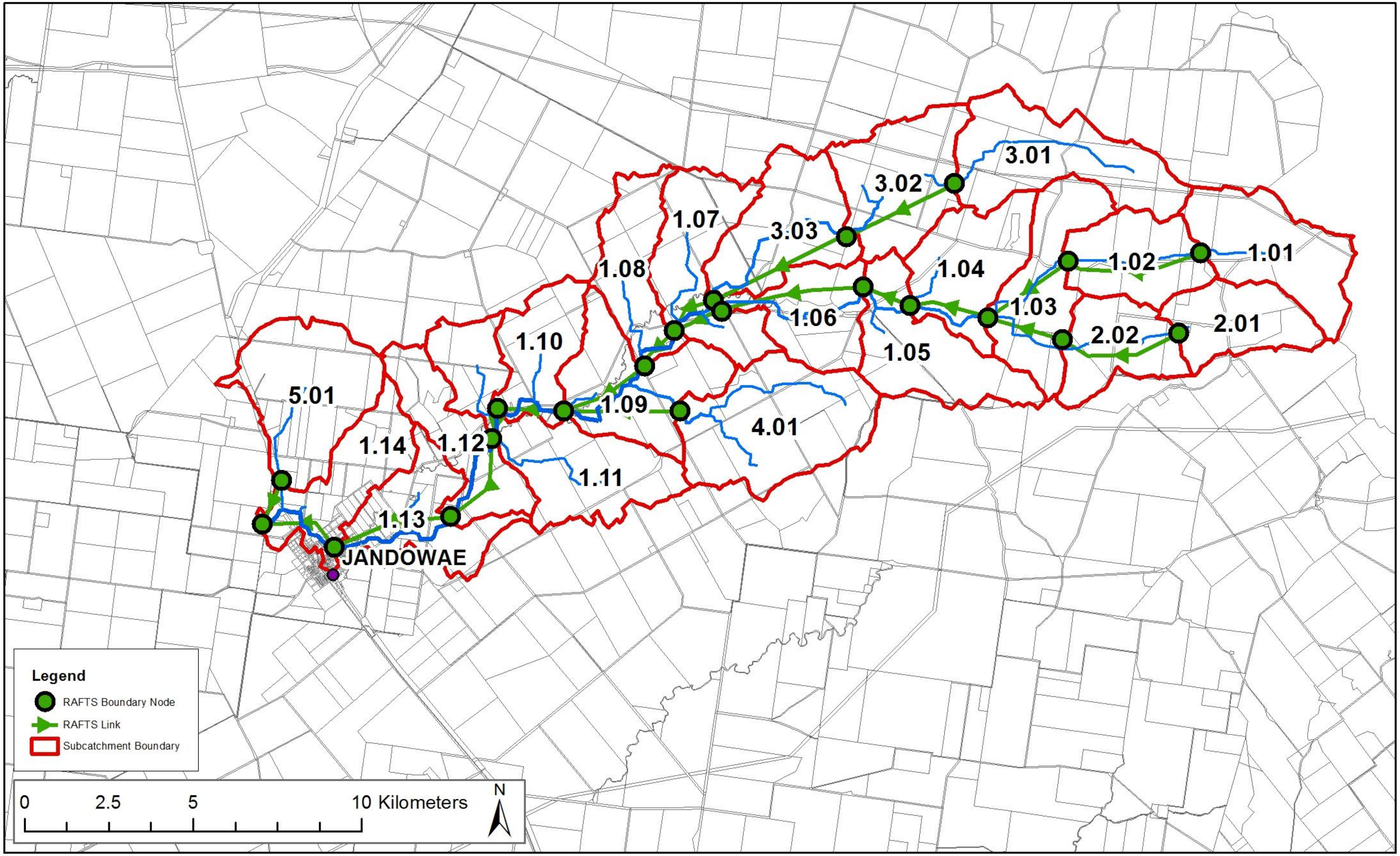

Figure 5.1 Jandowae RAFTS Model layout

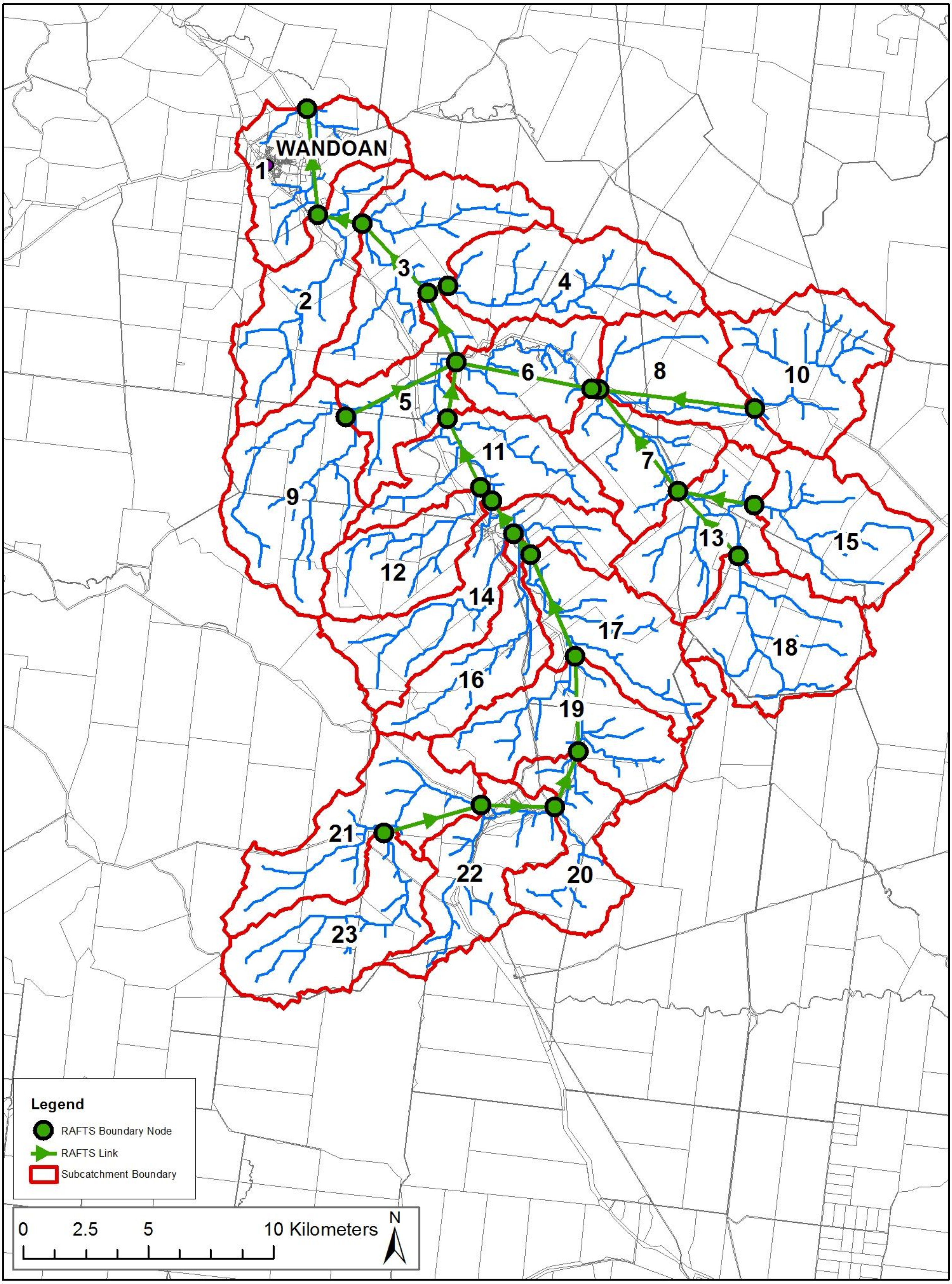

Figure 5.2 Wandoan RAFTS Model layout

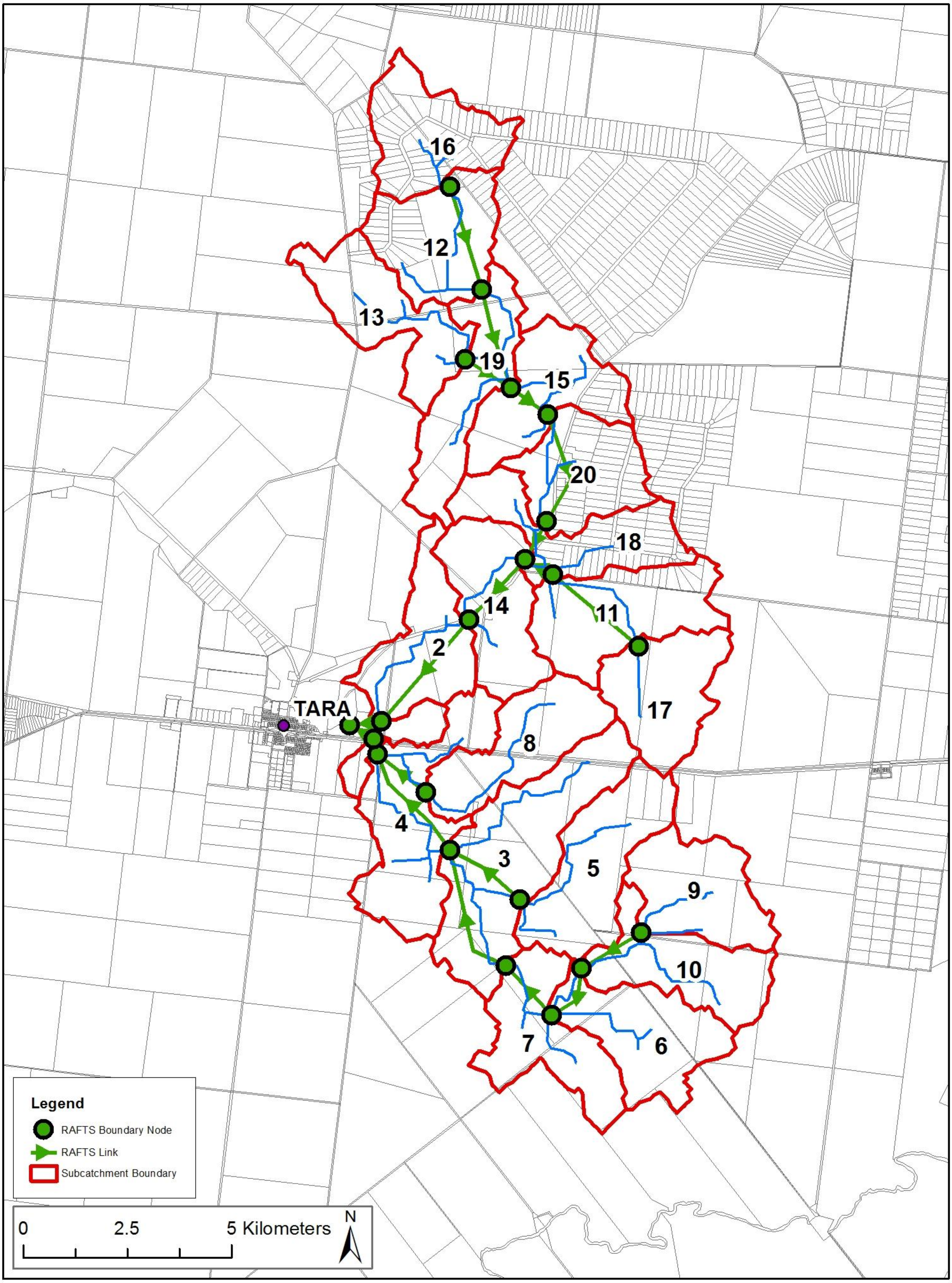

Figure 5.3 Tara RAFTS Model layout

5.2 RAFTS Results

A full suite of design events was analysed using the RAFTS model. Table 5.2, Table 5.3 and Table 5.4 show the adopted design rainfall loss parameters for Jandowae, Wandoan and Tara, respectively. As a check on the adopted discharge values, the initial and continuing loss values were used to "calibrate" the RAFTS model to reproduce the adopted design discharge values. The necessary initial and continuing loss values thus derived are considered acceptable for the purposes of this study.

Table 5.2 Rainfall Losses for the Adopted Discharge Estimates for Jandowae

AEP (1 in x)	Initial Loss (mm)	Continuing Loss (mm/hr)	Discharge (m^3/s)
2			
5			
10	52	5.2	60
20	55	5.5	120
50	51	5	290
100	40	5	500

Table 5.3 Rainfall Losses for the Adopted Discharge Estimates for Wandoan

AEP (1 in x)	Initial Loss (mm)	Continuing Loss (mm/hr)	Discharge (m^3/s)
2			
5			
10	45	4.5	300
20	50	4.7	470
50	50	4.9	730
100	50	5.1	950

Table 5.4 Rainfall Losses for the Adopted Discharge Estimates for Tara

AEP (1 in x)	Initial Loss (mm)	Continuing Loss (mm/hr)	Discharge (m^3/s)
2			
5			
10	50	4	40
20	45	3.8	90
50	25	3.3	200
100	4	1.3	360

6 RIVERINE FLOODING ANALYSIS

6.1 Overview

The MIKE FLOOD model was used to estimate flood levels for Jandowae, Wandoan, & Tara. The 1 in 100 AEP flood was adopted as the defined flood event (DFE). The following sections describe the design event modelling process.

Results are presented as maps of flood depth and flood hazard in Volume II, III and IV of this report for Jandowae, Wandoan and Tara respectively.

Figure 6.1, Figure 6.2 and Figure 6.3 show the topography and extent of the Jandowae, Wandoan and Tara hydraulic models, respectively.

6.2 MIKE FLOOD Model Configuration

The model area and grid size were chosen to allow for practical model run times and to cover the area required. The MIKE FLOOD models developed for this investigation all have the following characteristics:

- Model terrain based on available LIDAR data sets.
- Jandowae and Wandoan used a 10m grid size covering an area:
  - Jandowae - 5.51 km x 5.68 km
  - Wandoan - 5.29 km x 5.66 km.
- Tara used a 5m grid size covering an area 3.31 km x 4.02 km
- 0.5s timestep.
- Velocity based eddy viscosity of 0.1m2/s.
- Inflow boundary conditions (from RAFTS).
- Fixed tailwater boundary condition.

A critical parameter within the hydraulic model is the hydraulic roughness. Hydraulic roughness is usually expressed in terms of the parameter Manning's n and varied according to land use type. For this investigation, adopted Manning's n values (corresponding to the various land use zonings within the revised planning scheme) are presented in Table 6.1.

Hydraulic roughness maps for Jandowae, Wandoan and Tara are presented in Figure 6.4, Figure 6.5 and Figure 6.6 respectively.

Figure 6.1, Figure 6.2 and Figure 6.3 show the topography and extent of the Jandowae, Wandoan and Tara hydraulic models, respectively.

No structures were included in the hydraulic models for the three study towns.

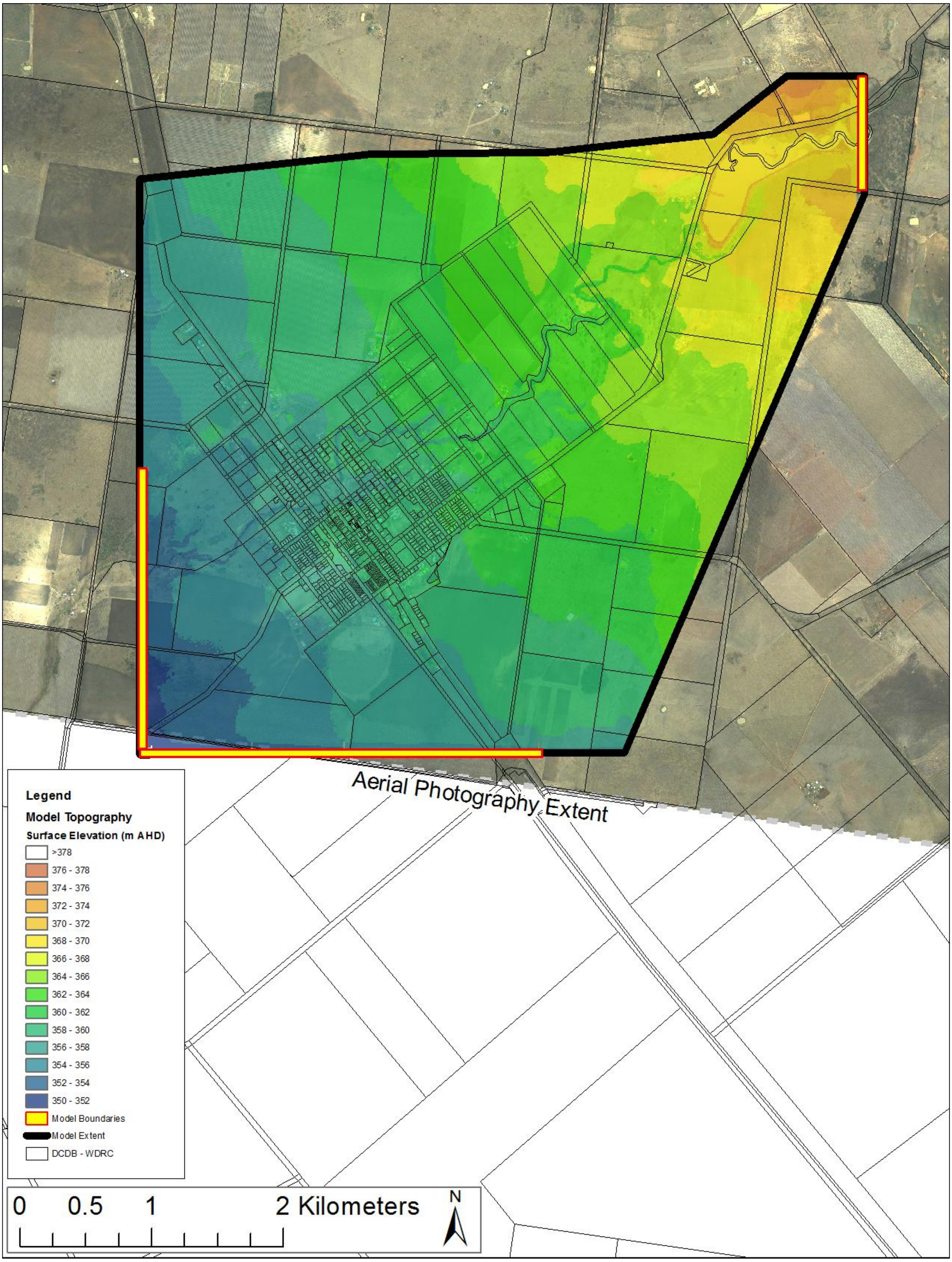

Figure 6.1 Jandowae Hydraulic Model Extent and Topography

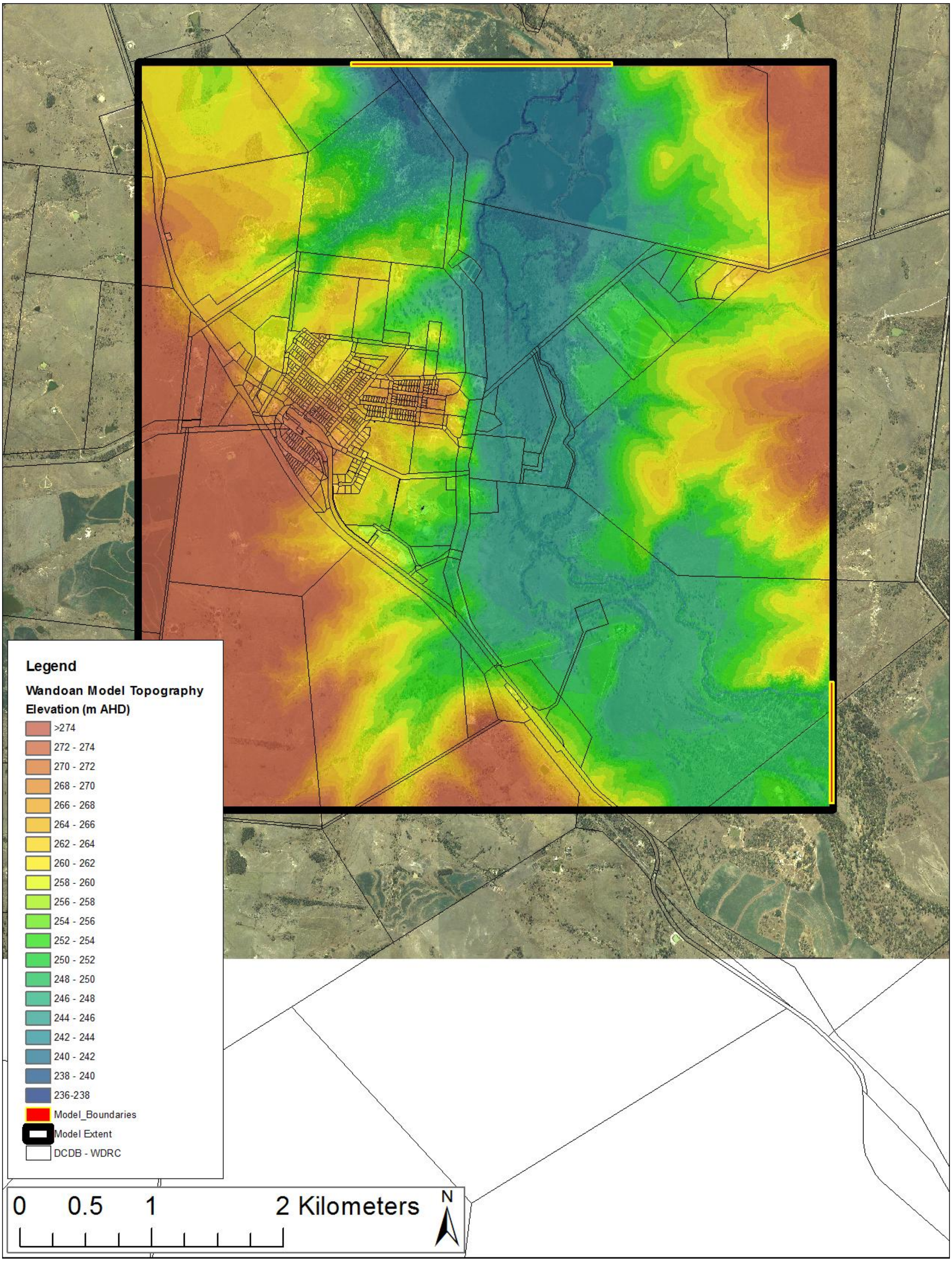

Figure 6.2 Wandoan Hydraulic Model Extent and Topography

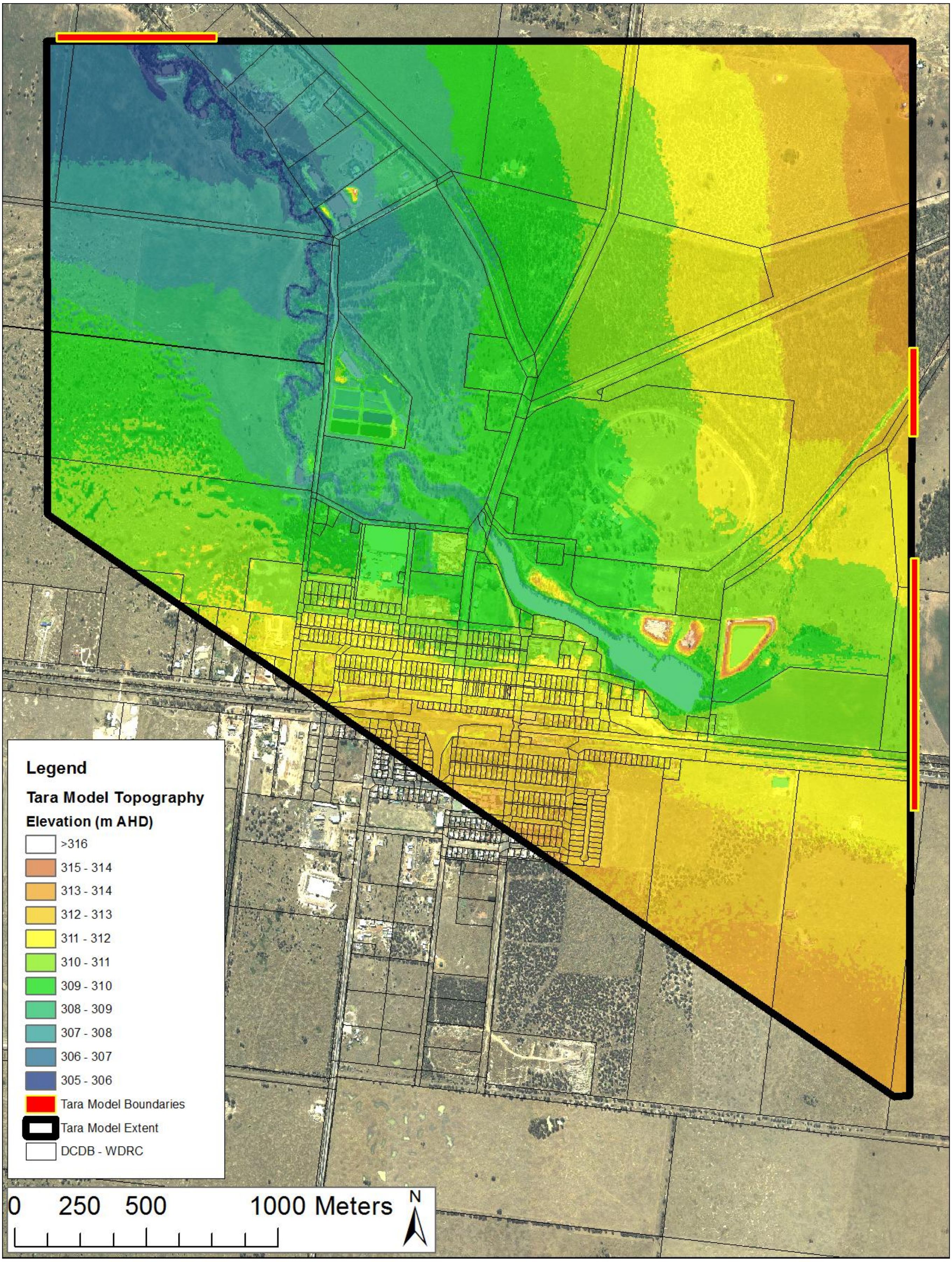

Figure 6.3 Tara Hydraulic Model Extent and Topography

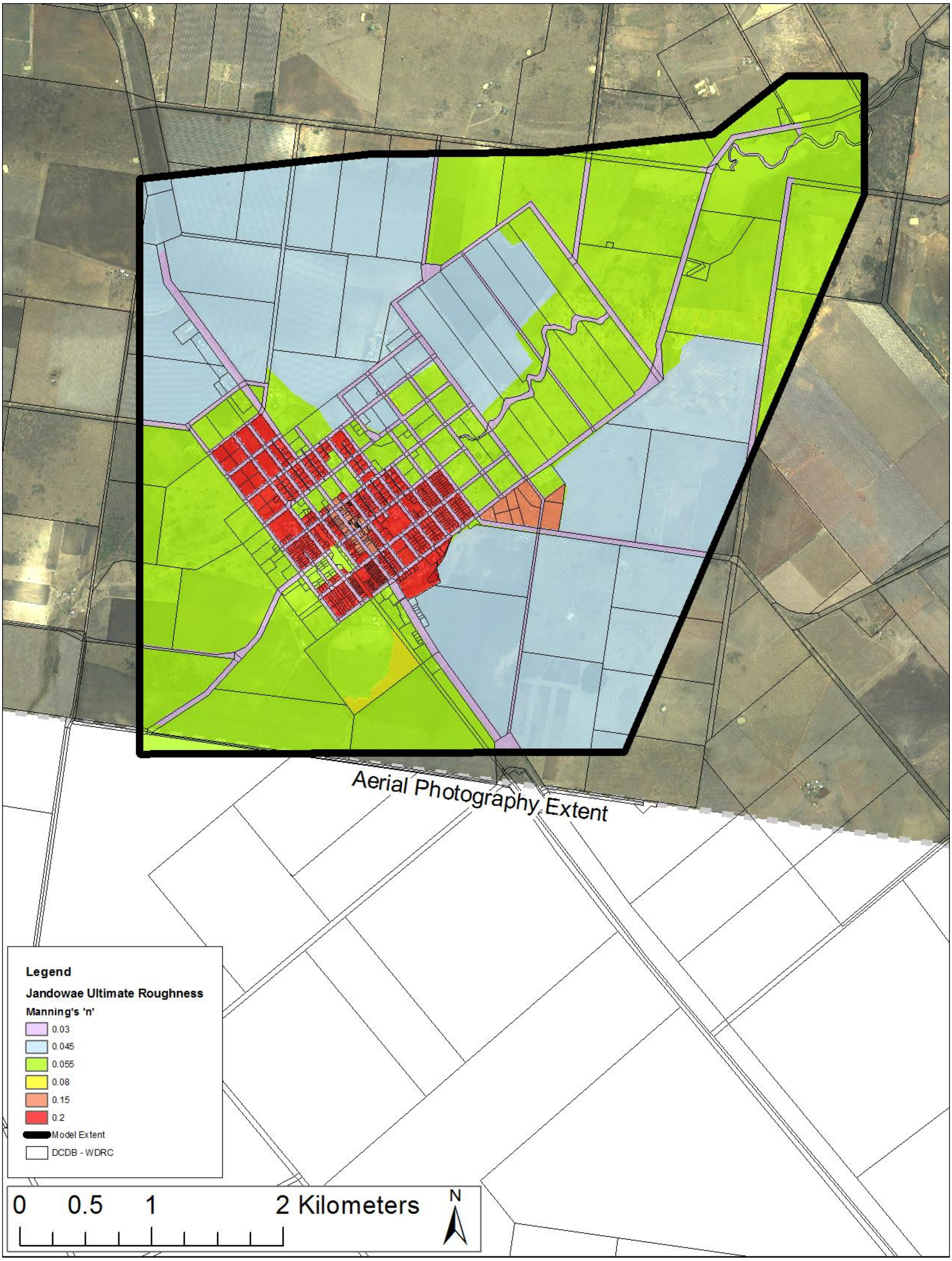

Figure 6.4 Jandowae Hydraulic Model Roughness Map – Ultimate Developed Conditions

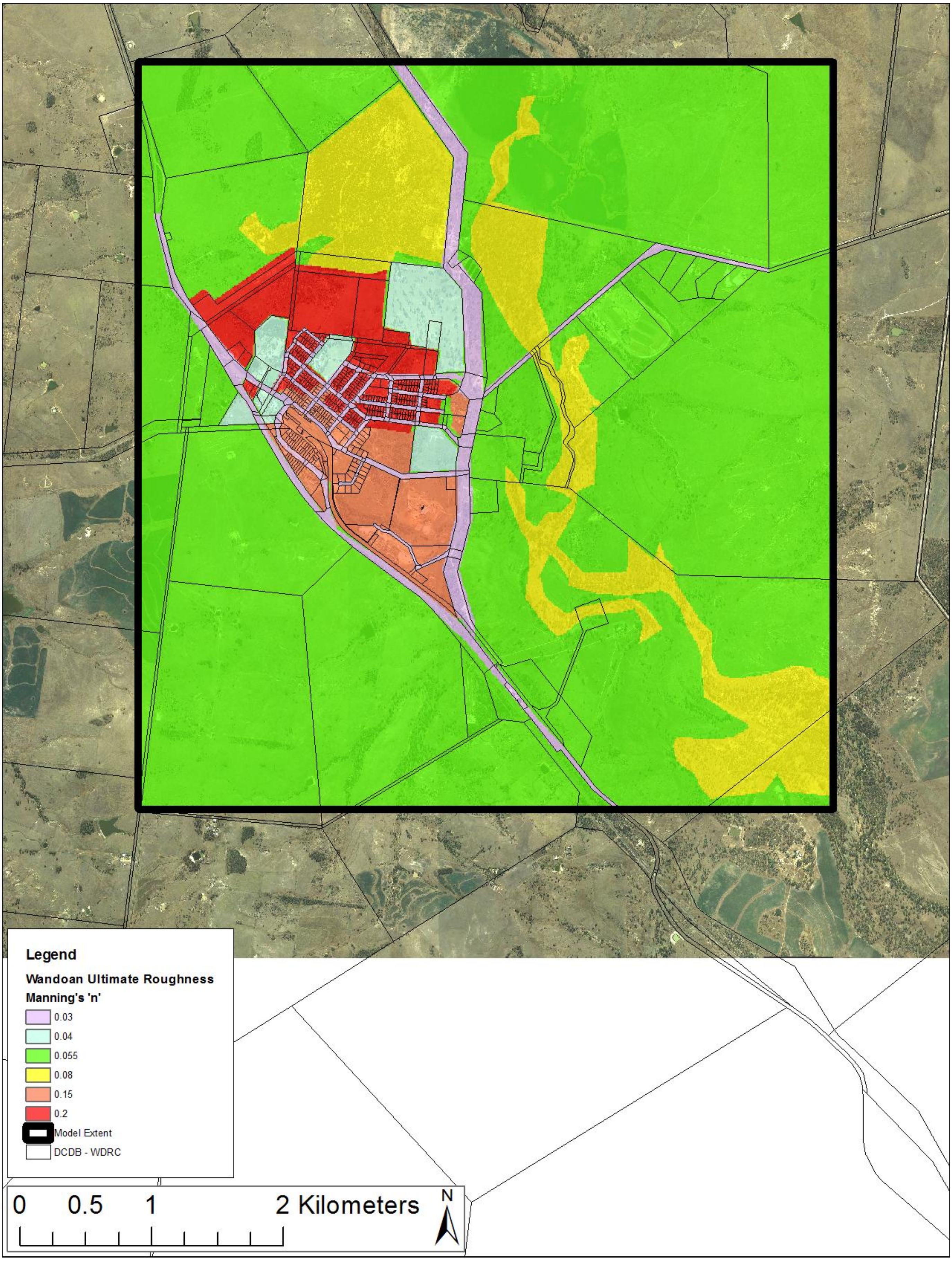

Figure 6.5 Wandoan Hydraulic Model Roughness Map – Ultimate Developed Conditions

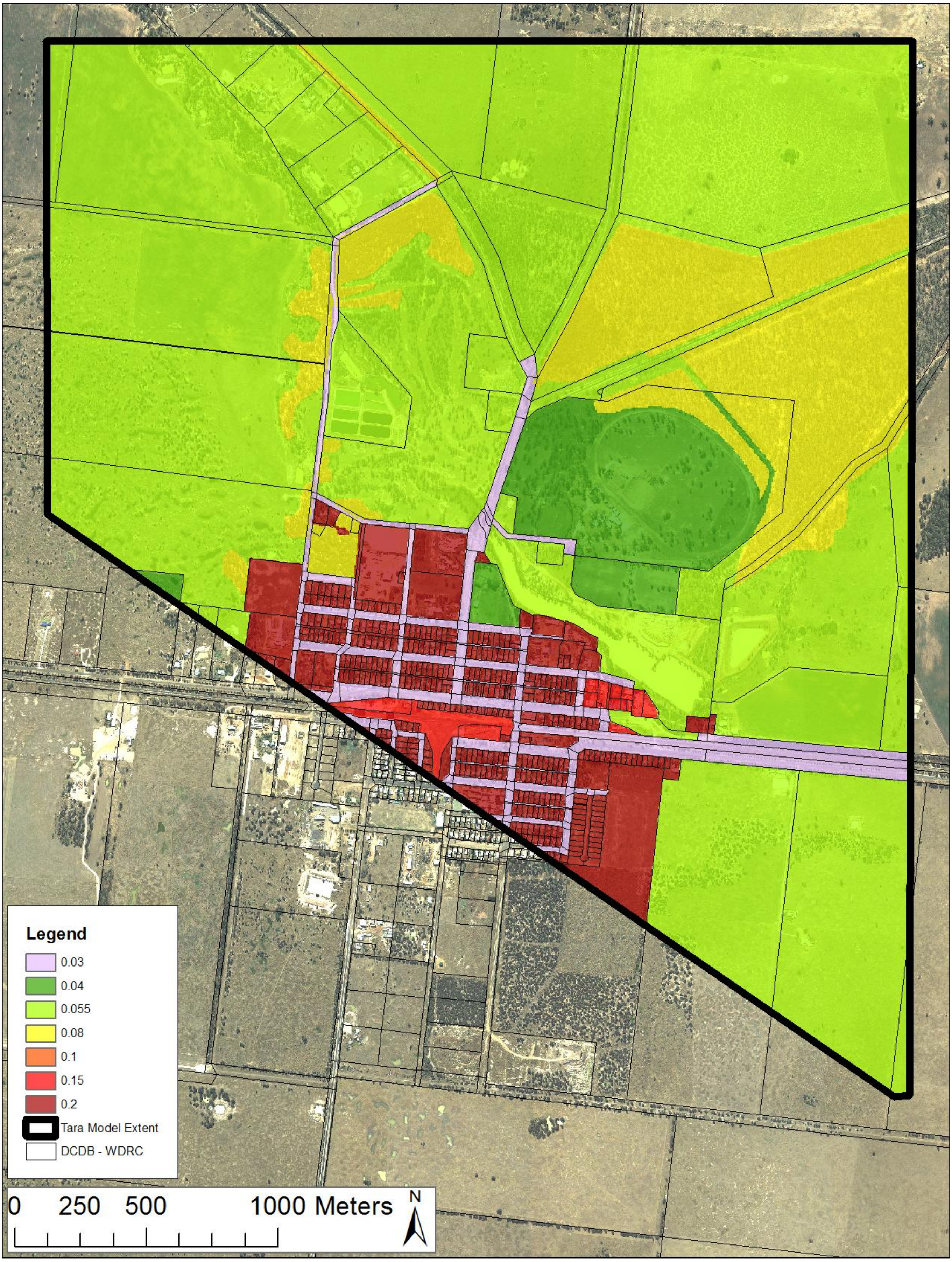

Figure 6.6 Tara Hydraulic Model Roughness Map – Ultimate Developed Conditions

Table 6.1 Adopted MIKE FLOOD Manning's n Values

Land Use	Manning's n
Roads	0.03
Cropping	0.045
Floodplain	0.055
Vegetation	0.08
Rural Residential	0.1
Industrial/Commercial	0.15
Dense Residential	0.2

6.3 Downstream Boundary Sensitivity Analysis

A downstream boundary sensitivity analysis was undertaken for the Jandowae, Wandoan and Tara MIKE FLOOD model. The results showed that the adopted normal depth boundary levels have a minimal effect within the study area. Full results of the sensitivity analysis are provided in Appendix A.

6.4 Mapping Conventions

6.4.1 Freeboard

A 300mm freeboard was added to the modelled defined flood level to create the Planning Scheme Overlay. The adopted freeboard is in accordance with the Queensland Urban Drainage Manual (NRW, 2007).

6.4.2 Hazard Mapping

Flood hazard categories were adopted from "*Floodplain Management in Australia: Best Practice Principles and Guidelines*" (CSIRO, 2000). Table 6.2 shows the adopted categories.

Table 6.2 Adopted Hazard Categories (CSIRO, 2000)

Criteria	Low	Medium	High	Extreme
Wading Ability	All including children and elderly (v*d <0.25)	Fit Adults (v*d <0.4)	Fit Adults have difficulty (v*d <0.6)	Wading not an option (v*d >= 0.6)
Max. Flood Velocity (m/s)	< 0.4	< 0.8	< 1.5	>1.5
Max. Flood Depths (m)	< 0.3	< 0.6	< 1.2	> 1.2
Typical Means of Egress	Sedan	Sedan early, but 4WD or trucks later	4WD or Trucks only in early stages, boats or helicopters	Large trucks, boats or helicopters

6.5 Hydraulic Results

Table 6.3 shows the seven different types of flood maps produced. Aerial photograph and cadastre are used as the background for all maps. These maps are presented in Volumes II (Jandowae), III (Wandoan) and IV (Tara) of this report.

Table 6.3 Riverine Flood Maps Produced

AEP (1 in x)	Flood Map Type	Description - Map Name
10	Extent + Depth	10% AEP riverine flood extent and depth
20	Extent + Depth	5% AEP riverine flood extent and depth
50	Extent + Depth	2% AEP riverine flood extent and depth
100	Extent + Depth	1 in 100 AEP riverine flood extent and depth
100	Extent + Hazard	Defined Flood Event (DFE): 1 in 100 AEP riverine flood hazard

7 UPDATE TO THE NOVEMBER 2012 REPORT

Following release of the November 2012 report, a substantial amount of additional data gathering and analysis was undertaken for the area, but unlike Dalby, Chinchilla and Miles, there was not a substantial increase in available data at Jandowae, Wandoan and Tara.

However, through discussion with members of the community and council officers, some modifications were made to the methodology used to calculate design flows for Jandowae, Wandoan and Tara. On the basis that the catchments were similar, design discharge estimates for Jandowae and Tara were based on scaled discharge estimates for Dalby. The catchment to Wandoan was considered to be most similar to the catchment to Miles, so scaled design discharge estimates for Miles were used for Wandoan.

This revised approach has lead to the design flows and corresponding levels for Jandowae, Wandoan and Tara as outlined in Tables 7 to 12 below. As a general comment, design discharges and associated levels have reduced through this process.

Table 7-1 Comparison between the previously adopted flows (Nov 2012 report) and current flows at Jandowae

AEP (1 in x)	Previous Discharge – Nov 2012 Report (m^3/s)	Revised Discharge - (m^3/s)
10	170	60
20	280	120
50	500	290
100	740	500

Table 7-2 Comparison between the previously adopted flows (Nov 2012 report) and current flows at Wandoan

AEP (1 in x)	Previous Discharge – Nov 2012 Report (m^3/s)	Revised Discharge - (m^3/s)
10	330	300
20	530	470
50	920	730
100	1340	950

Table 7-3 Comparison between the previously adopted flows (Nov 2012 report) and current flows at Tara

AEP (1 in x)	Previous Discharge – Nov 2012 Report (m^3/s)	Revised Discharge - (m^3/s)
10	120	40
20	200	90
50	350	200
100	510	360

Table 7-4 Comparison between adopted levels in 2012 and 2014 Report at Bridge on High St, Jandowae

AEP (1 in x)	Previous Levels – Nov 2012 (m AHD)	Revised Levels (m AHD)
10	357.98	357.52
20	358.16	357.87
50	358.38	358.20
100	358.55	358.40

Table 7-5 Comparison between adopted levels in 2012 and 2014 Report at Bridge on Roche Creek Rd, Wandoan

AEP (1 in x)	Previous Levels – Nov 2012 (m AHD)	Revised Levels (m AHD)
10	244.01	243.88
20	244.32	244.11
50	244.80	244.42
100	245.21	244.66

Table 7-6 Comparison between adopted levels in 2012 and 2014 Report at Overflow on Sara St, Tara

AEP (1 in x)	Previous Levels – Nov 2012 (m AHD)	Revised Levels (m AHD)
10	309.83	309.62
20	309.98	309.76
50	310.20	310.01
100	310.37	310.37

The reduction in design flows for Jandowae, Wandoan and Tara has produced a corresponding reductions in design levels.

Another difference between the levels presented in the November 2012 report and this current report is that in the previous report, the Defined Flood Event (DFE) was defined as the 1 in 100 AEP event + an allowance for 1oC climate change (5% increase in rainfall intensity). For the purposes of this current report, the climate change allowance has not been included and the DFE has been defined as the 1 in 100 AEP event.

An appropriate freeboard allowance (300mm has previously been adopted) should be added to the 1 in 100 AEP event levels for planning levels.

For Jandowae, Wandoan and Tara, Figure 7.1 to Figure 7.6 present:

- a comparison of flood levels from the November 2012 report and the current report,
- the 1 in 100 AEP flood depths, and
- indicators of the relative levels of historic events and the 1 in 100 AEP flood depths at indicative locations through the town.

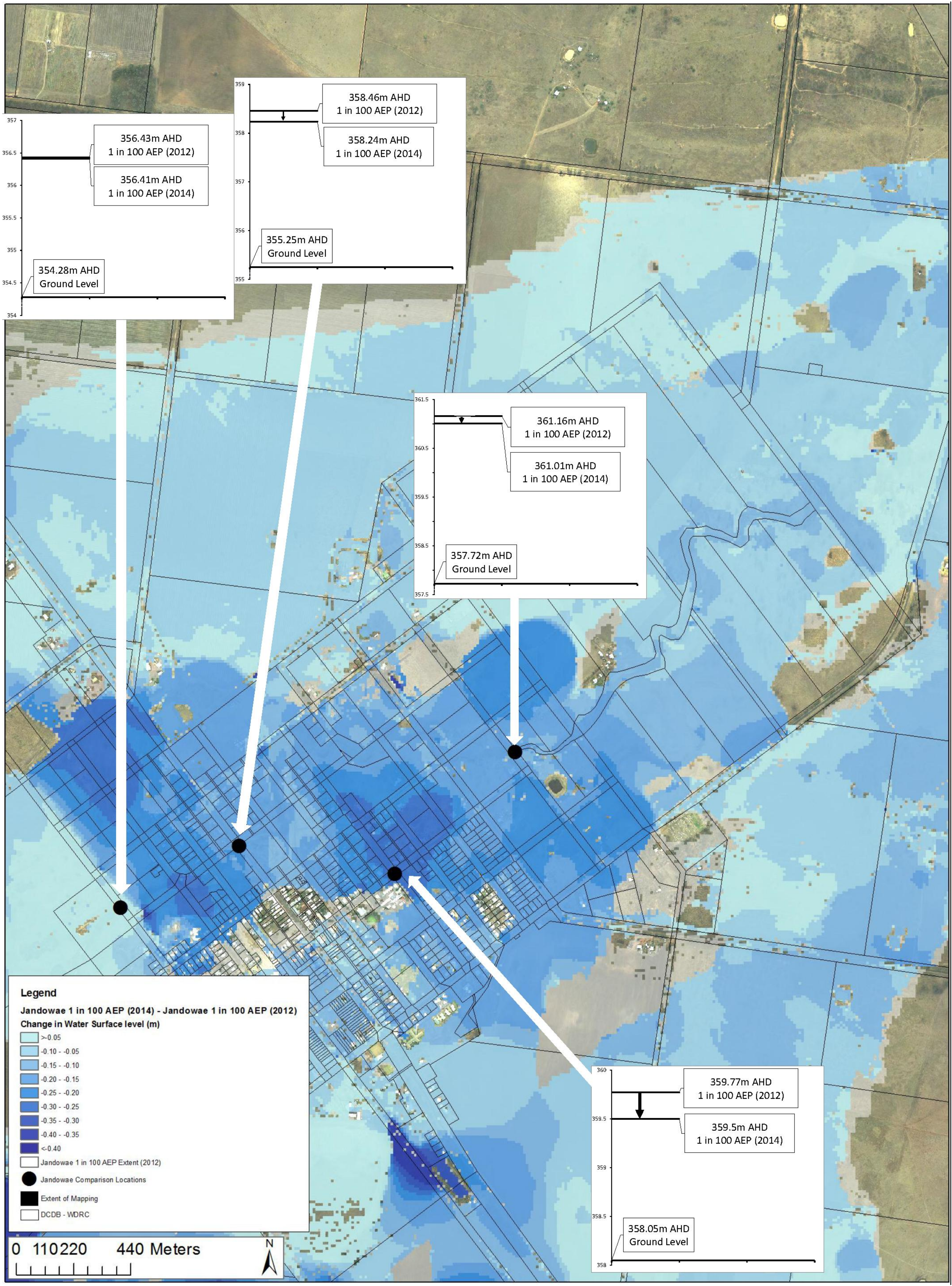

Figure 7.1 1 in 100 AEP flood level comparison – Revised flood levels compared to Nov 2012 flood levels - Jandowae

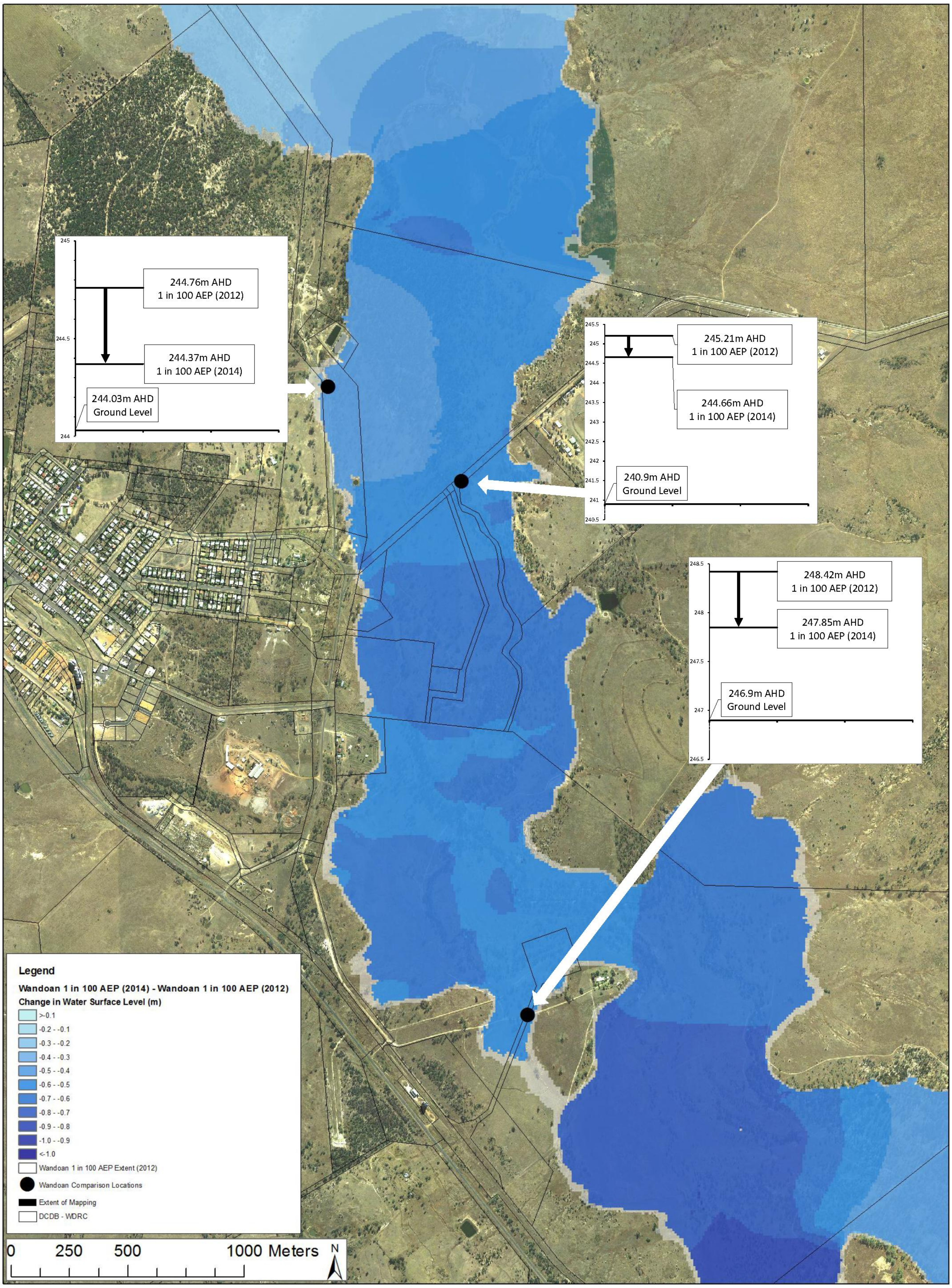

Figure 7.2 1 in 100 AEP flood level comparison – Revised flood levels compared to Nov 2012 flood levels - Wandoan

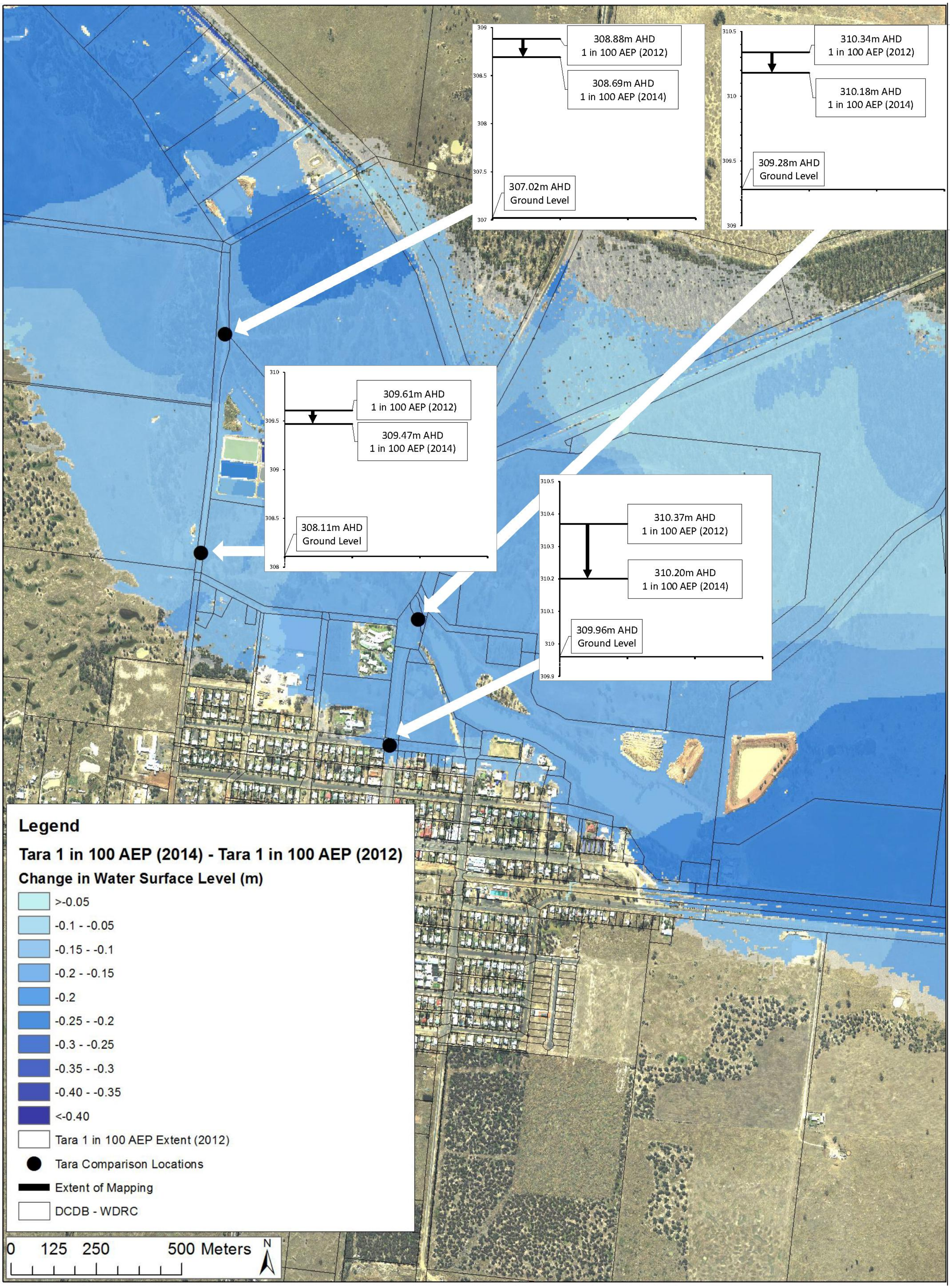

Figure 7.3 1 in 100 AEP flood level comparison – Revised flood levels compared to Nov 2012 flood levels - Tara

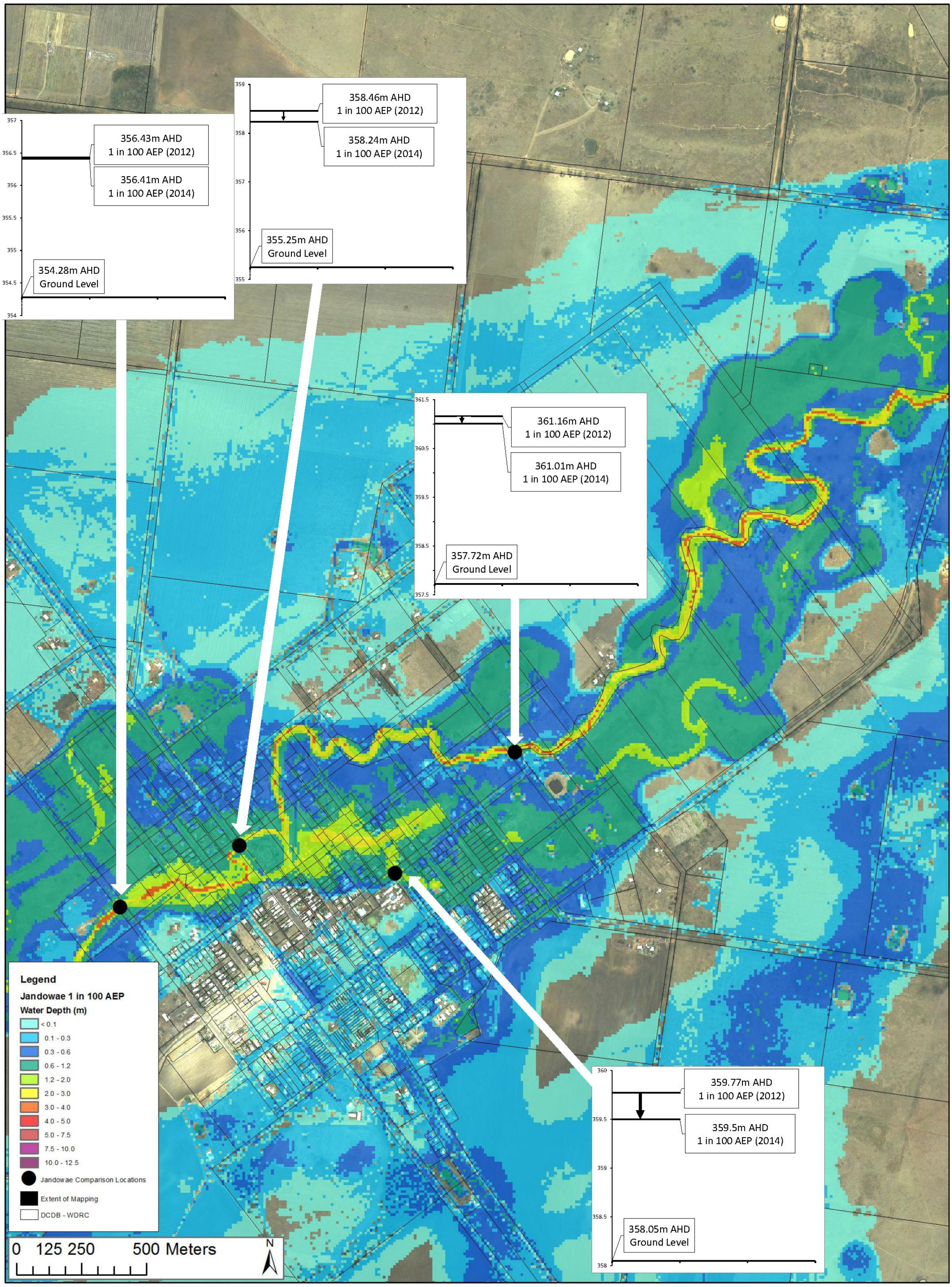

Figure 7.4 **1 in 100 AEP depths with indicators of historic and design levels at key locations – Jandowae**

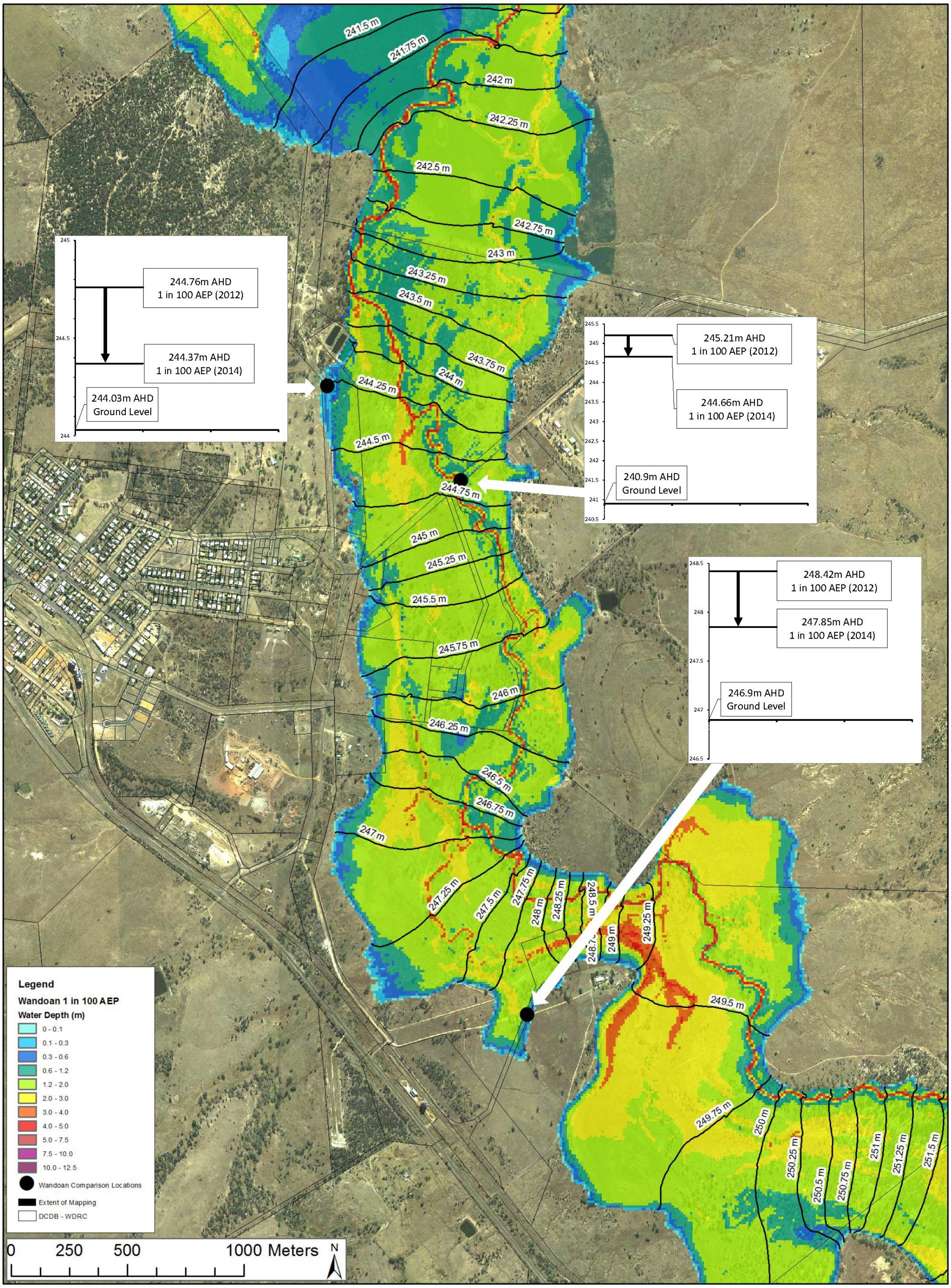

Figure 7.5 **1 in 100 AEP depths with indicators of historic and design levels at key locations - Wandoan**

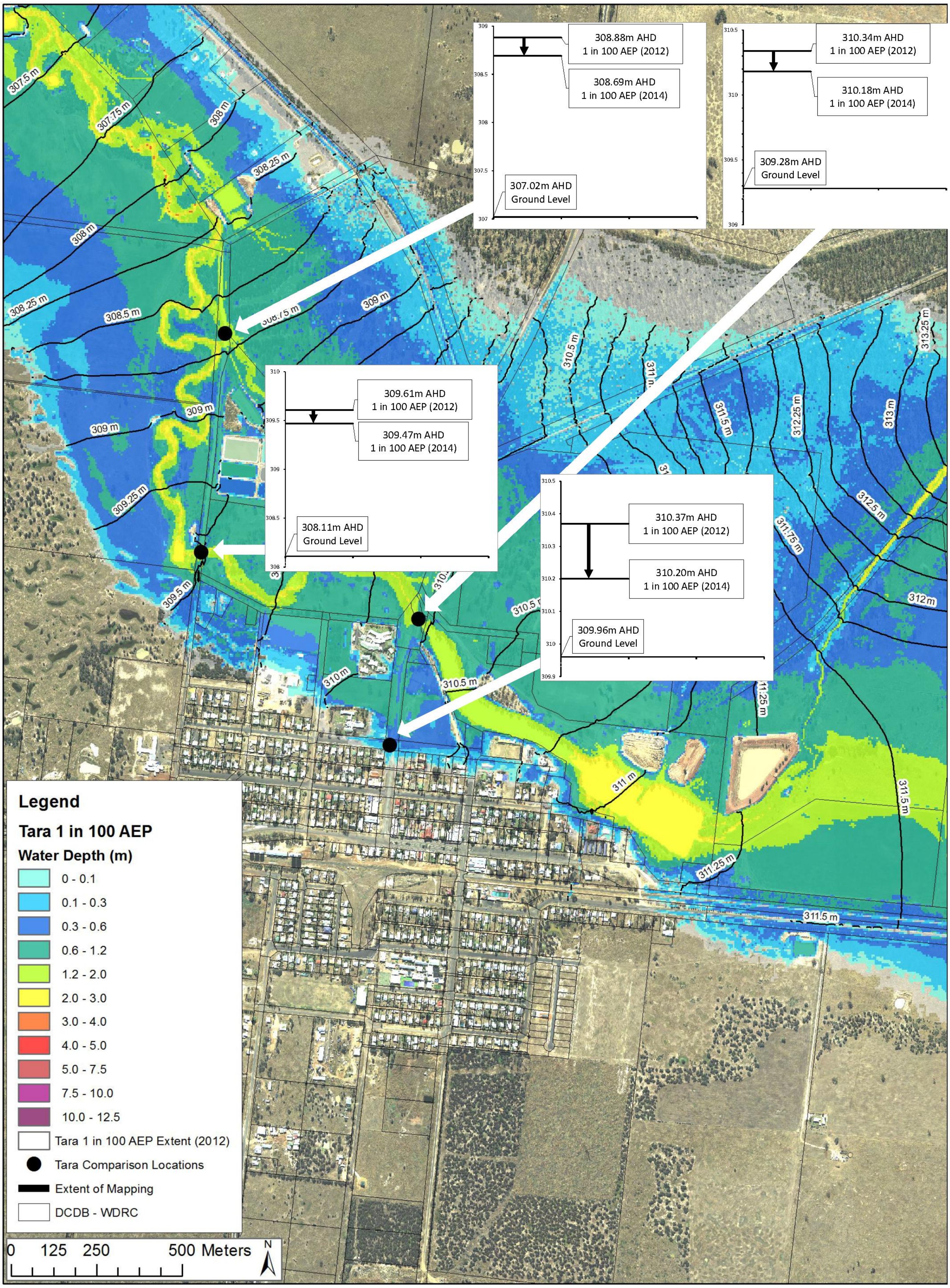

Figure 7.6 1 in 100 AEP depths with indicators of historic and design levels at key locations - Tara

8 STORMWATER FLOODING

8.1 Overview

Stormwater floods are local floods through the numerous overland flowpaths through the towns. These floods are short duration (an hour or so) and are usually the result of localised, short duration rainfall. These floods contrast with riverine floods, which are large regional floods from the creeks running through each town. These floods may last several days and are usually the result of widespread, long duration rainfall.

For the purposes of modelling stormwater, Jandowae, Wandoan and Tara were divided into a number of stormwater catchments. The 1 in 10, 1 in 50 and 1 in 100 AEP floods were modelled.

8.2 Catchments

Jandowae, Wandoan and Tara were divided into a number of catchments based upon the following:

- Location of flow paths.
- Desired location of discharge estimation points.
- Key infrastructure.

Appendix E shows the adopted stormwater catchments for each town.

8.3 Method

The Rational Method was used to determine discharges in accordance with the procedure defined in the Queensland Urban Drainage Manual (NRW, 2007). Note that NRW (2007) recommends that the maximum catchment area upon which the Rational Method may be applied is either 5 km^2 (urban catchments) or 25 km^2 (rural catchments). In a number of instances the catchment areas in this study are greater than these values. Notwithstanding the recommendations of NRW (2007), it is considered that the adoption of the Rational Method for this study is acceptable for the following reasons:

- The primary reason for the catchment area limit is because the Rational Method does not allow for channel routing.
- It is considered that the estimation error due to this is small, for small catchments, but increases with larger catchments. The 5 and 25 km^2 areas have been selected as the approximate catchment area where the error becomes significant.
- In larger catchments, the Rational Method will tend to overestimate discharges. Therefore, for the proposed application of the results of this study (to define planning levels), the use of the Rational Method provides a conservatively high discharge.
- There are no other suitable methods for discharge estimation for catchments of this size.

8.4 Hydrologic Analysis

8.4.1 Time of Concentration

The MIKE FLOOD hydraulic model was used to estimate the stream velocity. Table 8.1 shows the adopted velocities. For Jandowae, Wandoan and Tara, the application of one average velocity for all streams was appropriate.

8.4.2 Runoff Coefficients

An impervious percentage was assigned to each land use category in the revised planning scheme based upon recommendations in NRW (2007) and discussions with WDRC. Each impervious percentage was converted to a C10 runoff coefficient for use with the Rational Method. The same impervious percentage – land use category relationships were adopted for all towns within the WDRC area.

Table 8.2 shows the adopted impervious percentages and runoff coefficients for each land use category for the three towns.

Table 8.1 Adopted Average Stream Velocity for Rational Method Calculations

Town	Slope (m/m)	Velocity (m/s)
Miles	0.5	0.30
	0.6	0.40
	0.7	0.49
	0.8	0.59
Chinchilla	All	0.6
Wandoan	All	0.5
Jandowae	All	0.5
Tara	All	0.5

Table 8.2 Adopted Impervious Percentage and C10 Runoff Coefficients

Land Use	Impervious Percentage (%)	C10 Runoff Coefficient		Manning's 'n'	Comments
		Jandowae and Tara	Wandoan		
Rural Zone	0	0.39	0.46	0.05	Negligible
Township Zone	60	0.7	0.72	0.2	Residential – Lot size >750m2
Recreation Zone	0	0.39	0.46	0.04/0.08	Open Space (eg Parks)
Community Purpose Zone	Varies according to proposal	Mixed	Mixed	0.2	Open Space/Township
Rural Residential Zone	15	0.47	0.53	0.1	Rural – 2-5 dwelling per ha
Residential Living Zone	60	0.7	0.72	0.2	Residential – Lot size >750m2
Local Centre Zone	90	0.85	0.86	0.2	Commercial or Industrial
Emerging Communities Zone	60	0.7	0.72	0.2	Residential – Lot size >750m2
Major Centre Zone	100	0.85	0.86	0.2	Commercial or Industrial
Residential Choice Zone	60	0.7	0.72	0.2	Residential – Lot size >750m2
Medium Impact Industry Zone	90	0.85	0.86	0.15	Commercial or Industrial
Low Impact Industry Zone	90	0.85	0.86	0.15	Commercial or Industrial
Specialist Centre Zone	90	0.85	0.86	0.2	Commercial or Industrial
District Centre Zone	100	0.90	0.90	0.2	Central Business

8.4.3 Partial Area Effect

It was found that the catchment characteristics (long, elongated main streams with a number of short adjoining streams) created the partial area effect in a number of locations. This was evidenced in the results by having higher discharges in an upstream node. Where this occurred, the maximum discharge was adopted. Note that this adjustment for partial area effect results in identical discharges at a number of adjacent nodes in a reach.

8.4.4 Results

Rational Method parameters and results for each town are provided in the following appendices:

- Appendix B, Jandowae.
- Appendix C, Wandoan.
- Appendix D, Tara.

8.5 Stormwater Flood Hydraulic Modelling

8.5.1 Overview

The MIKE FLOOD hydraulic model was used to estimate stormwater flooding for the five study towns.

8.5.2 Model Configuration

8.5.2.1 Model Description

Hydraulic modelling of the study area has been undertaken utilising DHI Software's MIKE FLOOD modelling system. The following is of note:

- Adopted model Grid configurations have been previously presented in:
  - Figure 6.1, Jandowae.
  - Figure 6.2, Wandoan.
  - Figure 6.3, Tara.
- The stormwater model was run in steady state mode.

8.5.2.2 Modelled Events

The following events were modelled:

- 1 in 10 AEP.
- 1 in 50 AEP.
- 1 in 100 AEP.

8.5.2.3 Manning's n

Manning's n values were based upon the following:

- The majority of the modelled area adopted land use zonings from the revised planning scheme.

- Table 8.2 shows the adopted values for each land use.
- A Manning's n of 0.08 was adopted for major flow paths that were considered to be unlikely to be developed.
- Different roughness files were adopted for the riverine and stormwater hydraulic models for each town.

8.5.2.4 Structures

No structures were included in the hydraulic models for the three study towns.

8.5.2.5 Model Run Sequence

To avoid a significant overstatement of flows in the downstream reaches (as stream branches converge) each model for each town was split into a number of "component runs". Each component run modelled separate creek branches, with each successive run (generally) modelling a larger proportion of the catchment. Appendix E shows the model run sequence for each town.

8.5.3 Adopted Discharges

The calculated Rational Method discharges were adopted. The convention commonly adopted for steady state hydraulic models of inputting the estimated discharge for each node at the adjacent upstream node was adopted.

8.5.4 Results

The MIKE FLOOD model was run multiple times for each catchment to account for the partial area effect. The adopted flood extent for each AEP was developed from a mosaic of the maximum modelled flood extent from all model runs for each town. Maps of stormwater flood extent and depth were created for the 1 in 10, 1 in 50 and 1 in 100 AEP floods for Jandowae, Wandoan and Tara. The background for all maps is an aerial photograph and cadastre.

For convenience, the maps for each town are presented in separate volumes:

- Volume II: Jandowae Flood Study Maps.
- Volume III: Wandoan Flood Study Maps.
- Volume IV: Tara Flood Study Maps.

9 CONCLUSIONS

Western Downs Regional Council (WDRC) was created in March 2008 after the amalgamations of local government areas throughout Queensland. A full Planning Scheme review is currently being undertaken to create one Planning Scheme for the Western Downs Region. WDRC proposed to undertake flood studies of six towns in the region in conjunction with the Planning Scheme review of which Jandowae, Wandoan and Tara, the subjects of this report were one. There were two components to the flood studies; riverine flooding and stormwater flooding. The purpose of the riverine flood studies was to identify areas of risk of flood inundation, their impact upon current and future development and to identify flood hazard categories for the inundation areas for the defined flood event (DFE). The purpose of the stormwater flood analysis was to define and map stormwater corridors within current and future development areas. The six towns included in the study were Dalby, Chinchilla, Miles, Wandoan, Jandowae and Tara.

Two different types of floods were assessed; riverine and stormwater floods. Riverine floods are large regional floods from the creeks running through each town. These floods may last several days and are usually the result of widespread, long duration rainfall. Stormwater floods are local floods through the numerous overland flowpaths through the towns. These floods are short duration (an hour or so) and are usually the result of localised, short duration rainfall.

For the riverine flood, different flood magnitude estimation techniques were adopted for each town. This is a reflection of differences in the available data. The 1 in 100 AEP flood was modelled. Results were presented as maps of flood depths and flood hazard. The 1 in 100 AEP flood was adopted as the defined flood event (DFE).

Stormwater flooding was also assessed in detail.

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APPENDIX A HYDRAULIC MODEL DOWNSTREAM BOUNDARY SENSITIVITY TESTING

A downstream boundary sensitivity analysis was undertaken for the Jandowae, Wandoan and Tara MIKE FLOOD model. A normal depth was approximated from the preliminary water surface profile which was then refined by modelling to get a closer estimate. Water surface level (WSL) differences were then compared at a point 1000m upstream of the boundary as well as at a point that was deemed within the town area. Table A.1 shows the results of the sensitivity analysis.

Table A.1 shows that changes in the WSL 1000m upstream of the boundary were within 0.1m. When measured at a point within the town area changes in WSL were within 0.02m. The results indicate the adopted approximate normal depth boundary levels are acceptable with boundary level variations having a minimal affect within the study area. Figure A.1 shows the water surface profiles upstream of the boundary for Dogwood Creek.

Table A.1 Downstream Sensitivity Analysis Results

Town	Run	Boundary Level	Δ WSL 1000m Upstream	Distance to Town	Δ WSL at town
		(m AHD)	(m)	(m)	(m)
Jandowae	Adopted	353.65	-	900	0.00
	Increase	-	-		0.00
	Decrease	352	-0.01		-0.01
Wandoan	Adopted	241.6	-	2050	-
	Increase	241.65	0.00		0.00
	Decrease	240	-0.01		0.00
Tara	Adopted	301	-	2000	-
	Increase	307.1	0.00		0.00
	Decrease	305	0.00		0.00

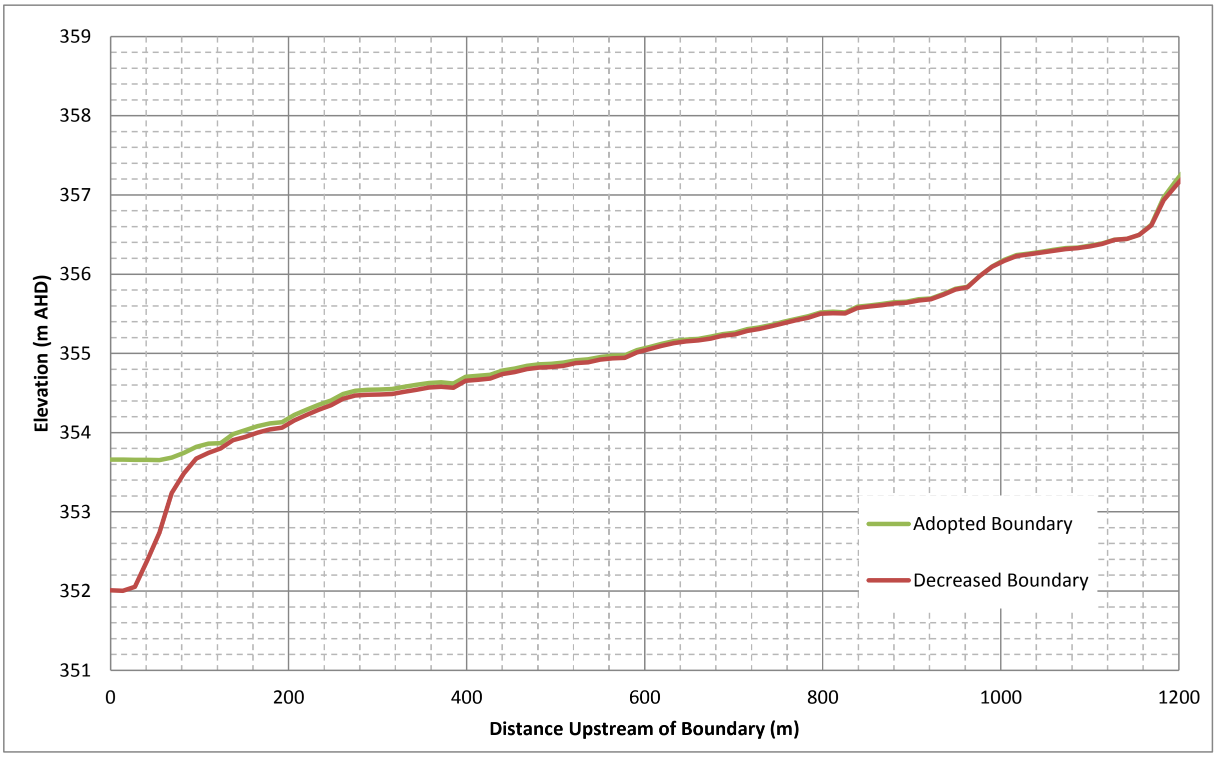

Figure A.1 Jandowae downstream water surface profile

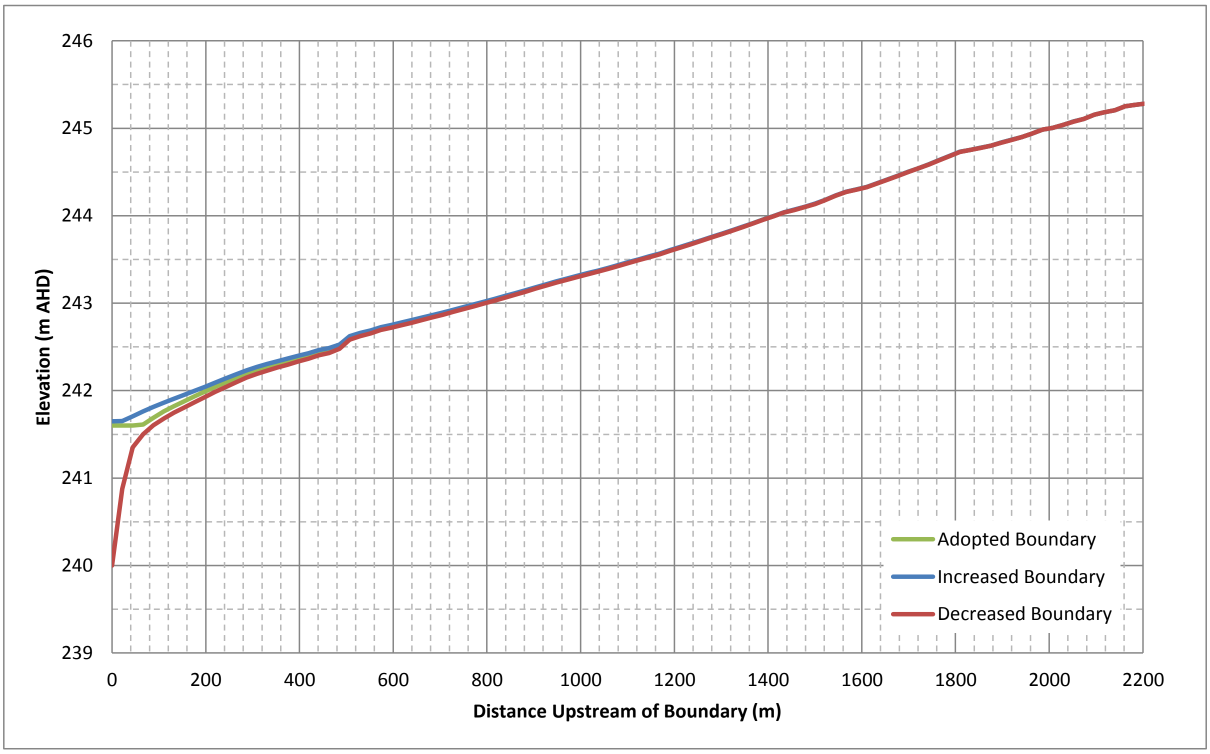

Figure A.2 Wandoan downstream water surface profile

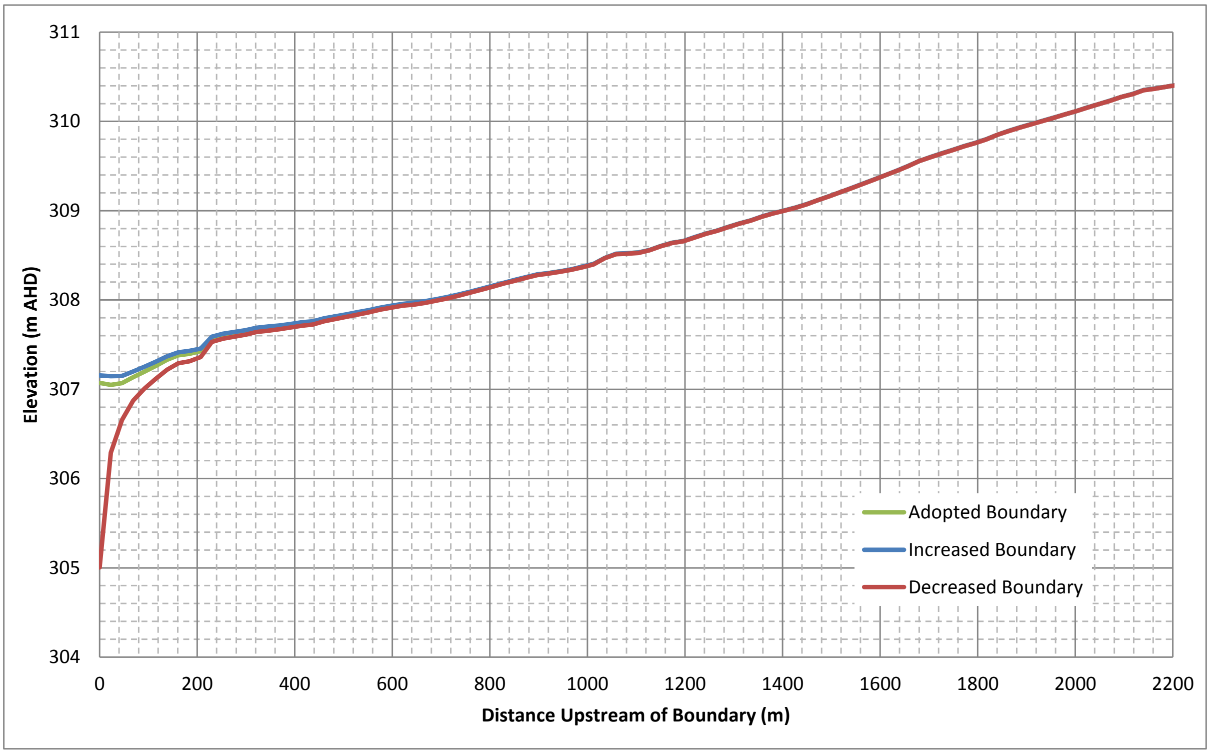

Figure A.3 Tara downstream water surface profile

APPENDIX B JANDOWAE STORMWATER MODELLING – RATIONAL METHOD PARAMETERS AND RESULTS

Table B.1 1 in 100 AEP Jandowae Stormwater Modelling - Model Parameters and Results

												Overland Flow										
Catchment ID	Area (ha)	Stream Length (m)	Slope (m/m)	Total Upstream Area (ha)	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length (m)	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time (mins)	Mannings n	Length (m)	Slope (m/m)	Overland flow travel time (mins)	Channel Velocity (m/s)	Tc Channel (mins)	Total Tc (min)	Rainfall Intensity (mm/hr)	Discharge (m^3/s)	Difference (m^3/s)	Corrected Discharge (for partial area effect) (m^3/s)
A1	17.4	497	0.002	17.4	0.39	0.39	497	1	0.47	overland		0.045	98.5	0.002	32.4	0.50	16.6	49.0	83.6	1.9	1.9	**1.9**
A2	22.9	810	0.003	40.3	0.43	0.41	1307	1	0.50							0.50	27.0	76.0	62.5	3.5	1.6	**3.5**
A3	35.3	302	0.003	75.7	0.44	0.43	1609	1	0.51							0.50	10.1	86.1	57.4	6.2	2.7	**6.2**
B1	16.5	417	0.006	16.5	0.39	0.39	417	1	0.47	overland		0.045	94.2	0.006	24.4	0.50	13.9	38.3	97.3	2.1	2.1	**2.1**
B2	20.7	518	0.001	37.2	0.39	0.39	935	1	0.47							0.50	17.3	55.6	77.1	3.7	1.6	**3.7**
C1	100.7	2100	0.002	100.7	0.39	0.39	2100	1	0.47	overland		0.045	98.2	0.002	31.3	0.50	70.0	101.3	51.1	6.7	6.7	**6.7**
C2	32.7	696	0.002	133.4	0.40	0.39	2796	1	0.47							0.50	23.2	124.5	44.0	7.7	1.0	**7.7**
C3	11.6	534	0.002	145.0	0.57	0.41	3330	1	0.49							0.50	17.8	142.3	39.8	7.8	0.1	**7.8**
C4	6.8	252	0.004	151.8	0.62	0.42	3582	1	0.50							0.50	8.4	150.7	38.1	8.0	0.2	**8.0**
C5	13.0	422	0.008	164.8	0.64	0.43	4004	1	0.52							0.50	14.1	164.7	35.6	8.5	0.5	**8.5**
D1	7.0	344	0.007	7.0	0.45	0.45	344	1	0.54	overland		0.045	93.2	0.007	23.5	0.50	11.5	35.0	102.7	1.1	1.1	**1.1**
D2	8.8	392	0.007	15.8	0.53	0.50	736	1	0.59							0.50	13.1	48.1	84.7	2.2	1.1	**2.2**
DB1	4.5	254	0.008	4.5	0.40	0.40	254	1	0.48	Std. Inlet	15					0.50	8.5	23.5	128.6	0.8	0.8	**0.8**
DB2	5.0	117	0.008	9.6	0.58	0.49	371	1	0.59							0.50	3.9	27.4	118.2	1.9	1.1	**1.9**
E1	21.6	639	0.003	21.6	0.61	0.61	639	1	0.73	Std. Inlet	15					0.50	21.3	36.3	100.5	4.4	4.4	**4.4**
F1	3.7	82	0.003	3.7	0.70	0.70	82	1	0.84	Std. Inlet	15					0.50	2.7	17.7	148.8	1.3	1.3	**1.3**
F2	2.2	246	0.003	5.8	0.72	0.71	328	1	0.85							0.50	8.2	25.9	121.8	1.7	0.4	**1.7**
F3	5.7	320	0.002	11.5	0.70	0.70	648	1	0.85							0.50	10.7	36.6	100.0	2.7	1.0	**2.7**
F4	5.9	304	0.004	17.4	0.58	0.66	952	1	0.79							0.50	10.1	46.7	86.2	3.3	0.6	**3.3**
F5	2.0	388	0.002	19.5	0.41	0.64	1340	1	0.76							0.50	12.9	59.7	73.6	3.0	-0.3	**3.3**
G1	4.5	108	0.002	4.5	0.79	0.79	108	1	0.95	Std. Inlet	15					0.50	3.6	18.6	145.2	1.7	1.7	**1.7**
G2	5.6	255	0.002	10.1	0.77	0.78	363	1	0.94							0.50	8.5	27.1	118.9	3.1	1.4	**3.1**
G3	3.3	228	0.000	13.4	0.75	0.77	591	1	0.93							0.50	7.6	34.7	103.2	3.6	0.5	**3.6**
H1	9.7	331	0.004	9.7	0.70	0.70	331	1	0.84	Std. Inlet	15					0.50	11.0	26.0	121.5	2.8	2.8	**2.8**
I1	5.8	196	0.004	5.8	0.68	0.68	196	1	0.81	Std. Inlet	15					0.50	6.5	21.5	134.6	1.8	1.8	**1.8**
I2	19.5	426	0.003	25.4	0.44	0.49	622	1	0.59							0.50	14.2	35.7	101.4	4.2	2.5	**4.2**
I3	13.5	365	0.003	38.9	0.39	0.46	987	1	0.55		5					0.50	12.2	47.9	84.9	5.0	0.8	**5.0**
IF1	1.0	88	0.004	1.0	0.70	0.70	88	1	0.84	Std. Inlet	15					0.50	2.9	17.9	147.9	0.3	0.3	**0.3**
IF2	9.7	187	0.002	10.7	0.58	0.59	275	1	0.71							0.50	6.2	24.2	126.6	2.7	2.3	**2.7**
J1	16.7	541	0.002	16.7	0.75	0.75	541	1	0.90	Std. Inlet	15					0.50	18.0	33.0	106.2	4.4	4.4	**4.4**
J2	10.4	312	0.001	27.0	0.57	0.68	853	1	0.82							0.50	10.4	43.4	90.2	5.5	1.1	**5.5**
J3	28.2	550	0.002	55.2	0.58	0.63	1403	1	0.75							0.50	18.3	61.8	72.1	8.3	2.8	**8.3**
J4	7.6	384	0.001	62.8	0.68	0.63	1787	1	0.76							0.50	12.8	74.6	63.3	8.4	0.1	**8.4**
J5	5.1	377	0.001	67.9	0.61	0.63	2164	1	0.76							0.50	12.6	87.1	56.9	8.1	-0.3	**8.4**
K1	40.3	810	0.003	40.3	0.42	0.42	810	1	0.50	overland		0.045	97.1	0.003	28.3	0.50	27.0	55.3	77.3	4.4	4.4	**4.4**
K2	15.1	237	0.003	55.5	0.41	0.42	1047	1	0.50							0.50	7.9	63.2	71.1	5.5	1.1	**5.5**

Table B.2 1 in 50 AEP Jandowae Stormwater Modelling - Model Parameters and Results

Catchment ID	Area	Stream Length	Slope	Total Upstream Area	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time	Overland Flow: Mannings n	Overland Flow: Length	Overland Flow: Slope	Overland Flow: Overland flow travel time	Channel Velocity	Tc Channel	Total Tc	Rainfall Intensity	Discharge	Difference	Corrected Discharge (for partial area effect)
	(ha)	(m)	(m/m)	(ha)			(m)				(mins)		(m)	(m/m)	(mins)	(m/s)	(mins)	(min)	(mm/hr)	(m^3/s)	(m^3/s)	(m^3/s)
A1	17.4	497	0.002	17.4	0.39	0.39	497	1	0.45	overland		0.045	98.5	0.002	32.4	0.50	16.6	49.0	75.1	1.6	1.6	**1.6**
A2	22.9	810	0.003	40.3	0.43	0.41	1307	1	0.48							0.50	27.0	76.0	56.2	3.0	1.4	**3.0**
A3	35.3	302	0.003	75.7	0.44	0.43	1609	1	0.49							0.50	10.1	86.1	51.7	5.3	2.3	**5.3**
B1	16.5	417	0.006	16.5	0.39	0.39	417	1	0.45	overland		0.045	94.2	0.006	24.4	0.50	13.9	38.3	87.4	1.8	1.8	**1.8**
B2	20.7	518	0.001	37.2	0.39	0.39	935	1	0.45							0.50	17.3	55.6	69.3	3.2	1.4	**3.2**
C1	100.7	2100	0.002	100.7	0.39	0.39	2100	1	0.45	overland		0.045	98.2	0.002	31.3	0.50	70.0	101.3	46.0	5.8	5.8	**5.8**
C2	32.7	696	0.002	133.4	0.40	0.39	2796	1	0.45							0.50	23.2	124.5	39.5	6.6	0.9	**6.6**
C3	11.6	534	0.002	145.0	0.57	0.41	3330	1	0.47							0.50	17.8	142.3	35.8	6.7	0.1	**6.7**
C4	6.8	252	0.004	151.8	0.62	0.42	3582	1	0.48							0.50	8.4	150.7	34.2	6.9	0.2	**6.9**
C5	13.0	422	0.008	164.8	0.64	0.43	4004	1	0.50							0.50	14.1	164.7	32.0	7.3	0.4	**7.3**
D1	7.0	344	0.007	7.0	0.45	0.45	344	1	0.52	overland		0.045	93.2	0.007	23.5	0.50	11.5	35.0	92.2	0.9	0.9	**0.9**
D2	8.8	392	0.007	15.8	0.53	0.50	736	1	0.57							0.50	13.1	48.1	76.1	1.9	1.0	**1.9**
DB1	4.5	254	0.008	4.5	0.40	0.40	254	1	0.46	Std. Inlet	15					0.50	8.5	23.5	115.3	0.7	0.7	**0.7**
DB2	5.0	117	0.008	9.6	0.58	0.49	371	1	0.57							0.50	3.9	27.4	106.1	1.6	0.9	**1.6**
E1	21.6	639	0.003	21.6	0.61	0.61	639	1	0.70	Std. Inlet	15					0.50	21.3	36.3	90.3	3.8	3.8	**3.8**
F1	3.7	82	0.003	3.7	0.70	0.70	82	1	0.81	Std. Inlet	15					0.50	2.7	17.7	133.2	1.1	1.1	**1.1**
F2	2.2	246	0.003	5.8	0.72	0.71	328	1	0.81							0.50	8.2	25.9	109.3	1.4	0.3	**1.4**
F3	5.7	320	0.002	11.5	0.70	0.70	648	1	0.81							0.50	10.7	36.6	89.8	2.3	0.9	**2.3**
F4	5.9	304	0.004	17.4	0.58	0.66	952	1	0.76							0.50	10.1	46.7	77.5	2.9	0.5	**2.9**
F5	2.0	388	0.002	19.5	0.41	0.64	1340	1	0.73							0.50	12.9	59.7	66.1	2.6	-0.2	**2.9**
G1	4.5	108	0.002	4.5	0.79	0.79	108	1	0.91	Std. Inlet	15					0.50	3.6	18.6	130.1	1.5	1.5	**1.5**
G2	5.6	255	0.002	10.1	0.77	0.78	363	1	0.90							0.50	8.5	27.1	106.7	2.7	1.2	**2.7**
G3	3.3	228	0.000	13.4	0.75	0.77	591	1	0.89							0.50	7.6	34.7	92.7	3.1	0.4	**3.1**
H1	9.7	331	0.004	9.7	0.70	0.70	331	1	0.81	Std. Inlet	15					0.50	11.0	26.0	109.0	2.4	2.4	**2.4**
I1	5.8	196	0.004	5.8	0.68	0.68	196	1	0.78	Std. Inlet	15					0.50	6.5	21.5	120.7	1.5	1.5	**1.5**
I2	19.5	426	0.003	25.4	0.44	0.49	622	1	0.57							0.50	14.2	35.7	91.1	3.6	2.1	**3.6**
I3	13.5	365	0.003	38.9	0.39	0.46	987	1	0.53		5					0.50	12.2	47.9	76.3	4.3	0.7	**4.3**
IF1	1.0	88	0.004	1.0	0.70	0.70	88	1	0.81	Std. Inlet	15					0.50	2.9	17.9	132.4	0.3	0.3	**0.3**
IF2	9.7	187	0.002	10.7	0.58	0.59	275	1	0.68							0.50	6.2	24.2	113.5	2.3	2.0	**2.3**
J1	16.7	541	0.002	16.7	0.75	0.75	541	1	0.86	Std. Inlet	15					0.50	18.0	33.0	95.4	3.8	3.8	**3.8**
J2	10.4	312	0.001	27.0	0.57	0.68	853	1	0.78							0.50	10.4	43.4	81.1	4.8	1.0	**4.8**
J3	28.2	550	0.002	55.2	0.58	0.63	1403	1	0.72							0.50	18.3	61.8	64.8	7.2	2.4	**7.2**
J4	7.6	384	0.001	62.8	0.68	0.63	1787	1	0.73							0.50	12.8	74.6	56.9	7.2	0.1	**7.2**
J5	5.1	377	0.001	67.9	0.61	0.63	2164	1	0.73							0.50	12.6	87.1	51.2	7.0	-0.2	**7.2**
K1	40.3	810	0.003	40.3	0.42	0.42	810	1	0.48	overland		0.045	97.1	0.003	28.3	0.50	27.0	55.3	69.5	3.8	3.8	**3.8**
K2	15.1	237	0.003	55.5	0.41	0.42	1047	1	0.48							0.50	7.9	63.2	63.9	4.7	1.0	**4.7**

Table H3: 1 in 10 AEP Jandowae Stormwater Modelling - Model Parameters and Results

												Overland Flow										
Catchment ID	Area	Stream Length	Slope	Total Upstream Area	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time	Mannings n	Length	Slope	Overland flow travel time	Channel Velocity	Tc Channel	Total Tc	Rainfall Intensity	Discharge	Difference	Corrected Discharge (for partial area effect)
	(ha)	(m)	(m/m)	(ha)			(m)				(mins)		(m)	(m/m)	(mins)	(m/s)	(mins)	(min)	(mm/hr)	(m^3/s)	(m^3/s)	(m^3/s)
A1	17.4	497	0.002	17.4	0.39	0.39	497	1	0.39	overland		0.045	98.5	0.002	32.4	0.50	16.6	49.0	56.4	1.1	1.1	**1.1**
A2	22.9	810	0.003	40.3	0.43	0.41	1307	1	0.41							0.50	27.0	76.0	42.2	2.0	0.9	**2.0**
A3	35.3	302	0.003	75.7	0.44	0.43	1609	1	0.43							0.50	10.1	86.1	38.8	3.5	1.5	**3.5**
B1	16.5	417	0.006	16.5	0.39	0.39	417	1	0.39	overland		0.045	94.2	0.006	24.4	0.50	13.9	38.3	65.5	1.2	1.2	**1.2**
B2	20.7	518	0.001	37.2	0.39	0.39	935	1	0.39							0.50	17.3	55.6	52.0	2.1	0.9	**2.1**
C1	100.7	2100	0.002	100.7	0.39	0.39	2100	1	0.39	overland		0.045	98.2	0.002	31.3	0.50	70.0	101.3	34.5	3.8	3.8	**3.8**
C2	32.7	696	0.002	133.4	0.40	0.39	2796	1	0.39							0.50	23.2	124.5	29.6	4.3	0.6	**4.3**
C3	11.6	534	0.002	145.0	0.57	0.41	3330	1	0.41							0.50	17.8	142.3	26.8	4.4	0.1	**4.4**
C4	6.8	252	0.004	151.8	0.62	0.42	3582	1	0.42							0.50	8.4	150.7	25.6	4.5	0.1	**4.5**
C5	13.0	422	0.008	164.8	0.64	0.43	4004	1	0.43							0.50	14.1	164.7	24.0	4.8	0.3	**4.8**
D1	7.0	344	0.007	7.0	0.45	0.45	344	1	0.45	overland		0.045	93.2	0.007	23.5	0.50	11.5	35.0	69.1	0.6	0.6	**0.6**
D2	8.8	392	0.007	15.8	0.53	0.50	736	1	0.50							0.50	13.1	48.1	57.1	1.2	0.6	**1.2**
DB1	4.5	254	0.008	4.5	0.40	0.40	254	1	0.40	Std. Inlet	15					0.50	8.5	23.5	86.0	0.4	0.4	**0.4**
DB2	5.0	117	0.008	9.6	0.58	0.49	371	1	0.49							0.50	3.9	27.4	79.2	1.0	0.6	**1.0**
E1	21.6	639	0.003	21.6	0.61	0.61	639	1	0.61	Std. Inlet	15					0.50	21.3	36.3	67.6	2.5	2.5	**2.5**
F1	3.7	82	0.003	3.7	0.70	0.70	82	1	0.70	Std. Inlet	15					0.50	2.7	17.7	98.8	0.7	0.7	**0.7**
F2	2.2	246	0.003	5.8	0.72	0.71	328	1	0.71							0.50	8.2	25.9	81.6	0.9	0.2	**0.9**
F3	5.7	320	0.002	11.5	0.70	0.70	648	1	0.70							0.50	10.7	36.6	67.3	1.5	0.6	**1.5**
F4	5.9	304	0.004	17.4	0.58	0.66	952	1	0.66							0.50	10.1	46.7	58.1	1.9	0.3	**1.9**
F5	2.0	388	0.002	19.5	0.41	0.64	1340	1	0.64							0.50	12.9	59.7	49.6	1.7	-0.2	**1.9**
G1	4.5	108	0.002	4.5	0.79	0.79	108	1	0.79	Std. Inlet	15					0.50	3.6	18.6	96.6	1.0	1.0	**1.0**
G2	5.6	255	0.002	10.1	0.77	0.78	363	1	0.78							0.50	8.5	27.1	79.7	1.7	0.8	**1.7**
G3	3.3	228	0.000	13.4	0.75	0.77	591	1	0.77							0.50	7.6	34.7	69.4	2.0	0.3	**2.0**
H1	9.7	331	0.004	9.7	0.70	0.70	331	1	0.70	Std. Inlet	15					0.50	11.0	26.0	81.4	1.5	1.5	**1.5**
I1	5.8	196	0.004	5.8	0.68	0.68	196	1	0.68	Std. Inlet	15					0.50	6.5	21.5	89.8	1.0	1.0	**1.0**
I2	19.5	426	0.003	25.4	0.44	0.49	622	1	0.49							0.50	14.2	35.7	68.2	2.4	1.4	**2.4**
I3	13.5	365	0.003	38.9	0.39	0.46	987	1	0.46		5					0.50	12.2	47.9	57.2	2.8	0.5	**2.8**
IF1	1.0	88	0.004	1.0	0.70	0.70	88	1	0.70	Std. Inlet	15					0.50	2.9	17.9	98.3	0.2	0.2	**0.2**
IF2	9.7	187	0.002	10.7	0.58	0.59	275	1	0.59							0.50	6.2	24.2	84.6	1.5	1.3	**1.5**
J1	16.7	541	0.002	16.7	0.75	0.75	541	1	0.75	Std. Inlet	15					0.50	18.0	33.0	71.4	2.5	2.5	**2.5**
J2	10.4	312	0.001	27.0	0.57	0.68	853	1	0.68							0.50	10.4	43.4	60.8	3.1	0.6	**3.1**
J3	28.2	550	0.002	55.2	0.58	0.63	1403	1	0.63							0.50	18.3	61.8	48.6	4.7	1.6	**4.7**
J4	7.6	384	0.001	62.8	0.68	0.63	1787	1	0.63							0.50	12.8	74.6	42.7	4.7	0.0	**4.7**
J5	5.1	377	0.001	67.9	0.61	0.63	2164	1	0.63							0.50	12.6	87.1	38.4	4.6	-0.1	**4.7**
K1	40.3	810	0.003	40.3	0.42	0.42	810	1	0.42	overland		0.045	97.1	0.003	28.3	0.50	27.0	55.3	52.2	2.5	2.5	**2.5**
K2	15.1	237	0.003	55.5	0.41	0.42	1047	1	0.42							0.50	7.9	63.2	48.0	3.1	0.6	**3.1**

APPENDIX C WANDOAN STORMWATER MODELLING – RATIONAL METHOD PARAMETERS AND RESULTS

Table C.1 1 in 100 AEP Wandoan Stormwater Modelling - Model Parameters and Results

Catchment ID	Area (ha)	Stream Length (m)	Slope (m/m)	Total Upstream Area (ha)	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length (m)	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time (mins)	Overland Flow: Mannings n	Overland Flow: Length (m)	Overland Flow: Slope (m/m)	Overland Flow: Overland flow travel time (mins)	Channel Velocity (m/s)	Tc Channel (mins)	Total Tc (min)	Rainfall Intensity (mm/hr)	Discharge (m^3/s)	Difference (m^3/s)	Corrected Discharge (for partial area effect) (m^3/s)
A1	201.0	1304	0.016	201.0	0.49	0.49	1304	1	0.59	overland		0.045	84.4	0.016	19.3	0.50	43.5	62.8	78.4	25.8	25.8	**25.8**
A2	2.9	197	0.016	211.0	0.85	0.51	1501	1	0.61							0.50	6.6	69.3	73.5	26.3	0.5	**26.3**
A3	2.1	132	0.016	234.4	0.86	0.54	1633	1	0.65							0.50	4.4	73.7	70.2	29.8	3.5	**29.8**
A4	29.0	750	0.014	263.4	0.86	0.58	2383	1	0.69							0.50	25.0	98.7	57.1	29.0	-0.8	**29.8**
AA1	7.1	240	0.016	7.1	0.86	0.86	240	1	1.03	overland	5	0.045	83.9	0.016	19.1	0.50	8.0	27.1	128.9	2.6	2.6	**2.6**
AB1	7.5	392	0.015	7.5	0.86	0.86	392	1	1.03	Std. Inlet	5					0.50	13.1	18.1	157.9	3.4	3.4	**3.4**
AB2	8.8	345	0.016	21.4	0.86	0.86	737	1	1.03							0.50	11.5	29.6	123.1	7.5	4.1	**7.5**
AZ1	12.1	457	0.008	12.1	0.46	0.46	457	1	0.55	overland	15	0.045	92.3	0.008	22.9	0.50	15.2	38.1	106.7	2.0	2.0	**2.0**
B1	20.4	485	0.017	20.4	0.80	0.80	485	1	0.96	Std. Inlet	5					0.50	16.2	21.2	146.3	7.9	7.9	**7.9**
B2	8.9	170	0.017	29.3	0.76	0.79	655	1	0.94							0.50	5.7	26.8	129.7	10.0	2.0	**10.0**
B3	25.2	605	0.022	54.5	0.63	0.72	1260	1	0.86							0.50	20.2	47.0	94.2	12.3	2.3	**12.3**
B4	3.4	272	0.020	58.0	0.47	0.70	1532	1	0.84							0.50	9.1	56.1	84.2	11.4	-0.8	**12.3**
BA1	5.0	140	0.016	5.0	0.86	0.86	140	1	1.03	Std. Inlet	15					0.50	4.7	19.7	151.7	2.2	2.2	**2.2**
BB1	15.6	642	0.000	15.6	0.72	0.72	642	1	0.86	Std. Inlet	15					0.50	21.4	36.4	109.6	4.1	4.1	**4.1**
BD1	5.3	205	0.000	5.3	0.56	0.56	205	1	0.68	overland		0.045	99.99	0.000	88.8	0.50	6.8	95.7	58.4	0.6	0.6	**0.6**
C1	110.3	1092	0.009	110.3	0.46	0.46	1092	1	0.55	overland	15	0.045	91.3	0.009	22.3	0.50	36.4	58.7	81.7	13.8	13.8	**13.8**
D1	5.8	194	0.034	5.8	0.72	0.72	194	1	0.86	Std. Inlet	15					0.50	6.5	21.5	145.3	2.0	2.0	**2.0**
D2	14.6	397	0.034	20.5	0.59	0.63	591	1	0.75							0.50	13.2	34.7	112.7	4.8	2.8	**4.8**
E1	8.4	150	0.018	8.4	0.79	0.79	150	1	0.95	Std. Inlet	15					0.50	5.0	20.0	150.4	3.3	3.3	**3.3**
E2	16.2	508	0.018	38.2	0.61	0.68	658	1	0.82							0.50	16.9	36.9	108.7	9.5	6.1	**9.5**
E3	13.9	368	0.024	52.1	0.68	0.68	1026	1	0.82							0.50	12.3	49.2	91.5	10.9	1.4	**10.9**
E4	26.0	948	0.015	78.1	0.48	0.62	1974	1	0.74							0.50	31.6	80.8	66.0	10.6	-0.3	**10.9**
ED1	7.3	122	0.024	7.3	0.72	0.72	122	1	0.86	Std. Inlet	15					0.50	4.1	19.1	153.9	2.7	2.7	**2.7**
ED2	6.3	170	0.024	13.6	0.69	0.71	292	1	0.85							0.50	5.7	24.7	135.3	4.3	1.6	**4.3**
F1	18.3	320	0.018	18.3	0.46	0.46	320	1	0.55	overland		0.045	82.5	0.018	18.7	0.50	10.7	29.4	123.5	3.5	3.5	**3.5**
F2	28.7	855	0.016	97.3	0.62	0.55	1175	1	0.66							0.50	28.5	57.9	82.5	14.7	11.2	**14.7**
F3	17.8	524	0.018	190.8	0.72	0.55	1699	1	0.66							0.50	17.5	75.3	69.0	24.2	9.5	**24.2**
F4	23.5	723	0.015	214.3	0.47	0.54	2422	1	0.65							0.50	24.1	99.4	56.8	22.0	-2.2	**24.2**
F5	21.7	612	0.010	235.9	0.46	0.53	3034	1	0.64							0.50	20.4	119.8	49.3	20.7	-1.3	**24.2**
G1	20.3	286	0.024	20.3	0.46	0.46	286	1	0.55	overland		0.045	76.3	0.024	17.2	0.50	9.5	26.7	130.0	4.1	4.1	**4.1**
G2	29.9	561	0.015	50.2	0.59	0.54	847	1	0.65							0.50	18.7	45.4	96.1	8.7	4.6	**8.7**
H1	26.4	493	0.025	26.4	0.46	0.46	493	1	0.55	overland		0.045	75.3	0.025	16.9	0.50	16.4	33.4	115.2	4.7	4.7	**4.7**
H2	40.3	1150	0.013	66.8	0.56	0.52	1643	1	0.63							0.50	38.3	71.7	71.7	8.3	3.7	**8.3**
HH1	23.1	233	0.013	23.1	0.46	0.46	233	1	0.55	overland		0.045	86.8	0.013	20.1	0.50	7.8	27.9	127.0	4.5	4.5	**4.5**
HY1	10.2	190	0.013	10.2	0.46	0.46	190	1	0.55	overland		0.045	86.8	0.013	20.1	0.50	6.3	26.5	130.6	2.0	2.0	**2.0**
I1	199.0	1990	0.010	199.0	0.46	0.46	1990	1	0.55	overland		0.045	90.5	0.010	21.8	0.50	66.3	88.1	61.9	18.9	18.9	**18.9**
I2	84.0	480	0.010	283.0	0.46	0.46	2470	1	0.55							0.50	16.0	104.1	54.8	23.8	4.9	**23.8**
I3	32.9	470	0.010	553.0	0.46	0.46	2940	1	0.55							0.50	15.7	119.8	49.4	41.8	18.1	**41.8**
I4	58.4	760	0.005	611.4	0.46	0.46	3700	1	0.55							0.50	25.3	145.1	42.7	40.1	-1.8	**41.8**
IC1	16.4	470	0.005	16.4	0.46	0.46	470	1	0.55	overland		0.045	95.5	0.005	25.8	0.50	15.7	41.4	101.7	2.6	2.6	**2.6**
IC2	29.0	485	0.005	45.4	0.46	0.46	955	1	0.55							0.50	16.2	57.6	82.7	5.8	3.2	**5.8**
J1	191.7	2170	0.012	191.7	0.46	0.46	2170	1	0.55	overland		0.045	88.5	0.012	20.8	0.50	72.3	93.2	59.5	17.5	17.5	**17.5**
K1	39.3	1537	0.012	39.3	0.48	0.48	1537	1	0.57	overland		0.045	88.4	0.012	20.8	0.50	51.2	72.0	71.4	4.5	4.5	**4.5**
Y1	26.4	775	0.019	26.4	0.46	0.46	775	1	0.55	overland		0.045	80.7	0.019	18.2	0.50	25.8	44.1	98.0	4.0	4.0	**4.0**
Y2	23.5	215	0.019	49.9	0.46	0.46	990	1	0.55							0.50	7.2	51.2	89.2	6.8	2.9	**6.8**
YH1	9.0	263	0.015	9.0	0.46	0.46	263	1	0.55	overland		0.045	85.5	0.015	19.7	0.50	8.8	28.4	125.7	1.7	1.7	**1.7**

Table C.1 1 in 100 AEP Wandoan Stormwater Modelling - Model Parameters and Results

												Overland Flow										
Catchment ID	Area	Stream Length	Slope	Total Upstream Area	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time	Mannings n	Length	Slope	Overland flow travel time	Channel Velocity	Tc Channel	Total Tc	Rainfall Intensity	Discharge	Difference	Corrected Discharge (for partial area effect)
	(ha)	(m)	(m/m)	(ha)			(m)				(mins)		(m)	(m/m)	(mins)	(m/s)	(mins)	(min)	(mm/hr)	(m^3/s)	(m^3/s)	(m^3/s)
Z1	381.7	3125	0.008	381.7	0.46	0.46	3125	1	0.55	overland		0.045	92.3	0.008	22.9	0.50	104.2	127.1	47.3	27.7	27.7	**27.7**
ZA1	69.6	936	0.008	69.6	0.46	0.46	936	1	0.55	overland		0.045	92.3	0.008	22.9	0.50	31.2	54.1	86.1	9.2	9.2	**9.2**
ZA2	35.6	730	0.008	105.2	0.46	0.46	1666	1	0.55							0.50	24.3	78.4	67.3	10.9	1.7	**10.9**
ZA3	19.8	632	0.008	125.0	0.46	0.46	2298	1	0.55							0.50	21.1	99.5	56.8	10.9	0.0	**10.9**
ZA4	21.1	616	0.008	156.7	0.46	0.46	2914	1	0.55							0.50	20.5	120.0	49.3	11.8	1.0	**11.8**
ZZ1	10.7	550	0.008	10.7	0.46	0.46	550	1	0.55	overland		0.045	92.3	0.008	22.9	0.50	18.3	41.2	102.0	1.7	1.7	**1.7**

Table C.2 1 in 50 AEP Wandoan Stormwater Modelling - Model Parameters and Results

Catchment ID	Area	Stream Length	Slope	Total Upstream Area	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time	Overland Flow: Mannings n	Overland Flow: Length	Overland Flow: Slope	Overland Flow: Overland flow travel time	Channel Velocity	Tc Channel	Total Tc	Rainfall Intensity	Discharge	Difference	Corrected Discharge (for partial area effect)
	(ha)	(m)	(m/m)	(ha)			(m)				(mins)		(m)	(m/m)	(mins)	(m/s)	(mins)	(min)	(mm/hr)	(m^3/s)	(m^3/s)	(m^3/s)
A1	201.0	1304	0.016	201.0	0.49	0.49	1304	1	0.57	overland		0.045	84.4	0.016	19.3	0.50	43.5	62.8	70.4	22.2	22.2	**22.2**
A2	2.9	197	0.016	211.0	0.85	0.51	1501	1	0.59							0.50	6.6	69.3	66.0	22.6	0.4	**22.6**
A3	2.1	132	0.016	234.4	0.86	0.54	1633	1	0.63							0.50	4.4	73.7	63.0	25.7	3.0	**25.7**
A4	29.0	750	0.014	263.4	0.86	0.58	2383	1	0.67							0.50	25.0	98.7	51.3	25.0	-0.7	**25.7**
AA1	7.1	240	0.016	7.1	0.86	0.86	240	1	0.99	overland	5	0.045	83.9	0.016	19.1	0.50	8.0	27.1	115.6	2.3	2.3	**2.3**
AB1	7.5	392	0.015	7.5	0.86	0.86	392	1	0.99	Std. Inlet	5					0.50	13.1	18.1	141.5	2.9	2.9	**2.9**
AB2	8.8	345	0.016	21.4	0.86	0.86	737	1	0.99							0.50	11.5	29.6	110.5	6.5	3.6	**6.5**
AZ1	12.1	457	0.008	12.1	0.46	0.46	457	1	0.53	overland	15	0.045	92.3	0.008	22.9	0.50	15.2	38.1	95.8	1.7	1.7	**1.7**
B1	20.4	485	0.017	20.4	0.80	0.80	485	1	0.92	Std. Inlet	5					0.50	16.2	21.2	131.2	6.8	6.8	**6.8**
B2	8.9	170	0.017	29.3	0.76	0.79	655	1	0.90							0.50	5.7	26.8	116.3	8.6	1.7	**8.6**
B3	25.2	605	0.022	54.5	0.63	0.72	1260	1	0.82							0.50	20.2	47.0	84.5	10.5	2.0	**10.5**
B4	3.4	272	0.020	58.0	0.47	0.70	1532	1	0.81							0.50	9.1	56.1	75.6	9.8	-0.7	**10.5**
BA1	5.0	140	0.016	5.0	0.86	0.86	140	1	0.99	Std. Inlet	15					0.50	4.7	19.7	136.0	1.9	1.9	**1.9**
BB1	15.6	642	0.000	15.6	0.72	0.72	642	1	0.82	Std. Inlet	15					0.50	21.4	36.4	98.4	3.5	3.5	**3.5**
BD1	5.3	205	0.000	5.3	0.56	0.56	205	1	0.65	overland		0.045	99.99	0.000	88.8	0.50	6.8	95.7	52.5	0.5	0.5	**0.5**
C1	110.3	1092	0.009	110.3	0.46	0.46	1092	1	0.53	overland	15	0.045	91.3	0.009	22.3	0.50	36.4	58.7	73.4	11.9	11.9	**11.9**
D1	5.8	194	0.034	5.8	0.72	0.72	194	1	0.83	Std. Inlet	15					0.50	6.5	21.5	130.3	1.8	1.8	**1.8**
D2	14.6	397	0.034	20.5	0.59	0.63	591	1	0.72							0.50	13.2	34.7	101.1	4.1	2.4	**4.1**
E1	8.4	150	0.018	8.4	0.79	0.79	150	1	0.91	Std. Inlet	15					0.50	5.0	20.0	134.8	2.8	2.8	**2.8**
E2	16.2	508	0.018	38.2	0.61	0.68	658	1	0.79							0.50	16.9	36.9	97.6	8.1	5.3	**8.1**
E3	13.9	368	0.024	52.1	0.68	0.68	1026	1	0.79							0.50	12.3	49.2	82.1	9.3	1.2	**9.3**
E4	26.0	948	0.015	78.1	0.48	0.62	1974	1	0.71							0.50	31.6	80.8	59.3	9.1	-0.2	**9.3**
ED1	7.3	122	0.024	7.3	0.72	0.72	122	1	0.83	Std. Inlet	15					0.50	4.1	19.1	138.0	2.3	2.3	**2.3**
ED2	6.3	170	0.024	13.6	0.69	0.71	292	1	0.81							0.50	5.7	24.7	121.4	3.7	1.4	**3.7**
F1	18.3	320	0.018	18.3	0.46	0.46	320	1	0.53	overland		0.045	82.5	0.018	18.7	0.50	10.7	29.4	110.8	3.0	3.0	**3.0**
F2	28.7	855	0.016	97.3	0.62	0.55	1175	1	0.63							0.50	28.5	57.9	74.0	12.6	9.6	**12.6**
F3	17.8	524	0.018	190.8	0.72	0.55	1699	1	0.63							0.50	17.5	75.3	62.0	20.8	8.2	**20.8**
F4	23.5	723	0.015	214.3	0.47	0.54	2422	1	0.62							0.50	24.1	99.4	51.0	18.9	-1.9	**20.8**
F5	21.7	612	0.010	235.9	0.46	0.53	3034	1	0.61							0.50	20.4	119.8	44.3	17.9	-1.1	**20.8**
G1	20.3	286	0.024	20.3	0.46	0.46	286	1	0.53	overland		0.045	76.3	0.024	17.2	0.50	9.5	26.7	116.6	3.5	3.5	**3.5**
G2	29.9	561	0.015	50.2	0.59	0.54	847	1	0.62							0.50	18.7	45.4	86.3	7.5	4.0	**7.5**
H1	26.4	493	0.025	26.4	0.46	0.46	493	1	0.53	overland		0.045	75.3	0.025	16.9	0.50	16.4	33.4	103.3	4.0	4.0	**4.0**
H2	40.3	1150	0.013	66.8	0.56	0.52	1643	1	0.60							0.50	38.3	71.7	64.4	7.2	3.2	**7.2**
HH1	23.1	233	0.013	23.1	0.46	0.46	233	1	0.53	overland		0.045	86.8	0.013	20.1	0.50	7.8	27.9	113.9	3.9	3.9	**3.9**
HY1	10.2	190	0.013	10.2	0.46	0.46	190	1	0.53	overland		0.045	86.8	0.013	20.1	0.50	6.3	26.5	117.2	1.8	1.8	**1.8**
I1	199.0	1990	0.010	199.0	0.46	0.46	1990	1	0.53	overland		0.045	90.5	0.010	21.8	0.50	66.3	88.1	55.6	16.3	16.3	**16.3**
I2	84.0	480	0.010	283.0	0.46	0.46	2470	1	0.53							0.50	16.0	104.1	49.2	20.5	4.2	**20.5**
I3	32.9	470	0.010	553.0	0.46	0.46	2940	1	0.53							0.50	15.7	119.8	44.3	36.0	15.6	**36.0**
I4	58.4	760	0.005	611.4	0.46	0.46	3700	1	0.53							0.50	25.3	145.1	38.4	34.5	-1.5	**36.0**
IC1	16.4	470	0.005	16.4	0.46	0.46	470	1	0.53	overland		0.045	95.5	0.005	25.8	0.50	15.7	41.4	91.3	2.2	2.2	**2.2**
IC2	29.0	485	0.005	45.4	0.46	0.46	955	1	0.53							0.50	16.2	57.6	74.3	5.0	2.8	**5.0**
J1	191.7	2170	0.012	191.7	0.46	0.46	2170	1	0.53	overland		0.045	88.5	0.012	20.8	0.50	72.3	93.2	53.4	15.1	15.1	**15.1**
K1	39.3	1537	0.012	39.3	0.48	0.48	1537	1	0.55	overland		0.045	88.4	0.012	20.8	0.50	51.2	72.0	64.2	3.9	3.9	**3.9**
Y1	26.4	775	0.019	26.4	0.46	0.46	775	1	0.53	overland		0.045	80.7	0.019	18.2	0.50	25.8	44.1	87.9	3.4	3.4	**3.4**
Y2	23.5	215	0.019	49.9	0.46	0.46	990	1	0.53							0.50	7.2	51.2	80.1	5.9	2.5	**5.9**
YH1	9.0	263	0.015	9.0	0.46	0.46	263	1	0.53	overland		0.045	85.5	0.015	19.7	0.50	8.8	28.4	112.8	1.5	1.5	**1.5**

Table C.2 1 in 50 AEP Wandoan Stormwater Modelling - Model Parameters and Results

												Overland Flow										
Catchment ID	Area (ha)	Stream Length (m)	Slope (m/m)	Total Upstream Area (ha)	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length (m)	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time (mins)	Mannings n	Length (m)	Slope (m/m)	Overland flow travel time (mins)	Channel Velocity (m/s)	Tc Channel (mins)	Total Tc (min)	Rainfall Intensity (mm/hr)	Discharge (m^3/s)	Difference (m^3/s)	Corrected Discharge (for partial area effect) (m^3/s)
Z1	381.7	3125	0.008	381.7	0.46	0.46	3125	1	0.53	overland		0.045	92.3	0.008	22.9	0.50	104.2	127.1	42.5	23.8	23.8	**23.8**
ZA1	69.6	936	0.008	69.6	0.46	0.46	936	1	0.53	overland		0.045	92.3	0.008	22.9	0.50	31.2	54.1	77.3	7.9	7.9	**7.9**
ZA2	35.6	730	0.008	105.2	0.46	0.46	1666	1	0.53							0.50	24.3	78.4	60.4	9.3	1.4	**9.3**
ZA3	19.8	632	0.008	125.0	0.46	0.46	2298	1	0.53							0.50	21.1	99.5	51.0	9.4	0.0	**9.4**
ZA4	21.1	616	0.008	156.7	0.46	0.46	2914	1	0.53							0.50	20.5	120.0	44.2	10.2	0.8	**10.2**
ZZ1	10.7	550	0.008	10.7	0.46	0.46	550	1	0.53	overland		0.045	92.3	0.008	22.9	0.50	18.3	41.2	91.5	1.4	1.4	**1.4**

Table C.3 1 in 10 AEP Wandoan Stormwater Modelling - Model Parameters and Results

												Overland Flow										
Catchment ID	**Area**	**Stream Length**	**Slope**	**Total Upstream Area**	**Catchment C10**	**Tot. u/s area Av. C10**	**Sum Stream Length**	**Fy**	**Cy**	**Overland Flow/Std Inlet Time**	**Std Inlet Time**	**Mannings n**	**Length**	**Slope**	**Overland flow travel time**	**Channel Velocity**	**Tc Channel**	**Total Tc**	**Rainfall Intensity**	**Discharge**	**Difference**	**Corrected Discharge (for partial area effect)**
	(ha)	**(m)**	**(m/m)**	**(ha)**			**(m)**				**(mins)**		**(m)**	**(m/m)**	**(mins)**	**(m/s)**	**(mins)**	**(min)**	**(mm/hr)**	**(m³/s)**	**(m³/s)**	**(m³/s)**
A1	201.0	1304	0.016	201.0	0.49	0.49	1304	1	0.49	overland		0.045	84.4	0.016	19.3	0.50	43.5	62.8	52.5	14.4	14.4	**14.4**
A2	2.9	197	0.016	211.0	0.85	0.51	1501	1	0.51							0.50	6.6	69.3	49.2	14.7	0.3	**14.7**
A3	2.1	132	0.016	234.4	0.86	0.54	1633	1	0.54							0.50	4.4	73.7	47.0	16.7	2.0	**16.7**
A4	29.0	750	0.014	263.4	0.86	0.58	2383	1	0.58							0.50	25.0	98.7	38.3	16.2	-0.5	**16.7**
AA1	7.1	240	0.016	7.1	0.86	0.86	240	1	0.86	overland	5	0.045	83.9	0.016	19.1	0.50	8.0	27.1	86.0	1.5	1.5	**1.5**
AB1	7.5	392	0.015	7.5	0.86	0.86	392	1	0.86	Std. Inlet	5					0.50	13.1	18.1	105.0	1.9	1.9	**1.9**
AB2	8.8	345	0.016	21.4	0.86	0.86	737	1	0.86							0.50	11.5	29.6	82.2	4.2	2.3	**4.2**
AZ1	12.1	457	0.008	12.1	0.46	0.46	457	1	0.46	overland	15	0.045	92.3	0.008	22.9	0.50	15.2	38.1	71.4	1.1	1.1	**1.1**
B1	20.4	485	0.017	20.4	0.80	0.80	485	1	0.80	Std. Inlet	5					0.50	16.2	21.2	97.4	4.4	4.4	**4.4**
B2	8.9	170	0.017	29.3	0.76	0.79	655	1	0.79							0.50	5.7	26.8	86.6	5.5	1.1	**5.5**
B3	25.2	605	0.022	54.5	0.63	0.72	1260	1	0.72							0.50	20.2	47.0	63.1	6.8	1.3	**6.8**
B4	3.4	272	0.020	58.0	0.47	0.70	1532	1	0.70							0.50	9.1	56.1	56.4	6.4	-0.5	**6.8**
BA1	5.0	140	0.016	5.0	0.86	0.86	140	1	0.86	Std. Inlet	15					0.50	4.7	19.7	100.9	1.2	1.2	**1.2**
BB1	15.6	642	0.000	15.6	0.72	0.72	642	1	0.72	Std. Inlet	15					0.50	21.4	36.4	73.3	2.3	2.3	**2.3**
BD1	5.3	205	0.000	5.3	0.56	0.56	205	1	0.56	overland		0.045	99.99	0.000	88.8	0.50	6.8	95.7	39.1	0.3	0.3	**0.3**
C1	110.3	1092	0.009	110.3	0.46	0.46	1092	1	0.46	overland	15	0.045	91.3	0.009	22.3	0.50	36.4	58.7	54.8	7.7	7.7	**7.7**
D1	5.8	194	0.034	5.8	0.72	0.72	194	1	0.72	Std. Inlet	15					0.50	6.5	21.5	96.8	1.1	1.1	**1.1**
D2	14.6	397	0.034	20.5	0.59	0.63	591	1	0.63							0.50	13.2	34.7	75.3	2.7	1.6	**2.7**
E1	8.4	150	0.018	8.4	0.79	0.79	150	1	0.79	Std. Inlet	15					0.50	5.0	20.0	100.1	1.8	1.8	**1.8**
E2	16.2	508	0.018	38.2	0.61	0.68	658	1	0.68							0.50	16.9	36.9	72.7	5.3	3.4	**5.3**
E3	13.9	368	0.024	52.1	0.68	0.68	1026	1	0.68							0.50	12.3	49.2	61.3	6.1	0.8	**6.1**
E4	26.0	948	0.015	78.1	0.48	0.62	1974	1	0.62							0.50	31.6	80.8	44.2	5.9	-0.1	**6.1**
ED1	7.3	122	0.024	7.3	0.72	0.72	122	1	0.72	Std. Inlet	15					0.50	4.1	19.1	102.4	1.5	1.5	**1.5**
ED2	6.3	170	0.024	13.6	0.69	0.71	292	1	0.71							0.50	5.7	24.7	90.2	2.4	0.9	**2.4**
F1	18.3	320	0.018	18.3	0.46	0.46	320	1	0.46	overland		0.045	82.5	0.018	18.7	0.50	10.7	29.4	82.5	1.9	1.9	**1.9**
F2	28.7	855	0.016	97.3	0.62	0.55	1175	1	0.55							0.50	28.5	57.9	55.2	8.2	6.3	**8.2**
F3	17.8	524	0.018	190.8	0.72	0.55	1699	1	0.55							0.50	17.5	75.3	46.2	13.5	5.3	**13.5**
F4	23.5	723	0.015	214.3	0.47	0.54	2422	1	0.54							0.50	24.1	99.4	38.1	12.3	-1.2	**13.5**
F5	21.7	612	0.010	235.9	0.46	0.53	3034	1	0.53							0.50	20.4	119.8	33.0	11.6	-0.7	**13.5**
G1	20.3	286	0.024	20.3	0.46	0.46	286	1	0.46	overland		0.045	76.3	0.024	17.2	0.50	9.5	26.7	86.8	2.3	2.3	**2.3**
G2	29.9	561	0.015	50.2	0.59	0.54	847	1	0.54							0.50	18.7	45.4	64.4	4.8	2.6	**4.8**
H1	26.4	493	0.025	26.4	0.46	0.46	493	1	0.46	overland		0.045	75.3	0.025	16.9	0.50	16.4	33.4	77.0	2.6	2.6	**2.6**
H2	40.3	1150	0.013	66.8	0.56	0.52	1643	1	0.52							0.50	38.3	71.7	48.0	4.7	2.0	**4.7**
HH1	23.1	233	0.013	23.1	0.46	0.46	233	1	0.46	overland		0.045	86.8	0.013	20.1	0.50	7.8	27.9	84.8	2.5	2.5	**2.5**
HY1	10.2	190	0.013	10.2	0.46	0.46	190	1	0.46	overland		0.045	86.8	0.013	20.1	0.50	6.3	26.5	87.2	1.1	1.1	**1.1**
I1	199.0	1990	0.010	199.0	0.46	0.46	1990	1	0.46	overland		0.045	90.5	0.010	21.8	0.50	66.3	88.1	41.5	10.5	10.5	**10.5**
I2	84.0	480	0.010	283.0	0.46	0.46	2470	1	0.46							0.50	16.0	104.1	36.7	13.3	2.7	**13.3**
I3	32.9	470	0.010	553.0	0.46	0.46	2940	1	0.46							0.50	15.7	119.8	33.0	23.4	10.1	**23.4**
I4	58.4	760	0.005	611.4	0.46	0.46	3700	1	0.46							0.50	25.3	145.1	28.6	22.3	-1.0	**23.4**
IC1	16.4	470	0.005	16.4	0.46	0.46	470	1	0.46	overland		0.045	95.5	0.005	25.8	0.50	15.7	41.4	68.0	1.4	1.4	**1.4**
IC2	29.0	485	0.005	45.4	0.46	0.46	955	1	0.46							0.50	16.2	57.6	55.4	3.2	1.8	**3.2**
J1	191.7	2170	0.012	191.7	0.46	0.46	2170	1	0.46	overland		0.045	88.5	0.012	20.8	0.50	72.3	93.2	39.9	9.8	9.8	**9.8**
K1	39.3	1537	0.012	39.3	0.48	0.48	1537	1	0.48	overland		0.045	88.4	0.012	20.8	0.50	51.2	72.0	47.9	2.5	2.5	**2.5**
Y1	26.4	775	0.019	26.4	0.46	0.46	775	1	0.46	overland		0.045	80.7	0.019	18.2	0.50	25.8	44.1	65.6	2.2	2.2	**2.2**
Y2	23.5	215	0.019	49.9	0.46	0.46	990	1	0.46							0.50	7.2	51.2	59.7	3.8	1.6	**3.8**
YH1	9.0	263	0.015	9.0	0.46	0.46	263	1	0.46	overland		0.045	85.5	0.015	19.7	0.50	8.8	28.4	84.0	1.0	1.0	**1.0**
Z1	381.7	3125	0.008	381.7	0.46	0.46	3125	1	0.46	overland		0.045	92.3	0.008	22.9	0.50	104.2	127.1	31.7	15.5	15.5	**15.5**

Table C.3 1 in 10 AEP Wandoan Stormwater Modelling - Model Parameters and Results

Catchment ID	Area (ha)	Stream Length (m)	Slope (m/m)	Total Upstream Area (ha)	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length (m)	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time (mins)	Overland Flow: Mannings n	Overland Flow: Length (m)	Overland Flow: Slope (m/m)	Overland Flow: Overland flow travel time (mins)	Channel Velocity (m/s)	Tc Channel (mins)	Total Tc (min)	Rainfall Intensity (mm/hr)	Discharge (m³/s)	Difference (m³/s)	Corrected Discharge (for partial area effect) (m³/s)
ZA1	69.6	936	0.008	69.6	0.46	0.46	936	1	0.46	overland		0.045	92.3	0.008	22.9	0.50	31.2	54.1	57.7	5.1	5.1	**5.1**
ZA2	35.6	730	0.008	105.2	0.46	0.46	1666	1	0.46							0.50	24.3	78.4	45.1	6.1	0.9	**6.1**
ZA3	19.8	632	0.008	125.0	0.46	0.46	2298	1	0.46							0.50	21.1	99.5	38.0	6.1	0.0	**6.1**
ZA4	21.1	616	0.008	156.7	0.46	0.46	2914	1	0.46							0.50	20.5	120.0	33.0	6.6	0.5	**6.6**
ZZ1	10.7	550	0.008	10.7	0.46	0.46	550	1	0.46	overland		0.045	92.3	0.008	22.9	0.50	18.3	41.2	68.2	0.9	0.9	**0.9**

APPENDIX D TARA STORMWATER MODELLING – RATIONAL METHOD PARAMETERS AND RESULTS

Table D.1 1 in 100 AEP Tara Stormwater Modelling - Model Parameters and Results

												Overland Flow										
Catchment ID	Area	Stream Length	Slope	Total Upstream Area	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time	Mannings n	Length	Slope	Overland flow travel time	Channel Velocity	Tc Channel	Total Tc	Rainfall Intensity	Discharge	Difference	Corrected Discharge (for partial area effect)
	(ha)	(m)	(m/m)	(ha)			(m)				(mins)		(m)	(m/m)	(mins)	(m/s)	(mins)	(min)	(mm/hr)	(m^3/s)	(m^3/s)	(m^3/s)
A1	57.4	670	0.002	57.4	0.47	0.47	670	1.2	0.57	overland		0.045	98.5	0.002	32.4	0.50	22.3	54.8	78.0	7.0	7.0	**7.0**
A2	5.4	373	0.003	62.8	0.39	0.47	1043	1.2	0.56							0.50	12.4	67.2	68.6	6.7	-0.4	**7.0**
B1	4.1	100	0.006	4.1	0.76	0.76	100	1.2	0.91	Std. Inlet	15					0.50	3.3	18.3	145.9	1.5	1.5	**1.5**
C1	30.2	850	0.003	30.2	0.71	0.71	850	1.2	0.85	overland		0.045	97	0.003	28.1	0.50	28.3	56.4	76.6	5.4	5.4	**5.4**
C2	6.0	304	0.001	36.2	0.70	0.70	1154	1.2	0.85							0.50	10.1	66.6	69.1	5.9	0.4	**5.9**
D1	21.8	430	0.002	21.8	0.76	0.76	430	1.2	0.92	Std. Inlet	15					0.50	14.3	29.3	113.6	6.3	6.3	**6.3**
D2	9.2	365	0.002	31.0	0.68	0.74	795	1.2	0.89							0.50	12.2	41.5	92.9	7.1	0.8	**7.1**
E1	25.5	1270	0.002	25.5	0.39	0.39	1270	1.2	0.47	overland		0.045	98.2	0.002	31.3	0.50	42.3	73.6	64.3	2.1	2.1	**2.1**
E2	6.0	516	0.008	31.5	0.39	0.39	1786	1.2	0.47							0.50	17.2	90.8	55.6	2.3	0.1	**2.3**
E3	102.7	710	0.004	226.6	0.39	0.39	2496	1.2	0.47							0.50	23.7	114.5	47.3	13.9	11.7	**13.9**
F1	15.3	368	0.007	15.3	0.66	0.66	368	1.2	0.79	Std. Inlet	15					0.50	12.3	27.3	118.3	4.0	4.0	**4.0**
FH1	13.1	639	0.003	13.1	0.66	0.66	639	1.2	0.79	Std. Inlet	15					0.50	21.3	36.3	100.5	2.9	2.9	**2.9**
H1	9.4	661	0.003	9.4	0.70	0.70	661	1.2	0.85	Std. Inlet	15					0.50	22.0	37.0	99.4	2.2	2.2	**2.2**
I1	33.0	590	0.003	33.0	0.51	0.51	590	1.2	0.61	Std. Inlet	15					0.50	19.7	34.7	103.3	5.7	5.7	**5.7**
JH1	92.4	1970	0.002	92.4	0.39	0.39	1970	1.2	0.47	overland		0.045	97.6	0.002	29.4	0.50	65.7	95.1	54.0	6.5	6.5	**6.5**
j1	38.5	987	0.004	38.5	0.39	0.39	987	1.2	0.47	overland		0.045	96	0.004	26.4	0.50	32.9	59.3	74.1	3.7	3.7	**3.7**
K1	217.5	2115	0.002	217.5	0.39	0.39	2115	1.2	0.47	overland		0.045	97.6	0.002	29.4	0.50	70.5	99.9	52.1	14.7	14.7	**14.7**
K2	11.6	720	0.002	229.0	0.39	0.39	2835	1.2	0.47							0.50	24.0	123.9	44.6	13.3	-1.4	**14.7**
K3	94.3	610	0.002	323.3	0.39	0.39	3445	1.2	0.47							0.50	20.3	144.3	40.0	16.8	3.5	**16.8**
L1	59.6	1610	0.000	59.6	0.39	0.39	1610	1.2	0.47	overland		0.045	99.99	0.000	88.8	0.50	53.7	142.5	40.3	3.1	3.1	**3.1**
M1	16.7	1026	0.004	16.7	0.39	0.39	1026	1.2	0.47	overland		0.045	95.9	0.004	26.3	0.50	34.2	60.5	73.2	1.6	1.6	**1.6**
N1	7.8	225	0.004	7.8	0.69	0.69	225	1.2	0.82	Std. Inlet	15					0.50	7.5	22.5	131.3	2.3	2.3	**2.3**
O1	10.3	458	0.003	10.3	0.70	0.70	458	1.2	0.84	Std. Inlet	15					0.50	15.3	30.3	111.6	2.7	2.7	**2.7**

Table D.2 1 in 50 AEP Tara Stormwater Modelling - Model Parameters and Results

Catchment ID	Area	Stream Length	Slope	Total Upstream Area	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time	Overland Flow: Mannings n	Overland Flow: Length	Overland Flow: Slope	Overland Flow: Overland flow travel time	Channel Velocity	Tc Channel	Total Tc	Rainfall Intensity	Discharge	Difference	Corrected Discharge (for partial area effect)
	(ha)	(m)	(m/m)	(ha)			(m)				(mins)		(m)	(m/m)	(mins)	(m/s)	(mins)	(min)	(mm/hr)	(m^3/s)	(m^3/s)	(m^3/s)
A1	57.4	670	0.002	57.4	0.47	0.47	670	1.15	0.54	overland		0.045	98.5	0.002	32.4	0.50	22.3	54.8	70.2	6.1	6.1	**6.1**
A2	5.4	373	0.003	62.8	0.39	0.47	1043	1.15	0.53							0.50	12.4	67.2	61.8	5.8	-0.3	**6.1**
B1	4.1	100	0.006	4.1	0.76	0.76	100	1.15	0.88	Std. Inlet	15					0.50	3.3	18.3	130.8	1.3	1.3	**1.3**
C1	30.2	850	0.003	30.2	0.71	0.71	850	1.15	0.81	overland		0.045	97	0.003	28.1	0.50	28.3	56.4	68.9	4.7	4.7	**4.7**
C2	6.0	304	0.001	36.2	0.70	0.70	1154	1.15	0.81							0.50	10.1	66.6	62.2	5.1	0.4	**5.1**
D1	21.8	430	0.002	21.8	0.76	0.76	430	1.15	0.88	Std. Inlet	15					0.50	14.3	29.3	102.1	5.4	5.4	**5.4**
D2	9.2	365	0.002	31.0	0.68	0.74	795	1.15	0.85							0.50	12.2	41.5	83.6	6.1	0.7	**6.1**
E1	25.5	1270	0.002	25.5	0.39	0.39	1270	1.15	0.45	overland		0.045	98.2	0.002	31.3	0.50	42.3	73.6	57.9	1.8	1.8	**1.8**
E2	6.0	516	0.008	31.5	0.39	0.39	1786	1.15	0.45							0.50	17.2	90.8	50.0	2.0	0.1	**2.0**
E3	102.7	710	0.004	226.6	0.39	0.39	2496	1.15	0.45							0.50	23.7	114.5	42.5	12.0	10.0	**12.0**
F1	15.3	368	0.007	15.3	0.66	0.66	368	1.15	0.76	Std. Inlet	15					0.50	12.3	27.3	106.3	3.4	3.4	**3.4**
FH1	13.1	639	0.003	13.1	0.66	0.66	639	1.15	0.75	Std. Inlet	15					0.50	21.3	36.3	90.4	2.5	2.5	**2.5**
H1	9.4	661	0.003	9.4	0.70	0.70	661	1.15	0.81	Std. Inlet	15					0.50	22.0	37.0	89.4	1.9	1.9	**1.9**
I1	33.0	590	0.003	33.0	0.51	0.51	590	1.15	0.58	Std. Inlet	15					0.50	19.7	34.7	92.9	5.0	5.0	**5.0**
JH1	92.4	1970	0.002	92.4	0.39	0.39	1970	1.15	0.45	overland		0.045	97.6	0.002	29.4	0.50	65.7	95.1	48.5	5.6	5.6	**5.6**
j1	38.5	987	0.004	38.5	0.39	0.39	987	1.15	0.45	overland		0.045	96	0.004	26.4	0.50	32.9	59.3	66.7	3.2	3.2	**3.2**
K1	217.5	2115	0.002	217.5	0.39	0.39	2115	1.15	0.45	overland		0.045	97.6	0.002	29.4	0.50	70.5	99.9	46.9	12.7	12.7	**12.7**
K2	11.6	720	0.002	229.0	0.39	0.39	2835	1.15	0.45							0.50	24.0	123.9	40.1	11.4	-1.3	**12.7**
K3	94.3	610	0.002	323.3	0.39	0.39	3445	1.15	0.45							0.50	20.3	144.3	35.9	14.4	3.0	**14.4**
L1	59.6	1610	0.000	59.6	0.39	0.39	1610	1.15	0.45	overland		0.045	99.99	0.000	88.8	0.50	53.7	142.5	36.2	2.7	2.7	**2.7**
M1	16.7	1026	0.004	16.7	0.39	0.39	1026	1.15	0.45	overland		0.045	95.9	0.004	26.3	0.50	34.2	60.5	65.9	1.4	1.4	**1.4**
N1	7.8	225	0.004	7.8	0.69	0.69	225	1.15	0.79	Std. Inlet	15					0.50	7.5	22.5	117.8	2.0	2.0	**2.0**
O1	10.3	458	0.003	10.3	0.70	0.70	458	1.15	0.81	Std. Inlet	15					0.50	15.3	30.3	100.4	2.3	2.3	**2.3**

Table D.3 1 in 10 AEP Tara Stormwater Modelling - Model Parameters and Results

												Overland Flow										
Catchment ID	Area	Stream Length	Slope	Total Upstream Area	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time	Mannings n	Length	Slope	Overland flow travel time	Channel Velocity	Tc Channel	Total Tc	Rainfall Intensity	Discharge	Difference	Corrected Discharge (for partial area effect)
	(ha)	(m)	(m/m)	(ha)			(m)				(mins)		(m)	(m/m)	(mins)	(m/s)	(mins)	(min)	(mm/hr)	(m^3/s)	(m^3/s)	(m^3/s)
A1	57.4	670	0.002	57.4	0.47	0.47	670	1	0.47	overland		0.045	98.5	0.002	32.4	0.50	22.3	54.8	52.8	4.0	4.0	**4.0**
A2	5.4	373	0.003	62.8	0.39	0.47	1043	1	0.47							0.50	12.4	67.2	46.4	3.8	-0.2	**4.0**
B1	4.1	100	0.006	4.1	0.76	0.76	100	1	0.76	Std. Inlet	15					0.50	3.3	18.3	97.3	0.8	0.8	**0.8**
C1	30.2	850	0.003	30.2	0.71	0.71	850	1	0.71	overland		0.045	97	0.003	28.1	0.50	28.3	56.4	51.8	3.1	3.1	**3.1**
C2	6.0	304	0.001	36.2	0.70	0.70	1154	1	0.70							0.50	10.1	66.6	46.7	3.3	0.2	**3.3**
D1	21.8	430	0.002	21.8	0.76	0.76	430	1	0.76	Std. Inlet	15					0.50	14.3	29.3	76.5	3.5	3.5	**3.5**
D2	9.2	365	0.002	31.0	0.68	0.74	795	1	0.74							0.50	12.2	41.5	62.8	4.0	0.5	**4.0**
E1	25.5	1270	0.002	25.5	0.39	0.39	1270	1	0.39	overland		0.045	98.2	0.002	31.3	0.50	42.3	73.6	43.5	1.2	1.2	**1.2**
E2	6.0	516	0.008	31.5	0.39	0.39	1786	1	0.39							0.50	17.2	90.8	37.5	1.3	0.1	**1.3**
E3	102.7	710	0.004	226.6	0.39	0.39	2496	1	0.39							0.50	23.7	114.5	31.8	7.8	6.5	**7.8**
F1	15.3	368	0.007	15.3	0.66	0.66	368	1	0.66	Std. Inlet	15					0.50	12.3	27.3	79.6	2.2	2.2	**2.2**
FH1	13.1	639	0.003	13.1	0.66	0.66	639	1	0.66	Std. Inlet	15					0.50	21.3	36.3	67.9	1.6	1.6	**1.6**
H1	9.4	661	0.003	9.4	0.70	0.70	661	1	0.70	Std. Inlet	15					0.50	22.0	37.0	67.1	1.2	1.2	**1.2**
I1	33.0	590	0.003	33.0	0.51	0.51	590	1	0.51	Std. Inlet	15					0.50	19.7	34.7	69.7	3.2	3.2	**3.2**
JH1	92.4	1970	0.002	92.4	0.39	0.39	1970	1	0.39	overland		0.045	97.6	0.002	29.4	0.50	65.7	95.1	36.4	3.6	3.6	**3.6**
j1	38.5	987	0.004	38.5	0.39	0.39	987	1	0.39	overland		0.045	96	0.004	26.4	0.50	32.9	59.3	50.1	2.1	2.1	**2.1**
K1	217.5	2115	0.002	217.5	0.39	0.39	2115	1	0.39	overland		0.045	97.6	0.002	29.4	0.50	70.5	99.9	35.1	8.3	8.3	**8.3**
K2	11.6	720	0.002	229.0	0.39	0.39	2835	1	0.39							0.50	24.0	123.9	29.9	7.4	-0.8	**8.3**
K3	94.3	610	0.002	323.3	0.39	0.39	3445	1	0.39							0.50	20.3	144.3	26.7	9.4	1.9	**9.4**
L1	59.6	1610	0.000	59.6	0.39	0.39	1610	1	0.39	overland		0.045	99.99	0.000	88.8	0.50	53.7	142.5	27.0	1.7	1.7	**1.7**
M1	16.7	1026	0.004	16.7	0.39	0.39	1026	1	0.39	overland		0.045	95.9	0.004	26.3	0.50	34.2	60.5	49.5	0.9	0.9	**0.9**
N1	7.8	225	0.004	7.8	0.69	0.69	225	1	0.69	Std. Inlet	15					0.50	7.5	22.5	88.0	1.3	1.3	**1.3**
O1	10.3	458	0.003	10.3	0.70	0.70	458	1	0.70	Std. Inlet	15					0.50	15.3	30.3	75.2	1.5	1.5	**1.5**

APPENDIX E STORMWATER HYDRAULIC MODEL CATCHMENTS AND RUN SEQUENCE DETAILS

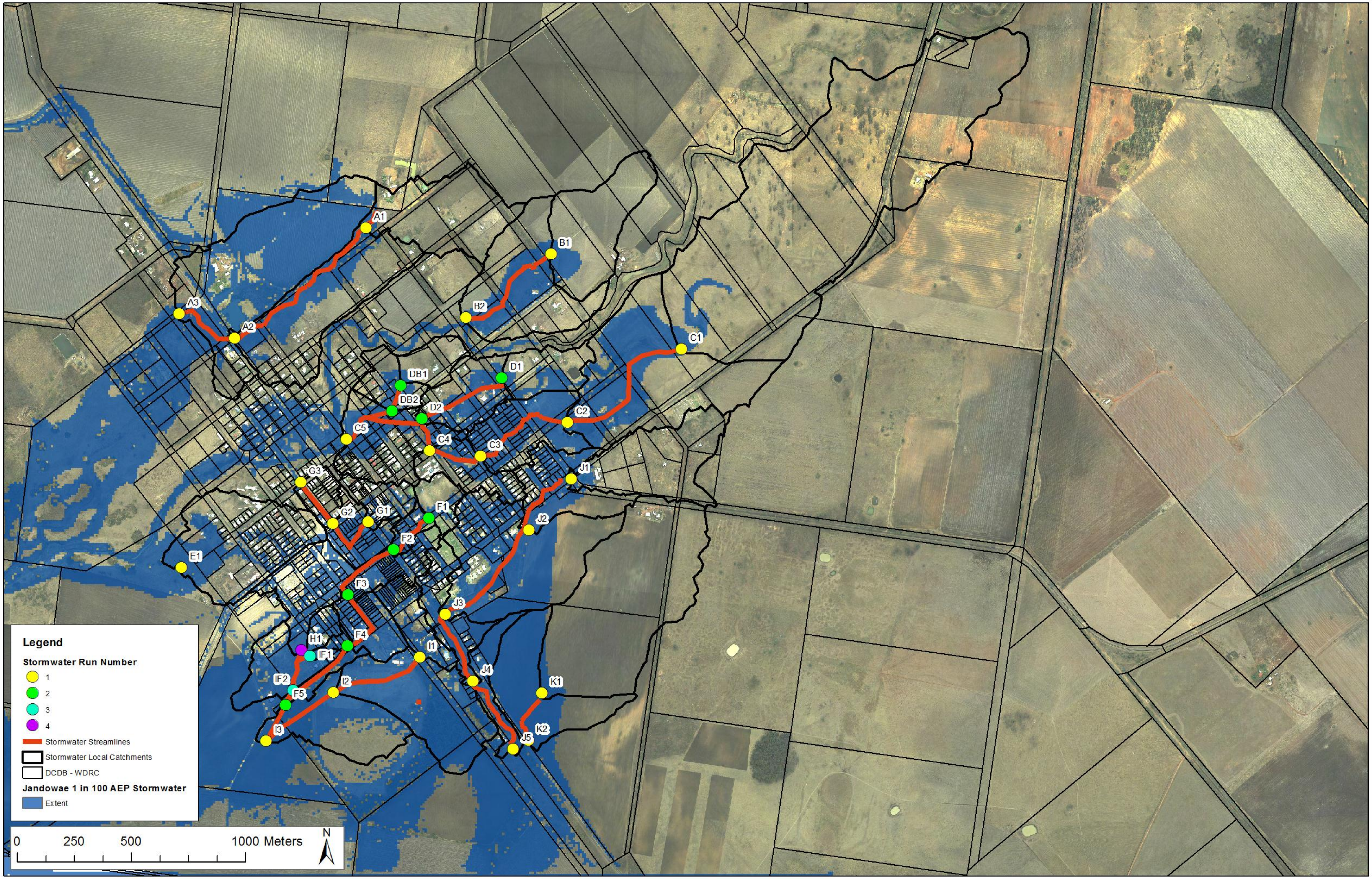

Figure E.1 Jandowae 1 in 100 AEP Stormwater Flood Extent – Stormwater Catchments and Nodes

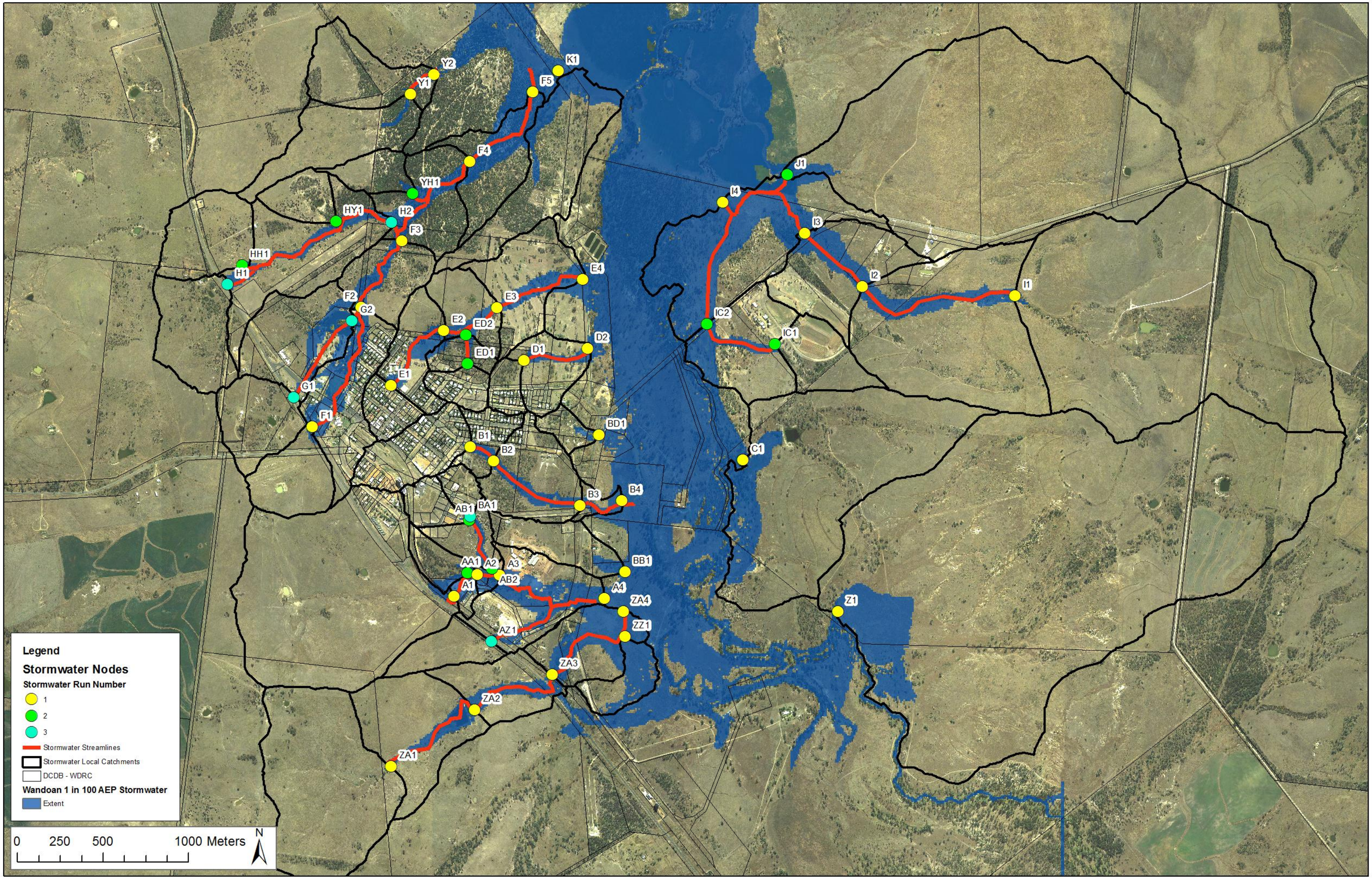

Figure E.2 Wandoan 1 in 100 AEP Stormwater Flood Extent – Stormwater Catchments and Nodes

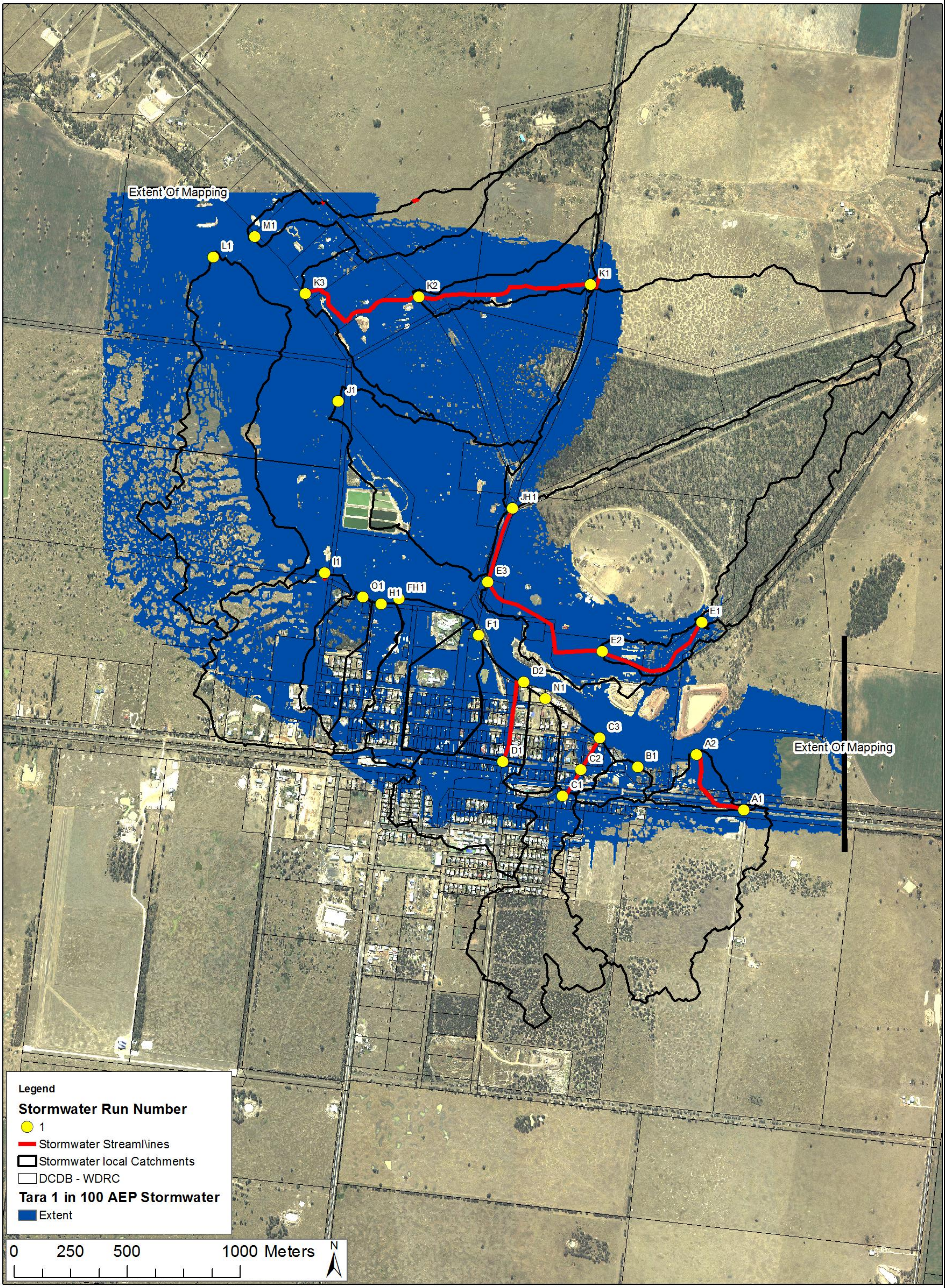

Figure E.3 Tara 1 in 100 AEP Stormwater Flood Extent – Stormwater Catchments and Nodes