WESTERN DOWNS REGIONAL COUNCIL

Chinchilla Flood Study
Volume I
Detailed Technical Report

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Executive Summary

Background

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

The Chinchilla 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 are able to 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; e.g. the 1942 flood).

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 Chinchilla Flood Study

As this is the first substantial flood study for Chinchilla, 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 Chinchilla, which has been a vital component of this study and will continue to be a valuable resource for the Chinchilla community 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 Chinchilla Flood Study report was submitted in November 2012. Since then a significant amount of additional work has been undertaken including:

- Extensive community consultation and additional data gathering which resulted in a significantly longer gauge record being identified. Previously, the earliest gauge record available was in 1969 whereas the gauge record now extends back to the 1893 event,

- A revised Flood Frequency Analysis using the latest available techniques (as currently being developed through the revision of Australian Rainfall and Runoff) was undertaken on the extended gauge record.

Through these additional investigations, an increased level of confidence in flood magnitude at Chinchilla has been gained, and the design flood levels (including 1 in 100 AEP level) have been revised. The revised 1 in 100 AEP discharge estimate is approximately 50% lower than the Nov 2012 discharge estimate.

The significant decrease in the design flows has resulted in a corresponding decrease in design levels for Charleys Creek through Chinchilla.

Chinchilla Flood Study – Lessons Learned

The Chinchilla Flood Study has provided an increased understanding of floods and flood hazard for Chinchilla. Specific lessons learned include:

- There is substantial flood hazard in and around the lower parts of the town adjacent to Charley's Creek (due to the depth of water). In most locations this flood hazard decreases relatively quickly with increasing terrain elevation,
- There has been a substantial amount of development in and around Chinchilla over recent decades. However, as this development has generally occurred on the town fringes, outside of the floodplain, it has not had a substantial impact on (and is not significantly exposed to) flood risk.
- While the areas where there is ongoing development pressure in Chinchilla (the town fringes) are at relatively low (Charley's Creek) flood risk, WDRC need to ensure appropriate management (through the Planning Scheme) of stormwater flooding.

Outcomes of the Chinchilla Flood Study

Outcomes of the Chinchilla Flood Study that will have direct benefit to the Chinchilla community include a series of maps detailing flood hazard for:

- Charley's Creek floods, and
- Local stormwater floods.

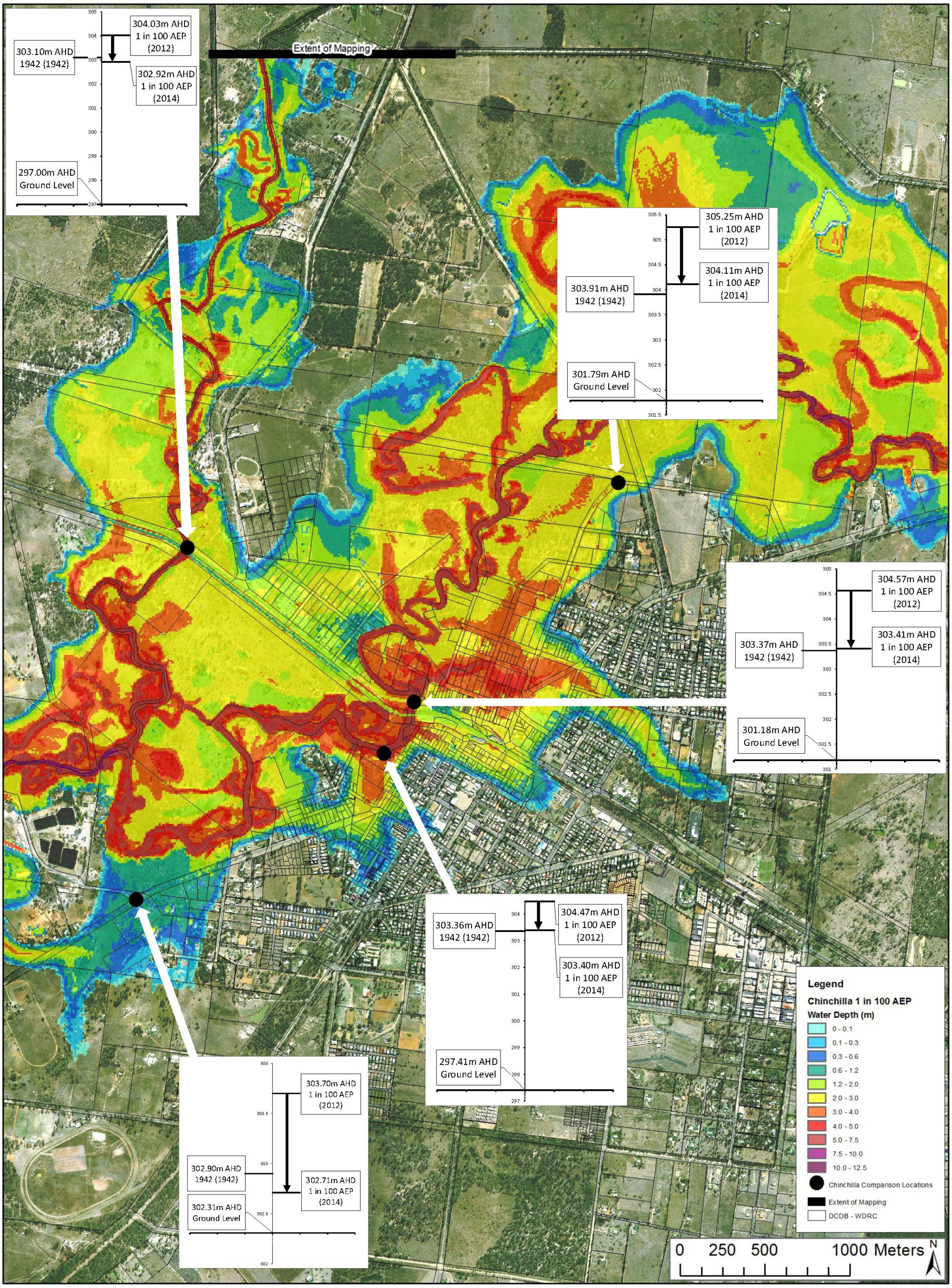
The maps will be an invaluable tool to ensure appropriate development that provides a suitable level of safety while not adversely impacting on existing properties or residents (e.g. by blocking of overland flowpaths and/or redirecting stormwater onto nearby properties).

Other outcomes of the study include a consolidated set of historic flood data that will be of ongoing value to the community and detailed survey information for the town.

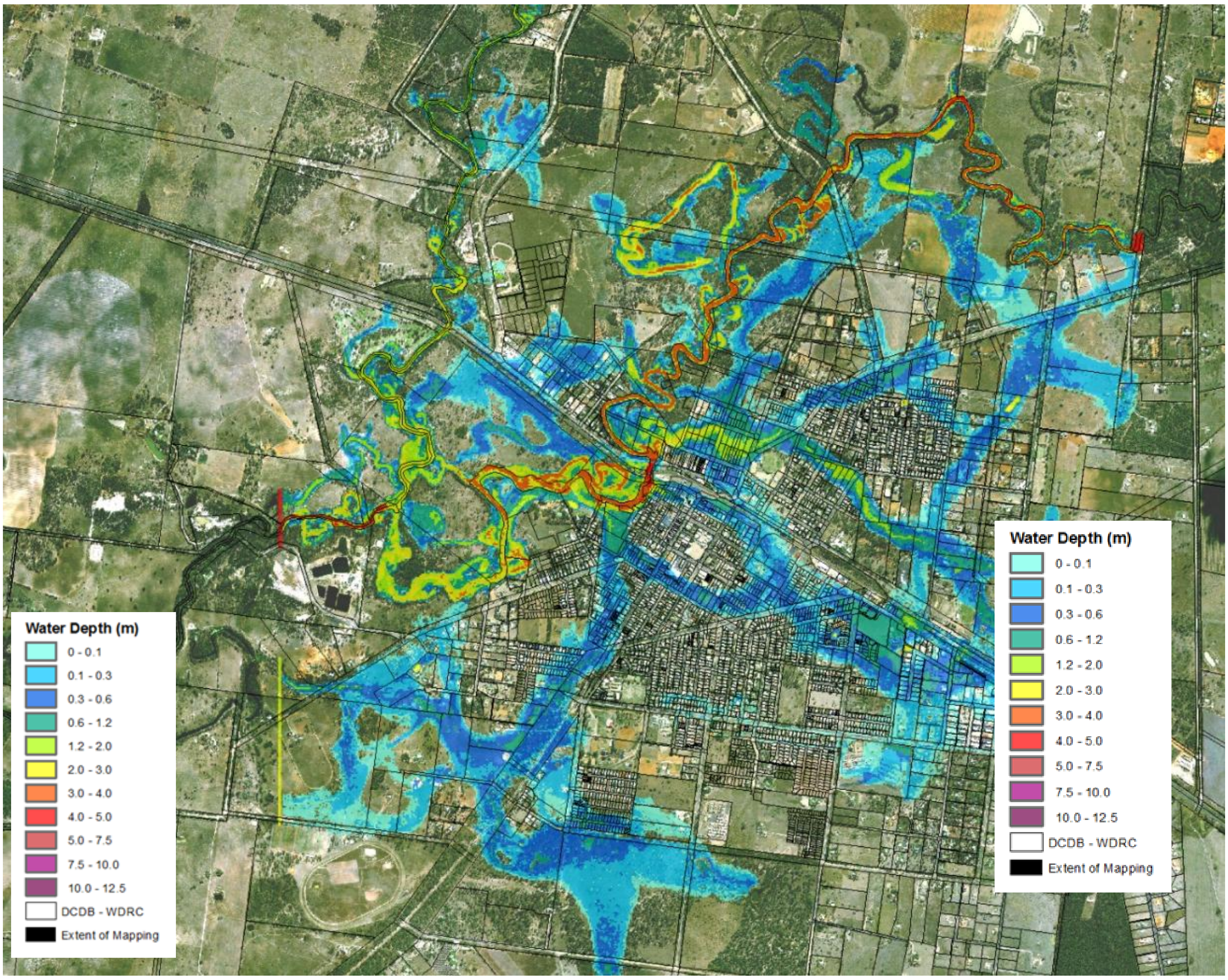
Report Format

For convenience, this report consists of two volumes:

- Volume I: Chinchilla Flood Study Detailed Technical Report (this document).
- Volume II: Chinchilla Flood Study Maps.



Chinchilla 1 in 100 AEP Riverine Flood



Chinchilla 1 in 100 AEP Stormwater Flood

Acknowledgements

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

- The residents of Chinchilla (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% 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 is 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 Chinchilla. This report consists of two volumes:

- Volume I: Chinchilla Flood Study Detailed Technical Report (this document).
- Volume II: Chinchilla Flood Study Maps.

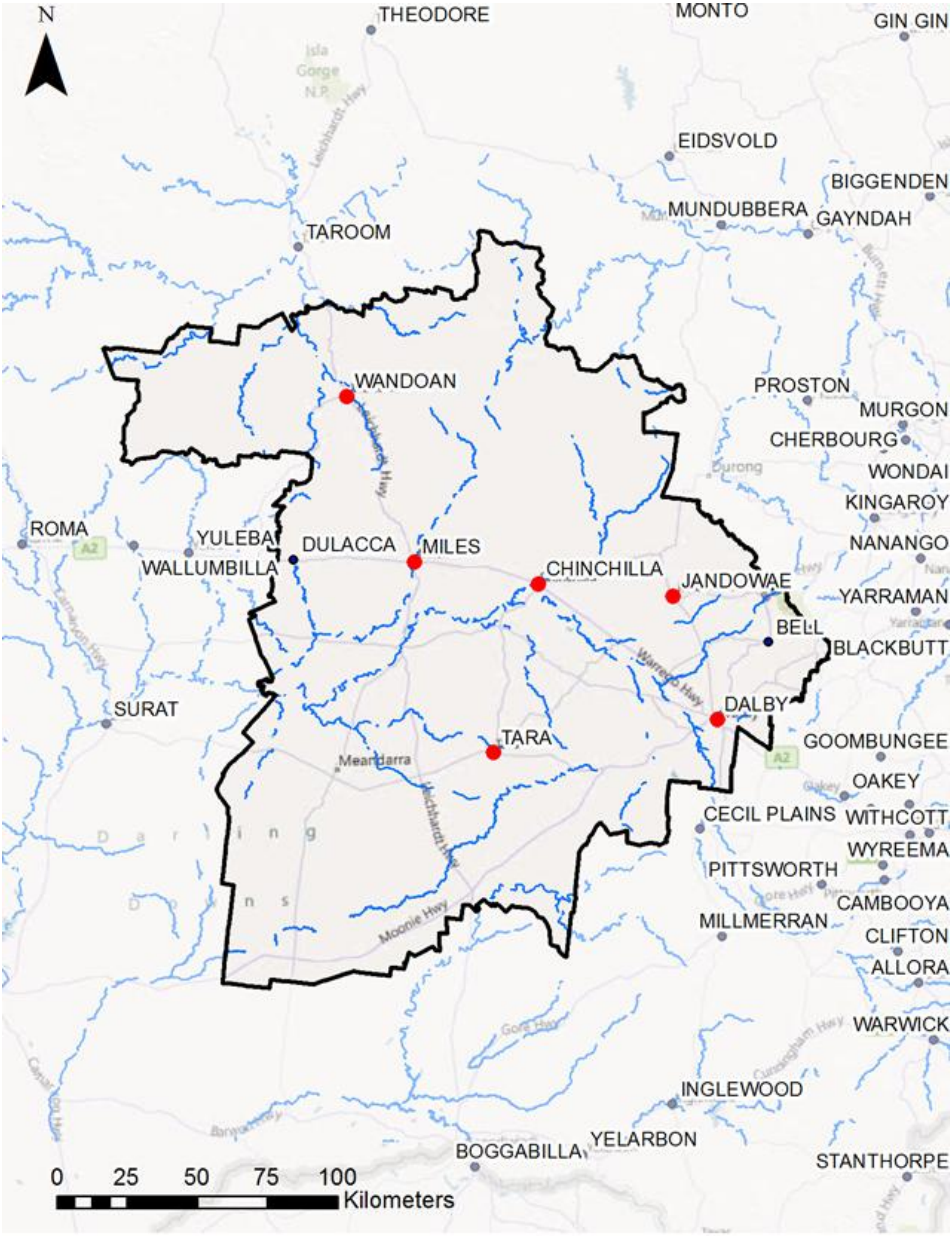

Figure 1.1 Western Downs Regional Council Area

(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

No previous investigations (in the form of formal flood studies) were available for Chinchilla.

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.
- Ground survey of the Gil Weir area on Dogwood Creek was undertaken by WDRC in 2010 to extend the LIDAR data extent for hydraulic modelling of the weir to develop a new weir rating curve.
- Topographic data with a resolution of 3 arc seconds was used to estimate the catchments for the riverine flood studies.

2.3 Hydrometeorological 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.

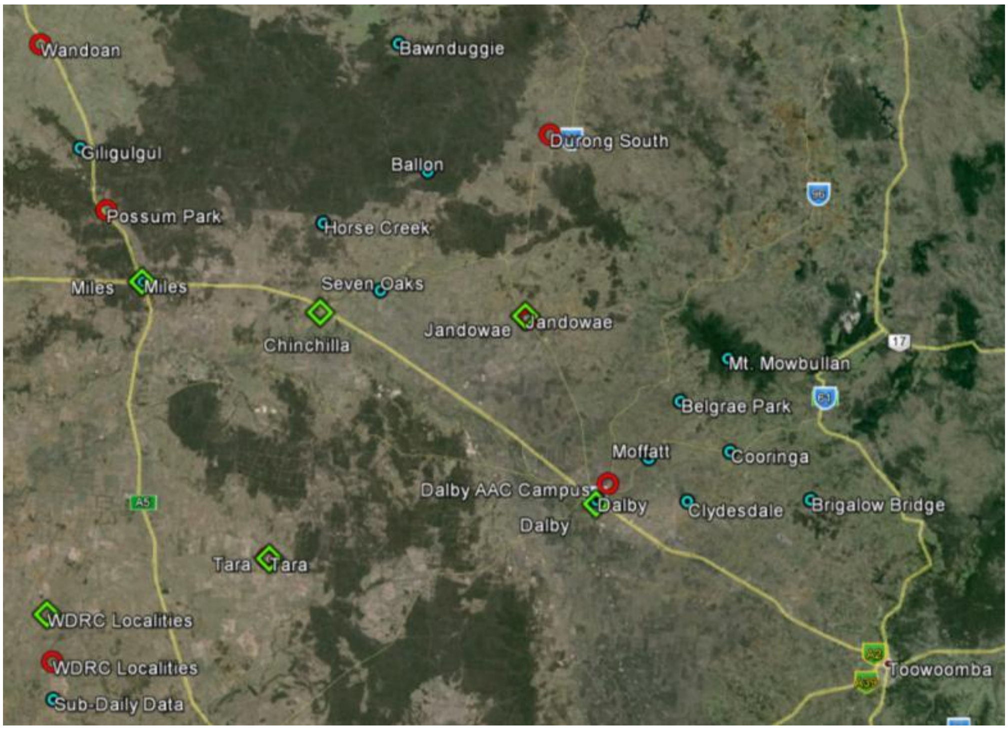

Figure 2.1 Available Rainfall Gauging Stations

(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

Table 2.2 presents the available stream gauge records for Charley's and Dogwood Creek. Figure 2.2 shows the location of the available stream gauging stations for Charley's and Dogwood Creek.

Table 2.2 Available Stream Gauging Stations

Station		Period of Record	Comments
Name	Number		
Charley's Creek @ STP Telemetry Gauge [1]	422343A (DERM)	19/9/2002 – present	Upstream of Weir near the Chinchilla Sewerage Treatment Plant (STP).
Charley's Creek @ Middle St	041411 (BoM) 422343A (DERM)	1/12/1969 – present	Manual Gauge
Charley's Creek @ Railway Bridge	041351 (BoM)	1943 – 1984	Manual Gauge
Charley's Creek @ Warrego Hwy	n/a	n/a	No gauge boards. Sometimes used as flood level reference.
Charley's Creek @ Seven Oaks	041020 (BoM)	18/5/1999 - present	Water level only – not rated
Dogwood Creek @ Gil Weir [2]	042107 (BoM) 422202B (DERM)	10/1/1949 – present	Upstream of Gil Weir
Dogwood Creek @ Warrego Highway	042049 (BoM)	9/2/1918 – present	- Dogwood Creek Bridge, Warrego Highway - Peak flood level only

Notes:

1) The correct place name is "Charley's Creek". However, DERM have adopted the gauge name "Charleys Creek". For clarity and consistency, the name "Charley's Creek" has been adopted in this report for both the place name and gauging station name.
2) The correct place name is "Gil Weir". However, DERM have adopted the gauge name "Dogwood Creek @ Gilweir". For clarity and consistency, the name "Gil Weir" has been adopted in this report for both the place name and gauging station name.

Figure 2.2 Available Stream Gauging Stations –Charley's and Dogwood Creeks

2.3.3 Chinchilla Gauging Stations.

Figure 2.3 shows the location of gauging stations within Chinchilla. There is some confusion in the both the anecdotal and historical records as to where the peak historical flood levels were measured. This is an important distinction as there is a considerable water level gradient between the gauges. For example, there was approximately 0.9m difference between the Middle St gauge and the Telemetry gauge (at the STP) water levels at the peak of the January 2011 flood.

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 Available Historical Flood Data Sets

Flood level data for selected large historical floods in Chinchilla is provided in Table 2.3. The data was sourced from:

- WDRC.
- The Department of Environment and Resource Management (DERM).
- The Bureau of Meteorology (BoM).
- Historical research undertaken as part of this study.
- Modelling results from this study.

Figure 2.3 Chinchilla Stream Gauging Stations

Table 2.3 Chinchilla Historical Floods – Charley's Creek at Middle St Manual Gauge

Date	Gauge Ht [1] (m)	Height (m AHD)	Source
Feb 1893 [2]	>6.81	>302.02	Current Study – based upon historical flood research and hydraulic modelling.
19 Mar 1908	7.61	302.82	
29 Dec 1921	7.72	302.93	
19 Feb 1928	7.68	302.89	
13 Feb 1942	7.81	303.02	
19 Feb 1950	4.5	299.71	Readings from Charley's Creek at Chinchilla Railway Manual Gauge
14 Feb 1954	5.18	300.39	
15 Jul 1954	6.77	301.98	
22 Jan 1956	7.22	302.43	
11 Feb 1956	6.24	301.45	
3 Mar 1961	5.4	300.61	
10 Dec 1970	6.01	301.22	
25 Feb 1971	4.71	299.92	
29 Dec 1971	4.58	299.79	
9 Feb 1981	5.95	301.16	
2 May 1983	6.64	301.85	
26 Mar 1983	4.65	299.86	
23 Nov 1983	4.96	300.17	
28 Jul 1984	5.44	300.65	
1 Feb 1992	4.86	300.07	Gauge Readings from Charley's Creek at Chinchilla Middle St Manual Gauge
1 Jan 1999	5.07	300.28	
10 Jan 2011	7.70	302.91	
1 Jan 2013	6.57	301.79	Gauge Reading from Chinchilla TM Gauge

Notes:

1) All data adjusted to Middle street gauge datum. Gauge No 041351/422915 Chinchilla at Middle St December 1969 to present - datum = 295.21m AHD
2) Estimate only. Exact height unclear.

2.6 Historical Data

Extensive research was undertaken as part of the study to identify and list historical floods for Chinchilla. This research included:

- Extensive research into historical floods based on community experiences.
- Research by the Dalby Family History Society, the Chinchilla Museum and the Miles Museum.
- Research by Council officers.
- Interviews with residents.
- Assessment of changes in land use back to 1920s.

The data collected generally consisted of:

- 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).

Of particular note, the community consultation provided historical levels for a number of extra historical floods.

The data was collated and assessed for accuracy and usefulness to the study. That is, was it possible to identify a flood height taken at the flood peak on a structure that was still present? Topographical survey was undertaken of the identified historical flood marks to provide an estimate of the flood height.

2.6.1 Historical Hydraulic Roughness and Topography Maps

Five historic hydraulic roughness and land use maps were developed to model the range of historical and ultimate land uses in Chinchilla. The five years/levels of development were:

- 1929.
- 1959.
- 1983.
- 2010.
- Ultimate development in accordance with planning scheme zones.

The four years mapped were the only ones with sufficient data available to determine land use (i.e. aerial photographs, survey, cadastre). These historical land use and roughness maps were used in the Chinchilla hydraulic model to simulate historical floods. The ultimate development maps were used to model the design flood levels for planning purposes.

Appendix A and Appendix B contain the Chinchilla historic surface roughness and topography difference maps, respectively.

2.7 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 Chinchilla are presented and discussed further in Section 5.2.

3 FLOOD ANALYSIS APPROACH

3.1 Overview

The flood analysis of Charley's Creek to Chinchilla was undertaken using a combination of hydrologic and hydraulic modelling techniques.

3.2 Hydrologic (Rainfall/Runoff) Analysis

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 for Charley's Creek to Chinchilla.

3.3 Hydraulic (Flow) Analysis

3.3.1 Overview

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 Charley's Creek floodplain through Chinchilla 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.).

3.4 Catchment Area

The adopted catchment area for all discharge estimation was 3,458 km^2. This is the adopted RAFTS model catchment size. The downstream catchment boundary **does not** align with any particular creek location (e.g. a gauging station); the size is a based upon an area of convenience for modelling.

For clarity, this catchment is named the "**RAFTS Catchment**" in this report.

4 JOINT CALIBRATION

4.1 Joint Calibration of the 1942 and 2011 Chinchilla Floods

Joint hydrologic/hydraulic model calibration of the 1942 and 11 January 2011 Chinchilla floods was undertaken. Appendix C shows the hydraulic model calibration results for these floods. The following is of note:

- The 1942 and 2011 flood models used the 1959 and 2010 topography and roughness layers, respectively.
- 1942 flood:
  - The historical rainfall data was too limited to use in the calibration; therefore, design rainfall was used.
  - No hydrograph was available.
  - The calibration points are surveyed levels of anecdotal flood heights from the historical data gathering undertaken as part of this study. Therefore, it is considered there is some error in the flood height data.
  - Some of the comparisons between observed and modelled flood levels show relatively good agreement (e.g. comparisons within ± 0.2m). Other comparisons show significant discrepancies. It is important to note that there is no discernable bias in the comparison between modelled and observed water levels (e.g. majority high or low).
  - Given the data constraints (rainfall and flood level) the calibration is considered to be adequate.
- 2011 flood:
  - The 2011 hydrograph calibration at the Manual Middle Street gauge (BoM #041351) and Chinchilla Weir telemetry gauge (BoM #541074) are shown in Figure 4.1.
  - The flood level data is considered considerably more accurate than that for 1942.
  - The calibration is considered acceptable with most model results being within 0.1m of the observed flood level.

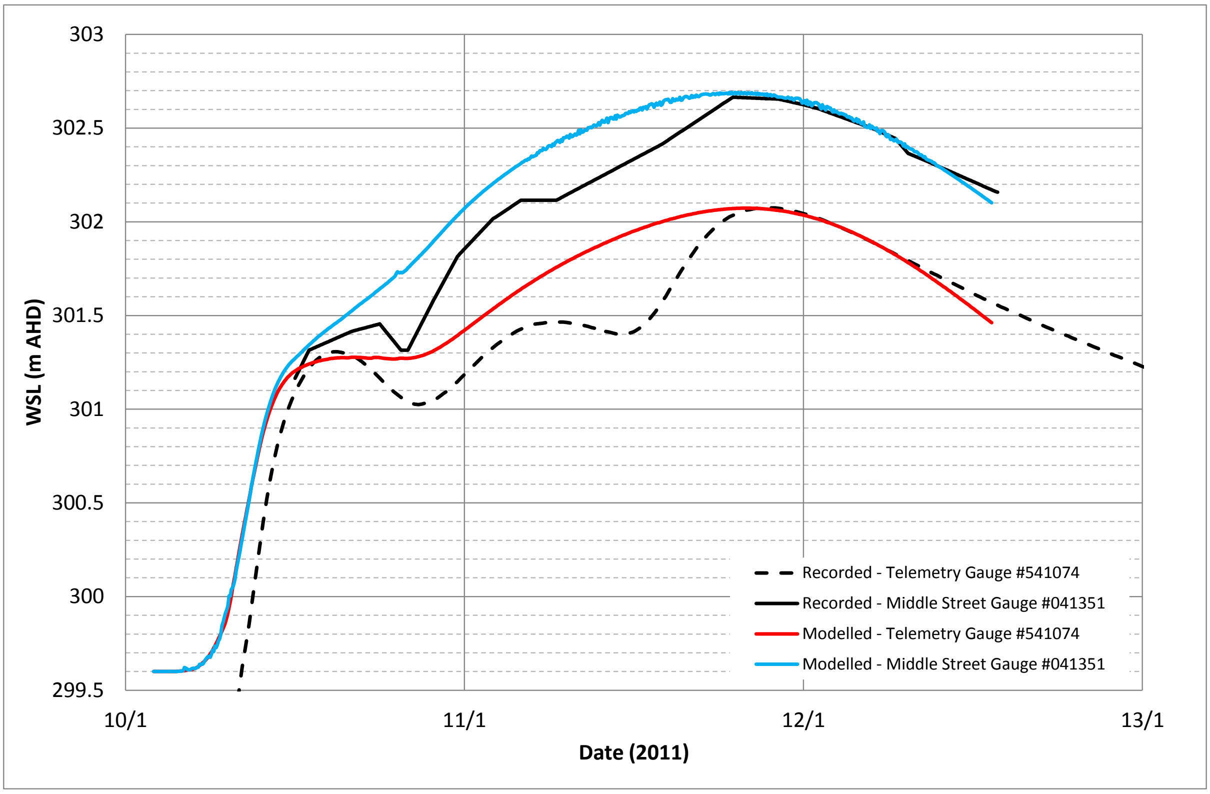

Figure 4.1 Chinchilla 2011 Flood Hydraulic Model Calibration

5 FLOOD HYDROLOGY

5.1 Overview

Uncertainty in flood magnitude estimation is a fundamental problem in flood hydrology. The geography of Charley's Creek at Chinchilla (and the Charley's Creek catchment generally) is hydrologically complex. The hydrological behaviour of the floodplain shows variation in space and time of infiltration characteristics, flowpaths, roughness and storage. Further, the extensive, flat floodplain introduces uncertainty into flow gauging and makes flood discharge estimation a complex task.

Given the uncertainty in discharge estimate, a number of techniques were employed in order to define the range of design events of Charley's Creek at Chinchilla. These techniques included the following methods for determining design event discharges and are discussed in following sections:

- Australian Regional Flood Frequency Analysis (ARFF).
- A Flood Frequency Analysis (FFA) using the FLIKE analysis package.
- The Design Rainfall technique.

5.2 Regional Flood Frequency

5.2.1 Australian Regional Flood Frequency

The regional discharge-area technique provides a way to check flood magnitude estimates. It identifies poor data, non-representative catchments, compares results from different techniques (e.g. design rainfall, ARFF) and provides catchment understanding.

The Australian Regional Flood Frequency (ARFF) Model (Engineers Australia, 2012) was used to estimate Chinchilla flood magnitudes. Note that Engineers Australia (2012) recommends that the ARFF is applicable for catchments with areas between 20 and 1000 km^2. The Charley's Creek catchment to Chinchilla (area 3,458 km^2) is outside this range. Notwithstanding this, the ARFF estimate is useful to provide an estimate to assist with flood magnitude selection. Table 5.1 shows the ARFF flood magnitude estimates for Charley's Creek at Chinchilla.

Table 5.1 ARFF Discharge Estimates for Charley's Creek at Chinchilla (RAFTS Catchment)

AEP (1 in x)	Discharge (m^3/s)
2	270
5	780
10	1260
20	1830
50	2700
100	3430

5.3 Design Rainfall Technique

The design rainfall technique (DRT) was applied to the Charley's Creek catchment (RAFTS Catchment) to provide a peak discharge estimate. The calibrated 2011 flood hydrology and hydraulic models were adopted. Table 5.2 shows the 1 in 100 AEP RAFTS model discharges for a range of initial loss (IL) and continuing loss (CL). The following is of note:

- The calibrated 2011 IL and CL were 16 mm and 3.8 mm/hr, respectively.
- The 1 in 100 AEP design discharge estimate using the 2011 loss parameters was 2,150 m^3/s.
- Changing the CL from 3.8 to 2 mm/hr (a reasonable assumption) results in a peak 1 in 100 AEP discharge of 2,740 m^3/s.
- Different combinations of (reasonable) IL and CL result in 1 in 100 AEP discharge estimates of between (approximately) 1,910 and 3,500 m^3/s.

5.3.1 General Comments on the Design Rainfall Technique

The DRT can be summarised as follows. A rainfall-runoff model is calibrated against one or more historical floods, the principal calibration parameters usually being the rainfall losses. These can vary greatly between calibration events; as much as an order of magnitude in large semi-arid catchments. Design rainfall of a given AEP is then applied to the calibrated model to produce design a discharge of the same AEP. The design rainfall losses are somewhat arbitrarily chosen; based upon the calibrated event losses, "experience" or "ARR recommendations". The resulting design discharge are highly sensitive to these rainfall losses and there is thus significant uncertainty surrounding these design discharge estimates.

5.3.2 Results of the Design Rainfall Technique

The design rainfall technique has considerable limitations; especially when applied to large catchments. Notwithstanding this, the range of DRT discharge estimates do provide a check on results from other flood magnitude estimation techniques. The results of this study indicate that the 1% AEP discharge for Charley's Creek at Chinchilla is between 1,910 and 3,500 m^3/s. This is consistent with other estimation techniques used in this study.

Table 5.2 Chinchilla - Design Rainfall Technique Summary (RAFTS Catchment)

Event	Initial Loss (mm)	Continuing Loss (mm/hr)	Critical Storm Duration (hrs)	Discharge (m^3/s)
2011	16	3.8	9	1270
1% AEP	5	1	72	3500
	5	2	72	2910
	5	3	24	2560
	5	3.8	18	2340
	5	4	18	2310
	5	5	18	2100
	10	1	72	3400
	10	2	36	2850
	10	3	24	2480
	10	3.8	18	2260
	10	4	18	2220
	10	5	18	2010
	16	1	72	3290
	16	2	36	2740
	16	3	24	2370
	16	3.8	18	2150
	16	4	18	2110
	16	5	18	1910
	20	1	72	3220
	20	2	36	2660
	20	3	24	2290
	20	3.8	18	2079
	20	4	18	2035
	20	5	18	1840

5.4 Flood Frequency Analysis

5.4.1 Overview

There is a long history of flooding in Chinchilla with the first known large flood during European settlement occurring in approximately 1893. The recorded flood record however is imprecise, with a manual water level gauge not being installed at Middle Street until 1969 and an automatic telemetry gauge 33 years later in 2002.

While there are a number of stream gauges in the Charley's Creek catchment, none of these is suitable for flood frequency estimation due to one or more of the following reasons:

- The shortness of record.
- The gauge is only a water level gauge used for flood warning. That is, there is no rating upon which to estimate discharges.
- The gauge location is in a flood plain area or there is no detailed survey to use to develop a rating table.

A Flood Frequency Analysis (FFA) was undertaken for Myall Charley's Creek at Chinchilla, based on the available gauge record using the FLIKE Flood Frequency Analysis package. FLIKE is a Flood Frequency Analysis tool that provides a comprehensive Bayesian analysis for a probability model fitted to gauged and censored historic data. Model outputs include probability plots showing data, quantiles and confidence limits, a text file summarising all the input data and results, and plots of the posterior density surface.

The following sections provide an overview of the low flow censored flood frequency analysis of historical floods for Charleys Creek.

5.4.2 Low Flow Censored Flood Frequency Analysis

A low flow censored flood frequency analysis (FFA) was undertaken of the major historical floods in Chinchilla. The following methodology was applied:

- The calibrated 2011 Chinchilla hydrology and hydraulic models were run with a range of discharges for four different historical development scenarios (see Section 2.6.1).
- A rating curve at the Warrego Highway, Middle Street and TM gauges were created for each of the four historical scenarios.
- The rating curves were used to estimate peak discharges (for the RAFTS Catchment) for selected historical floods. The most representative (i.e. nearest in time) development scenario (topography and roughness map) was used.
- A low flow censored flood frequency analysis was undertaken of the adopted discharges using the FLIKE software.

Table 5.3 shows the historic events and discharges adopted for the flood frequency analysis.

5.4.3 Estimation of 1893 Flood Magnitude

Anecdotal evidence indicated that the 1893 flood was possibly the highest flood in Chinchilla since European settlement. However, the available evidence is contradictory and it was not possible to place an estimate on the 1893 flood without wide error bands. Therefore, some sensitivity testing of the impact of the 1893 flood on the FFA was undertaken.

5.4.4 Historic Flows

Historic flows greater than 337 m^3/s were input as gauged flows with the exception of the flow for the 1893 event which was input as a censored flow greater than 1,775 m^3/s. Table 5.4 shows the flow censoring adopted for FLIKE.

Table 5.3 Adopted Flood Record for the Chinchilla Low Flow Censored Flood Frequency Analysis (RAFTS Catchment)

Year	Peak Discharge (m^3/s)
1893	>1,775[1]
1908	1000
1922	1610
1928	640
1942	1,775
1954	710
1956	1,074
1961	150
1971	340
1981	650
1983	780
1984	170
2011	1270
2013	530
2013	200

1. There is uncertainty associated with the discharge estimate for 1893. The most accurate representation for the flood frequency analysis was to characterise the 1893 discharge as greater than 1,775 m^3/s.

Table 5.4 FLIKE Censored Data

Threshold Value (m^3/s)	Ungauged Years > Threshold (years)	Ungauged Years <= Threshold (years)
337	0	107
1,775	1	0

5.4.5 Distribution

A number of distributions were fitted to the data to assess the best fit. The Log-Normal distribution provided the best fit (from range of generally used distributions); however, the fit was still poor (based upon a visual assessment). Figure 5.1 shows the Log-Normal fit to the data.

It was considered that the Log-Normal fit did not adequately represent the data. Therefore, a manual fit was applied (based upon a visual assessment). Table 5.2 shows the adopted FFA. Note that the 1893 flood estimate was not used in the final adopted manual fit.

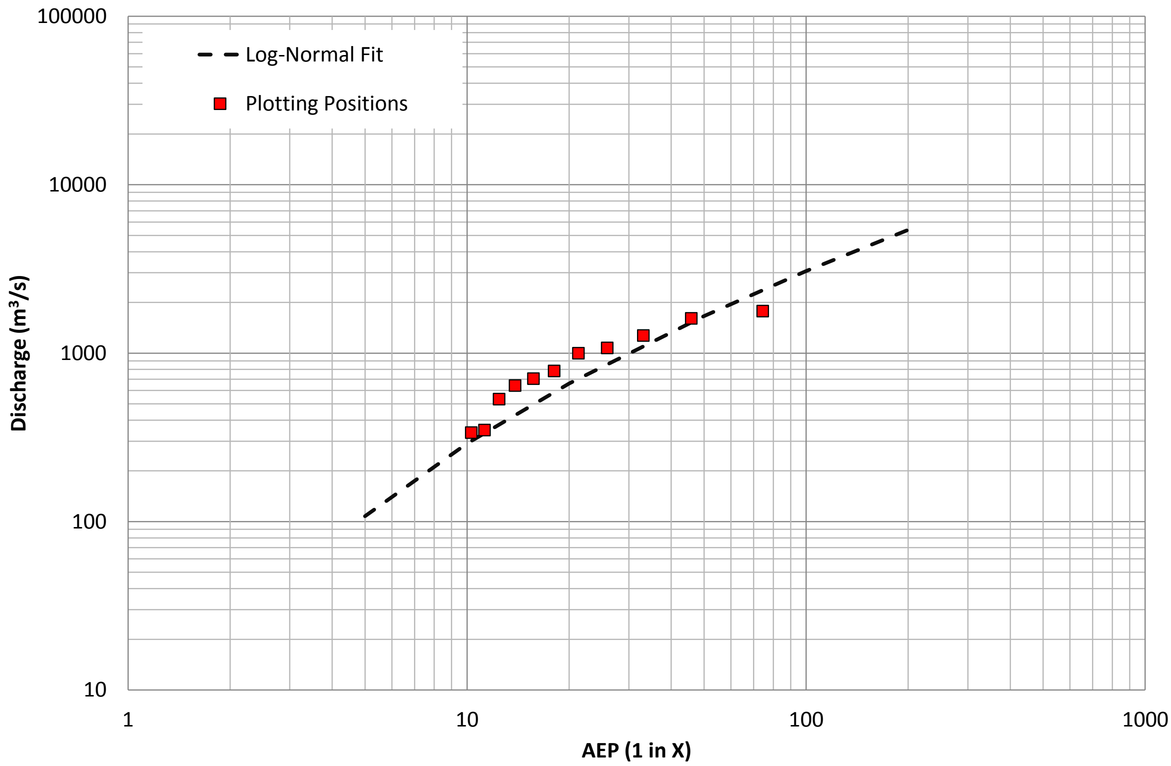

Figure 5.1 Flood Frequency Analysis Results – Log-Normal Distribution (NOT ADOPTED)

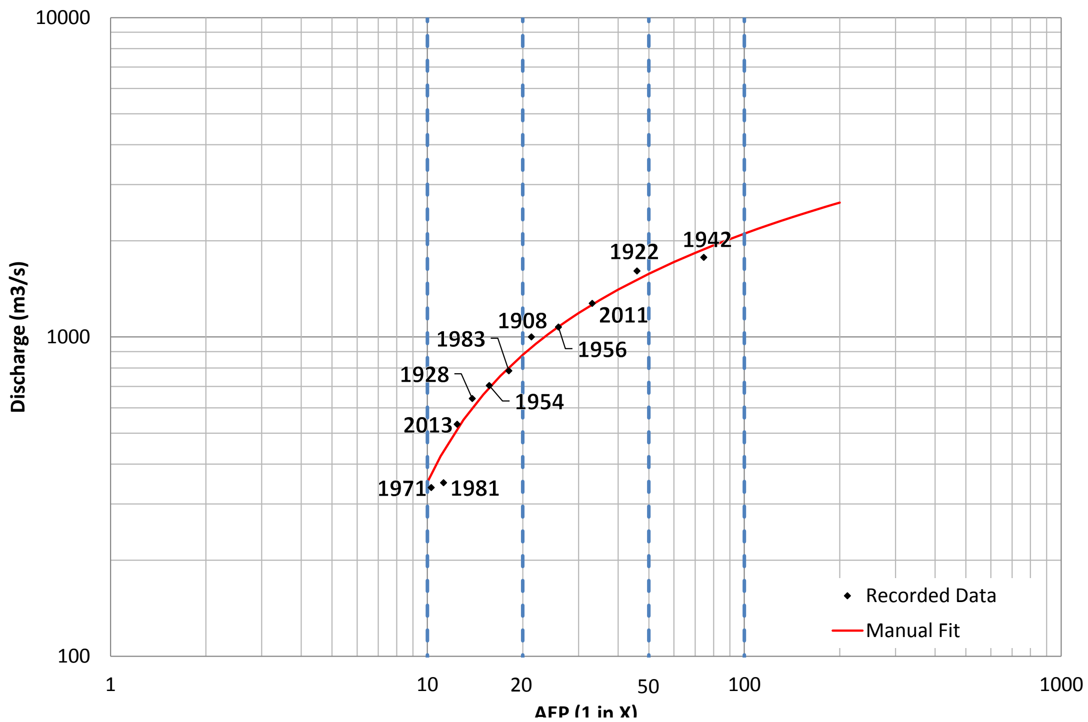

Figure 5.2 Adopted Flood Frequency Analysis Results – Manual Fit

5.4.6 Results

Table 5.5 and Figure 5.2 show the adopted FFA results.

Table 5.5 FFA Results (RAFTS Catchments)

AEP (1 in x)	Discharge (m^3/s)
2	- [a]
5	- [a]
10	350
20	880
50	1580
100	2100

a) FFA discharge estimates for less than the 1 in 10 AEP flood are not applicable due to the low flow censoring used in the analysis.

5.5 Design Discharge Selection

5.5.1 1 in 100 AEP

Estimates for the 1 in 100 AEP discharge for Charley's Creek at Chinchilla are:

- Flood frequency analysis: 2,100 m^3/s.
- Design rainfall technique: between 1,910 and 3,500 m^3/s.
- Australian regional flood frequency estimate: 2,950 m^3/s.

It was considered that the flood frequency analysis provided the most accurate estimation of the 1 in 100 AEP discharge for this study. Further, the FFA estimate was supported by the results of the other estimation techniques.

5.5.2 1 in 10 to 1 in 50 AEP

It was considered that the flood frequency analysis provided the most accurate estimation of the 1 in 10 to 1 in 50 AEP discharges. The following is of note:

- The low flow censoring threshold was 337 m^3/s. This is slightly lower than the 1 in 10 AEP estimate of 350 m^3/s.
- Generally, the low flow censoring threshold represents the lower limit of estimation.
- Given the absence of other more representative data, it is considered that the low flow threshold is close enough to the 1 in 10 AEP estimate to warrant the adoption of the FFA estimate.
- It follows that the FFA is unsuitable for estimation of the 1 in 2 and 1 in 5 AEP discharges.

5.6 Adopted Discharges

Table 5.6 shows the adopted 1 in 10 to 1 in 100 AEP discharges for Charley's Creek at Chinchilla.

Table 5.6 Adopted 1 in 10 to 1 in 100 AEP Discharge Estimates for Charley's Creek at Chinchilla

AEP (1 in x)	Discharge (m^3/s)
10	350
20	880
50	1580
100	2100

6 HYDROLOGIC MODELLING

The 'RAFTS' runoff-routing model (XP Software, 2001) was used to model hydrologic processes for Charley's Creek to Chinchilla.

6.1 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) 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 Muskingum K parameter was used as a calibration parameter during the joint calibration of the 2011 flood.
  - The calibrated 2011 stream velocity was 0.6 m/s for all catchments except the four upper catchments in the north eastern area of the catchment. This was to account for the steeper catchments and also assist in calibration. These velocities were adopted to calculate the Muskingum K parameters for all design runs.
- 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.

Figure 6.1 shows the RAFTS model layout.

6.2 RAFTS Results

A full suite of design events was analysed using the RAFTS model. Table 6.1 shows the adopted design rainfall loss parameters. Of particular note, the adopted rainfall loss parameters are higher than what would normally be considered "reasonable" for the design rainfall technique. However, for this large catchment, the design rainfall technique is not representing the physical processes (e.g. the DRT assumes spatially even rainfall distribution; an assumption that does not hold for low magnitude floods). Therefore, the loss parameters are surrogate parameters for a range of catchment processes; they do not represent rainfall loss alone. Therefore, the adopted rainfall loss parameters are considered appropriate.

Table 6.1 Design Rainfall Results for the 1 in 10 to 1 in 100 AEP Discharge Estimates for Charley's Creek at Chinchilla

AEP (1 in x)	Initial Loss (mm)	Continuing Loss (mm/hr)	Discharge (m^3/s)
10	58	3	350
20	48	3	880
50	30	3	1570
100	25	3	2100

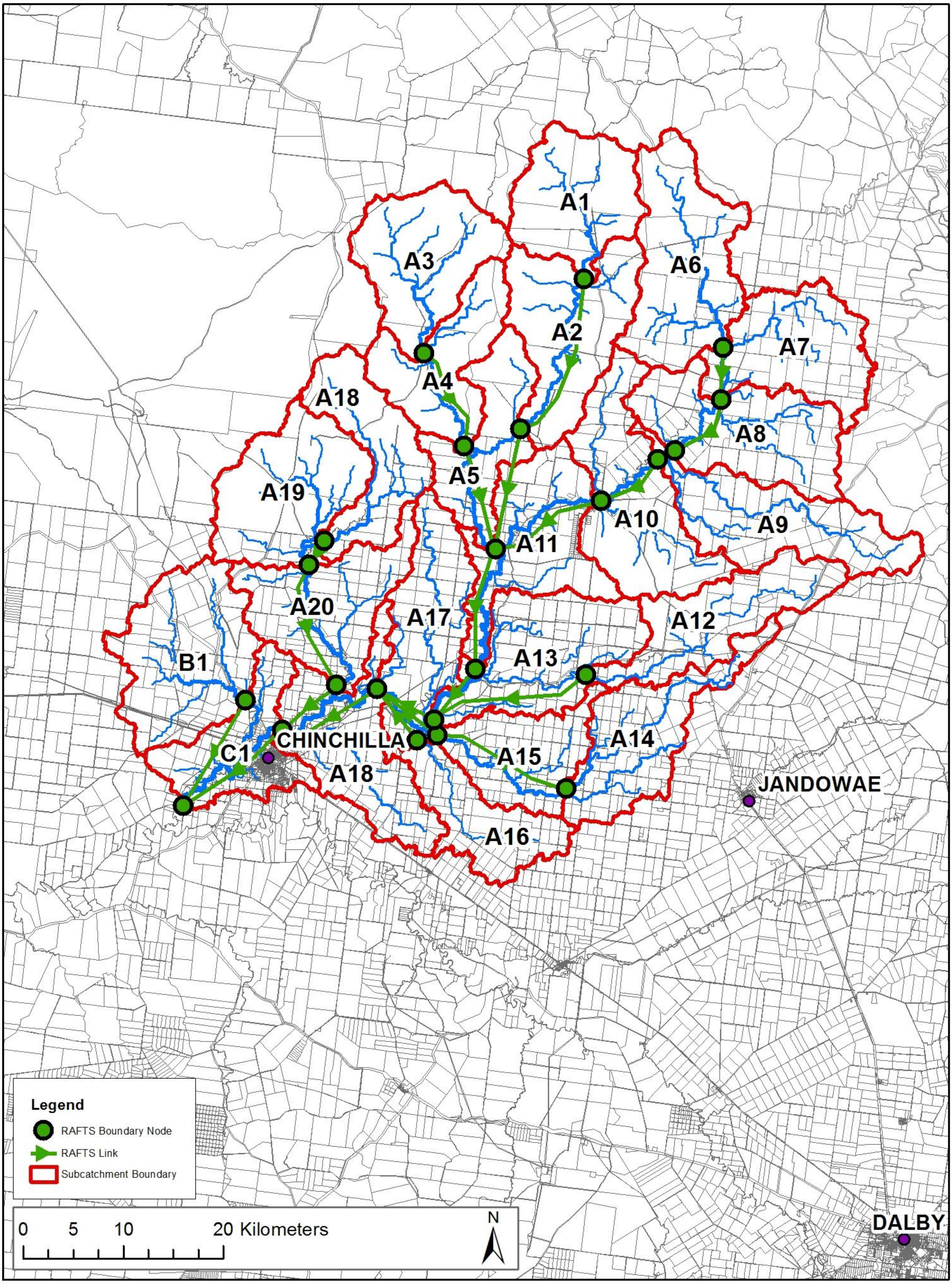

Figure 6.1 Chinchilla RAFTS model layout

7 RIVERINE FLOODING ANALYSIS

7.1 Overview

The MIKE FLOOD model was used to estimate flood levels for Chinchilla. The 1% AEP flood was adopted as the defined flood event (DFE). The following sections describe the design event modelling process.

Model results are presented as maps of flood depth and flood hazard in Volume II of this report.

Figure 7.1 shows the topography and extent of the hydraulic model.

7.2 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 Dalby MIKE FLOOD model developed for this investigation has the following characteristics:

- Model terrain based on available LIDAR data sets.
- 10m grid size covering an area 0.77km x 6.63km.
- 0.5s timestep.
- Velocity based eddy viscosity of $0.1m^2/s$.
- 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 7.1.

Figure 7.2 shows the hydraulic roughness map used in the hydraulic model. The roughness is that for ultimate land use development in accordance with the planning scheme.

Appendix D contains the following maps:

- The hydraulic model layout and extent.
- The ultimate development roughness.
- The location of structures in the model.

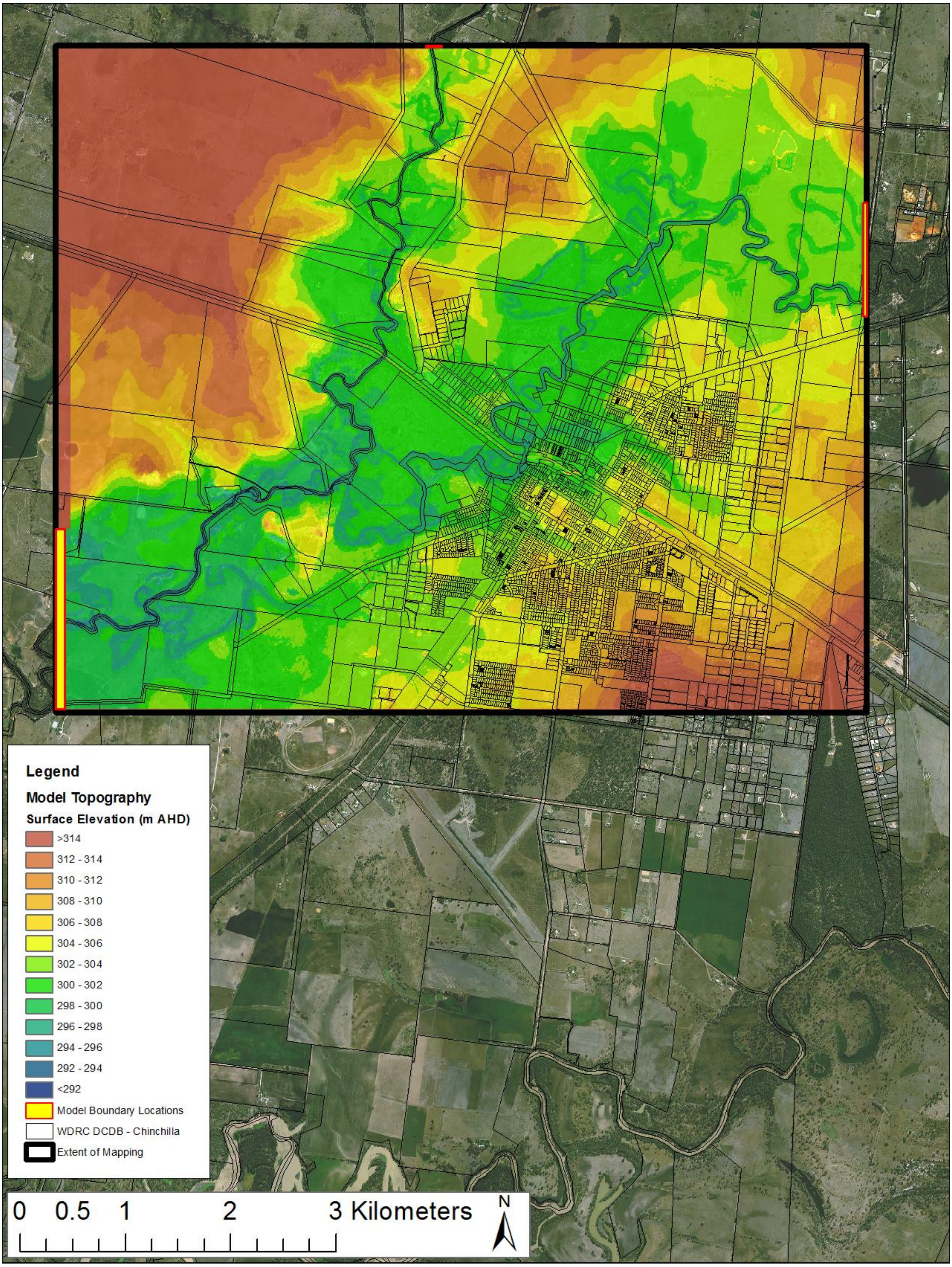

Figure 7.1 Hydraulic Model Extent and Topography

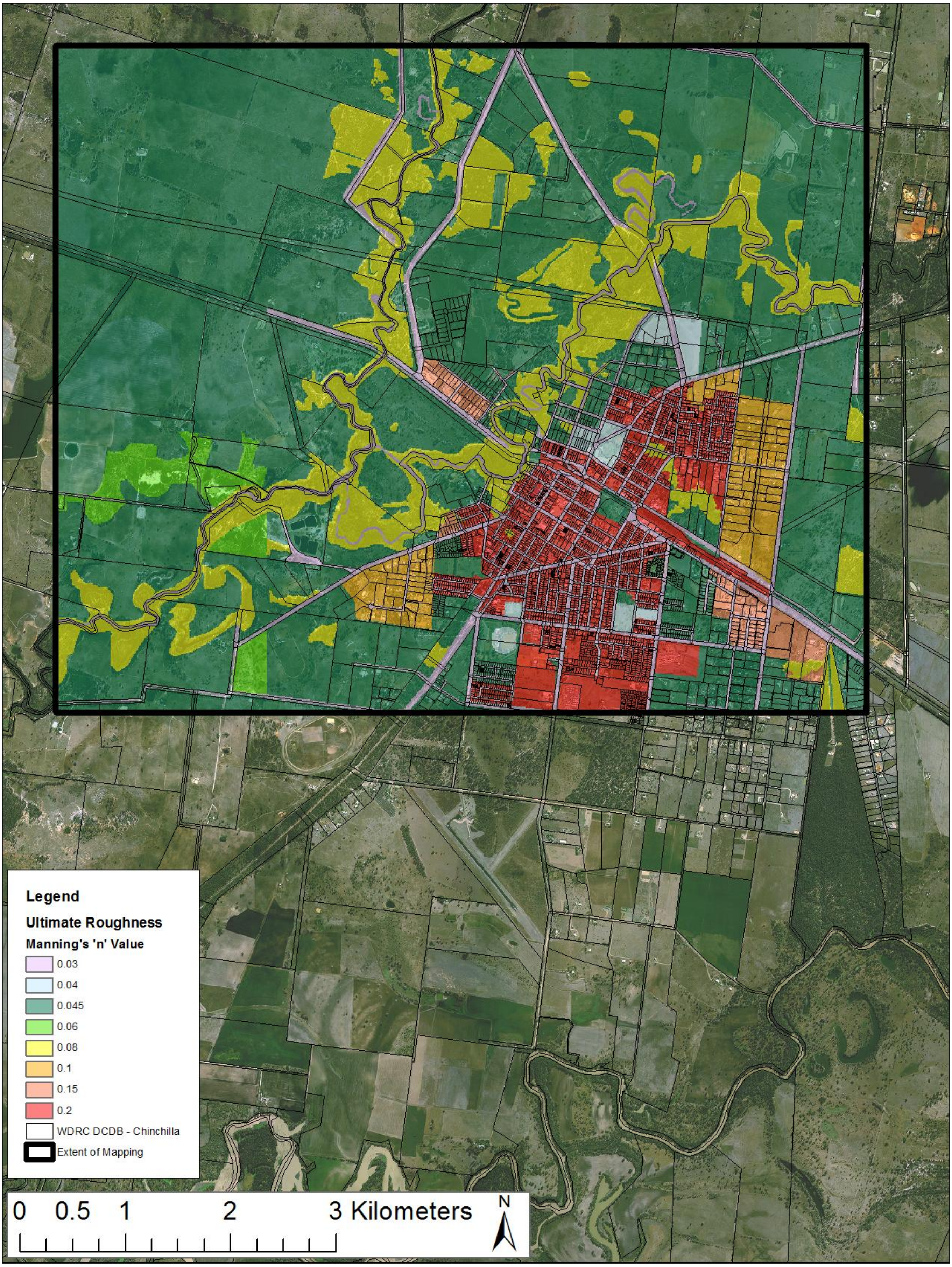

Figure 7.2 Hydraulic Roughness Map – Ultimate Development Conditions

Table 7.1 Adopted MIKE FLOOD Manning's n Values

Land Use	Manning's n
Roads	0.03
Cropping	0.05
Vegetation	0.08
Rural Residential	0.1
Industrial/Commercial	0.15
Dense Residential	0.2

7.3 Downstream Boundary Sensitivity Analysis

A downstream boundary sensitivity analysis was undertaken for Chinchilla. The analysis showed the model results were insensitive to the adopted downstream boundary conditions. Appendix E contains full details of the analysis.

7.4 Mapping Conventions

7.4.1 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).

7.4.2 Hazard Mapping

Flood hazard categories were adopted from *"Floodplain Management in Australia: Best Practice Principles and Guidelines"* (CSIRO, 2000). Table 7.2 shows the adopted categories.

Table 7.2 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

7.5 Hydraulic Results

Table 7.3 shows the different types of flood maps produced. Aerial photograph and cadastre are used as the background for all maps. These maps are presented in Volume II of this report.

Table 7.3 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% AEP riverine flood extent and depth
100	Extent + Hazard	Defined Flood Event (DFE): 1% AEP riverine flood hazard

8 UPDATE TO THE NOVEMBER 2012 REPORT

The initial Chinchilla Flood Study report was submitted in November 2012. Since then a significant amount of additional work has been undertaking. More specifically:

- Significant quantities of additional flood level information were gathered through the efforts of WDRC officers and the community,
- Through further consultation with the community, new gauge records (at the railway) were identified resulting in a significantly longer flow record (the earliest records available previously were in 1969 whereas the gauge record has now been extended back to the 1893 event). Although BoM are aware of the existence of this gauge, the gauge records are not available through their standard data retrieval processes.
- A revised Flood Frequency Analysis using the latest available techniques (as currently being developed through the revision of Australian Rainfall and Runoff) was undertaken on the extended gauge record.

This additional data and the corresponding Flood Frequency Analysis has resulted in a significant decrease in the design flows and corresponding levels for Charleys Creek through Chinchilla.

Table 8-1 and Table 8-2 below present comparisons of the design flows and associated levels for Charley's Creek as presented in the Nov 2012 report and this current report for Chinchilla.

Table 8-1 Comparison between the previously adopted flows (Nov 2012 report) and current flows at Charley's Creek, Chinchilla

AEP (1 in x)	Previous Discharge – Nov 2012 Report (m^3/s)	Revised Discharge - (m^3/s)
10	1060	350
20	1710	880
50	2900	1580
100	4130	2100

Please note that the significant reduction in design flows is a result of the revised Flood Frequency Analysis.

Table 8-2 Comparison between adopted levels in 2012 and 2014 Report at Charley's Creek, Chinchilla

AEP (1 in x)	Previous Levels – Nov 2012 (m AHD)	Revised Levels (m AHD)
10	302.46	301.43
20	303.05	302.27
50	303.86	302.99
100	304.48	303.40

For Myall Creek in Dalby, the reduction in design levels between the November 2012 report and this current report associated with the reduction in design inflows for Myall Creek were not uniformly distributed across the floodplain. However, the reduction in design flows for Charleys Creek at Chinchilla has produced a corresponding reduction in design level.

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.

Figure 8.1 and Figure 8.2 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.

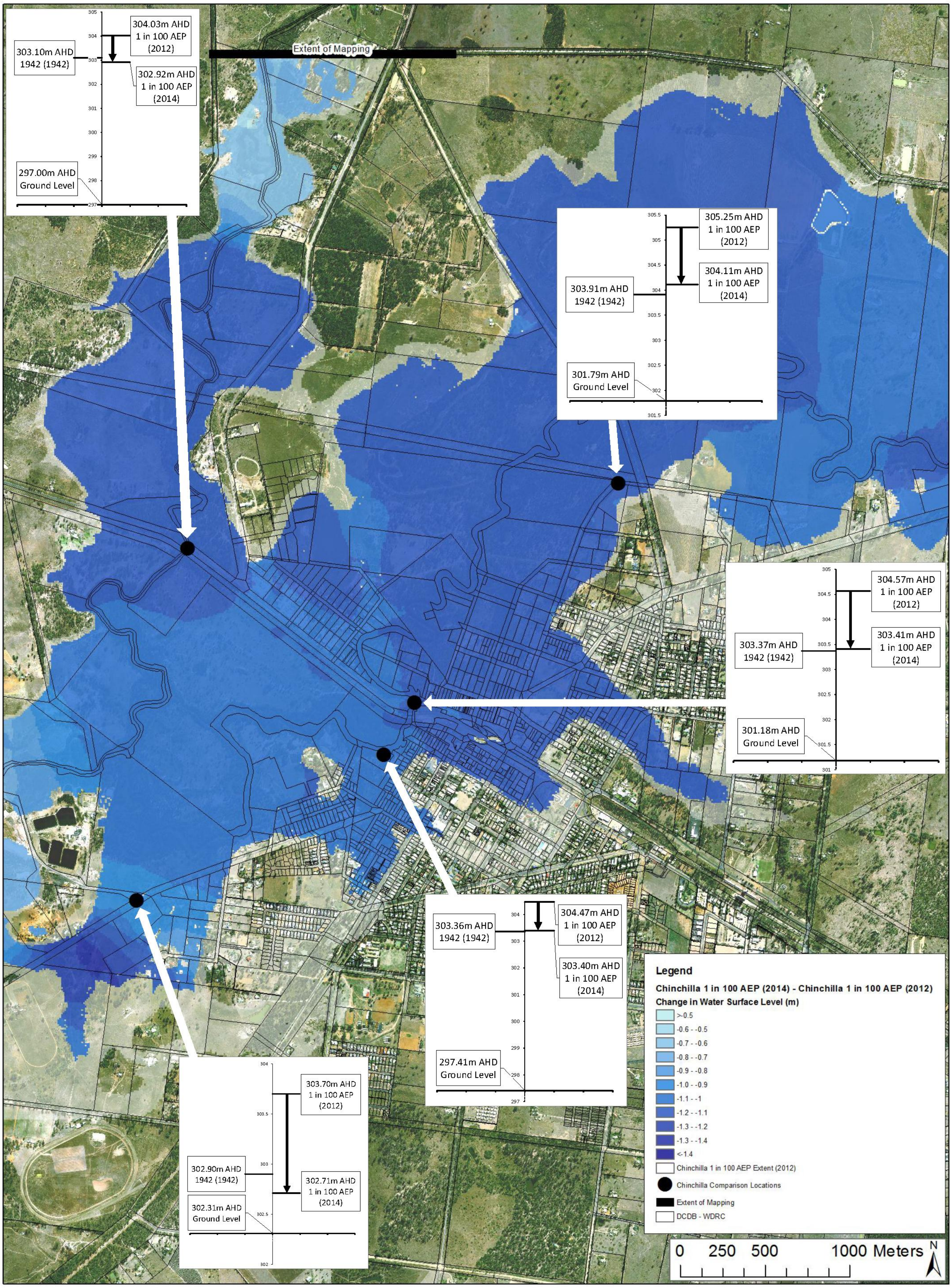

Figure 8.1 1 in 100 AEP flood level comparison – Revised flood levels compared to Nov 2012 flood levels

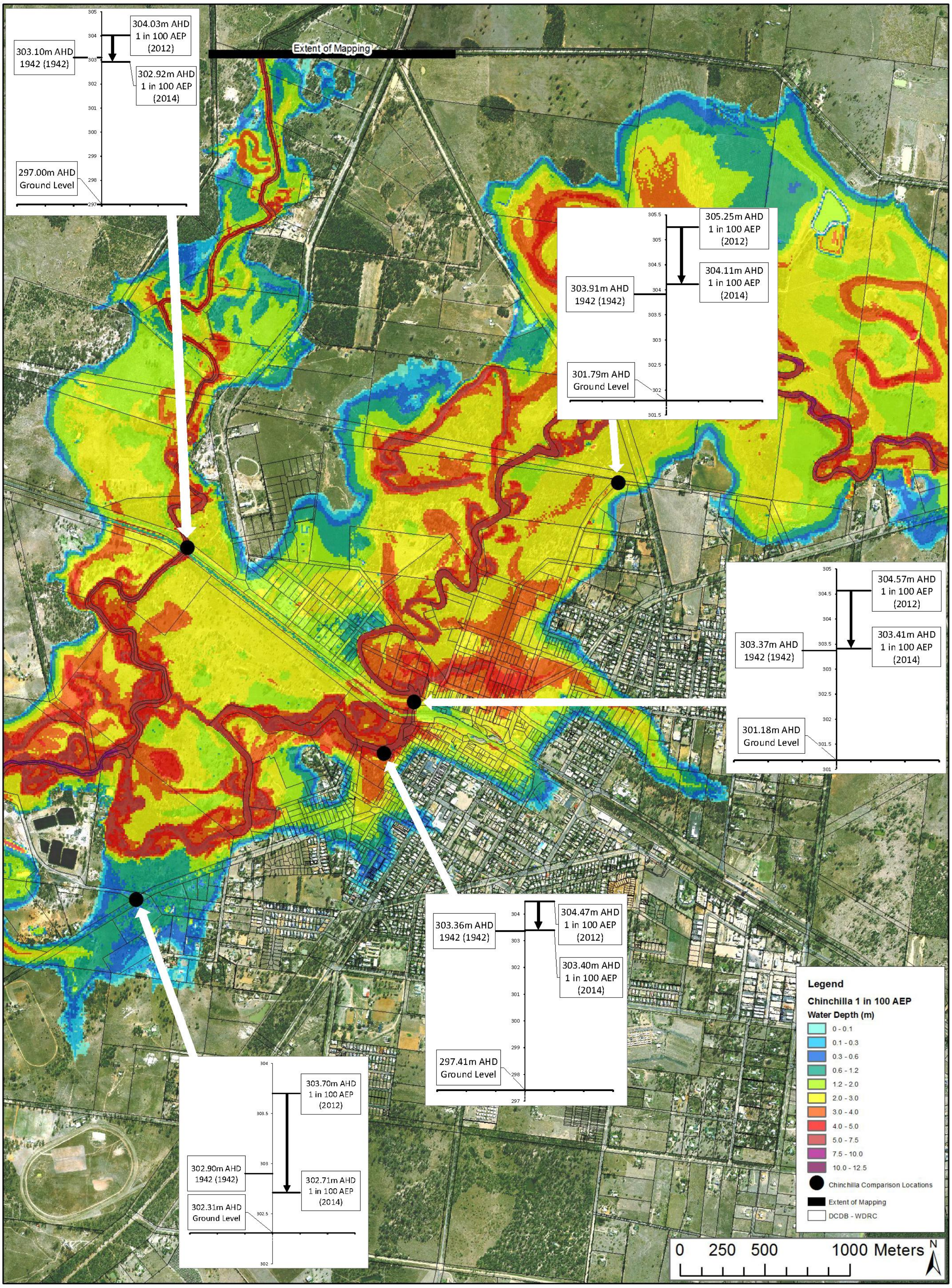

Figure 8.2 1 in 100 AEP depths with indicators of historic and design levels at key locations

9 STORMWATER FLOODING

9.1 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, Chinchilla was divided into a number of stormwater catchments. The 1 in 10, 1 in 50 and 1 in 100 AEP stormwater floods were modelled.

9.2 Catchments

Chinchilla was divided into a number of catchments based upon the following:

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

Appendix F shows the adopted stormwater catchments for Chinchilla.

9.3 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.

9.4 Hydrologic Analysis

9.4.1 Time of Concentration

The MIKE FLOOD hydraulic model was used to estimate the stream velocity. Table 9.1 shows the adopted velocities. It was found that a number of different velocities were required for the Chinchilla catchment, based upon stream slope.

9.4.2 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 9.2 shows the adopted impervious percentages and runoff coefficients for each land use category for Chinchilla.

9.4.3 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.

9.4.4 Results

Rational Method parameters and results for Chinchilla are provided in Appendix G.

Table 9.1 Adopted Average Stream Velocity for Rational Method Calculations

Town	Slope (%)	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 9.2 Adopted Impervious Percentage and C10 Runoff Coefficients

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

9.5 Stormwater Flood Hydraulic Modelling

9.5.1 Overview

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

9.5.2 Model Configuration

9.5.2.1 Model Description

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

- The stormwater hydraulic model used a reduced overall grid size compared to the riverine model to reduce run times.
- The stormwater model was run in steady state mode.

9.5.2.2 Modelled Events

The following events were modelled:

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

9.5.2.3 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 9.2 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.

9.5.2.4 Structures

Structure locations are provided in Appendix D. Note that only structures that were considered to have a substantial effect on flooding were included. For example, there are numerous small culverts under roads in Chinchilla. These were considered to have negligible impact on flooding and were ignored.

9.5.2.5 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 F shows the model run sequence for each town.

9.5.3 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.

9.5.4 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 Chinchilla. The background for all maps is an aerial photograph and cadastre. All maps are provided in Volume II of this report.

10 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 Dalby, the subject of this report was 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.

Extensive research was undertaken as part of the study to identify and list historical floods for Chinchilla. This included:

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

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. In Chinchilla, a number of different techniques were employed to reduce the estimation uncertainty. The 1% 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 CHINCHILLA HISTORICAL AND ULTIMATE SURFACE ROUGHNESS DIFFERENCE MAPS

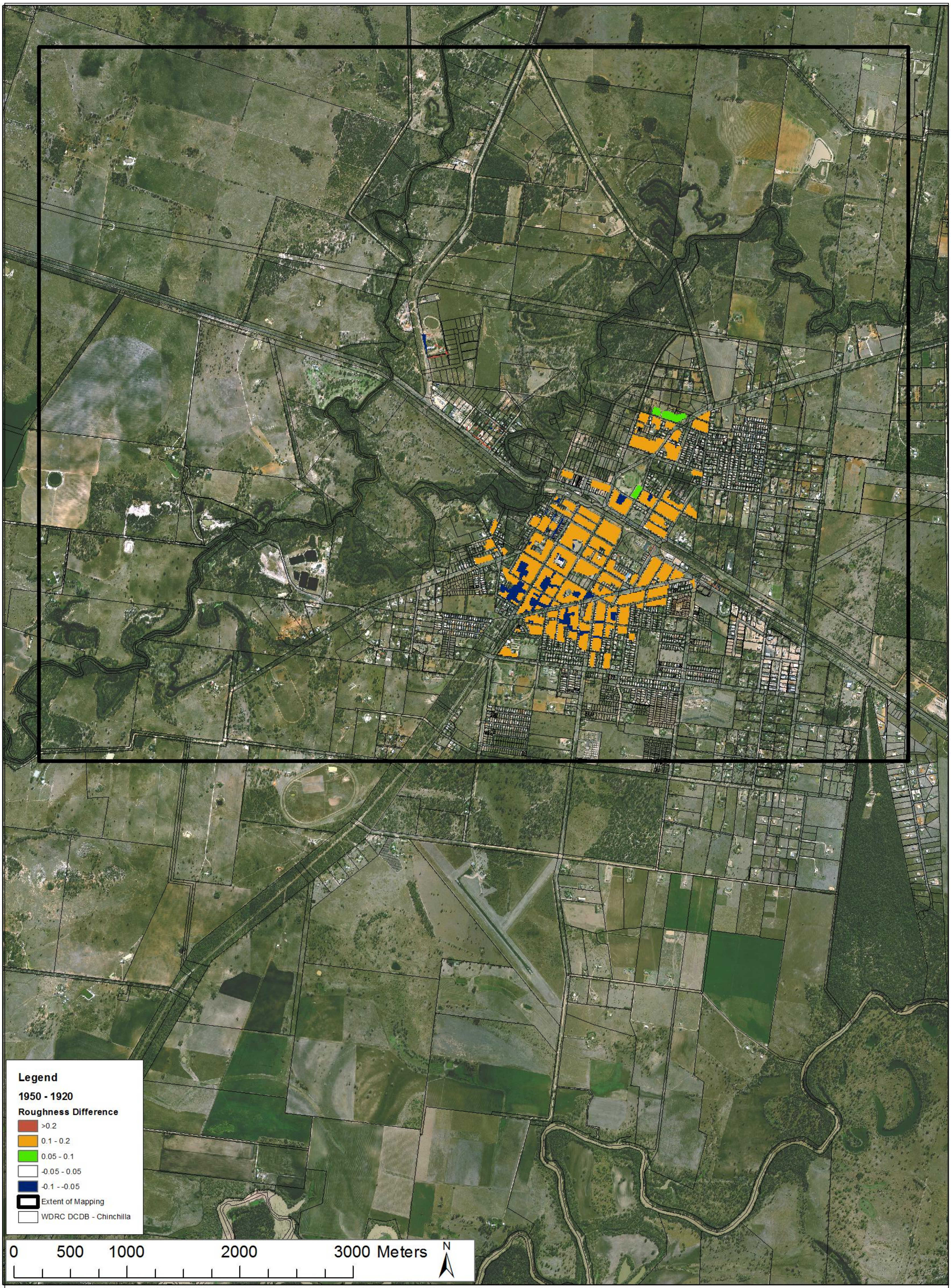

Figure A.1 Change in Roughness in Chinchilla from 1920 - 1950

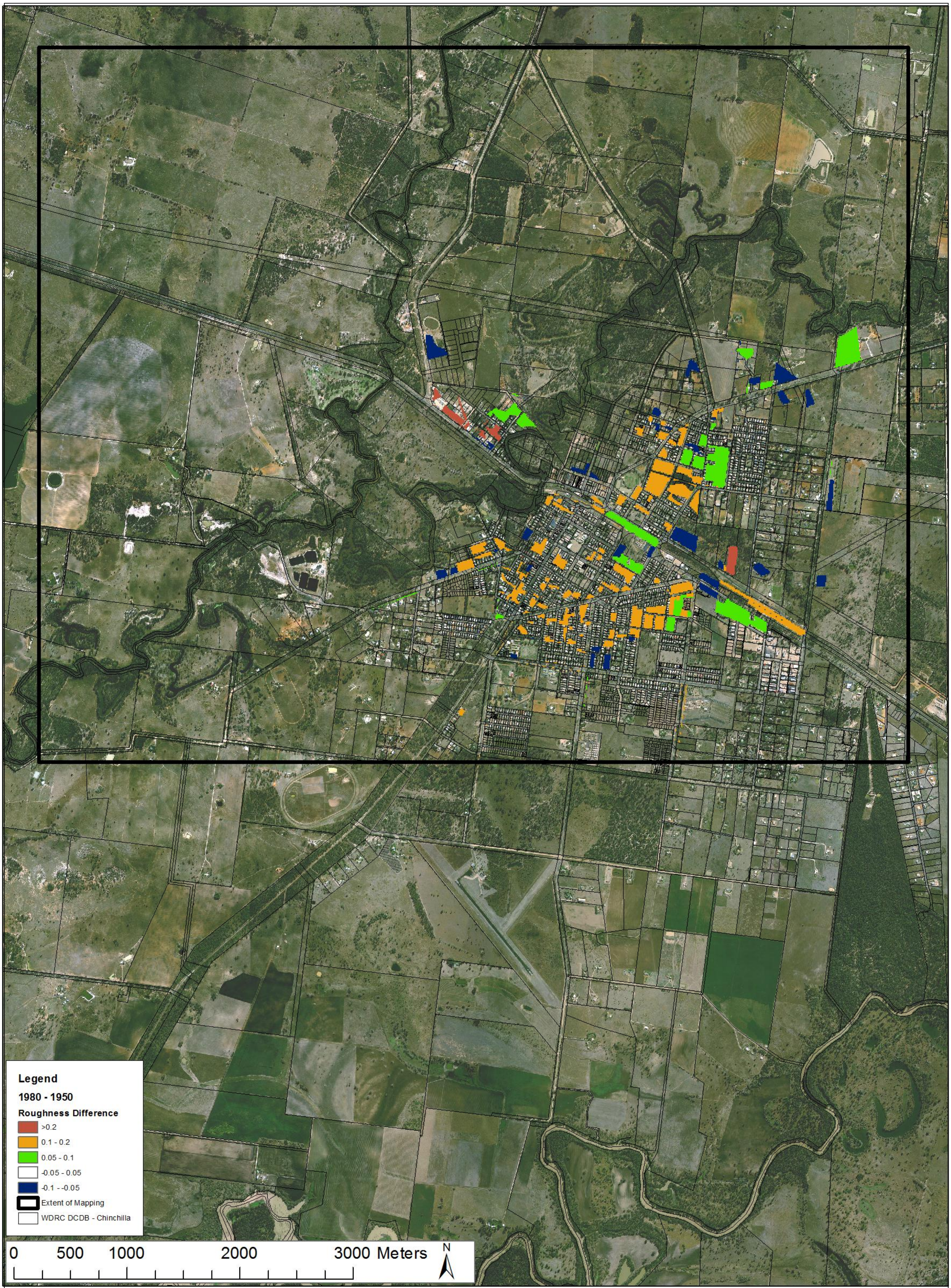

Figure A.2 **Change in Roughness in Chinchilla from 1950 - 1980**

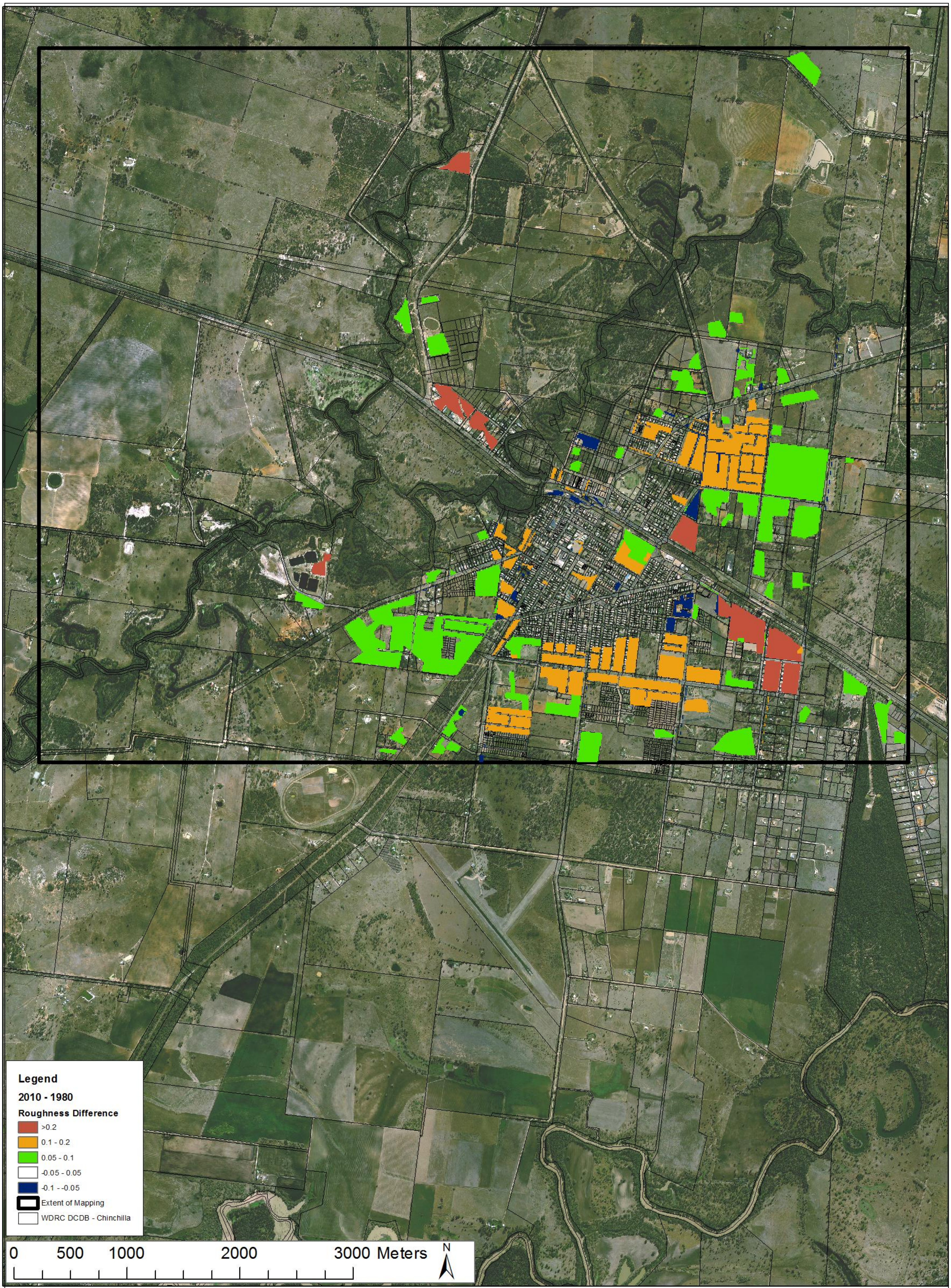

Figure A.3 Change in Roughness in Chinchilla from 1980 - 2010

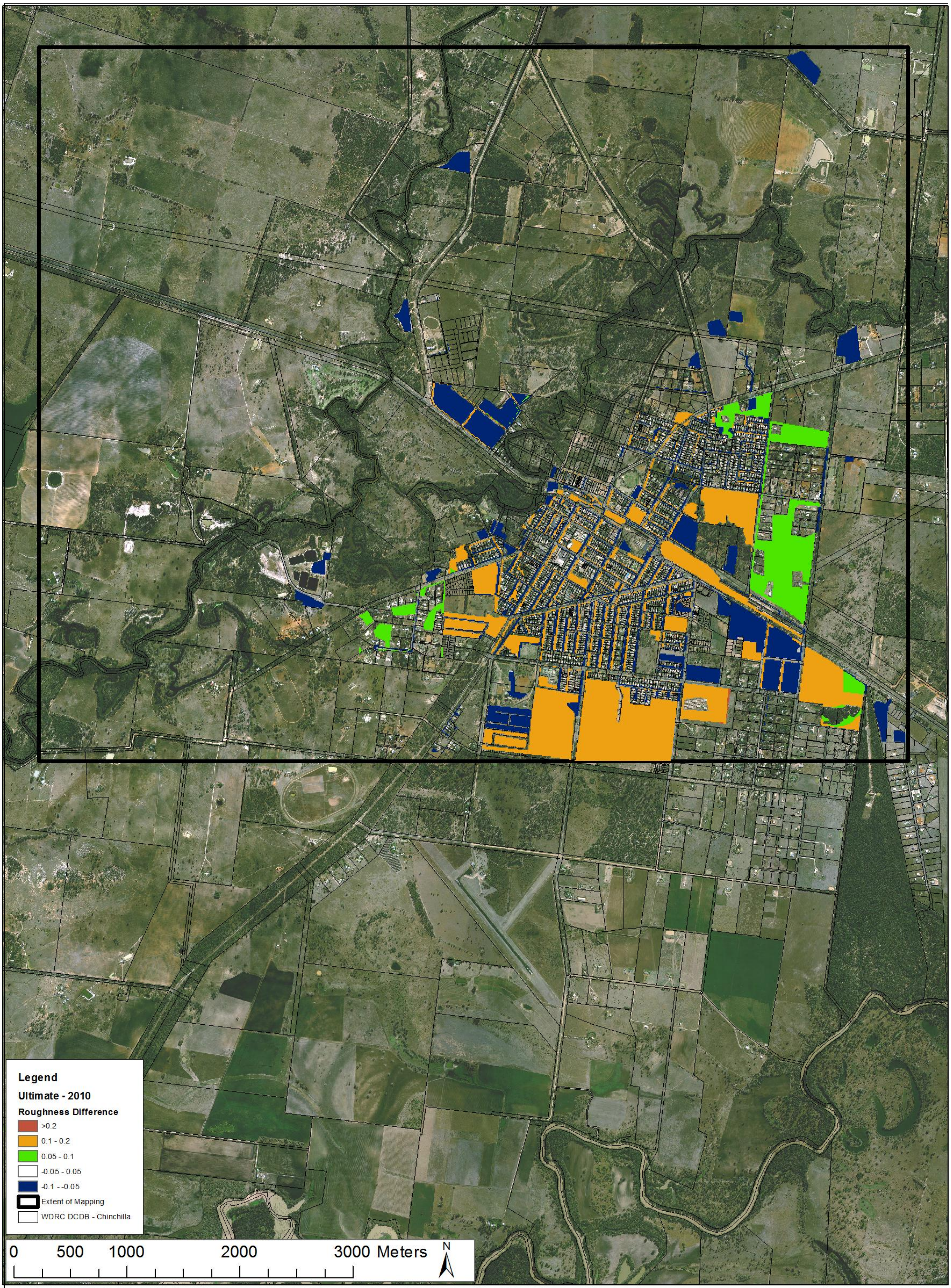

Figure A.4 Change in Roughness in Chinchilla from 1920 – Ultimate Development Case

APPENDIX B CHINCHILLA HISTORICAL AND ULTIMATE TOPOGRAPHY DIFFERENCE MAP

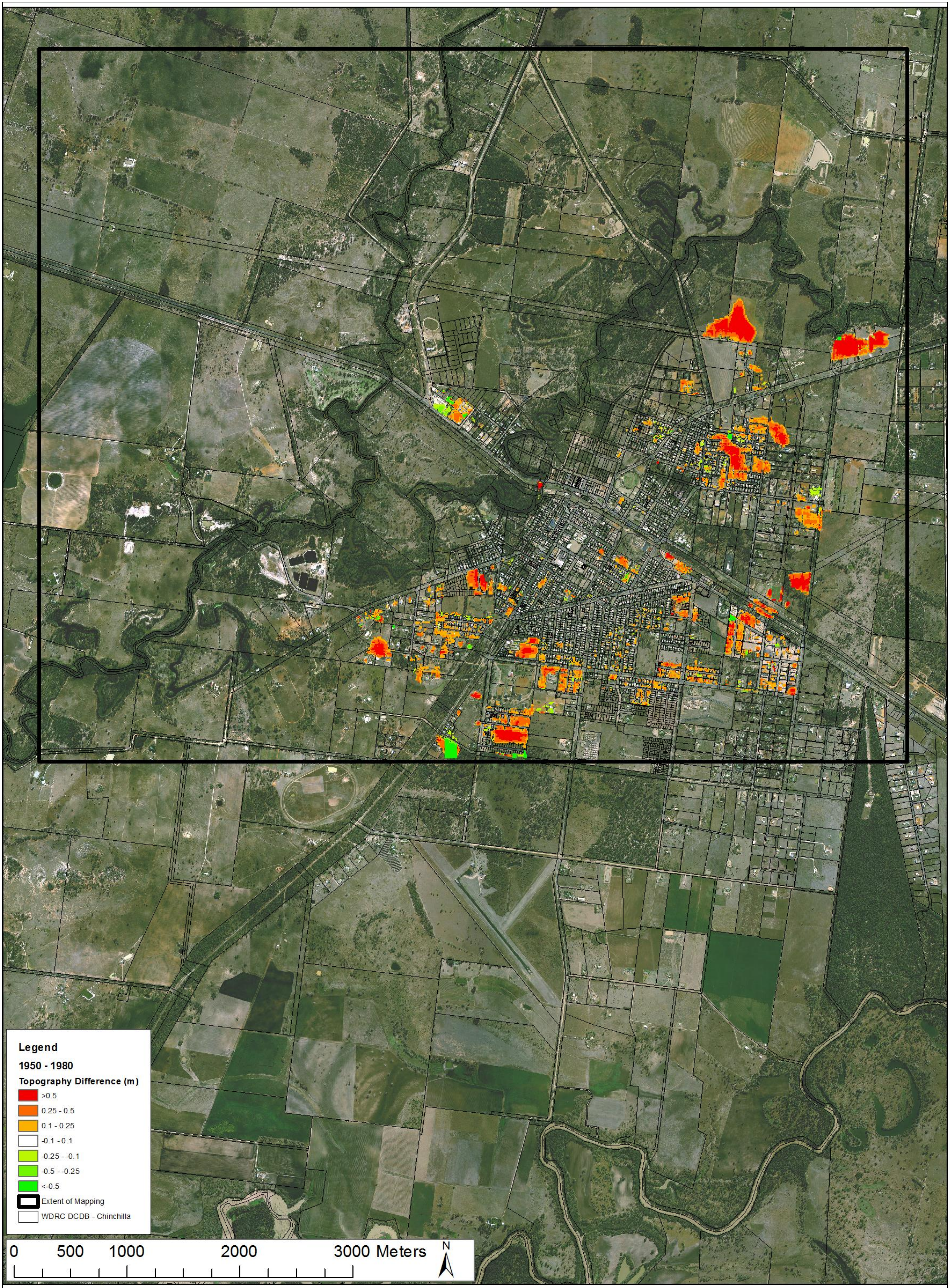

Figure B.1 Change in Topography in Chinchilla from 1950 - 1980

Figure B.2 Change in Topography in Chinchilla from 1980 - 2010

APPENDIX C JOINT CALIBRATION OF THE 1942 AND 2011 CHINCHILLA FLOODS - RESULTS

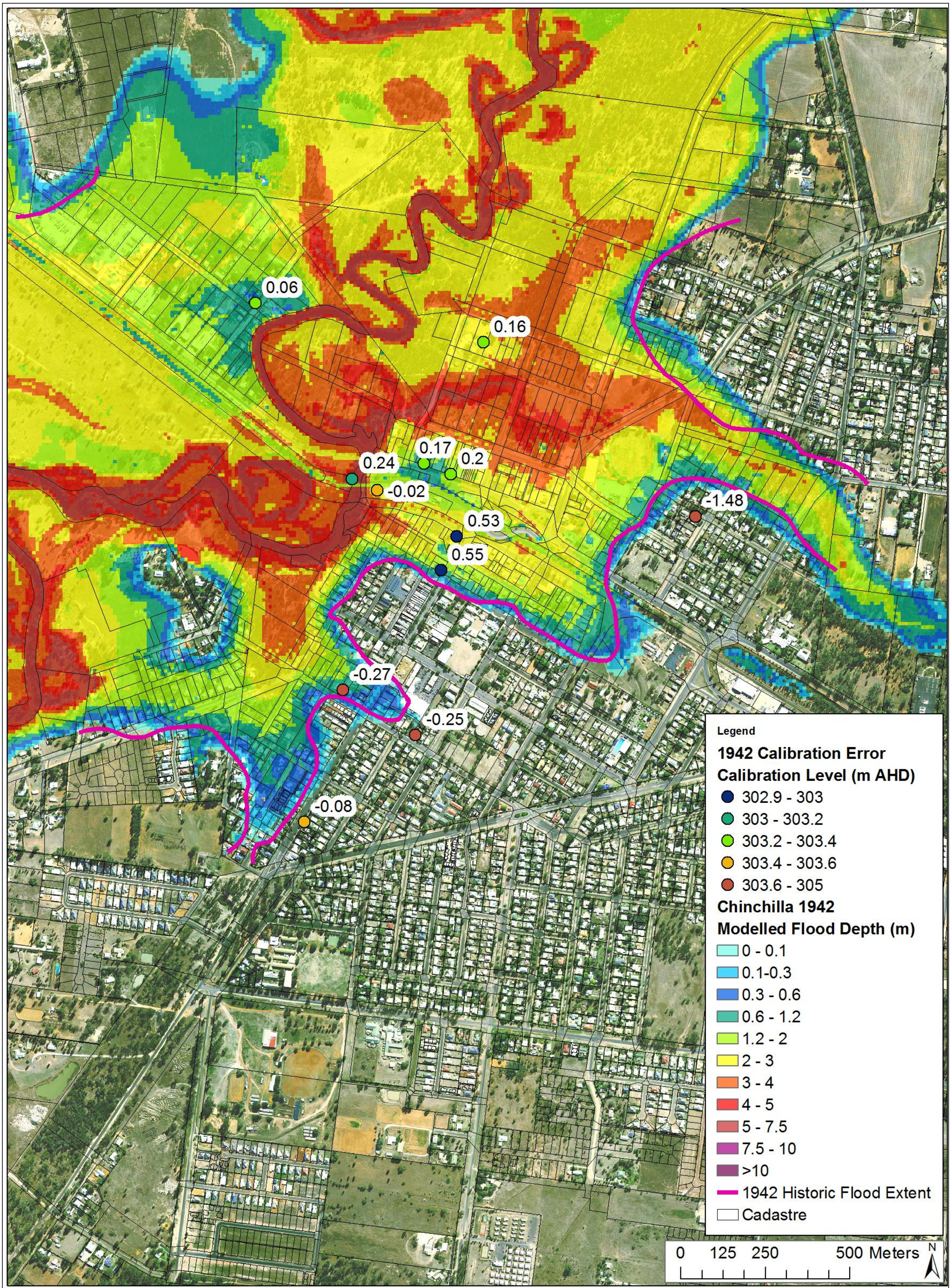

Figure C.1 **Chinchilla 1942 Flood - Calibration Results**

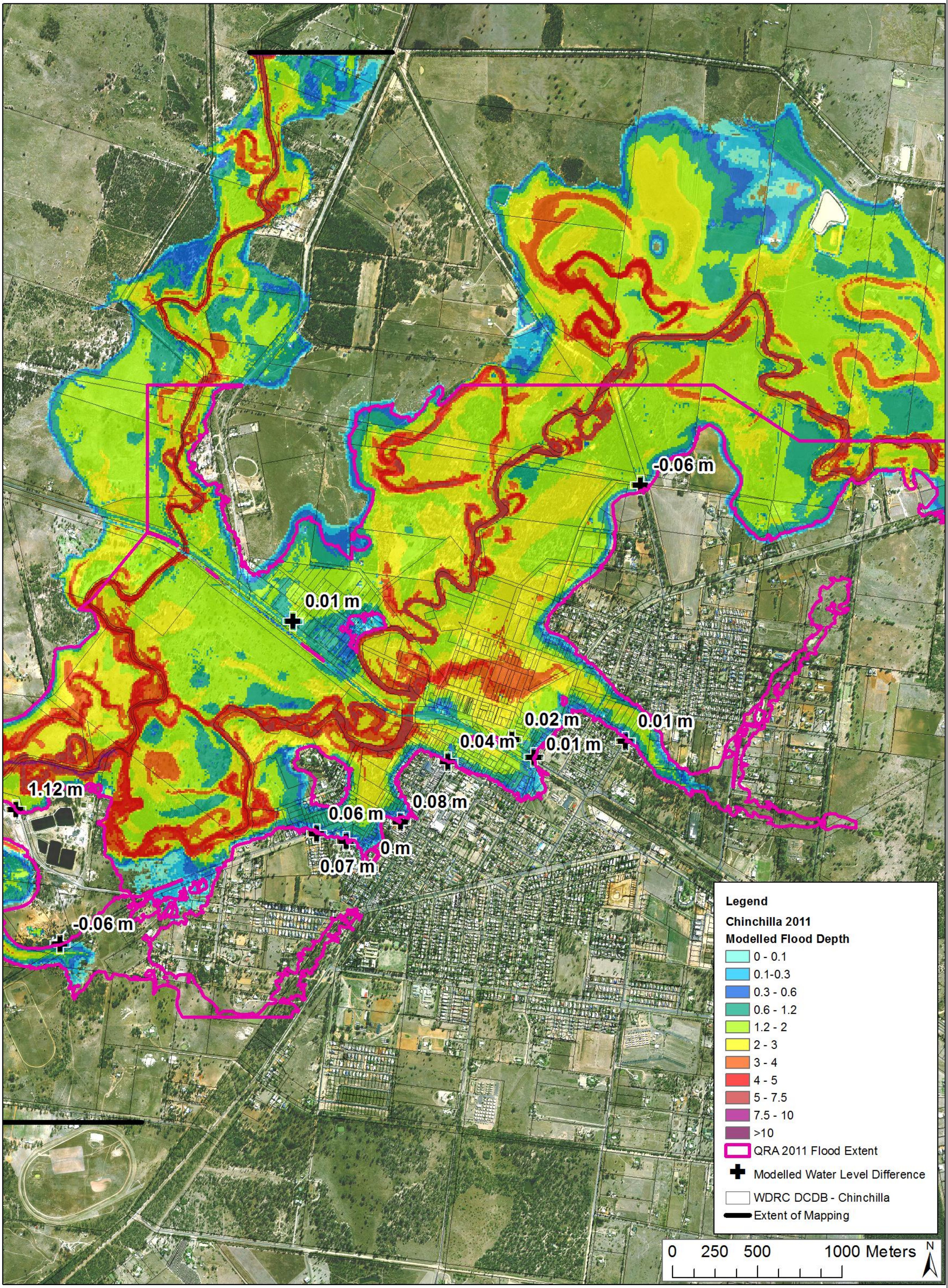

Figure C.2 Chinchilla 2011 Flood - Calibration Results

APPENDIX D CHINCHILLA HYDRAULIC MODEL CONFIGURATION

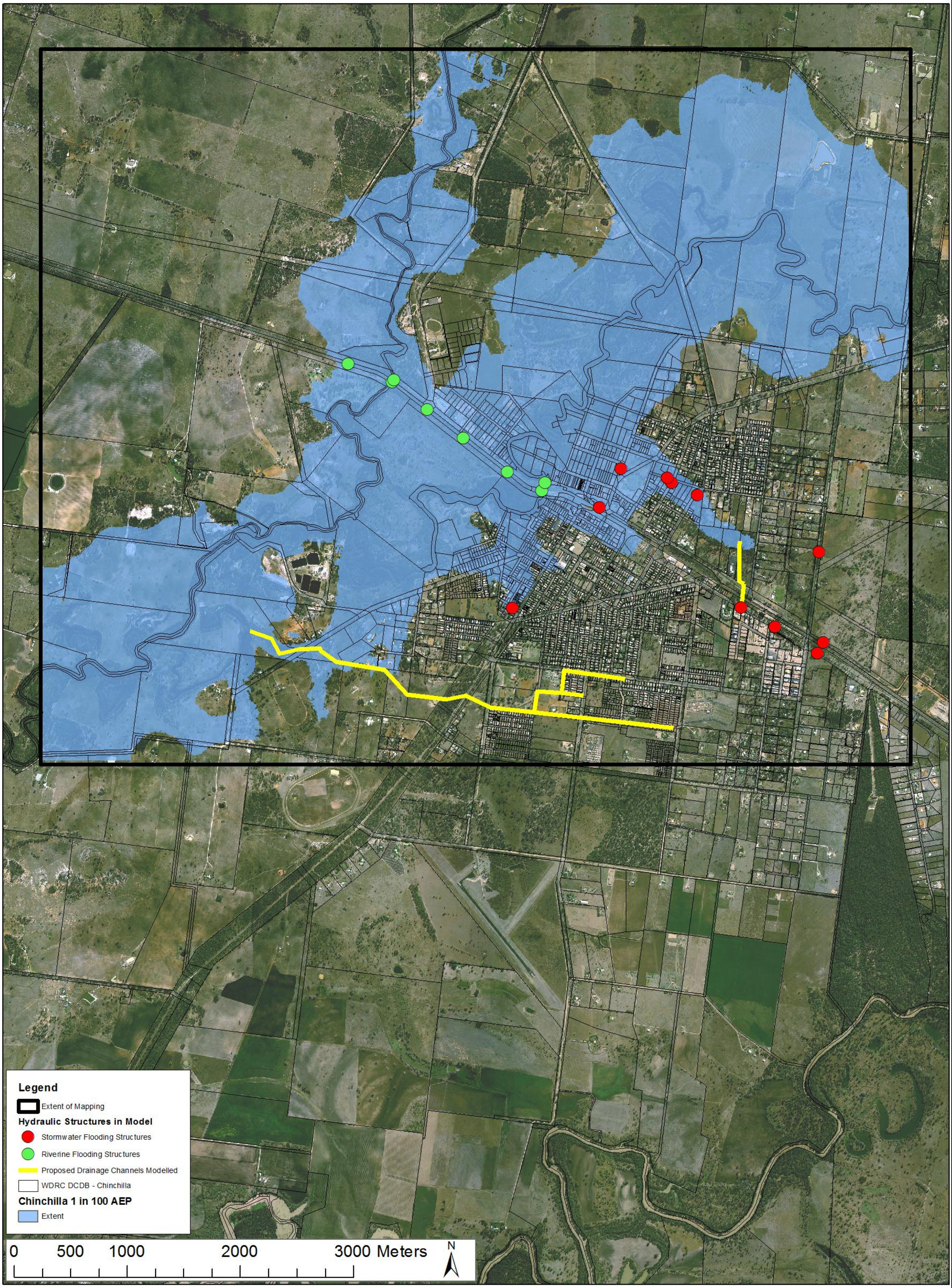

Figure D.1 **Chinchilla Hydraulic Structures**

APPENDIX E HYDRAULIC MODEL DOWNSTREAM BOUNDARY SENSITIVITY TESTING

E.1 2011 Chinchilla Flood Tailwater Analysis

A downstream boundary sensitivity analysis was undertaken for Chinchilla. 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 E.1 shows the results of the sensitivity analysis.

Table E.1 shows that changes in the WSL 1000m upstream of the boundary were within 0.11 m. 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 E.1. Four runs were undertaken in Chinchilla. The “adopted”, “increase” and “decrease” runs were run under steady state conditions. The boundary was further refined by using MIKE11 to develop a downstream boundary rating curve. The model was then run under unsteady state conditions and is shown in the table as “adopted refined”.

Table E.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)
Chinchilla	Adopted – Refined [1]	300.9	-	3000	-
	Adopted	300.95	0.01		-0.02
	Increase	301.15	0.11		0.01
	Decrease	300.7	-0.07		-0.02

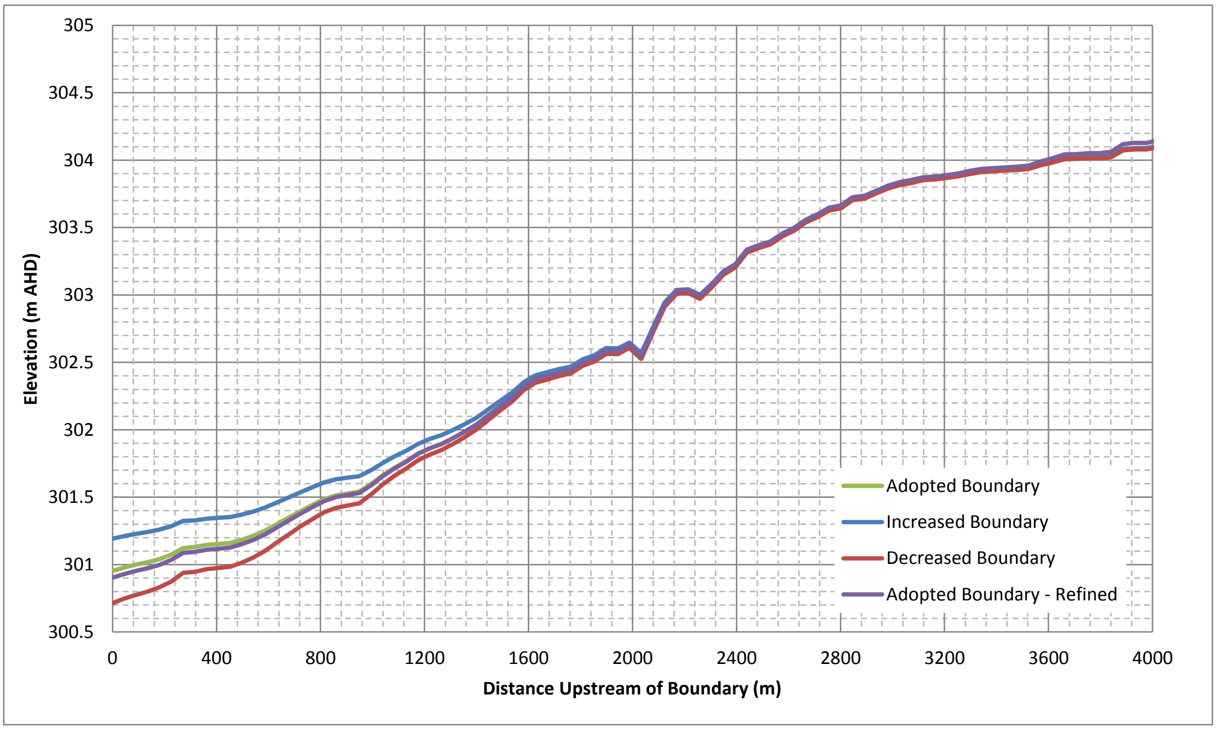

Figure E.1 Chinchilla downstream water surface profile

APPENDIX F STORMWATER HYDRAULIC MODEL CATCHMENTS AND RUN SEQUENCE DETAILS

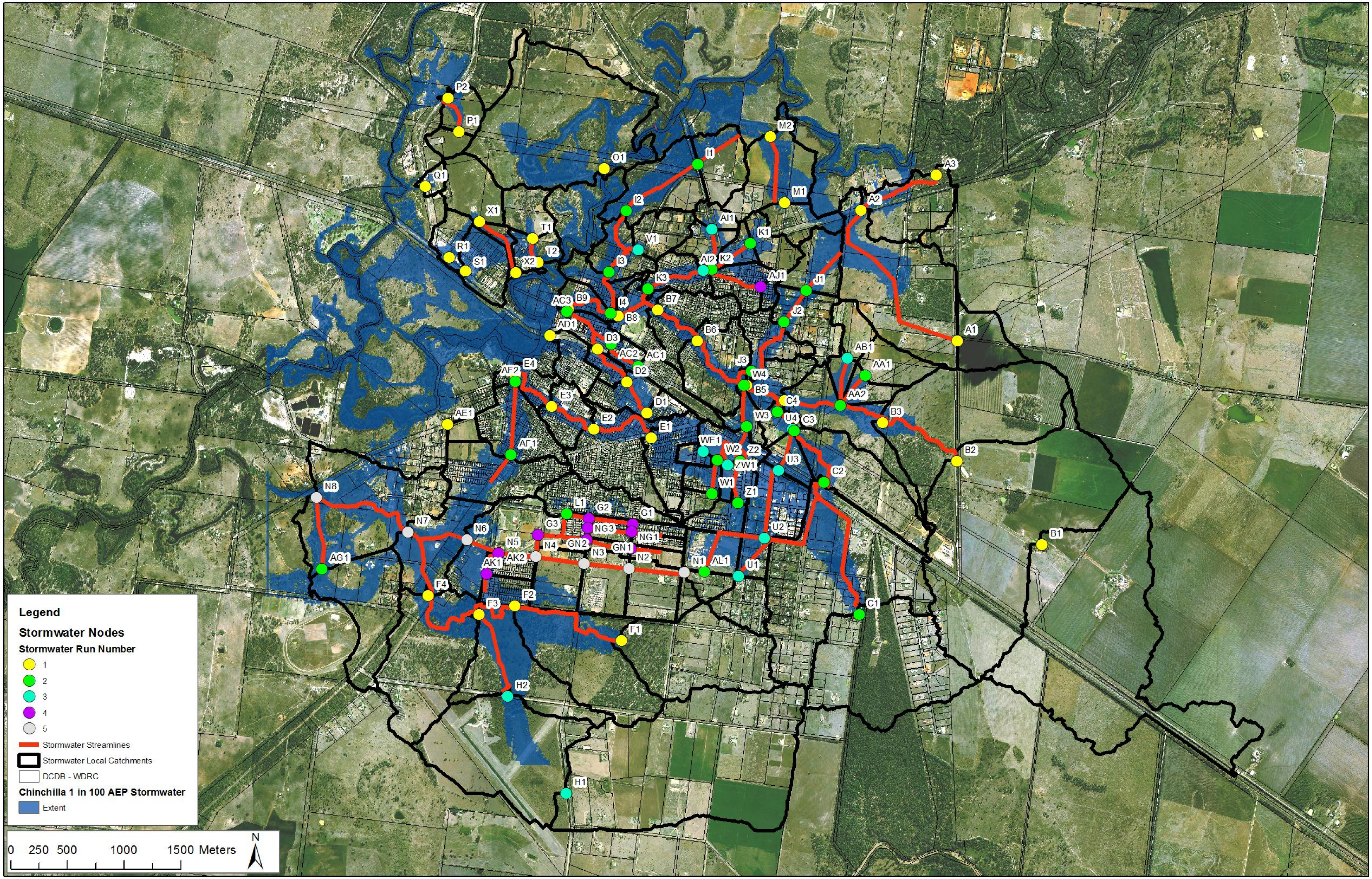

Figure F.1 Chinchilla 1 in 100 AEP Stormwater Flood Extent – Stormwater Catchments and Nodes

APPENDIX G CHINCHILLA STORMWATER MODELLING – RATIONAL METHOD PARAMETERS AND RESULTS

Table G.1 1 in 100 AEP Chinchilla 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	23.6	513	0.004	23.6	0.39	0.39	513	1	0.47	overland		0.045	95.7	0.004	26.0	0.60	14.3	40.3	94.5	2.9	2.9	**2.9**
A2	96.2	1788	0.002	119.8	0.39	0.39	2301	1	0.47							0.60	49.7	90.0	55.9	8.7	5.8	**8.7**
A3	37.8	816	0.002	157.6	0.39	0.39	3117	1	0.47							0.60	22.7	112.6	47.9	9.8	1.1	**9.8**
AA1	18.6	539	0.006	18.6	0.39	0.39	539	1	0.47	overland		0.045	94.5	0.006	24.7	0.60	15.0	39.7	95.4	2.3	2.3	**2.3**
AA2	9.6	342	0.002	28.1	0.39	0.39	881	1	0.47							0.60	9.5	49.2	83.6	3.1	0.8	**3.1**
AB1	12.6	492	0.006	12.6	0.39	0.39	492	1	0.47	overland		0.045	94.4	0.006	24.6	0.60	13.7	38.2	97.4	1.6	1.6	**1.6**
AB2	6.4	418	0.002	19.0	0.39	0.39	910	1	0.47							0.60	11.6	49.9	82.8	2.1	0.5	**2.1**
AC1	13.3	770	0.002	13.3	0.75	0.75	770	1	0.90	Std. Inlet	15					0.60	21.4	36.4	100.4	3.3	3.3	**3.3**
AC2	6.3	313	0.002	19.6	0.75	0.75	1083	1	0.90							0.60	8.7	45.1	88.2	4.3	1.0	**4.3**
AC3	10.5	496	0.002	58.6	0.78	0.74	1579	1	0.89							0.60	13.8	58.9	74.5	10.8	6.5	**10.8**
AD1	14.1	544	0.007	14.1	0.83	0.83	544	1	0.99	Std. Inlet	15					0.60	15.1	30.1	112.0	4.4	4.4	**4.4**
AE1	5.4	316	0.002	5.4	0.72	0.72	316	1	0.87	overland		0.045	98	0.002	30.6	0.60	8.8	39.4	95.8	1.3	1.3	**1.3**
AF1	39.8	304	0.011	39.8	0.70	0.70	304	1	0.84	Std. Inlet	15					0.60	8.4	23.4	128.4	11.9	11.9	**11.9**
AF2	32.5	703	0.002	72.3	0.69	0.70	1007	1	0.83							0.60	19.5	43.0	90.9	15.2	3.3	**15.2**
AG1	53.2	915	0.015	53.2	0.43	0.43	915	1	0.51	overland		0.045	85.2	0.015	19.6	0.60	25.4	45.0	88.3	6.7	6.7	**6.7**
AI1	6.9	179	0.002	6.9	0.66	0.66	179	1	0.80	overland		0.045	98.5	0.002	32.4	0.60	5.0	37.4	98.7	1.5	1.5	**1.5**
AI2	12.3	395	0.002	19.1	0.70	0.69	574	1	0.82							0.60	11.0	48.4	84.5	3.7	2.2	**3.7**
AJ1	3.9	167	0.017	3.9	0.60	0.60	167	1	0.72	overland		0.045	83	0.017	18.9	0.60	4.6	23.5	128.3	1.0	1.0	**1.0**
AJ2	16.0	509	0.002	19.9	0.70	0.68	676	1	0.82							0.60	14.1	37.6	98.4	4.4	3.4	**4.4**
AK1	10.9	480	0.004	10.9	0.70	0.70	480	1	0.84	Std. Inlet	15					0.60	13.3	28.3	115.8	2.9	2.9	**2.9**
AK2	8.7	244	0.002	19.6	0.69	0.69	724	1	0.83							0.60	6.8	35.1	102.5	4.7	1.7	**4.7**
AL1	7.9	226	0.002	7.9	0.70	0.70	226	1	0.84	overland		0.045	97.72	0.002	29.8	0.60	6.3	36.0	100.9	1.9	1.9	**1.9**
AL2	17.6	576	0.002	25.5	0.70	0.70	802	1	0.84							0.60	16.0	52.0	80.7	4.8	2.9	**4.8**
B1	242.2	2500	0.002	242.2	0.39	0.39	2500	1	0.47	overland		0.045	98	0.002	30.6	0.60	69.4	100.0	52.1	16.4	16.4	**16.4**
B2	226.3	1054	0.002	468.5	0.39	0.39	3554	1	0.47							0.60	29.3	129.3	43.3	26.5	10.1	**26.5**
B3	114.2	854	0.002	582.7	0.39	0.39	4408	1	0.47							0.60	23.7	153.0	38.2	29.1	2.6	**29.1**
B4	41.6	879	0.002	671.4	0.43	0.39	5287	1	0.47							0.60	24.4	177.4	34.3	30.2	1.1	**30.2**
B5	16.2	354	0.002	1062.4	0.56	0.44	5641	1	0.53							0.60	9.8	187.3	33.0	51.3	21.1	**51.3**
B6	37.4	694	0.002	1148.4	0.61	0.45	6335	1	0.54							0.60	19.3	206.6	30.6	52.5	1.2	**52.5**
B7	29.7	435	0.002	1178.1	0.70	0.45	6770	1	0.55							0.60	12.1	218.6	29.4	52.4	-0.1	**52.5**
B8	18.3	410	0.002	1273.9	0.54	0.47	7180	1	0.56							0.60	11.4	230.0	28.3	56.2	3.8	**56.2**
B9	10.2	586	0.002	1437.1	0.39	0.48	7766	1	0.57							0.60	16.3	246.3	26.9	61.3	5.1	**61.3**
C1	108.2	775	0.004	108.2	0.43	0.43	775	1	0.52	overland		0.045	96.2	0.004	26.7	0.60	21.5	48.3	84.6	13.2	13.2	**13.2**
C2	138.5	1122	0.002	246.7	0.52	0.48	1897	1	0.58							0.60	31.2	79.4	61.2	24.2	11.0	**24.2**
C3	52.1	650	0.002	298.8	0.40	0.47	2547	1	0.56							0.60	18.1	97.5	53.0	24.7	0.4	**24.7**
C4	8.4	360	0.002	374.7	0.47	0.52	2907	1	0.62							0.60	10.0	107.5	49.4	31.9	7.3	**31.9**
D1	5.8	305	0.007	5.8	0.74	0.74	305	1	0.89	Std. Inlet	15					0.60	8.5	23.5	128.4	1.8	1.8	**1.8**
D2	16.0	330	0.002	21.7	0.70	0.71	635	1	0.85							0.60	9.2	32.6	107.0	5.5	3.7	**5.5**
D3	6.7	399	0.002	28.4	0.75	0.72	1034	1	0.86							0.60	11.1	43.7	90.0	6.1	0.6	**6.1**
E1	24.5	471	0.011	24.5	0.71	0.71	471	1	0.85	Std. Inlet	15					0.60	13.1	28.1	116.4	6.7	6.7	**6.7**
E2	47.5	615	0.002	71.9	0.70	0.70	1086	1	0.84							0.60	17.1	45.2	88.1	14.8	8.1	**14.8**
E3	17.8	466	0.002	89.7	0.77	0.71	1552	1	0.86							0.60	12.9	58.1	75.1	16.1	1.2	**16.1**
E4	11.7	431	0.002	173.7	0.66	0.70	1983	1	0.84							0.60	12.0	70.1	66.7	27.1	11.1	**27.1**
F1	80.1	1132	0.003	80.1	0.48	0.48	1132	1	0.57	overland		0.045	97.42	0.003	29.0	0.60	31.4	60.5	73.2	9.3	9.3	**9.3**
F2	74.6	1021	0.002	154.7	0.41	0.44	2153	1	0.53							0.60	28.4	88.8	56.5	12.9	3.6	**12.9**
F3	57.0	695	0.002	366.4	0.39	0.44	2848	1	0.52							0.60	19.3	108.1	49.2	26.2	13.3	**26.2**

Table G.1 1 in 100 AEP Chinchilla 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)
F4	81.6	804	0.002	448.0	0.40	0.43	3652	1	0.51							0.60	22.3	130.5	43.0	27.5	1.3	**27.5**
G1	4.8	442	0.005	4.8	0.70	0.70	442	1	0.84	Std. Inlet	15					0.60	12.3	27.3	118.3	1.3	1.3	**1.3**
G2	3.7	391	0.002	8.5	0.70	0.70	833	1	0.84							0.60	10.9	38.1	97.6	1.9	0.6	**1.9**
G3	9.4	412	0.002	56.3	0.70	0.70	1245	1	0.84							0.60	11.4	49.6	83.1	10.9	9.0	**10.9**
GN1	5.3	442	0.002	5.3	0.70	0.70	442	1	0.84	Std. Inlet	15					0.60	12.3	27.3	118.3	1.5	1.5	**1.5**
GN2	4.1	391	0.002	9.4	0.70	0.70	833	1	0.84							0.60	10.9	38.1	97.6	2.1	0.7	**2.1**
H1	215.0	1807	0.003	215.0	0.41	0.41	1807	1	0.49	overland		0.045	97.2	0.003	28.5	0.60	50.2	78.7	61.5	17.9	17.9	**17.9**
H2	105.2	1091	0.002	320.2	0.39	0.40	2898	1	0.48							0.60	30.3	109.0	48.9	20.9	3.0	**20.9**
I1	24.0	425	0.006	24.0	0.49	0.49	425	1	0.58	overland		0.045	94	0.006	24.2	0.60	11.8	36.0	101.0	3.9	3.9	**3.9**
I2	38.1	709	0.002	62.0	0.40	0.43	1134	1	0.52							0.60	19.7	55.7	77.2	6.9	3.0	**6.9**
I3	19.3	704	0.002	81.3	0.43	0.43	1838	1	0.52							0.60	19.6	75.3	63.2	7.4	0.5	**7.4**
I4	13.1	341	0.002	94.5	0.40	0.43	2179	1	0.51							0.60	9.5	84.7	58.5	7.9	0.5	**7.9**
J1	21.5	485	0.005	21.5	0.46	0.46	485	1	0.56	overland		0.045	94.8	0.005	25.0	0.60	13.5	38.5	97.1	3.2	3.2	**3.2**
J2	27.2	340	0.002	48.7	0.53	0.50	825	1	0.60							0.60	9.4	47.9	85.0	6.9	3.7	**6.9**
J3	19.6	755	0.002	68.3	0.69	0.56	1580	1	0.67							0.60	21.0	68.9	67.5	8.5	1.6	**8.5**
K1	14.4	269	0.002	14.4	0.55	0.55	269	1	0.66	overland		0.045	97.6	0.002	29.4	0.60	7.5	36.9	99.5	2.6	2.6	**2.6**
K2	8.1	450	0.002	22.5	0.66	0.59	719	1	0.70							0.60	12.5	49.4	83.3	3.7	1.1	**3.7**
K3	15.9	547	0.002	77.5	0.70	0.66	1266	1	0.79							0.60	15.2	64.6	70.4	12.0	8.3	**12.0**
L1	28.0	611	0.002	28.0	0.70	0.70	611	1	0.84	Std. Inlet	15					0.60	17.0	32.0	108.2	7.1	7.1	**7.1**
M1	16.5	442	0.010	16.5	0.47	0.47	442	1	0.56	overland		0.045	90.4	0.010	21.8	0.60	12.3	34.0	104.4	2.7	2.7	**2.7**
M2	40.8	588	0.002	57.3	0.43	0.44	1030	1	0.53							0.60	16.3	50.4	82.3	7.0	4.3	**7.0**
N1	4.8	280	0.005	4.8	0.70	0.70	280	1	0.84	overland		0.045	94.7	0.005	24.9	0.60	7.8	32.7	106.9	1.2	1.2	**1.2**
N2	23.0	472	0.002	27.8	0.70	0.70	752	1	0.84							0.60	13.1	45.8	87.4	5.7	4.5	**5.7**
N3	22.3	395	0.002	50.1	0.70	0.70	1147	1	0.84							0.60	11.0	56.7	76.3	8.9	3.2	**8.9**
N4	22.7	427	0.002	72.9	0.70	0.70	1574	1	0.84							0.60	11.9	68.6	67.7	11.5	2.6	**11.5**
N6	43.0	320	0.002	191.7	0.48	0.65	1894	1	0.78							0.60	8.9	77.5	62.1	25.8	14.3	**25.8**
N7	39.0	583	0.002	678.8	0.48	0.49	2477	1	0.59							0.60	16.2	93.7	54.5	60.9	35.1	**60.9**
N8	92.2	888	0.002	824.1	0.45	0.48	3365	1	0.58							0.60	24.7	118.4	46.1	61.3	0.4	**61.3**
NG1	6.3	432	0.002	6.3	0.70	0.70	432	1	0.84	Std. Inlet	15					0.60	12.0	27.0	119.0	1.7	1.7	**1.7**
NG2	4.0	395	0.002	10.3	0.70	0.70	827	1	0.84							0.60	11.0	38.0	97.9	2.3	0.6	**2.3**
O1	146.2	1170	0.009	146.2	0.39	0.39	1170	1	0.47	overland		0.045	90.8	0.009	22.0	0.60	32.5	54.5	78.3	14.9	14.9	**14.9**
P1	7.4	268	0.007	7.4	0.39	0.39	268	1	0.47	overland		0.045	92.8	0.007	23.2	0.60	7.4	30.7	110.8	1.1	1.1	**1.1**
P2	12.8	358	0.004	20.2	0.39	0.39	626	1	0.47							0.60	9.9	40.6	94.0	2.5	1.4	**2.5**
Q1	4.7	219	0.012	4.7	0.39	0.39	219	1	0.47	overland		0.045	88	0.012	20.6	0.60	6.1	26.7	119.7	0.7	0.7	**0.7**
R1	11.8	414	0.014	11.8	0.67	0.67	414	1	0.81	overland		0.045	86	0.014	19.8	0.60	11.5	31.3	109.5	2.9	2.9	**2.9**
S1	21.8	355	0.002	21.8	0.77	0.77	355	1	0.93	overland		0.045	98	0.002	30.6	0.60	9.9	40.4	94.3	5.3	5.3	**5.3**
T1	16.2	393	0.017	16.2	0.39	0.39	393	1	0.47	overland		0.045	82.6	0.017	18.7	0.60	10.9	29.7	112.9	2.4	2.4	**2.4**
T2	12.4	257	0.002	28.6	0.51	0.44	650	1	0.53							0.60	7.1	36.8	99.7	4.2	1.8	**4.2**
U1	17.9	466	0.002	17.9	0.68	0.68	466	1	0.81	overland		0.045	98	0.002	30.6	0.60	12.9	43.5	90.2	3.6	3.6	**3.6**
U2	9.3	442	0.003	27.2	0.70	0.68	908	1	0.82							0.60	12.3	55.8	77.1	4.8	1.1	**4.8**
U3	29.1	681	0.002	56.3	0.85	0.77	1589	1	0.92							0.60	18.9	74.7	63.6	9.2	4.4	**9.2**
U4	11.2	337	0.002	67.5	0.64	0.75	1926	1	0.90							0.60	9.4	84.1	58.9	9.9	0.7	**9.9**
V1	17.5	412	0.025	17.5	0.63	0.63	412	1	0.76	overland		0.045	75	0.025	16.9	0.60	11.4	28.3	115.9	4.3	4.3	**4.3**
W1	6.2	285	0.002	6.2	0.78	0.78	285	1	0.94	Std. Inlet	15					0.60	7.9	22.9	130.0	2.1	2.1	**2.1**
W2	7.9	301	0.002	14.0	0.80	0.79	586	1	0.95							0.60	8.4	31.3	109.6	4.1	2.0	**4.1**
W3	15.9	507	0.002	55.6	0.82	0.82	1093	1	0.98							0.60	14.1	45.4	87.9	13.3	9.2	**13.3**
W4	9.2	354	0.002	64.8	0.47	0.77	1447	1	0.92							0.60	9.8	55.2	77.6	12.9	-0.4	**13.3**

Table G.1 1 in 100 AEP Chinchilla 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)
WE1	4.6	194	0.002	4.6	0.75	0.75	194	1	0.90	Std. Inlet	15					0.60	5.4	20.4	138.2	1.6	1.6	**1.6**
X1	24.5	556	0.018	24.5	0.39	0.39	556	1	0.47	overland		0.045	82.4	0.018	18.7	0.60	15.4	34.1	104.2	3.3	3.3	**3.3**
X2	5.7	591	0.002	30.2	0.62	0.43	1147	1	0.52							0.60	16.4	50.5	82.1	3.6	0.3	**3.6**
Z1	11.1	343	0.002	11.1	0.84	0.84	343	1	1.01	Std. Inlet	15					0.60	9.5	24.5	125.4	3.9	3.9	**3.9**
Z2	6.1	389	0.002	17.2	0.85	0.85	732	1	1.01							0.60	10.8	35.3	102.1	5.0	1.0	**5.0**
ZW1	3.8	287	0.000	3.8	0.85	0.85	287	1	1.02	Std. Inlet	15					0.60	8.0	23.0	129.8	1.4	1.4	**1.4**

Table G.2 1 in 50 AEP Chinchilla 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	23.6	513	0.004	23.6	0.39	0.39	513	1	0.45	overland		0.045	95.7	0.004	26.0	0.60	14.3	40.3	85.0	2.5	2.5	**2.5**
A2	96.2	1788	0.002	119.8	0.39	0.39	2301	1	0.45							0.60	49.7	90.0	50.3	7.5	5.0	**7.5**
A3	37.8	816	0.002	157.6	0.39	0.39	3117	1	0.45							0.60	22.7	112.6	43.0	8.5	0.9	**8.5**
AA1	18.6	539	0.006	18.6	0.39	0.39	539	1	0.45	overland		0.045	94.5	0.006	24.7	0.60	15.0	39.7	85.8	2.0	2.0	**2.0**
AA2	9.6	342	0.002	28.1	0.39	0.39	881	1	0.45							0.60	9.5	49.2	75.3	2.6	0.7	**2.6**
AB1	12.6	492	0.006	12.6	0.39	0.39	492	1	0.45	overland		0.045	94.4	0.006	24.6	0.60	13.7	38.2	87.7	1.4	1.4	**1.4**
AB2	6.4	418	0.002	19.0	0.39	0.39	910	1	0.45							0.60	11.6	49.9	74.5	1.8	0.4	**1.8**
AC1	13.3	770	0.002	13.3	0.75	0.75	770	1	0.86	Std. Inlet	15					0.60	21.4	36.4	90.3	2.9	2.9	**2.9**
AC2	6.3	313	0.002	19.6	0.75	0.75	1083	1	0.86							0.60	8.7	45.1	79.4	3.7	0.9	**3.7**
AC3	10.5	496	0.002	58.6	0.78	0.74	1579	1	0.85							0.60	13.8	58.9	67.1	9.3	5.6	**9.3**
AD1	14.1	544	0.007	14.1	0.83	0.83	544	1	0.95	Std. Inlet	15					0.60	15.1	30.1	100.7	3.8	3.8	**3.8**
AE1	5.4	316	0.002	5.4	0.72	0.72	316	1	0.83	overland		0.045	98	0.002	30.6	0.60	8.8	39.4	86.2	1.1	1.1	**1.1**
AF1	39.8	304	0.011	39.8	0.70	0.70	304	1	0.80	Std. Inlet	15					0.60	8.4	23.4	115.3	10.3	10.3	**10.3**
AF2	32.5	703	0.002	72.3	0.69	0.70	1007	1	0.80							0.60	19.5	43.0	81.8	13.1	2.9	**13.1**
AG1	53.2	915	0.015	53.2	0.43	0.43	915	1	0.49	overland		0.045	85.2	0.015	19.6	0.60	25.4	45.0	79.5	5.8	5.8	**5.8**
AI1	6.9	179	0.002	6.9	0.66	0.66	179	1	0.76	overland		0.045	98.5	0.002	32.4	0.60	5.0	37.4	88.8	1.3	1.3	**1.3**
AI2	12.3	395	0.002	19.1	0.70	0.69	574	1	0.79							0.60	11.0	48.4	76.0	3.2	1.9	**3.2**
AJ1	3.9	167	0.017	3.9	0.60	0.60	167	1	0.69	overland		0.045	83	0.017	18.9	0.60	4.6	23.5	115.2	0.9	0.9	**0.9**
AJ2	16.0	509	0.002	19.9	0.70	0.68	676	1	0.78							0.60	14.1	37.6	88.5	3.8	3.0	**3.8**
AK1	10.9	480	0.004	10.9	0.70	0.70	480	1	0.80	Std. Inlet	15					0.60	13.3	28.3	104.1	2.5	2.5	**2.5**
AK2	8.7	244	0.002	19.6	0.69	0.69	724	1	0.80							0.60	6.8	35.1	92.2	4.0	1.5	**4.0**
AL1	7.9	226	0.002	7.9	0.70	0.70	226	1	0.81	overland		0.045	97.72	0.002	29.8	0.60	6.3	36.0	90.8	1.6	1.6	**1.6**
AL2	17.6	576	0.002	25.5	0.70	0.70	802	1	0.81							0.60	16.0	52.0	72.6	4.1	2.5	**4.1**
B1	242.2	2500	0.002	242.2	0.39	0.39	2500	1	0.45	overland		0.045	98	0.002	30.6	0.60	69.4	100.0	46.8	14.1	14.1	**14.1**
B2	226.3	1054	0.002	468.5	0.39	0.39	3554	1	0.45							0.60	29.3	129.3	38.9	22.8	8.7	**22.8**
B3	114.2	854	0.002	582.7	0.39	0.39	4408	1	0.45							0.60	23.7	153.0	34.3	25.0	2.2	**25.0**
B4	41.6	879	0.002	671.4	0.43	0.39	5287	1	0.45							0.60	24.4	177.4	30.7	25.9	0.9	**25.9**
B5	16.2	354	0.002	1062.4	0.56	0.44	5641	1	0.51							0.60	9.8	187.3	29.5	44.1	18.1	**44.1**
B6	37.4	694	0.002	1148.4	0.61	0.45	6335	1	0.52							0.60	19.3	206.6	27.4	45.1	1.0	**45.1**
B7	29.7	435	0.002	1178.1	0.70	0.45	6770	1	0.52							0.60	12.1	218.6	26.3	45.0	-0.1	**45.1**
B8	18.3	410	0.002	1273.9	0.54	0.47	7180	1	0.54							0.60	11.4	230.0	25.3	48.2	3.2	**48.2**
B9	10.2	586	0.002	1437.1	0.39	0.48	7766	1	0.55							0.60	16.3	246.3	24.1	52.6	4.4	**52.6**
C1	108.2	775	0.004	108.2	0.43	0.43	775	1	0.50	overland		0.045	96.2	0.004	26.7	0.60	21.5	48.3	76.2	11.4	11.4	**11.4**
C2	138.5	1122	0.002	246.7	0.52	0.48	1897	1	0.55							0.60	31.2	79.4	55.0	20.9	9.5	**20.9**
C3	52.1	650	0.002	298.8	0.40	0.47	2547	1	0.54							0.60	18.1	97.5	47.7	21.3	0.4	**21.3**
C4	8.4	360	0.002	374.7	0.47	0.52	2907	1	0.60							0.60	10.0	107.5	44.4	27.5	6.3	**27.5**
D1	5.8	305	0.007	5.8	0.74	0.74	305	1	0.85	Std. Inlet	15					0.60	8.5	23.5	115.3	1.6	1.6	**1.6**
D2	16.0	330	0.002	21.7	0.70	0.71	635	1	0.82							0.60	9.2	32.6	96.2	4.8	3.2	**4.8**
D3	6.7	399	0.002	28.4	0.75	0.72	1034	1	0.83							0.60	11.1	43.7	81.0	5.3	0.5	**5.3**
E1	24.5	471	0.011	24.5	0.71	0.71	471	1	0.81	Std. Inlet	15					0.60	13.1	28.1	104.6	5.8	5.8	**5.8**
E2	47.5	615	0.002	71.9	0.70	0.70	1086	1	0.81							0.60	17.1	45.2	79.3	12.8	7.0	**12.8**
E3	17.8	466	0.002	89.7	0.77	0.71	1552	1	0.82							0.60	12.9	58.1	67.6	13.9	1.1	**13.9**
E4	11.7	431	0.002	173.7	0.66	0.70	1983	1	0.81							0.60	12.0	70.1	60.0	23.4	9.6	**23.4**
F1	80.1	1132	0.003	80.1	0.48	0.48	1132	1	0.55	overland		0.045	97.42	0.003	29.0	0.60	31.4	60.5	65.9	8.0	8.0	**8.0**
F2	74.6	1021	0.002	154.7	0.41	0.44	2153	1	0.51							0.60	28.4	88.8	50.8	11.1	3.1	**11.1**
F3	57.0	695	0.002	366.4	0.39	0.44	2848	1	0.50							0.60	19.3	108.1	44.2	22.5	11.4	**22.5**
F4	81.6	804	0.002	448.0	0.40	0.43	3652	1	0.49							0.60	22.3	130.5	38.6	23.7	1.1	**23.7**

Table G.2 1 in 50 AEP Chinchilla 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)
G1	4.8	442	0.005	4.8	0.70	0.70	442	1	0.81	Std. Inlet	15					0.60	12.3	27.3	106.3	1.1	1.1	**1.1**
G2	3.7	391	0.002	8.5	0.70	0.70	833	1	0.81							0.60	10.9	38.1	87.8	1.7	0.5	**1.7**
G3	9.4	412	0.002	56.3	0.70	0.70	1245	1	0.80							0.60	11.4	49.6	74.8	9.4	7.7	**9.4**
GN1	5.3	442	0.002	5.3	0.70	0.70	442	1	0.81	Std. Inlet	15					0.60	12.3	27.3	106.3	1.3	1.3	**1.3**
GN2	4.1	391	0.002	9.4	0.70	0.70	833	1	0.81							0.60	10.9	38.1	87.8	1.8	0.6	**1.8**
H1	215.0	1807	0.003	215.0	0.41	0.41	1807	1	0.47	overland		0.045	97.2	0.003	28.5	0.60	50.2	78.7	55.4	15.4	15.4	**15.4**
H2	105.2	1091	0.002	320.2	0.39	0.40	2898	1	0.46							0.60	30.3	109.0	44.0	18.0	2.6	**18.0**
I1	24.0	425	0.006	24.0	0.49	0.49	425	1	0.56	overland		0.045	94	0.006	24.2	0.60	11.8	36.0	90.8	3.4	3.4	**3.4**
I2	38.1	709	0.002	62.0	0.40	0.43	1134	1	0.50							0.60	19.7	55.7	69.5	6.0	2.6	**6.0**
I3	19.3	704	0.002	81.3	0.43	0.43	1838	1	0.50							0.60	19.6	75.3	56.9	6.4	0.4	**6.4**
I4	13.1	341	0.002	94.5	0.40	0.43	2179	1	0.49							0.60	9.5	84.7	52.7	6.8	0.4	**6.8**
J1	21.5	485	0.005	21.5	0.46	0.46	485	1	0.53	overland		0.045	94.8	0.005	25.0	0.60	13.5	38.5	87.4	2.8	2.8	**2.8**
J2	27.2	340	0.002	48.7	0.53	0.50	825	1	0.58							0.60	9.4	47.9	76.5	6.0	3.2	**6.0**
J3	19.6	755	0.002	68.3	0.69	0.56	1580	1	0.64							0.60	21.0	68.9	60.8	7.4	1.4	**7.4**
K1	14.4	269	0.002	14.4	0.55	0.55	269	1	0.63	overland		0.045	97.6	0.002	29.4	0.60	7.5	36.9	89.5	2.3	2.3	**2.3**
K2	8.1	450	0.002	22.5	0.66	0.59	719	1	0.67							0.60	12.5	49.4	75.0	3.2	0.9	**3.2**
K3	15.9	547	0.002	77.5	0.70	0.66	1266	1	0.76							0.60	15.2	64.6	63.4	10.3	7.2	**10.3**
L1	28.0	611	0.002	28.0	0.70	0.70	611	1	0.81	Std. Inlet	15					0.60	17.0	32.0	97.3	6.1	6.1	**6.1**
M1	16.5	442	0.010	16.5	0.47	0.47	442	1	0.54	overland		0.045	90.4	0.010	21.8	0.60	12.3	34.0	93.9	2.3	2.3	**2.3**
M2	40.8	588	0.002	57.3	0.43	0.44	1030	1	0.51							0.60	16.3	50.4	74.1	6.0	3.7	**6.0**
N1	4.8	280	0.005	4.8	0.70	0.70	280	1	0.81	overland		0.045	94.7	0.005	24.9	0.60	7.8	32.7	96.2	1.0	1.0	**1.0**
N2	23.0	472	0.002	27.8	0.70	0.70	752	1	0.81							0.60	13.1	45.8	78.7	4.9	3.9	**4.9**
N3	22.3	395	0.002	50.1	0.70	0.70	1147	1	0.81							0.60	11.0	56.7	68.7	7.7	2.8	**7.7**
N4	22.7	427	0.002	72.9	0.70	0.70	1574	1	0.80							0.60	11.9	68.6	60.9	9.9	2.2	**9.9**
N6	43.0	320	0.002	191.7	0.48	0.65	1894	1	0.75							0.60	8.9	77.5	55.9	22.3	12.3	**22.3**
N7	39.0	583	0.002	678.8	0.48	0.49	2477	1	0.57							0.60	16.2	93.7	49.0	52.5	30.2	**52.5**
N8	92.2	888	0.002	824.1	0.45	0.48	3365	1	0.56							0.60	24.7	118.4	41.4	52.8	0.3	**52.8**
NG1	6.3	432	0.002	6.3	0.70	0.70	432	1	0.81	Std. Inlet	15					0.60	12.0	27.0	106.9	1.5	1.5	**1.5**
NG2	4.0	395	0.002	10.3	0.70	0.70	827	1	0.81							0.60	11.0	38.0	88.0	2.0	0.5	**2.0**
O1	146.2	1170	0.009	146.2	0.39	0.39	1170	1	0.45	overland		0.045	90.8	0.009	22.0	0.60	32.5	54.5	70.5	12.8	12.8	**12.8**
P1	7.4	268	0.007	7.4	0.39	0.39	268	1	0.45	overland		0.045	92.8	0.007	23.2	0.60	7.4	30.7	99.6	0.9	0.9	**0.9**
P2	12.8	358	0.004	20.2	0.39	0.39	626	1	0.45							0.60	9.9	40.6	84.6	2.1	1.2	**2.1**
Q1	4.7	219	0.012	4.7	0.39	0.39	219	1	0.45	overland		0.045	88	0.012	20.6	0.60	6.1	26.7	107.6	0.6	0.6	**0.6**
R1	11.8	414	0.014	11.8	0.67	0.67	414	1	0.77	overland		0.045	86	0.014	19.8	0.60	11.5	31.3	98.4	2.5	2.5	**2.5**
S1	21.8	355	0.002	21.8	0.77	0.77	355	1	0.89	overland		0.045	98	0.002	30.6	0.60	9.9	40.4	84.8	4.6	4.6	**4.6**
T1	16.2	393	0.017	16.2	0.39	0.39	393	1	0.45	overland		0.045	82.6	0.017	18.7	0.60	10.9	29.7	101.5	2.0	2.0	**2.0**
T2	12.4	257	0.002	28.6	0.51	0.44	650	1	0.51							0.60	7.1	36.8	89.7	3.6	1.6	**3.6**
U1	17.9	466	0.002	17.9	0.68	0.68	466	1	0.78	overland		0.045	98	0.002	30.6	0.60	12.9	43.5	81.2	3.1	3.1	**3.1**
U2	9.3	442	0.003	27.2	0.70	0.68	908	1	0.79							0.60	12.3	55.8	69.4	4.1	1.0	**4.1**
U3	29.1	681	0.002	56.3	0.85	0.77	1589	1	0.89							0.60	18.9	74.7	57.2	7.9	3.8	**7.9**
U4	11.2	337	0.002	67.5	0.64	0.75	1926	1	0.86							0.60	9.4	84.1	53.0	8.5	0.6	**8.5**
V1	17.5	412	0.025	17.5	0.63	0.63	412	1	0.73	overland		0.045	75	0.025	16.9	0.60	11.4	28.3	104.1	3.7	3.7	**3.7**
W1	6.2	285	0.002	6.2	0.78	0.78	285	1	0.90	Std. Inlet	15					0.60	7.9	22.9	116.7	1.8	1.8	**1.8**
W2	7.9	301	0.002	14.0	0.80	0.79	586	1	0.91							0.60	8.4	31.3	98.5	3.5	1.7	**3.5**
W3	15.9	507	0.002	55.6	0.82	0.82	1093	1	0.94							0.60	14.1	45.4	79.1	11.5	8.0	**11.5**
W4	9.2	354	0.002	64.8	0.47	0.77	1447	1	0.88							0.60	9.8	55.2	69.9	11.1	-0.4	**11.5**
WE1	4.6	194	0.002	4.6	0.75	0.75	194	1	0.86	Std. Inlet	15					0.60	5.4	20.4	124.0	1.4	1.4	**1.4**

Table G.2 1 in 50 AEP Chinchilla 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)
X1	24.5	556	0.018	24.5	0.39	0.39	556	1	0.45	overland		0.045	82.4	0.018	18.7	0.60	15.4	34.1	93.7	2.9	2.9	**2.9**
X2	5.7	591	0.002	30.2	0.62	0.43	1147	1	0.50							0.60	16.4	50.5	73.9	3.1	0.2	**3.1**
Z1	11.1	343	0.002	11.1	0.84	0.84	343	1	0.97	Std. Inlet	15					0.60	9.5	24.5	112.6	3.4	3.4	**3.4**
Z2	6.1	389	0.002	17.2	0.85	0.85	732	1	0.97							0.60	10.8	35.3	91.9	4.3	0.9	**4.3**
ZW1	3.8	287	0.000	3.8	0.85	0.85	287	1	0.98	Std. Inlet	15					0.60	8.0	23.0	116.6	1.2	1.2	**1.2**

Table G.3 1 in 10 AEP Chinchilla 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	23.6	513	0.004	23.6	0.39	0.39	513	1	0.39	overland		0.045	95.7	0.004	26.0	0.60	14.3	40.3	63.8	1.6	1.6	**1.6**
A2	96.2	1788	0.002	119.8	0.39	0.39	2301	1	0.39							0.60	49.7	90.0	37.7	4.9	3.3	**4.9**
A3	37.8	816	0.002	157.6	0.39	0.39	3117	1	0.39							0.60	22.7	112.6	32.2	5.5	0.6	**5.5**
AA1	18.6	539	0.006	18.6	0.39	0.39	539	1	0.39	overland		0.045	94.5	0.006	24.7	0.60	15.0	39.7	64.4	1.3	1.3	**1.3**
AA2	9.6	342	0.002	28.1	0.39	0.39	881	1	0.39							0.60	9.5	49.2	56.5	1.7	0.4	**1.7**
AB1	12.6	492	0.006	12.6	0.39	0.39	492	1	0.39	overland		0.045	94.4	0.006	24.6	0.60	13.7	38.2	65.8	0.9	0.9	**0.9**
AB2	6.4	418	0.002	19.0	0.39	0.39	910	1	0.39							0.60	11.6	49.9	56.0	1.2	0.3	**1.2**
AC1	13.3	770	0.002	13.3	0.75	0.75	770	1	0.75	Std. Inlet	15					0.60	21.4	36.4	67.8	1.9	1.9	**1.9**
AC2	6.3	313	0.002	19.6	0.75	0.75	1083	1	0.75							0.60	8.7	45.1	59.6	2.4	0.6	**2.4**
AC3	10.5	496	0.002	58.6	0.78	0.74	1579	1	0.74							0.60	13.8	58.9	50.4	6.1	3.6	**6.1**
AD1	14.1	544	0.007	14.1	0.83	0.83	544	1	0.83	Std. Inlet	15					0.60	15.1	30.1	75.4	2.4	2.4	**2.4**
AE1	5.4	316	0.002	5.4	0.72	0.72	316	1	0.72	overland		0.045	98	0.002	30.6	0.60	8.8	39.4	64.7	0.7	0.7	**0.7**
AF1	39.8	304	0.011	39.8	0.70	0.70	304	1	0.70	Std. Inlet	15					0.60	8.4	23.4	86.2	6.7	6.7	**6.7**
AF2	32.5	703	0.002	72.3	0.69	0.70	1007	1	0.70							0.60	19.5	43.0	61.5	8.6	1.9	**8.6**
AG1	53.2	915	0.015	53.2	0.43	0.43	915	1	0.43	overland		0.045	85.2	0.015	19.6	0.60	25.4	45.0	59.7	3.8	3.8	**3.8**
AI1	6.9	179	0.002	6.9	0.66	0.66	179	1	0.66	overland		0.045	98.5	0.002	32.4	0.60	5.0	37.4	66.7	0.8	0.8	**0.8**
AI2	12.3	395	0.002	19.1	0.70	0.69	574	1	0.69							0.60	11.0	48.4	57.1	2.1	1.2	**2.1**
AJ1	3.9	167	0.017	3.9	0.60	0.60	167	1	0.60	overland		0.045	83	0.017	18.9	0.60	4.6	23.5	86.1	0.6	0.6	**0.6**
AJ2	16.0	509	0.002	19.9	0.70	0.68	676	1	0.68							0.60	14.1	37.6	66.4	2.5	1.9	**2.5**
AK1	10.9	480	0.004	10.9	0.70	0.70	480	1	0.70	Std. Inlet	15					0.60	13.3	28.3	78.0	1.6	1.6	**1.6**
AK2	8.7	244	0.002	19.6	0.69	0.69	724	1	0.69							0.60	6.8	35.1	69.2	2.6	1.0	**2.6**
AL1	7.9	226	0.002	7.9	0.70	0.70	226	1	0.70	overland		0.045	97.72	0.002	29.8	0.60	6.3	36.0	68.1	1.0	1.0	**1.0**
AL2	17.6	576	0.002	25.5	0.70	0.70	802	1	0.70							0.60	16.0	52.0	54.6	2.7	1.7	**2.7**
B1	242.2	2500	0.002	242.2	0.39	0.39	2500	1	0.39	overland		0.045	98	0.002	30.6	0.60	69.4	100.0	35.1	9.2	9.2	**9.2**
B2	226.3	1054	0.002	468.5	0.39	0.39	3554	1	0.39							0.60	29.3	129.3	29.0	14.8	5.6	**14.8**
B3	114.2	854	0.002	582.7	0.39	0.39	4408	1	0.39							0.60	23.7	153.0	25.6	16.2	1.4	**16.2**
B4	41.6	879	0.002	671.4	0.43	0.39	5287	1	0.39							0.60	24.4	177.4	22.9	16.8	0.6	**16.8**
B5	16.2	354	0.002	1062.4	0.56	0.44	5641	1	0.44							0.60	9.8	187.3	21.9	28.5	11.7	**28.5**
B6	37.4	694	0.002	1148.4	0.61	0.45	6335	1	0.45							0.60	19.3	206.6	20.4	29.1	0.6	**29.1**
B7	29.7	435	0.002	1178.1	0.70	0.45	6770	1	0.45							0.60	12.1	218.6	19.5	29.0	-0.1	**29.1**
B8	18.3	410	0.002	1273.9	0.54	0.47	7180	1	0.47							0.60	11.4	230.0	18.7	31.0	2.1	**31.0**
B9	10.2	586	0.002	1437.1	0.39	0.48	7766	1	0.48							0.60	16.3	246.3	17.8	33.8	2.8	**33.8**
C1	108.2	775	0.004	108.2	0.43	0.43	775	1	0.43	overland		0.045	96.2	0.004	26.7	0.60	21.5	48.3	57.2	7.4	7.4	**7.4**
C2	138.5	1122	0.002	246.7	0.52	0.48	1897	1	0.48							0.60	31.2	79.4	41.3	13.6	6.2	**13.6**
C3	52.1	650	0.002	298.8	0.40	0.47	2547	1	0.47							0.60	18.1	97.5	35.7	13.9	0.2	**13.9**
C4	8.4	360	0.002	374.7	0.47	0.52	2907	1	0.52							0.60	10.0	107.5	33.2	17.9	4.1	**17.9**
D1	5.8	305	0.007	5.8	0.74	0.74	305	1	0.74	Std. Inlet	15					0.60	8.5	23.5	86.1	1.0	1.0	**1.0**
D2	16.0	330	0.002	21.7	0.70	0.71	635	1	0.71							0.60	9.2	32.6	72.1	3.1	2.1	**3.1**
D3	6.7	399	0.002	28.4	0.75	0.72	1034	1	0.72							0.60	11.1	43.7	60.8	3.5	0.4	**3.5**
E1	24.5	471	0.011	24.5	0.71	0.71	471	1	0.71	Std. Inlet	15					0.60	13.1	28.1	78.3	3.8	3.8	**3.8**
E2	47.5	615	0.002	71.9	0.70	0.70	1086	1	0.70							0.60	17.1	45.2	59.6	8.4	4.6	**8.4**
E3	17.8	466	0.002	89.7	0.77	0.71	1552	1	0.71							0.60	12.9	58.1	50.8	9.0	0.7	**9.0**
E4	11.7	431	0.002	173.7	0.66	0.70	1983	1	0.70							0.60	12.0	70.1	45.1	15.3	6.2	**15.3**
F1	80.1	1132	0.003	80.1	0.48	0.48	1132	1	0.48	overland		0.045	97.42	0.003	29.0	0.60	31.4	60.5	49.5	5.2	5.2	**5.2**
F2	74.6	1021	0.002	154.7	0.41	0.44	2153	1	0.44							0.60	28.4	88.8	38.1	7.3	2.0	**7.3**
F3	57.0	695	0.002	366.4	0.39	0.44	2848	1	0.44							0.60	19.3	108.1	33.1	14.7	7.4	**14.7**
F4	81.6	804	0.002	448.0	0.40	0.43	3652	1	0.43							0.60	22.3	130.5	28.8	15.4	0.7	**15.4**

Table G.3 1 in 10 AEP Chinchilla 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)
G1	4.8	442	0.005	4.8	0.70	0.70	442	1	0.70	Std. Inlet	15					0.60	12.3	27.3	79.6	0.7	0.7	**0.7**
G2	3.7	391	0.002	8.5	0.70	0.70	833	1	0.70							0.60	10.9	38.1	65.9	1.1	0.4	**1.1**
G3	9.4	412	0.002	56.3	0.70	0.70	1245	1	0.70							0.60	11.4	49.6	56.2	6.1	5.1	**6.1**
GN1	5.3	442	0.002	5.3	0.70	0.70	442	1	0.70	Std. Inlet	15					0.60	12.3	27.3	79.6	0.8	0.8	**0.8**
GN2	4.1	391	0.002	9.4	0.70	0.70	833	1	0.70							0.60	10.9	38.1	65.9	1.2	0.4	**1.2**
H1	215.0	1807	0.003	215.0	0.41	0.41	1807	1	0.41	overland		0.045	97.2	0.003	28.5	0.60	50.2	78.7	41.5	10.1	10.1	**10.1**
H2	105.2	1091	0.002	320.2	0.39	0.40	2898	1	0.40							0.60	30.3	109.0	32.9	11.7	1.7	**11.7**
I1	24.0	425	0.006	24.0	0.49	0.49	425	1	0.49	overland		0.045	94	0.006	24.2	0.60	11.8	36.0	68.2	2.2	2.2	**2.2**
I2	38.1	709	0.002	62.0	0.40	0.43	1134	1	0.43							0.60	19.7	55.7	52.2	3.9	1.7	**3.9**
I3	19.3	704	0.002	81.3	0.43	0.43	1838	1	0.43							0.60	19.6	75.3	42.7	4.2	0.3	**4.2**
I4	13.1	341	0.002	94.5	0.40	0.43	2179	1	0.43							0.60	9.5	84.7	39.5	4.4	0.3	**4.4**
J1	21.5	485	0.005	21.5	0.46	0.46	485	1	0.46	overland		0.045	94.8	0.005	25.0	0.60	13.5	38.5	65.6	1.8	1.8	**1.8**
J2	27.2	340	0.002	48.7	0.53	0.50	825	1	0.50							0.60	9.4	47.9	57.5	3.9	2.1	**3.9**
J3	19.6	755	0.002	68.3	0.69	0.56	1580	1	0.56							0.60	21.0	68.9	45.6	4.8	0.9	**4.8**
K1	14.4	269	0.002	14.4	0.55	0.55	269	1	0.55	overland		0.045	97.6	0.002	29.4	0.60	7.5	36.9	67.2	1.5	1.5	**1.5**
K2	8.1	450	0.002	22.5	0.66	0.59	719	1	0.59							0.60	12.5	49.4	56.3	2.1	0.6	**2.1**
K3	15.9	547	0.002	77.5	0.70	0.66	1266	1	0.66							0.60	15.2	64.6	47.6	6.7	4.7	**6.7**
L1	28.0	611	0.002	28.0	0.70	0.70	611	1	0.70	Std. Inlet	15					0.60	17.0	32.0	72.9	4.0	4.0	**4.0**
M1	16.5	442	0.010	16.5	0.47	0.47	442	1	0.47	overland		0.045	90.4	0.010	21.8	0.60	12.3	34.0	70.4	1.5	1.5	**1.5**
M2	40.8	588	0.002	57.3	0.43	0.44	1030	1	0.44							0.60	16.3	50.4	55.7	3.9	2.4	**3.9**
N1	4.8	280	0.005	4.8	0.70	0.70	280	1	0.70	overland		0.045	94.7	0.005	24.9	0.60	7.8	32.7	72.1	0.7	0.7	**0.7**
N2	23.0	472	0.002	27.8	0.70	0.70	752	1	0.70							0.60	13.1	45.8	59.1	3.2	2.5	**3.2**
N3	22.3	395	0.002	50.1	0.70	0.70	1147	1	0.70							0.60	11.0	56.7	51.6	5.0	1.8	**5.0**
N4	22.7	427	0.002	72.9	0.70	0.70	1574	1	0.70							0.60	11.9	68.6	45.8	6.5	1.5	**6.5**
N6	43.0	320	0.002	191.7	0.48	0.65	1894	1	0.65							0.60	8.9	77.5	42.0	14.5	8.0	**14.5**
N7	39.0	583	0.002	678.8	0.48	0.49	2477	1	0.49							0.60	16.2	93.7	36.7	34.2	19.7	**34.2**
N8	92.2	888	0.002	824.1	0.45	0.48	3365	1	0.48							0.60	24.7	118.4	31.0	34.3	0.1	**34.3**
NG1	6.3	432	0.002	6.3	0.70	0.70	432	1	0.70	Std. Inlet	15					0.60	12.0	27.0	80.0	1.0	1.0	**1.0**
NG2	4.0	395	0.002	10.3	0.70	0.70	827	1	0.70							0.60	11.0	38.0	66.1	1.3	0.3	**1.3**
O1	146.2	1170	0.009	146.2	0.39	0.39	1170	1	0.39	overland		0.045	90.8	0.009	22.0	0.60	32.5	54.5	53.0	8.4	8.4	**8.4**
P1	7.4	268	0.007	7.4	0.39	0.39	268	1	0.39	overland		0.045	92.8	0.007	23.2	0.60	7.4	30.7	74.7	0.6	0.6	**0.6**
P2	12.8	358	0.004	20.2	0.39	0.39	626	1	0.39							0.60	9.9	40.6	63.5	1.4	0.8	**1.4**
Q1	4.7	219	0.012	4.7	0.39	0.39	219	1	0.39	overland		0.045	88	0.012	20.6	0.60	6.1	26.7	80.5	0.4	0.4	**0.4**
R1	11.8	414	0.014	11.8	0.67	0.67	414	1	0.67	overland		0.045	86	0.014	19.8	0.60	11.5	31.3	73.8	1.6	1.6	**1.6**
S1	21.8	355	0.002	21.8	0.77	0.77	355	1	0.77	overland		0.045	98	0.002	30.6	0.60	9.9	40.4	63.7	3.0	3.0	**3.0**
T1	16.2	393	0.017	16.2	0.39	0.39	393	1	0.39	overland		0.045	82.6	0.017	18.7	0.60	10.9	29.7	76.1	1.3	1.3	**1.3**
T2	12.4	257	0.002	28.6	0.51	0.44	650	1	0.44							0.60	7.1	36.8	67.3	2.4	1.0	**2.4**
U1	17.9	466	0.002	17.9	0.68	0.68	466	1	0.68	overland		0.045	98	0.002	30.6	0.60	12.9	43.5	61.0	2.0	2.0	**2.0**
U2	9.3	442	0.003	27.2	0.70	0.68	908	1	0.68							0.60	12.3	55.8	52.1	2.7	0.6	**2.7**
U3	29.1	681	0.002	56.3	0.85	0.77	1589	1	0.77							0.60	18.9	74.7	42.9	5.2	2.5	**5.2**
U4	11.2	337	0.002	67.5	0.64	0.75	1926	1	0.75							0.60	9.4	84.1	39.7	5.6	0.4	**5.6**
V1	17.5	412	0.025	17.5	0.63	0.63	412	1	0.63	overland		0.045	75	0.025	16.9	0.60	11.4	28.3	78.0	2.4	2.4	**2.4**
W1	6.2	285	0.002	6.2	0.78	0.78	285	1	0.78	Std. Inlet	15					0.60	7.9	22.9	87.2	1.2	1.2	**1.2**
W2	7.9	301	0.002	14.0	0.80	0.79	586	1	0.79							0.60	8.4	31.3	73.9	2.3	1.1	**2.3**
W3	15.9	507	0.002	55.6	0.82	0.82	1093	1	0.82							0.60	14.1	45.4	59.4	7.5	5.2	**7.5**
W4	9.2	354	0.002	64.8	0.47	0.77	1447	1	0.77							0.60	9.8	55.2	52.5	7.3	-0.2	**7.5**
WE1	4.6	194	0.002	4.6	0.75	0.75	194	1	0.75	Std. Inlet	15					0.60	5.4	20.4	92.4	0.9	0.9	**0.9**

Table G.3 1 in 10 AEP Chinchilla 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 (m³/s)	Difference (m³/s)	Corrected Discharge (for partial area effect) (m³/s)
X1	24.5	556	0.018	24.5	0.39	0.39	556	1	0.39	overland		0.045	82.4	0.018	18.7	0.60	15.4	34.1	70.3	1.9	1.9	**1.9**
X2	5.7	591	0.002	30.2	0.62	0.43	1147	1	0.43							0.60	16.4	50.5	55.5	2.0	0.2	**2.0**
Z1	11.1	343	0.002	11.1	0.84	0.84	343	1	0.84	Std. Inlet	15					0.60	9.5	24.5	84.2	2.2	2.2	**2.2**
Z2	6.1	389	0.002	17.2	0.85	0.85	732	1	0.85							0.60	10.8	35.3	68.9	2.8	0.6	**2.8**
ZW1	3.8	287	0.000	3.8	0.85	0.85	287	1	0.85	Std. Inlet	15					0.60	8.0	23.0	87.1	0.8	0.8	**0.8**