Floodplain Risk Management Study and Plan Report

Cessnock City (Black Creek)

W4951

Prepared for
Cessnock City Council

February 2016

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Foreword

The NSW Government *Flood Prone Land Policy* is directed towards providing solutions to existing flood problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the policy, the management of flood prone land is the responsibility of Local Government. The State Government subsidises flood management measures to alleviate existing flooding problems, and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities. The Commonwealth Government also assists with the subsidy of floodplain management measures.

The Policy identifies the following floodplain management 'process' for the identification and management of flood risks:

1. Formation of a Committee	Established by a Local Government body (Local Council) and includes community group representatives and State agency specialists.
2. Data Collection	The collection of data such as historical flood levels, rainfall records, land use, soil types etc.
3. Flood Study	Determines the nature and extent of the flooding problem.
4. Floodplain Risk Management Study	Evaluates floodplain management measures for the floodplain in respect of both existing and proposed development.
5. Floodplain Risk Management Plan	Involves formal adoption by Council of a management plan for the floodplain.
6. Implementation of the Plan	Implementation of actions to manage flood risks for existing and new development.

The Black Creek Flood Study was prepared by DHI Water and Environment (DHI, 2010). The flood study has been updated as part of the floodplain risk management study. This report has been prepared for Cessnock City Council by Cardno (NSW/ACT) Pty Ltd to examine floodplain risk management options in the Black Creek catchment (the fourth stage of the floodplain management process) to inform the preparation of the Floodplain Risk Management Plan, the fifth stage of the floodplain management process.

Executive Summary

Cessnock City Council has engaged Cardno (NSW/ACT) Pty Ltd to prepare the Black Creek Floodplain Risk Management Study (Chapter 2 to Chapter 14 of this report) and the Black Creek Floodplain Risk Management Plan (Chapter 15 of this report) in accordance with the NSW Government *Floodplain Development Manual* (NSW Government, 2005). Flooding in the catchment can pose a hazard to residents and businesses near the creeks, channels and overland flow paths.

The purpose of this study is to identify and examine options for the management of flooding within the Black Creek catchment.

The purpose of this plan is to document a strategy of suitable actions for implementation.

The Black Creek catchment is located within the Cessnock Local Government Area (LGA) and comprises all urban areas including the Cessnock Central Business District (CBD) and surrounding suburbs. Black Creek has several tributaries, including Bellbird Creek, Lavender Creek, Limestone Creek, Kearsley Creek and Aberdare Creek. Other tributaries include the Oliver Street channel in South Cessnock and the East Cessnock Drain. These tributaries flow through rural areas towards Cessnock and generally comprise concrete lined trapezoidal channels in the urban areas. Given the numerous creeks converging in Cessnock, flooding has occurred regularly including in 1949, 1977, 1990, 1992 and 2007.

As part of this study, the existing hydrological and hydraulic models developed as part of the Black Creek Flood Study (DHI, 2010) were extended to include areas outside of the Cessnock CBD where limited information on flooding behaviour existed including Bellbird, Mount View detention basin and surrounds and northeast of the CBD. Up-to-date ground survey information was collected in 2011 and was used to represent the terrain in the hydraulic model. Flood modelling was undertaken for seven design storm events ranging from the 20% Annual Exceedance Probability (AEP) event up to the Probable Maximum Flood (PMF) event in order to assess flood behaviour in the extended hydraulic model.

A number of key differences from the DHI (2010) study resulted from the extension of the hydraulic model and incorporation of up-to-date survey information including a reduction in 1% AEP flood levels ranging from 0.2m to 0.5m along Bellbird Creek and a reduction in flood levels of 0.2m along East Cessnock Drain. The updated hydraulic model provides detailed information on flood behaviour and overland flow paths in the vicinity of Mount View detention basin and through the urban areas of Cessnock. The revised flood extents were adopted by Council in March 2014.

An assessment was undertaken on the number of properties that would be subject to overground and overfloor flooding within the floodplain under various design storm events ranging from the 20% AEP event up to the PMF. The results are summarised in the table below.

Flood affected properties and associated damages under existing conditions

Flood Event	Properties with Overfloor Flooding	Properties with Overground (Yard) Flooding	Flood Damage
20% AEP	20	185	$1,729,269
10% AEP	40	386	$3,713,300
5% AEP	119	621	$8,705,999
2% AEP	240	910	$16,092,255
1% AEP	346	1102	$22,536,603
0.5% AEP	489	1254	$30,826,304
PMF	2218	2366	$169,456,152
Average Annual Damages			**$2,473,550**

Options to reduce or manage the effects of flooding in the catchment were investigated to manage the risks of flooding. Under the merits-based approach outlined in the NSW State Government's Floodplain Development

Manual (NSW Government, 2005) a number of potential options for the management of flooding were identified, namely:

> Flood modification measures (FM Options);

> Property modification measures (P Options); and

> Emergency response modification measures (EM Options).

An extensive list of options was assessed against a range of criteria (technical, economic, environmental and social) and hydraulic modelling of some of the flood mitigation options was undertaken to provide a comprehensive analysis of those options that would involve significant capital expenditure.

The highest ranking options identified by the multi criteria analysis include:

> FM5, proposed bund/flood wall east of Sixth Street properties and railway line in South Cessnock;

> EM4, Public awareness and education;

> EM5, Flood warning signs at critical locations;

> P6, Land Swap;

> P3, House Raising; and,

> P4, House Rebuilding;

A number of structural options assessed were not considered viable either due to:

> adverse impacts on flood levels such as Option FM2 (A combination of a detention basin, a bund and channel reshaping along Bellbird Creek); or,

> where the cost benefit ratio indicated the cost of implementing the option were much higher than the resultant reduction in flood damages, including:

  - Option FM1 (Combination of detention basins along Black Creek);
  - Option FM3 (A combination of channel widening, channel reshaping and culvert upgrades on Black Creek);
  - Option FM4 (Channel widening of the existing Oliver Street channel at South Cessnock); and,
  - Option FM6 (Detention Basin at Austar Coal Mine Site on Bellbird Creek upstream).

The ranking is used as the basis for prioritising the components of the Floodplain Risk Management Plan (Chapter 15). It is noted that scoring adopted is not absolute and the proposed scoring and weightings used should be reviewed in future.

The Floodplain Risk Management Plan (Chapter 15) represents the proposed implementation plan of actions for the management of flood risks in the Black Creek Floodplain. The action list contains a mix of approaches to managing flood risks with a priority system of high, medium and low for implementation of the actions.

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Glossary and Abbreviations

Australian Height Datum (AHD)	A standard national surface level datum approximately corresponding to mean sea level.
Annual Exceedance Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded each year; it would occur quite often and would be relatively small. A 1% AEP flood has a low probability of occurrence or being exceeded each year; it would be fairly rare but it would be relatively large. The 1% AEP event is equivalent to the 1 in 100 year Average Recurrence Interval event.
Average Recurrence Interval (ARI)	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that periods between exceedances are generally random. That is, an event of a certain magnitude may occur several times within its estimated return period.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events. E.g. some roads may be designed to be overtopped in the 1 in 1 year ARI flood event.
Development	The erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flash flooding	Flooding which is sudden and often unexpected because it is caused by sudden local heavy rainfall or rainfall in another area. Often defined as flooding which occurs within 6 hours of the rain which causes it.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Flood fringe	The remaining area of flood prone land after floodway and flood storage areas have been defined.
Flood hazard	Potential risk to life and limb caused by flooding.
Flood prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land. Floodplain Risk Management Plans encompass all flood prone land, rather than being restricted to land subject to designated flood events.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.
Floodplain management measures	The full range of techniques available to floodplain managers.
Floodplain management options	The measures which might be feasible for the management of a particular area.
Flood planning area	The area of land below the flood planning level and thus subject to flood related development controls.
Flood planning levels (FPLs)	Flood levels selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plains. The concept of FPLs supersedes the “Standard flood event” of the first edition of the Manual. As FPLs do not necessarily extend to the limits of flood prone land (as

	defined by the probable maximum flood), floodplain management plans may apply to flood prone land beyond the defined FPLs.
Flood storages	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with naturally defined channels. Floodways are areas which, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.
Geographical Information Systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High hazard	Flood conditions that pose a possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Low hazard	Flood conditions such that should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.
Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
NPER	National Professional Engineers Register. Maintained by Engineers Australia.
NSW	New South Wales
Overland Flow	The term overland flow is used interchangeably in this report with “flooding”.
Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood	The flood calculated to be the maximum that is likely to occur.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a more detailed explanation see Average Recurrence Interval.

1 Introduction

Cardno (NSW/ACT) Pty Ltd (Cardno) has been commissioned by Cessnock City Council (Council) to undertake a Floodplain Risk Management Study (FRMS) and a Floodplain Risk Management Plan (FRMP) for the Black Creek Catchment. This FRMS (Chapters 2 – 14) has been undertaken to define the existing flooding behaviour and associated hazards and to investigate possible management options to reduce flood damage and risk.

This study follows on from the Black Creek Flood Study (DHI 2010) which was prepared in 2010 and subsequently adopted by Council.

A number of floodplain management options have been examined as part of this FRMS to manage flooding within the Black Creek Catchment. The identification and examination of these options was done in accordance with the *NSW Floodplain Development Manual: The Management of Flood Liable Land* (NSW Government, 2005).

The FRMP (Chapter 15) represents the proposed implementation plan of actions for the management of flood risks in the Black Creek Floodplain.

1.1 Study Context

The NSW Government *Flood Prone Land Policy* is directed towards providing solutions to existing flood problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the policy, the management of flood prone land is the responsibility of Local Government. The State Government subsidises flood management measures to alleviate existing flooding problems, and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities. The Commonwealth Government also assists with the subsidy of floodplain management measures.

The Policy identifies the following floodplain management 'process' for the identification and management of flood risks:

1. Formation of a Floodplain Management Committee;
2. Data collection;
3. Flood Study;
4. **Floodplain Risk Management Study;**
5. **Floodplain Risk Management Plan; and**
6. Implementation of the Floodplain Risk Management Plan.

Council have completed stages 1-3; the study represents stage 4 of the floodplain management process and the plan represents stage 5 of the floodplain management process.

1.2 Purpose

The purpose of the study is to:

> Review Council's existing environmental planning policies and instruments including Councils long-term planning strategies for the study area;

> Identify works, measures and restrictions aimed at reducing the social, environmental and economic impacts of flooding and the losses caused by flooding on development and the community, both existing and future, over the full range of potential flood events;

> Assess the effectiveness of these works and measures for reducing the effects of flooding on the community and development, both existing and future;

- Consider whether the proposed works and measures might produce adverse effects (environmental, social, economic or worsened flooding) and whether they can be minimised;
- Inform the amendment and/or preparation of planning policies relating to flood risk management;
- Examine the present flood warning system, community flood awareness and emergency response measures in the context of the NSW State Emergency Service's development and disaster planning requirements; and
- Identify modifications that are required to current policies in light of the investigations.

The purpose of the plan is to set out the proposed approach to implementation of actions to be undertaken to manage flood risks.

1.3 Project Objectives

The specific objectives of the study and plan are to:

- Identify measures to reduce the flood hazard and risk to people and property in the community in the present day, and to ensure future development is controlled in a manner consistent with the flood hazard and risk;
- Identify measures to reduce private and public losses due to flooding;
- Where possible, identify measures to protect and enhance waterways and the floodplain environment;
- Be consistent with the objectives of relevant state policies, in particular, the Government's *Flood Prone Land* and *State Rivers and Estuaries Policies* and satisfy the objectives and requirements of the *Environmental Planning and Assessment Act 1979*;
- Recommend actions for incorporation in the floodplain risk management plan to reduce flood risk; and
- Ensure actions recommended for incorporation in the floodplain risk management plan are sustainable in social, environmental, ecological and economic terms.

1.4 Project Methodology

The report structure follows the project methodology outlined below:

- An overview of the features of the catchment and floodplain (Section 2);
- Details of available data to inform the study (Section 3);
- A summary of the stakeholder consultation undertaken for the study (Section 4);
- An overview of the existing flood behaviour and updates undertaken following the Stage 3 Flood Study (Section 6);
- An assessment of the economic impact of flooding under existing conditions (Section 7);
- An overview of the existing flood emergency response arrangements (Section 8);
- Discussion of policies and planning controls around flooding (Section 9);
- An assessment of the appropriate flood planning levels for development (Section 10);
- An overview of the potential flood management options, including discussion of the flood modelling results for structural options (Section 11);
- An economic assessment of potential options and an assessment (Section 12);
- A multi-criteria matrix assessment of the relevant merits of these options for the Black Creek floodplain (Section 13);
- Conclusions and recommendations for the floodplain risk management plan (Section 14); and
- The Floodplain Risk Management Plan (Section 15).

2 Catchment Description

The Black Creek study area incorporates the catchment upstream of Lovedale Road Bridge including Black, Bellbird, Lavender, Limestone, Kearsley and Aberdare Creeks and associated tributaries including Oliver Street Channel and East Cessnock Drain. The confluence of the above creeks in the vicinity of Cessnock, combined with the urbanised floodplains, results in complicated flood behaviour through the Cessnock CBD. A brief description of each creek is outlined below:

- The Broken Back Ranges form the western boundary of the Black Creek catchment with the Wallis/Swamp Creek catchment bounding the east. The creek flows from south to north in direction through Cessnock to Branxton and subsequently the Hunter River. The terrain varies from steep and mountainous areas in the west to undulating floodplains. The creek is highly modified in the urban areas of Cessnock and enters a concrete trapezoidal channel at North Avenue and re-enters the natural creek downstream of the CBD;
- Kearsley Creek is a tributary of Black Creek and comprises a concrete trapezoidal channel downstream of Quarrybylong Road with a branch through South Cessnock known as the Oliver Street Channel.
- Aberdare Creek comprises a concrete trapezoidal channel and drains the suburb of Aberdare and eastern Cessnock and joins Black Creek downstream of Henderson Avenue.
- East Cessnock Drain is predominantly natural channel and conveys flow through the east of Aberdare and joins Black Creek downstream of the CBD;
- Bellbird Creek flows through Bellbird and in a north easterly direction through Cessnock where it joins Black Creek, downstream of the CBD. It comprises natural channel upstream of Cessnock and becomes a concrete trapezoidal channel upstream of Cessnock Showgrounds.
- Limestone Creek is a natural channel tributary of Bellbird Creek with a predominantly rural catchment; and
- Lavender Creek flows in an easterly direction from the Broken Back ranges and the catchment is predominantly rural with urban area on the lower part of the creek. Mount View detention basin was constructed on Lavender Creek in the late 1970s to attenuate flood waters and provide protection to downstream properties. Lavender Creek joins Bellbird Creek just upstream of Allandale Road.

The study area is outlined in **Figure 2-1**.

3 Available Data

3.1 Previous Studies and Reports

A number of studies have been undertaken within the Black Creek catchment. These reports were reviewed as part of this study and relevant information incorporated as required. Relevant studies are summarised in **Table 3-1**.

Table 3-1 Summary of Relevant Previous Studies

Study	Description
Black Creek Flood Study (2010) DHI Water and Environment Pty Ltd	This study determined existing flood behaviour for the Black Creek catchment, including all major tributaries and the city of Cessnock. An xp-rafts hydrological model was built for the catchment and a detailed 1D/2D MIKE FLOOD hydraulic model used to estimate flood behaviour. The model was calibrated to a number of historical events which occurred in 1974, 1977, 1990 and 2007. Flood modelling was undertaken for the 20%, 10%, 5%, 2%, 1%, 0.5% AEP and PMF events with mapping completed for flood levels, depths, velocities, hazard and hydraulic categorisation. Results of the study were used to identify areas within Cessnock that are worst affected by flooding in a range of AEP events including parts of Bellbird, along Bellbird and Lavender Creeks, within Cessnock CBD itself and parts of South Cessnock. The 2010 Flood Study was subsequently adopted by Council. Information gathered and data used as part of this study has been used as a basis for this Black Creek Floodplain Risk Management Study and Plan.
Lavender and Bellbird Creek Flood Study (2004) Patterson Britton & Partners Pty Ltd	Determination of existing flood behaviour for Lavender Creek and Bellbird Creek in the west and southwest of Cessnock. An xp-rafts hydrological model was built for the upper catchments of both creeks to quantify catchment flows which were input to a HEC-RAS 1D hydraulic model developed using survey information for both creeks. Flood behaviour was assessed for the 5%, 2%, 1% AEP and PMF events. The study identified the existing Mount View detention basin has sufficient capacity to attenuate the 1% AEP event, however downstream of the basin flow is estimated to break out of both Lavender Creek and Bellbird Creek. The study noted that flow in both creeks is likely impacted by flow within Black Creek and warranted further investigation.

The Black Creek (Stage 2) study area is located directly downstream of the study area for this project and the flood study for this catchment is currently in preparation.

3.2 Survey Information & ALS Data

Council provided Aerial Laser Scanning (ALS) survey data as follows:

- April 2012 including Cessnock CBD and Bellbird; and
- April 2014 including areas to the north and west of Cessnock CBD.

The accuracy of ALS data is ± 0.15m to one standard deviation for the z-coordinate on hard surfaces and is considered the best available information for the study and was used to update to model the existing topography used in the hydraulic model. The extent of ALS survey data is shown in **Figure 3-1**.

3.3 GIS Data

Council has provided all the relevant Geographic Information System (GIS) data relevant to the Floodplain Risk Management Study and Plan for the Black Creek Catchment. The following data has been provided:

- Black Creek Flood Study Results (DHI, 2010);
- Aerial Photography (dated 2002);
- Cadastral information;
- Hunter Water channel information;
- Pit and Pipe data;
- Contour information (2m and 10m);
- Location of heritage and environmental areas within the study area; and
- Land use zoning information.

3.4 Hydrological and Hydraulic Models

The following hydrological and hydraulic model data was provided:

- Xp-rafts hydrological model for the Black Creek catchment; and
- MIKE FLOOD (1D/2D) hydraulic model developed as part of the Black Creek Flood Study (2010).

3.5 Site Inspections

Detailed site inspections of the study area were conducted in March 2012, March 2013 and March 2014 by Cardno in the company of Council personnel. The site visits provided the opportunity to identify various stormwater drainage features for inclusion in the hydraulic model and to visit those areas worst affected by flooding in the catchment.

4 Consultation

Consultation activities undertaken for the Black Creek Floodplain Risk Management Study and Plan have included:

- **Press Release**: a press release was prepared in June 2012 introducing the study;
- **Stakeholder Consultation:** An initial letter and questionnaire was sent to key stakeholders in May 2012, including some services and utilities providers, as well as others who may hold information relevant to the study;
- **Information Brochure and Resident Survey:** In October 2013 an information brochure and resident survey was sent to residential and commercial properties within the Black Creek catchment. The key objective of this survey was to gain an understanding of residents' opinions on generic types of flood management options and to seek information on historical flooding that has occurred within the catchment. This framed the first contact for the residents' involvement in the project. A subsequent information brochure update was distributed in March 2015 to advise residents on progress to date;
- **Floodplain Management Committee:** Regular progress updates were provided to the Floodplain Management Committee. The Committee is comprised of members of the community, SES, State Government and Council.
- **Public Exhibition:** of this Draft Report: to be undertaken.

4.1 Resident Survey

The resident survey prepared by Cardno consisted of a brochure and questionnaire (see Appendix C). The brochure provided an outline of the floodplain risk management process and described some preliminary flood management options. The questionnaire sought information about historical flooding and feedback on possible flood management options. The survey was distributed to all residents and business owners in the Black Creek catchment, a total of 1,600 properties.

From the distribution, 84 responses were received, representing a return rate of approximately 5.25%, which is slightly below average for similar studies. As well as the hard copy questionnaires, an online response system, Floodengage, was used to gather responses to the survey, which netted a total of 4 of the 84 submissions that were made.

A summary of the findings of the resident survey are presented in Sections 4.1.1 to 4.1.6.

4.1.1 Years at Address

Residents were asked to provide information about their current address and how long they had resided there. A majority of responses were from owner occupiers (78%), with the remainder made up of tenants and businesses. Freestanding homes made up 90% of respondents, while 5% resided in an apartment or dual occupancy dwelling. No respondents resided in a caravan or mobile home.

Of the 84 respondents, 69% had been at their property longer than 15 years, and about 82% had been living in the Cessnock LGA for more than 15 years (**Figure 4-1**).

These questions are useful in understanding how aware the average respondent might be about flooding issues in the local area. This information can also be useful in considering the most effective means of consulting with both property owners who may be affected by any planning controls arising out of the study, as well as how best to distribute future flood education materials.

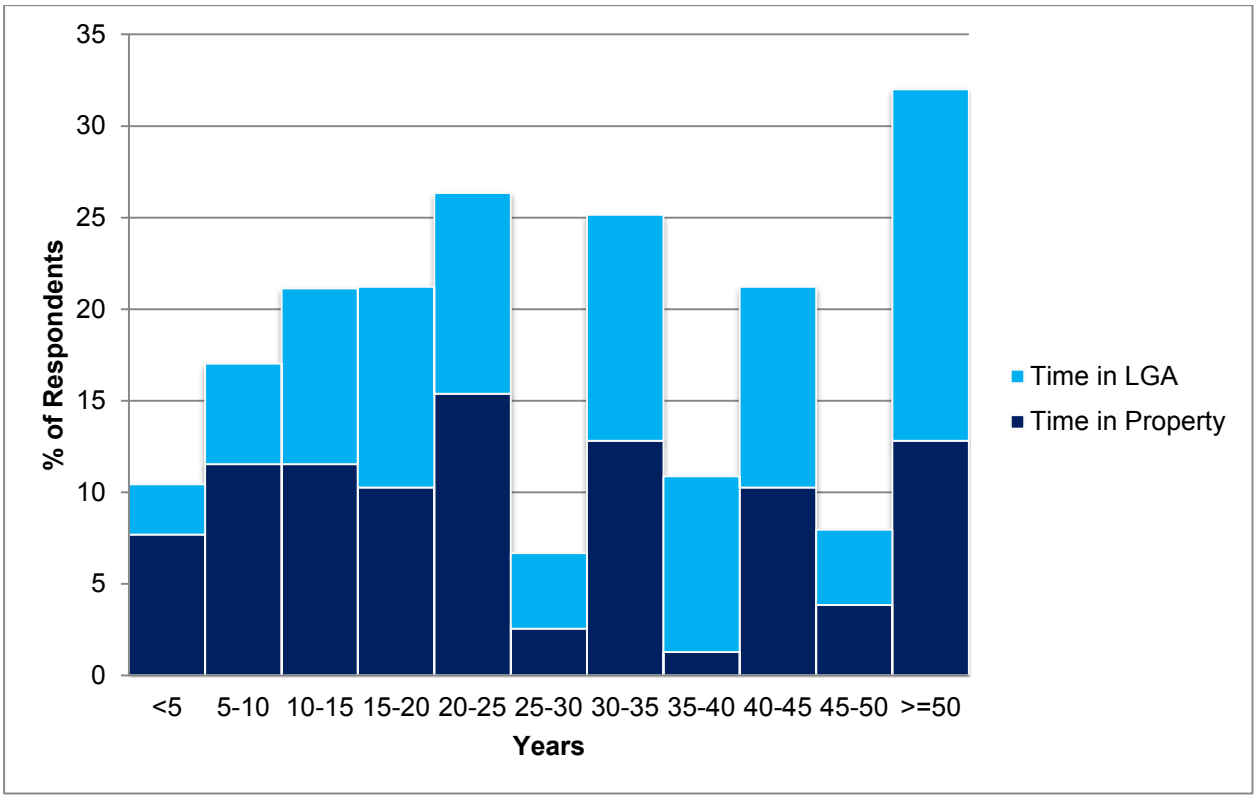


Figure 4-1 Years at Current Address and in the Cessnock LGA

4.1.2 Demographic Information

The survey also included some questions seeking basic information on the number and ages of people in each household. This information is useful for emergency management and planning for flood events, and understanding the existing risk within the floodplain (Table 4-1). Based on the responses provided, it appears that there is a relatively high proportion of residents that may be difficult to evacuate in an emergency (e.g. 37% are aged 65+ years). However, it is important to note that this information is only applicable to those who have responded to the questionnaire, and therefore may be skewed towards a particular demographic. More information on the demographics for the general area, based on census data, is provided in Section 5.3 which reveals that over 80% of the population is under 60.

Table 4-1 Age Structure of Residents within the Catchment (Respondents to Survey Only)

No. of permanent residents at respondents' address aged:				Total no. of permanent residents at an address where the minimum age is 65 years	Total no. of permanent residents at an address where the minimum age is 65 years who experienced overfloor/yard flooding
0-4 years	5-24 years	25-64 years	65+ years		
5	21	79	62	52	29

4.1.3 Flooding Experience and Awareness

The questionnaire also sought to determine residents' previous experiences of flooding, the results of which have been summarised in **Figure 4-2**. A significant proportion of respondents had experienced flooding (69 %), which is expected given the size and extent of the June 2007 flood event. However, only 11% of respondents experienced floodwaters entering their house or business, and 48% experienced flooding in their yard. A majority of respondents' flooding experiences were not related to their own properties, as 41% of all respondents had not indicated that they had experienced flooding on their property. Furthermore, 44% had noted flooding in other parts of their neighbourhood and 31% could not drive their car because the road was flooded.

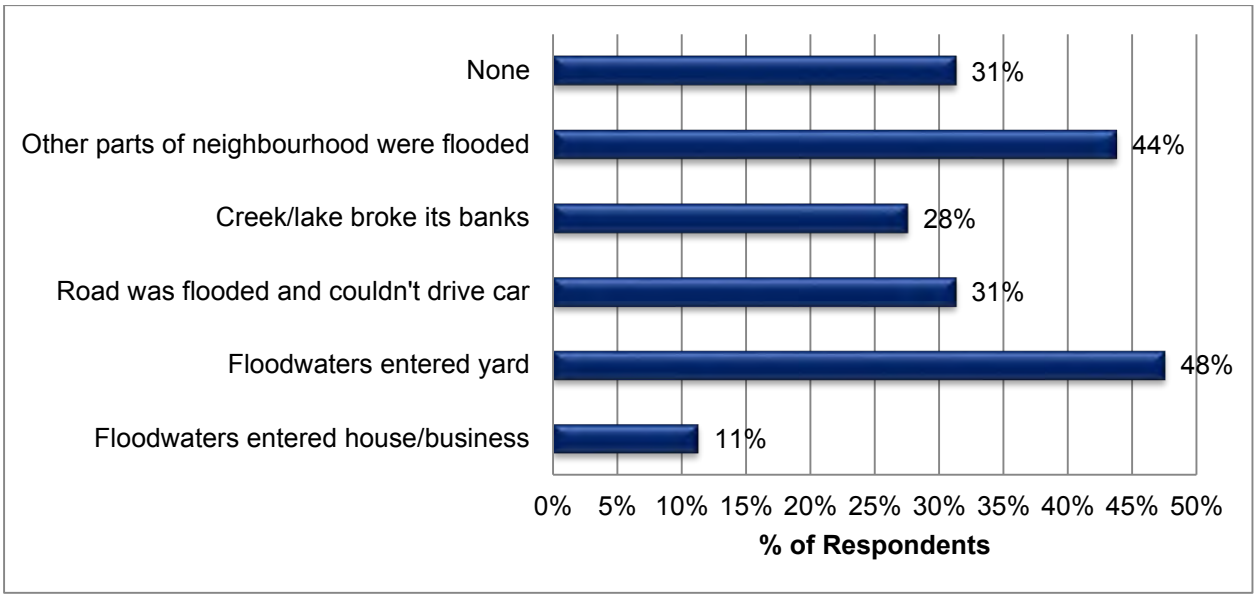


Figure 4-2 Respondents' Flooding Experiences

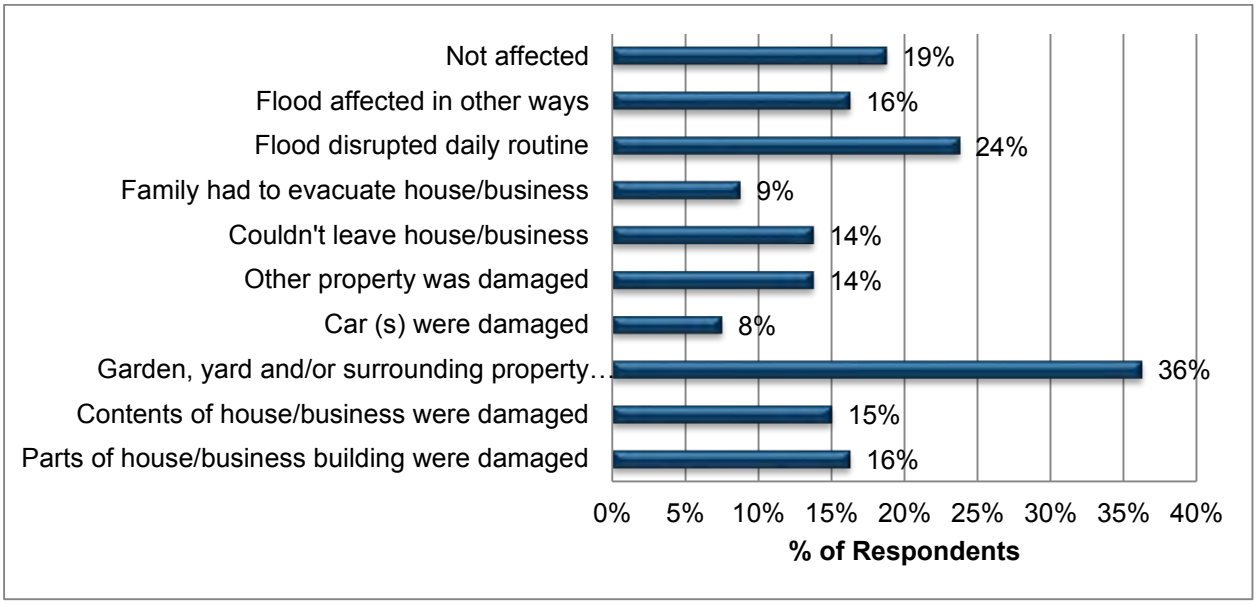


Figure 4-3 Flood Impacts on Respondents

Based on the residents' responses, damage to garden, yard or surrounding property was the most common form of property damage (36%). By and large, most respondents were affected by flooding in other ways mainly due to social disruption or stress, and transportation difficulties.

Residents were also asked to comment on whether they thought their property could be impacted by flooding in future. The majority of residents (69%) believed that they would be unaffected or that flooding would only impact a small part of their yard, while 24% believed that significant portions of their outdoor space would be flooded, and a further 20% believed that they would experience over-floor flooding. These responses are generally consistent with what people had experienced during the past, likely governed by the recent June 2007 event.

4.1.4 Flood Education and Information Sources

Residents were also asked if, and if so how, they had sought information about flooding on their property. The majority of respondents (40%) had not sought any information, and 25% believe that their property is not affected by flooding. For those respondents who did seek information, the most popular method was "other information from Council" (i.e. flood studies and planning documents) (**Figure 4-4**). Council's customer service

centre and information from relatives, friends, neighbours, or the previous owners were respectively the second and third most common means of receiving information. Viewing a Property Planning (Section 149) Certificate and other information were the least preferred method.

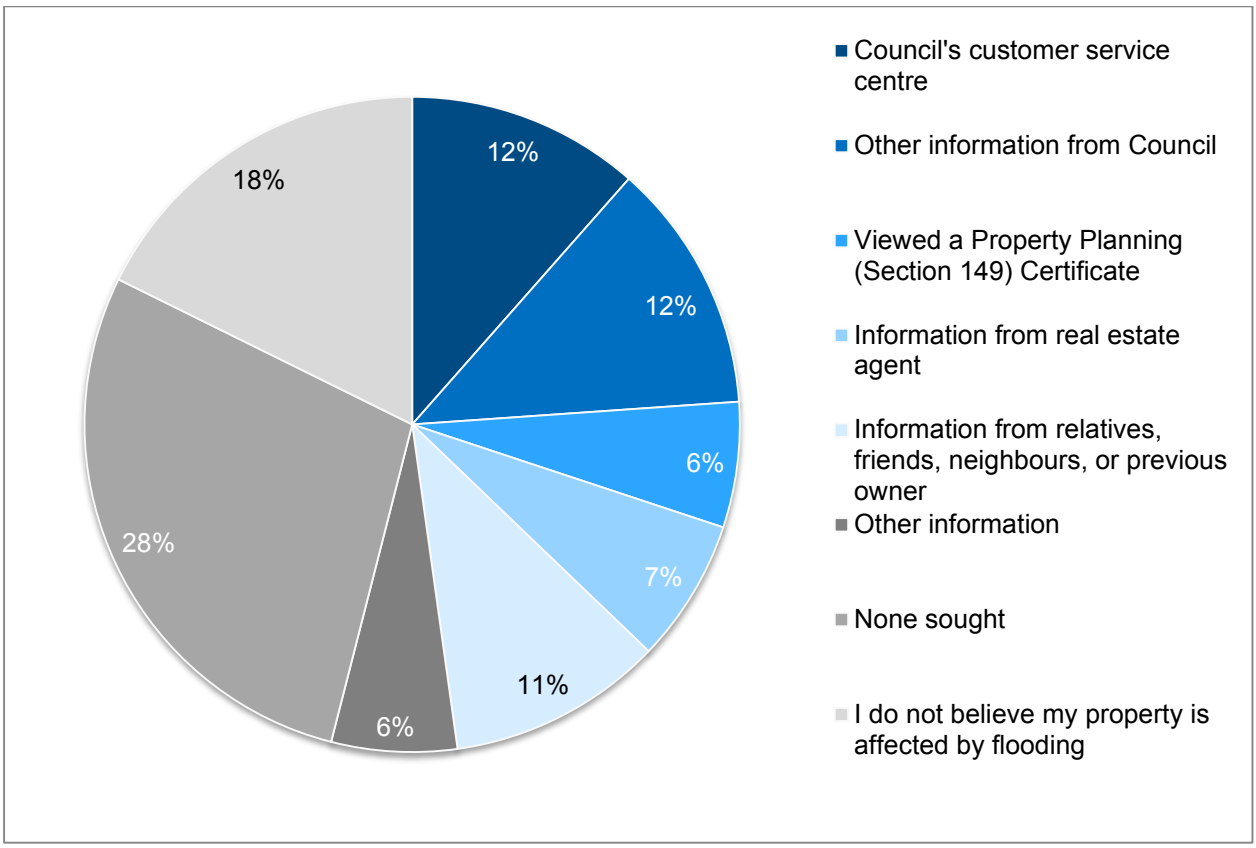


Figure 4-4 Source of Flood Information

In order to determine the most effective way to gain input and feedback from the local community about the project, residents were asked to nominate their preferred communication channels. The responses have been ranked in **Table 4-2**. This is useful for any future flood education activities proposed by Council.

Table 4-2 Preferred Communication Channels

Preferred methods for input and feedback from the community	Percentage preference
Mail-outs to all residents/business owners in the study area	66%
Council's information page in the local paper	48%
Other articles in the local paper	38%
Information days in the local area	29%
Community meetings	23%
Council's Floodplain Management Committee	15%
Council's website	14%
Emails from Council's	13%
Formal Council meetings	9%

4.1.5 Flood Management Options

One of the main objectives of the survey was to gain information on residents' preferences for different types of generic flood management options. Respondents were asked to give a mark of 1 to 5 for a list of potential management options, with 5 being the most preferred and 1 the least preferred.

Environmental channel improvements were the most preferred option among the respondents (**Figure 4-5**). This option was followed closely by improved flow paths, culvert/bridge/pipe enlargements, planning and flood-related development controls, and retarding or detention basin (**Figure 4-5**). Diversion of creeks and channels was least preferred.

Eight respondents (10%) recommended other flood management options including:

> Ensure stormwater on roads goes into drains and not over property;

> Keep stormwater channels clear; and

> Ensuring stormwater drains and channels are clear (i.e. not blocked with shopping trolleys and the like).

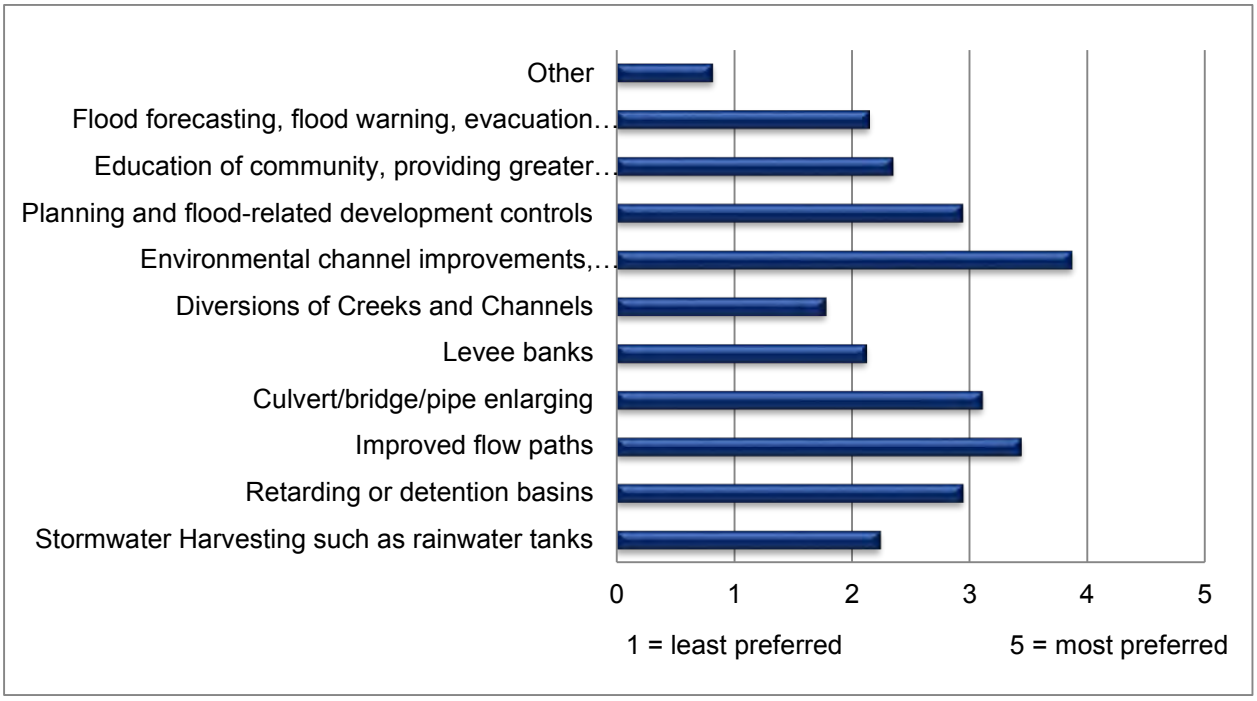


Figure 4-5 Preferred Flood Management Options

4.1.6 Historical Flood Information

Information was also sought from the community on historical flood experiences and flood behaviour. Documents provided with the returned surveys included:

> Photos of flooding and water marks inside houses and sheds (1990, 2007 and 2011);

> Photos of flooded lawn, road and damaged fencing (2007, 2008 and 2009); and

> Transcripts of residents memories of flooding (1949, 1950's, and 1999).

A number of the survey responses referenced the June 2007 flood but did not include any documents or photos, and one survey referenced a flood in November 2013.

4.2 Stakeholder Consultation

A number of stakeholders were engaged to obtain input on a number of flooding issues such as:

> Suggestions for flood mitigation options;

> Flooding experiences; and

> Planned or future practices/developments by the stakeholder which may impact on the nature of flooding.

Table 4-3 summarises the responses provided by the various organisations contacted.

Table 4-3 Stakeholder Responses

Stakeholder	Summary of Response
Australian Rail Track Corporation	None received.
Bureau of Meteorology	None received.
Hunter-Central Rivers Catchment Management Authority (CMA)	In summary, the CMA operates according to the Catchment Action Plan, which is a statutory document. The section of Black Creek in the immediate area around Cessnock is not a priority stream for riparian actions as it is classed primarily as having moderate recovery potential, with some sections with low recovery potential, as per the Riverstyles methodology. There are some tributaries, such as Deadmans Creek and the upper reaches of Black Creek that have been prioritised for rehabilitation. The area is a priority area for salinity actions. One of the most important issues from the CMA's perspective is native vegetation and connectivity through the landscape, which is a priority for in the immediate area around Cessnock. Hunter Lowland Redgum Forest is commonly associated with the riparian area and slopes in the vicinity of Black Creek. As such the management of weeds that impact biodiversity in the riparian area remains a priority.
Hunter Water Corporation	Hunter Water owns a large amount of the open stormwater channels running through the centre of Cessnock, and as such expressed an interest in the outcomes of this study. They are particularly interested in the upgrades recommended to the stormwater system to reduce flooding. Hunter Water would like to be involved in the review of the reports prior to public exhibition. Hunter Water is also interested in potential blockages of the stormwater channels and would like to ensure that future management looks at ways to minimise cars/or other large floatables ending up in the stormwater system. They advised that a large extent of the stormwater channel in the CBD area has now been covered to allow for additional parking. In light of potential for additional projects of that nature, they would like to understand if this is having any impact on flooding. Hunter Water is currently planning on undertaking rehabilitation of a number of concrete panels throughout the Cessnock area. The current rehabilitation work will be to repair or replace the existing panels.
NSW State Emergency Service	Provided details of the SES requirements from the Flood Risk Management Process and the Flood Emergency Response Planning Classification of Communities.
Roads and Maritime Services	Advised of no specific flood-related issues in Black Creek, Cessnock. Advised that there are no future development proposals for this area in their 10 year plan.

4.3 Public Exhibition

The final draft FRMS&P was placed on public exhibition from 14 July 2015 until 14 August 2015. The final draft report was made available:

- On Council's website (http://www.cessnock.nsw.gov.au/community/exhibition);
- At Council's offices at 62-78 Vincent Street, Cessnock; and
- At the Cessnock and Kurri Kurri libraries.

One submission was received during the exhibition period from the Austar Coal Mine. The points raised in the submission are summarised in **Table 4-4** with a brief comment as to how they have been considered.

Table 4-4 Summary of Issues Raised by the Submission

Issue Raised	Summary of Response
There is a sinkhole in the Bellbird Creek catchment that may currently be attenuating flood flows from this catchment. Although this sinkhole is proposed for remediation, The model calibration approach should be reviewed to ensure that the hydrologic model does not inadvertently understate flows to compensate for the loss of runoff from the catchment that may have occurred during some of the calibration events.	The hydrology model setup and associated calibration was undertaken as part of the original Black Creek Flood Study (DHI, 2010) and this model setup was adopted for this FRMS&P. As such, knowledge of such features and inclusion in the hydrology model was not part of the scope of this study. The updated flood model results were validated against the DHI Flood Study. However, a review of the 2007 calibration event was undertaken to investigate the potential impacts on the calibration parameters. This comparison shows that the model overestimates flood levels at the highest quality surveyed flood marks along Bellbird Creek. This indicates that flows have not been understated inadvertently in the hydrologic model. It suggests that a more accurate calibration would have been achieved if the sinkhole were accounted for in the calibration as lower flows would have been derived and lower flood levels closer to the surveyed flood marks would have been calculated. All design event modelling has been undertaken with no sink hole included, and as such, effectively assumes that the remediation is already in place.
The predicted 100 year ARI (or 1%AEP) flood extent in the Bellbird Creek Floodplain is provided in Figure 6-9 of the FRMSP. These model results indicate that runoff from the sinkhole Catchment has not been applied to the model at the Wollombi Road Culverts, where following the remediation of the sinkhole, it will enter the Bellbird Creek Floodplain. It is recommended that the FRMSP model is modified to apply Sinkhole Catchment inflows upstream of the Wollombi Road Culverts. All flood and flood risk mapping should be revised accordingly.	The model setup has been adjusted to apply these inflows at the Wollombi Road culverts and all results maps updated to reflect this change.
Information presented in this submission has demonstrated that the sinkhole in its current state has inadvertently provided a flood mitigation benefit to the Bellbird Creek Floodplain and other downstream areas for a number of decades. As a result, the latent flood risk associated with its future remediation may not be reliably understood by both Council and the community. It is recommended that the existence of the sinkhole and its potential flood mitigating influence over recent decades should be documented in the FRMS&P. The FRMS&P should also note that the sinkhole is expected to be remediated in the near future.	This flood mitigation benefit currently provided by the sinkhole is discussed in Chapter 11. The potential sinkhole remediation proposal under consideration by Austar is also discussed in Chapter 11.
The submission presented an alternative flood mitigation option (detention basin at DB1) that may provide a superior cost-benefit to the mitigation measures presented in the FRMS&P. It is recommended that Council considers formally adopting this option in the Floodplain Risk Management Study and Plan.	The alternative flood mitigation option (detention basin at DB1) has been modelled and associated flood damages, benefit cost ratio calculated and this FM option has been included in the Multi-Criteria Assessment (refer Section 11 to Section 14)

A community workshop was also held during the exhibition period, on 28 July 2015. A total of 15 community members attended. The issues raised at the workshop have been summarised in Table 4-5, with a brief comment as to how they were considered.

Table 4-5 Summary of Issues Raised by the Community

Issue Raised	Summary of Response
Property owners seeking early advice on proposed flood planning levels for purposes of ensuring their development will have appropriate finished floor levels.	It was suggested that the relevant flood levels for the property be provided to enable the owner to progress the development with appropriate incorporation of flood risk management.
Concern regarding vegetation growth (overgrowth) within creeks and flowpaths.	These locations have been passed on to Council's maintenance crew to incorporate into their program.
Concern regarding blockage of culverts, bridges and other drainage structures.	These locations have been passed on to Council's maintenance crew to incorporate into their program.
Concern regarding the impact of sewer overflows.	It is understood that this is an issue in the catchment. This issue is beyond the scope of the current study. The relevant locations have been identified to Council.
Flooding due to drainage issues in the vicinity of Oliver Street drain.	Two options have been investigated to address this issue: channel widening (FM4) and an upstream bund/basin (FM5) (refer Chapter 11).
Suggestion that flood control valves could be implemented on outlets of detention basins to allow real time control of flood flows and optimise basin storage. The valves shut off when the downstream level is getting too high.	This is possible in smaller events where there is sufficient capacity to store floodwaters, but not for larger events like the 1% AEP as this is the maximum capacity of the basin. There is also a risk that using a basin for storage (i.e. and preventing controlled releases) may become an issue in the event that the storm becomes larger, or a second storm follows quickly before the basin can empty. This would compromise the function of the basin. For these reasons, the option was not considered further as part of this study.
As a solution to flooding in South Cessnock/Oliver St Drain, it was suggested to upgrade the culvert under the Arts Centre and Vincent Street as it is currently under capacity. Could this culvert be upgraded and the channel down to North Cessnock be enlarged?	Acknowledged that this may be the ultimate solution to flooding, however, noted that the proposed solution will be a significant expense and will not likely stack up in a benefit cost analysis. There are other solutions for the South Cessnock area. Two options have been investigated to address this issue: channel widening (FM4) and an upstream bund/basin (FM5) (refer Chapter 11). A combination of the two options was also investigated. Also explained that the study is looking at the best benefits community wide for expenditure. So other options such as house raising and house purchasing or land swap may be a better cost-benefit ratio to the community.
Concern that there has been too many studies and too much delay in taking action and implementing flood mitigation measures.	It is acknowledged that there has been a long delay between commencing flooding investigations and delivering on the ground works to reduce flood risk. The NSW Government requires a step-wise process to developing a Floodplain Risk Management Plan, as described in the Foreword and Chapter 1.1. This process is necessary in order to ensure that: ▪ A range of potential options are considered; ▪ The potential options are assessed to see if they will successfully reduce flood impacts; ▪ The relative costs and benefits of the full suite of options are assessed in order to optimize the use of public funds; and ▪ The chosen options will be eligible to receive funding under the NSW Government floodplain risk management program. It is noted that the completion of this FRMS&P will now enable Council to apply for funding to implement flood mitigation options, which will deliver the on-ground works.
Concerns that the mitigation options presented do not do enough to reduce flood levels in the 1% AEP. Also concerned that there have been multiple flood events in recent years.	It is understood that there is a high level of concern amongst community members about the impacts of the April 2015 event, which was approximately a 10% AEP flood event (refer Section 6.1.5 and Appendix G for details). This study attempts to identify those flood management options that will provide the highest cost-benefit ratio, and provide the optimal outcomes for the community. In some instances, this may be achieved by targeting options that mitigate flood risk from the smaller, more regularly occurring flood events (e.g. 50% to 5% AEP)

Issue Raised	Summary of Response
	such as that which occurred in April 2015 and which cause damage more frequently. Hence the benefit of mitigating flood risk in larger, less frequent events (e.g. a 1% AEP event) may in fact be lower or not achievable. This is demonstrated in the options assessment in Chapter 11.
Edgeworth Street flooding is seen to occur from two sources: first from overland flows coming down the street and then rising waters from Oliver St Drain. This is due to: ▪ Overland flow issues - lack of kerb and guttering to direct flows; ▪ Insufficient drainage capacity; and, ▪ Large drain not cleaned frequently. Maintenance issues.	Two options have been investigated to address this issue: channel widening (FM4) and an upstream bund/basin (FM5) (refer Chapter 11. It is agreed there may be some benefit to diverting flows via provision of kerb and guttering one or two streets further back up the catchment to prevent waters arriving at Edgeworth. However, this is beyond the scope of this project which focuses on main channel flooding as opposed to overland flows. The recommendation has been passed on to Council for further consideration as part of their capital works program. House Rebuilding (Option P3) is a valid mitigation option that has been assessed in the FRMS&P. Could rebuild houses at the back of the blocks which were flood free in April 2015 event.

5 Environmental and Social Assessment

The physical, environmental and social characteristics of the study area may influence the type and extent/location of flood management options able to be implemented under the FRMP.

Environmental characteristics, such as topography, sensitive environments, the presence of threatened species, and soils are constraints for any structural flood modification works.

Social characteristics such as housing and demographics may impact the community's response to flooding and therefore affect the type of flood management options proposed.

The following physical, environmental and social characteristics have been considered in the assessment:

- Catchment topography;
- Land use;
- Demographic characteristics;
- Geology and soils;
- Flora and fauna; and
- Aboriginal and non-Aboriginal cultural heritage.

5.1 Catchment Topography

The terrain within the study area varies from undulating creek flats and floodplains, to steeper terrain, west of the study area. The catchment contains landscapes associated with coalfields and vineyards (Cessnock City Council, 2009).

The coalfields landscape is characterised by undulating land of only moderate slopes, low fertility and underlying coal seams. The vineyards landscape is characterised by the undulating valley floor of Black Creek, running back to the hilly foot slopes of the Broken Back Range.

Land along the western boundary of the study area (Broken Back Range) has slopes of greater than 15 degrees and is also classified as protected land as it is with the Pokolbin State Forest. A small amount of land along the southern boundary of the study area is also classified as having steep slopes, a proportion of which are also protected lands as they are within the Werakata National Park. Scattered across the study area are several small, isolated areas of steep slopes. Slopes less than 2 degrees are mainly found along the creek line of Black Creek and its tributaries (Cessnock City Council, 2009).

5.2 Land Use

Land use within the catchment is controlled by the *Cessnock Local Environment Plan 2011* (LEP), which indicated locations where certain activities and types of development are permissible. Much of the land within the wider LGA is classified as E1 (National Parks and Nature Reserves), RU2 (Rural Landscape), RU3 (Forestry), and RU4 (Primary Production Small Lots). The town of Cessnock is located roughly in the centre of the LGA with the town of Kurri Kurri to its east. Cessnock is predominantly low and medium density residential with a commercial core and business park. Kurri Kurri is predominantly low and medium density residential with light, heavy and general industrial areas. Further details on land use and the floodplain can be found in Chapter 9.

5.3 Demographic Characteristics

A knowledge of demographic character assists in the preparation and evaluation of flood risk management options that are appropriate for the local community. For example, demographic data is relevant in the consideration of emergency response or evacuation procedures (e.g. information may need to be presented in a range of languages and special arrangements may need to be made for less mobile members of the community).

The demographic characteristics of the Black Creek catchment presented in this chapter includes the Cessnock LGA, which encompasses the whole of Cessnock, including the CBD, and the localities of Bellbird,

Kitchener, Kearsley, Pelton, Nulkaba, Neath and Abernethy. Population data was sourced from the Australian Bureau of Statistics (ABS) 2011 Census for the Cessnock LGA, and was considered to be representative of the Black Creek catchment population.

In summary, the data revealed that:

> Approximately 40% of people living in the Cessnock LGA are aged between 30-59 years (**Table 5-1**) with approximately 80% of the population aged below 60 years. This indicates that the community is likely to be primarily able-bodied, able to evacuate effectively and/or assist with evacuation procedures;

> English was the only language spoken in approximately 93% of homes in the LGA. Other languages spoken at home other than English were German, Cantonese, Tagalog, French and Italian (**Table 5-2**);

> The median weekly income for individuals in the region was $472, compared to the NSW average of $561. This trend of being below average income for the region, compared to the NSW average, was also evident for family and household incomes (**Table 5-3**). This may have implications for the economic damages incurred on property contents and the ability for residents to recover after a flood event;

> The majority of households within the LGA (76.2%) are composed of family or a group household, so it is likely that most people in the community would have assistance from friends or family during evacuation events if needed (**Table 5-4**);

> In the LGA, the majority of dwelling structures for most households are separate houses (91.7%) as shown in **Table 5-5**. This information has been utilised in the calculation of economic damages incurred during a flood event;

> In 2012 the median house price in Cessnock was $253,000, and the unit price was $256,500 (**Table 5-6**). In NSW, the median house price was $440,000, and unit price was $445,000 (APM, 2012). This information may be utilised in the calculation of economic damages incurred during a flood event in the catchment.

Table 5-1 Age structure of the catchment (ABS 2011)

Age Group (Years)	Persons in the Catchment	% of Total Persons in the Catchment	% of Total Persons in NSW
0-4 years	3,801	7.5	6.6
5-9 years	3,450	6.8	6.3
10-14 years	3,614	7.1	6.3
15-19 years	3,417	6.7	6.4
20-29 years	6,230	12.3	13.3
30-39 years	6,480	13.1	14.6
40-49 years	6,614	13.0	14.0
50-59 years	6,814	13.4	12.9
60-69 years	5,626	11.0	10.0
70-79 years	2,907	5.8	6.1
80-84 years	1,025	2.0	2.2
85 years and over	862	1.7	2.0
Total	50,840	100	100

Table 5-2 Languages spoken at home in the catchment (ABS 2011)

Languages Spoken at Home	Persons in the Catchment	% of Total Persons in the Catchment	% of Total Persons in NSW
English Only	47,275	93.0	72.5
German	79	0.2	0.3
Cantonese	47	0.1	2.0
Tagalog	46	0.1	0.5
French	42	0.1	0.3
Italian	41	0.1	1.2

Table 5-3 Median weekly income for people 15 and over in the catchment (ABS 2011)

Income (For Population Aged 15 Years+)	Catchment	NSW
Median Individual Income (weekly)	$472	$561
Median Family Income (weekly)	$1,265	$1,477
Median Household Income (weekly)	$1,042	$1,237

Table 5-4 Household composition within the catchment (ABS 2011)

Household Composition	Persons in the Catchment	% of Total Persons in the Catchment	% of Total Persons in NSW
Family households	13,417	73.6	71.9
Single (or lone) persons households	4,343	23.8	24.2
Group households	468	2.6	3.8

Table 5-5 Dwelling structure of occupied private dwellings in the catchment (ABS 2011)

Dwelling Structure	No. of Occupants	% of Total Persons in the Catchment	% of Total Persons in NSW
Separate house	16,708	91.7	69.5
Semi-detached, row or terrace house, townhouse etc.	881	4.8	10.7
Flat, unit or apartment	554	3.0	18.8
Other dwelling	71	0.4	0.9

Table 5-6 Median house and unit prices within the catchment for 2012 (source: www.realestate.com.au 2013)

Suburb	Median House Price	Median Unit Price
Cessnock	$253,000	$256,500

5.4 Geology and Soils

5.4.1 Geology

When developing floodplain risk management options it is important to understand the geology of the catchment to ensure appropriate locations for management options are selected and to assist with the planning and construction of suitable building foundations based on the geological constraints present.

The majority of the study area lies within the Maitland Group and Dalwood Group and is comprised of four geological formations, as illustrated in **Appendix C**:

- Rutherford Formation – comprising Permian siltstone, marl and minor sandstone;
- Farley Formation – comprising early Permian silty sandstone;
- Greta Coal Measures – comprising Permian coal seams, siltstone, sandstone and conglomerate; and
- Branxton Formation comprising Permian conglomerate, sandstone and siltstone.

The geological constraints on floodplain management depend on the management options selected to be implemented. At this stage, no significant geological constraints have been identified that would impact the preliminary assessment of options in this FRMS.

5.4.2 Soils

According to the Soil Landscape Map of Singleton (Scale 1:250,000) the catchment is located on the Branxton, Aberdare and Neath soil landscape groups as shown in Appendix C.

The Branxton landscape group is generally characterised by having red podzolic soils on the crests and upper slopes, yellow podzolic soils mid slope and yellow soloths on lower slopes and drainage lines. The Branxton terrain is described as undulating rises to low hills, relief 10m to 40m, and slopes to 5%. This group has a high erosion hazard and is susceptible to tunnel and gully erosion due to high dispersibility.

The Aberdare landscape group comprises generally brown podzolic soil and characterised by poorly-structured dark brown loamy sand to clayey sand horizons, overlying a dark brown light clay horizon. The topsoil and subsoil of brown podzolic soils can also be highly erodible.

The Neath landscape group is described as gently undulating rises of grey Solodic soils in poorly drained areas associated with exposed coal seams, and Yellow Solodic Soils on the better drained lower slopes. There is also potential for wind erosion with the removal of ground cover.

Acid Sulfate Soils (ASS) occur when soils containing iron sulfides are exposed to air, and the sulfides oxidise, producing sulphuric acid. This usually occurs when soils are disturbed through excavation or drainage works. The production of sulfuric acid results in numerous environmental problems.

A review of the Cessnock Local Environment Plan 2011 shows that no ASS is known to occur within the study area.

5.5 Contaminated Land and Licensed Discharges

Contaminated land refers to any land which contains a substance at such concentrations as to present a risk of harm to human or environmental health, as defined in the *Contaminated Land Management Act 1997*.

The Office of Environment and Heritage (OEH) is authorised to regulate contaminated land sites and maintains a record of written notices issued by the Environment Protection Authority (EPA) in relation to the investigation or remediation of site contamination. A search of the OEH Contaminated Land Register in March 2013 showed no known contaminated sites within the study area. It is important to note that there are limitations to the Contaminated Lands Register and other areas may be contaminated that are not on the register.

A search of the *Protection of the Environment Operations Act 1997* (PoEO Act) licensed premises public register in March 2013 identified five licensed premise within the catchment as shown in **Table 5-7**.

Table 5-7 Items listed on the PoEO Licensed Premises Register (EPA 2012)

Organisation Name and Address	Activity
Cessnock City Council 62-78 Vincent Street, Cessnock NSW 2325	Application of herbicides
Cessnock Waste and Reuse Centre Old Maitland Road, Cessnock NSW 2325	Waste disposal
Hunter Environ-Mining (Operations) Pty Ltd The former Aberdare East and Aberdare Shaft Cessnock Street, Aberdare NSW 2325	Mining for coal

Organisation Name and Address	Activity
Hunter Water Corporation Cessnock Wastewater Treatment Works, Off Government Road, Cessnock NSW 2325	Sewage treatment processing by small plants
Hunter Water Corporation Kearsley Wastewater Treatment Works, Off Neath Road, Kearsley NSW 2325	Sewage treatment processing by small plants

Flood modification works in the catchment should both consider the protection of these facilities from flood damages and the compatibility of the flood works with the operations of the facilities.

5.6 Flora and Fauna

A large portion of the study area comprises cleared agricultural land and residential areas that have modified a great majority of the original native vegetation. Many of the flora and fauna species that previously occurred in these areas are no longer present. The eastern portion of the study area contains natural forests which are a part of the Werakata State Conservation Area, which expected to contain the majority of the flora and fauna within the catchment.

The Bionet Atlas of NSW Wildlife (OEH, 2013a) was searched for flora species listed under the Threatened Species Conservation (TSC) Act (records since 2000) within the study area and the Commonwealth's Environment Protection and Biodiversity Conservation (EPBC) Database was searched for flora species listed under the EPBC Act within the study area. Both databases were searched in March 2013 and showed a combined total of 42 known species within the study area that are listed under one or both of the Acts. The distribution of flora species listed under the TSC Act that were recorded within the study area are mostly within the Werakata State Conservation Area and are shown in Appendix C.

Any proposed flood modification options or flood protection works should consider if these species would be affected.

The Bionet Atlas of NSW Wildlife (OEH, 2013a) was searched for fauna species listed under the TSC Act (records since 2000) within the study area and the Commonwealth's EPBC Database was searched for fauna species listed under the EPBC Act within the study area. Both databases were searched in March 2013 and showed a combined total of 271 known species within the study area that are listed under one or both of the Acts. Appendix C shows a concentrated distribution of species within the Werakata State Conservation Area, however, there are numerous recordings throughout the study area.

Any proposed flood management options or flood protection works should consider the large number protected species and type of species the management option may affect.

5.7 Aboriginal and Non-Aboriginal Cultural Heritage

5.7.1 Aboriginal Heritage

The Black Creek Catchment area is within the Mindaribba Local Aboriginal Land Council (LALC). The Wonnarua, Worimi and Awabakal nations lived throughout the Hunter Valley and would travel to Sydney to exchange goods and perform ceremonies along the way. A large number of historic Aboriginal sites have been found in the region along with rock engravings, sharpening grooves, hand stencils, tribal markings and other images in caves and outcrops (Mindaribba LALC, 2013).

A preliminary investigation of Aboriginal heritage was undertaken by searching the online Aboriginal Heritage Information Management System (AHIMS) in March 2013 (OEH, 2013b) for known or potential Aboriginal archaeological or cultural heritage sites within or surrounding the Black Creek Catchment. The AHIMS search results are shown in Appendix C with 56 listed Aboriginal artefacts and sites within the study area. Given the high number of heritage items, it is recommended that a more detailed heritage assessment be undertaken prior to implementation of any management actions to ensure that the impacts of any proposed flood mitigation works on these sites can be appropriately managed.

The following qualifications apply to an AHIMS search:

> AHIMS only includes information on Aboriginal objects and Aboriginal places that have been provided to OEH;

> Large areas of New South Wales have not been the subject of systematic survey or recording of Aboriginal history. These areas may contain Aboriginal objects and other heritage values which are not recorded on AHIMS;

> Recordings are provided from a variety of sources and may be variable in their accuracy. When an AHIMS search identifies Aboriginal objects in or near the area it is recommended that the exact location of the Aboriginal object be determined by re-location on the ground; and

> The criteria used to search AHIMS are derived from the information provided by the client and OEH assumes that this information is accurate.

All Aboriginal sites are protected under the *National Parks and Wildlife Act 1974* (NPW Act) and therefore any management considerations that impact upon Aboriginal sites must include this in their design. Known Aboriginal sites should be left undisturbed if possible, however if a flood management option requires harm to or destruction of an Aboriginal artefact, an Aboriginal Heritage Impact Permit (AHIP) must be sought from OEH. Under the NPW Act it is a requirement that any developments show "due diligence" with regard to Aboriginal heritage in the area.

Land Rights and Native Title are two different avenues in which traditional land owners can gain access to land or claim compensation for previous dispossession of their land.

Under the *Aboriginal Land Rights Act 1983* (ALR Act) local Aboriginal land councils can claim Crown lands provided the lands are vacant and not otherwise required for an essential public purpose. A search on the Land Claims Register, maintained by the Office of the Registrar ALR Act database (ORALRA), on 12 March 2013 found no Native Title claims in the study area.

5.7.2 Non-Aboriginal Heritage

There are three different types of statutory heritage listings of non-Aboriginal origin; local, state or national heritage items. A property is a heritage item if it falls into a listings category. The category an item falls into depends on whether it is considered to be significant to the nation, state or a local area. The significance of an item is a status determined by assessing its historical, scientific, cultural, social, archaeological, architectural, natural or aesthetic value.

A desktop review of non-Aboriginal heritage was undertaken for the catchment. Searches were undertaken on the following databases to investigate the non-Aboriginal cultural heritage present within this area:

> Australian Heritage Database (incorporates World Heritage List; National Heritage List; Commonwealth Heritage List);

> NSW Heritage Office – State Heritage Register; and

> RailCorp S170 Heritage and Conservation Register.

No items of heritage within the study area were found on these registers.

The Cessnock Local Environmental Plan 2011 (LEP 2011) lists 57 heritage items that are found within the study area under Schedule 5 of the LEP.

The provisions that must be followed in relation to heritage items in the catchment area are outlined in Part 5, Clause 5.10 of the Cessnock LEP 2011. Due to the extensive heritage listed in the LEP within the study area, it is recommended that a more detailed heritage assessment is undertaken prior to implementation of any management options, as there are development restrictions and procedures that need to be followed.

5.8 Summary of Environmental and Social Issues

Environmental and social characteristics of the study area may influence the type and extent of flood modification measures able to be implemented. The key issues identified through this review include:

> The soil types that are present may potentially pose issues related to erosion and dispersibility;

> No ASS are known to occur in the Black Creek catchment area;

- English was the only language spoken in approximately 93% of homes in the Cessnock LGA. The most common languages spoken at home other than English are German, Cantonese, Tagalog, French and Italian;
- The eastern portion of the study area contains natural forests which are a part of the Werakata State Conservation Area, which is expected to contain the majority of the flora and fauna within the catchment. Any proposed flood management options or flood protection works should consider the large number protected species and type of species the management option may affect;
- Fifty-six Aboriginal heritage items were identified within the catchment. Given the high number of heritage items, it is recommended that a more detailed heritage assessment be undertaken prior to implementation of any management actions to ensure that the impacts of any proposed flood mitigation works on these sites can be appropriately managed; and
- No non-Aboriginal heritage items listed on the Australian, NSW or Section 170 databases were found within the catchment area. Fifty-seven items are listed under the Cessnock LEP 2011.

6 Hydraulic Model Update

6.1 Model Extension

The Black Creek Flood Study was completed in 2010 by DHI who developed an xp-rafts hydrological model and a combined 1D/2D MIKE FLOOD hydraulic model. The 1D (one-dimensional) component evaluates hydraulics within the main creeks and channels while the 2D component assesses overland flow within the floodplain. The model was calibrated to historical storm events and existing flood behaviour was estimated within the study area.

As the City of Cessnock is undergoing significant growth, up to date flooding information is essential to inform future development. The 2D (two-dimensional) model area identified as part of the Flood Study (2010) is not sufficiently large to provide detailed flooding information at a number of locations on the outskirts of Cessnock. It was decided by Council to extend the existing hydraulic model 2D area.

6.1.1 Updates to Existing Model

The 2D model extension area is shown in **Figure 6-1**.

The Flood Study (2010) assessed storm durations ranging from 30mins up to 36 hours and concluded that the 9 hour storm duration was dominant in the majority of the floodplain.

Preliminary analysis for the extended model suggested that a lower storm duration may be critical in parts of the floodplain including Bellbird Creek and Aberdare Creek which may result in higher peak flood levels. This assessment reviewed the full range of storm durations (1 hour up to 48 hours) for the extended model 1% AEP event and determined the critical storm duration and hence peak flood levels throughout the study area.

It was found that a lower storm duration was critical in places including 6hrs in parts of Bellbird Creek, 2hrs along Aberdare Creek and 12 hours on part of Black Creek at its confluence with Kearsley Creek, as shown in **Figure 6-2**. In addition, the critical storm duration at Mount View Basin was found to be 48hrs as the retarding basin was incorporated into the 2D model area. Elsewhere within the study area, the 9hr storm duration was critical.

Peak water levels were identified throughout the study area based on the maximum of each storm duration for each Annual Exceedance Probability (AEP) event.

6.1.2 Verification to June 2007 Storm Event

The Flood Study model (DHI, 2010) was calibrated to the storm event of June 2007 using surveyed flood levels available in Cessnock CBD, South Cessnock, Bellbird and Aberdare regions. The extended model was also run for the 2007 event and verified to the results of the calibration run from the DHI Flood Study (2010) to ensure consistency between both hydraulic models.

Results are included in Appendix D and show modelled flood levels +/- 20mm compared to observed flood levels along Oliver Street Channel in South Cessnock. Along Kearsley Creek, reasonable correlation was found with an average difference of 110mm and within the inundated area between Bellbird Creek and Lavender Creek, downstream of Barratt Avenue, an average difference of 100mm resulted between modelled and observed flood levels.

6.1.3 Differences

Figure 6-3 outlines the 1% AEP differences between the current extended model and the previous Flood Study model (DHI, 2010) with the main differences discussed below:

> The Flood Study model was based on photogrammetry with contours developed at 0.5m intervals for the study area. This was supplemented with ground survey data, where available. The availability of LiDAR survey data (collected in 2011) has resulted in much greater definition of existing terrain and creeks. This is most noticeable along Bellbird Creek where the 1D cross sections schematised as part of the Flood Study are relatively far apart;

- In Bellbird, the extended model results show general decreases in expected 1% AEP flood levels. Bellbird Creek and its floodplain is better defined in the 2D model area with reductions in expected flood depths ranging from 200mm to 500mm;
- Limestone Creek was included in the extended 2D model area with flow breaking out near Bellbird Creek and overland flow paths identified through current vacant land;
- Lavender Creek was incorporated into the 2D model area downstream of Mount View Road. Two branches converge east of Mount View Road and flow towards the retarding basin. The creek alignment is not greatly defined with a number of connected dams through the currently vacant land. As a result the expected 1% AEP flood extents are relatively broad with typical flood depths ranging up to 500mm;
- The existing Mount View retarding basin was assessed in the hydrological model and not explicitly modelled as part of the Flood Study (2010) hydraulic model. The 2D model area was extended to include the existing retarding basin and part of the Lavender Creek catchment upstream. Results indicate the basin is not overtopped in the 1% AEP event. The southern spillway is engaged and flow is conveyed around the southern and eastern embankments towards Lavender Creek. However, a significant portion of flow is conveyed overland through the holiday park and current vacant land, east of the basin;
- This overland flow combined with breakout from Bellbird Creek at the Sports Avenue crossing, results in increases in peak flood levels of up to 400mm downstream of Barrett Avenue between Bellbird Creek and Lavender Creek. Both creeks overflow causing inundation of properties between them in the vicinity of Barrett Avenue and Hunter Avenue;
- Minor reductions in flood levels ranging up to 100mm are evident along Black Creek south of Cessnock CBD with reductions of up to 200mm through the CBD itself. Further downstream flood levels are influenced by overflow from Bellbird Creek and Aberdare Creek with increases of up to 300mm along Blackwood Avenue;
- Higher flood levels are reported along Aberdare Creek where the assessment of the full range of storm durations indicated a critical duration of 2 hours. The critical duration corresponds to water level increases of up to 200mm along the Creek and at the confluence with Black Creek;
- Flood extents along Oliver Street channel and Kearsley Creek in South Cessnock are similar to previous results with minor increases in flood depth up to 100mm expected; and
- East Cessnock Drain was incorporated into the extended 2D model area. Results indicate significant reductions in expected 1% AEP flood levels in excess of 200mm through residential areas between Old Maitland Road and Government Road. This drain was modelled previously with a number 1D cross sections and the availability of LiDAR survey data has greatly helped to define the existing terrain.

6.1.4 Revised 1% AEP Flood Extents

The 1% AEP flood extents throughout the study area (1D and 2D areas) as a result of the hydraulic model updates are shown in **Figure 6-4** to **Figure 6-9** in **Appendix A**.

The revised extents were adopted by Council in March 2014.

6.1.5 Validation of the April 2015 Storm Event

In April 2015 a significant flood event occurred causing flooding within Cessnock and surrounding townships. In particular, the South Cessnock area experienced widespread flooding with a number of properties inundated. During and after the flood event, flood levels were recorded at several locations within the catchment.

As such, this presented an opportunity to validate the flood model used in the Floodplain Risk Management Study and Plan to the April 2015 flood event. Appendix G details the rainfall data sourced for this flood event and summarises the comparison between the recorded flood levels and the modelled results. All the preferred structural mitigation options in the Floodplain Risk Management Study and Plan were also assessed for the April 2015 Storm. Section 11.2.3 details the outcomes of the assessment.

6.2 Flood Mapping

The extended and updated hydraulic model was run for seven events namely the 20%, 10%, 5%, 2%, 1%, 0.5% AEP and the PMF events for a full range of storm durations ranging from 1 hour to 48 hours. The following flood mapping is included in **Appendix A**:

> The expected 5% AEP flood extents, flood contours, flood depths and velocities are shown in **Figure 6-10** to **Figure 6-12**;

> The expected 1% AEP flood extents, flood contours, flood depths and velocities are shown in **Figure 6-14** to **Figure 6-16**; and

> The expected PMF flood extents, flood contours, flood depths and velocities are shown in **Figure 6-20** to **Figure 6-22**.

Results for all AEP events assessed will be provided electronically to Council following completion of the project.

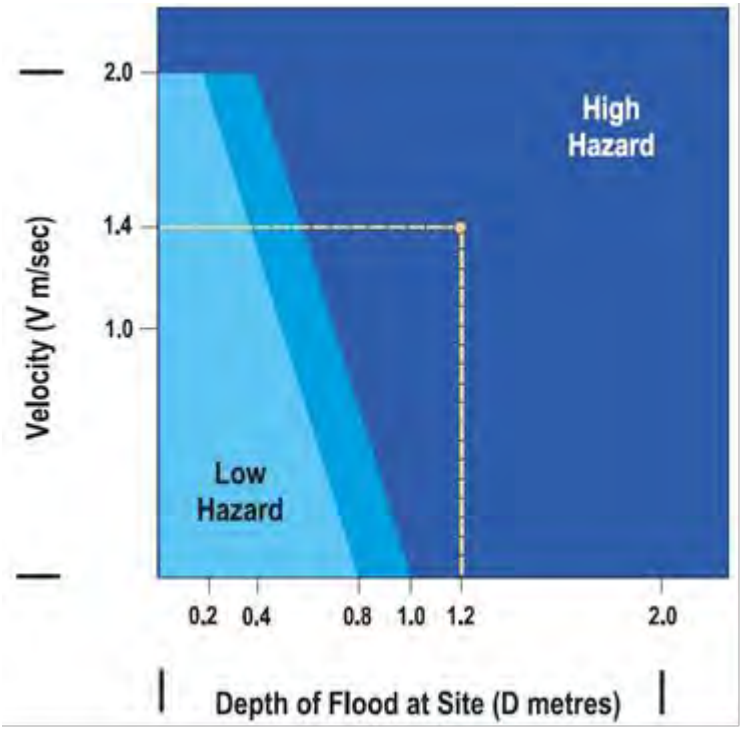
6.3 Flood Hazard

6.3.1 Provisional Flood Hazard

Flood hazard can be defined as the risk to life caused by a flood. The hazard caused by a flood varies both in time and place across the floodplain. Provisional flood hazard is determined through a relationship developed between the depth and velocity of floodwaters and is based strictly on hydraulic considerations (Appendix L; NSW Government, 2005). The Floodplain Development Manual (NSW Government, 2005) defines two categories for provisional hazard – high and low as shown in **Figure 6-1** .

> High hazard – possible danger to personal safety, evacuation by trucks difficult, able-bodied adults would have difficulty in wading to safety, potential for significant structural damage to buildings; and

> Low hazard – should it be necessary, a truck could be used to evacuate people and their possessions, able-bodied adults would have little difficulty in wading to safety.



Source: Floodplain Development Manual, NSW Government, 2005

Figure 6-1 Provisional Hazard Categorisation

Provisional hazard mapping is outlined in **Figure 6-17** and **Figure 6-23** for the 1% AEP and PMF events respectively.

6.3.2 True Flood Hazard

Provisional flood hazard categorisation based around the hydraulic parameters above does not consider a range of other factors that influence the "true" flood hazard. In addition to water depth and velocity, other factors contributing to the true flood hazard include:

- Size of the flood,
- Effective warning time,
- Flood readiness,
- Rate of rise of floodwaters,
- Duration of flooding,
- Ease of evacuation,
- Effective flood access,
- Type of development in the floodplain.

Hazard categorisation based on all of the above factors is part of establishing a Floodplain Risk Management Plan. Flood hazard may be defined as either the provisional or true flood hazard. Provisional flood hazard is determined through a relationship developed between the depth and velocity of floodwaters as detailed in the Floodplain Development Manual (NSW Government, 2005). True hazard is determined based on these hydraulic parameters as well as those factors listed above.

In the Black Creek catchment many of the above factors are not applicable in terms of affecting hazard identification. However, to provide a thorough assessment process, all of the above factors have been considered in this report. While some properties may be classed as high hazard based on the following discussion, they have not been mapped for privacy reasons.

Size of Flood

The size of a flood and the damage it causes varies from one event to another. In order to define the "true" flood hazard in varied magnitudes of storm events, flood hazard has been assessed for the PMF and 1% AEP events in this study.

Effective Warning Time

The effective warning time is the actual time available prior to a flood during which people may undertake appropriate actions (such as lift or transport belongings and/or evacuation). Effective warning time is always less than the total warning time available to emergency service agencies. This is related to the time needed to pass the flood warning to people located in the floodplain and for them to begin effective property protection and/or evacuation procedures.

The critical duration storm in the study area in a 1% AEP event generally ranges from 1hour to 9 hours. The peak duration for the PMF event is generally the 2 hour to 3 hour duration event. Although the critical duration varies across the catchment, all regions of the catchment are susceptible to flash flooding and consequently no region is more at risk due to warning time that any other. As discussed in Section 8, there is still opportunity to improve the local flood warning systems for residents in the catchment and thus the warning is not considered to decrease the flood hazard.

Flood Readiness

Flood readiness or preparedness can greatly influence the time taken by flood-affected residents and visitors to respond in an efficient manner to flood warnings. In communities with a high degree of flood readiness, the response to flood warnings is prompt, efficient and effective.

Flood readiness is generally influenced by the time elapsed since the area last experienced severe flooding. Responses from the community questionnaire indicated a relatively high awareness of flooding in reference to

the June 2007 flood event. As a result, no particular part of the catchment is likely to be any more prepared for a flood than another, thus flood readiness has not been considered in the preparation of hazard extents.

Depth and Velocity of Floodwaters

As outlined above, provisional hazard mapping is determined from a relationship between velocity and depth and has been used as the base to determine true flood hazard.

Rate of Rise of Floodwaters

The rate of rise of floodwater affects the magnitude of the consequences of a flood event. Situations where floodwaters rise rapidly are potentially far more dangerous and cause more damage than situations where flood levels increase slowly. The rate of rise of floodwaters is affected by catchment and floodplain characteristics.

A rate of rise of 0.5 m/hr has been adopted as indicative of high hazard. However, it is important to note that if an area has a rate of rise greater than 0.5m/hr this does not automatically result in the area being categorised as high hazard. For instance, if the rate of rise is very high but flood depths only reach 200mm, this is not considered to pose any greater hazard than slowly rising waters. Therefore, peak flood depths were considered in conjunction with the rate of rise in defining areas affected by true high hazard.

A flood depth of 0.5m was selected as the trigger depth for high hazard where the rate of rise was equal to or greater than 0.5m/hr.

Duration of Flooding

The duration of flooding or length of time a community, town or single dwelling is cut off by floodwaters can have a significant impact on the costs and disruption associated with flooding. Flooding durations in the study area are generally between 6hrs to 9hrs, even in the longer duration events. In the PMF event the critical durations are between 2 to 3 hours.

Those properties in the catchment that are affected by longer periods of inundation are already identified by the provisional high hazard criteria.

Ease of Evacuation

The levels of damage and disruption caused by a flood are also influenced by the difficulty of evacuating flood-affected people and property. Evacuation may be difficult due to a number of factors, including:

- The number of people requiring assistance;
- Mobility of those being evacuated;
- Time of day; and
- Lack of suitable evacuation equipment.

A flood event in the catchment is likely to be a flash flood scenario, with limited warning time and exposure time therefore evacuation may not be viable. It is noted that the percentage of people aged 60+ years in the LGA is approximately 20% and within the study area, retirement villages and aged care facilities are classified as having difficult evacuation requirements given the demographics of the residents at these locations.

Effective Flood Access

The availability of effective access routes to or from flood affected areas can directly influence personal safety and potential damage reduction measures. Effective access implies that there is an exit route available that remains trafficable for sufficient time to evacuate people and possessions.

Flood access issues vary across the catchment. For this assessment, properties were identified as being in one of four flood access categories:

- Site is flooded and evacuation required through a high hazard flooded roadway;
- Site is flooded and evacuation is required through a flooded roadway;
- Site is flooded and evacuation is possible through a non-flooded roadway directly from site; and
- Site is flood free, however all road access is impeded by floodwaters.

To consolidate these categories and determine the implication of flood access issues on hazard mapping, criteria were set to establish effective flood access. It was determined that effective access is a road which is flooded by less than 0.3m of water. For the purposes of this assessment 0.3m is the threshold depth at which vehicles become unstable, even at very low velocities.

Type of Development

The degree of hazard to be managed is a function of the type of development and resident mobility. This may alter the type of development considered appropriate in new development areas and may also change management strategies in existing development areas. The land-use in the study area is predominantly residential, with some commercial and industrial areas.

True Hazard Mapping

Figure 6-18 and **Figure 6-24** show the true high hazard areas and low hazard areas mapped in the 1% AEP event and the PMF event respectively.

6.4 Hydraulic Category Mapping

Flood hazard relates to the impact of flooding on development and people and hydraulic categorisation is used to reflect the impact of development activity on flood behaviour. The Floodplain Development Manual (2005) defines flood prone land to be one of the following three hydraulic categories:

> Floodway – Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas;

> Flood Storage – Areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it will result in elevated water levels and/or elevated discharges. Flood storage areas, if completely blocked would cause peak flood levels to increase by 0.1m and/or would cause the peak discharge to increase by more than 10 percent; and

> Flood Fringe – Remaining area of flood prone land after Floodway and Flood Storage areas have been defined. Blockage or filling of this area will not have any significant effect on the flood pattern or flood levels.

The criteria used to define floodways and flood storage is described below (based on Howells et al, 2003). It provides a framework for the FRMSP and guides planning for properties potentially requiring a detailed assessment for future development.

As a minimum, the floodway was assumed to follow the channels from bank to bank. In addition, the following depth and velocity criteria were used to define a floodway:

> Velocity x Depth product must be greater than 0.25m^2/s and velocity must be greater than 0.25m/s; or,

> Velocity is greater than 1m/s.

Flood storage was defined as those areas outside the floodway, which if completely filled would cause peak flood levels to increase by 0.1 m and/or would cause peak discharges to increase by more than 10%. The criteria were applied to the model results as described below.

Previous analysis of flood storage in 1D cross sections assumed that if the cross-sectional area is reduced such that 10 percent of the conveyance is lost, the criteria for flood storage would be satisfied. To determine the limits of 10 percent conveyance in a cross-section, the depth was determined at which 10 percent of the flow was conveyed. This depth averaged over several cross-sections was found to be 0.2m (Howells et al, 2003). Thus the criteria used to determine the flood storage is:

> Depth greater than 0.2m; and

> Not classified as floodway.

Hydraulic categorisation mapping has been undertaken for the 5%, 1% AEP and PMF flood events and is shown in **Figure 6-13**, **Figure 6-19** and **Figure 6-25**.

6.5 Climate Change Assessment

Changes to climate conditions are expected to have an adverse impact on rainfall intensities. The NSW Office of Environment and Heritage guidelines, *Practical Consideration of Climate Change* (2007), provide advice for consideration of climate change in flood investigations. It states that sensitivity analysis be undertaken for:

> 10%, 20%, and 30% increase in peak rainfall and storm volume.

The model was run for the 1% AEP event, 9 hour storm duration, with 10%, 20% and 30% increases in rainfall intensities. The resulting increases in flood levels at key locations within the study area are outlined in **Table 6-1** and the locations identified in **Figure 6-26**.

Table 6-1 Sensitivity Analysis – Increasing Rainfall Intensity due to Climate Change

Reference Location	100yr Existing Water Level (mAHD)	Increase in Rainfall Intensity					
		+10% Water Level (mAHD)	Difference (m)	+20% Water Level (mAHD)	Difference (m)	+30% Water Level (mAHD)	Difference (m)
A	91.33	91.35	0.02	91.36	0.04	91.38	0.05
B	76.32	76.38	0.06	76.43	0.11	76.47	0.15
C	71.84	71.86	0.01	71.89	0.04	71.92	0.07
D	74.58	74.62	0.04	74.65	0.08	74.68	0.11
E	70.27	70.43	0.15	70.55	0.28	70.65	0.38
F	68.46	68.66	0.20	68.87	0.40	69.04	0.58
G	74.59	74.78	0.19	74.92	0.33	75.04	0.45
H	72.05	72.07	0.02	72.09	0.05	72.12	0.08
I	71.31	71.36	0.05	71.41	0.10	71.46	0.16
J	71.27	71.33	0.06	71.38	0.11	71.43	0.16
K	70.11	70.21	0.10	70.33	0.21	70.43	0.32
L	70.08	70.20	0.12	70.32	0.24	70.43	0.35
M	68.54	68.56	0.02	68.58	0.04	68.60	0.05
N	67.62	67.91	0.29	68.15	0.53	68.33	0.71
O	71.40	71.43	0.04	71.47	0.08	71.51	0.12

Impact maps for each scenario are shown in **Figure 6-27**, **Figure 6-28** and **Figure 6-29**.

7 Economic Impact of Flooding

7.1 Background

The economic impact of flooding can be defined by what is commonly referred to as flood damages. The various types of flood damages are categorised in **Table 7-1**.

Table 7-1 Flood Damages Categories

Type of Flood Damages	Description
Direct	Building contents (internal) Structure (building repair and clean) External items (vehicles, contents of sheds etc.)
Indirect	Clean-up (immediate removal of debris) Financial (loss of revenue, extra expenditure) Opportunity (non-provision of public services)
Intangible	Social – increased levels of insecurity, depression, stress General inconvenience in post-flood stage

Direct damage costs are just one component of the entire cost of a flood event. There are also indirect costs. Both direct and indirect costs are referred to as tangible costs. In addition to this there are also intangible costs such as social distress. The flood damage values discussed in this report are the tangible damages and do not include an assessment of the intangible costs which are difficult to calculate in economic terms.

The assessment is based on damage curves that relate the depth of flooding on a property to the likely damage within the property. Ideally, the damage curves should be prepared for the particular catchment for which the study is being carried out. However, damage data in most catchment is not available and recourse is generally made to damage curves from other catchments.

7.2 Floor Level and Property Survey

A survey of 2,665 properties was undertaken in 2011 for the Black Creek catchment and comprised ground levels and floor levels of habitable buildings. This data was used to complete the flood damages assessment.

7.3 Damages Analysis

NSW Office of Environment and Heritage (OEH) has conducted research and prepared a methodology to develop damage curves based on state-wide historical data. OEH guidelines include a template spreadsheet program that determines damage curves for residential properties including:

> Single storey, slab on ground;

> Two storey, slab on ground; and

> Single storey, high set.

The methodology for determination of flood damages within the Black Creek Catchment is outlined in the following sections.

7.3.1 Residential Damage Curves

Damages are generally incurred on a property prior to any overfloor flooding. The OEH curves allow for external damage of $10,487 (May 2012 dollars) to be incurred when the water level reaches the base of the house (the base of the house is determined by 0.5m below the floor level for slab on ground). It has been assumed that this remains constant until overfloor flooding occurs.

A nominal value of $3,000 has been allowed to represent damage to gardens where the ground level of the property is overtopped. There are a number of input parameters required for the damage curves including floor area and level of flood awareness. The following parameters were adopted:

> 175m^2 has been adopted as an estimate of the floor area for residential dwellings. With a floor area of 175m^2, the default contents value is $43,750 (based on November 2001 dollars);

> The Effective Warning Time has been assumed to be zero due to the absence of any flood warning systems in the catchment. A long Effective Warning Time allows residents to prepare for flooding by moving valuable household contents (e.g. the placement of valuables on top of tables and benches); and,

> The Black Creek catchment is part of the overall larger regional area and as such is not likely to cause any post flood inflation. These inflation costs are generally experienced in small towns in regional areas, where re-construction resources are limited and large floods can cause a strain on these resources.

7.3.2 Average Weekly Earnings

OEH damage curves are derived for late 2001. It is recommended that values in residential damage curves are adjusted by Average Weekly Earnings (AWE) rather than by the inflation rate as measured by the Consumer Price Index (CPI). AWE is considered a better representation of societal wealth, and hence an indirect measure of the building and contents value of a home.

The most recent data from the Australian Bureau of Statistics at the time of this study is for May 2012 with AWE = $1,058.70, hence all ordinates in the residential flood damage curves were updated to May 2012 dollars by an adjustment factor of 1.57. In addition, all damage curves include GST as per OEH recommendations.

7.3.3 Commercial Damage Curves

Commercial damage curves were adopted from the FLDamage Manual (Water Studies Pty Ltd, 1992). FLDamage allows for three types of commercial properties:

> Low value commercial;

> Medium value commercial; and

> High value commercial.

For the purpose of this assessment all commercial properties have been classified as medium value commercial. In determination of these damage curves, it has been assumed that the effective warning time is zero and the loss of trading days as a result of the flooding has been taken as 10.

These curves are determined based on the floor area of the property and an area of 100m^2 has been used for this assessment. This is considered conservative for some commercial properties throughout the CBD and this will be updated to reflect larger premises.

The Consumer Price Index (CPI) obtained from the Australian Bureau of Statistics website was used to bring the 1990 data to May 2012 dollars resulting in an increase of 76%. It was assumed that the Water Studies Pty Ltd data was in June 1990 dollars.

7.3.4 Industrial Damage Curves

Cardno conducted a survey of industrial properties in 1998 for Wollongong City Council as part of another project. The damage curves derived from this survey are more recent than those presented in FLDamage and have been used in a number of previous studies. These damage curves have also been adopted in this assessment.

The curves were prepared for three categories:

> Low Value Industrial; and

> Medium Value Industrial.

For the purpose of this assessment all industrial properties have been classified as medium value industrial, as no other information was available in the survey provided. It is noted that this may be conservative and will be updated to reflect any major industrial premises within the study area.

The survey conducted only accounts for structural and contents damage to the property. Clean up costs and indirect financial costs were estimated based on the FLDamage Manual. Actual internal damage could be estimated, along with potential internal damage, using various factors within FLDamage. Using both the actual and potential internal damages, estimation of both the clean-up costs and indirect financial costs could be made.

The values were adjusted to May 2012 dollars using CPI statistics resulting in an increase of 49% compared to 1998 values.

7.4 Average Annual Damage

Annual Average Damage (AAD) is calculated on a probability approach, using the flood damages calculated for each design event. Flood damages for each design event are calculated by using the 'damage curves' described in Section 7.3. The total damage for a design event is determined by adding all the individual property damages for that event.

Figure 7-1 is a probability curve based on the flood damages calculated for each design event. For example, the 100 year ARI design event has a probability of occurrence of 1% in any given year, and as such the 100 year ARI flood damage is plotted at this point on the AAD curve. AAD is then calculated by determining the area under this curve. For this study, the damage resulting from events more frequent than a 50% AEP were assumed to be zero for the AAD analysis. Further information on the calculation of AAD is provided in Appendix M of the Floodplain Development Manual (2005).

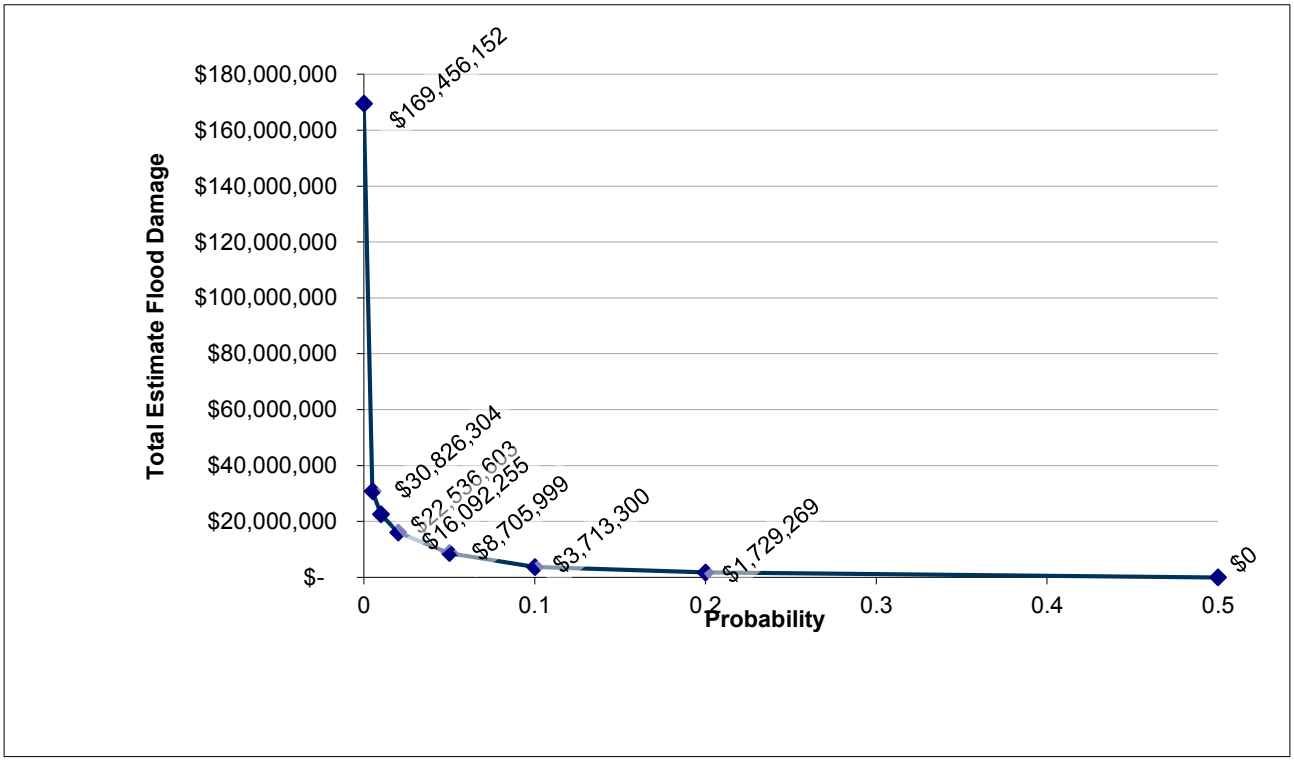


Figure 7-1 Average Annual Damages Curve for the Black Creek Catchment

7.5 Results

The results of the flood damage assessment are shown in **Table 7-2**. The average annual damage within the floodplain under existing catchment conditions is estimated at **$2,473,550**.

Table 7-2 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Properties with Overground Flooding	Estimated Total Damage ($May 2015)
PMF					
Residential	1891	1.74	4.58	2029	$154,027,021
Commercial	283	2.21	4.74	288	$14,450,753
Industrial	44	2.29	4.19	49	$978,377
PMF Total	**2218**			**2366**	**$169,456,152**
0.5% AEP					
Residential	395	0.40	1.56	1127	$28,408,293
Commercial	80	0.43	1.53	102	$2,258,905
Industrial	14	0.35	0.99	25	$159,105
0.5% AEP Total	**489**			**1254**	**$30,826,304**
1% AEP					
Residential	278	0.34	1.32	996	$20,985,285
Commercial	59	0.32	1.3	86	$1,459,850
Industrial	9	0.28	0.64	20	$91,468
1% AEP Total	**346**			**1102**	**$22,536,603**
2% AEP					
Residential	183	0.31	1.16	827	$15,080,781
Commercial	51	0.22	1.13	72	$955,626
Industrial	6	0.23	0.5	11	$55,848
2% AEP Total	**240**			**910**	**$16,092,255**
5% AEP					
Residential	93	0.25	0.83	574	$8,272,904
Commercial	23	0.19	0.81	41	$406,185
Industrial	3	0.16	0.38	6	$26,910
5% AEP Total	**119**			**621**	**$8,705,999**
10% AEP					
Residential	32	0.19	0.53	368	$3,580,603
Commercial	7	0.14	0.36	16	$119,292
Industrial	1	0.25	0.25	2	$13,405
10% AEP Total	**40**			**386**	**$3,713,300**
20% AEP					
Residential	18	0.17	0.47	177	$1,705,623
Commercial	1	0.06	0.06	6	$16,197
Industrial	1	0.12	0.12	2	$7,450
20% AEP Total	**20**			**185**	**$1,729,269**

Figure 7-2 in **Appendix A** outlines the properties affected by overfloor flooding in 20% and 10% AEP events. Overfloor flooding for these events is concentrated in a number of distinct areas including:

> South Cessnock in the vicinity of Oliver Street channel;

> East Cessnock Drain to the northeast of Cessnock; and

> Various properties through the CBD.

These areas are likely to contribute a higher proportion to AAD than other areas where overfloor flooding does not occur and provide a useful guide to focus development of flood mitigation options. For example, areas with higher AAD values, or areas where overfloor flooding occurs in frequent events, will generally have a better cost benefit outcome.

8 Emergency Response Arrangements

8.1 Flood Emergency Response

Flooding in Cessnock is primarily associated with rising water levels in Black Creek, Bellbird Creek, Aberdare Creek, Kearsley Creek and Lavender Creek. Historical patterns of development have effectively infilled parts of the floodplain and significant flooding occurs near these creeks when floodwaters overtop the creek banks and flow overland, particularly at the confluence of several creeks in Cessnock.

The term “critical storm duration” describes the amount of time that it takes for flood waters to rise, and then fall, in response to a storm event. The critical storm duration for the study area is generally 9hrs (see **Figure 6-2**) with some specific localities experiencing different critical durations of:

- 2hrs along Aberdare Creek;
- 6hrs in parts of Bellbird Creek;
- 12hrs on Black Creek at its confluence with Kearsley Creek; and
- 48hrs at the Mount View Basin.

Based on these critical durations, it is reasonable to assume that the time between the onset of the storm (when water levels start to rise) and the realisation of peak flood levels is relatively short, with only a few hours warning time available ahead of the flood event. This is considered short duration “flash” flooding.

Due to the rapid onset of flood conditions experienced in most parts of the catchment, there is little in the way of warning that can be provided. Any warning provided would generally be for immediate safety precautions such as temporary refuge (if available nearby or on-site), raising of items off the ground and accounting for people on-site.

The relatively short warning time available may not allow sufficient time to evacuate residents from their properties, except for some locations in the floodplain. In areas that experience flash flooding, evacuation is generally not recommended as the response during a flood event as it is likely to be hurried and uncoordinated, which can expose evacuees to a hazardous situation. As such, the preferred response in flash flooding catchments is for people to remain within the property, preferably on the upper floor levels, if available. The suitability of the shelter-in-place approach should be considered in consultation with the State Emergency Service (SES) for the preparation of a Local Flood Plan.

It is important that residents are aware of signs that will signal an approaching flood, and are aware of the appropriate response such that the small time period before the flood arrives may be used as effectively as possible.

8.2 Flood Emergency Response Documentation

Flood emergency measures are an effective means of reducing the costs of flooding and managing the continuing and residual risks to the area. Current flood emergency response arrangements for management flooding in the Black Creek floodplain are discussed below.

8.2.1 DISPLAN

The Black Creek floodplain is located within the Hunter SES Region and for emergency management purposes is part of the Hunter Central Coast Emergency Management District. Flood emergency management for the Black Creek floodplain is organised under the *New South Wales State Disaster Plan* (DISPLAN) (2010). No district DISPLAN has been prepared for this district.

The DISPLAN details emergency preparedness, response and recovery arrangement for NSW to ensure the coordinated response by all agencies having responsibilities and functions in emergencies.

The DISPLAN has been prepared to coordinate the emergency management measures necessary at State level when an emergency occurs, and to provide direction at District and Local level.

The plan is consistent with district plans prepared for areas across NSW and covers the following aspects at a state level:

- Roles and strategies for prevention of disasters;
- Planning and preparation measures;
- Control, coordination and communication arrangements;
- Roles and responsibilities of agencies and officers;
- Conduct of response operations; and
- Co-ordination of immediate recovery measures.

The state DISPLAN states that:

"*Each District and Local Emergency Management Committee is to develop and maintain its own District / Local Disaster Plan, with appropriate Supporting Plans and Sub Plans, as required by Functional Area Coordinators and Combat Agency Controllers at the appropriate level. Supporting plans are to be the exception at local level and their development must be approved by District Functional Area Coordinators*."

In particular the purpose of a District DISPLAN is to:

- Identify responsibilities at a District and Local level in regards to the prevention, preparation, response and recovery for each type of emergency situation likely to affect the district;
- Detail arrangements for coordinating resource support during emergency operations at both a District and Local level;
- Outline the tasks to be performed in the event of an emergency at a District and Local level;
- Specifies the responsibilities of the Hunter Central Coast District Emergency Operations Controller and Local Emergency Operations Controllers within the Hunter Central Coast EM District;
- Detail the responsibilities for the identification, development and implementation of prevention and mitigation strategies;
- Detail the responsibilities of the District & Local Emergency Management Committees within the District;
- Detail agreed Agency and Functional Area roles and responsibilities in preparation for, response to and recovery from, emergencies;
- Outline the control, coordination and liaison arrangements at District and Local levels;
- Detail arrangements for the acquisition and coordination of resources;
- Detail public warning systems and responsibility for implementation;
- Detail public information arrangements and public education responsibilities;
- Specifies arrangements for reporting before, during and after an operation; and
- Detail the arrangements for the review, testing, evaluation and maintenance of the Plan.

8.2.2 State Flood Sub-plan

The *New South Wales State Flood Sub-plan* (2008) is used to set out the arrangements for the emergency management of flooding.

The State Flood Sub-plan is a sub-plan to the state DISPLAN. The Sub-plan sets out the emergency management aspects of prevention, preparation, response and initial recovery arrangements for flooding and the responsibilities of agencies and organisations with regards to these functions.

There is a requirement for the development and maintenance of a Flood Sub-plan for:

- The State of New South Wales;
- Each SES Region; and
- Each council area with a significant flood problem. In some cases the flood problems of more than one council area may be addressed in a single plan or the problems of a single council area may be addressed in more than one.

Annex B of the Sub-plan lists the Local Flood Sub Plans which exist or are to be prepared in New South Wales and indicates which river, creek and/or lake systems are to be covered in each plan. The Cessnock City is listed in Annex B. Further detail on the contents of the *Cessnock City Local Flood Plan* (2009) is provided below.

8.2.3 Cessnock City Local Flood Plan

The SES prepared a detailed *Local Flood Plan* (CCC and SES, 2009) following the 2007 flood event. It includes detailed information on the following:

- Description of local flooding conditions (see Annex A);
- Responsibilities for the various combat agencies active in flood preparedness, warning, emergency response and recovery;
- Information and procedures relevant to flood preparedness, including:
  - Regular update of the Plan,
  - Floodplain risk management community education,
  - Development of flood intelligence and warning systems, and
  - Training and resourcing.
- Procedures for flood response, including:
  - The lead combat agency (the SES) during the flood event and the location of operations centres;
  - Protocols for interagency liaison and communications both between organisations and with the community;
  - Definition as to where flood intelligence can be obtained (e.g. the BoM) and when the plan is triggered;
  - The different types of warnings (e.g. Livestock and Equipment, Flood Warnings, Evacuation, etc.) and when they/how they are delivered;
  - Procedures for road closures and traffic control, along with location of road closures due to flooding;
  - Flood rescue, evacuation procedures (including for travellers and animals), and the location of evacuation centres;
  - Logistical issues such as keeping providers of critical infrastructure up to date, providing sandbags, and aircraft management;
  - Re-supply of flood isolated areas; and
  - The provision of an “all clear” following the event.
- Information and procedures relevant to flood recovery, including:
  - Recovery coordination;
  - Welfare for flood affected community members, particularly those that have been evacuated; and
  - Arrangements for de-briefs and post-flood reviews.

In addition, the Plan provides some detail on flood risk based on historic flood information and the location of urban population centres and rural properties. Critically, vulnerable developments such as child care facilities and special needs groups are also identified.

8.3 Emergency Services Operators

As detailed in the *Cessnock City Local Flood Plan* (CCC and SES, 2009), the emergency response to any flooding of the Black Creek floodplain will be coordinated by the lead combat agency, the SES, from their Local Operations Centres:

> Cessnock City CES Operations Centre on South Avenue, Cessnock; and

> Cessnock City Emergency Operations Centre located in the Council Administration Building on Vincent Street, Cessnock.

Office to office communications shall be via telephone, GRN radio and facsimile, with the GRN radio being the primary means of communications to and between deployed SES resources. Backup communications systems identified in the Plan include the Cessnock Rural Fire Service radio system and the Cessnock Council UHF radio system.

The Hunter Region SES issues SES Flood Bulletins to media outlets on behalf of all SES units in the region, including the Cessnock Local SES, and will provide regular updates throughout a flood event.

The relevant flood information from the Black Creek Flood Study Update and this FRMS and FRMP should be transferred to Cessnock City SES Operations Centre and the Cessnock City Emergency Operations Centre.

8.4 Flood Warning Systems

For flash flood catchments (such as the Black Creek floodplain), the BoM provides general warning services, including:

> Flood Watches – early appreciation of a developing weather system that could lead to flooding;

> Flood Warnings – river height readings from gauges and height-time predictions;

> Severe Weather Warnings; and

> Severe Thunderstorm Warnings.

In some cases, 2-3 days advanced notice may be available (e.g. where an East Coast Low develops off Sydney). However, at other times it may only be possible to issue a flood warning a few hours in advance, if at all.

The warnings issued by BoM are typically for a much larger region, or catchment, that includes the local flash flood site. It is noted that the creeks located in the Study Area are not gauged, and therefore the most commonly used warnings issued by the BoM are the more general warnings, and probably also the rain radars.

In the case of the Black Creek floodplain, flood warnings are typically based on a combination of BoM severe weather / flood warnings, which are provided to the Hunter Region SES headquarters, and local observations of creek conditions made by the Cessnock City SES officers. The Local Flood Plan identifies that the Hunter Region SES will pass on to the local SES BoM warnings and information on flooding and its consequences in the local area. The Cessnock City SES will then notify the Local Emergency Operations Controller and Local Emergency Management Officer.

In turn, the local SES may contact the Hunter Region SES with advice on the current and expected impacts of flooding. This includes notification of the Hunter Region SES to enable issue of SES Livestock and Equipment Warnings and updated Local Flood Advices.

The local Cessnock SES conducts a range of monitoring activities based on a combination of local knowledge and a series of rain, river and road gauges monitored by a combination of local readers or other organisations including:

> Cessnock City Council;

> Various Rural Fire Service groups;

> Cessnock Voluntary Rescue Association;

> The local Police; and

> Roads and Maritime.

Further detail is provided in Annex C of the Local Flood Plan (CCC and SES, 2009).

There is opportunity to improve the local flood warning system to provide additional gauges for Black Creek and the other watercourses, or flood markers at key locations, such that local flood conditions are more easily monitored, this is considered further as part of the Emergency Management Options in Section 11.4.5.

8.5 Access and Movement during a Flood

Any flood response suggested for the study area must take into account the availability of flood free access, and the ease with which movement may be accomplished. Movement may be evacuation from flood affected areas, medical personnel attempting to provide aid, or SES personnel installing flood defences

8.5.1 Access Road Flooding

Roads subject to inundation are identified in Part 9 of Annex B of the Cessnock Local Flood Plan (CCC and SES, 2009), focussing primarily on main roads. The Plan also identifies the main evacuation routes (also mapped on **Figure 7-3**) as follows:

> Branxton – MR220 (Branxton to Cessnock via Wine Country Road);

> East Branxton-Greta – New England Highway to Lochinvar; and

> Loxford-Weston-Cliftleigh – as appropriate in individual cases, to Kurri Kurri.

Table 8-1 provides a summary of road flooding depths in the Black Creek floodplain. Locations inundated in the 20% AEP event and which exceed 0.3m depth in any event up to the 1% AEP event have been identified. Reference locations are outlined in **Figure 6-26**.

Table 8-1 Access Road Flooding

Reference ID	Reference Location	Depth of Flooding (m)											
		20% AEP		10% AEP		5% AEP		2% AEP		1% AEP		PMF	
		Depth (m)	Time (hh:mm)	Depth (m)	Time (hh:mm)	Depth (m)	Time (hh:mm)	Depth (m)	Time (hh:mm)	Depth (m)	Time (hh:mm)	Depth (m)	Time (hh:mm)
A	Abbotsford St, Bellbird	1.40	5:50	1.50	5:30	1.58	5:20	1.63	2:30	1.66	2:20	2.21	0:50
B	Mount View Rd near Mount View Park	0.34	7:00	0.35	6:40	0.36	6:30	0.46	6:00	0.60	5:10	1.66	2:30
D	Sports Ave near Cessnock Showground	0.16	7:20	0.21	6:50	0.28	6:30	0.34	6:00	0.37	5:30	2.40	1:50
C	Mount View Rd near Hunter Ave	0.52	6:40	0.66	6:20	0.81	6:00	0.91	5:10	0.98	4:50	1.90	1:10
E	Westcott St	0.32	5:30	0.70	5:00	1.36	4:50	1.68	4:40	1.83	4:20	4.24	0:30
F	Allandale Rd near Maitland Rd	0.22	6:40	0.54	5:50	0.86	5:30	1.15	5:00	1.35	4:50	4.90	0:40
G	Vincent St near Bradley Park	0.18	6:00	0.21	5:40	0.24	5:20	0.28	4:50	0.53	4:30	2.83	1:40
H	Sixth St	0.17	4:50	0.21	4:40	0.25	4:10	0.28	3:10	0.30	3:00	1.73	0:20
I	McFarlane St near Oliver St	0.34	5:20	0.40	5:00	0.49	4:50	0.59	4:20	0.65	3:50	2.74	0:20
J	Edgeworth St	0.37	5:10	0.44	4:50	0.52	4:30	0.62	3:50	0.69	3:20	2.81	0:30
K	Snape St	0.16	6:30	0.27	5:40	0.37	5:10	0.47	5:00	0.55	4:50	3.70	0:30
L	South Ave near Hunter TAFE – Cessnock Campus	0.04	10:10	0.42	8:00	0.52	6:30	0.66	5:50	0.79	5:30	3.95	1:10
M	Maitland Rd near Koree St	0.35	0:25	0.36	0:25	0.38	0:20	0.40	0:40	0.42	0:40	2.38	0:20
N	Ferguson St near Preston St	0.07	6:30	0.29	6:00	0.67	5:30	1.02	5:10	1.33	4:50	4.53	0:50
O	Maitland Rd near Quarry St	0.09	6:40	0.17	6:00	0.26	5:30	0.32	5:00	0.35	4:50	1.56	0:40

It is recommended that permanent flood depth markers be installed on either side of roads which are subject to significant inundation to provide an indication to motorists of water levels at these locations when the road is flooded (this may also include adjacent intersections and low points).

8.6 Flood Emergency Response Classifications

To assist in the planning and implementation of response strategies, the SES classifies communities according to the impact flooding has on them. Flood affected communities are those in which the normal functioning of services is altered either directly or indirectly because a flood results in the need for external assistance. This impact relates directly to the operational issues of evacuation, re-supply and rescue. The classifications adopted by the SES are (DECC, 2007):

- **Flood Islands**. These are inhabited or potentially habitable areas of high ground within a floodplain linked to the flood-free valley sides by a road across the floodplain and with no alternative overland access. The road can be cut by floodwater, closing the only evacuation route and creating an island. Flood islands can be further classified as:
  - High Flood Island (the flood island contains enough flood free land to cope with the number of people in the area or there is opportunity for people to retreat to higher ground).
  - Low Flood Island (the flood island does not have enough flood free land to cope with the number of people in the area or the island will eventually become inundated by flood waters).
- **Trapped Perimeter Areas**. These would generally be inhabited or potentially habitable areas at the fringe of the floodplain where the only practical road or overland access is through flood prone land and unavailable during a flood event. The ability to retreat to higher ground does not exist due to topography or impassable structures. Trapped Perimeter Areas are further classified according to their evacuation route:
  - High Trapped Perimeter (the area contains enough flood free land to cope with the number of people in the area or there is opportunity for people to retreat to higher ground).
  - Low Trapped Perimeter (the area does not have enough flood free land to cope with the number of people in the area or the island will eventually become inundated by flood waters).
- **Areas Able to be Evacuated**. These are inhabited areas on flood prone ridges jutting into the floodplain or on the valley side that are able to be evacuated.
  - Areas with Overland Escape Route (access roads to flood free land cross lower lying flood prone land).
  - Areas with Rising Road Access (access roads rise steadily uphill and away from the rising floodwaters).
- **Indirectly Affected Areas**. These areas are outside the limit of flooding and therefore will not be inundated, nor will they lose road access. However, they may be indirectly affected as a result of flood damaged infrastructure or due to the loss of transport links, electricity supply, water supply, sewage or telecommunications services and they may therefore require resupply or in the worst case, evacuation.
- **Overland Refuge Areas**. These are areas that other areas of the floodplain may be evacuated to, at least temporarily, but which are isolated from the edge of the floodplain by floodwaters and are therefore effectively flood islands or trapped perimeter areas.

The flood emergency response planning classifications for the floodplain have been prepared in accordance with NSW Government (2007) and are shown in **Figure 8-2**, **Figure 8-3** and **Figure 8-4**. Even in the more regular flood events such as the 5% AEP flood, large areas comprise Trapped Perimeter Areas or Low Flood Island, although most of the more densely inhabited areas are High Trapped Perimeter Areas.

9 Policies and Planning

9.1 Planning Instruments & Policies

The Black Creek floodplain is located within the Cessnock LGA where development is controlled through two key planning instruments, the Cessnock Local Environment Plan (LEP) and Development Control Plan (DCP). Specifically, the study area falls under the Cessnock LEP 2011 and DCP 2010.

The LEP is a planning instrument which designates land uses and permissible development in the LGA, whilst the DCP provides specific guidelines and parameters for development. In addition to the LEP and DCP, other local policies and specifications have been created by Council to provide additional information regarding development. In addition to the LEP and DCP, there are a range of relevant state environmental planning policies (SEPPs) which prevail over the provisions of the LEP and DCP and local policies and specifications.

This section reviews flood controls covered by the LEP, DCP, local policies and specifications. Reference is included to key SEPPs that are of relevance to flood-related planning.

Council does not have a specific Floodplain Risk Management Policy for the whole of the Local Government Area that sets the high level direction for the management of flood risks.

9.2 Cessnock Local Environmental Plan 2011

9.2.1 Current Land Use Zoning

Under the LEP (2011), the upper portions of the Black Creek catchment is primarily comprised of rural land uses, with some areas of residential and commercial land uses (**Figure 9-1**). However, the floodplain of the Cessnock CBD and surrounds is a mixture of medium and low density residential land use, commercial core and mixed use as well as a range of other uses. Downstream (north) of the Cessnock CBD (towards Nulkaba), the majority of the floodplain area is zoned as rural landscape. A portion of this northern area of the floodplain has been identified for urban land release in the Cessnock DCP 2010 (Section 9.3).

These zones and the flood affected area of land associated with each zone are described in **Table 9-1**.

It is noted that parts of the land zoned for low (R2) and medium (R3) density residential have not yet been developed. A review of the most up to date aerial photography was undertaken in order to assess what proportion of these land use zonings has already been developed. This was based on a visual assessment and is approximate only. Of the 67.76 ha of land zoned R2, it is estimated 40 ha have been developed. Of the land zoned R3, 83 ha has been developed, out of a total of 84.97 ha that is located within the 100 year ARI flood extent.

It is noted that the Floodplain Development Manual (NSW Government, 2005) does not specifically preclude development on the floodplain, provided the risk can be appropriately managed. Residential development in the floodplain has a level of inherent risk, and this is usually managed by implementation of a range of flood management measures, including development controls. In some circumstances, where it is considered the risk cannot be adequately mitigated, a local Council may propose to re-zone the land.

Table 9-1 Land Use Zoning

Land Use Zone	Zone Objectives	Area Affected by 100 Year ARI (ha)
B1 Neighbourhood Centre	▪ To provide a range of small-scale retail, business and community uses that serve the needs of people who live or work in the surrounding neighbourhood. ▪ To provide services to tourists and visitors at the Greta Migrant Camp.	0.04

Land Use Zone	Zone Objectives	Area Affected by 100 Year ARI (ha)
B3 Commercial Core	▪ To provide a wide range of retail, business, office, entertainment, community and other suitable land uses that serve the needs of the local and wider community. ▪ To encourage appropriate employment opportunities in accessible locations. ▪ To maximise public transport patronage and encourage walking and cycling.	10.91
B4 Mixed Use	▪ To provide a mixture of compatible land uses. ▪ To integrate suitable business, office, residential, retail and other development in accessible locations so as to maximise public transport patronage and encourage walking and cycling.	21.95
B7 Business Park	▪ To provide a range of office and light industrial uses. ▪ To encourage employment opportunities. ▪ To enable other land uses that provide facilities or services to meet the day to day needs of workers in the area.	8.45
E1 National Parks & Nature Reserves	▪ To enable the management and appropriate use of land that is reserved under the *National Parks and Wildlife Act 1974* or that is acquired under Part 11 of that Act. ▪ To enable uses authorised under the *National Parks and Wildlife Act 1974*. ▪ To identify land that is to be reserved under the National Parks and Wildlife Act 1974 and to protect the environmental significance of that land.	3.85
E2 Environmental Conservation	▪ To protect, manage and restore areas of high ecological, scientific, cultural or aesthetic values. ▪ To prevent development that could destroy, damage or otherwise have an adverse effect on those values.	14.05
IN2 Light Industrial	▪ To provide a wide range of light industrial, warehouse and related land uses. ▪ To encourage employment opportunities and to support the viability of centres. ▪ To minimise any adverse effect of industry on other land uses. ▪ To enable other land uses that provide facilities or services to meet the day to day needs of workers in the area. ▪ To support and protect industrial land for industrial uses.	5.61
R2 Low Density Residential	▪ To provide for the housing needs of the community within a low density residential environment. ▪ To enable other land uses that provide facilities or services to meet the day to day needs of residents.	67.76
R3 Medium Density Residential	▪ To provide for the housing needs of the community within a medium density residential environment. ▪ To provide a variety of housing types within a medium density residential environment. ▪ To enable other land uses that provide facilities or services to meet the day to day needs of residents.	84.97
R5 Large Lot Residential	▪ To provide residential housing in a rural setting while preserving, and minimising impacts on, environmentally sensitive locations and scenic quality. ▪ To ensure that large residential lots do not hinder the proper and orderly development of urban areas in the future. ▪ To ensure that development in the area does not unreasonably increase the demand for public services or public facilities. ▪ To minimise conflict between land uses within this zone and land uses within adjoining zones.	0.37

Land Use Zone	Zone Objectives	Area Affected by 100 Year ARI (ha)
RE1 Public Recreation	▪ To enable land to be used for public open space or recreational purposes. ▪ To provide a range of recreational settings and activities and compatible land uses. ▪ To protect and enhance the natural environment for recreational purposes.	111.65
RE2 Private Recreation	▪ To enable land to be used for private open space or recreational purposes. ▪ To provide a range of recreational settings and activities and compatible land uses. ▪ To protect and enhance the natural environment for recreational purposes.	5.34
RU2 Rural Landscape	▪ To encourage sustainable primary industry production by maintaining and enhancing the natural resource base. ▪ To maintain the rural landscape character of the land. ▪ To provide for a range of compatible land uses, including extensive agriculture. ▪ To enable other forms of development that are associated with rural activity and require an isolated location or support tourism and recreation. ▪ To ensure that the type and intensity of development is appropriate in relation to the rural capability and suitability of the land, the preservation of the agricultural, mineral and extractive production potential of the land, the rural environment (including scenic resources) and the costs of providing services and amenities.	310.16
RU4 Primary Production Small Lots	▪ To enable sustainable primary industry and other compatible land uses. ▪ To encourage and promote diversity and employment opportunities in relation to primary industry enterprises, particularly those that require smaller lots or that are more intensive in nature. ▪ To minimise conflict between land uses within this zone and land uses within adjoining zones. ▪ To maintain prime viticultural land and enhance the economic and ecological sustainability of the vineyards district. ▪ To encourage appropriate tourist development (including tourist-related retail) that is consistent with the rural and viticultural character of the vineyards district. ▪ To enable the continued rural use of land that is complementary to the viticultural character of the land.	17.80
RU5 Village	▪ To provide for a range of land uses, services and facilities that are associated with a rural village. ▪ To ensure that development is compatible with the amenity, functioning and scale of a rural village.	5.09
SP2 Infrastructure	▪ To provide for infrastructure and related uses. ▪ To prevent development that is not compatible with or that may detract from the provision of infrastructure.	10.56

9.2.2 Flood-related LEP Provisions

Clause 7.3 *Flood Planning* of the LEP applies to all land uses within the LEP and outlines the objectives for land below the flood planning level (1% AEP + 0.5m). The objectives are:

> To minimise the flood risk to life and property associated with the use of land;

- To allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change; and
- To avoid significant adverse impacts on flood behaviour and the environment.

The LEP states that development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

- Is compatible with the flood hazard of the land;
- Is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties;
- Incorporates appropriate measures to manage risk to life from flood;
- Is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses; and
- Is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

At the time of preparation of this study, the mapping series accompanying the LEP did not include mapping of flood extents (for the flood planning event or any other events), nor did it include any mapping to show flood control lots for the purposes of exempt and complying development (see Clause 1.5 – *State Environmental Planning Policy (Exempt and Complying Development Codes) (2008))*, also see Section 9.5).

In addition, *Part 6 Urban Land Release Areas* also states that development consent will not be granted unless a development control plan has been prepared for the relevant urban release land as specified under Clause 6.3 (no specific urban release land is identified in the LEP). This site-specific DCP for urban release areas will need to address a range of issues, namely the "amelioration of natural and environmental hazards, including bush fire, *flooding* and site contamination and, in relation to natural hazards, the safe occupation of, and the evacuation from, any land so affected".

9.3 Cessnock Development Control Plan

The Cessnock DCP (2010) is intended to support the LEP with more detailed planning and design guidelines. It covers the whole of the LGA, including the Black Creek Floodplain.

The DCP is divided into a number of Parts:

- Parts A and B provide an introduction and list general requirements for development applications.
- Part C – General Guidelines deals with a range of issues and risks (such as contamination, flora and fauna, waste management and the like) but does not include any over-arching information with regard to flood-related development control across the LGA.
- Parts D and E include information relevant to flooding and the management of flood risk for existing and infill development (some controls specific to land use type and some controls specific to a site).
- Part F deals with urban land release areas, which includes the Cessnock BC5 Urban Release Area that lies within the Black Creek Floodplain. It also deals with North Ridge, Bellbird Heights, however this area only lies adjacent to the Black Creek Floodplain, and not within the floodplain.

A review of each Part of the DCP relevant to the Black Creek Floodplain is provided below.

9.3.1 Part D of the DCP – Controls by Development Type and Land Use Zone

Part D – Specific Development deals with a range of specific development types, including subdivision, urban housing, industrial, tourist and a range of other specific development types. It also addresses controls for developments in some zones for some specific land use zones.

In general, a review of the Part D provisions reveals that:

- Across Part D the terminology used to describe the design flood events is not consistent; that is, ARIs are used in some locations and AEPs in others. The terminology adopted should be consistent throughout the DCP;

- The term “flood free” is used but does not seem to be defined in the DCP (where in normal practice it would refer to those lands not affected by floods up to and including the Probable Maximum Flood);
- There is no over-arching specific flood planning level provided in the DCP (noting that the LEP sets the flood planning level at the 1%AEP + 0.5 m, as per Section 9.2 of this report). However, flood planning levels are applied at some specific sites (see **Table 9-2,** which deals with both Part D and Part E of the DCP). It would be preferable to set a common flood planning level consistent with the LEP provisions and ensure that the LEP is amended to be sufficiently flexible to allow alternate flood planning levels in some cases (lower for flood compatible land uses and higher for vulnerable developments);
- Prescriptive development control criteria are set in some cases for specific sites that do not take into account the different types of development that may be constructed within the relevant land use zones. For example, higher risk developments such as aged care or child care facilities may require more stringent controls than single lot dwellings. The DCP would benefit from a more general approach to development control as a starting point for all flood affected land, with site specific or precinct specific controls relevant to flood behaviour in those areas as an adjunct.
- On-site detention as a means of controlling flood flows would benefit from a catchment specific analysis.

Details of the specific flood-related provisions in Part D of the DCP are provided below.

Subdivision

The general development principles for subdivision include the following flood-related principles (Clause D.1.3.1):

- (iii) adequate all weather flood-free access shall be available to each allotment to be created by the subdivision and located so as to minimise the risk of soil erosion; and
- (v) each allotment to be created by the subdivision shall include flood-free land for building sites and in rural areas for the movement of stock during floods.

With respect to rural subdivision, Clause D1.1.3(f) states the flood-related objective is to “ensure that rural subdivision and housing take account of physical constraints such as bush fire, **flooding**, landslip, etc.”

Under Part D of the DCP, more specific requirements are articulated for different land use zones. On-site detention (OSD) is discussed more frequently than flooding. Where flooding is discussed, it is in terms of more general performance criteria, such as:

- Subdivision of flood prone land shall not result in increased risk to life or property, on the subject land or adjoining lands (for land zoned RU2 or R5); and
- Drainage systems shall be designed so as to ensure safety and minimise the likelihood of stormwater inundation of existing and future dwelling houses (for land zoned RU5, R2 or R3).

9.3.2 Parts D and E of the DCP – Controls by Specific Location

Site specific development controls are generally contained in Part E of the DCP but are also included in Part D. These have been summarised in **Table 9-2**.

In general the 1% AEP event plus a freeboard of 0.5m has been adopted, although this is not consistently applied (which does not accord with the LEP, which states that the flood planning level is the 1%AEP plus a freeboard of 0.5 m).

In the case of the Government Road Precinct, land below the 1% AEP event flood is effectively rendered un-developable for residential purposes due to flood risk.

Table 9-2 Summary of Flood-Related Controls for Specific Sites Under Part D and Part E of the DCP

DCP Section	Relevant Development Control
Part D.1, Schedule 6 – Nulkaba Village and Surrounding Area	
2 Special Considerations	Drainage and flooding issues are addressed with reference to a Flood Study for the subject site. Development must be carried out so as to make provision for the drainage corridors identified in the above study and minimise damage resulting from flood events. In addition, in the mapped flood control area, on-site detention (OSD) storage systems shall be constructed to serve all new lots before any dwelling houses or impervious surface is constructed. OSD storage systems shall be designed so that existing flow rates are not exceeded. The specific controls include: in the Flood Control Area shown on Map 1 (hatched), no buildings or structures shall be permitted; the minimum floor level of habitable buildings (outside the hatched area) shall be at least 0.5 m above the relevant 1 in 100 year flood level contour; all subdivision applications shall show development / building envelopes. These shall be sited outside the flood prone area shown (hatched) on Map 1; and development applications shall be accompanied by a survey from a Registered Surveyor to determine the contours of the land at an interval of 0.5 m and a vertical datum of AHD.
D2 Urban Housing	
2.5.3 Stormwater Management	The following criteria shall be considered in the design of on-site stormwater management systems: ▪ the downstream capacity and need for on-site stormwater detention and re-use; ▪ the scope for on-site infiltration of water; ▪ the minimisation of detrimental impacts on existing water table and quality; ▪ the sustainability and maintenance needs of the stormwater system; ▪ the safety of pedestrians and vehicles; ▪ emergency spillways and/or **overland flowpaths**; and ▪ potential impact on adjacent properties. No flood planning level is provided, and there is not specific discussion of flooding.
D.3: Industrial Development	
3.2.8 Drainage	Includes the following principles ▪ To ensure adequate drainage facilities are provided within the site to collect and carry stormwater to external drainage systems. ▪ To prevent the hazard of **flooding** and diversion or concentration of water onto adjoining properties or public areas. ▪ To ensure that the public drainage systems can adequately accept additional runoff generated by developments. Controls include: ▪ Stormwater run-off from roofs and paved areas is to be collected on-site and disposed of to the street drainage system, drainage easement, natural drainage course or infiltration trench or other means as determined by Council.
D.4: Purpose Built Rural Tourist Accommodation	
4.5.2 Site Location	Give careful consideration to whether a proposed site, and proposed concept, has…..potential for problems with bushfires, **flooding**, land degradation, groundwater recharge, and other natural hazards.
4.5.5 Land Management & Flooding	The performance objectives include: ▪ Buildings shall be **clear of local flood levels** (design event and freeboard not specified). Where land has been identified by Council as flood affected, in some cases it may be necessary for the applicant to undertake a **flood study** to identify appropriate levels for any structures.
4.5.10 Access & Parking	If creek crossings can become flooded, then applicants shall demonstrate suitable management response arrangements, included four wheel drive access in the case of the need for site departures, especially in emergency circumstances.

DCP Section	Relevant Development Control
4.7 Good Ongoing Management	An **Emergency Action Plan** shall be included in the Management Plan submitted to Council with the application. It is important that guests (who may not be familiar with the locality) are aware of emergency action plans in the event of a bushfire, flood or other natural disasters. The requirements for the Plan are then specified.
D.7 Construction of Dams	
7.1.4 Aims and Objectives	The specific objectives of this Chapter are to: (c) ensure that no adverse impact results on local drainage or **floodway** characteristics in a catchment from dam construction;
D.8: Temporary Events	
8.6.5 Emergency Procedures	▪ Make reasonable provisions to cater for emergency situations. ▪ Consideration shall be given to what procedures would need to be implemented in the case of an emergency at an event. ▪ In particular, permanent access for emergency vehicles to and from the premises shall be provided. ▪ Emergency procedures shall include consideration of people with disabilities who may have special needs and the actions of potentially intoxicated people. ▪ All staff, in particular security staff shall be familiar with emergency procedures.
E.11 North Bellbird Precinct	
11.1.3 Objectives	The objectives include: To provide for appropriate development of the land having regard to general flooding considerations and the need for specific development controls catering for development affected by the **PMF event**.
11.4.5 Flooding	Reference is made to a Floodplain Risk Management and Stormwater Management Strategy (Patterson Britton & Partners, 2007), which defines flood behaviour and provides recommendations for management of flood risk.
	The stated objectives are: ▪ To ensure development is constructed to mitigate the risk of flooding and stormwater and that development on flood affected land is constructed to withstand the impact of flooding. ▪ To ensure development does not increase the flood risk to existing or future development. ▪ To ensure development of flood affected land is carried out in accordance with the relevant requirements of the Floodplain Development Manual, North Bellbird Rezoning Floodplain Risk Management and Stormwater Management Strategy and other relevant legislation, guidelines and controls. Development should be carried out so as to make provision for the drainage corridors identified in the above study and minimise damage resulting from flood events.
	Requirements include: ▪ Development is to address the relevant requirements of the North Bellbird Rezoning Floodplain Risk Management and Stormwater Management Strategy (Appendices 4 and 5). ▪ For subdivision of land affected by the (PMF or land which relies on access through land affected by the PMF, the subdivision design and planning controls shall be designed to consider: ▪ Provision of a **flood warning system** for Limestone and Bellbird Creeks; ▪ Provision of adequate **overland flow paths** to minimise inundation depths during extreme events; ▪ Provision of adequate emergency evacuation routes; and ▪ Provision of adequate **flood refuge** for all affected dwellings. ▪ Full details will be required to be submitted with the subdivision application and shall address the requirements of the Floodplain Development Manual (April 2005). ▪ Council may consider applications for development on land affected by the **1 in 100 ARI** flood level where it can be demonstrated that: ▪ The minimum floor level of any habitable space in a dwelling house must be at least **500mm clear of the identified 1 in 100 year ARI flood level**.

DCP Section	Relevant Development Control
	▪ Applications for development located at or below the 1 in 100 year ARI flood level are accompanied by a detailed report from an appropriate professional demonstrating the building or structure can withstand the force of flowing flood waters, including debris and buoyancy forces, as appropriate. ▪ Filling on lots **at or below the 1 in 100 year ARI flood level** is to be in accordance with the relevant recommendations of the North Bellbird Rezoning Floodplain Risk Management and Stormwater Management Strategy and confined to the perimeter of the residential building on that lot and not have adverse impacts on upstream or downstream flood levels and adjoining existing residential development. ▪ Fencing located **at or below the 1 in 100 year ARI flood level** is to be constructed in a manner that does not unduly impede the movement of floodwaters. Full details of proposed fencing are to be submitted with development applications. ▪ Any required OSD storage systems must be constructed to serve all new lots before any new dwelling is constructed. OSD storage systems shall be designed so that existing flow rates are not exceeded. The applicant should consult Council's Works Department in regard to the design of the OSD storage system. In this case, a flood planning level of the **100 Year ARI plus a 0.5m freeboard** has effectively been adopted.
E.12 Government Road Precinct	
12.3.2 Stormwater and Flood Management	Flood risk for the subject site has previously been defined under the Flooding and Stormwater Management Assessment Northrop Engineers, 2007). The site performance criteria include: ▪ To ensure residential development is located **above localised flood waters**. The following prescriptive measures are required: ▪ Residential development should not occur below the **1% AEP flood line**. ▪ Habitable floor levels should be designed a minimum of **500mm above peak 1% AEP flood levels** on site. ▪ Stormwater management for the development will comply with the requirements of Cessnock DCP 2010, Part D Chapter 1 – Subdivision Guidelines, Council's Engineering Requirements for Development and industry best practice.
E.13 Cessnock Civic	
13.1 Introduction	The principal objectives include: ▪ To provide guidelines which detail the methods in which mine subsidence, **flooding** and drainage issues are to be managed on the site. There does not appear to be any specific guidance as to performance targets or how this will be achieved.
13.2.2 Detailed Development Considerations	Flood behaviour for the subject land is defined in Cessnock Civic Flood Study for Rezoning GCA Engineering Solutions, 2011). The development principles for the site include: ▪ Development is to be in general accordance with the principles of the NSW Floodplain Development Manual (NSW Government Department of Infrastructure Planning and Natural Resources, 2005). ▪ Flooding of properties upstream or downstream of the site is not to be adversely affected by the development of the Cessnock Civic site. The following development controls are provided in support of these principles: ▪ An underground piped drainage system is to be constructed within the road alignments to provide sufficient depth for lots to drain and shall be designed to convey the flow rate from the design 10 year ARI event. ▪ Additional piped drainage features (e.g. inter-allotment drainage lines) are permissible for areas other than roads within the development, where required and appropriate. ▪ The combination of the pipe drainage network and water within the road reserve is to convey the 100 year ARI event. The depth velocity product of surface water for the 100 year ARI event within the road reserve is to be less than 0.4m^2/s unless special safety features are provided. ▪ Cross drainage (culverts and bridges) shall be designed to convey the design critical 100 year ARI storm event. The design of subdivision earthworks levels

DCP Section	Relevant Development Control
	shall consider the potential increase in flood water as a result of the cross drainage structures, including an appropriate allowance for blockage. Concessions may be granted for larger culvert diameters, open span bridges or where additional features (i.e. trash racks) are installed to reduce the likelihood and magnitude of blockage. ▪ Finished ground levels within the Zone B7 Business Park are to be designed so that all lots less than 5000m^2 in area have at least 80% of the lot area at or above the design 1% AEP flood level. Lots greater than 5000m^2 in area are to have at least 50% of the lot area at, or above, the design 1% AEP flood level. ▪ All buildings shall have finished floor levels above the 1% AEP flood level, within the B7 Business Park zone ▪ There is no specified minimum surface level within asset protection zones, land to be dedicated to Council as drainage reserve, or other non-developable areas of the site. ▪ Earthworks levels are to be designed with consideration to evacuation and egress during an extreme flood event. All parts of the access route shall be of 'all weather' type construction (i.e. bitumen seal, segmental paving, or concrete). ▪ Development consent will not be granted for the subdivision of land unless a flood assessment report has been prepared to the satisfaction of Council that determined the measures prescribed in this DCP will be achieved by the development.

9.3.3 Part F – Urban Land Release – Cessnock BC5

Section F.2 of the DCP deals with the urban land release area of Cessnock (referred to as area BC5). The DCP currently includes very little detail on urban land release requirements. Given the land lies within the Black Creek Floodplain, it is appropriate to expand the DCP to include detailed flood risk management requirements for the land release, in accordance with the requirements of Part 6 of the Cessnock 2011 LEP, using the information contained in this Floodplain Risk Management Study and Plan.

9.4 Other Local Policies and Specifications

9.4.1 Cessnock Council's Engineering Standards for Development

Council's Engineering Standards provide additional general specifications for the detailed design of developments. These standards deal with:

> Site drainage and overland flows (specified for different types of developments)

> Required capacity for major and trunk drainage, and overland flow paths

> Flood impact assessment for some types of development (Section 6.1 states that *All subdivisions are to be designed so as not to increase the limits of upstream and downstream flooding for all floods over the range 1:1 to 1:100 year ARI design storm*)

> Design floor levels for some types of development (some of which vary from the flood planning level set in the LEP) (Section 9.2). For example:

- Section 6.1.1 – Urban Residential Developments – No design floor level specified;
- Section 6.1.2 – Industrial and Commercial Developments – For commercial buildings the specified floor level is 0.5m above the 100 Year ARI flood level, and for industrial buildings a minimum of the 100 Year ARI flood level (no freeboard);

The use of the word "limits" with respect to flood impact assessment is somewhat vague and it is recommended that this be updated to more clearly define the performance criteria with respect to both flood extents and depths.

9.4.2 Flood-Related Policies

Policy No. S40.6 provides controls for subdivisions in relation to natural watercourses and has as its objective to ensure that the dedication and preservation of all major watercourses as drainage reserves occurs within development areas. All major watercourses within subdivisions must be dedicated as easements.

The policy applies to urban, residential and village land uses, and adopts the following requirements:

> The area of required dedication shall be determined by the extent of inundation in the **100 Year ARI Flood Event** or the defined banks of creeks, whichever is the greater.

> The extent of inundation shall be determined at the Subdivision Application stage by a catchment analysis carried out in accordance with Council's Engineering Requirements for Developments. Such analysis shall accompany each Subdivision Application affected by major watercourses.

> Major watercourses shall be defined as those watercourses and natural flowpaths that have a flood velocity of 1 m/sec and/or a flood discharge of 1 cubic metre per second for the 100 Year ARI Flood.

> In areas of generally level topography, a building floor height restriction shall be applied to land adjacent to major watercourses which incorporates a **500 mm freeboard above the 100 year ARI Flood** profile.

> In all cases, a merit based approach to flood investigation, design and building floor heights shall be applied to the requirements of the dedication of major natural watercourses and to this policy.

It is noted that the imposition of easements for all areas affected by the 100 Year ARI flood event may result in effective sterilisation of large areas of land to development. It may be useful to review this policy in light of some case studies.

9.5 State Environmental Planning Policies

There are a range of State Environmental Planning Policies (SEPPs) that apply in NSW. Key SEPPs with relevance to floodplain risk management are described below. These policies prevail over any LEP or DCP provisions except where stated in the SEPP.

The *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* applies across the whole state. The aims of this policy are *to provide streamlined assessment processes for development that complies with specified development standards by:*

> *providing exempt and complying development codes that have State-wide application, and*

> *identifying, in the exempt development codes, types of development that are of minimal environmental impact that may be carried out without the need for development consent, and*

> *identifying, in the complying development codes, types of complying development that may be carried out in accordance with a complying development certificate as defined in the Act, and*

> *enabling the progressive extension of the types of development in this Policy, and*

> *providing transitional arrangements for the introduction of the State-wide codes, including the amendment of other environmental planning instruments.*

This SEPP gives rise to the concept of 'flood control lots' where a range of types of development cannot be exempt or complying by virtue of their flood-prone nature. Developments that fall within the concept of flood control lots include industrial buildings, commercial premises, dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (other than development for the purposes of group homes or seniors housing). Clause 3.36C of the SEPP sets the development standards for flood control lots. Council could utilise the information contained within this Floodplain Risk Management Study to create a map of flood control lots for the Black Creek Floodplain.

The *State Environmental Planning Policy (Housing for Seniors or People with a Disability) (2004)* applies across the whole state. The purpose of the SEPP is to facilitate development to meet requirements for seniors or people with a disability, except on land identified as being environmentally sensitive in an environmental planning instrument (i.e. the Cessnock LEP 2011). Environmentally sensitive land is defined in Schedule 1 of the SEPP to be floodway or high flooding hazard. The SEPP makes development on land adjacent to land that is zoned for residential purposes permissible for the purposes of housing for seniors or people with a disability. These types of developments could be considered vulnerable to flood risk given the restrictions on movement for occupants. Therefore, in order for Council to ensure that development of this type does not proceed on flood prone lands within the Black Creek Floodplain an amendment to the Cessnock LEP is required to ensure

that vulnerable developments are defined in the LEP and that floodway and high flood hazard areas are defined as part of the LEP.

The *State Environmental Planning Policy (Major Developments) 2005* applies across the whole state. For development proposals that fall under this instrument, the following flood-related objectives apply:

> To minimise the flood risk to life and property associated with the use of land;

> To allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change; and

> To avoid significant adverse impacts on flood behaviour and the environment.

The flood related clause applies to land at or below the flood planning level.

Similar to the Cessnock LEP 2011, under the SEPP development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

> Is compatible with the flood hazard of the land;

> Will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties;

> Incorporates appropriate measures to manage risk to life from flood;

> Will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction or riparian vegetation or a reduction in the stability of river banks or watercourses; and

> Is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

There are no state significant sites listed in the SEPP that lie within the Black Creek Floodplain.

9.6 Key Findings and Recommendations for the Black Creek Floodplain

Based on the review of the documents presented in the previous sections, the following overall planning recommendations are made:

> There is a lack of consistency between the Cessnock LEP 2011, the Cessnock DCP 2010 and Council's Engineering Standards. It is recommended that a comprehensive consistency review be undertaken and either the LEP or the DCP (or both) updated along with a concurrent update of the Engineering Standards to ensure accurate cross referencing between the three documents.

> The LEP, DCP and Council's Engineering Standards should also be updated in light of the improved understanding of flood behaviour in the Black Creek floodplain arising out of the FRMS;

> Flood-related development controls are dealt with separately in several different sections and parts of the Cessnock DCP 2010 and with reference to different types of development. It is recommended that the flood-related controls be consolidated into a single section of the DCP (Part C) (or a supporting Floodplain Management Policy) so as to minimise confusion and provide a single point of reference for all relevant controls. Part C of the DCP should be expanded to include a specific chapter on general flood controls that apply to all flood-prone land within the LGA. Much of the site specific information or zone-specific information that is confined to only some sites and some zones could be transferred out of Parts D and E of the DCP into a general set of controls and then Parts D and E could be re-framed to deal with flooding on a precinct basis where precincts are identified on the basis of similar flood behaviour.

> Part F of the DCP (specifically Section F.2) contains no information with regard to the need for the management of flood risks associated with the Black Creek Floodplain. It is recommended that this portion of the DCP be updated to include controls specific to the management of flood risks in accordance with the requirements of Part 6 of the Cessnock 2011 LEP.

> The requirement for a site specific flood study is identified in Part E of the Cessnock DCP 2010 for a few specific locations. It is recommended that the need for a site specific flood study is reviewed in light of the findings of this FRMS and the improved understanding of flood behaviour. It may be

the case that only developments of a specific size or type are subject to site specific flood studies as part of revised DCP requirements;

> The flood planning levels in the LEP, DCP and the Engineering Standards should be reviewed in light of the recommendations in Section 10;

> The flood related controls should also consider the type of development and consider the need for more stringent controls for critical infrastructure and vulnerable developments (such as aged care);

> Consideration of the modification of the LEP to ensure that developments that are vulnerable to flood risk are precluded from the floodplain, either by defining vulnerable developments in the LEP explicitly or defining the floodway and high flood hazard areas as per Schedule 1 of the SEPP (Housing for Seniors and People with a Disability);

> Council could utilise the information contained within this Floodplain Risk Management Study to create a map of flood control lots for the Black Creek Floodplain to ensure that the majority of development requires consent rather than falling under the exempt or complying development process as per the SEPP (Exempt and Complying Development Codes).

> The flood management provisions in the Cessnock DCP 2010 do not provide consideration of the impacts of climate change on flooding and how that should be responded to in development. The DCP should be updated to identify Council's current position on climate change and floodplain management;

> Emergency response provisions for new development should consider access and egress during flood events. Whilst this is addressed with respect to some types of development in the DCP, emergency access requirements do not appear to have been considered for all types of development. In addition, the design criteria (e.g. road level above the 100 Year ARI for critical infrastructure) do not appear to have been clearly defined;

> Council may wish to consider using the outcomes of the Black Creek Flood Study (DHI, 2010) and the updated flood modelling presented in this FRMS to develop OSD requirements specific to the catchment requirements. In particular, there may be areas in the catchment where OSD should not be incorporated, as it may adversely impact on downstream areas; and

> There may be opportunities to incorporate flood management measures into new developments as a condition of consent, Section 94 contribution offsets or government-related funding. The nature of the flood controls implemented will be dependent on the location of the development, the flooding behaviour and the type of development. However, allowance and / or requirements for these works could be identified through amendments to the Cessnock DCP 2010.

10 Flood Planning Level Review

The Flood Planning Level (FPL) for the majority of areas across New South Wales has been traditionally based on the 1% AEP flood level plus a freeboard. The freeboard for habitable floor levels is generally set between 0.3m to 0.5m for residential properties and can vary for industrial and commercial properties.

A variety of factors are worthy of consideration in determining an appropriate FPL. Most importantly, the flood behaviour and the risk posed by the flood behaviour to life and property in different areas of the floodplain and different types of land use need to be accounted for in the setting of an FPL.

The Floodplain Development Manual (2005) identifies the following issues to be considered:

- Risk to life;
- Long term strategic plan for land use near and on the floodplain;
- Existing and potential land use;
- Current flood level used for planning purposes;
- Land availability and its needs;
- FPL for flood modification measures (levee banks etc.);
- Changes in potential flood damages caused by selecting a particular flood planning level;
- Consequences of floods larger than the flood planning level;
- Environmental issues along the flood corridor;
- Flood warning, emergency response and evacuation issues;
- Flood readiness of the community (both present and future);
- Possibility of creating a false sense of security within the community;
- Land values and social equity;
- Potential impact of future development on flooding; and
- Duty of care.

These issues are discussed collectively in the following sections.

10.1 Likelihood of Flooding

As a guide, **Table 10-1** has been reproduced from the Floodplain Development Manual (2005) to indicate the likelihood of the occurrence of an event in an average lifetime to indicate the potential risk to life. The data indicates that there is a 50% chance of a 1% AEP event occurring at least once in a 70 year period. Given this potential, it is reasonable from a risk management perspective to give further consideration to the adoption of the 1 in 100 year flood event as the basis for the flood planning level. Given the social issues associated with a flood event and the non-tangible effects (such as stress and trauma), it is appropriate to limit the exposure of people to floods.

It is noted that a 30% chance of exposure to at least one flood remains for a 0.5% AEP event over a 70 year period. This gives rise to the consideration of the adoption of a rarer flood event (such as the PMF) as the flood planning level for some types of development.

Table 10-1 Probability of Experiencing a Given Flood or Higher in an Average Lifetime

Likelihood of Occurrence in any year (AEP)	Probability of experiencing at least one event in 70 years (%)	Probability of experiencing at least two events in 70 years (%)
10%	99.9	99.3
5%	97	86
2%	75	41
1%	50	16
0.5%	30	5

10.2 Current Flood Planning Level

In the Black Creek floodplain, development is controlled through the Cessnock Local Environment Plan (LEP) and Development Control Plan (DCP). Council generally utilises the following flood planning levels:

> Residential habitable floor levels to be above the 1% AEP +0.5m flood level; and

> Industrial and Commercial Developments: for commercial buildings the specified floor level is set at the 1% AEP +0.5 flood, and for industrial buildings a minimum of the 1% AEP flood level (no freeboard).

Further details can be found in Chapter 9 on the current flood planning levels.

10.3 Land Use Planning

The hydrological regime of the catchment can change as a result of changes in land use, particularly with an increase in the density of development. The removal of pervious areas in the catchment can increase the peak flow arriving at various locations, and hence the flood levels can increase.

A potential impact on flooding can arise through the intensity of development on the floodplain, which may either remove flood storage or impact on the conveyance of flows. Council planning and building controls restricts building within the floodway and recommends against filling in flood storage areas. Hydraulic category mapping is included in **Appendix A**.

To assist in minimising the impact of development on flooding, it would be recommended to control development such that any increase in impervious area is countered by appropriate use of on-site or regional detention.

10.4 Flood Damages Cost Differential between Events

Based on the existing flood behaviour and the assessment of flood damages, the incremental difference in Annual Average Damage (AAD) for different recurrence intervals is shown in **Table 10-2**. The table shows the AAD of a given property for different scenarios at the commencement of overfloor flooding, and the net present value (NPV) of those damages over 30 years at a rate of 7%

Table 10-2 Flood Damages Cost Differential Between Events

Event period	Incremental AAD	Properties with overfloor flooding	Average AAD per property	Changes in AAD	NPV of AAD	Change in NPV
Up to 20% AEP	$255,843	18	$14,214	-	$176,376	-
20% to 10% AEP	$264,311	32	$8,260	$5,954	$102,495	$73,881
10% to 5% AEP	$296,338	93	$3,186	$5,073	$39,540	$62,955
5% to 2% AEP	$350,305	183	$1,914	$1,272	$23,754	$15,787
2% to 1% AEP	$180,330	278	$649	$1,266	$8,049	$15,704
1% to 0.5% AEP	$123,484	395	$313	$336	$3,879	$4,170
0.5% AEP to PMF	$456,088	1891	$241	$71	$2,993	$886

Table 10-2 indicates that the largest incremental difference between AAD per property occurs between the more frequent events. The greatest difference between damages occurs between the 20% and 10% AEP events. It can be seen that the differences between the 2% and 1% AEP event, and the 1% AEP event and the PMF are relatively small which suggests that increasing the FPL beyond the 2% AEP level does not significantly alter the savings achieved from a reduction in damages.

10.5 Incremental Height Difference Between Events

Consideration of the average height difference between various design flood levels is another way of selecting an appropriate FPL.

Based on the existing flood behaviour, the average incremental height difference between events is shown in **Table 10-3** for selected events. These are determined based on the flood levels determined at each of the properties within the catchment as part of the flood damages analysis.

Table 10-3 Flood Level Difference between Design Events

Event (AEP)	Difference PMF (m)	Difference 0.5% AEP (m)	Difference 1% AEP (m)	Difference 2% AEP (m)	Difference 5% AEP (m)	Difference 10% AEP (m)
0.5%	1.69	-	-	-	-	-
1%	1.77	0.08	-	-	-	-
2%	1.82	0.14	0.06	-	-	-
5%	1.88	0.19	0.11	0.05	-	-
10%	1.89	0.20	0.12	0.06	0.01	-
20%	1.96	0.27	0.20	0.14	0.08	0.08

Table 10-3 indicates a dramatic difference in flood level for the PMF compared to other events. The incremental difference between flood events is in the order 0.01 to 0.27m for all other events.

On the basis of this analysis, it is considered that the 1% AEP flood level would be suitable for use in developing a flood planning level for residential development. If a freeboard of 0.5m is included in the flood planning level, this would be above the 0.5% AEP is some locations. For more critical infrastructure such as hospitals or key emergency evacuation routes, the PMF may be a more appropriate flood planning level.

10.6 Adopting PMF as a Flood Planning Level

Analysis of the flood damages indicates that the choice of the PMF event over the 1% AEP event as the FPL would result in significant economic benefits, in annualised terms, to the community. However, the difference in average flood levels between the 1% AEP and the PMF event indicate that the use of the PMF as the FPL would result in much higher floor levels (1.77m) and as a result higher economic costs and inconvenience to the community. In addition, the incremental AAD per building from the 1% AEP to the PMF is relatively low.

Given this, the economic costs may outweigh the benefits of using the PMF event as the FPL and the use of the PMF level as the FPL may also conflict with other development/building controls in Council's DCP and would be inconsistent with current state government planning directives for flood planning levels. It is recommended that emergency response facilities and critical infrastructure are located outside of the floodplain and other facilities including schools and day care centres should have a floor level at the PMF level.

10.7 Environmental and Social Issues

The selection of a high FPL can result in housing being placed higher than it would otherwise be. This can lead to a reduction in visual amenity for surrounding property owners, and may lead to encroachment on neighbouring property rights. This may also cause conflict with other development controls already present within the Council's development assessment process.

10.8 Risk

The selection of an appropriate FPL also depends on the potential risk of different development types. Consideration should be given for different FPLs for industrial, commercial and residential properties which have different implications should overfloor flooding occur.

Critical infrastructure, such as hospitals, fire stations, electricity sub-stations has widespread implications should inundation occur and typically FPLs selected for these types of facilities are higher than those for residential, commercial or industrial properties.

10.9 Freeboard

Freeboard accounts for uncertainties in deriving the design flood levels and as such should be used as a safety margin for the adopted FPL. This consideration may result in the adopted FPL being higher than the PMF in certain cases. However, given the inherent purpose of freeboard, the FPL should still be used in such cases. The freeboard may account for factors including:

- Changes in the catchment;
- Changes in the creek/channel vegetation;
- Accuracy of model inputs (e.g. accuracy of ground survey at ±0.15m approximately, accuracy of design rainfall inputs for the area);
- Hydraulic model sensitivity;
- Local flood behaviour such as afflux whereby increases in local flood levels due to obstructions not account for in the modelling;
- Culvert blockage; and
- Climate change impacts on increasing rainfall intensity.

Council currently adopts a 500mm freeboard for residential and commercial properties and a 0mm freeboard for industrial properties. The 500mm freeboard for residential properties is considered reasonable based on the above variables.

11 Floodplain Risk Management Options

Flood risk can be categorised as existing, future or residual risk:

> Existing Flood Risk – existing buildings and developments on flood prone land. Such buildings and developments by virtue of their presence and location are exposed to an 'existing' risk of flooding

> Future Flood Risk – buildings and developments that may be built on flood prone land. Such buildings and developments would be exposed to a flood risk when they are built

> Residual Flood Risk – buildings and development that would be at risk if a flood were to exceed management measures already in place. Unless a floodplain management measure is designed to withstand the PMF, it will be exceeded by a sufficiently large event at some time in the future.

The alternate approaches to managing risk are outlined in **Table 11-1**.

Table 11-1 Flood Risk Management Alternatives (SCARM, 2000)

Alternative	Examples
Preventing / Avoiding risk	Appropriate development within the flood extent, setting suitable planning levels
Reducing likelihood of risk	Structural measures to reduce flooding risk such as drainage augmentation, levees, and detention
Reducing consequences of risk	Development controls to ensure structures are built to withstand flooding
Transferring risk	Via insurance – may be applicable in some areas depending on insurer
Financing risk	Natural disaster funding
Accepting risk	Accepting the risk of flooding as a consequence of having the structure where it is

Measures available for the management of flood risk can be categorised according to the way in which the risk is managed. There are three broad categories of management;

> Flood modification measures – Flood modification measures are structural options aimed at preventing / avoiding or reducing the likelihood of flood risks;

> Property modification measures – Property modification measures are focused on preventing / avoiding and reducing consequences of flood risks; and

> Emergency response modification measures – Emergency response modification measures aim to reduce the consequences of flood risks.

11.2 Flood Modification Measures

Based on the flood model results, historical information, community feedback and engineering judgement, preliminary flood modification measures (i.e. structural options) for the study area were identified. These options are outlined in **Table 11-2** and shown in **Appendix H**.

Table 11-2 Preliminary Flood Mitigation Options

Option	Details	Expected Benefit	Major Constraints
Detention Basins			
DB1	Proposed detention basin on Bellbird Creek, upstream of urban area	Reduce flood impacts at downstream residential properties	Located on private land, heritage listed former colliery site, environmental constraints
DB2	Proposed detention basin east of Wollombi Road	Reduce flood impacts at downstream residential properties	Located on private land, environmental constraints. Basin outlet pipe required across Wollombi Road
DB3/DB4	Proposed detention basins on Bellbird Creek	Reduce flood impacts downstream within Cessnock	Area subject to future development
DB5	Proposed detention basins on Bellbird Creek, east of existing Mount View detention basin	Reduce flood impacts downstream within Cessnock	Area subject to future development
DB6	On south side of Bellbird Creek, former PCYC Centre at 196 Wollombi Road	Provide additional storage and reduce flood levels downstream	Relatively small space available for construction of basin, area subject to future development
DB7, DB8, DB9, DB12, DB13	Potential detention basin locations on Black Creek, upstream of CBD	Reduce flood impacts downstream within Cessnock	Located on private land, heritage listed former colliery site, environmental constraints
DB10	Proposed detention basin location on Kearsley Creek, east of railway	Reduce flood impacts downstream within Cessnock	Located on private land, heritage listed former colliery site, environmental constraints
DB11	Proposed detention basin upstream of South Cessnock	Reduce flood impacts at residential properties in South Cessnock, impacted by overflow from Oliver Street channel.	Located on private land, heritage listed former colliery site, environmental constraints
DB14	Proposed detention basin on Kitchener Drain	Reduce flood impacts at residential properties within Kitchener	Located on private land, potential environmental constraints
DB15	Proposed detention basin on Aberdare Creek	Reduce flood impacts downstream within Aberdare	Located on private land, potential environmental constraints
DB16, DB17	Proposed detention basins on East Cessnock Drain	Reduce flood impacts downstream within East Cessnock	Located on private land, heavily vegetated, potential environmental constraints
DB18	Proposed detention basin in existing open space within South Cessnock	Reduce flood impacts downstream	Relatively small space available for detention basin
DB19	Proposed detention basin within Cessnock Showgrounds	Reduce flood impacts from Bellbird Creek	Located on private land, pipe/channel connections from Bellbird Creek required
Channel Widening/Channel reshaping			
Bellbird Creek	Reshaping of existing concrete trapezoidal channel between Stephen Street and confluence with Lavender Creek	Provide additional capacity within the existing channel	No major constraints

Option	Details	Expected Benefit	Major Constraints
Black Creek	Upgrade Wollombi Road culvert, widening of existing channel from Wollombi Road to Ferguson Street, reshaping of existing channel downstream of Ferguson Street	Provide additional capacity at Wollombi Road crossing and within Black Creek channel	Removal of existing open space to widen channel, potential environmental constraints
East Cessnock Drain	Widening of existing channel from Old Maitland Road downstream to confluence with Black Creek	Provide additional capacity within the existing channel	Additional culvert at Government Road required, significant environmental impacts with working in natural creek
Oliver Street Channel	Widening of existing trapezoidal Oliver Street channel within South Cessnock	Provide additional capacity within channel and reduce impact of flooding on surrounding residential properties	No major constraints
Levees/Flood Walls/Bunds			
FW1	Proposed flood wall (575m length, height 1m approx.) along rear of properties	Prevent flows from Bellbird Creek impacting residential properties	Located on private land, potential environmental constraints
FW2	Proposed flood wall (1,200m length, height 1m approx.) to divert flows from Bellbird Creek and Lavender Creek to Mavis Street Channel	Divert flow from urban areas of Cessnock and reduce downstream flood levels	Former golf course subject to development, significant environmental impacts, major culvert crossings required
FW3	Proposed flood wall (250m length, height 1m approx.) at corner of Quarrybylong Street and Neath Street on Aberdare Creek	Provide protection to residential properties downstream	Located on private land, potential environmental constraints
FW4	Proposed flood wall on East Cessnock Drain, upstream of Maitland-Wollombi Road	Provide attenuation of flow in existing open space and reduce downstream flood levels	Located on private land, potential environmental constraints
FW5	Local bund at end of Stephen Street (height 0.5m-1m approx.)	Provide protection to residential properties	No major constraints

11.2.2 Option Assessment

All preliminary mitigation options were reviewed in consultation with Council and the feasibility of preferred structural mitigation options investigated further. The preferred options outlined below were run for the 20%, 10%, 5%, 2% and 1% AEP events to ensure they provided the expected benefits and did not result in adverse flood behaviour. The results of this analysis are summarised in Table 11-3.

Table 11-3 Structural Options Assessment

Option ID	Option	Assessment Outcome	Option Layout and Water Level Impact Figure
FM1	Detention basin (DB7) west of Vincent Street and Baddely Park Detention basin (DB8) east of Quorrobolong Road and south of railway Detention basin (DB12) west of Quorrobolong Road and Mountain View Place Detention basin (DB13) West of Stanford Street, Kitchener	This option results in reductions of flood levels downstream of the basins along the creek. The reductions are up to 500mm. This option has large benefits with major reductions in overfloor flooding properties in larger storms.	Figure 11-1 to Figure 11-6
FM2	Detention basin (DB6) adjacent to Bellbird Creek at 196 Wollombi Road Local bund on Bellbird Creek at end of Stephen Street Bellbird Creek channel reshaping from Stephen Street to confluence with Lavender Creek	In a 1% AEP there are reductions in flood levels ranging from typically 10mm to 50mm on the north and western sides of Bellbird Creek. Reductions of up to 150mm are observed in some areas. However increases typically 50mm are observed on the south and eastern sides of Bellbird Creek and localised increase of up to 150mm occur upstream of the confluence with Black Creek. The bund at Stephen Street provides protection to residential properties in the 20% AEP event.	Figure 11-7 to Figure 11-12
FM3	Widening of Black Creek channel from Wollombi Road to Ferguson Street Reshaping existing Black Creek channel downstream of Ferguson Street, provide flood walls on channel Culvert upgrades at Wollombi Road, Doyle Street and Henderson Street	In a 1% AEP widespread reductions are evident in urban areas upstream of Henderson Avenue. The proposed reshaping and floodwalls downstream of Ferguson Street result in greater flows being conveyed in the channel, however, local stormwater ponding occurs at the rear of the floodwalls.	Figure 11-13 to Figure 11-19
FM4	Channel widening of existing Oliver Street Channel, South Cessnock	The existing terrain is extremely flat with the existing channel having reverse grade in places. The proposed widened channel has been optimised as much as possible however results show increases in 1% AEP flood level of up to 30mm impacting residential properties.	Figure 11-21 to Figure 11-26
FM5	Proposed bund at RL 75m with Low Flow Pipe outlet connecting to trunk drainage system east of Sixth Street and overflow weir at 74m AHD in South Cessnock. (variation to DB11).	In a 1% AEP the proposed bund results in reductions in flood levels downstream of Sixth Street ranging from 50mm to 300mm. Larger reductions are observed for more frequent events of up to 500mm. Flood level increases up to 150mm are seen in a 1% AEP just downstream of proposed bund at Quarrybylong St/Edgeworth Street.	Figure 11-28 to Figure 11-33
FM6	Detention basin (DB1) Bellbird Creek - Austar Coal Mine site	The detention basin option at Austar Coal Mine site results in reduction of flood levels in an order of 10mm to 200mm all along Bellbird Creek downstream of the basin.	Figure 11-36 to Figure 11-41

Table 11-4 shows the number of overfloor flooding properties for both the Existing scenario and all the flood mitigation options modelled in the Floodplain Risk Management Study and Plan. Reductions in overfloor flooding properties can be observed by comparison with the Existing scenario. Option FM1 has a major reduction in overfloor flooding properties in larger storms (5% AEP to 1% AEP) while Option FM5 has significant benefits in smaller storms (20% AEP to 5% AEP).

Table 11-4 Overfloor Flooding Properties

Mitigation Option	Design Events				
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
Existing (9hr)	20	37	112	235	345
Option FM1	18	30	86	173	261
Option FM2	20	42	124	248	346
Option FM3	20	34	103	228	328
Option FM4	18	37	113	236	344
Option FM5	5	20	96	221	326
Option FM6	18	32	100	217	323

It is also noted that there is a “sinkhole” located on Austar’s Mining Lease to the east of Wollombi Road near Starke Street on an unnamed tributary of Bellbird Creek. During flow events, runoff from the contributing catchment enters the underground mine workings thereby intercepting flows from arriving at the culverts under Wollombi Road and the railway. As such, during rainfall events the sinkhole is providing an incidental mitigation benefit, particularly for low flow events, and has likely been doing so for some years.

Austar currently have plans to remediate the sinkhole to eliminate flows entering the sinkhole and re-establish the natural surface flow by constructing a watercourse from upstream of the sinkhole to the railway culverts and upgrading the culverts under the railway and Wollombi Road. This will re-instate flows from this sinkhole catchment entering Bellbird Creek. While these plans have not been finalised, all design event modelling has been undertaken assuming no mitigation benefit from the sinkhole with all sinkhole catchment flows applied to Bellbird Creek.

11.2.3 April 2015 Event

Cessnock and surrounding townships experienced a storm event in April 2015 that caused significant and widespread flooding, particularly in the South Cessnock area. The mitigation options identified in the Floodplain Risk Management Study and Plan outlined above were run for the April 2015 event to provide context to the community as to the flood mitigation benefits that could have been expected if the mitigation options were implemented during the April 2015 event. **Appendix G** details the outcomes of the assessment.

The outcomes are summarised below:

- Detention basin adjacent to Bellbird Creek and bund on Bellbird Creek (FM2) has negligible changes in flood levels due to this option.
- Widening of Black Creek channel (FM3) shows reductions in flood levels up to 150mm upstream of Ferguson Street culverts.
- Channel widening of existing Oliver Street Channel (FM4) shows reductions in flood levels up to 120mm on Oliver Street.
- The proposed bund at South Cessnock (FM5) results in significant reductions in flood levels up to 450-500mm at Oliver Street and Edgeworth Street.
- The Detention basin at Austar Coal Mine site (FM6) results in reductions of flood levels up to 200mm along the Bellbird Creek downstream of the basin.

The assessment demonstrates that properties along Oliver St and surrounding streets such as Edgeworth St would have benefitted from a mitigation solution such as FM5 or similar, which retards flows upstream, thereby reducing flood flows and flood levels through the residential areas. Other mitigation options would have had either a small or negligible benefit for reducing flooding during the April 2015 event.

11.2.4 Environmental Considerations

According to State Environmental Planning Policy (SEPP) (Infrastructure) 2007, flood mitigation works "may be carried out by or on behalf of a public authority without consent on any land". These works include construction, routine maintenance and environmental management works which applies to most of the flood mitigation options in **Table 11-3**. Although consent is not required, most flood mitigation works will require further environmental assessment and approval by the determining authority under Part 5 of the *Environmental Planning and Assessment Act*, 1979.

The determining authority, in this case Cessnock City Council, is required to "examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity" complying with Section 111 of the EP&A Act, most likely in the form of a Review of Environmental Factors.

When carrying out flood mitigation works, Council will be required to take out further permits, licenses and approvals such as:

> Flood mitigation works which emit into a water body will need an Environment Protection Licence complying with the Protection of the Environment Operations Act (POEO) 1997;

> Any removal of vegetation and debris in the water body may need a Threat Abatement Plan complying with the Fisheries Management Act 1999; and

> A licence to harm threatened species, population or ecological community or damage habitat under the Fisheries Management Act 1999.

11.3 Property Modification Measures

A number of property modification measures were identified for the Black Creek floodplain including the following:

> Option P1 - LEP Update;

> Option P2 - Building and Development Controls;

> Option P3 - House Raising;

> Option P4 - House Rebuilding;

> Option P5 - Voluntary Purchase;

> Option P6 - Land Swap;

> Option P7 - Council Redevelopment; and

> Option P8 - Flood proofing.

11.3.1 Option P1 – LEP Update

Local environment plans are prepared by councils to guide planning decisions for local government areas. Through zoning and development controls, the LEP allows councils to supervise the ways in which land is used.

The Cessnock Local Environmental Plan 2011 (LEP 2011) is the statutory planning instrument that establishes what forms of development and land use are permissible and/or prohibited on all land within the Cessnock Local Government Area.

The Cessnock LEP is discussed in Chapter 9 and a number of recommendations are made in Section 9.6 for its review, including the need to undertake a consistency review to ensure accurate cross referencing between both the LEP and DCP. It is also recommended that the LEP is updated following the improved understanding of flood behaviour as a result of this study.

11.3.2 Option P2 – Building and Development Controls

Council building and development controls have been reviewed as part of this study. Recommended updates to these documents are discussed in Chapter 9 (Section 9.6).

11.3.3 Option P3 – House Raising

House raising is a potential option to reduce the incidence of overfloor flooding in properties. However, while house raising can reduce the occurrence of overfloor flooding, there are issues related to the practise, including:

- Difficulties in raising some houses, such as slab on ground buildings. In some slab on ground situations it may be possible to install a false floor, although this is limited by the ceiling heights;
- The potential for damage to items on a property other than the raised dwelling are not reduced – such as gardens, sheds, garages etc.;
- Unless a dwelling is raised above the level of the PMF, the potential for above floor flooding still exists – i.e. there will still be a residual risk;
- Evacuation may be required during a flood event for a medical emergency or similar, even if no overfloor flooding occurs, and this evacuation is likely to be hampered by floodwaters surrounding a property;
- Ensure new footings or piers can withstand flood-related forces; and
- Potential conflict with height restrictions imposed for a specific zone or locality within the local government area.

For a single storey property, the flooding damage that occurs for overfloor flooding in the depth range of 0-0.5m is approximately $40,000. **Table 11-5** provides the approximate Average Annual Damage (AAD) for overfloor flooding commencing in different AEP events for individual residential properties. Note that damages as a result of overground flooding only are not included for the purpose of this calculation. It assumes that overfloor flooding damage is constant at $40,000 for each overfloor flooding event. This provides a typical AAD for an individual property which can be used as a guide.

Table 11-5 Estimates of AAD and NPV for Various Overfloor Flooding Scenarios

Event in which overfloor flooding commences	Number of properties with overfloor flooding*	Annual Average Damage per property	NPV (30yrs) per property
20% AEP	18	$14,214	$176,376
10% AEP	32	$8,260	$102,495
5% AEP	93	$3,186	$39,540
2% AEP	183	$1,914	$23,754
1% AEP	278	$649	$8,049
0.5% AEP	395	$313	$3,879
PMF	1891	$241	$2,993

*Based on the number of residential properties outlined as part of the economic assessment.

For the purposes of costing the house raising option it has been assumed that all houses that are inundated in the 10% AEP (32 houses) would be raised to the Flood Planning Level (1% AEP + 500mm), at a cost of $80,000 per house, based on similar work undertaken in NSW. Out of 32 overfloor flooding properties in a 10% AEP, 11 are “Slab on ground” and 21 are “Elevated on piers” construction type. Typically, houses with a pier and strip footing type construction are the best candidates for house raising, however, each property would need to be assessed in detail to determine if it is a suitable candidate for house raising.

It is noted that raising houses that lie below the 10% AEP flood level would unfairly disadvantage those properties which are inundated between the 10% AEP and the 5% AEP. This particular format has been assumed for assessment purposes only, as there are a number of different options available such as the sliding subsidy scheme. If this option is considered viable, then these additional options could be considered by

Council in establishing the scheme. Funding for this option may occur jointly between Council, NSW Government and residents.

Table 11-6 outlines the reductions in AAD that could be achieved from various house raising scenarios.

The table shows that the raising costs for properties affected by the 20% and 10% AEP flooding are comparable with the reduction in flood damages. However, beyond the 10% AEP event, the cost of raising is significantly higher than the reduction in damages, which suggests that house raising if only feasible for properties that experience flooding in the more frequent events.

Table 11-6 Reduction in AAD resulting from Various House Raising Scenarios

House raising option	Number of properties with overfloor flooding*	Reduction in AAD per property	Overall reduction in AAD	NPV of reduction	Estimated cost of raising
20% AEP to FPL	18	$5,954	$107,168.34	$1,329,856	$1,440,000
10% AEP to FPL	32	$5,073	$162,345.64	$2,014,554	$2,560,000
5% AEP to FPL	93	$1,272	$118,313.68	$1,468,159	$7,440,000
2% AEP to FPL	183	$1,266	$231,598.62	$2,873,917	$14,640,000
1% AEP to FPL	278	$336	$93,422.64	$1,159,285	$22,240,000

11.3.4 Option P4 – House Rebuilding

Under a rebuilding scheme, the property owner would have the option of utilising the subsidy for house raising described above for reconstruction instead. In a number of cases, the ability to raise properties can be difficult and therefore rebuilding may be the only option. The advantage of this option is that the new structure can also be built in a flood compatible way (such as including a second storey for flood refuge above the PMF level). The subsidy could be used to cover any additional costs associated with flood proofing a development in a high risk location (for example, flood compatible materials and setting floor levels above the FPL). All residential properties that are inundated in the 10% AEP (32 houses) could be considered for this option.

One of the issues associated with this option is that there is still a significant cost for the property owner to redevelop their land. In addition, this provides an inequitable situation for those properties that are subject to the subsidy and those that are not. It can have the effect of skewing the property redevelopment market, where those properties subject to the subsidy are more attractive for development than those properties that are not.

11.3.5 Option P5 – Voluntary Purchase

An alternative to the construction of flood modification options and for properties where house raising is not possible is the use of voluntary purchase (VP) of existing properties. This option would free both residents and emergency service personnel and volunteers from the hazard of future floods. This can be achieved by the purchase of properties and the removal and demolition of buildings. Properties could be purchased by Council at an equitable price and only when voluntarily offered. Such areas would then need to be rezoned to a flood compatible use, such as recreation or parkland or possibly redeveloped in a manner that is consistent with the flood hazard. However, this option should be considered after other, more practical options have been investigated and exhausted.

The recommended criteria to determine properties that are eligible for voluntary purchase are:

> Properties located in high hazard areas for the 1% AEP flood event. In the Black Creek study area there are 976 cadastral lots within this category, this may be refined by review of the 346 properties identified as subject to overfloor flooding in a 1% AEP event;

> Occurrence of above floor flooding in the 20% AEP flood event. In the Black Creek study area, 18 properties have been identified as subject to overfloor flooding in the 20% AEP event.

> Economic value of damages for a particular property is comparable to the property market value.

Typical prices of properties in the suburb of Cessnock, and particular in the Black Creek floodplain, are in the order of $300,000 (based on a search of the listed property prices for the area through www.realestate.com.au

as at January 2015). The net present value of savings in Average Annual Flood damages for removing one of the properties above from the floodplain is estimated at $102,495 as per Table 11-5. The cost of purchasing the properties in the catchment would therefore be significantly higher than the savings in terms of flood damages. In addition, voluntary purchase only benefits a few properties and not the wider floodplain. This effectively results in an inequitable distribution of Council funds. By comparison, some of the flood modification options may in fact be less expensive and benefit the wider floodplain.

11.3.6 Option P6 – Land Swap

An alternative to pure voluntary purchase is the consideration of a land swap program whereby Council swaps a parcel of land in a non-flood prone area (e.g. an existing park) for the flood prone land with the appropriate transfer of park facilities to the acquired site. After the land swap, Council would then arrange for demolition of the building and have the land rezoned to open space. The land swap approach may result in a significant saving on the land component of the voluntary purchase costs.

Eighteen residential properties have been identified as subject to overfloor flooding in a 20% AEP event and 32 properties in a 10% AEP event and these properties would act as a basis for further investigation. This option would benefit individual properties and not the catchment as a whole. For the purposes of costing it has been assumed $50,000 per house for the demolition of existing building and rezoning to open area.

It is recommended that this approach be investigated prior to any voluntary purchase and has been included in the multi-criteria matrix assessment as a stand-alone option.

11.3.7 Option P7 - Council Redevelopment

This option also provides an alternative to the Voluntary Purchase (Option P5) scheme. While Council would still purchase the worst affected properties, it would redevelop these properties in a flood compatible manner and re-sell them with a break even objective.

The following provides an estimate of the various costs involved for a single residential development, where Council redevelopment occurs only on those properties identified in for voluntary purchase. Reconstruction costs are estimated based on a single storey elevated building using the Allianz building express calculator (http://homebuilding.cordell.com.au/ accessed in January 2015) with the purchase cost of the property estimated as per P5 above.

- Purchase of property = $300,000;
- Reconstruction costs = $350,000; and
- Reduction in flood damages = $103,070.

Council would need to sell the property at approximately $650,000 in order to break even on the development, in a one-for-one development approach. This excludes other costs such as transaction expenses.

However, using a cost benefit analysis and including the reduction in flood damages then the development would need to resell at approximately $550,000 plus transaction costs in order for Council to break even.

It is noted that there are significant risks for Council in undertaking this option. In particular, the property market may vary during the construction period, resulting in a difficulty in re-selling the property or re-selling the property at a price lower than the purchase price and it requires a large upfront cost to Council. An alternative would be to consider the acquisition of multiple flood-affected properties, and redevelopment with a high density, flood compatible development where possible and as permitted in the zoning under the LEP.

This option would be focused on properties that would be subjected to overfloor flooding in more regular storms such as the 20% AEP event with 18 residential properties expected to be inundated above floor level. This option would benefit individual properties and not the catchment as a whole. Given the average property prices in Cessnock, redevelopment on a one-for-one approach would not be feasible in the study area; however this option may be considered further if higher density development is proposed.

11.3.8 Option P8 – Flood Proofing

Flood proofing involves undertaking structural changes and other procedures in order to reduce or eliminate the risk to life and property, and thus the damage caused by flooding. Flood proofing of buildings can be

undertaken through a combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding.

These include modifications or adjustments to building design, site location or placement of contents. Measures range from elevating or relocating, to the intentional flooding of parts of the building during a flood in order to equalise pressure on walls and prevent them from collapsing.

Examples of proofing measures include:

> All structural elements below the flood planning level shall be constructed from flood compatible materials;

> All structures must be designed and constructed to ensure structural integrity for immersion and impact of debris up to the 1% AEP flood event. If the structure is to be relied upon for shelter-in-place evacuation then structural integrity must be ensured up to the level of the PMF; and

> All electrical equipment, wiring, fuel lines or any other service pipes and connections must be waterproofed to the flood planning level.

In addition to flood proofing measures that are implemented to protect a building, temporary/emergency flood proofing measures may be undertaken prior to, or during, a flood to protect the contents of the building. These measures are generally best applied to commercial properties. These measures should be carried out according to a pre-arranged plan and may include:

> Raising belongings by stacking them on shelves or taking them to a second storey of the building;

> Secure objects that are likely to float and cause damage;

> Relocate waste containers, chemical and poisons well above floor level; and

> Install any available flood proofing devices, such as temporary levees and emergency water sealing of openings.

The SES business Flash Flood Tool Kit (SES, 2012) provides businesses with a template to create a flood-safe plan and to be prepared to implement flood proofing measures.

It is recommended that flood proofing guidelines are prepared and the tool kit distributed to the 286 commercial properties and 47 industrial properties that would be affected by flooding in a PMF event.

11.4 Emergency Response Modification Options

A number of emergency response modification options have been considered for the Black Creek floodplain including the following:

> Option EM1 - Information transfer to SES;

> Option EM2 - Preparation of Local Flood Plans and DISPLAN update;

> Option EM3 - Flood warning system;

> Option EM4 - Public awareness and education; and

> Option EM5 - Flood warning signs at critical locations.

11.4.1 Option EM1 – Information Transfer to SES

The findings of the updated Black Creek Flood Study and this Floodplain Risk Management Study and Plan provide an extremely useful data source for the State Emergency Service. Information could be provided in two forms:

> Electronic information (flood extent mapping and flood hazard mapping in GIS format); and

> Laminated plans (hard copies of flood extent and hazard mapping) in laminated plan format for use in the operations centre to assist with directing teams to the most likely affected localities. This can also help to overcome any issues associated with power loss or difficulty with accessing information in an emergency.

Liaison with SES should be undertaken prior to the transfer of information to confirm the type of data and the format of data required.

11.4.2 Option EM2 – Update of Local Flood Plan and DISPLAN

Recommendations to update the Local Flood Plan and DISPLAN are outlined in Section 8.2.

11.4.3 Option EM3 – Flood Warning System

As discussed in Section 8, the critical storm duration and response times for flooding in the catchment may mean the implementation of a flood warning system, beyond the current BoM warning system, is not feasible. However, there is opportunity to improve the local flood warning system to provide additional gauges for Black Creek and the other contributing watercourses, or flood markers at key locations, such that local flood conditions are more easily monitored. This is considered further in Section 11.4.5 below.

11.4.4 Option EM4 – Public Awareness and Education

Flood awareness is an essential component of flood risk management for people residing in the floodplain. The affected community must be made aware, and remain aware, of their role in the overall floodplain management strategy for the area. This includes the defence of their property and their evacuation, if required, during the flood event.

Flood education involves ensuring the affected community is aware of the flash flooding behaviour in the catchment and what this means with regards to risk to property, vehicle and pedestrian movement during a flood and the expected duration of flooding.

Flood awareness campaigns should be an ongoing process and requires the continuous effort of related organisations (e.g. Council and SES). The major factor determining the degree of awareness within the community is the frequency of moderate to large floods in the recent history of the area. The more recent and frequent the flooding, the greater the level of community awareness. The community consultation, as discussed in Section 4, identified a high level of flood awareness within the community.

However, for effective flood emergency planning, it is important to maintain an adequate level of flood awareness during the extended periods when flooding does not occur. A continuous awareness program needs to be undertaken to ensure new residents are informed, the level of awareness of long-term residents is maintained, and to cater for changing circumstances of flood behaviour and new developments. An effective awareness program requires ongoing commitment.

It is recommended that the following awareness campaigns be considered for the floodplain:

- Preparation of a FloodSafe brochure, with say a fridge magnet, may prove to be a more effective means of ensuring people retain information. The brochure can be uploaded to the SES website (www.ses.nsw.gov.au) in portable document format where it is available under the local communities section;
- Development of a Schools Package from existing materials developed by the SES and distribution to schools accordingly. Education at schools is not only useful in educating the students, but can be useful in the dissemination of information to the wider community.
- The meeting of local community groups could be used to arrange flood awareness programs at regular intervals; and
- Information dissemination is included in Council rates notices for all affected properties.

11.4.5 Option EM5 – Flood Warning Signs at Critical Locations

A number of public places in the catchment experience high hazard flooding in the 1% AEP event. It is therefore important that appropriate flood warning signs are posted at these locations. These signs may contain information on flooding issues, or be depth gauges to inform residents of the flooding depth over roads and paths.

It is recommended that at a minimum, depth gauges be installed at road crossings and parks which are subject to inundation in frequent events as shown in **Figure 6-26**.

11.5 Data Collection Strategies

This would involve the preparation of a flood data collection form to be used following a flood event. This would allow for more information to be gathered concerning the nature of flooding within the catchment, building on the knowledge gained the flood study and also may be of use for future studies.

The flood data collection form would include the request for information such as location of flood marks on buildings within properties, location of any debris marks as a result of flood water, any photographic or video evidence obtained during or after the flood event and a section to record address and contact details in order to follow up.

12 Economic Assessment of Options

It is possible to quantitatively assess the economic benefits of some of the options, namely those that were hydraulically modelled, and those with known benefits. For those options, a benefit-cost ratio can be calculated. This calculation is outlined below.

12.1 Preliminary Cost Estimates

Cost estimates were prepared for those options which allow for an economic assessment. A summary of these estimated capital costs are provided in **Table 12-1** and Appendix E.

Prior to any option proceeding, it is recommended that in addition to detailed analysis and design of the option, that these costs be revised prior to budget allocation to allow for a more accurate assessment of the overall cost. Detailed rates and quantities will also be required at the detailed design phase.

Table 12-1 Preliminary Cost Estimates

Option ID	Option	Capital Cost	Ongoing Cost
FM1	Combination of four options - Detention Basin (DB7) west of Vincent Street and Baddely Park, Detention Basin (DB8) east of Quorrobolong Road and south of railway, Detention basin (DB12) west of Quorrobolong Road and Mountain View Place and Detention basin (DB13) West of Stanford Street, Kitchener	$70,315,800	$703,158
FM2	Combination of three options - Detention Basin (DB6), Local Bund (Bellbird Creek) and Channel Reshaping (Bellbird Creek)	$19,646,400	$196,464
FM3	Combination of three options – Culvert Upgrades (Wollombi Road, Doyle Street and Henderson Street), Channel Widening (Black Creek) Channel Reshaping (Black Creek)	$19,726,500	$197,265
FM4	Channel Widening (Oliver Street Channel) – From Sixth Street to Edgeworth Road	$2,322,600	$23,226
FM5	Proposed bund/detention basin east of Sixth Street properties and railway line	$690,700	$6,907
FM6	Detention basin (DB1) Bellbird Creek - Austar Coal Mine site	$7,278,900	$72,789

12.1.2 Land Acquisition

Land acquisition has not been included as a line item in the preliminary cost estimates. This is because there are many potential acquisition methods or compensation arrangements with different associated costs and the final arrangement with an option cannot be determined at this stage. Furthermore, the detailed design of options may adjust the land acquisition needs such as in the case of detention basins, the shape may be optimised to reduce surface area and therefore cost.

In order to allow an estimate of the total cost of each option, **Table 12-2** identifies an approximate land acquisition cost for each option, with unit rates of $\$10/m^2$ to $\$25/m^2$ and $\$400/m^2$ for rural and residential land respectively (values approximated from realestate.com.au listings, 2015). The preliminary costings include a contingency of 50%, which may be sufficient to absorb some or all of the land acquisition costs associated with a mitigation option. Inclusion of the below estimated land acquisition costs in the BCR do not affect the ranking of options.

Table 12-2 Indicative Land Acquisition Cost for Assessed Options

Reference	Area of land required (m^2)	Rural/Residential	Indicative Acquisition Cost ($)
FM1	1,050,000	Rural	$10,500,000 to $26,250,000
FM2	48,000	Residential	$19,200,000
FM3	15,000	Residential	$6,000,000
FM4	10,000	Residential	$4,000,000
FM5	7,000	Rural	$70,000 to $175,000
FM6	70000	Rural	$700,000 to $1,750,000

12.2 Average Annual Damage for Assessed Options

The total damage costs were evaluated for each of the options assessed by hydraulic modelling. The average annual damage for each of the options is shown comparatively against the existing case in **Table 12-3**. Results show that structural option FM5 is the most effective option in reducing flood damages. Planning related measures P3, P4, P5, P6 and P7 all results in large savings in average annual damage. While the average annual damage is reduced to various degrees for different options, this reduction needs to be offset against the capital and recurrent costs of the option which are outlined below.

Table 12-3 Average Annual Damage for Assessed Options

Reference	Average Annual Damage	Reduction in AAD*
Existing (9 hr)	$2,419,215	
FM1	$2,244,065	$175,150
FM2	$2,458,701	-$39,486
FM3	$2,373,869	$45,346
FM4	$2,411,670	$7,544
FM5	$1,913,429	$505,786
FM6	$2,094,194	$325,020
P3	$2,200,764	$272,786
P4	$2,200,764	$272,786
P5	$2,267,260	$206,290
P6	$2,267,260	$206,290
P7	$2,267,260	$206,290

*The reductions in AAD for Option FM1 to Option FM6 is based on comparison with the 9 hour storm duration events, while reductions for Option P3 to Option P7 is based on comparison to peak results.

12.3 Benefit Cost Ratio

The economic evaluation of each modelled option was assessed by considering the reduction in the amount of flood damage incurred and comparing this with the preliminary costs estimates developed for each option. The existing condition (was used as the base case to compare the performance of modelled options.

Table 12-4 summarises the overall economics for each option that was able to be economically assessed. The indicator adopted to rank options on economic merit is the benefit-cost ratio (B/C). The B/C ratio provides an insight into how the damage savings from an option, relate to its cost of construction and maintenance:

> Where the B/C is greater than 1 the economic benefits are greater than the implementation costs;

> Where the B/C is less than 1 but greater than 0, there is still an economic benefit from implementing the option but the cost of implementing the option is greater than the economic benefit;

> Where the B/C is equal to zero, there is no economic benefit from implementing the option; and

> Where the B/C is less than zero, there is a negative economic impact of implementing the option.

Table 12-4 Economic Assessment of Options

Option	AAD	Reduction in AAD	NPW of Benefit*	Capital Cost	Recurrent Cost	NPW of Option*	B/C Ratio	Rank
FM1	$2,244,065	$175,150	$2,417,200	$70,315,800	$703,158	$80,019,905	0.03	9
FM2	$2,458,701	-$39,486	-$544,938	$19,646,400	$196,464	$22,357,750	0.00	11
FM3	$2,373,869	$45,346	$625,811	$19,726,500	$197,265	$22,448,904	0.03	10
FM4	$2,411,670	$7,544	$104,118	$2,322,600	$23,226	$2,643,136	0.04	8
FM5	$1,913,429	$505,786	$6,980,221	$690,700	$6,907	$786,022	8.88	1
FM6	$2,094,194	$325,020	$4,485,525	$7,278,900	$72,789	$8,283,443	0.54	6
P3	$2,200,764	$272,786	$3,764,656	$2,560,000	$0.00	$2,560,000	1.47	3
P4	$2,200,764	$272,786	$3,764,656	$2,560,000	$0.00	$2,560,000	1.47	3
P5	$2,267,260	$206,290	$2,846,963	$5,400,000	$0.00	$5,400,000	0.53	7
P6	$2,267,260	$206,290	$2,846,963	$900,000	$0.00	$900,000	3.16	2
P7	$2,267,260	$206,290	$2,846,963	$4,500,000	$0.00	$4,500,000	0.63	5

* NPW – Net Present Worth is calculated using 7% interest over 50yrs.

13 Multi-Criteria Options Assessment

A multi-criteria matrix assessment approach was adopted for the comparative assessment of all options identified using a similar approach to that recommended in the Floodplain Development Manual (2005). This approach to assessing the merits of various options uses a subjective scoring system. The principle merits of such a system are that it allows comparisons to be made between alternatives using a common index. In addition, it makes the assessment of alternatives transparent (i.e. all important factors are included in the analysis). However, this approach does not provide an absolute right answer as to what should be included in the Floodplain Risk Management Plan, and what should be omitted. Rather, it provides a method by which stakeholders can re-examine options and, if necessary, debate the relative scoring assigned.

Each option is given a score according to how well the option meets specific considerations. In order to keep the scoring relatively simple, a system was developed for each criterion as shown in **Table 13-1**.

13.1 Scoring System

A scoring system was devised to subjectively rank each option against a range of criteria given the background information on the nature of the catchment and floodplain as well as the likely community preferences. The scoring is based on a triple bottom line approach, incorporating economic, social and environmental criterion. The criteria adopted are shown in **Table 13-1**.

Table 13-1 Multi Criteria and Weightings

Category	Category Weighting	Criteria	Relative Weighting - individual criteria score	Relative Weighting
Economic	50%	Benefit Cost Ratio	50%	25%
		Capital Cost	30%	15%
		Operating Costs	20%	10%
Social	25%	Compatibility with Council Policies and Plans	40%	10%
		Reduction in Social Disruption	30%	7.5%
		Level of Community and Stakeholder Support	30%	7.5%
Environmental	25%	Compatibility with Water Quality Objectives	25%	6.3%
		Groundwater	25%	6.3%
		Heritage	25%	6.3%
		Fauna/Flora Impact including street trees	25%	6.3%

Each option is assigned a score for each criterion. The score for each category (i.e. economic, environment and social) is determined by the score for each criterion, factored by a weighting as shown in **Table 13-1**. The overall score for the option is then calculated by the weights for each of the categories.

It is noted that the economic category is given more weight than either the environment or social categories. This is due to the economic category being the most direct measure of both the effectiveness of the option on flooding as well as its affordability. Options that rank highly on environmental or social categories do not necessarily provide significant flooding benefits and therefore are not the most suitable actions to reduce flood risks.

A rank based on the total score is calculated to identify those options with the greatest potential for implementation.

Table 13-2 Scoring System

Category	Criteria	Metric	Score				
			-2	-1	0	1	2
Economic	Benefit Cost Ratio	BCR	<-1	-0.5	0-0.5	0.5-1.0	>1
	Capital Cost	Capital cost of option	Extreme >$10 million	High $5 million – $10 million	Medium $1 million – $5 million	Low $500,000 – $1 million	Very Low $0 – $500,000
	Operating Costs	Operating cost of option	Extreme >$100,000 per year	High $50,000 – $100,000 per year	Medium $10,000 – $50,000 per year	Low $5,000 – $10,000 per year	Very Low $0 - $5,000 per year
Social	Compatibility with Council Policies & Plans	Level of compatibility	Strong disagreement	Disagreement	Neutral/No response	Support	Strong support
	Reduction in Social Disruption	Changes in social disruption	Major increase in social disruption	Slight increase in social disruption	No change to social disruption	Slight reduction of social disruption	Major reduction of social disruption
	Community & Stakeholder Support	Level of agreement	Majority strong disagreement	Majority disagreement	Neutral or limited responses provided	Majority support	Majority strong support
Environment	Compatibility with Water Quality Objectives	Compatibility with objectives	Completely incompatible	Slightly incompatible	Neutral	Compatible	Completely Compatible
	Groundwater	Impact on groundwater	High potential to negatively impact groundwater quality and/or flow	Slight potential to negatively impact groundwater quality and/or flow	No impact	Slight potential to positively impact groundwater quality and/or flow	High potential to positively impact groundwater quality and/or flow
	Heritage	Impacts to heritage items, including consideration of heritage items.	Destruction of State or National Heritage Item	Likely impact on State or National Heritage Item or possible impact on local heritage item5	No impact	Some benefit	Considerable benefit
	Fauna/Flora Impact - Including Street Trees	Impacts to flora/ fauna	Broad-scale vegetation / habitat impacts or impacts on threatened species	Isolated vegetation / habitat impacts	No impact	Isolated vegetation / habitat benefits	Broad-scale vegetation / habitat benefits

13.2 Results

The assignment of each flood mitigation option with a score for each criterion is included in **Appendix F**. A rank based on the total score was calculated to identify those options with the greatest potential for implementation.

Based on the multi criteria assessment, the top options include the following:

> FM5, proposed bund/flood wall east of Sixth Street properties and railway line in South Cessnock;

> EM4, Public awareness and education;

> EM5, Flood warning signs at critical locations;

> P6, Land Swap;

> P3, House Raising;

> P4, House Rebuilding; and,

This ranking has been used as a basis for prioritising projects as part of the Floodplain Risk Management Plan (Chapter 15).

14 Study Recommendations and Conclusions

Cardno were commissioned by Cessnock City Council to undertake the Floodplain Risk Management Study and Plan for the Black Creek catchment including the city of Cessnock. Flooding in the catchment can pose a hazard to residents and businesses near the creeks, channels and overland flow paths. The purpose of this study was to identify and examine options for the management of flooding with the Black Creek catchment.

The existing Black Creek MIKE FLOOD (1D/2D) hydraulic model was extended and updated to include Bellbird, Mount View detention basin and surrounds and land to the north east of the CBD. Flood modelling was complete for seven design storm events ranging from 20% AEP up to the PMF event in order to assess flood behaviour in the extended hydraulic model. The model was validated to the storm event of June 2007 with reasonable correlation of results. Flood mapping was prepared for all design storm events including peak water levels, depths, velocities, flood hazard categorisation and hydraulic categories and the impacts of climate change on existing flood behaviour. The revised flood extents were adopted by Council in March 2014.

An assessment was undertaken on the number of properties that would be subject to overground and overfloor flooding within the catchment under various frequency storm events ranging from the 20% AEP event up to the PMF and these are summarised in the table below:

Table 14-1 Flood affected properties and associated damages under existing condition

Flood Event	Properties with Overfloor Flooding	Properties with Overground (Yard) Flooding	Flood Damage
20% AEP	20	185	$1,729,269
10% AEP	40	386	$3,713,300
5% AEP	119	621	$8,705,999
2% AEP	240	910	$16,092,255
1% AEP	346	1,102	$22,536,603
0.5% AEP	489	1,254	$30,826,304
PMF	2,218	2,366	$169,456,152
Average Annual Damage			**$2,704,640**

A review of Councils planning documents has been undertaken and recommendation for DCP modifications identified in Section 9 including all flood-related controls be consolidated into a single section of the DCP (Part C) (or a supporting Floodplain Management Policy) so as to minimise confusion and provide a single point of reference for all relevant controls. The requirement for a site specific flood study is identified in Part E of the Cessnock DCP 2010 for a few specific locations. It is recommended that the need for a site specific flood study is reviewed in light of the findings of this FRMSP and the improved understanding of flood behaviour. In addition, Council could utilise the information contained within this Floodplain Risk Management Study to create a map of flood control lots for the Black Creek Floodplain to ensure that the majority of development requires consent rather than falling under the exempt or complying development process as per the SEPP (Exempt and Complying Development Codes).

Options to reduce or manage the effects of flooding in the catchment were investigated to manage the risks of flooding. Under the merits-based approach outlined in the NSW State Government's Floodplain Development Manual (NSW Government, 2005) a number of potential options for the management of flooding were identified, namely:

- Flood mitigation measures;
- Property modification measures; and
- Emergency response measure.

An extensive list of options was assessed against a range of criteria (technical, economic, environmental and social) and hydraulic modelling of some of the flood mitigation options was undertaken to provide a

comprehensive analysis of those options that would involve significant capital expenditure. The highest ranking options identified as part of the multi criteria analysis include:

- FM5, proposed bund/flood wall east of Sixth Street properties and railway line in South Cessnock;
- EM4, Public awareness and education;
- EM5, Flood warning signs at critical locations;
- P6, Land Swap;
- P3, House Raising; and,
- P4, House Rebuilding;

A number of structural options assessed were not considered viable due to adverse impacts on flood levels such as Option FM4, and where the benefit cost ratio indicated the cost of implementing the option were much higher than the resultant reduction in flood damages, including Option FM1, Option FM2 and Option FM3.

It is important to recognise that some options are mutually exclusive and therefore only one of the options would need to proceed. In the case of those high ranking options listed above, Options P6 (Land Swap), P3 (Housing Raising) and P4 (House Rebuilding) effectively address the same properties. As a consequence, only one of these three options would need to be incorporated in the Floodplain Risk Management Plan. It may be that for different properties, different approaches would be more effective or more acceptable to private land holders. It is therefore recommended that the Floodplain Risk Management Plan contain the highest cost of the three options for budgeting purposes and that the most suitable option of the three be selected once consultation with individual land holders has occurred.

Modifications to planning instruments, whilst not incorporated in the multi-criteria matrix assessment are a critical aspect of the long-term management of flood risk and it is recommended that Options P1 and P2 be incorporated into the Floodplain Risk Management Plan.

Likewise, some of the emergency response modification measures, also not incorporated into the multi-criteria matrix assessment are critical to the management of flood risk. It is recommended that Options EM1 and EM2 be incorporated into the Floodplain Risk Management Plan.

These outcomes of the study have been used as the basis of the Floodplain Risk Management Plan (Chapter 15).

15 Floodplain Risk Management Plan

15.1 Plan Objectives

The overall objective of this Floodplain Risk Management Plan is to devise a strategy that addresses the existing, future and continuing issues in the Black Creek catchment in accordance with the NSW Government's Flood Policy, as detailed in the NSW Floodplain Development Manual (NSW Government, 2005).

The objectives for this Plan are to:

> Reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with the flood hazard and risk;

> Reduce private and public losses due to flooding;

> Protect and where possible enhance the floodplain environment;

> Be consistent with the objectives of relevant State policies, in particular, the Government's Flood Prone Land and State Rivers and Estuaries Policies and satisfy the objectives and requirements of the Environmental Planning and Assessment Act (1979);

> Ensure that it is fully integrated with Council's existing corporate, business and strategic plans, existing and proposed planning proposals, meets Council's obligations under the Local Government Act, 1993 and has the support of the local community;

> Ensure actions are sustainable in social, environmental, ecological and economic terms;

> Ensure that it is fully integrated with the local emergency management plan (flood plan) and other relevant catchment management plans; and

> Establish a program for implementation and suggest a mechanism for the funding of the plan which should include priorities, staging, funding, responsibilities, constraints, and monitoring.

15.2 Implementation Program

Flood modification measures are structural options aimed at preventing, avoiding or reducing the likelihood of flood risks. The options are discussed in detail in Section 11 and are summarised in **Table 11-3**.

The measures identified are generally based on opportunities for short to medium term work and comprise bunds to divert overland flow, channel widening and reshaping. The majority of the measures are independent and therefore can be undertaken as isolated projects.

The options identified in the Floodplain Risk Management Study were assessed using a multi-criteria assessment, which incorporated a benefit / cost analysis for the structural options which can be quantitatively assessed and are shown in **Appendix G**. The multi-criteria assessment utilised a triple bottom line approach to assess the options on their economic, environmental and social suitability. For the purposes of selecting a list of options for the Plan, the overall ranking in the multi-criteria assessment has been used.

15.3 Floodplain Risk Management Measures

The implementation program essentially forms the action list for this Plan and is shown in **Table 15-1**.

The benefit of following this sequence is that gradual improvement of the floodplain occurs, as the funds become available for implementation of these options.

Further steps in the floodplain management process include:

> Draft Plan to be exhibited for public comment

> Plan to be finalised incorporating public comments

> Floodplain Management Committee to consider and adopt recommendations of this Plan;

> Council to consider the Floodplain Management Committee's recommendations;

> Council to adopt the Plan and submit an application for funding assistance to OEH and other agencies as appropriate; and

> As funds become available from Council's own resources, OEH and/or other state government agencies, implement the measures in accordance with the established priorities.

This Plan should be regarded as a dynamic instrument requiring review and modification over time. Catalysts for change may include new flood events and experiences, legislative changes and the availability of funding and reviews of council planning policies. In any event, a review every five years is warranted to ensure the ongoing relevance of the Plan.

The measures identified in **Table 15-1** represent a capital outlay of approximately $20M over the life of the plan. However, high priority actions have a total cost of approximately $800,000.

It is noted that a specific timeframe for the Plan has not been explicitly identified. Experience with these types of Plans has identified that the works are undertaken when and as funding becomes available, as well as when various opportunities might arise specifically for an option. In general:

> Non-structural measures can generally be implemented in the short term (1 to 3 years), as they are relatively low in capital expenditure and generally revolve around policy and information; and

> Structural measures can generally be implemented in the medium term (1 to 10 years), and will be implemented as funding and opportunities arise including land availability.

15.4 Key Stakeholders

As a part of the implementation of the Plan and the detailed design phase of some of the options, liaison should be undertaken with key stakeholders. These stakeholders should include, but are not limited to:

> Local residents and community groups, in particular, those affected by proposed works;

> Business owners within Cessnock CBD who would be impacted by the proposed options;

> RMS with regard to any impacts on any RMS roads in the study area;

> SES should also be kept informed of changes to the flood behaviour resulting from any of the implemented option; and

> OEH given it is likely that funding would be sourced from OEH for a number of the options, they should be consulted as a part of the design process.

Table 15-1 Floodplain Risk Management Measures Recommended for Implementation

ID	Description	Estimated Capital Cost	Estimated Recurring Cost	Funding Sources/ Responsibility	Priority for Implementation
EM4	Public awareness and education	$20,000	$5,000	Council/OEH	High
EM5	Flood warning signs at critical locations	$20,000	$1,000	Council/OEH	High
P1	Review of LEP	$20,000	$1,000	Council	High
P2	Review of DCP and Engineering Standards	$40,000	$5,000	Council	High
EM1	Information transfer to SES	$5,000	-	Council/SES	High
EM2	Local Flood Plan and DISPLAN update	$10,000	-	Council/SES	High
FM5	Proposed bund/flood wall east of Sixth Street properties and railway line[+]	$690,700	$6,907	Council/OEH	High
P6/P3/ P4	Land Swap or House Raising or House Rebuilding*	$2,560,000	-	Council/OEH	Medium
P5	Voluntary Purchase**	$5,400,000	-	Council/OEH	Medium
FM6	Detention basin (DB1) Bellbird Creek - Austar Coal Mine site[+]	$7,278,900	$72,789	Council/OEH	Low

*As per recommendation of Floodplain Risk Management Study (See Chapter 14)

** Voluntary purchase budget allocation presuming that some properties identified could be dealt with under the P6/P3/P4 scheme and therefore not all properties identified in the Floodplain Risk Management Study would need to be purchased.

[+] Land acquisition has not been included in the estimated capital cost. This is because there are many potential acquisition methods or compensation arrangements with different associated costs and the final arrangement for an option cannot be determined at this stage. Furthermore, the detailed design of options may adjust the land acquisition needs or cost of land acquisition may differ at the time of implementation. Indicative current land acquisition costs for FM5 are $70,000 to $175,000 and for FM6 are $700,000 to $1,750,000.

15.5 Plan Implementation

The development and adoption of this plan is the first step towards implementation. It outlines the beneficial measures to achieve reduced flood risk within the Black Creek floodplain and the priorities for implementation. For less expensive measures, Council may be able to source funding readily and these measures can progress through implementation relatively quickly. For more expensive measures Council will need to submit an application for funding assistance to OEH and other agencies as appropriate.

It should be noted that some measures such as planning related matters can be implemented by Council fairly readily, whereas, a structural modification will need to progress to a detailed design stage before it can be built. This is to develop the detail of the measure for construction taking due consideration of all physical, environmental and social constraints. During this process, the concept option may be altered marginally or significantly to suit such constraints. This detailed design will also be required to be modelled to demonstrate the mitigation benefits of the final design are appropriate and meet the flood mitigation objectives.

15.6 Plan Review

It is recommended that this Plan be reviewed every five years or following the occurrence of a significant flood in the area.

16 References

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Cessnock City (Black Creek)

APPENDIX A
FIGURES

Cardno
Shaping the Future

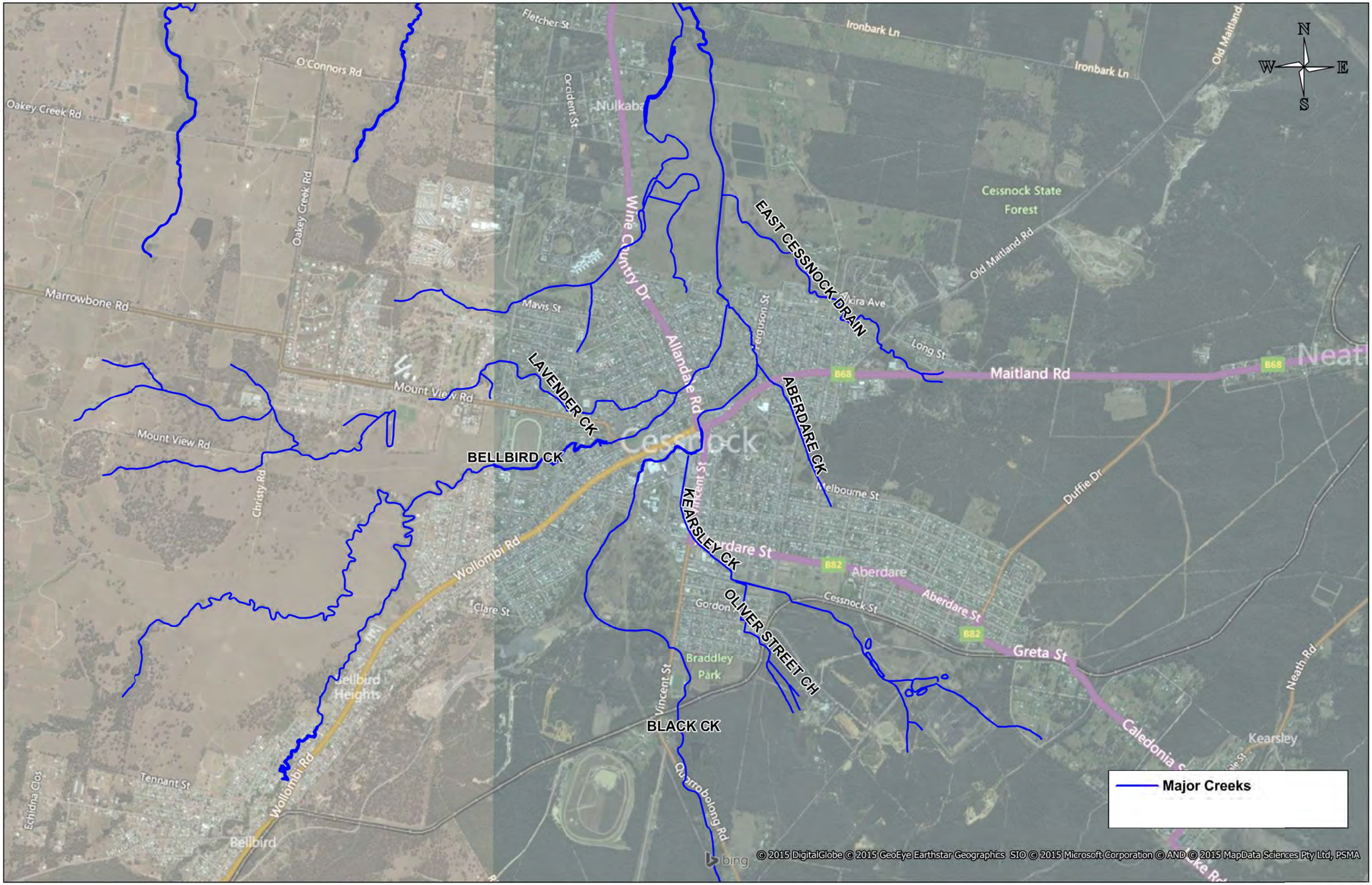

FIGURE 2-1 :STUDY AREA

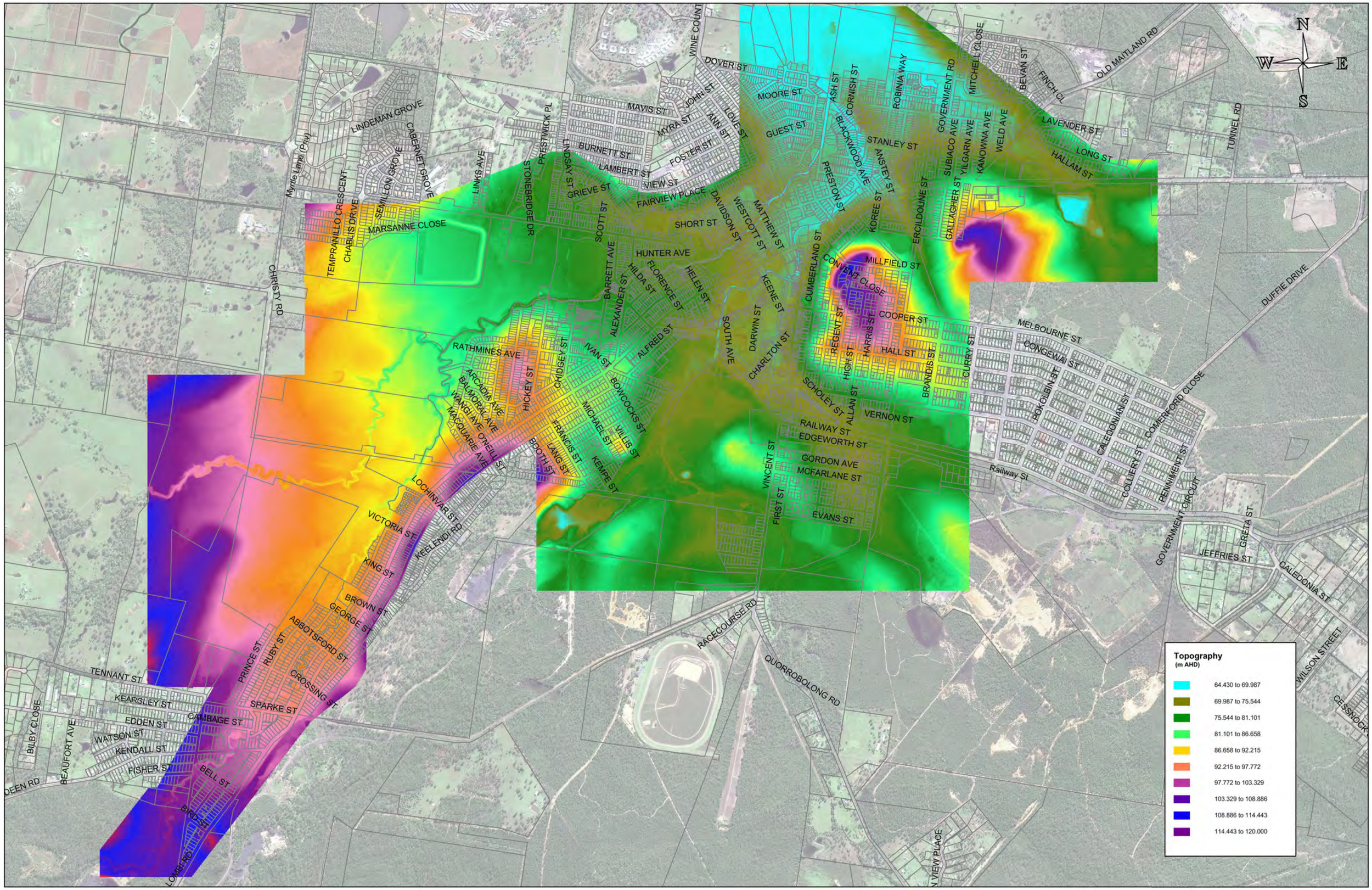

FIGURE 3-1 : LIDAR DATA EXTENTS/TOPOGRAPHY GRID

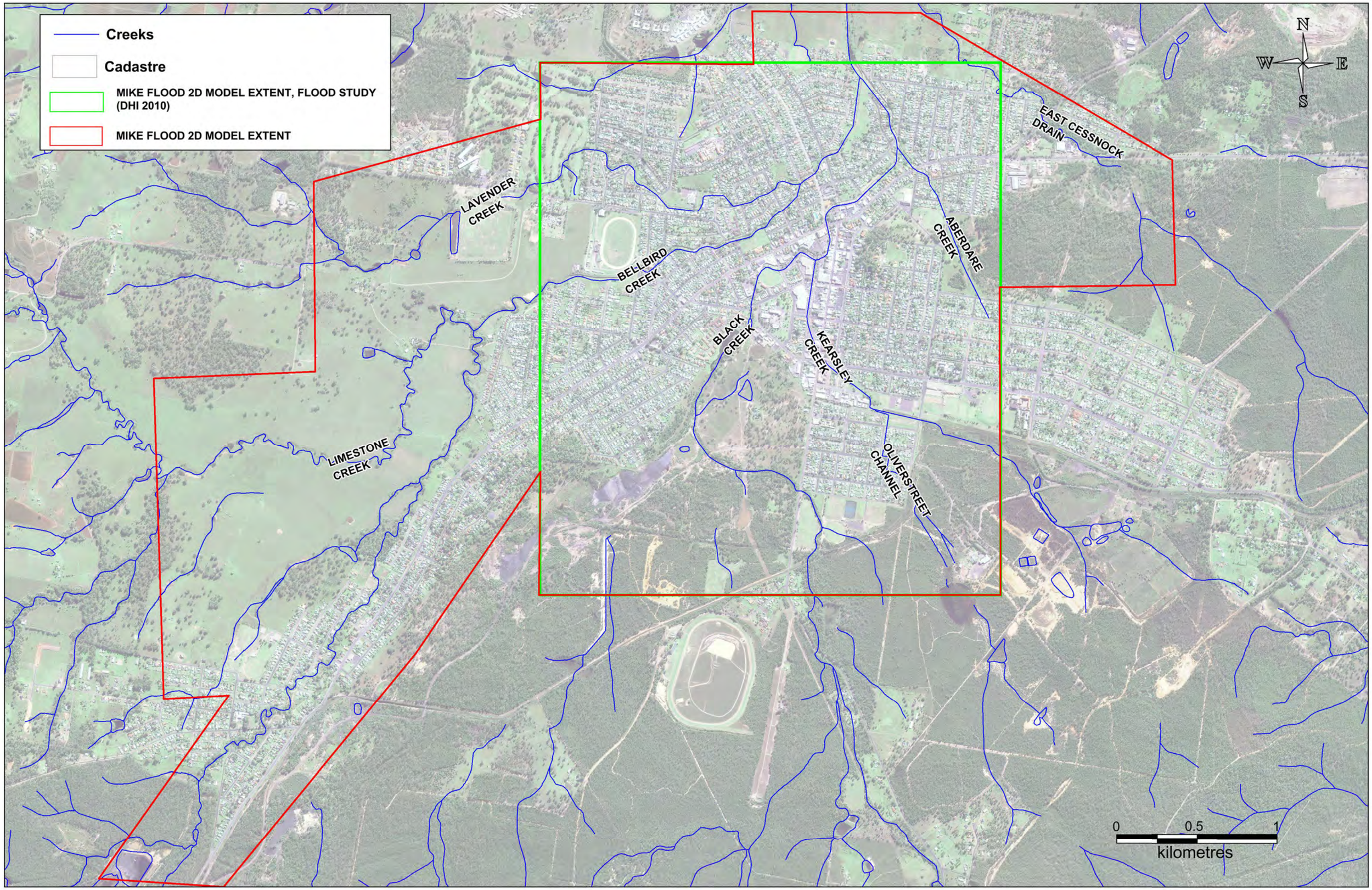

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FIGURE 6-1 : EXISTING MODEL 2D AREA EXTENSION

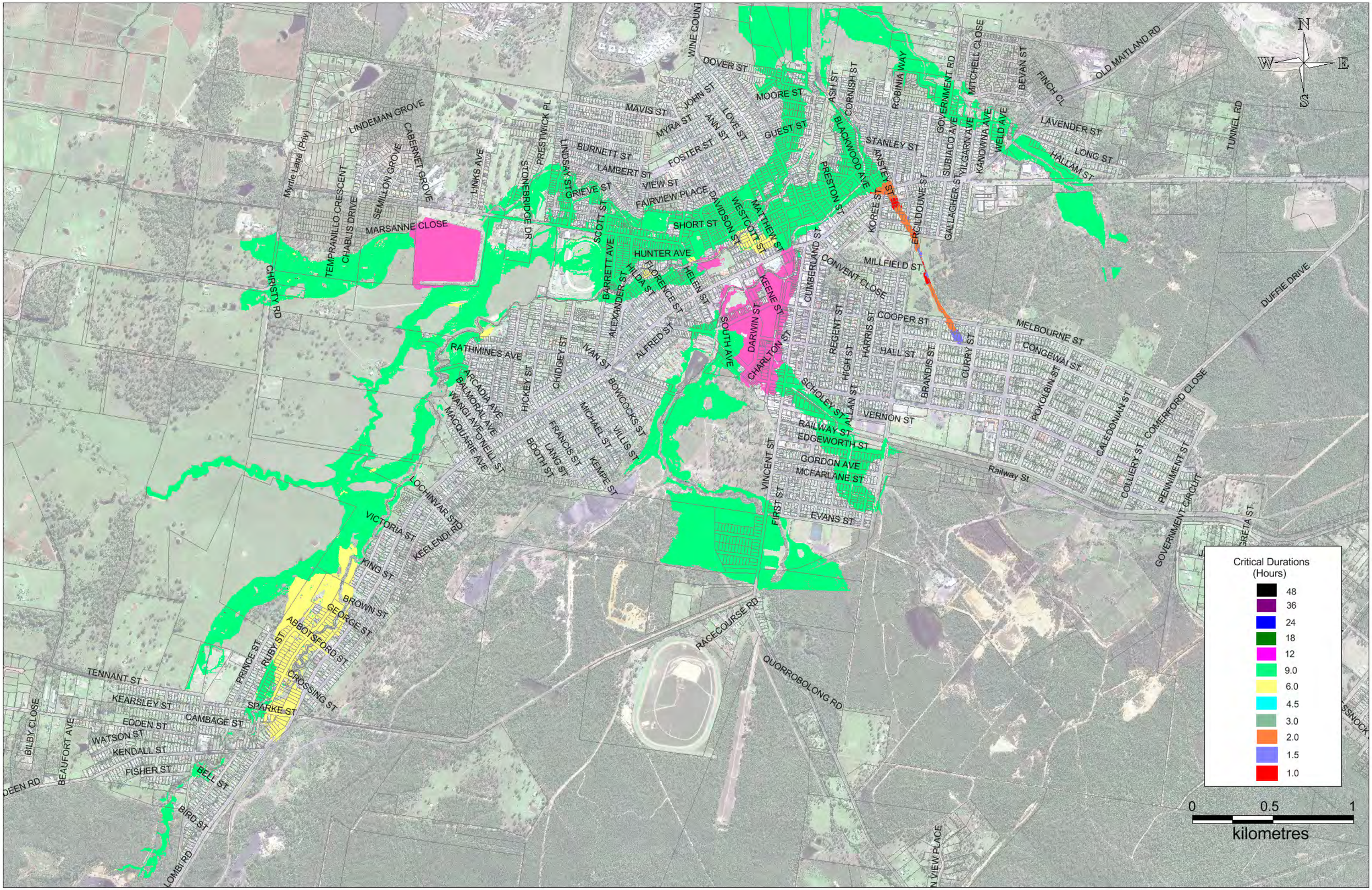

FIGURE 6-2 : CRITICAL STORM DURATION

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FIGURE 6-3 : 1% AEP DIFFERENCE PLOT
(Current Results Less 2010 Flood Study Results)

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

Flood Extent

REGION A

REGION B

REGION C

REGION D

REGION E

N

W

E

S

GRADY RD

LOVEDALE RD

LONDONS RD

OLSEN RD

DE BEYERS RD

RACECOURSE LANE

INGLES LANE

PHILLIPS LANE

TALLOWOOD DRIVE

PINCHEN ST

OCCIDENT ST

BRANXTON ST

FLETCHER ST

MCKENSEY ST

BOREAS ST

FLEMING ST

McCARTHY ROAD

LOMAS LANE

IRONBARK LANE

WINE COUNTRY DRIVE

DUGUID CLOSE

OLD MAITLAND RD

PANGARI PDE

ROBINIA WAY

ASH ST

CORNISH ST

JOHN ST

MOORE ST

GUEST ST

STANLEY ST

NEWTON AVE

ATTWATER AVE

SUBIACO AVE

YILGARN AVE

KANOWNA AVE

WELD AVE

LAVENDER ST

LONG ST

TUNNEL RD

MAITLA

BIRKDALE BVD

MACKELLAR ST

BURNETT ST

FOSTER ST

STONEBRIDGE RD

LINKS AVE

GRIEVE ST

FAIRVIEW PLACE

SHORT ST

SPERRY ST

DOYLE ST

VICTORIA ST

NEATH ST

DUFFIE DRIVE

BARRETT AVE

HILDA ST

HELEN ST

LYELL ST

KEENE ST

DARWIN ST

CUMBERLAND ST

CHAPMAN ST

COOPER ST

HALL ST

REGENT ST

HIGH ST

CURRY ST

MELBOURNE ST

CONGEWAI ST

MULBRING ST

KEARSLEY ST

CALEDONIAN ST

COMERFORD CLOSE

PENNIMENT ST

GOVERNMENT CIRCUIT

GRETA ST

ELLALONG

CALEDONIA ST

WILSON STREET

CESSNOCK ST

Myrtle Lane (Priv)

LINDEMAN GROVE

TEMPRANILLO CRESCENT

CHABLIS DRIVE

SEMILLON GROVE

CHRISTY RD

ARCADIA AVE

O'NEILL ST

CHIDGEY ST

ALFRED ST

BOWCOCKS ST

MICHAEL ST

FRANCIS ST

LANG ST

KEMPE ST

VILLIS ST

VINCENT ST

Snape St

RAILWAY ST

VERNON ST

GORDON AVE

JEFFRIES ST

EVANS ST

Railway St

KEELENDI RD

KING ST

BROWN ST

ABBOTSFORD ST

RUBY ST

CROSSING ST

SPARKE ST

TENNANT ST

CAMBAGE ST

WATSON ST

FISHER ST

BELL ST

BIRD ST

WOLLOMBI RD

BEAUFORT AVE

BILBY CLOSE

RACECOURSE RD

QUORROBOLONG RD

MOUNTAIN VIEW PLACE

BELLBIRD ST

STANFORD ST

HEDDON ST

ABERMAIN ST

HEBBURN ST

ABERNETHY ST

MURRAY ST

BRUCE ST

STUART

SOUTHAMS RD

MIDDLE RD

BOUNDARY LINE ROAD

0 0.5 1

kilometres

FIGURE 6-4 :1% AEP EVENT FLOOD EXTENTS OVERALL

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Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

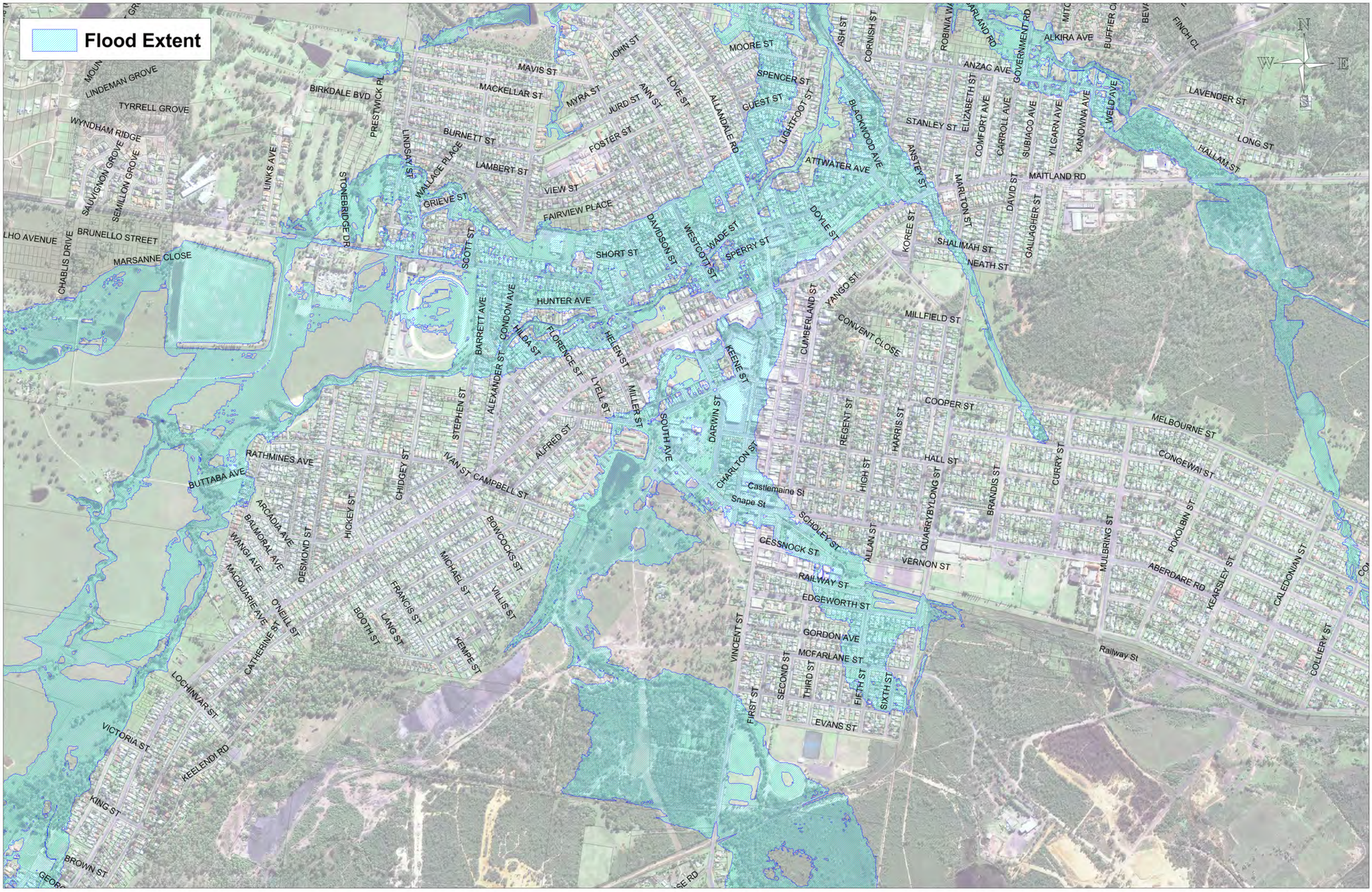

FIGURE 6-5 : 1% AEP EVENT FLOOD EXTENTS- REGION A

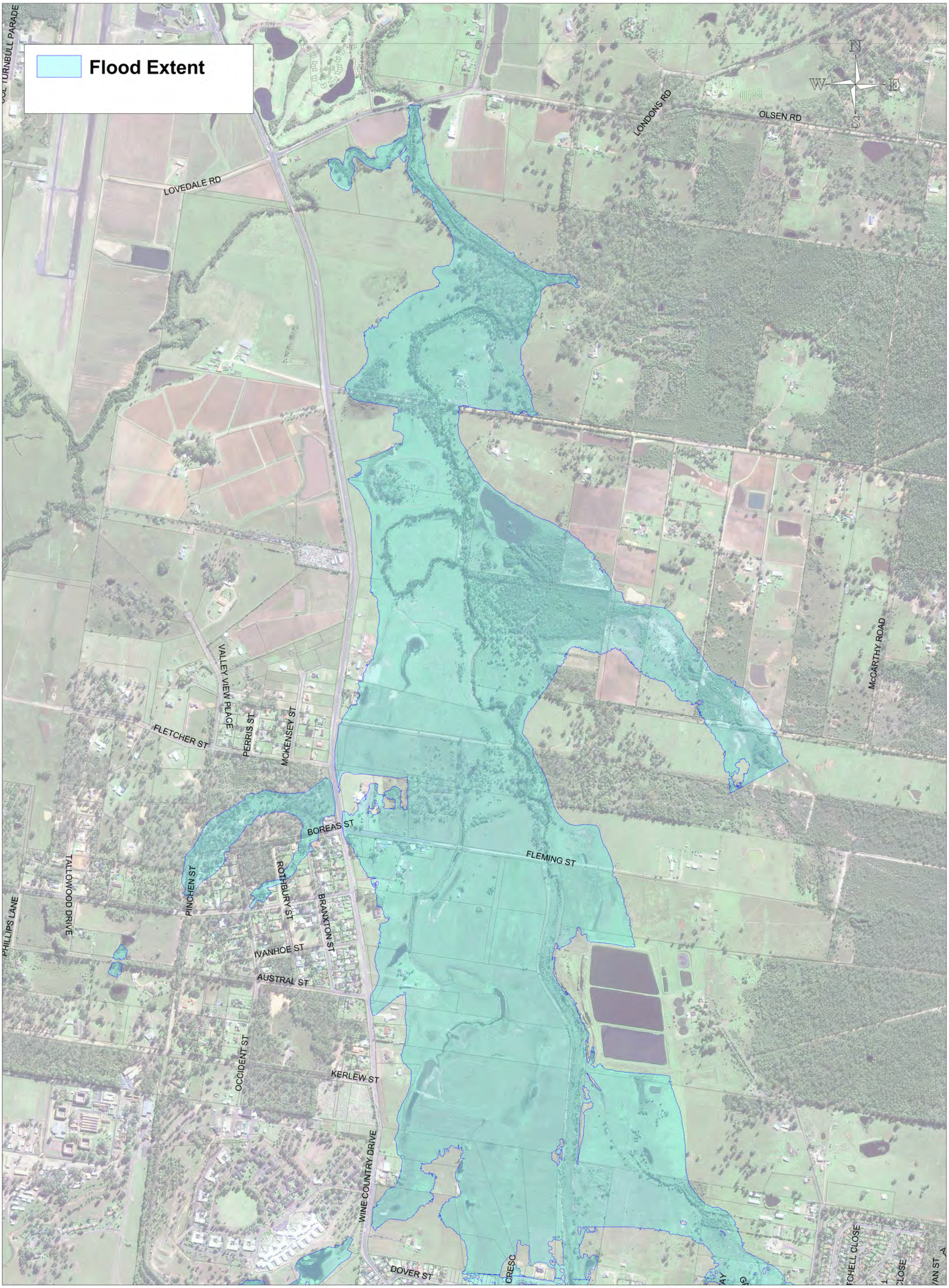

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FIGURE 6-6 :1% AEP EVENT FLOOD EXTENTS - REGION B

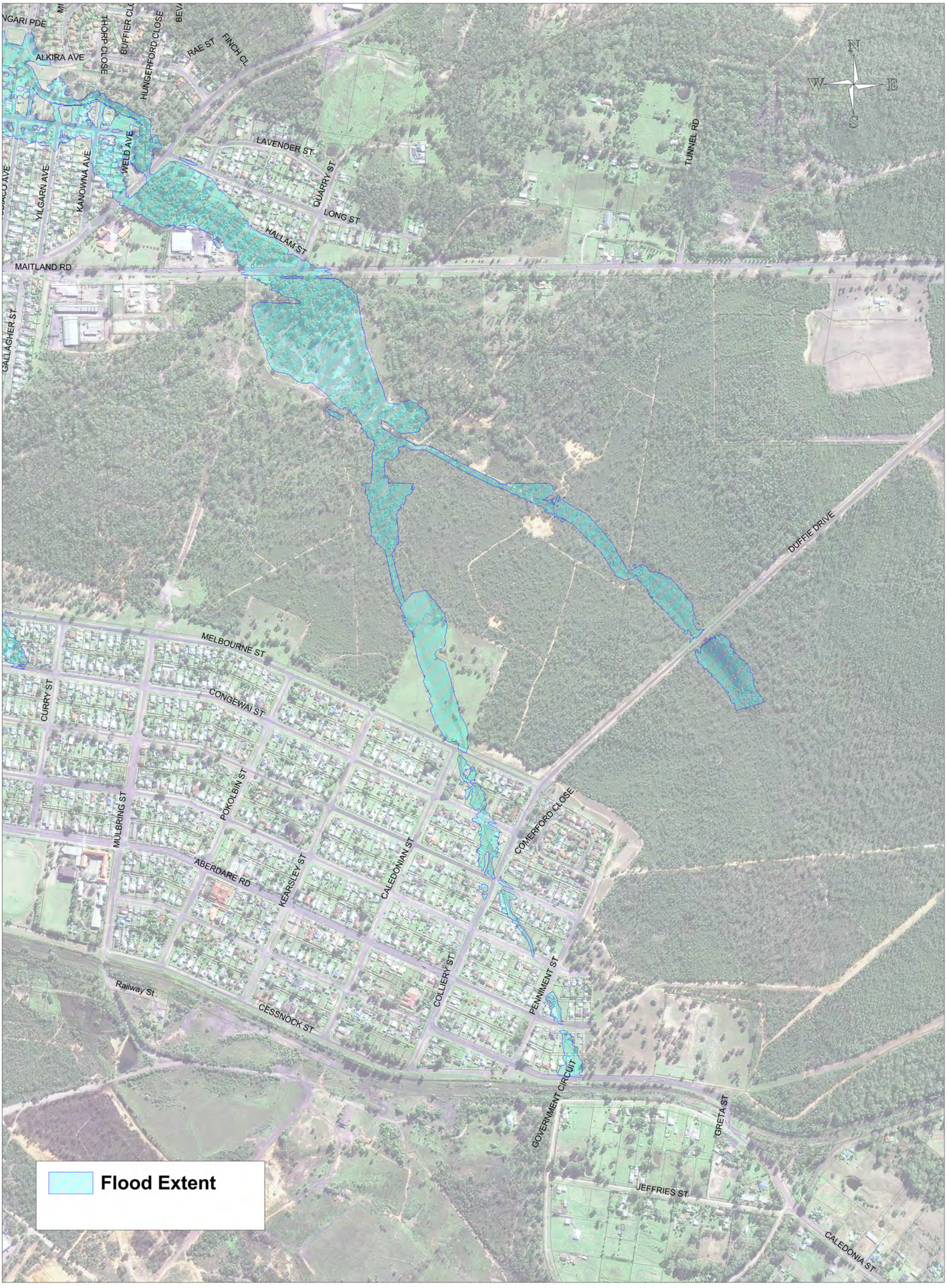

FIGURE 6-7 :1% AEP EVENT FLOOD EXTENTS - REGION C

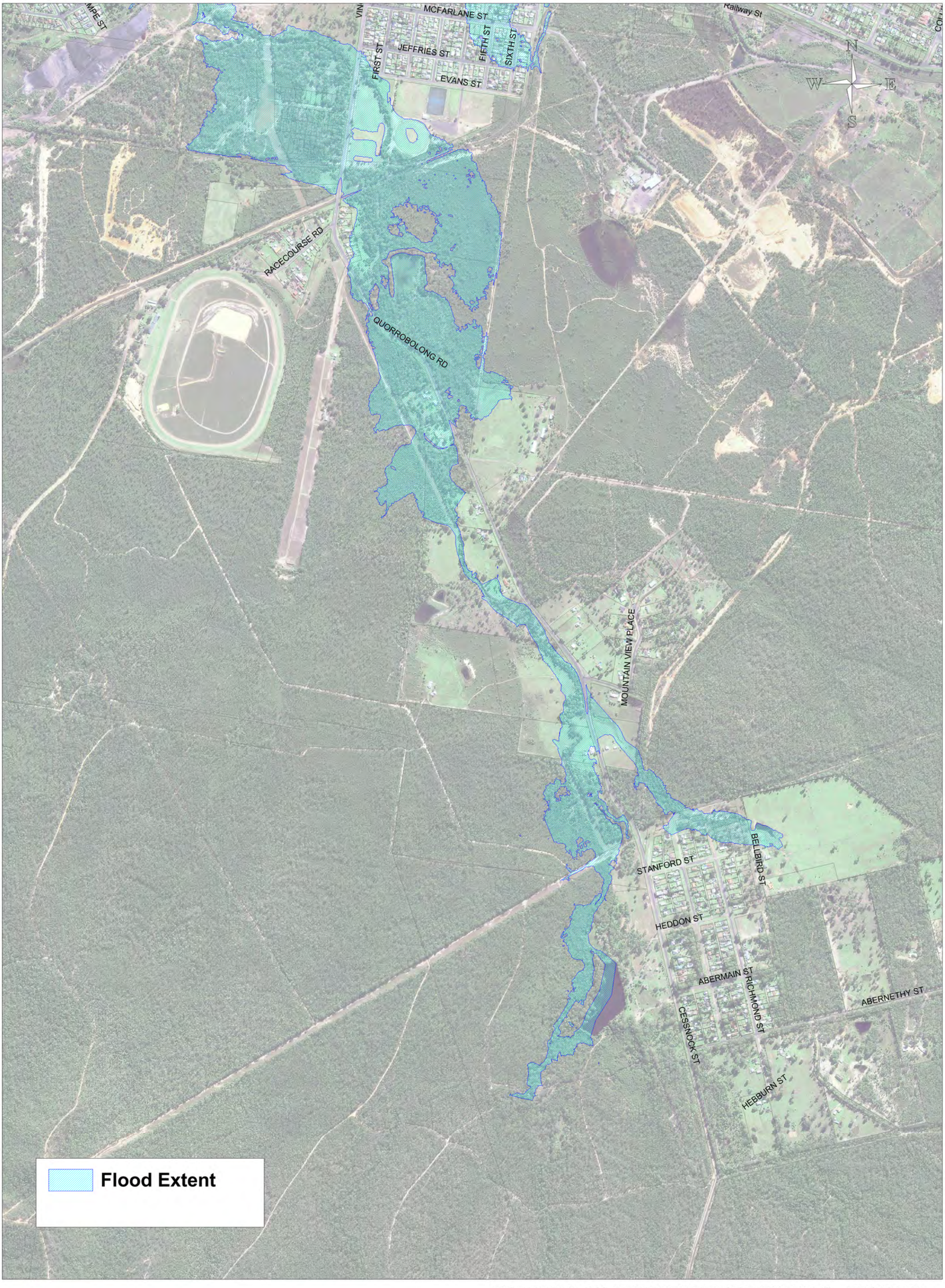

FIGURE 6-8 :1% AEP EVENT FLOOD EXTENTS - REGION D

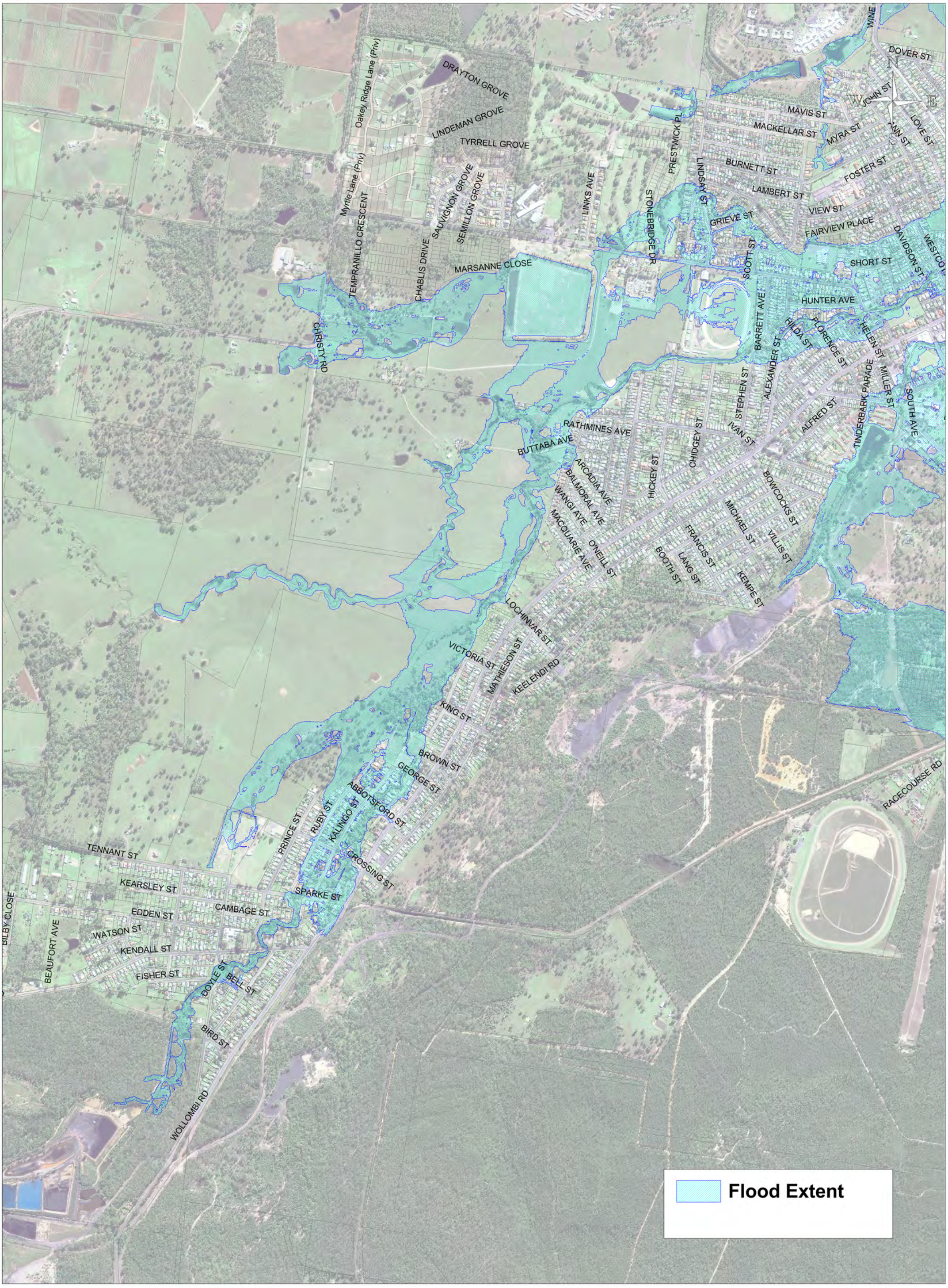

FIGURE 6-9 :1% AEP EVENT FLOOD EXTENTS - REGION E

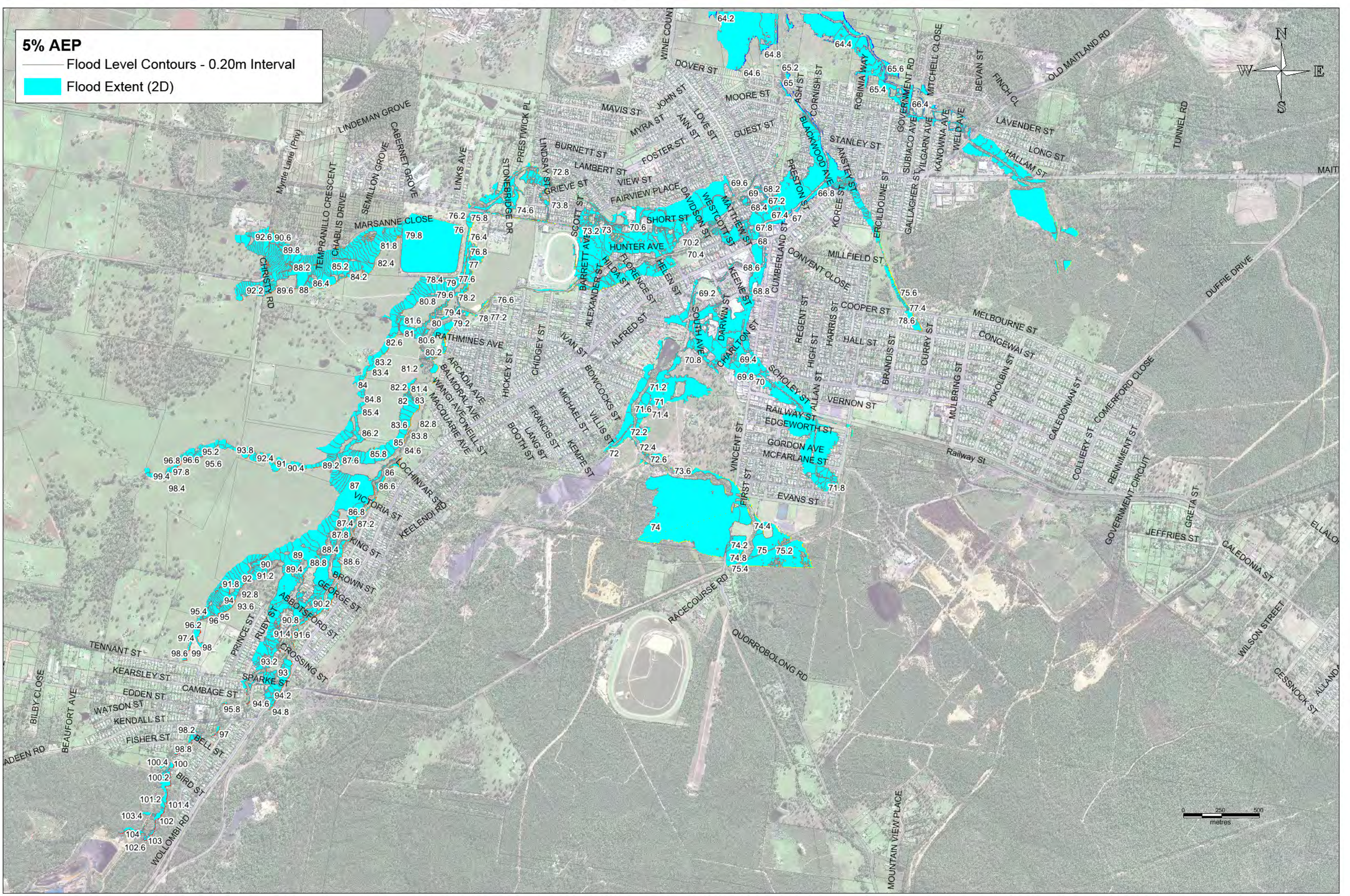

FIGURE 6-10 : 5% AEP FLOOD LEVEL CONTOURS

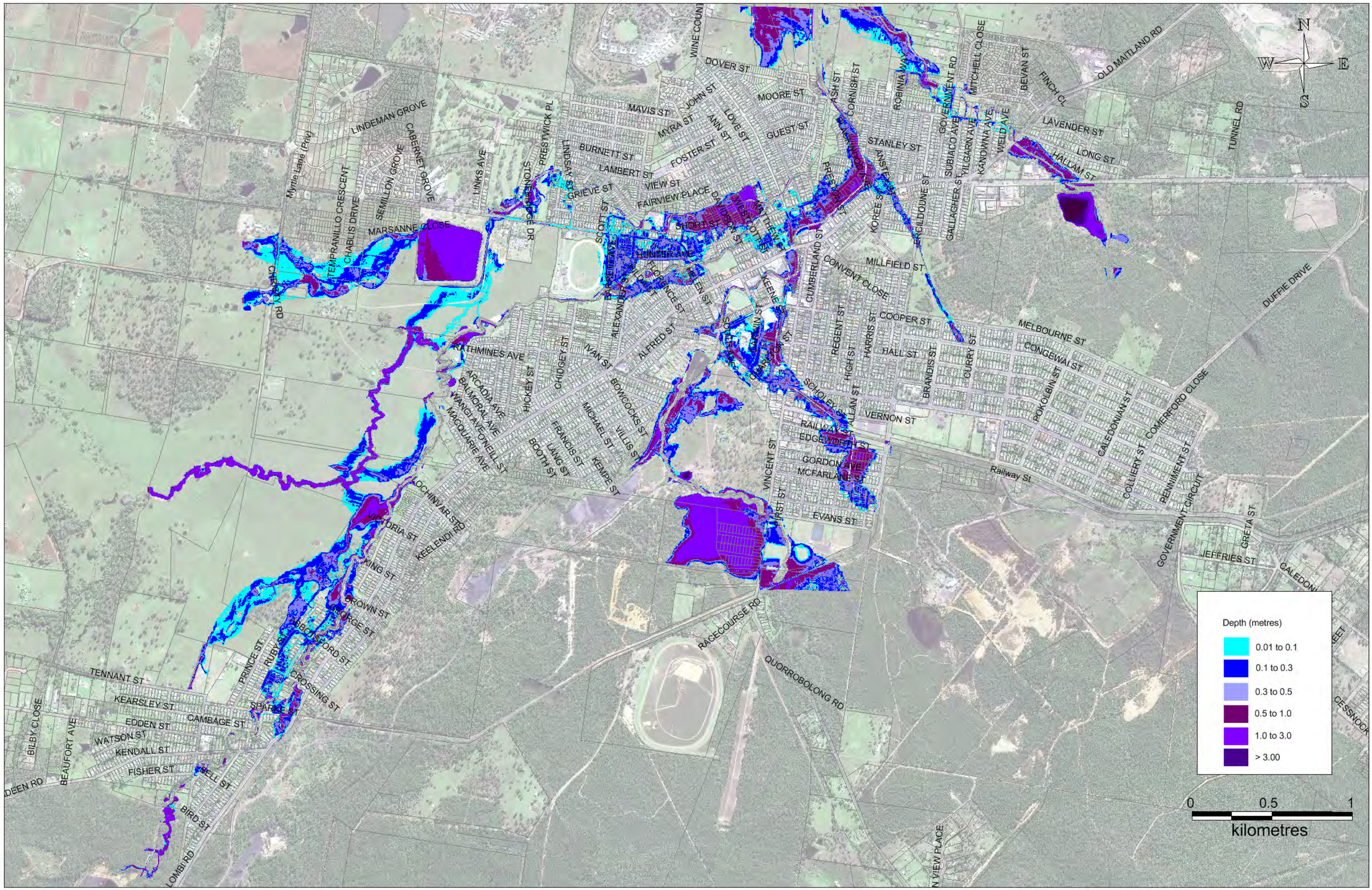

FIGURE 6-11: 5% AEP EVENT FLOOD DEPTHS

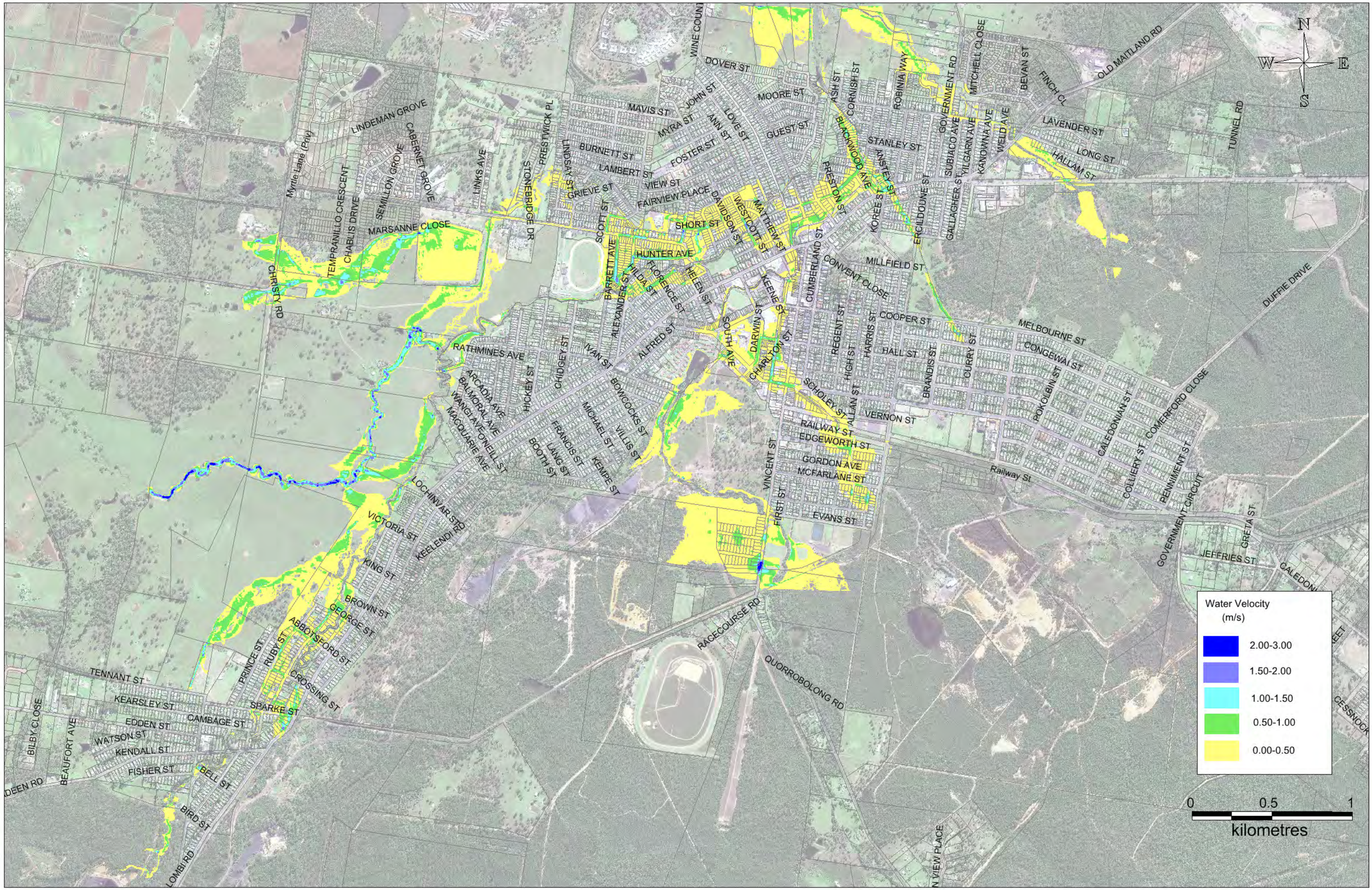

FIGURE 6-12: 5% AEP FLOOD VELOCITIES

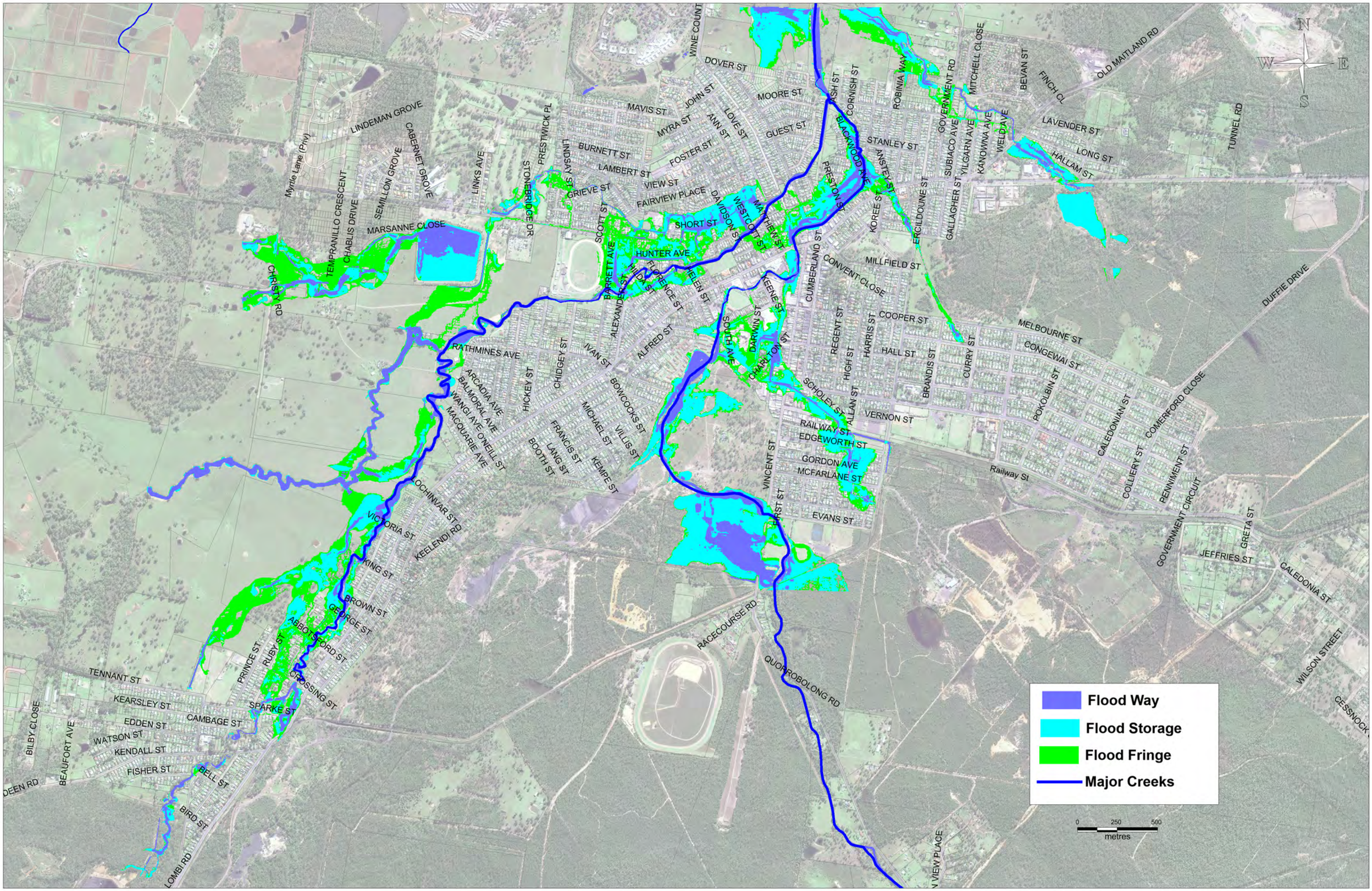

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FIGURE 6-13 : HYDRAULIC CATEGORIES
5% AEP EVENT

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Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

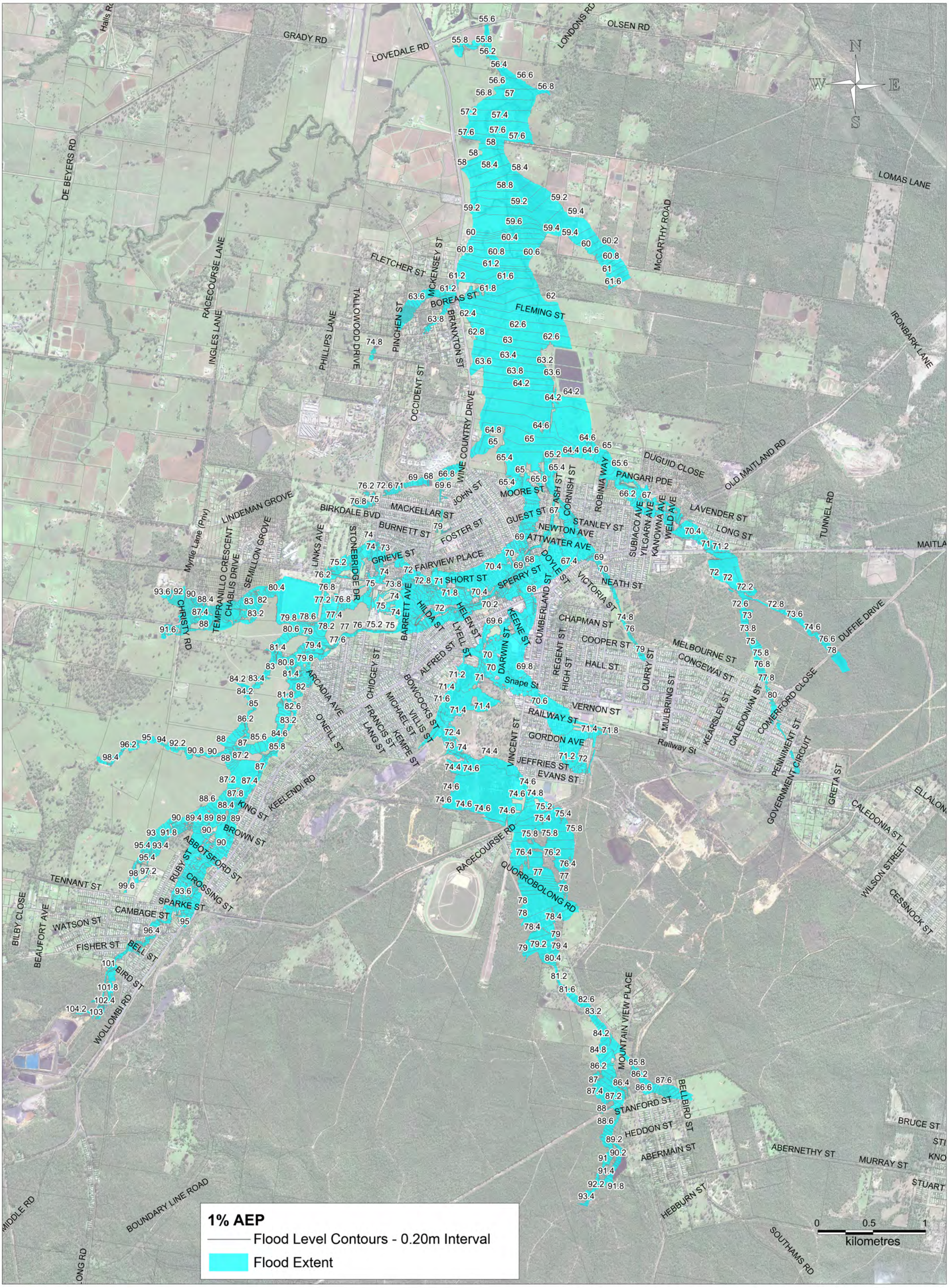

FIGURE 6-14 :1% AEP FLOOD LEVEL CONTOURS

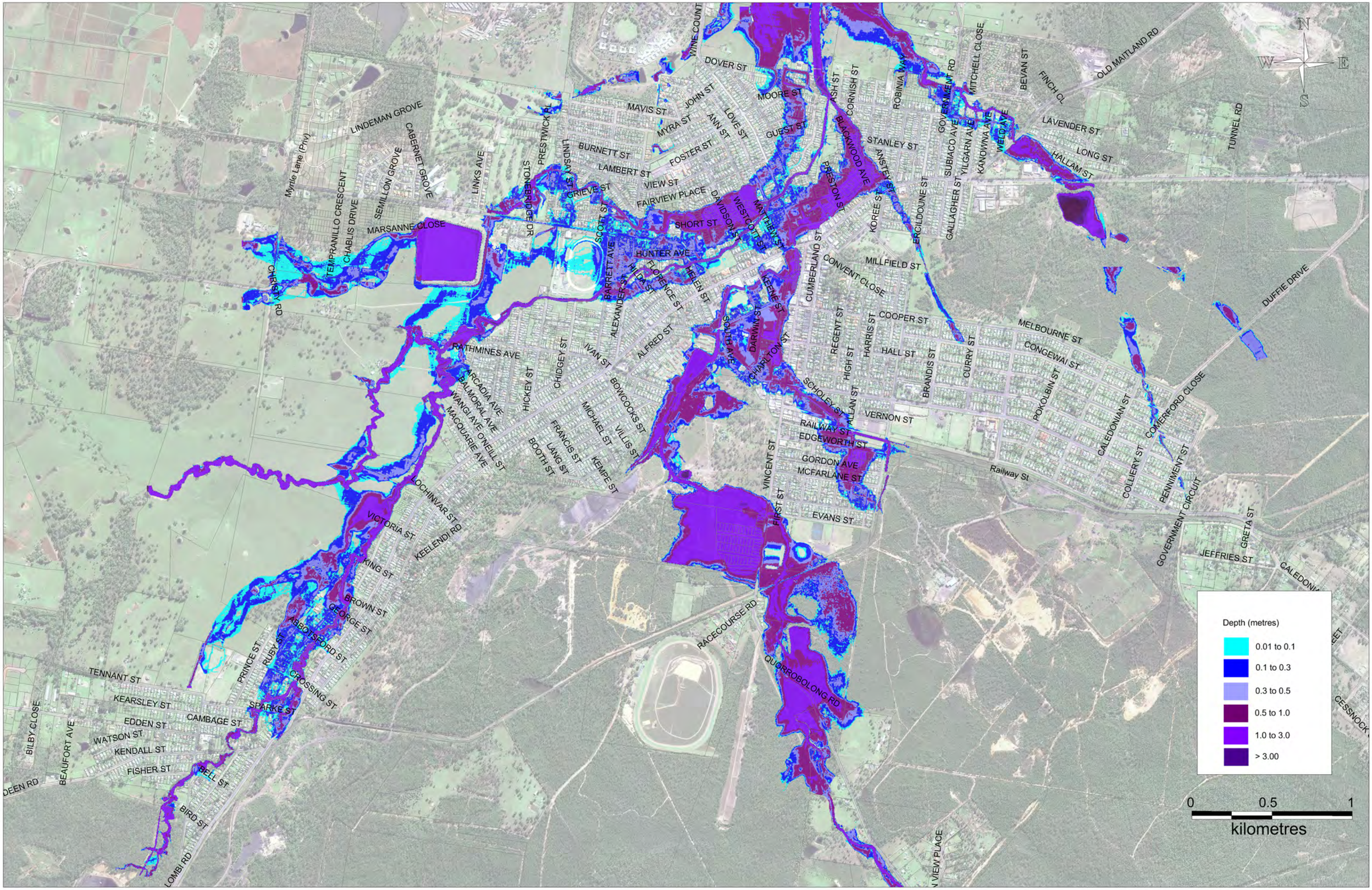

FIGURE 6-15 : 1% AEP EVENT FLOOD DEPTHS

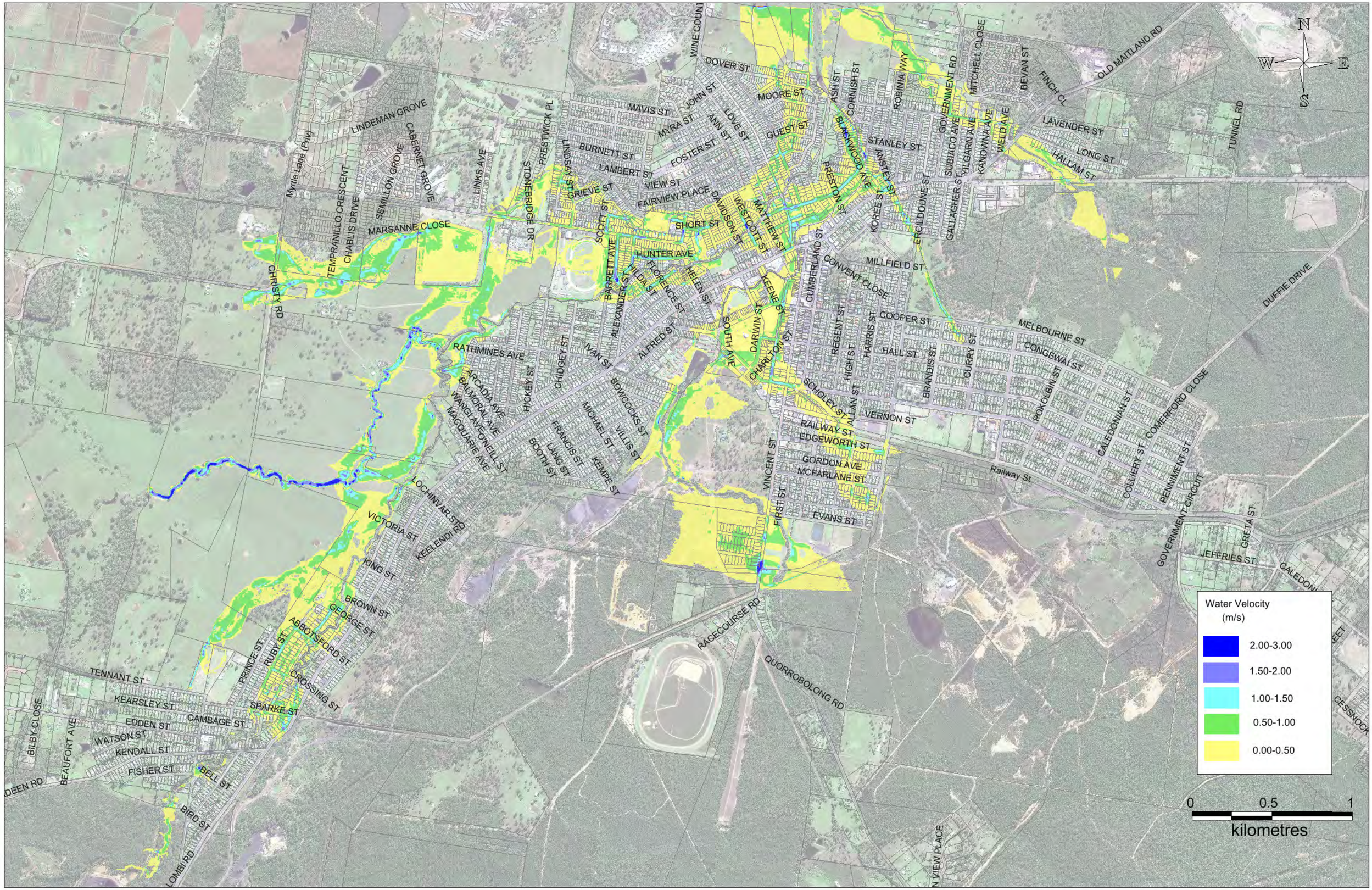

FIGURE 6-16: 1% AEP FLOOD VELOCITIES

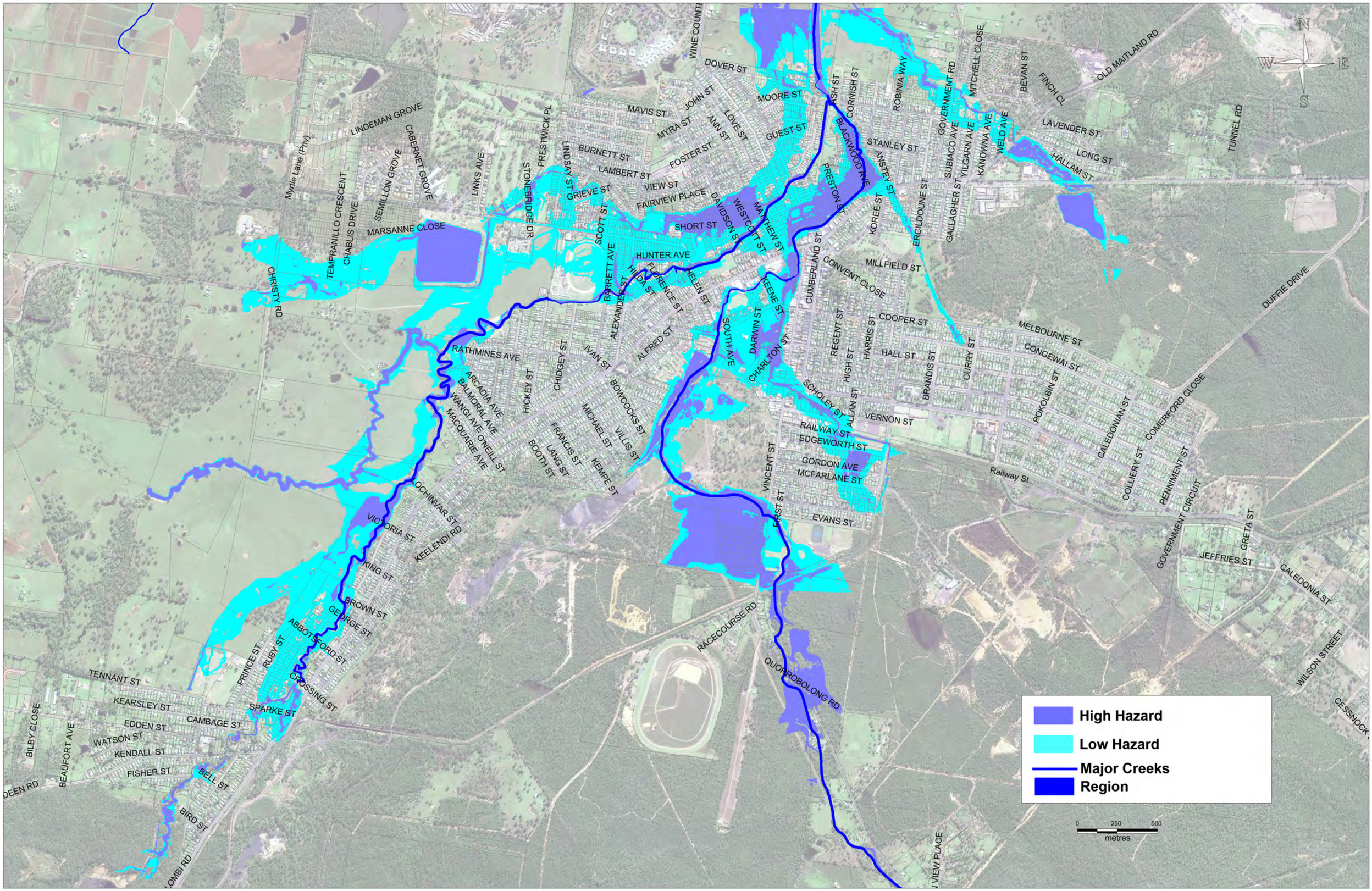

FIGURE 6-17 : PROVISIONAL HAZARD 1% AEP EVENT

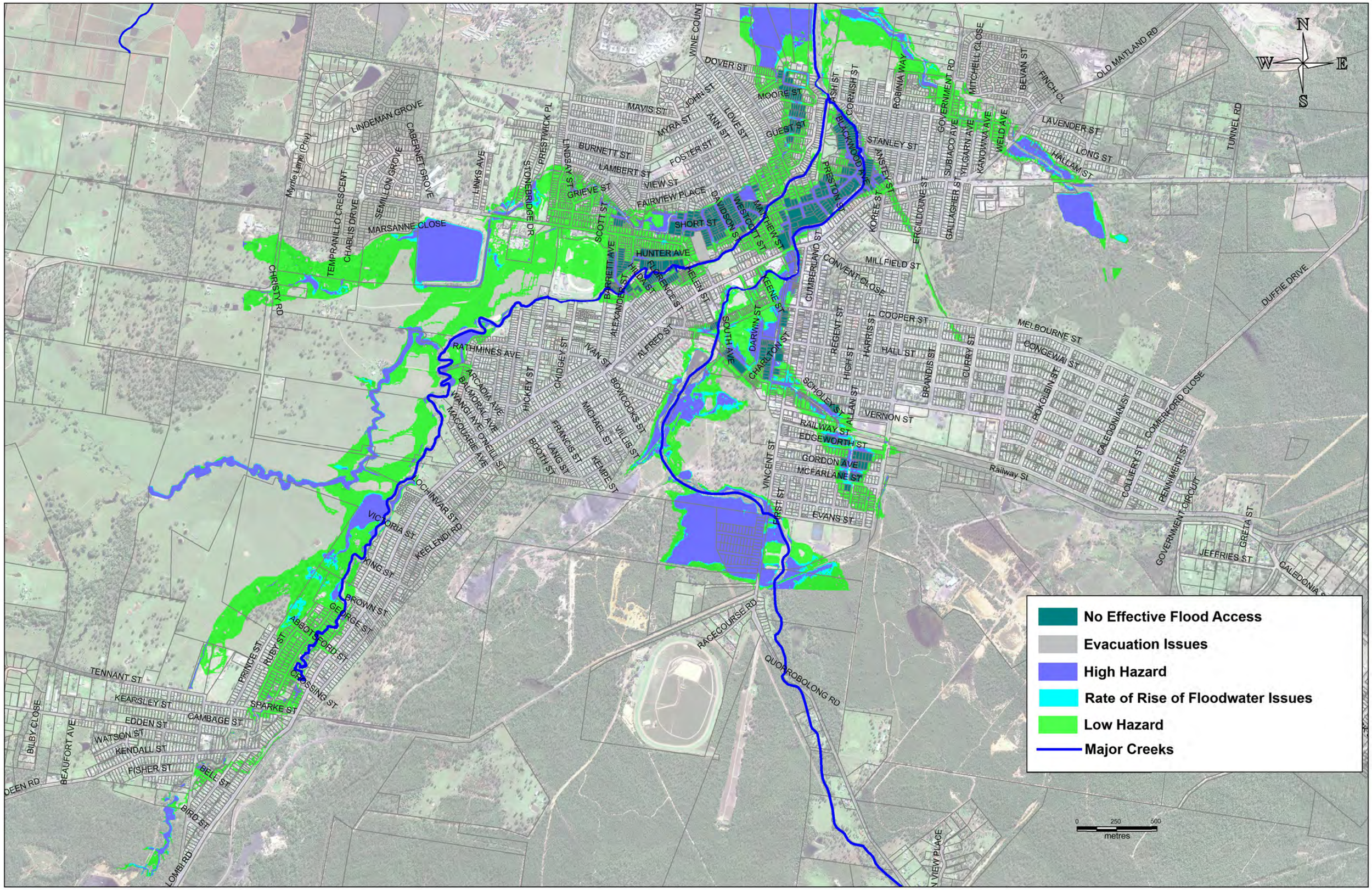

FIGURE 6-18 : TRUE HAZARD
1% AEP EVENT

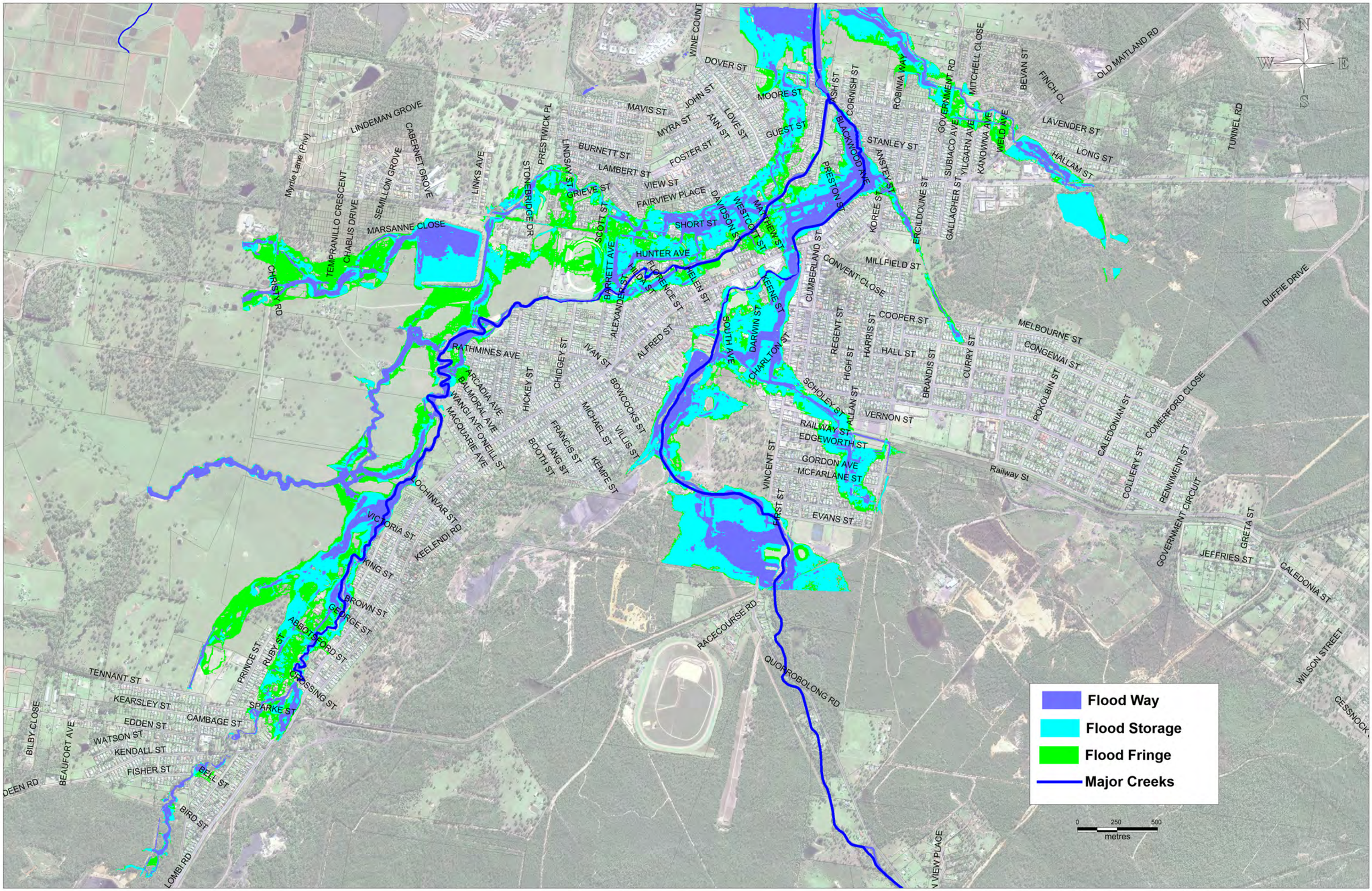

FIGURE 6-19 : HYDRAULIC CATEGORIES
1% AEP EVENT

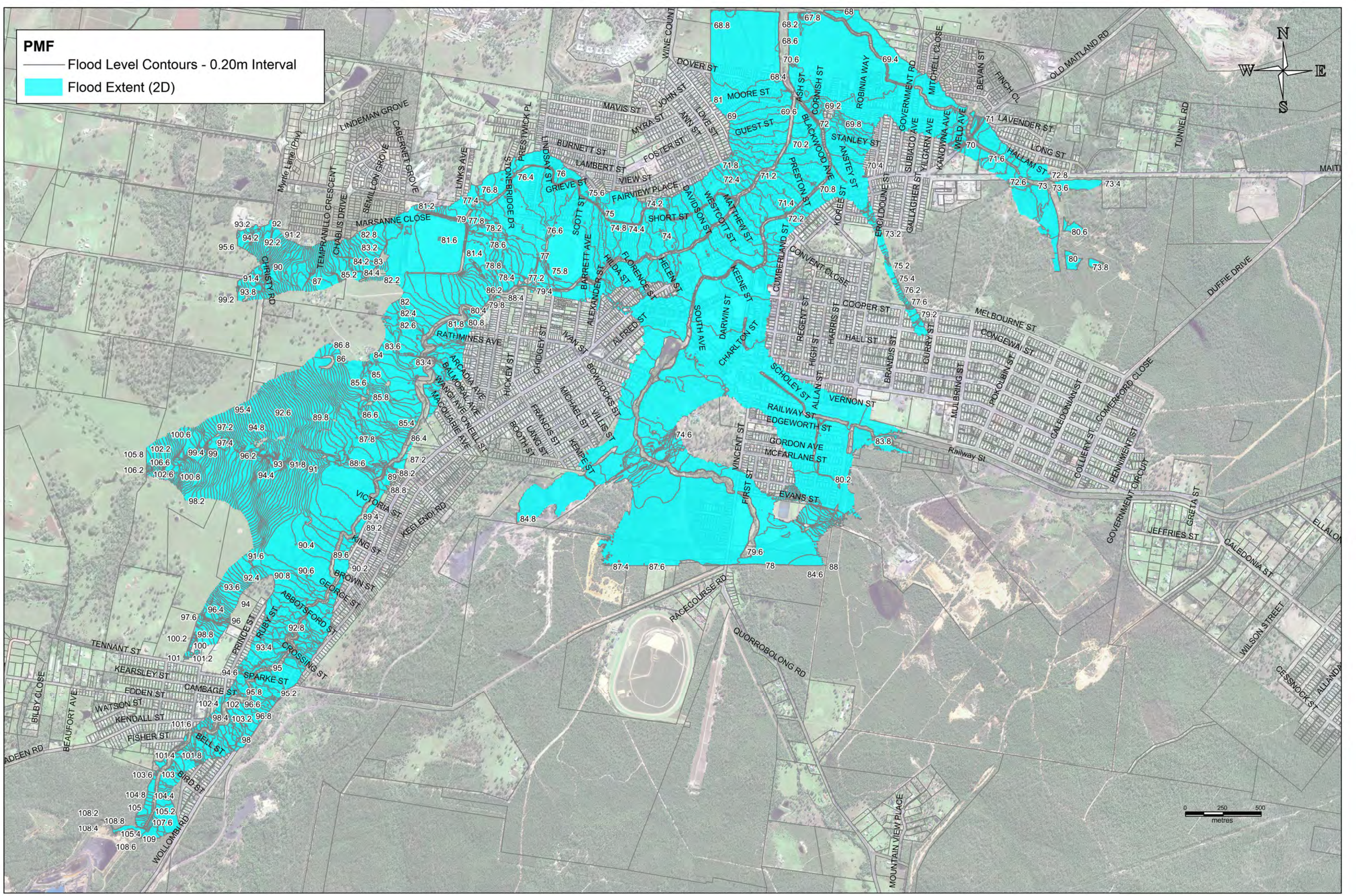

FIGURE 6-20 :PMF FLOOD LEVEL CONTOURS

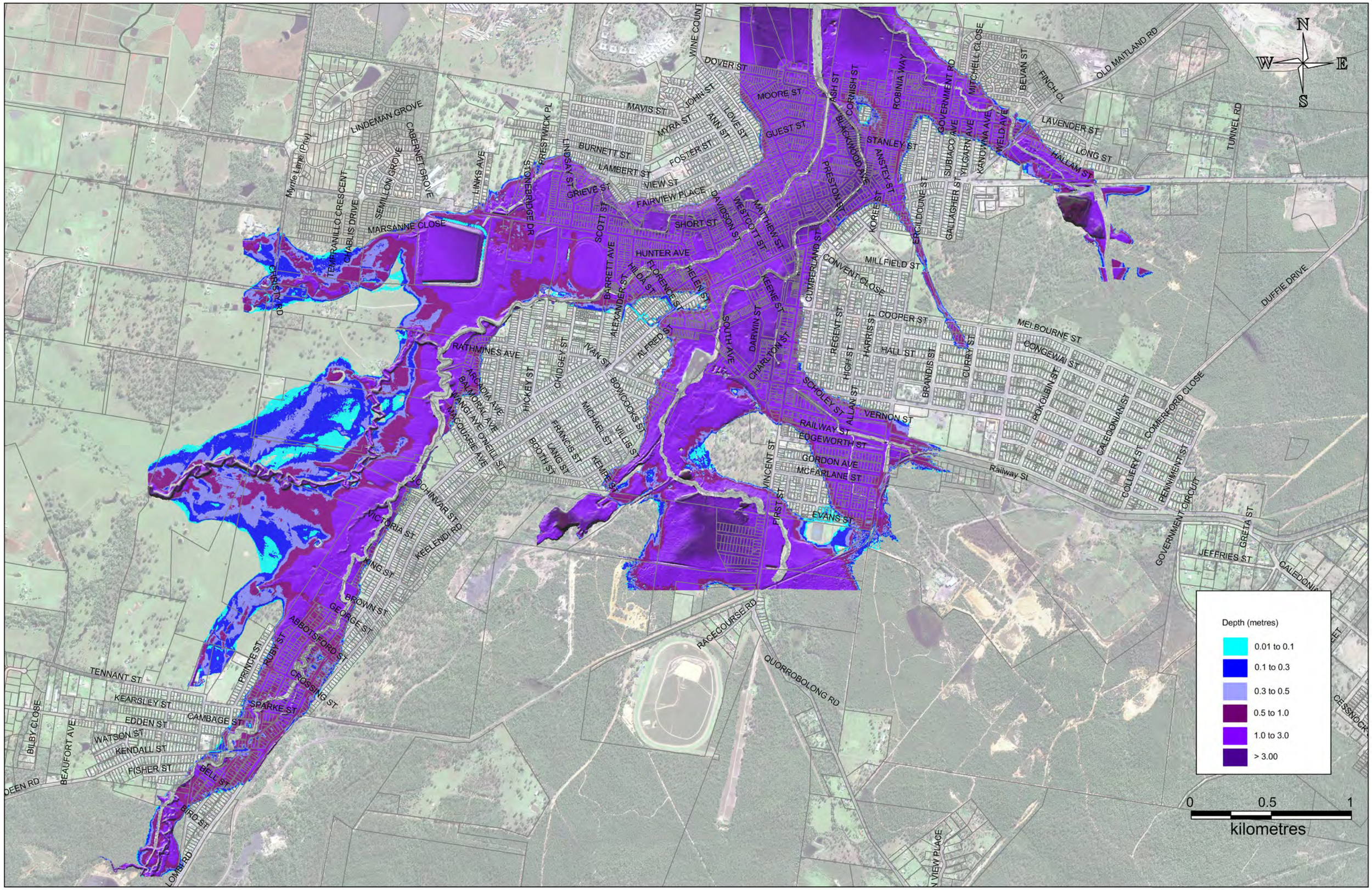

FIGURE 6-21: PMF FLOOD DEPTHS

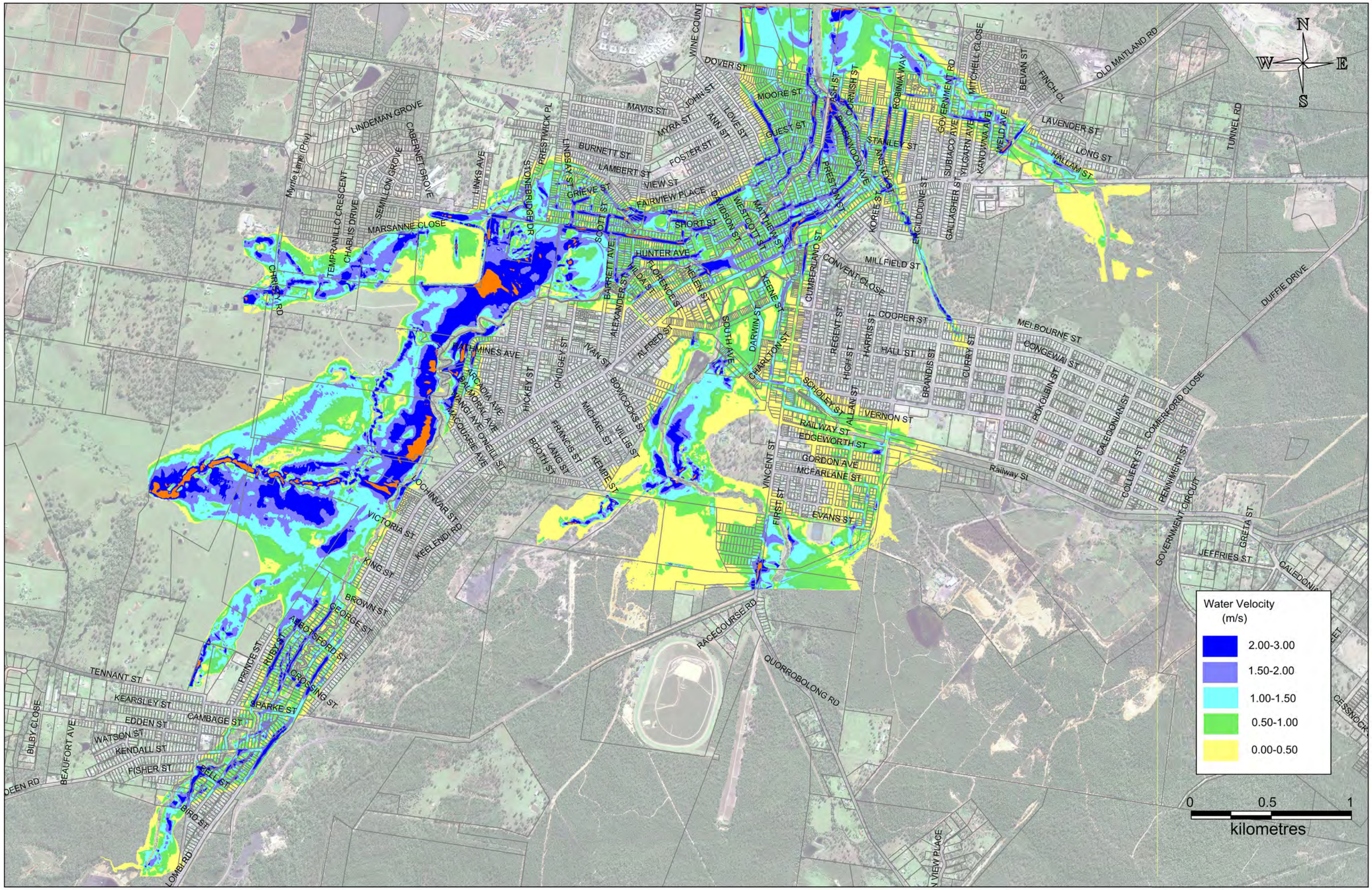

FIGURE 6-22: PMF FLOOD VELOCITIES

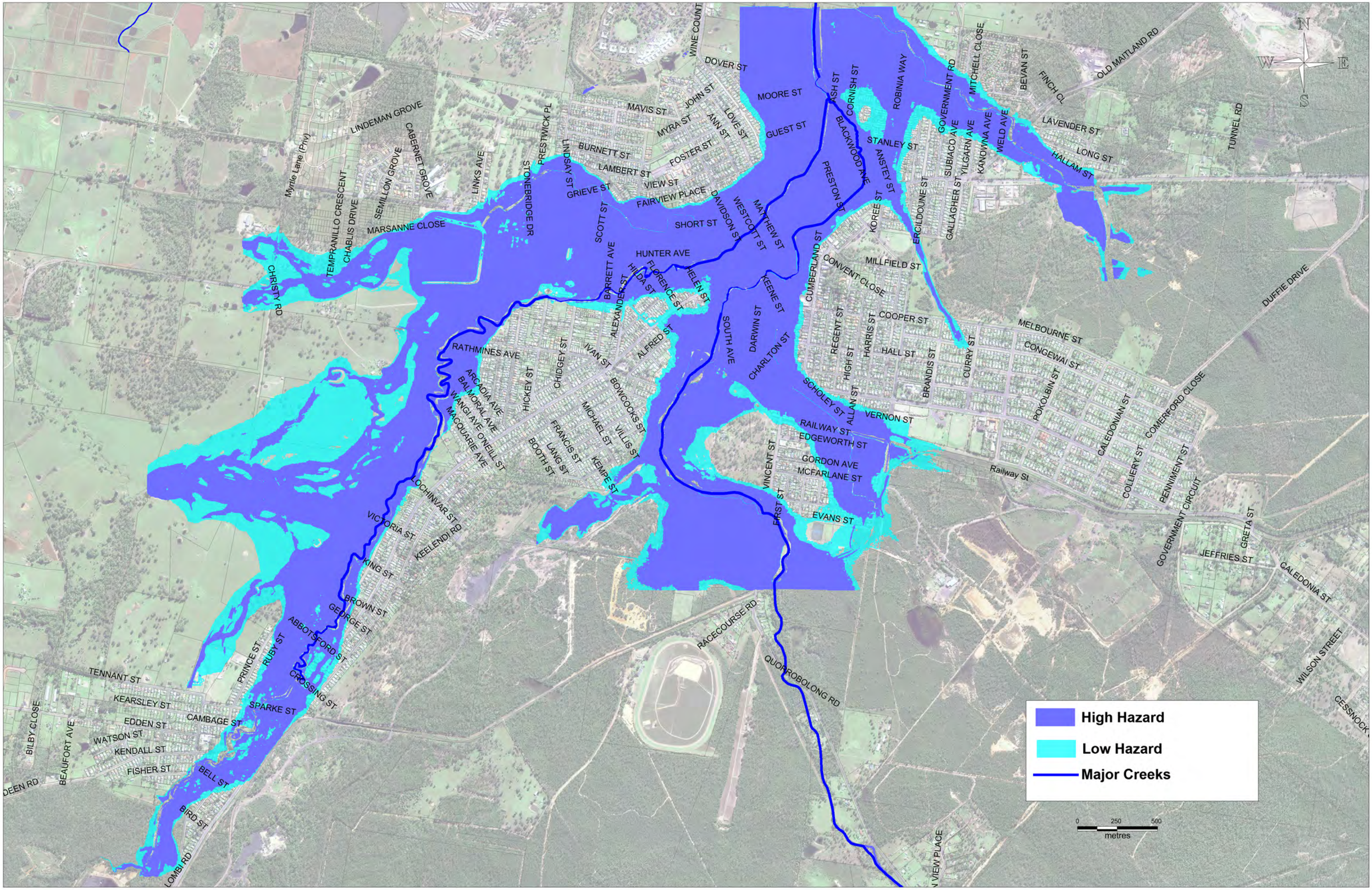

FIGURE 6-23 : PMF PROVISIONAL HAZARD

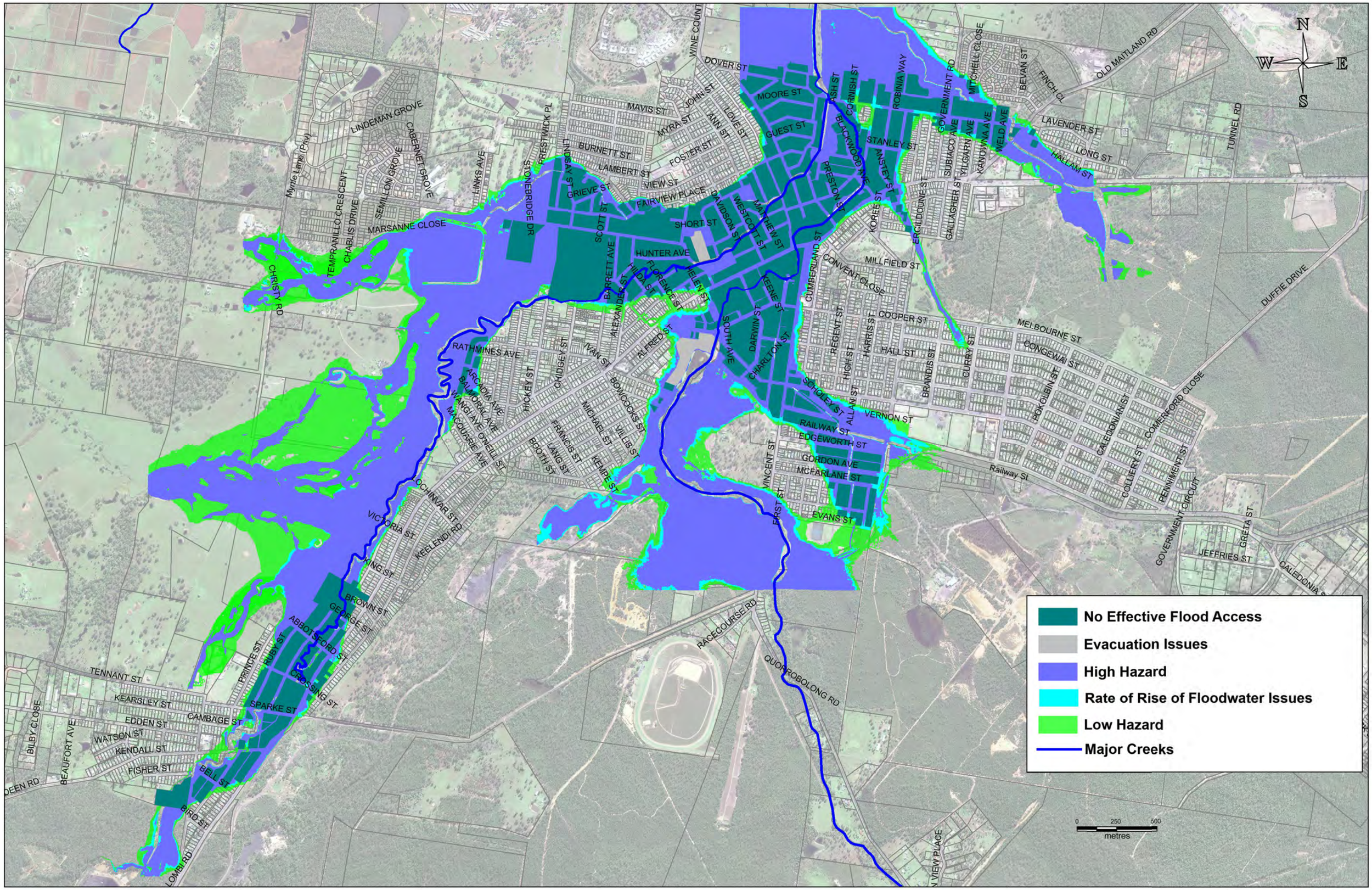

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FIGURE 6-24 : TRUE HAZARD PMF EVENT

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

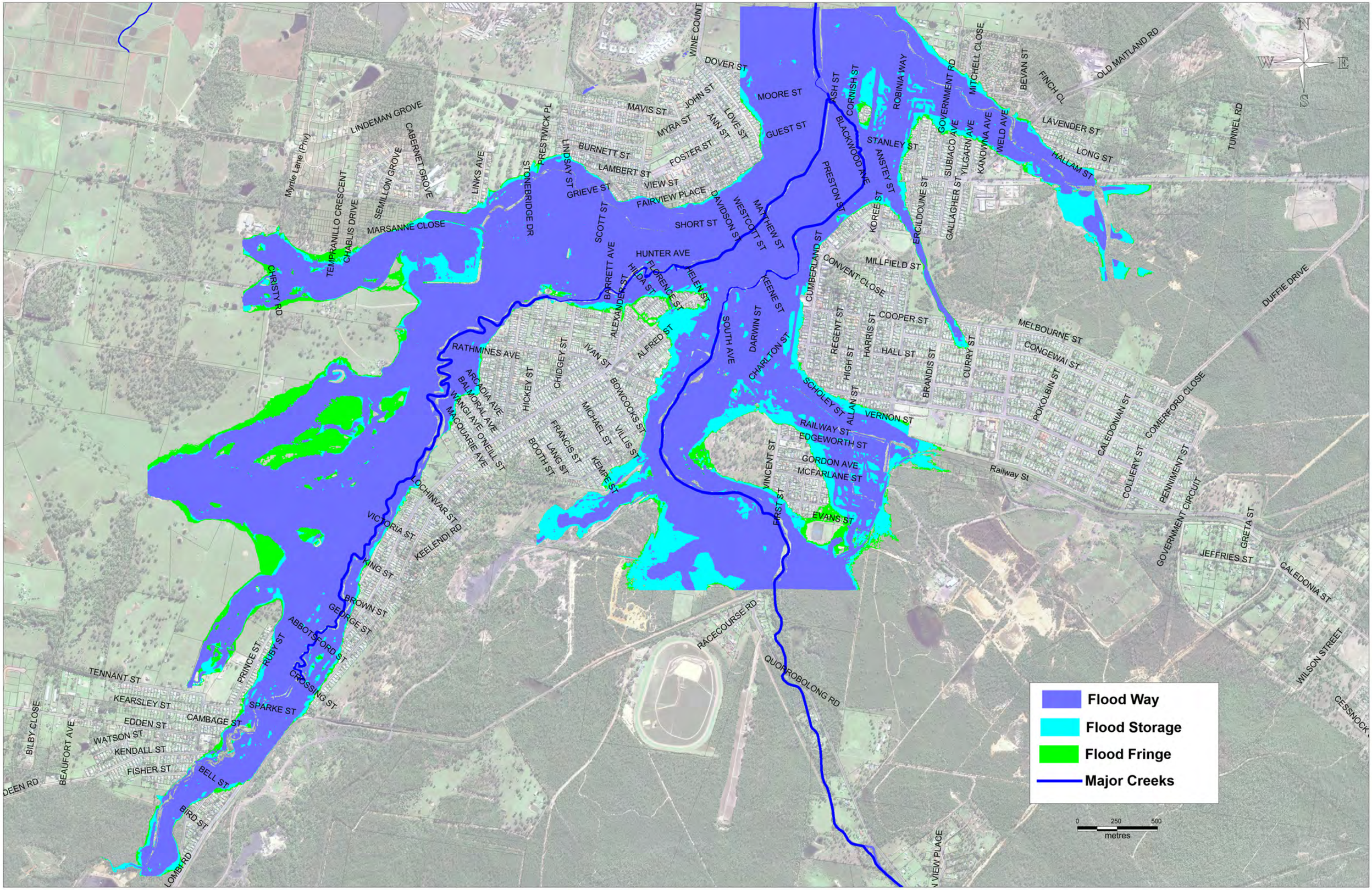

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FIGURE 6-25 : HYDRAULIC CATEGORIES PMF EVENT

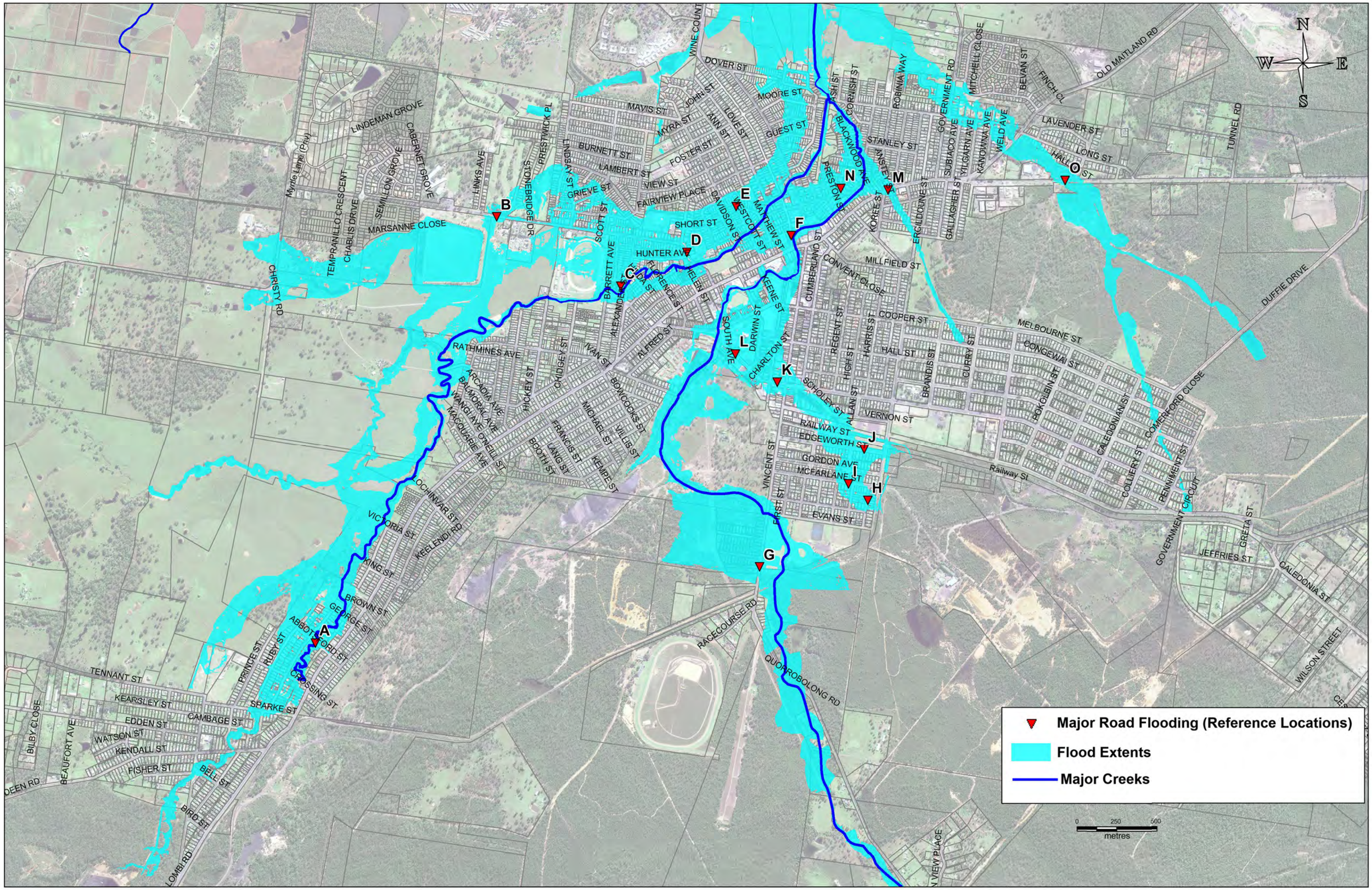

FIGURE 6-26 :MAJOR ACCESS ROAD FLOODING PEAK DEPTHS/WATER LEVELS - REFERENCE LOCATIONS

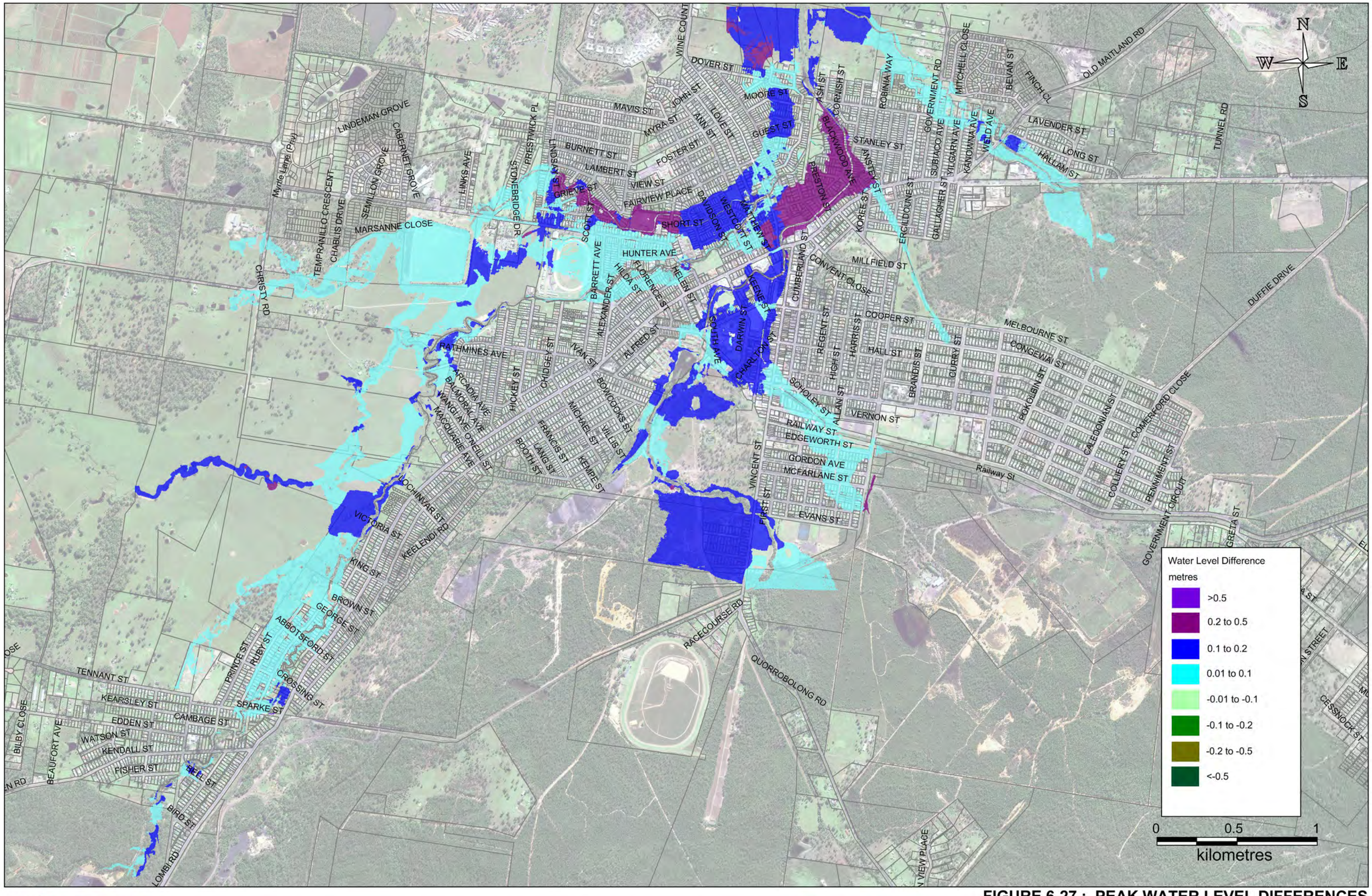

FIGURE 6-27 : PEAK WATER LEVEL DIFFERENCES
Climate Change (1% AEP +10% Rainfall) Less Existing

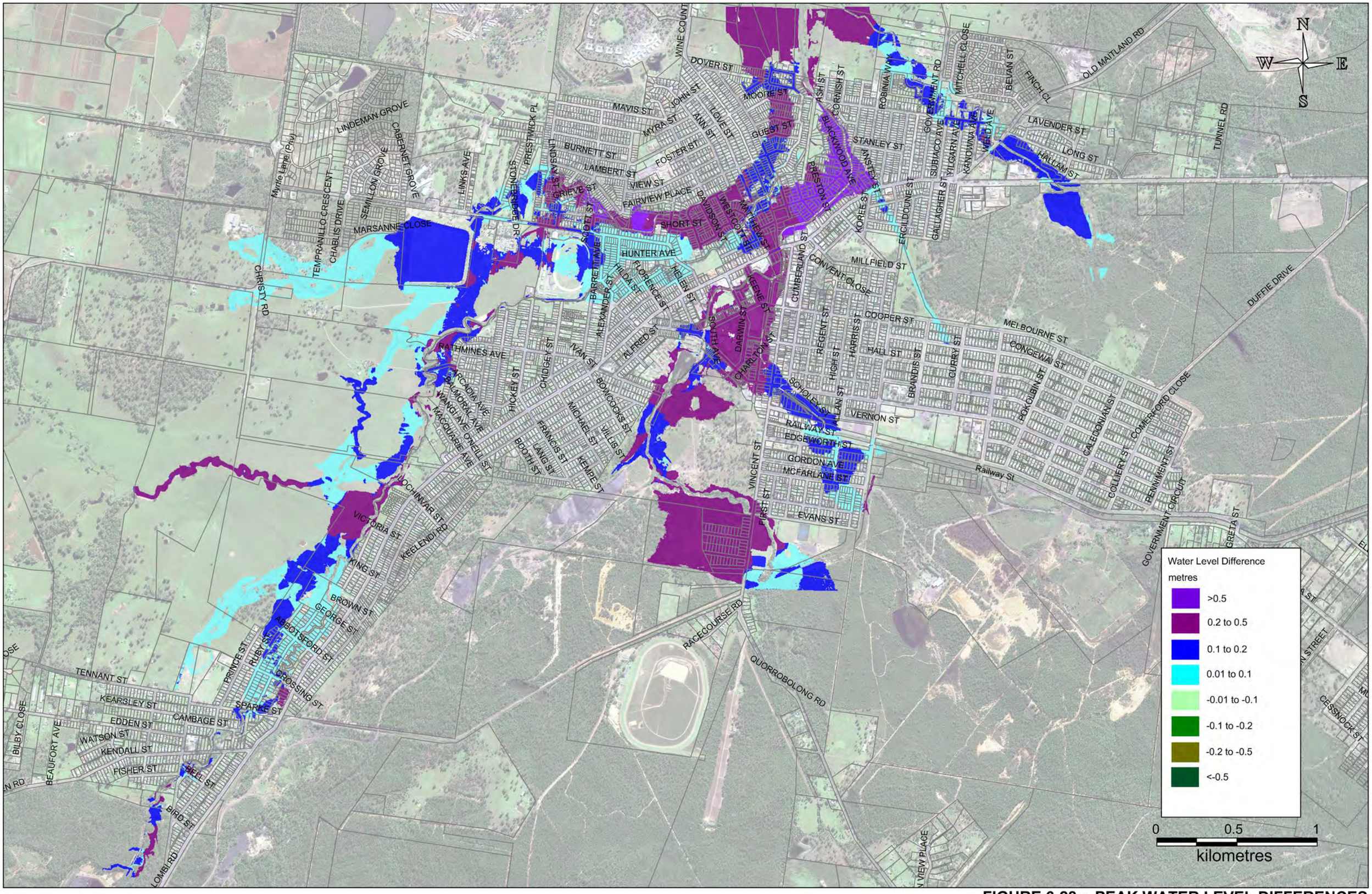

FIGURE 6-28 : PEAK WATER LEVEL DIFFERENCES
Climate Change (1% AEP +20% Rainfall) Less Existing

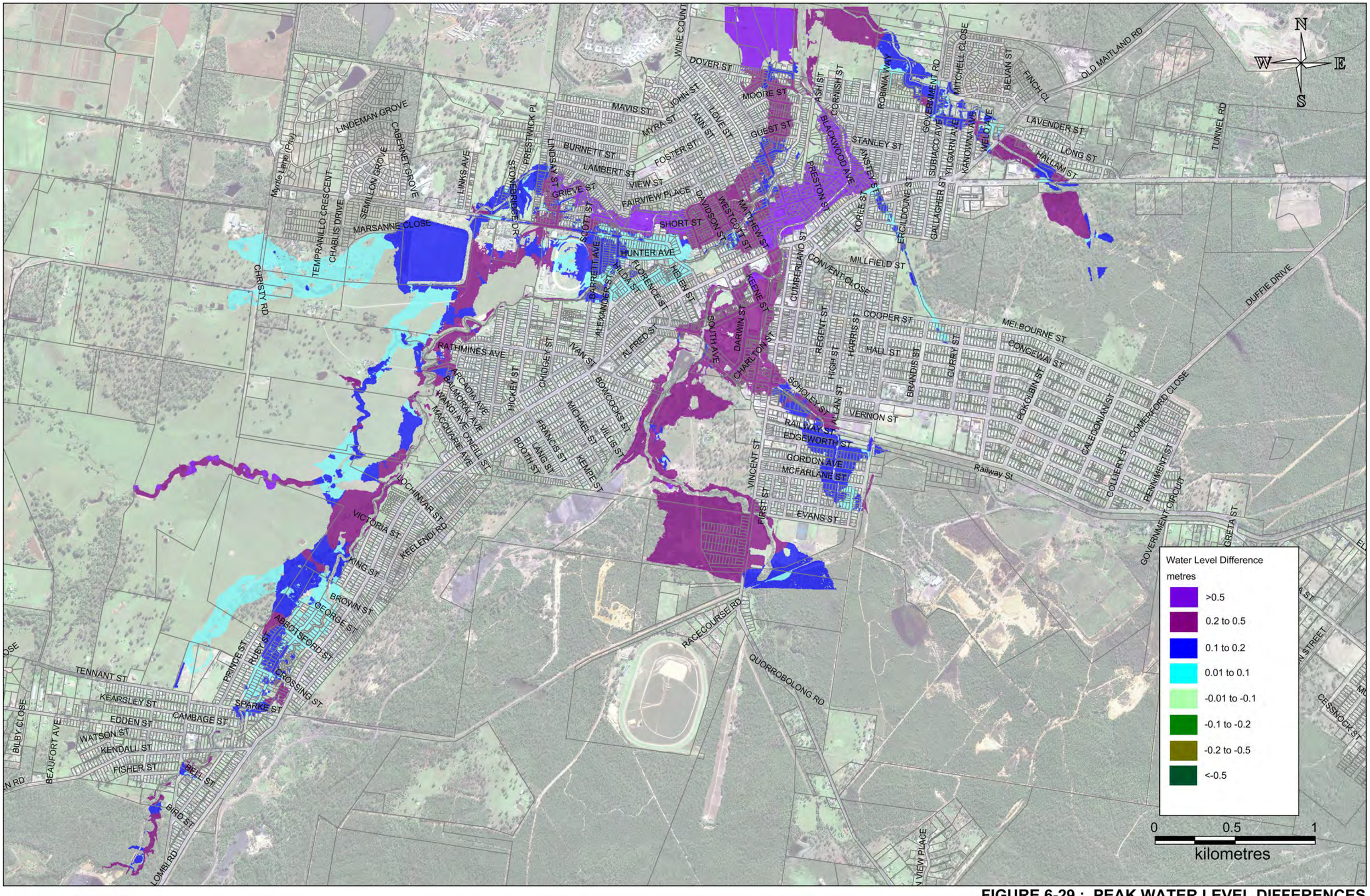

FIGURE 6-29 : PEAK WATER LEVEL DIFFERENCES
Climate Change (1% AEP +30% Rainfall) Less Existing

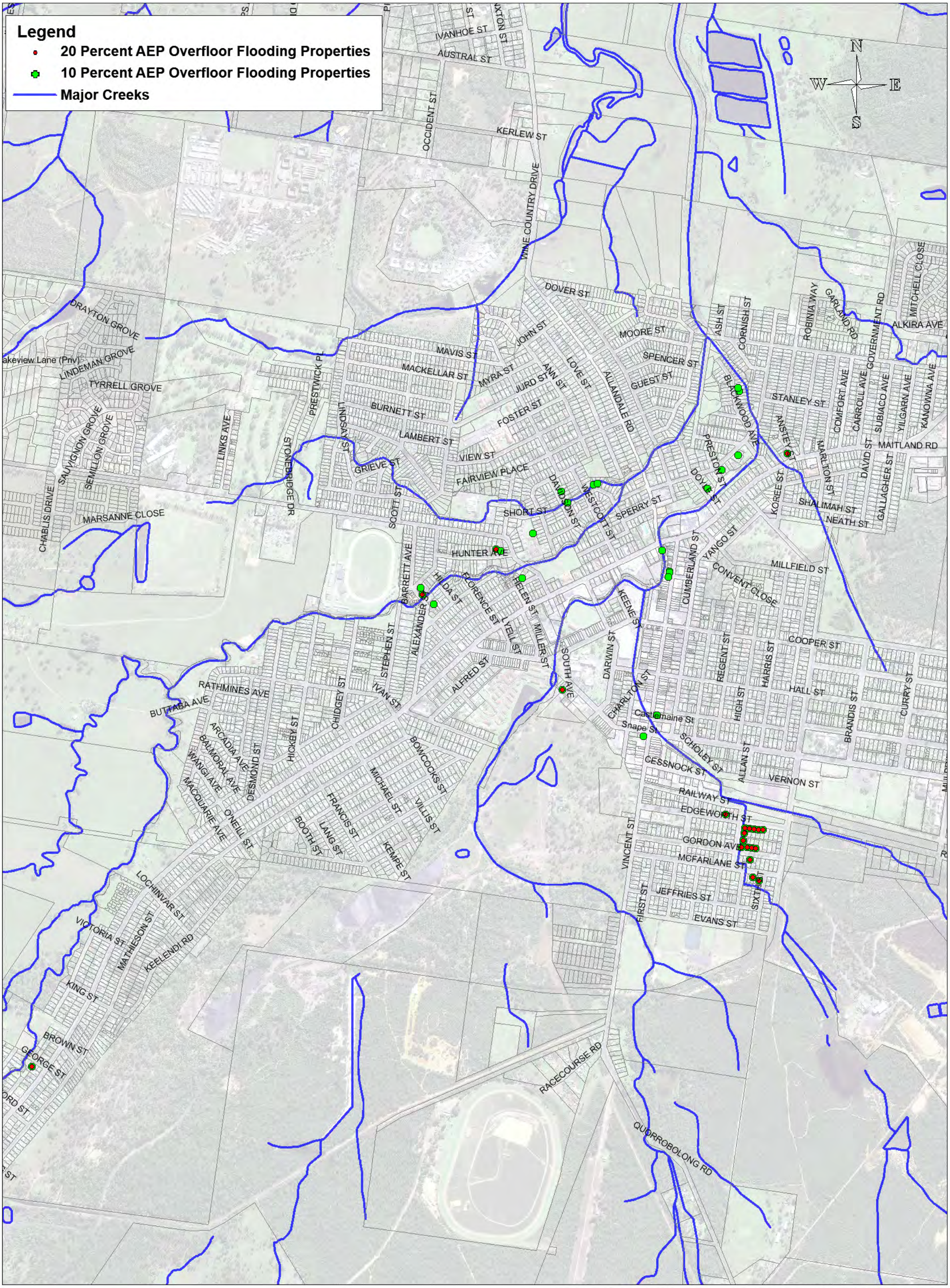

FIGURE 7-2 :OVERFLOOR FLOODING PROPERTIES 20% & 10% AEP FLOOD EVENTS

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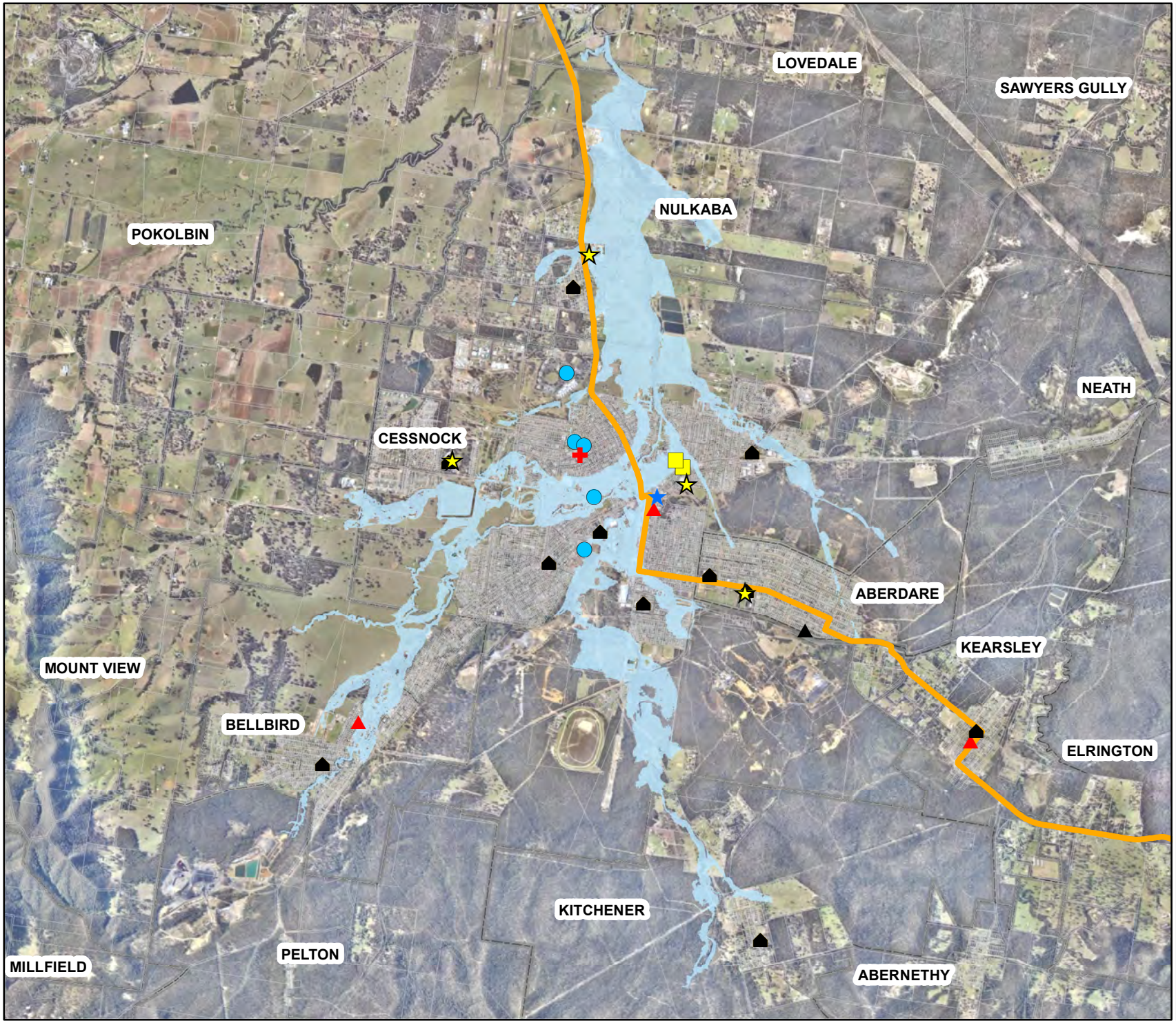

Critical Infrastructure

BLACK CREEK FLOODPLAIN RISK MANAGEMENT STUDY

Legend

- Evacuation Centres (CCC & SES 2009)
- School
- Preschool
- Guide and Scout Halls
- Nursing Home, Community Home, Retirement Village
- Hospital
- Police Station
- Fire Station
- Key Evacuation Route (CCC & SES 2009)
- D09_100Y_1D2Dcombined_Extent_MAY...
- Cadastre
- Suburb Boundaries

N
W E
S

FIGURE 8-1

1:60,000 Scale at A4

Kilometres

0 0.5 1 2 3

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Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2016-05-13
Coordinate System: GDA 1994 MGA Zone 56
Project: W4951
Map: G1002_CriticalInfrastructure.mxd 02

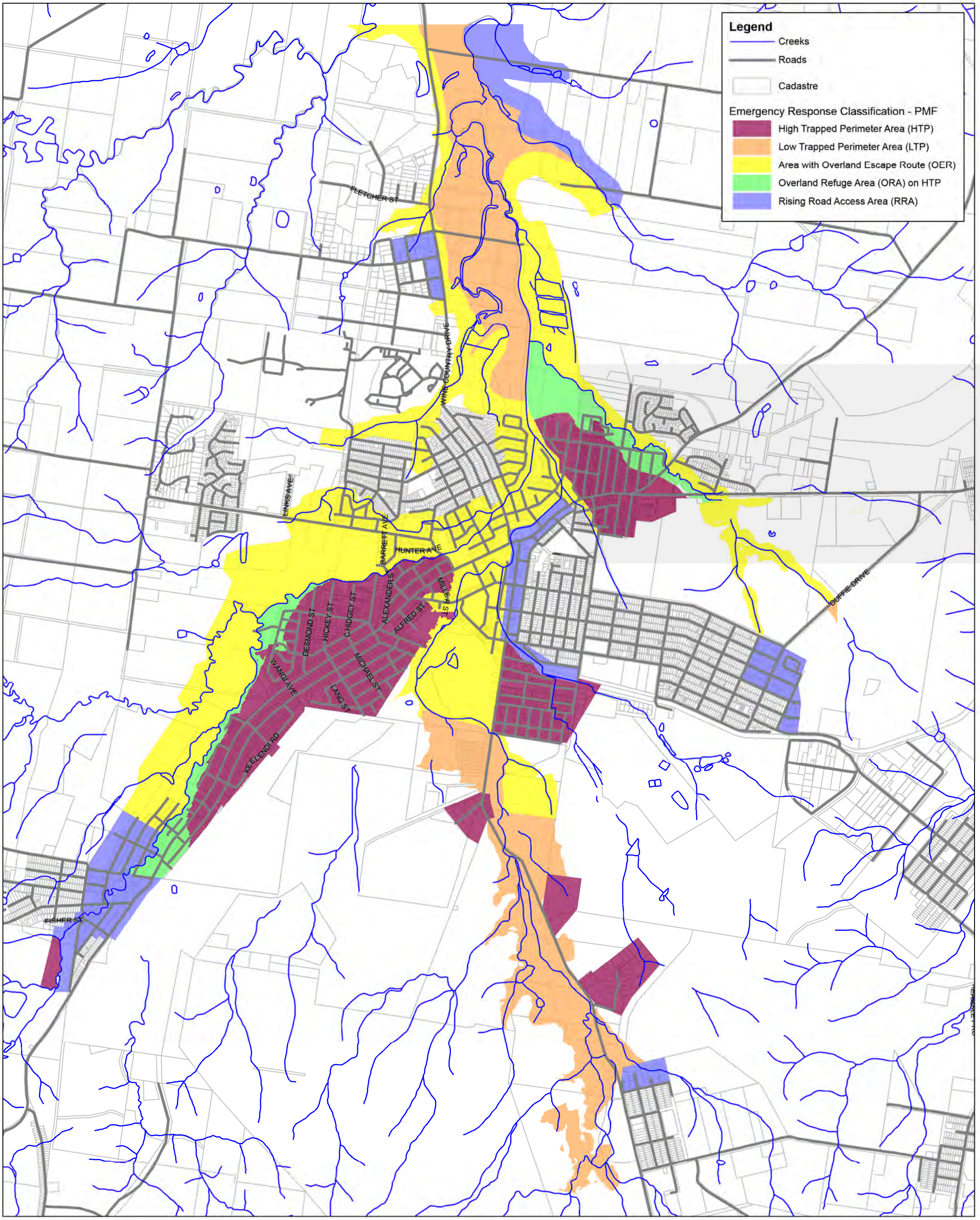
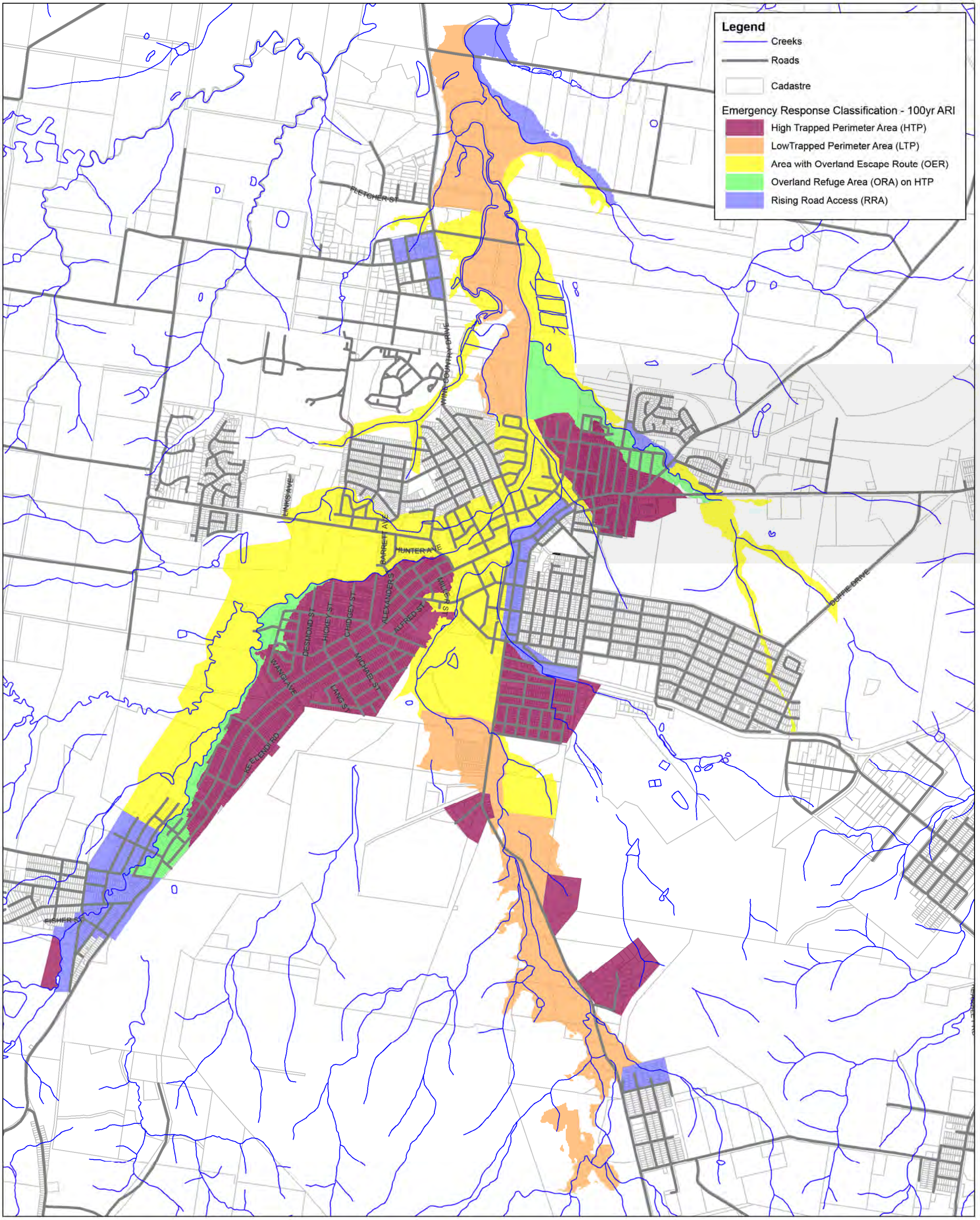


FIGURE 8-2: EMERGENCY RESPONSE CLASSIFICATION - PMF



Emergency Response Classification - 100 Year ARI

BLACK CREEK FLOODPLAIN RISK MANAGEMENT STUDY

Scale 1:30,000 Scale at A3

Kilometres

0 0.5 1

N W E S

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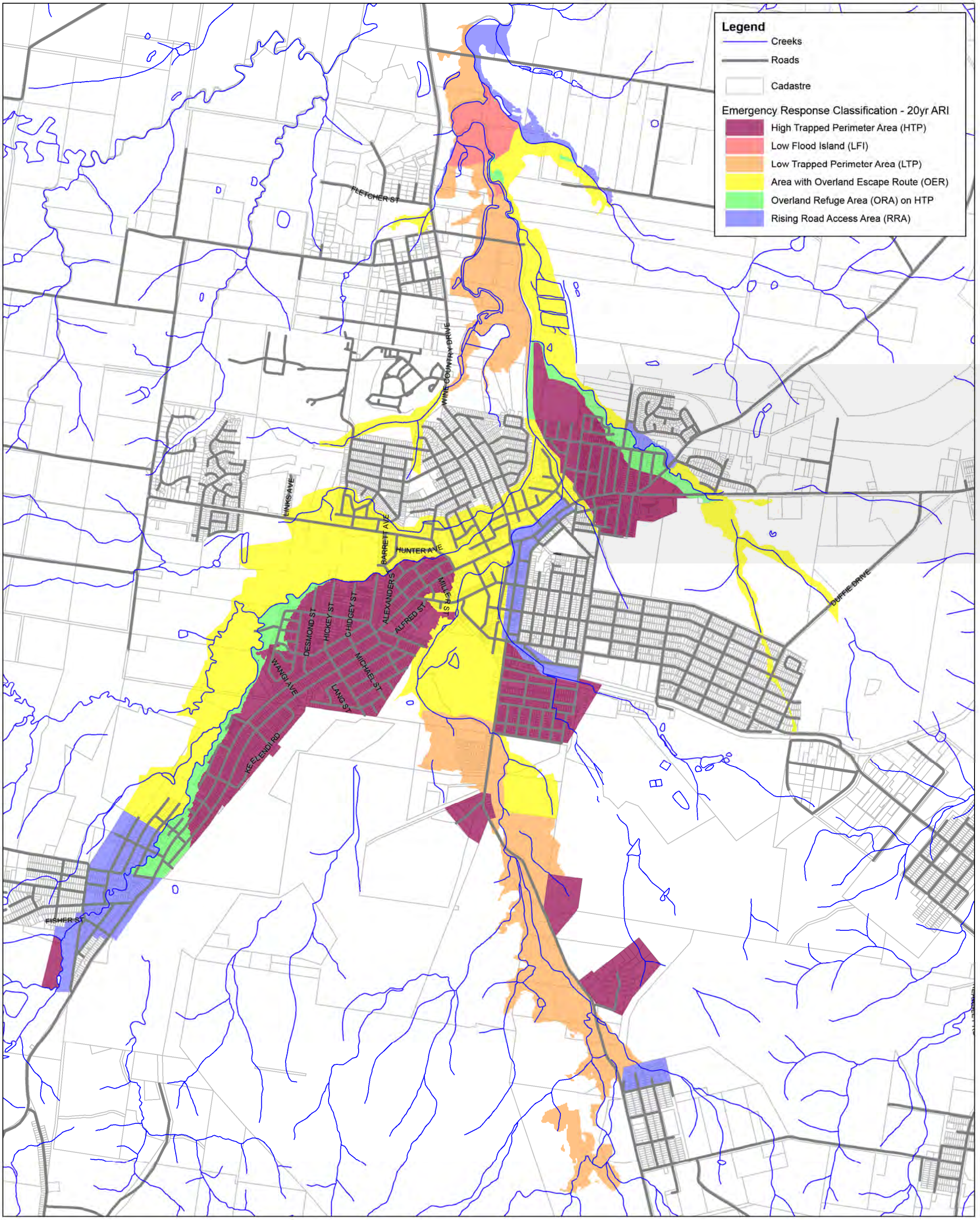
Map Produced by Cardno NSW/ACT Pty Ltd
Date: 5 December 2012
Coordinate System: Zone 56 MGA/GDA 94
GIS MAP REF:
W4951_G1001_ERClass_PMF.wor 02

FIGURE 8-3: EMERGENCY RESPONSE CLASSIFICATION - 1% AEP



Emergency Response Classification - 20 Year ARI

Scale 1:30,000 Scale at A3

Kilometres

0 0.5 1

BLACK CREEK FLOODPLAIN RISK MANAGEMENT STUDY

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Map Produced by Cardno NSW/ACT Pty Ltd
Date: 5 December 2012
Coordinate System: Zone 56 MGA/GDA 94
GIS MAP REF:
W4951_G1003_ERClass_20yr.wor 02

FIGURE 8-4: EMERGENCY RESPONSE CLASSIFICATION - 5% AEP

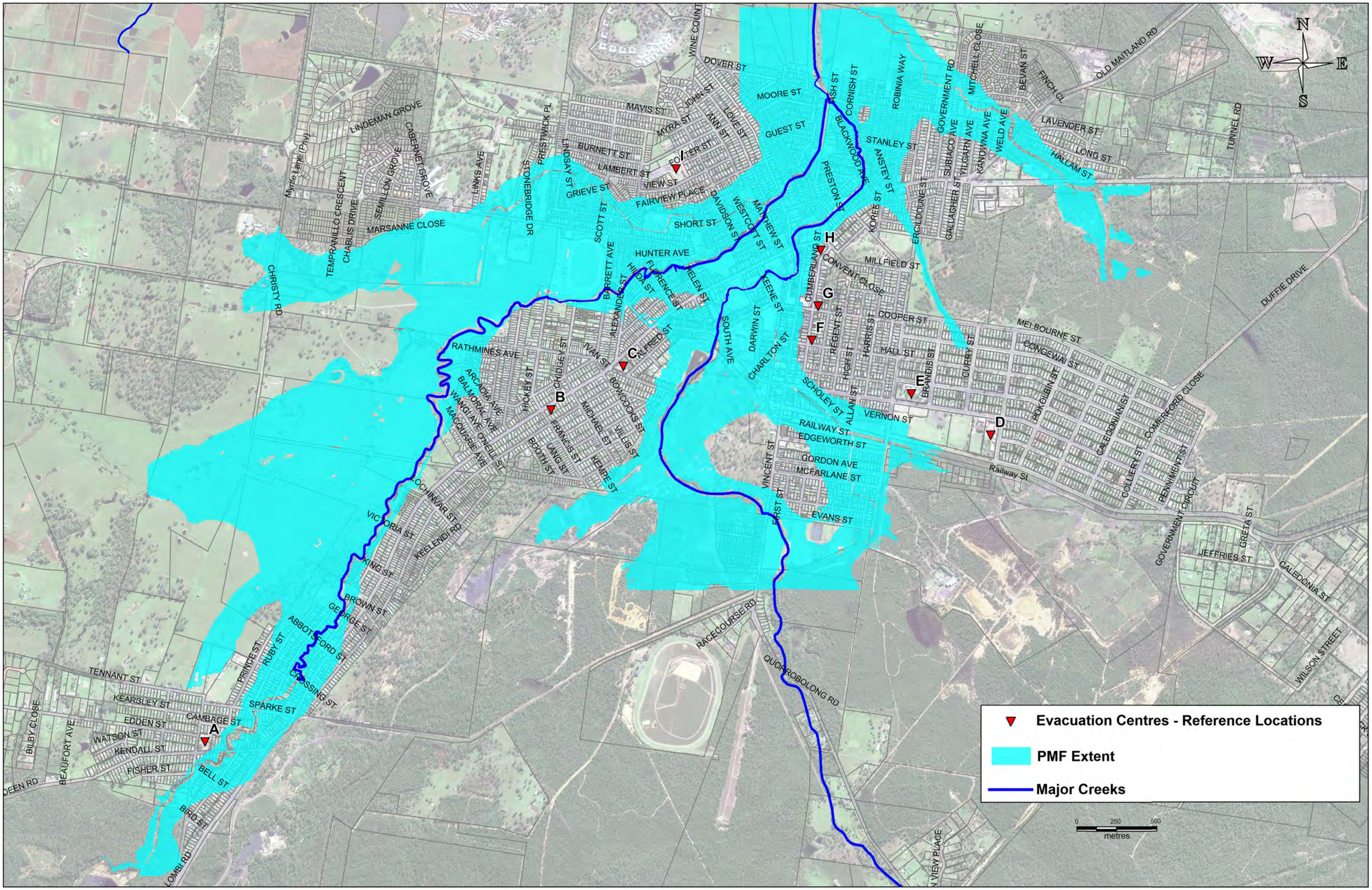

FIGURE 8-5 : LOCATION OF EVACUATION CENTRES

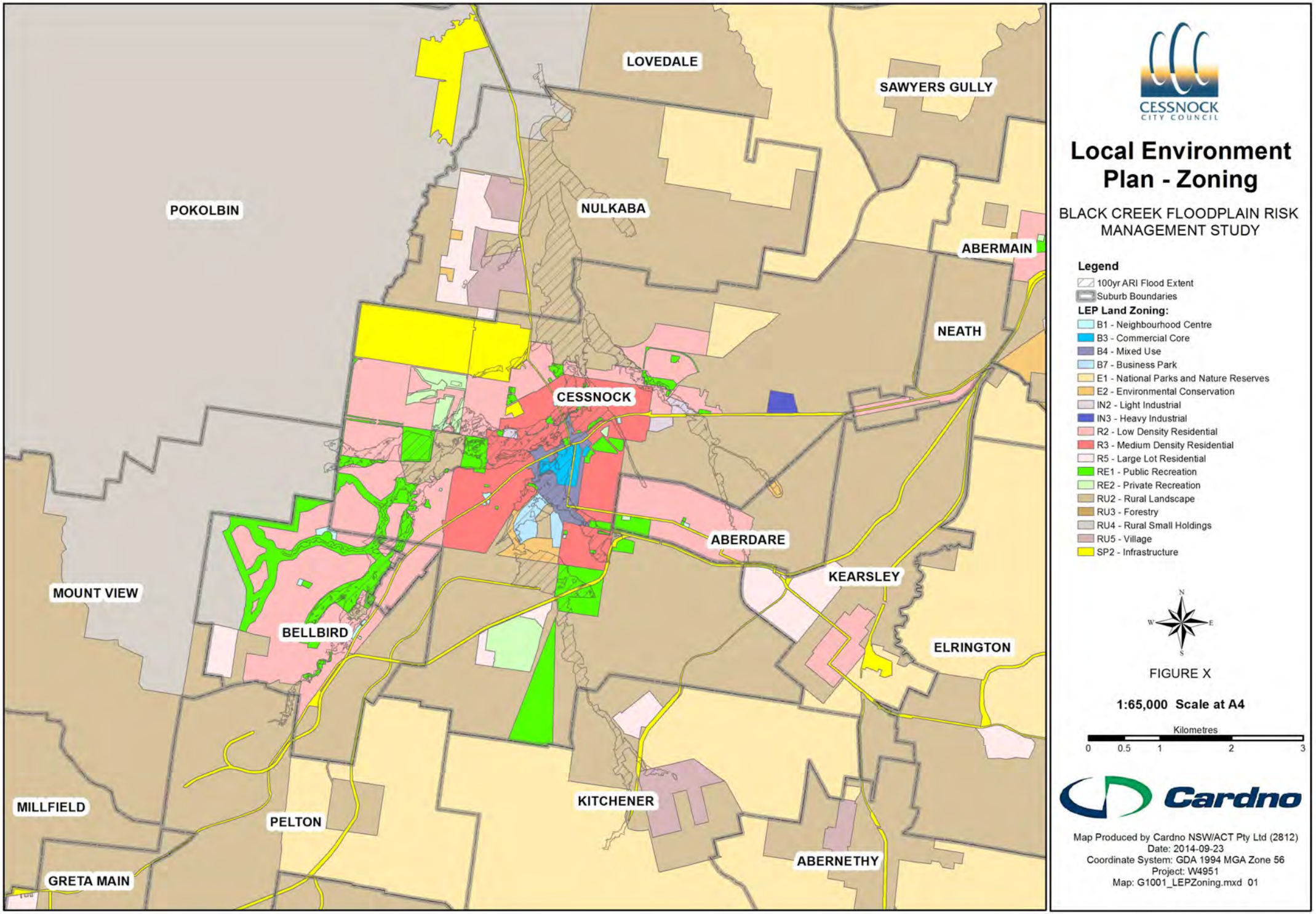

FIGURE 9-1: LEP Zoning

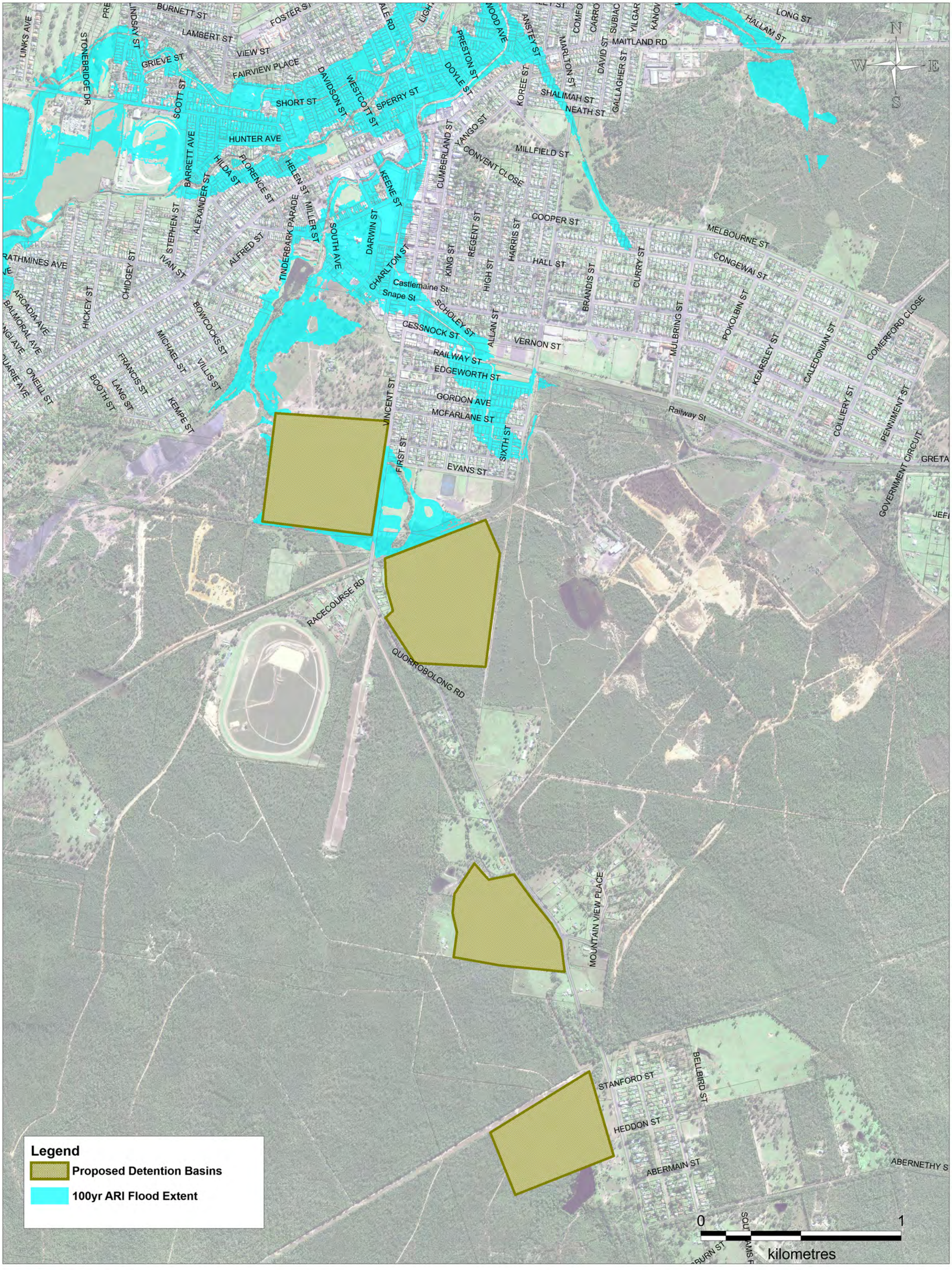

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FIGURE 11-1 : FM1 OPTION LAYOUT

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

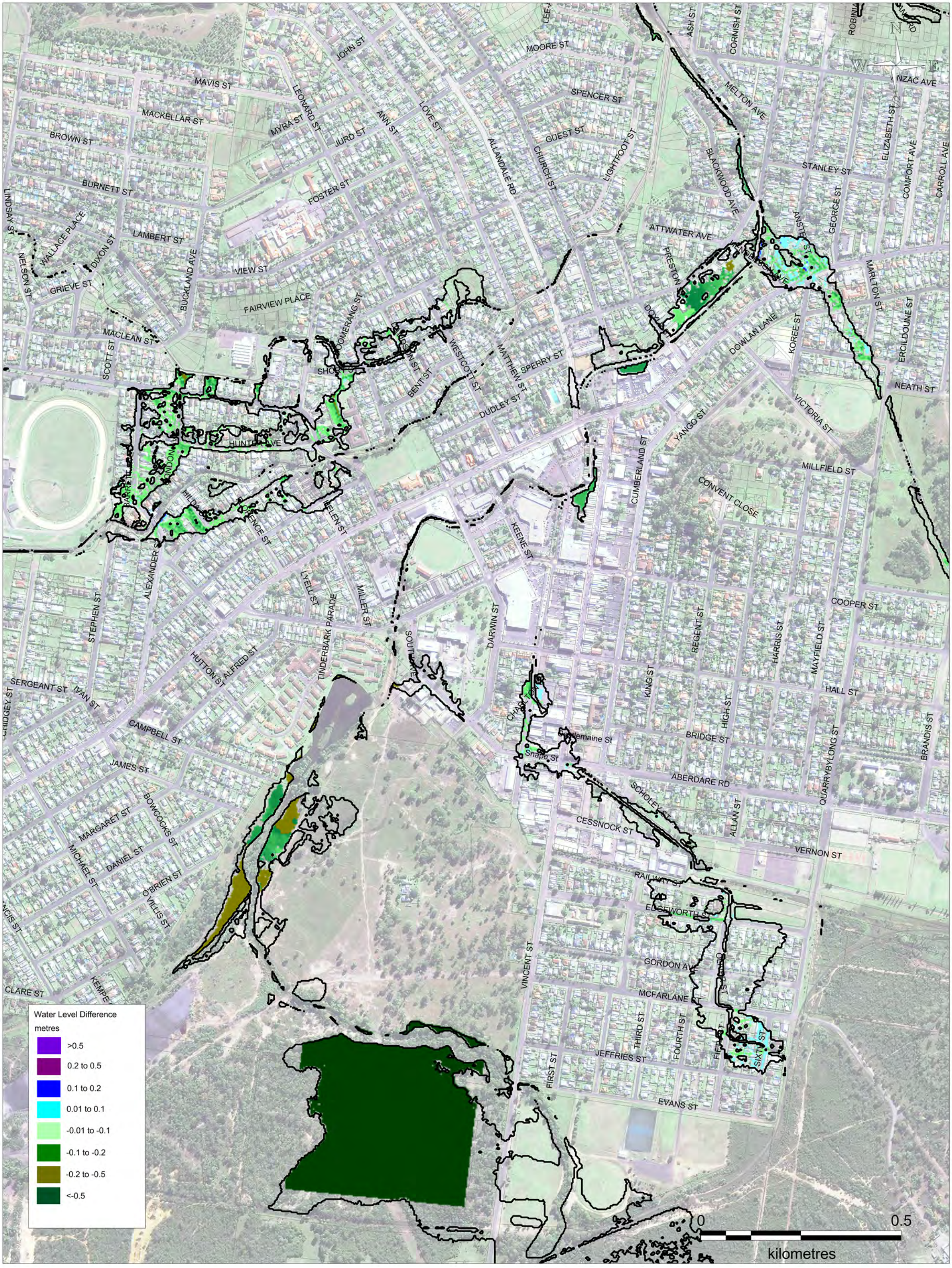

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FIGURE 11-2 : 20% AEP - PEAK WATER LEVEL DIFFERENCE
FM1 Results Less Existing Results

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

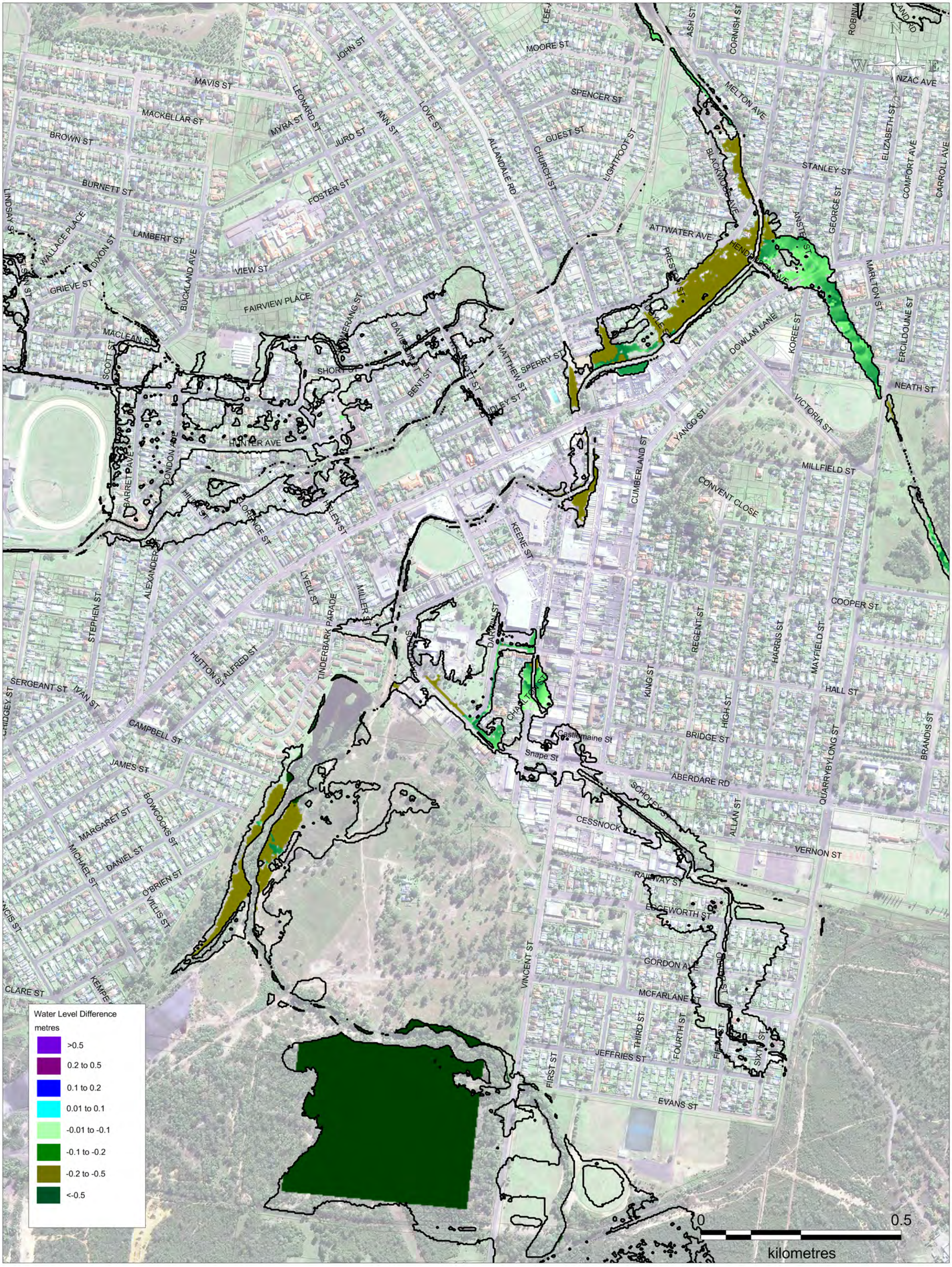

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FIGURE 11-3 : 10% AEP - PEAK WATER LEVEL DIFFERENCE
FM1 Results Less Existing Results

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

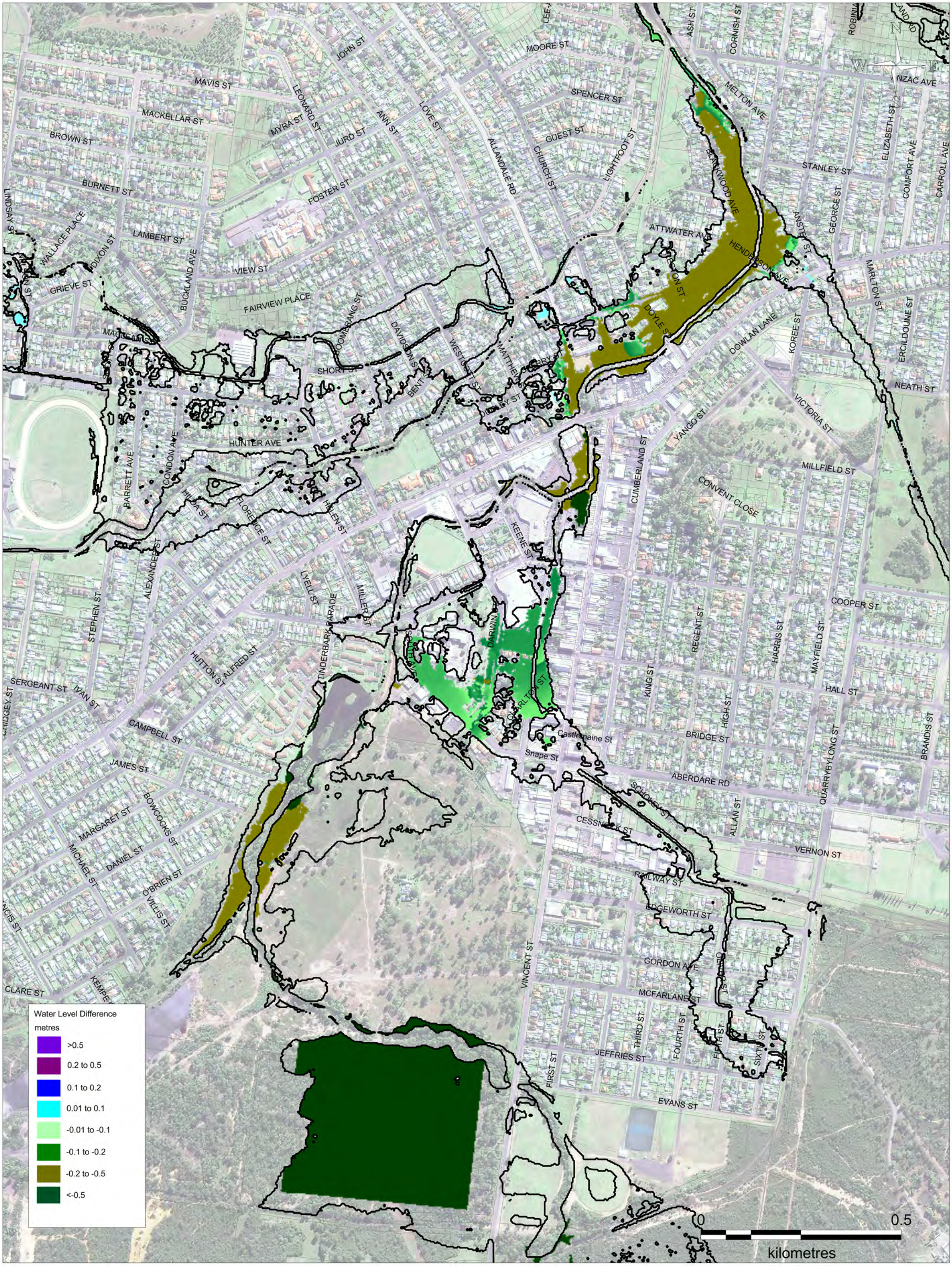

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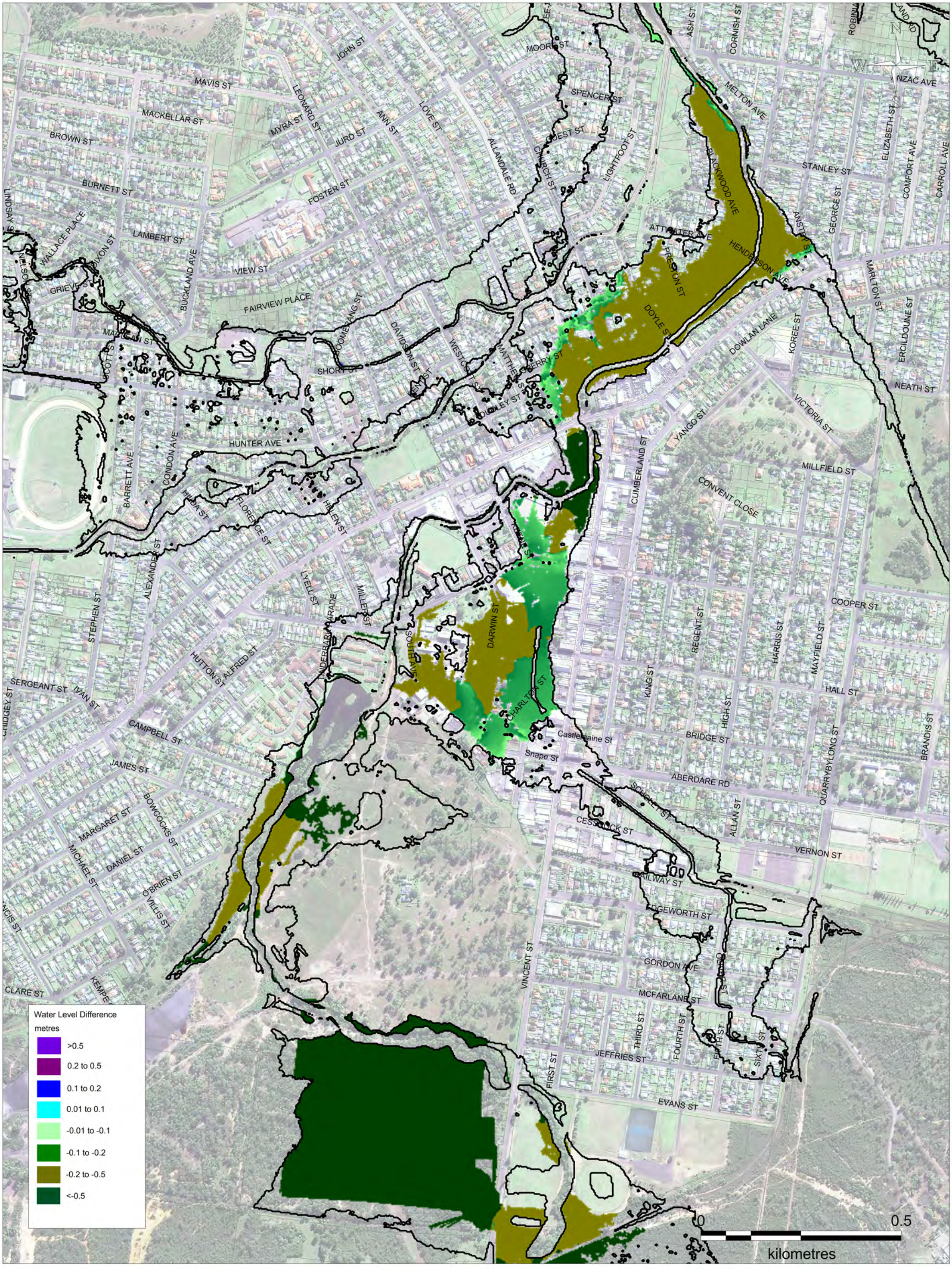
FIGURE 11-4 : 5% AEP - PEAK WATER LEVEL DIFFERENCE
FM1 Results Less Existing Results

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan



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April 2015

FIGURE 11-5 : 2% AEP - PEAK WATER LEVEL DIFFERENCE
FM1 Results Less Existing Results

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

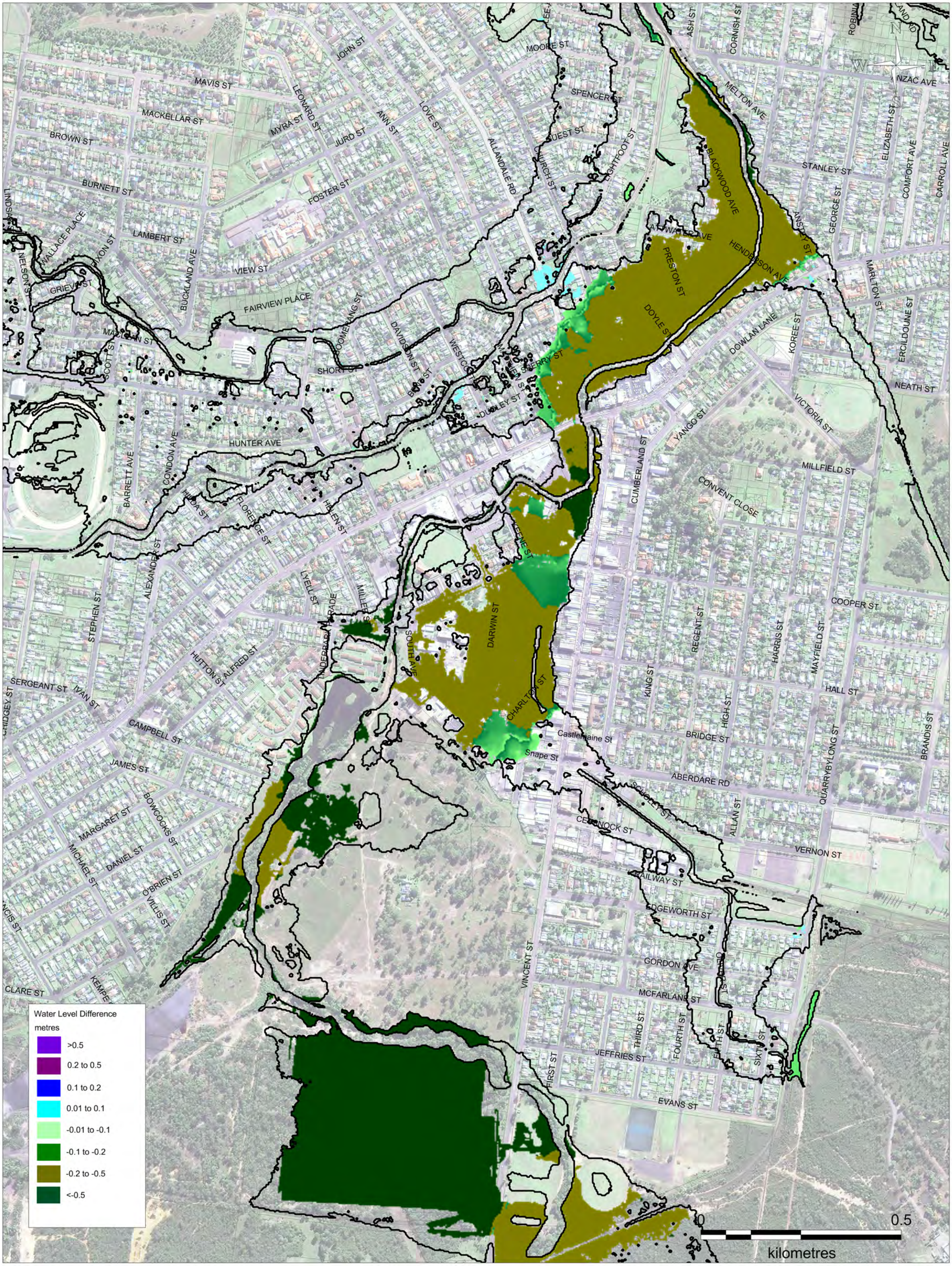

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FIGURE 11-6 : 1% AEP - PEAK WATER LEVEL DIFFERENCE
FM1 Results Less Existing Results

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

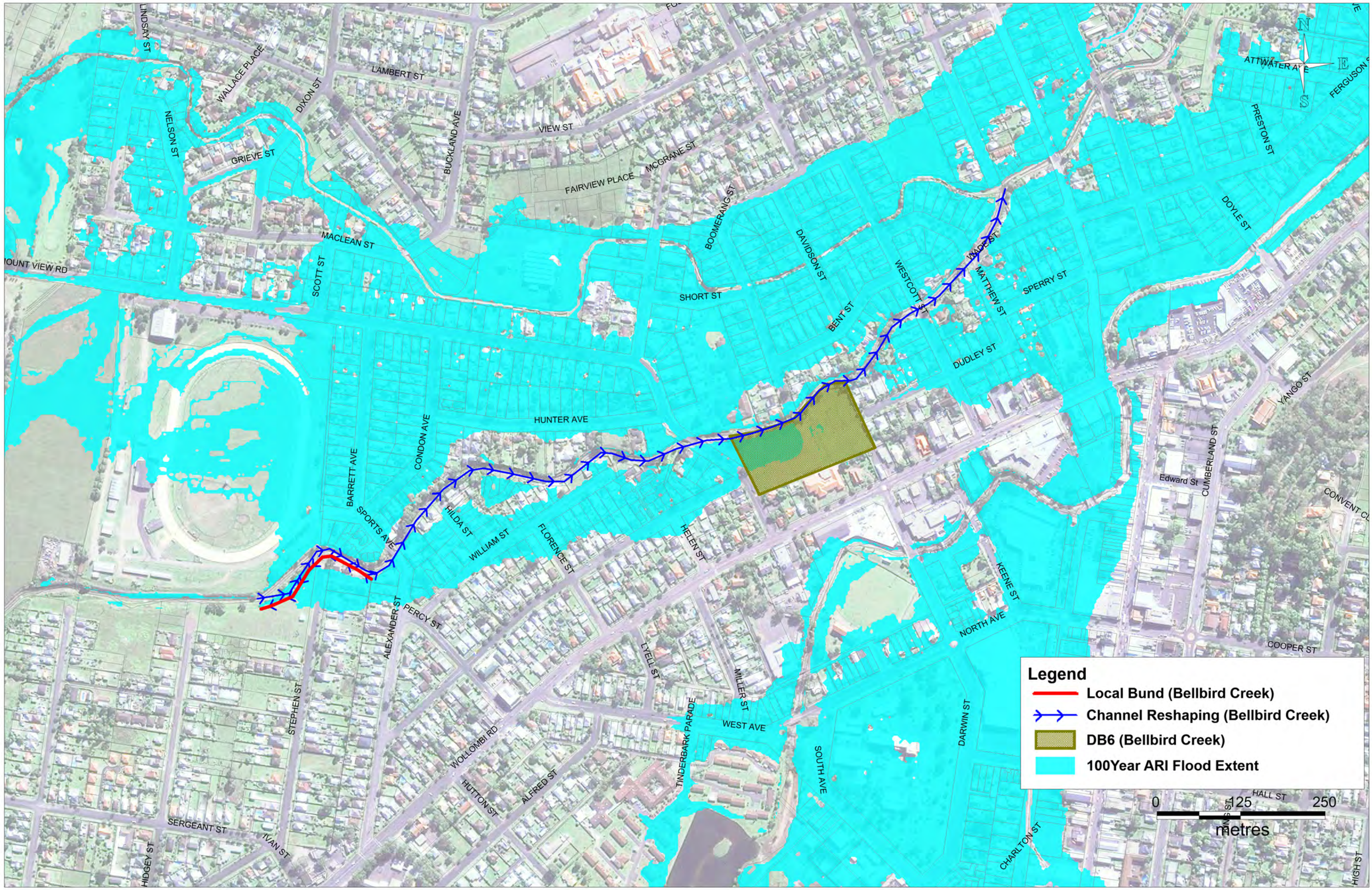

FIGURE 11-7 : FM2 OPTION LAYOUT

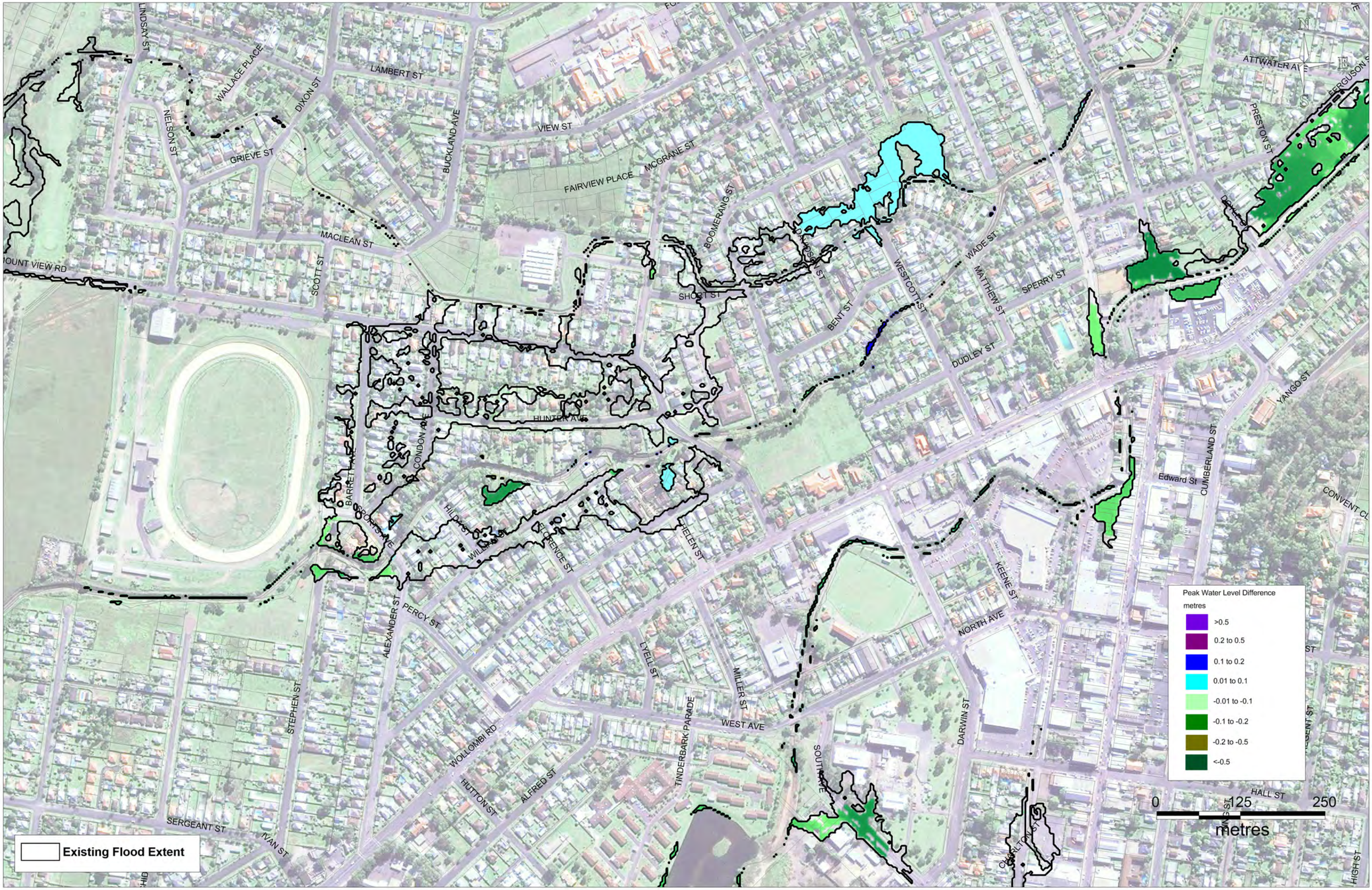

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FIGURE 11-8 : 20% AEP - PEAK WATER LEVEL DIFFERENCES
FM2 Results Less Existing Results

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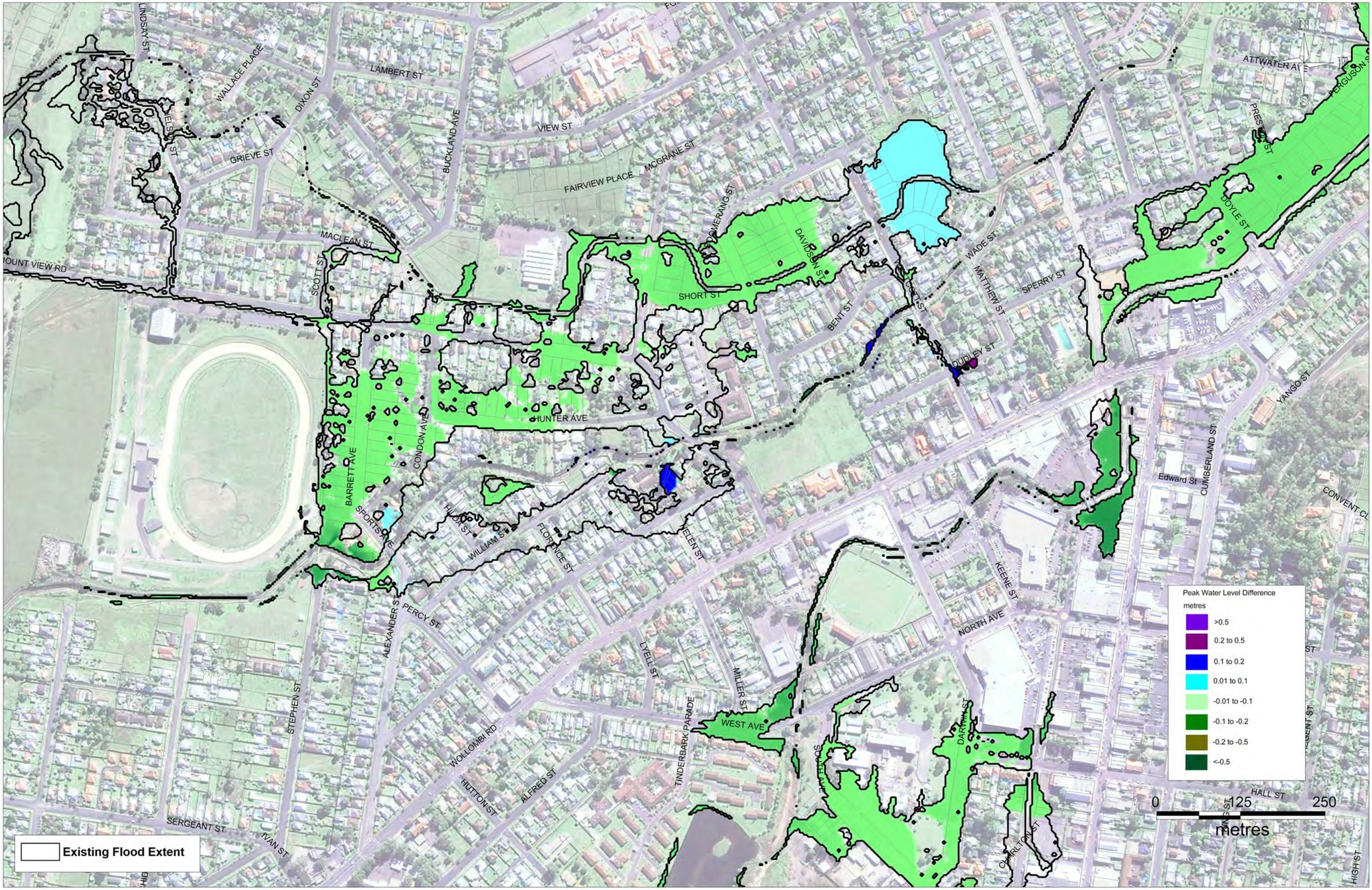
April 2015

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan



Cardno

FIGURE 11-9 : 10% AEP - PEAK WATER LEVEL DIFFERENCES
FM2 Results Less Existing Results

W4951
April 2015

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

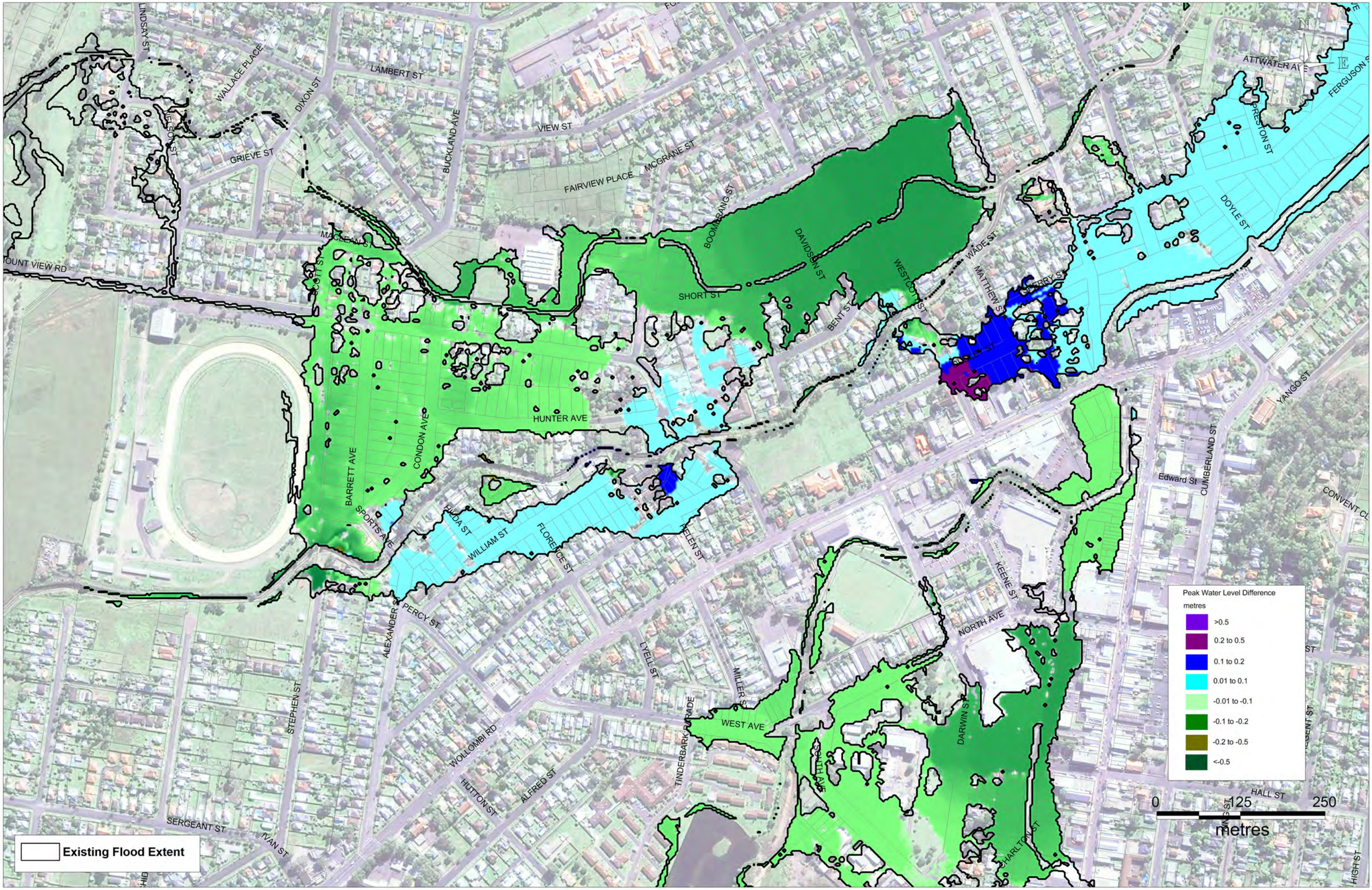
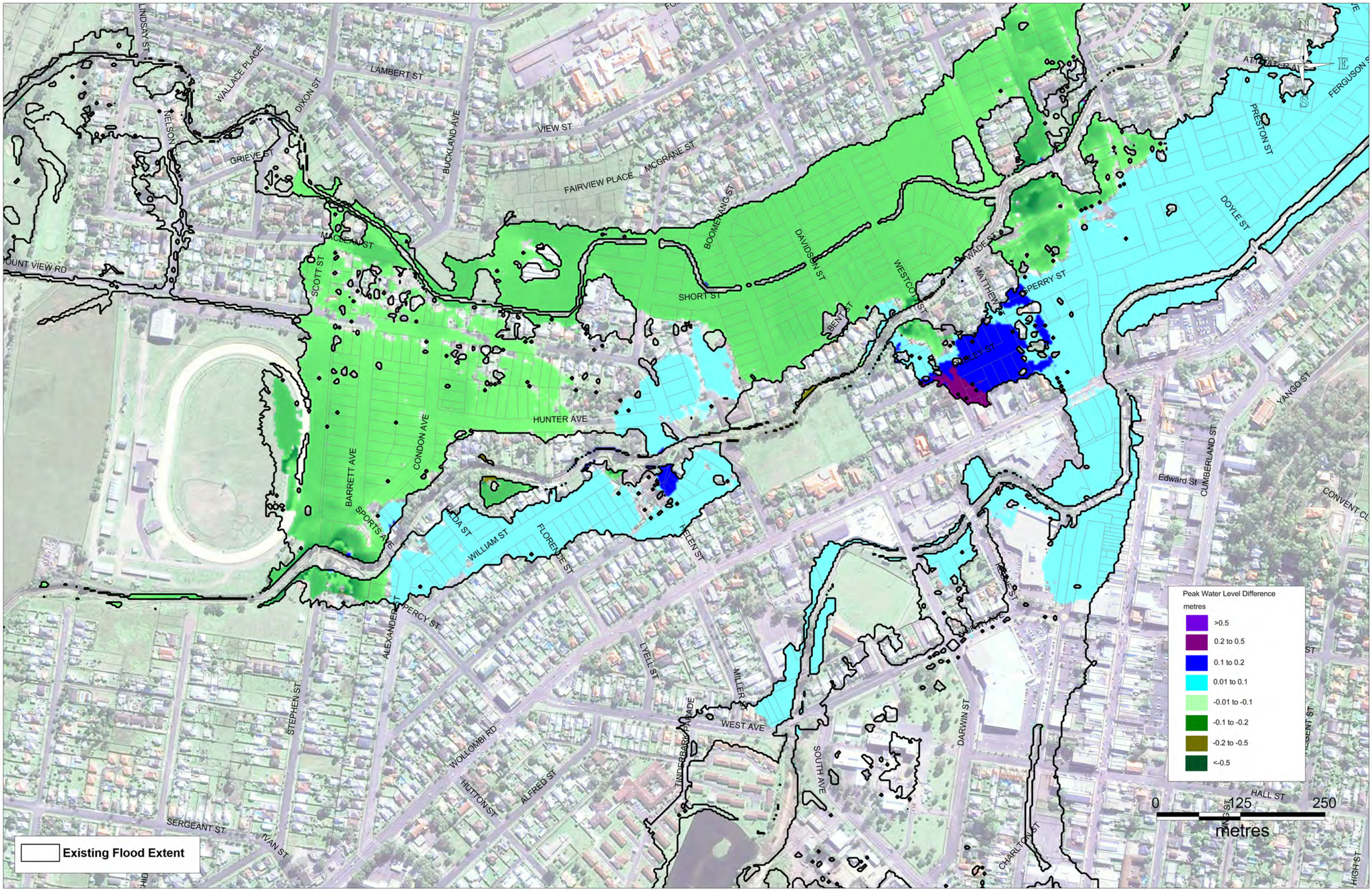


FIGURE 11-10 : 5% AEP - PEAK WATER LEVEL DIFFERENCES
FM2 Results Less Existing Results

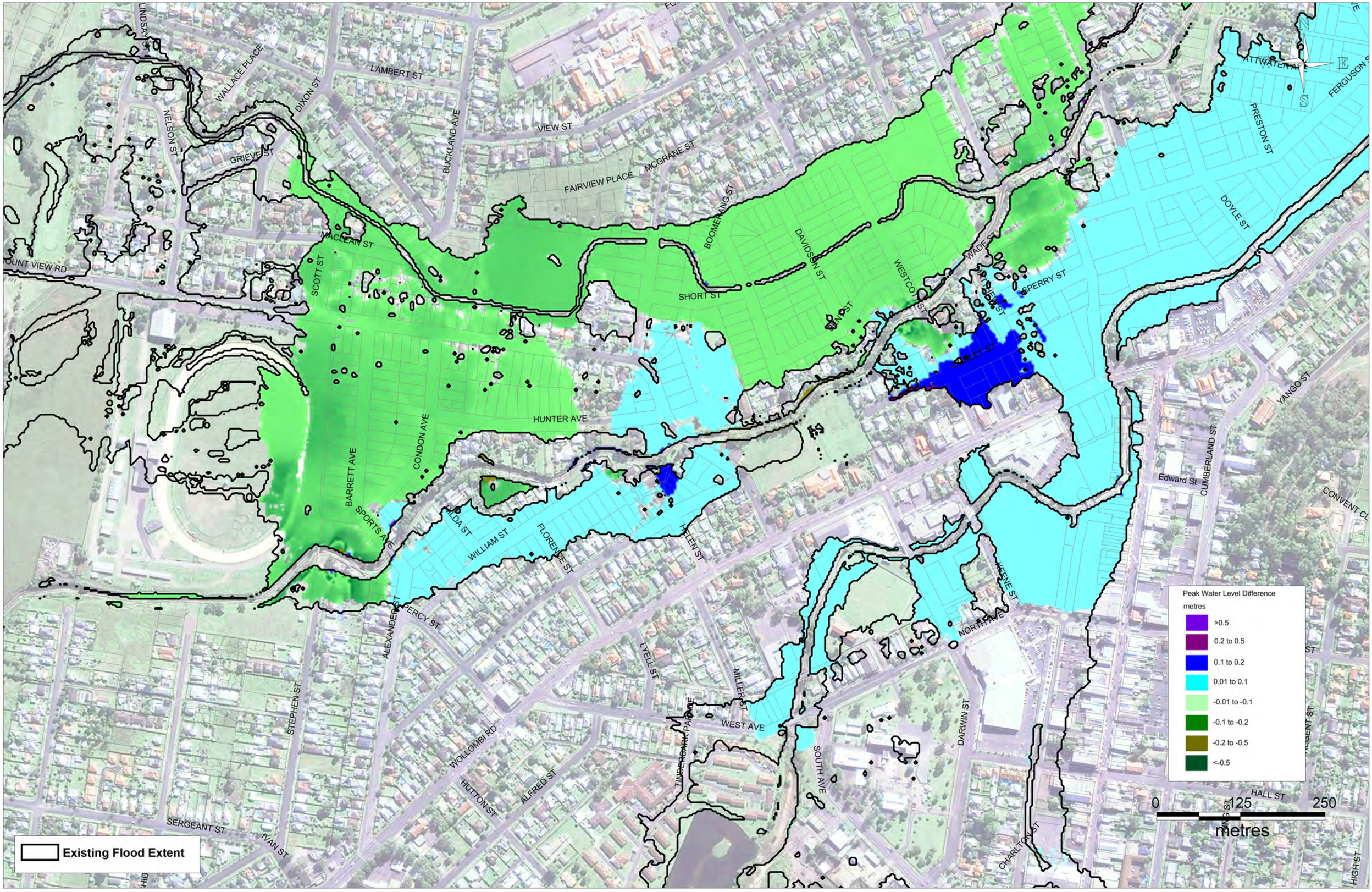


Cardno

FIGURE 11-11 : 2% AEP - PEAK WATER LEVEL DIFFERENCES
FM2 Results Less Existing Results

W4951
April 2015

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan



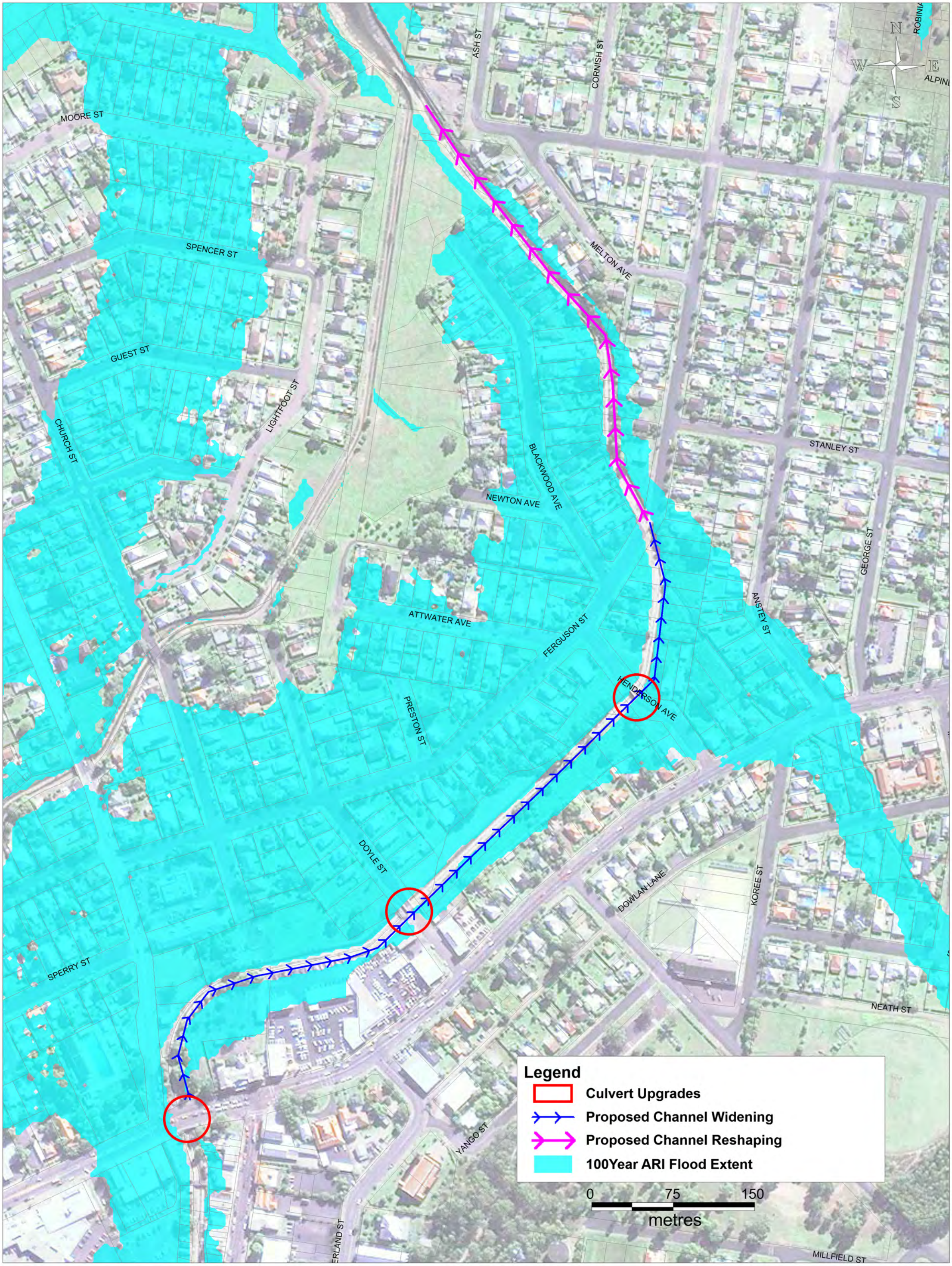
Cardno

FIGURE 11-12 : 1% AEP - PEAK WATER LEVEL DIFFERENCES
FM2 Results Less Existing Results

W4951
April 2015

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

FIGURE 11-13 : APRIL 2015 STORM - PEAK WATER LEVEL DIFFERENCES
FM2 Results Less Existing Results

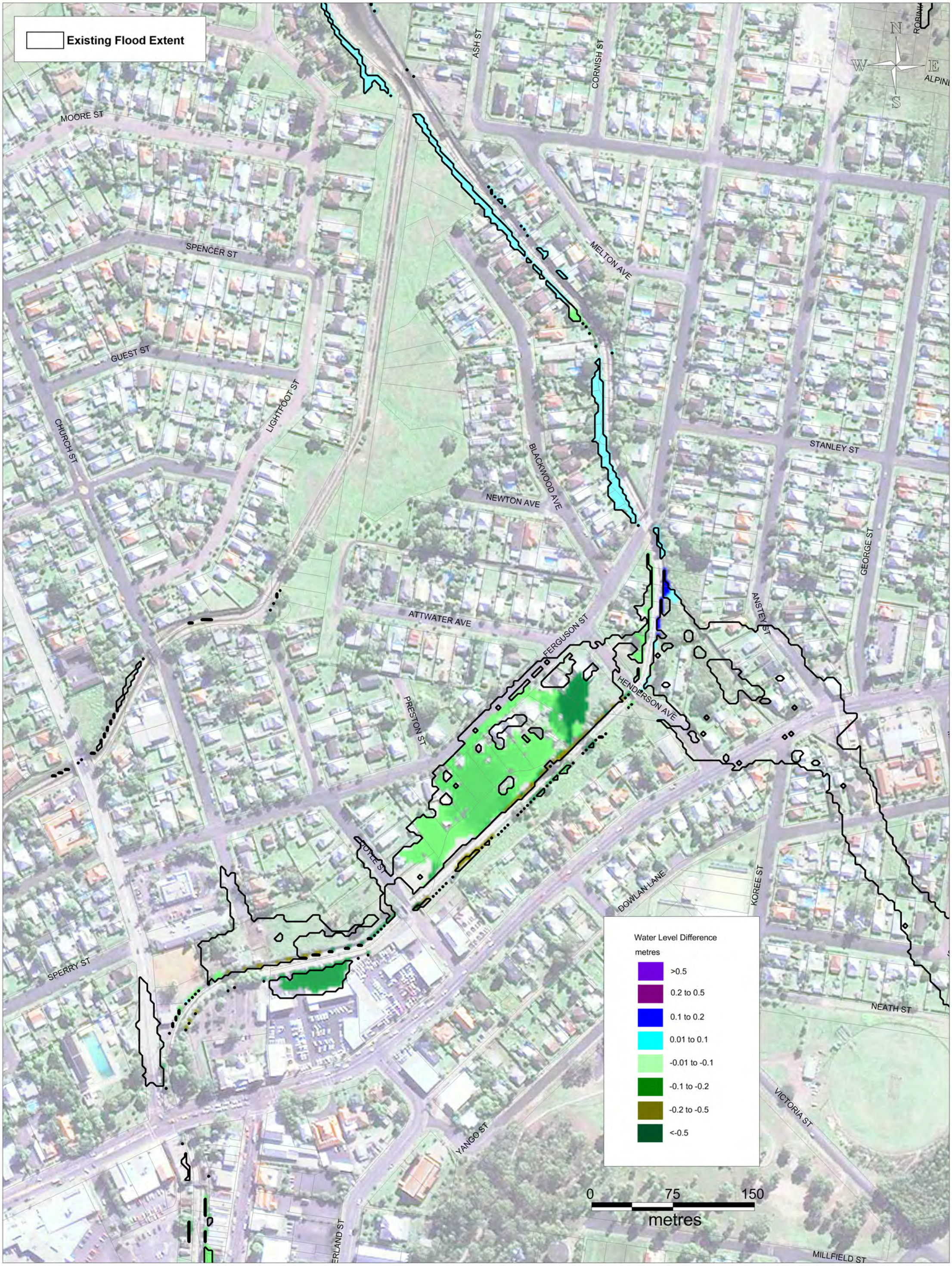


Cardno

FIGURE 11-14 : FM3 OPTION LAYOUT

W4951
April 2015

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan



Cardno

W4951
April 2015

FIGURE 11-15 : 20% AEP - PEAK WATER LEVEL DIFFERENCES
FM3 Results Less Existing Results

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

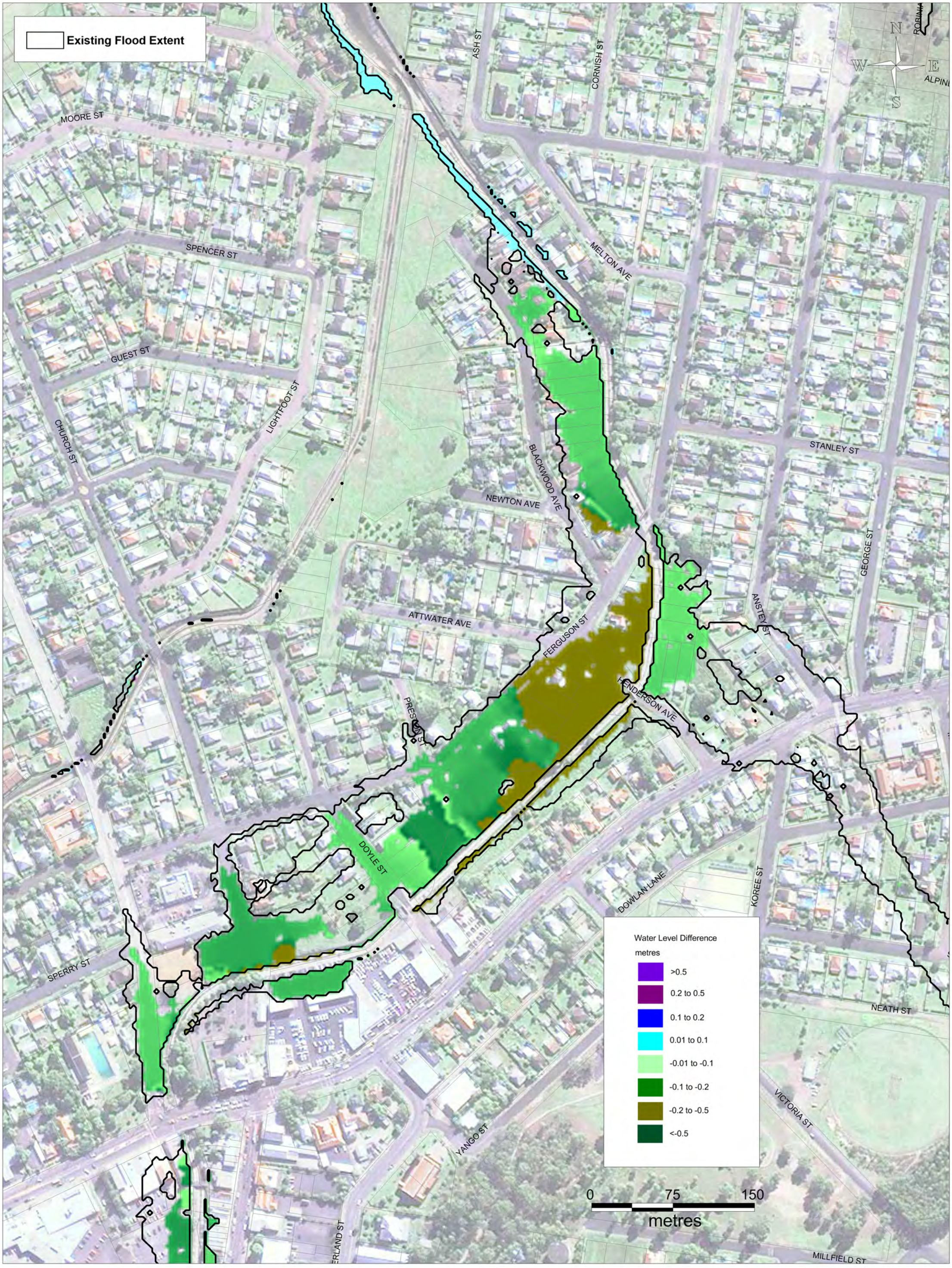
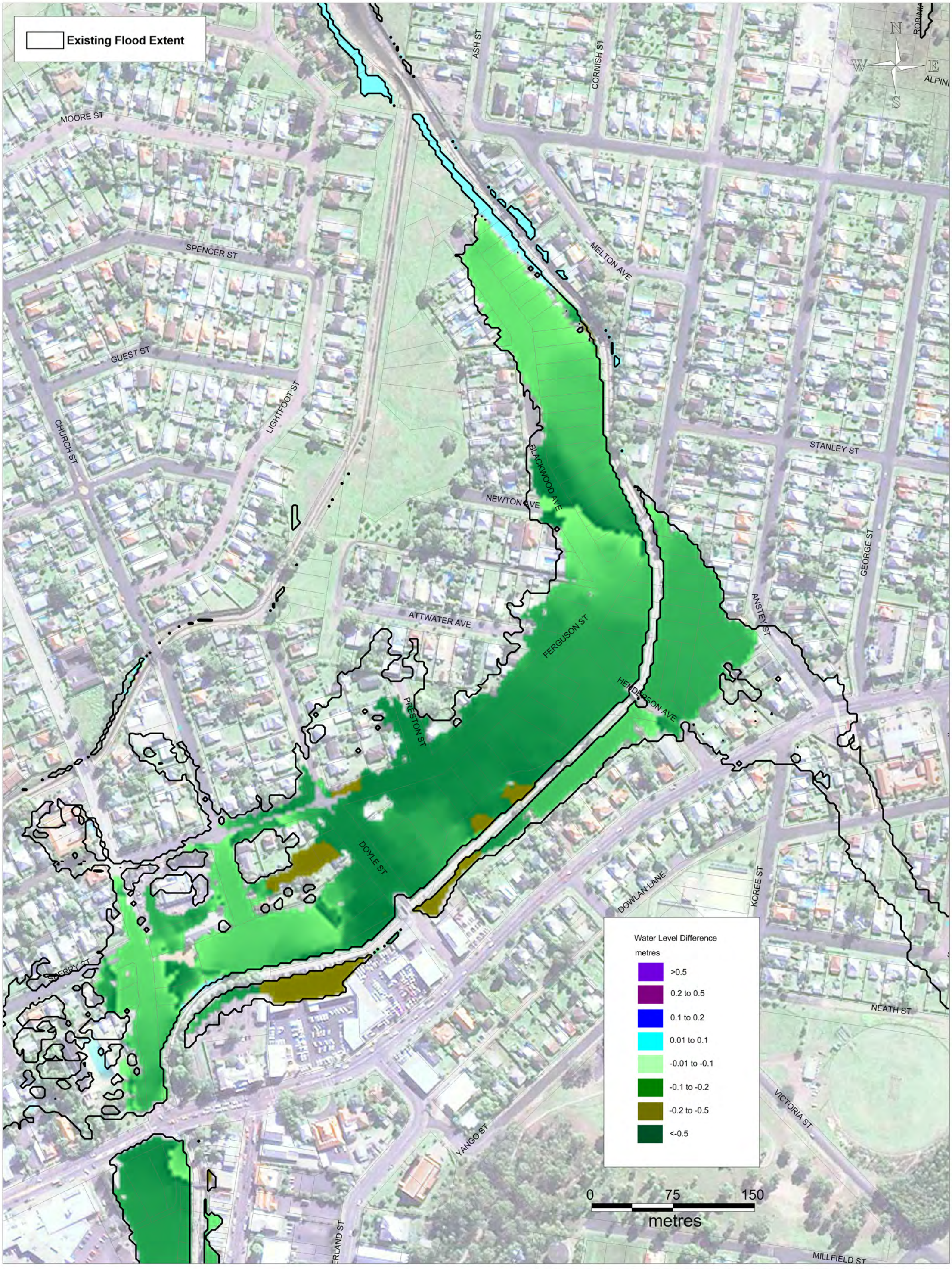


FIGURE 11-16 : 10% AEP - PEAK WATER LEVEL DIFFERENCES
FM3 Results Less Existing Results

Cardno

W4951
April 2015

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

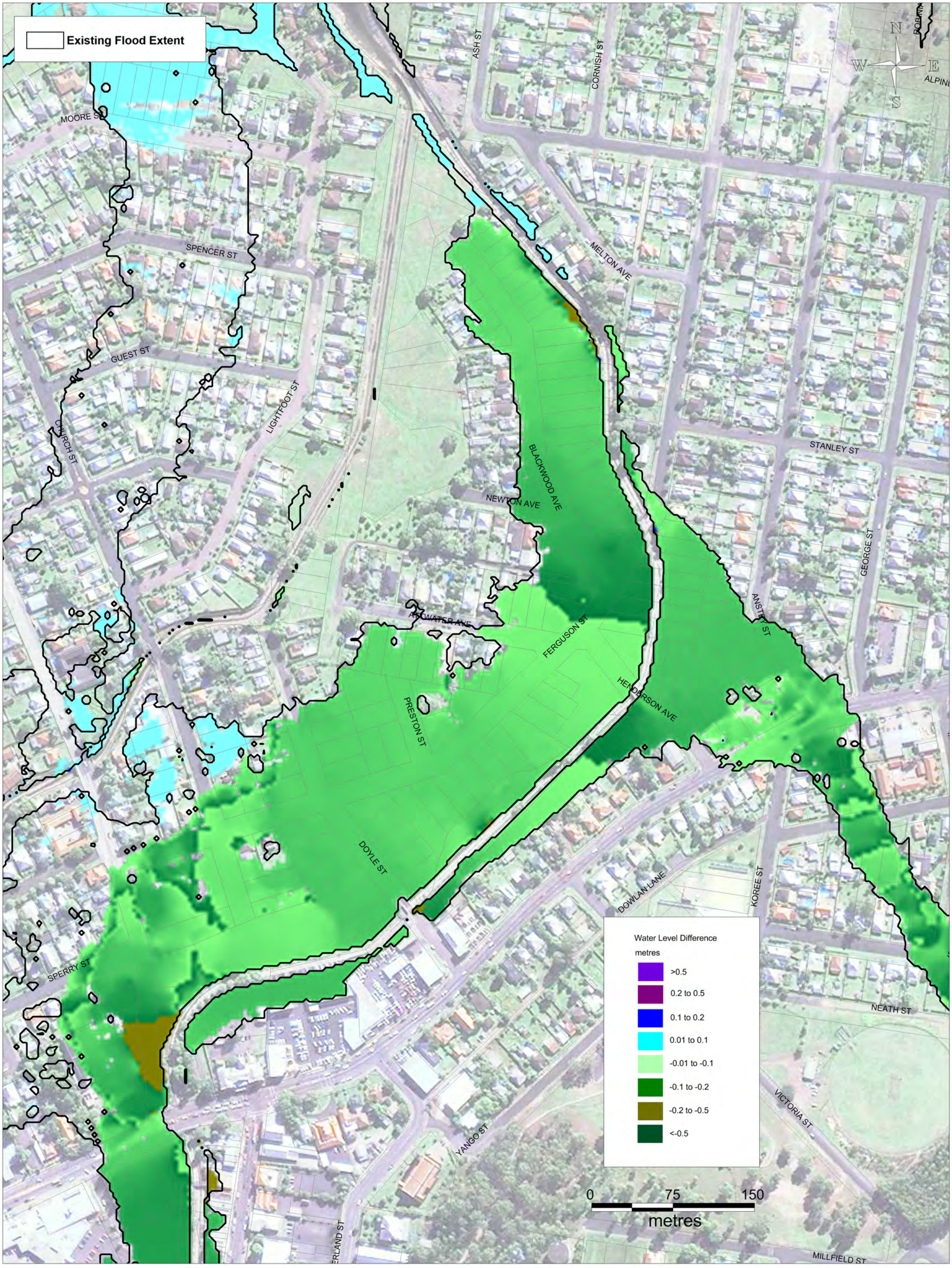


Cardno

W4951
April 2015

FIGURE 11-17 : 5% AEP - PEAK WATER LEVEL DIFFERENCES
FM3 Results Less Existing Results

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

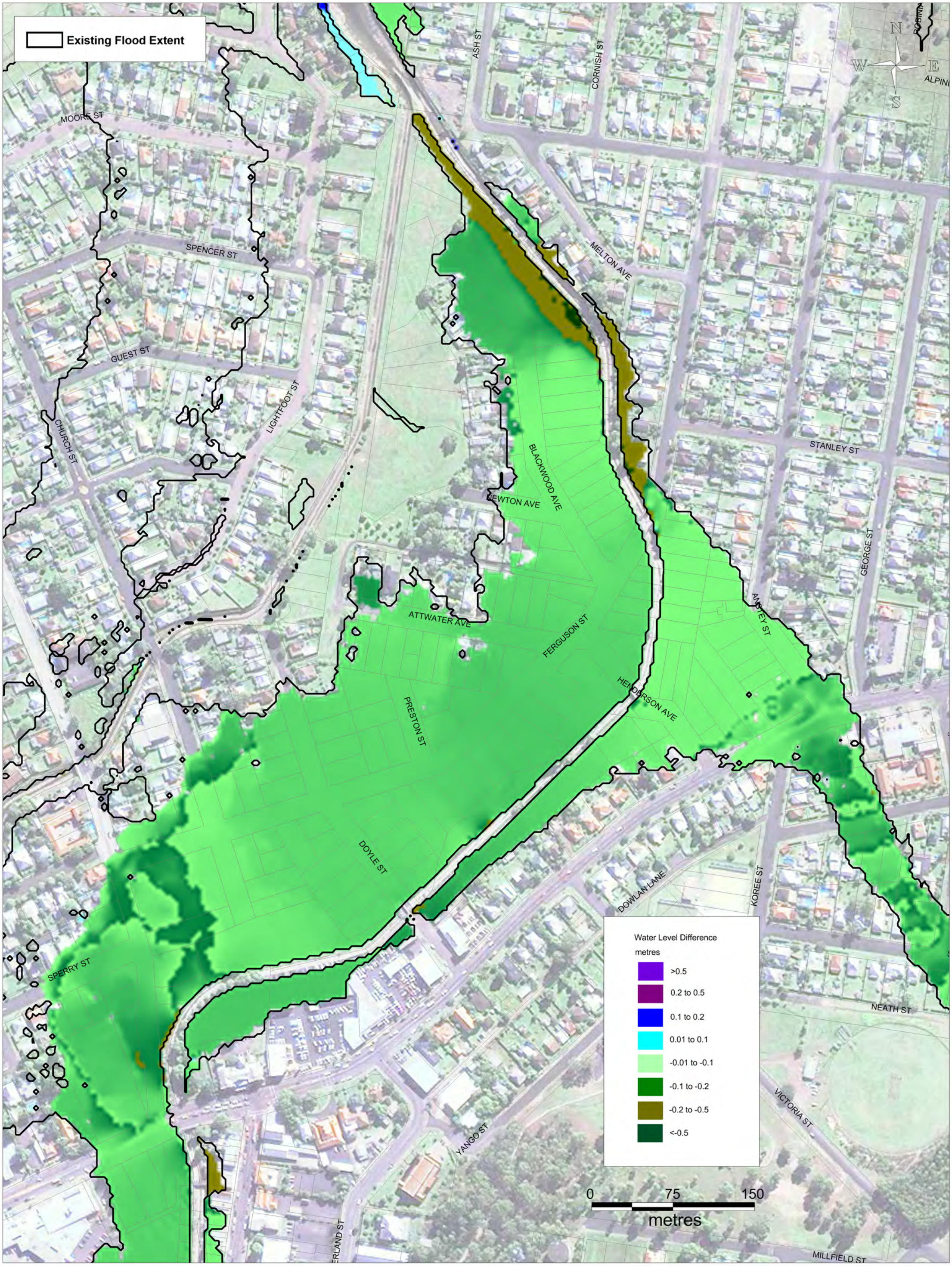


Cardno

W4951
April 2015

FIGURE 11-18 : 2% AEP - PEAK WATER LEVEL DIFFERENCES
FM3 Results Less Existing Results

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

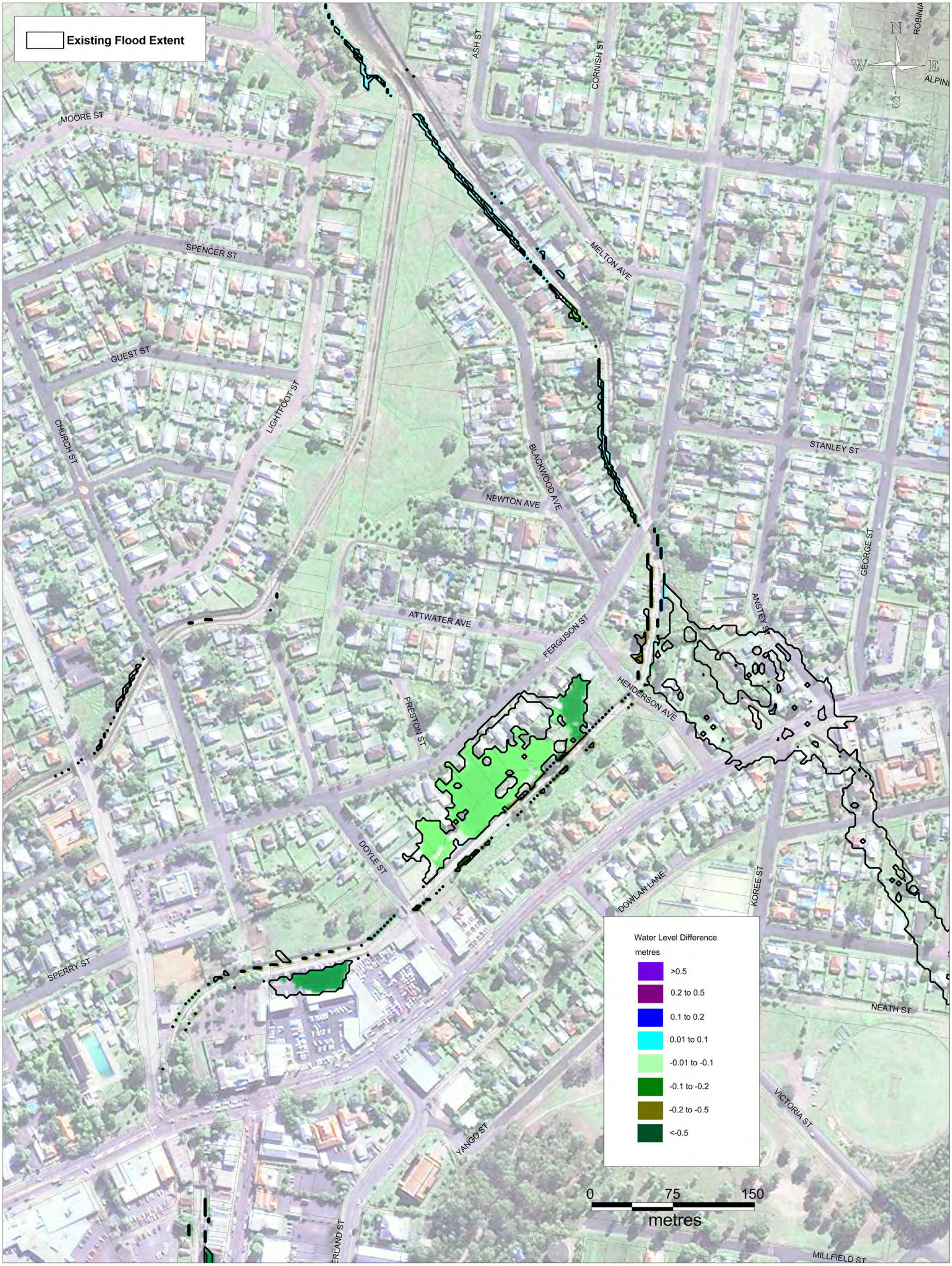


Cardno

W4951
April 2015

FIGURE 11-19 : 1% AEP - PEAK WATER LEVEL DIFFERENCES
FM3 Results Less Existing Results

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan



Cardno

W4951
April 2015

FIGURE 11-20 : APRIL 2015 EVENT - PEAK WATER LEVEL DIFFERENCES
FM3 Results Less Existing Results

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

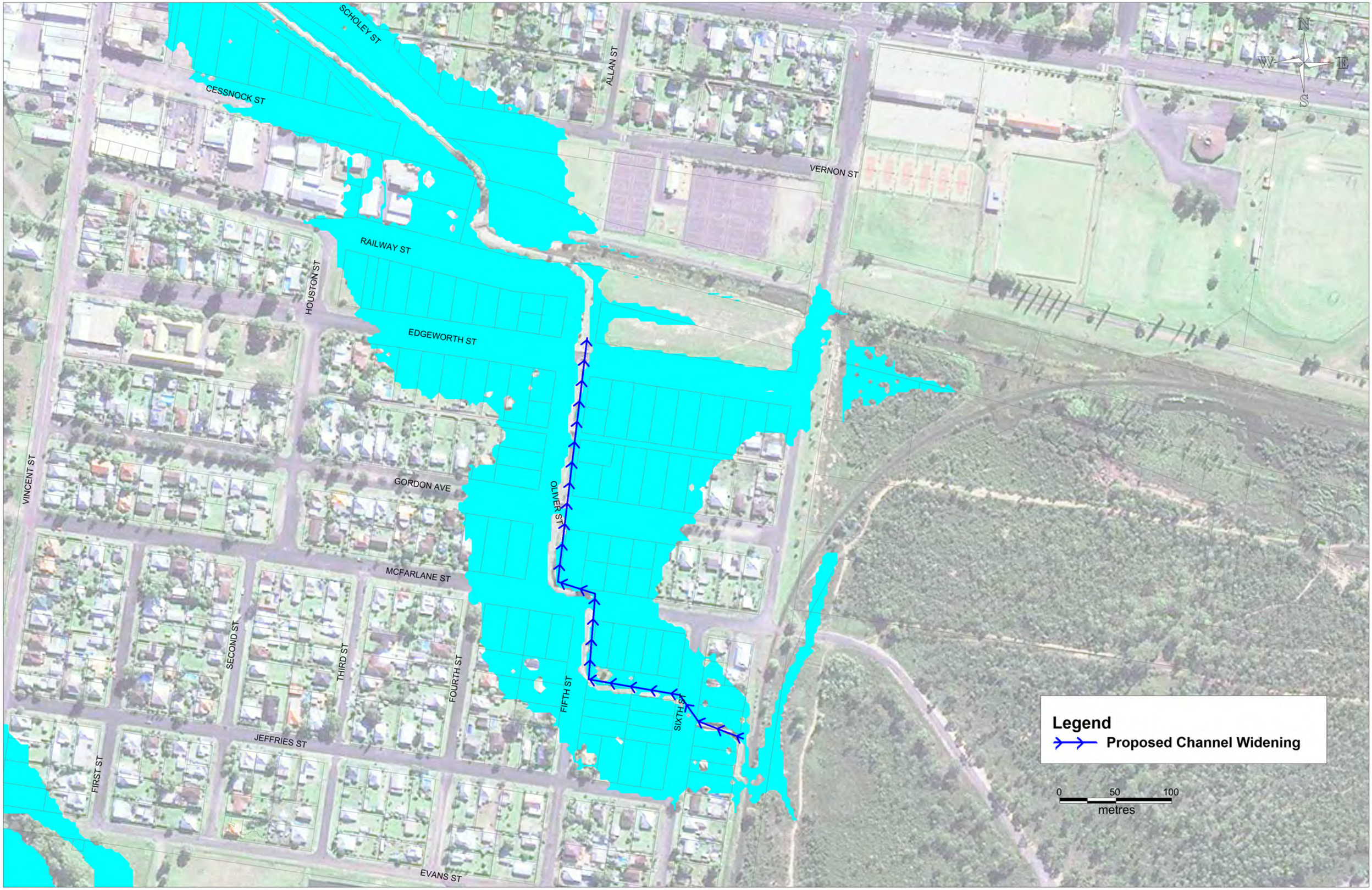
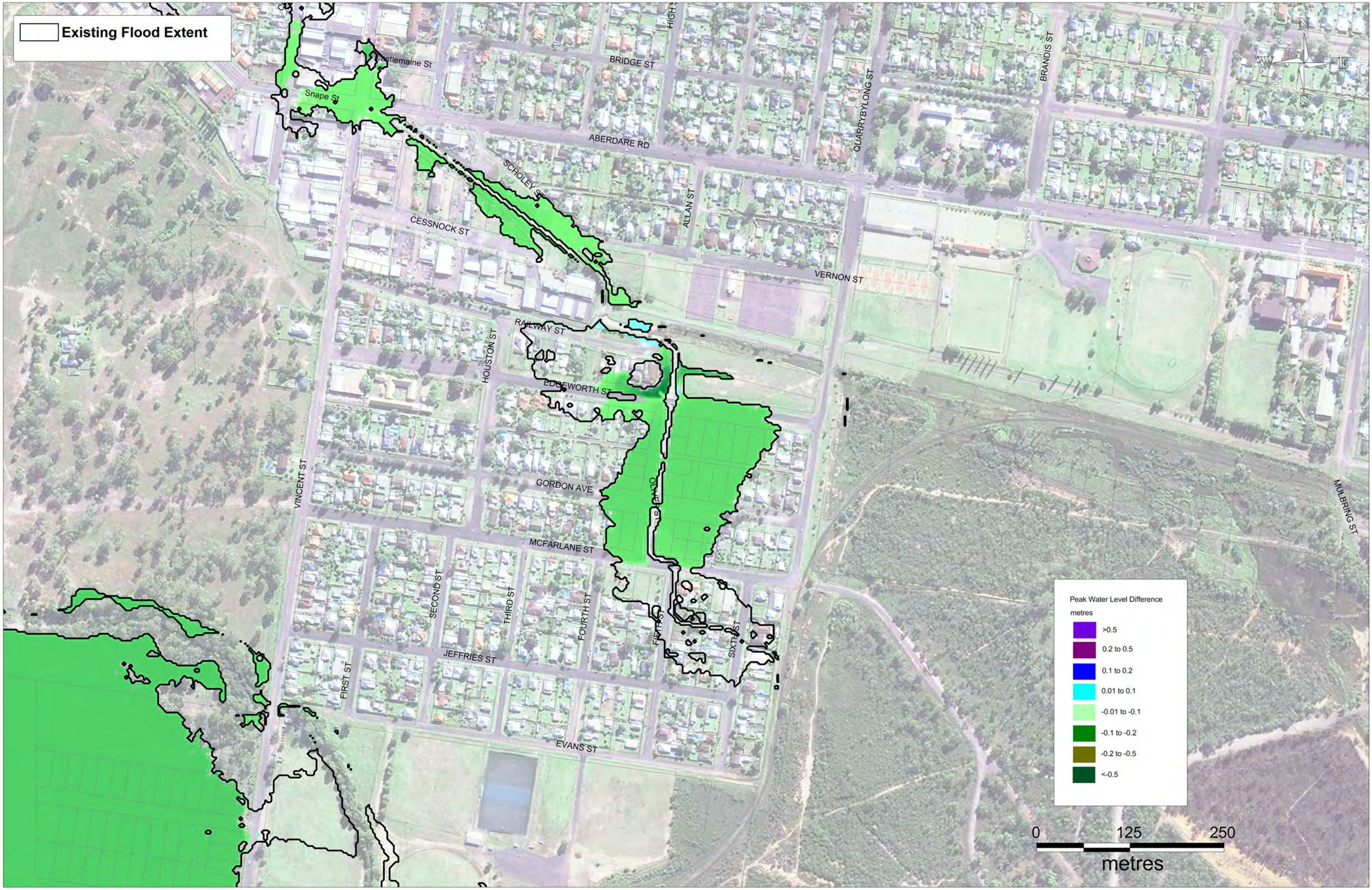


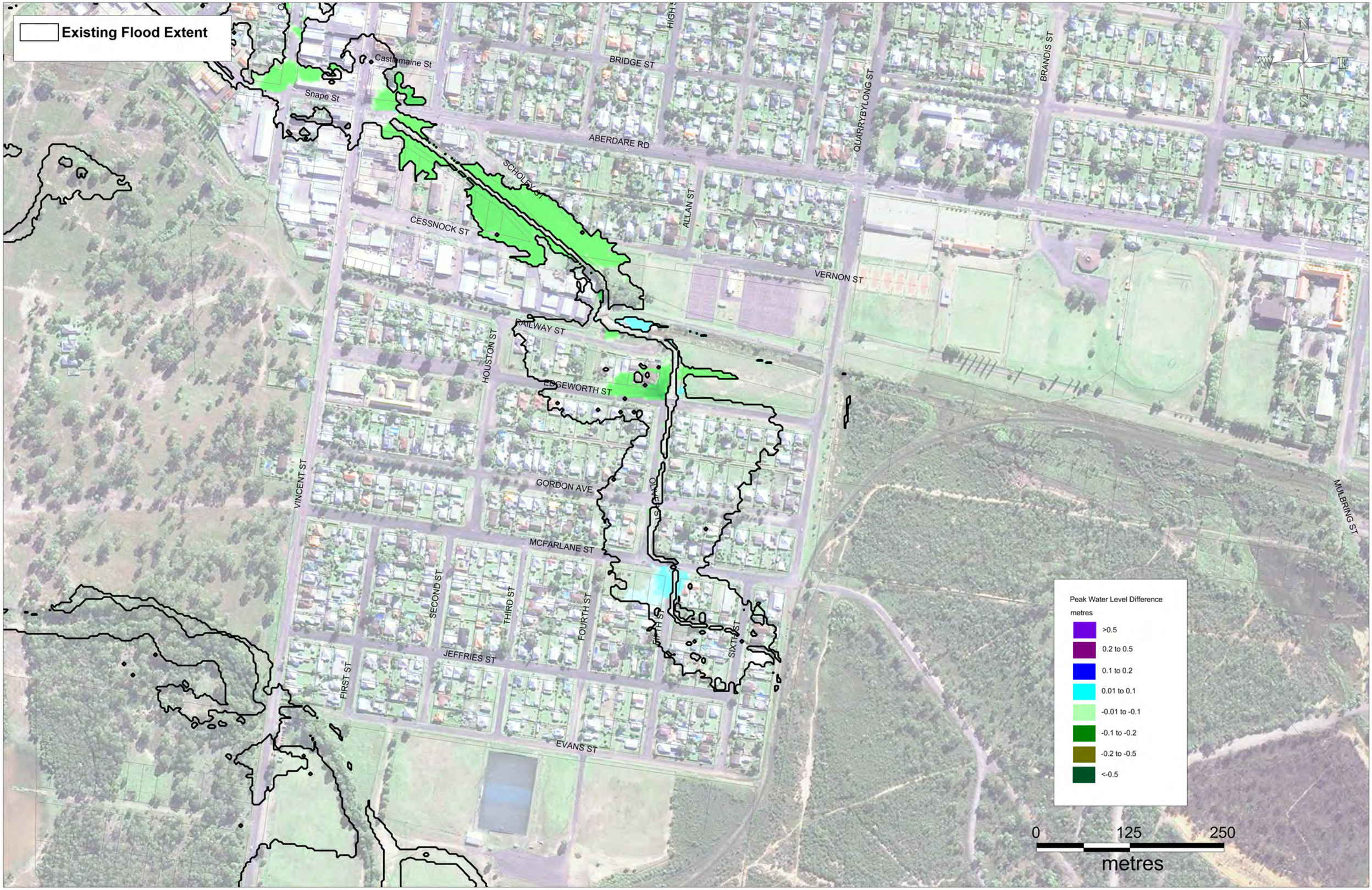
FIGURE 11-21 : FM4 OPTION LAYOUT



Cardno

W4951
November 2015

FIGURE 11-22 : 20% AEP - PEAK WATER LEVEL DIFFERENCES
FM4 Results Less Existing Results



Cardno

FIGURE 11-23 : 10% AEP - PEAK WATER LEVEL DIFFERENCES
FM4 Results Less Existing Results

Existing Flood Extent

Castlemaine St
Snape St
BRIDGE ST
ABERDARE RD
QUARRYBYLONG ST
BRANDIS ST
SHORT ST
ALLAN ST
CESSNOCK ST
VERNON ST
RAILWAY ST
EDGEWORTH ST
HOUSTON ST
VINCENT ST
GORDON AVE
MCFARLANE ST
SECOND ST
THIRD ST
FOURTH ST
FIFTH ST
SIXTH ST
FIRST ST
JEFFRIES ST
EVANS ST
MULBRING ST

Peak Water Level Difference
metres
- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

0 125 250
metres

Cardno

FIGURE 11-24 : 5% AEP - PEAK WATER LEVEL DIFFERENCES
FM4 Results Less Existing Results

W4951
November 2015

Black Creek (Cessnock City) Floodplain Risk Management Study and Plan

Existing Flood Extent

Castlemaine St
Snape St
BRIDGE ST
HIGH ST
ABERDARE RD
QUARRYBYLONG ST
BRANDIS ST
SCHOLEY ST
CESSNOCK ST
ALLAN ST
VERNON ST
RAILWAY ST
EDGEWORTH ST
HOUSTON ST
VINCENT ST
GORDON AVE
OLIVER ST
MULBRING ST
MCFARLANE ST
SECOND ST
THIRD ST
FOURTH ST
FIFTH ST
SIXTH ST
FIRST ST
JEFFRIES ST
EVANS ST

N
W
E
S

Peak Water Level Difference
metres
>0.5
0.2 to 0.5
0.1 to 0.2
0.01 to 0.1
-0.01 to -0.1
-0.1 to -0.2
-0.2 to -0.5
<-0.5

0 125 250
metres

Cardno

FIGURE 11-25 : 2% AEP - PEAK WATER LEVEL DIFFERENCES
FM4 Results Less Existing Results

W4951
November 2015

Existing Flood Extent

Castlemaine St
Snape St
BRIDGE ST
ABERDARE RD
SCHOLEY ST
CESSNOCK ST
ALLAN ST
QUARRYBYLONG ST
BRANDIS ST
VERNON ST
RAILWAY ST
HOUSTON ST
EDGEWORTH ST
VINCENT ST
GORDON AVE
MCFARLANE ST
SECOND ST
THIRD ST
FOURTH ST
FIFTH ST
SIXTH ST
FIRST ST
JEFFRIES ST
EVANS ST
MULBRING ST

Peak Water Level Difference
metres
- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

0 125 250
metres

Cardno

FIGURE 11-26 : 1% AEP - PEAK WATER LEVEL DIFFERENCES
FM4 Results Less Existing Results

W4951
November 2015

Existing Flood Extent

Castlemaine St
Snape St
BRIDGE ST
ABERDARE RD
SCHOLEY ST
CESSNOCK ST
ALLAN ST
QUARRYBYLONG ST
BRANDIS ST
VERNON ST
RAILWAY ST
HOUSTON ST
EDGEWORTH ST
GORDON AVE
MCFARLANE ST
VINCENT ST
SECOND ST
THIRD ST
FOURTH ST
FIFTH ST
SIXTH ST
JEFFRIES ST
FIRST ST
EVANS ST
MULBRING ST

Peak Water Level Difference
metres
- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

0 125 250
metres

Cardno

FIGURE 11-27 : APRIL 2015 STORM - PEAK WATER LEVEL DIFFERENCES
FM4 Results Less Existing Results

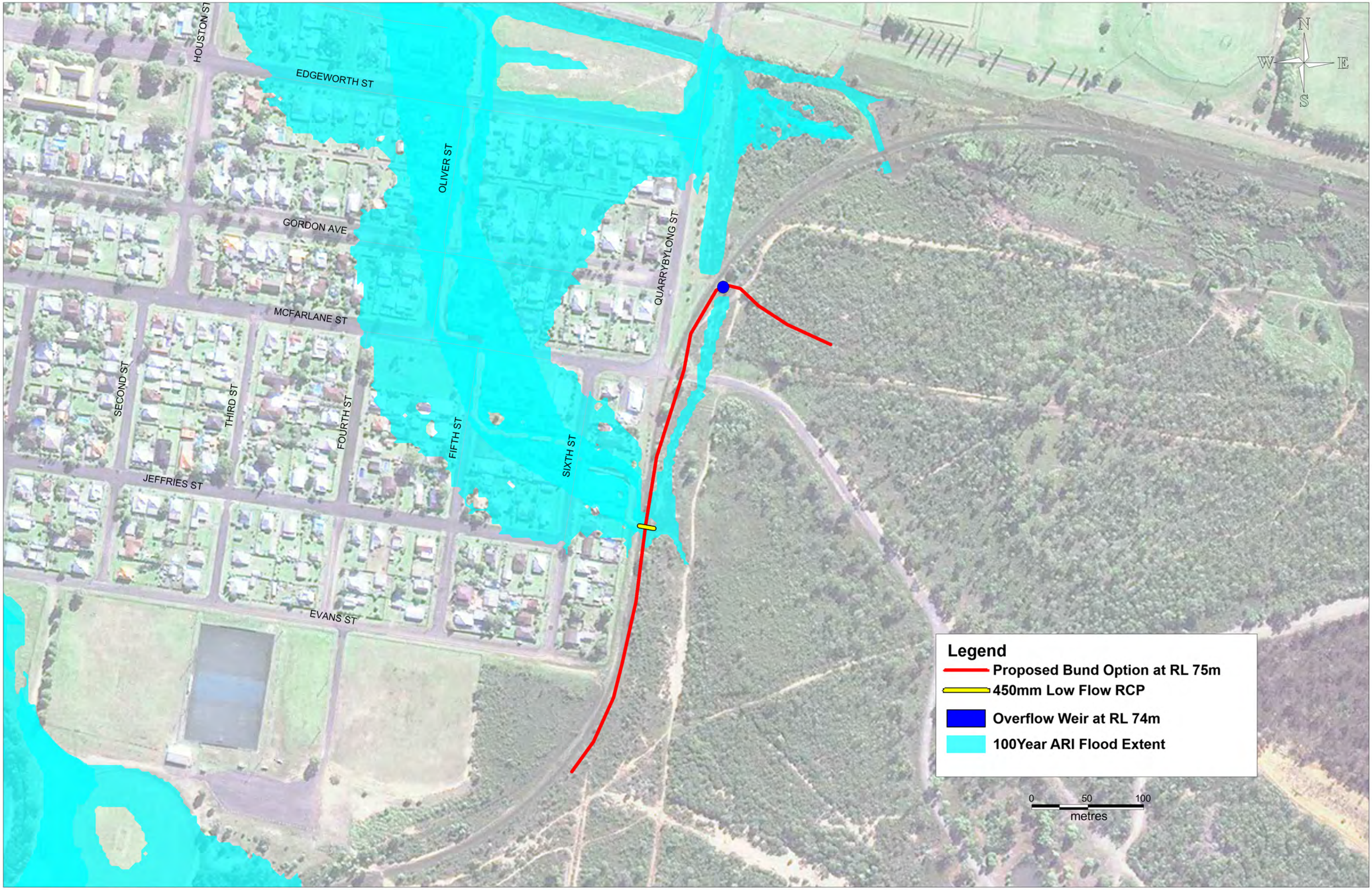
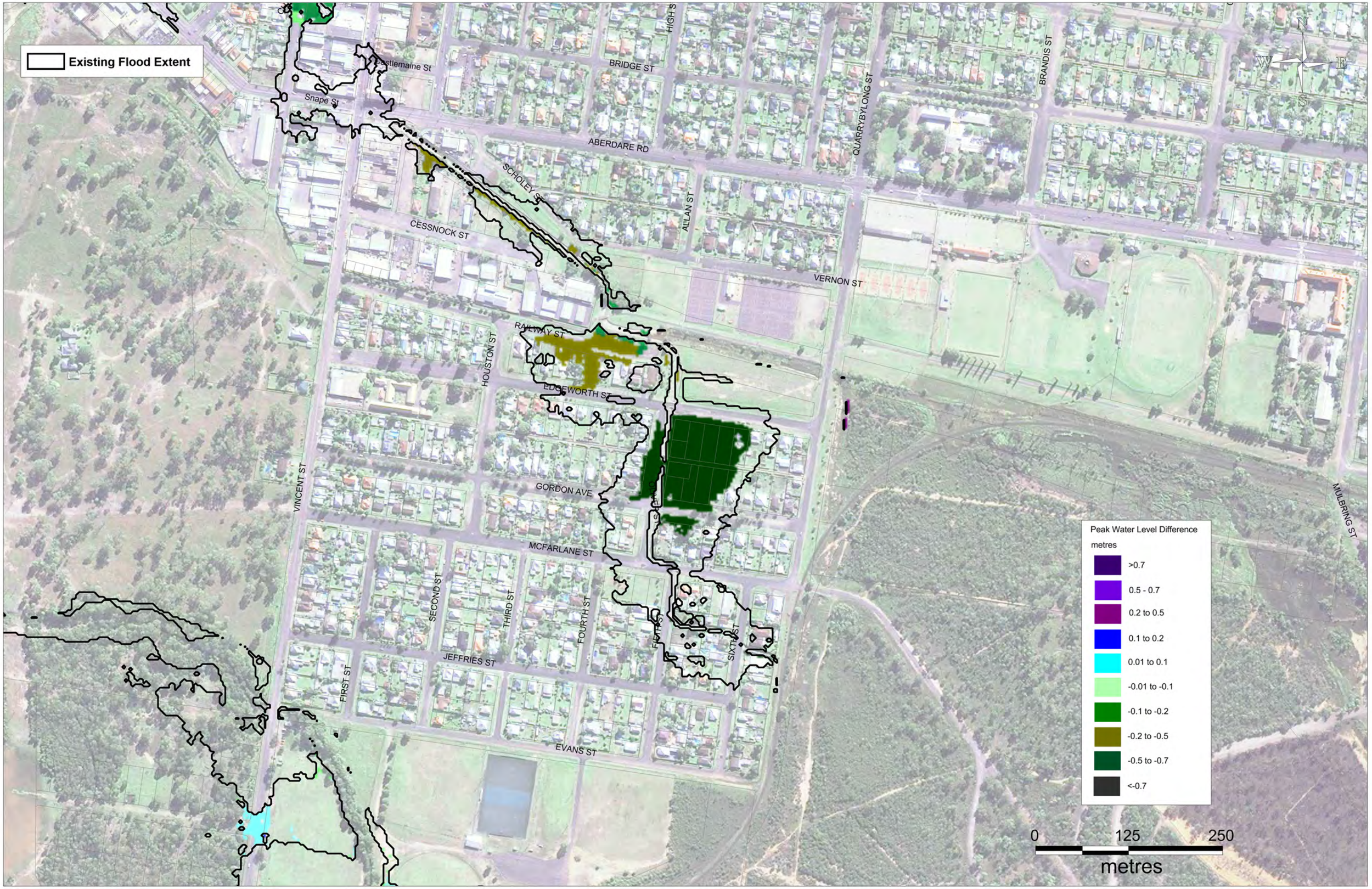
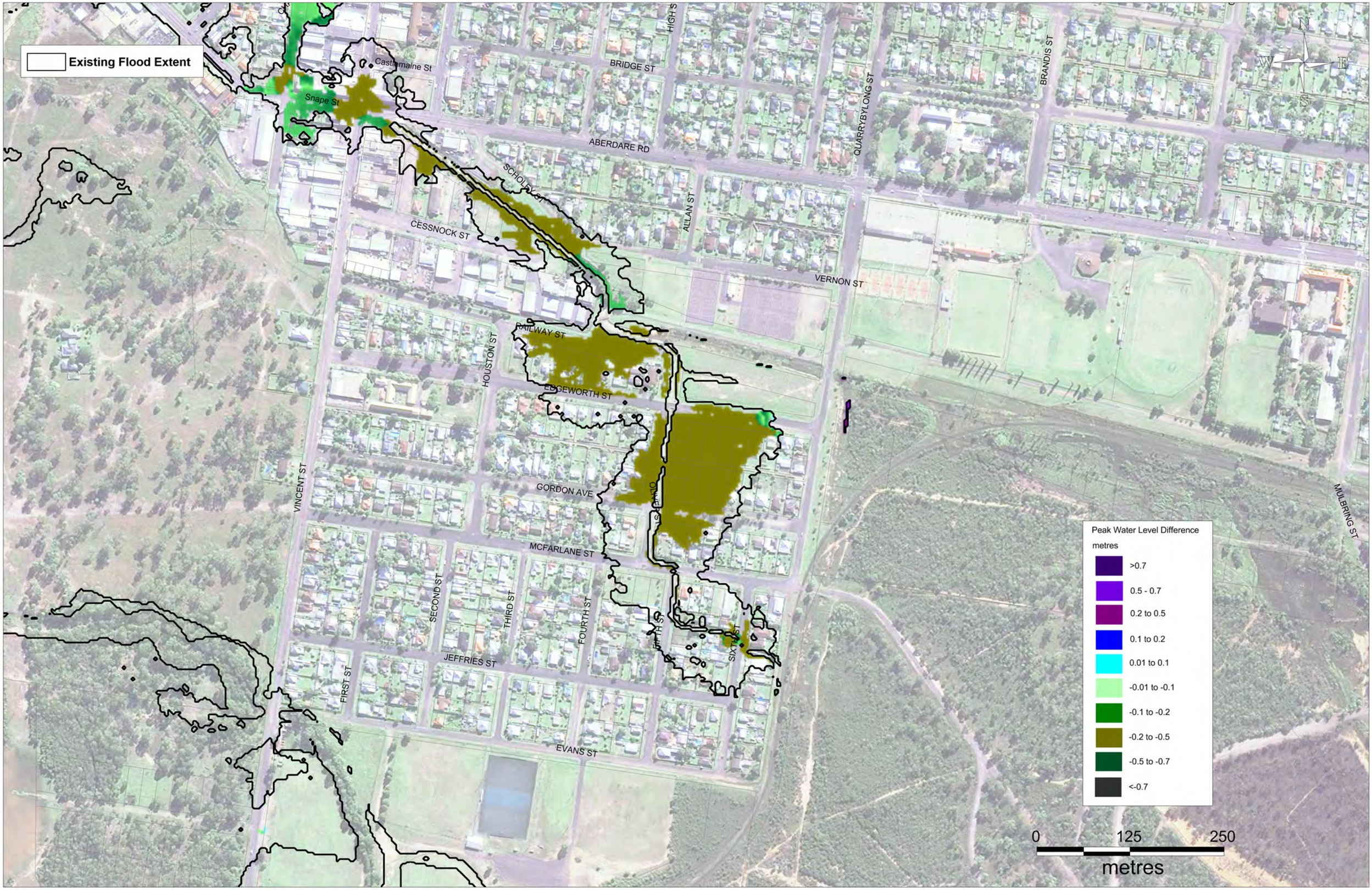


FIGURE 11-28 : FM5 OPTION LAYOUT



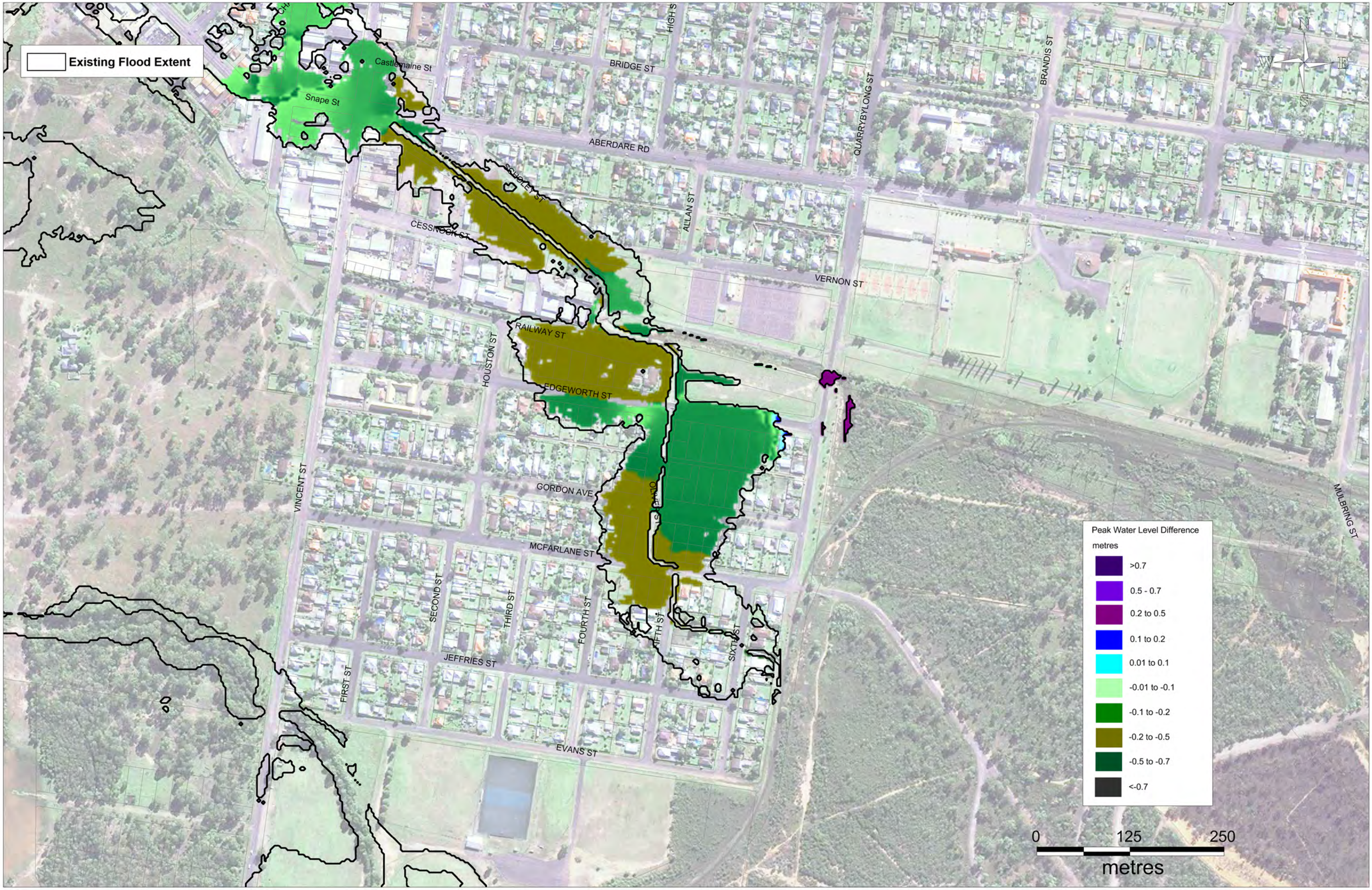
Cardno

FIGURE 11-29 : 20% AEP- PEAK WATER LEVEL DIFFERENCES
FM5 Results Less Existing Results



Cardno

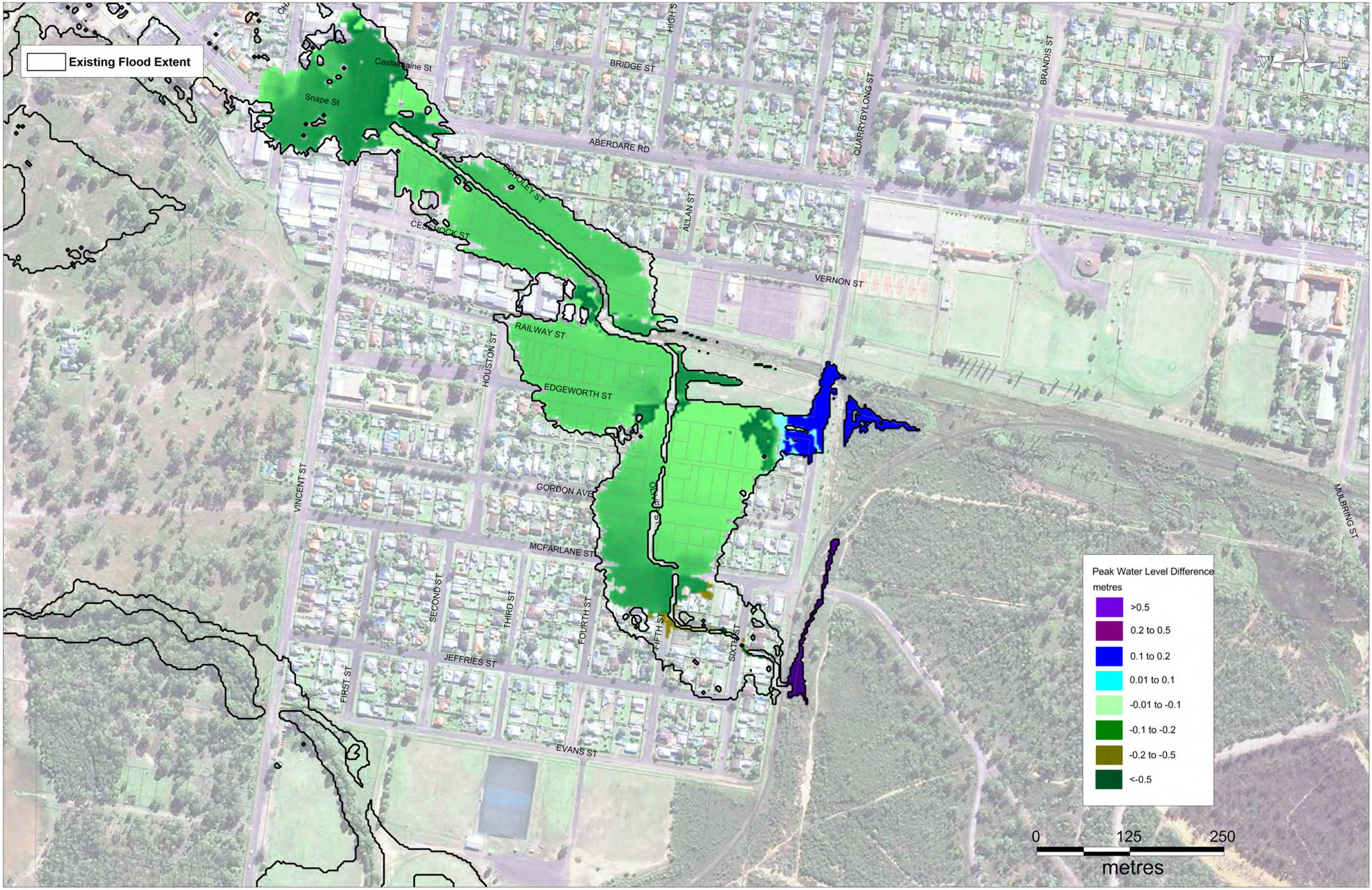
FIGURE 11-30 : 10% AEP- PEAK WATER LEVEL DIFFERENCES
FM5 Results Less Existing Results



Cardno

FIGURE 11-31 : 5% AEP- PEAK WATER LEVEL DIFFERENCES
FM5 Results Less Existing Results

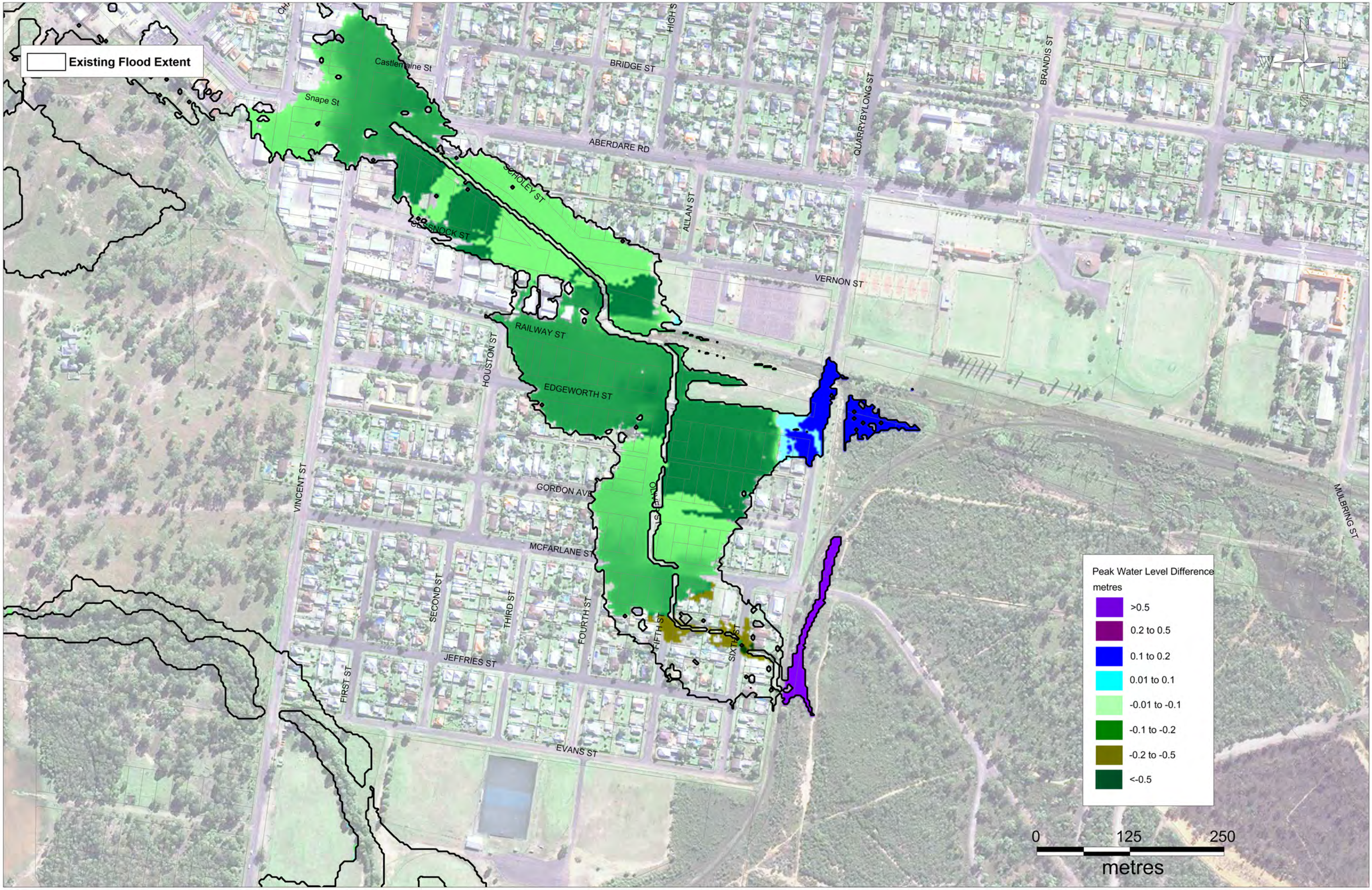
W4951
November 2015



Cardno

FIGURE 11-32 : 2% AEP- PEAK WATER LEVEL DIFFERENCES
FM5 Results Less Existing Results

W4951
November 2015



Cardno

FIGURE 11-33 : 1% AEP- PEAK WATER LEVEL DIFFERENCES
FM5 Results Less Existing Results

Existing Flood Extent

Castlemaine St
Snape St
BRIDGE ST
HIGH ST
ABERDARE RD
QUARRYBYLONG ST
BRANDIS ST
SCHOLEY ST
CESSNOCK ST
ALLAN ST
VERNON ST
RAILWAY ST
HOUSTON ST
EDGEWORTH ST
VINCENT ST
GORDON AVE
MULBRING ST
MCFARLANE ST
SECOND ST
THIRD ST
FOURTH ST
FIFTH ST
SIXTH ST
JEFFRIES ST
FIRST ST
EVANS ST

N
W
E
S

Peak Water Level Difference
metres
>0.7
0.5 - 0.7
0.2 to 0.5
0.1 to 0.2
0.01 to 0.1
-0.01 to -0.1
-0.1 to -0.2
-0.2 to -0.5
-0.5 to -0.7
<-0.7

0 125 250
metres

Cardno

FIGURE 11-34 : APRIL 2015 EVENT- PEAK WATER LEVEL DIFFERENCES
FM5 Results Less Existing Results

Cardno

FIGURE 11-35 : APRIL 2015 EVENT - PEAK WATER LEVEL DIFFERENCES
FM4+FM5 Results Less Existing Results

W4951
November 2015

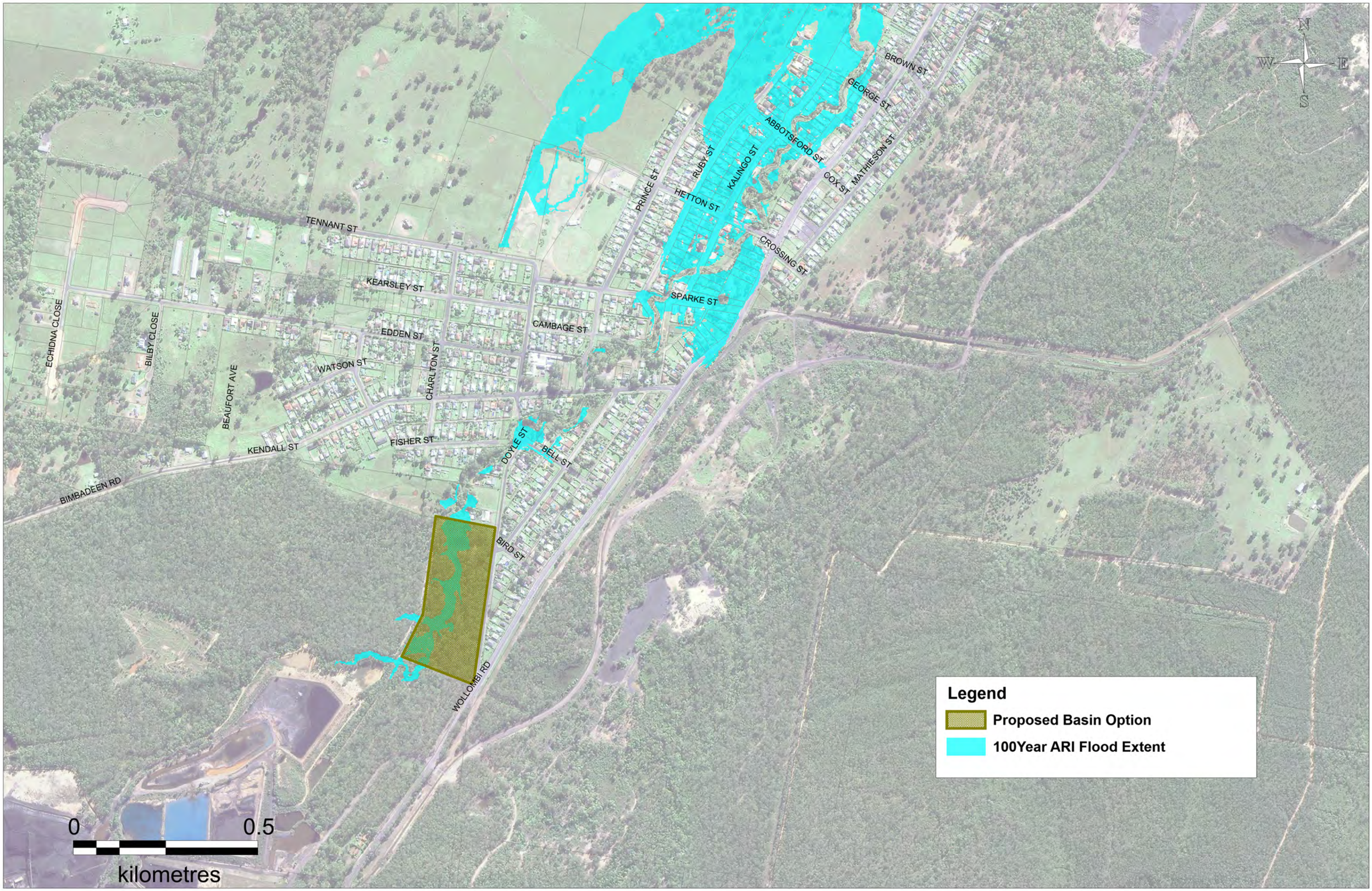
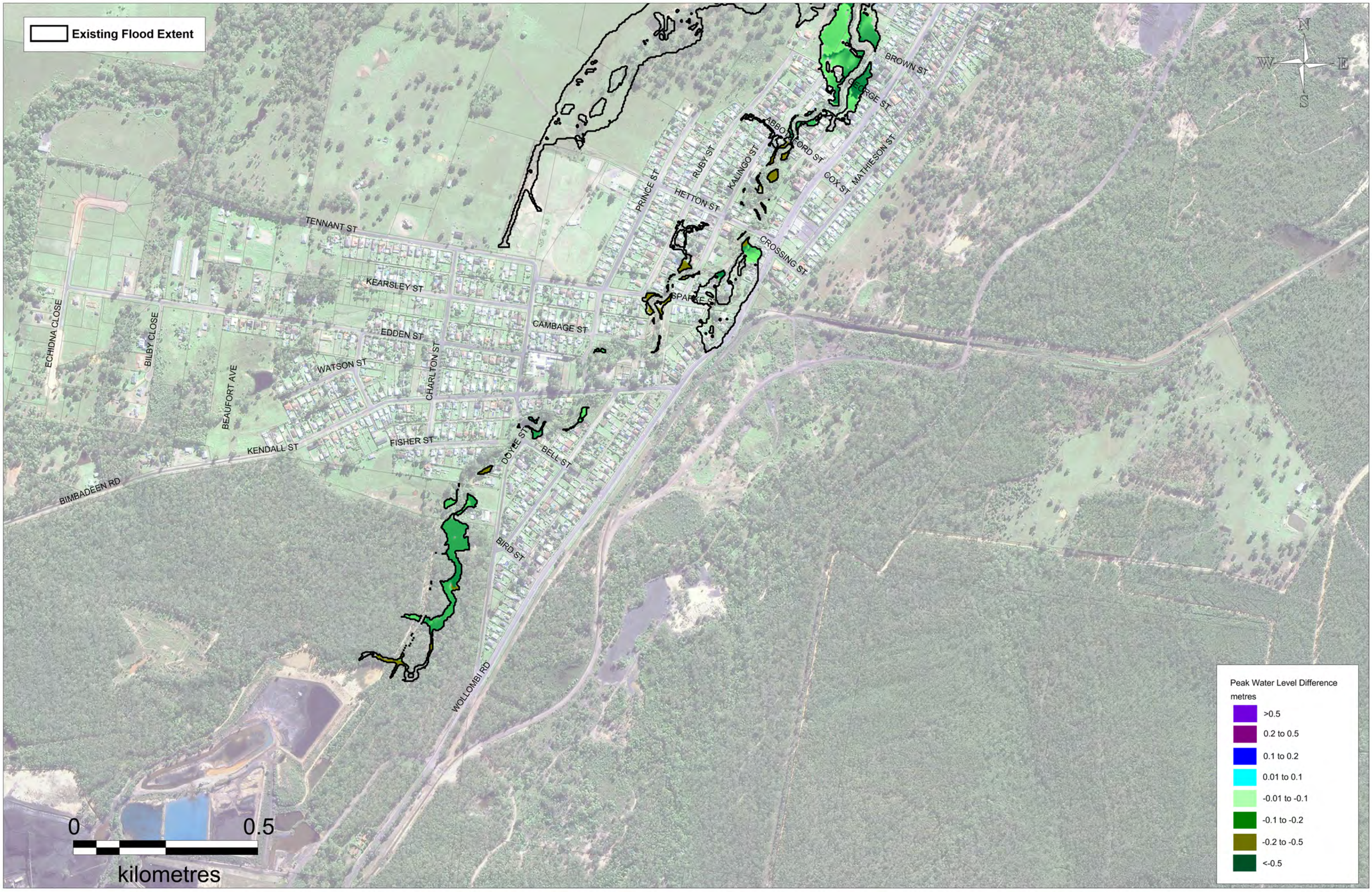
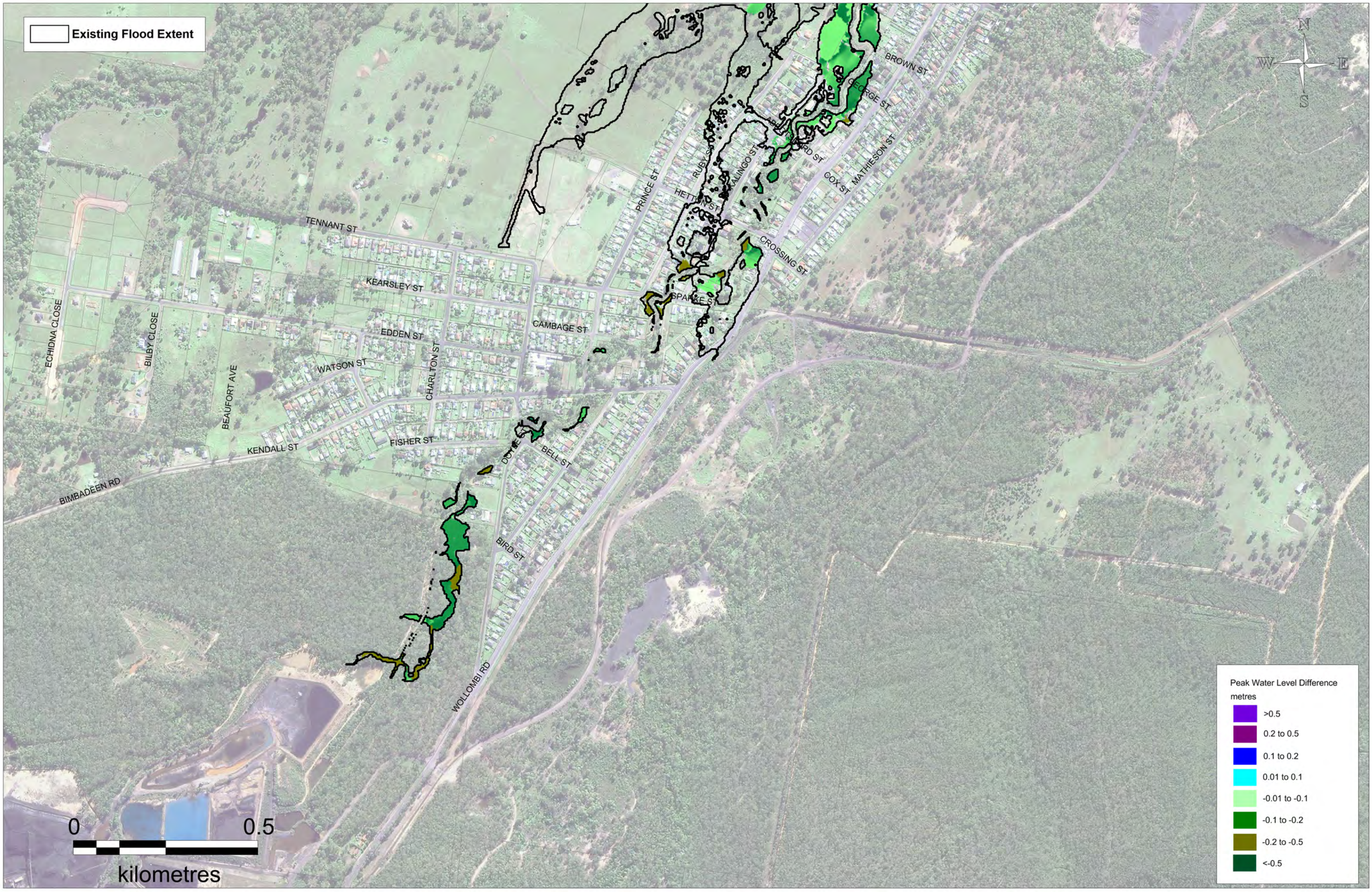


FIGURE 11-36 : FM6 OPTION LAYOUT



Cardno

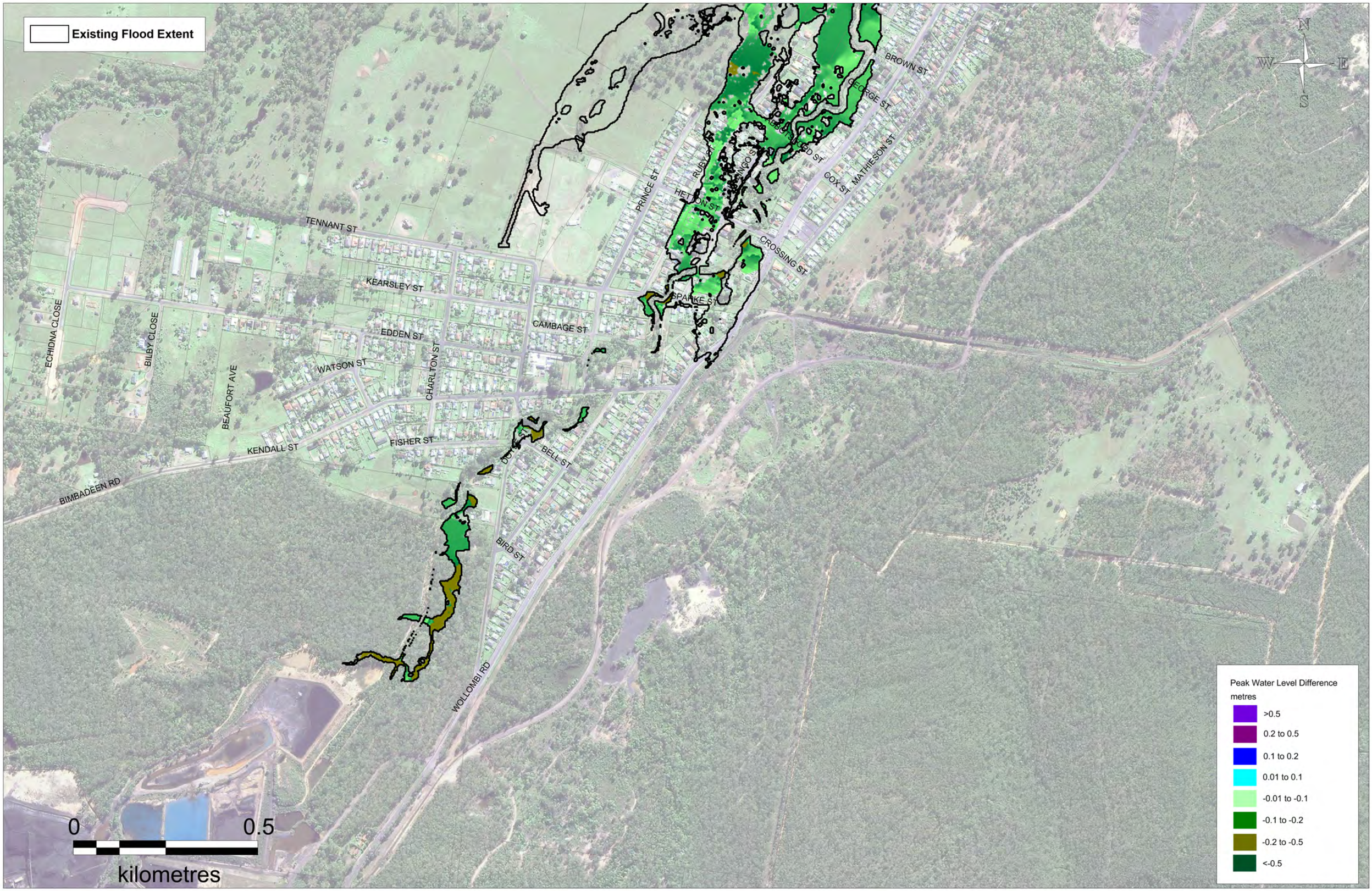
FIGURE 11-37 : 20% AEP - PEAK WATER LEVEL DIFFERENCES
FM6 Results Less Existing Results



Cardno

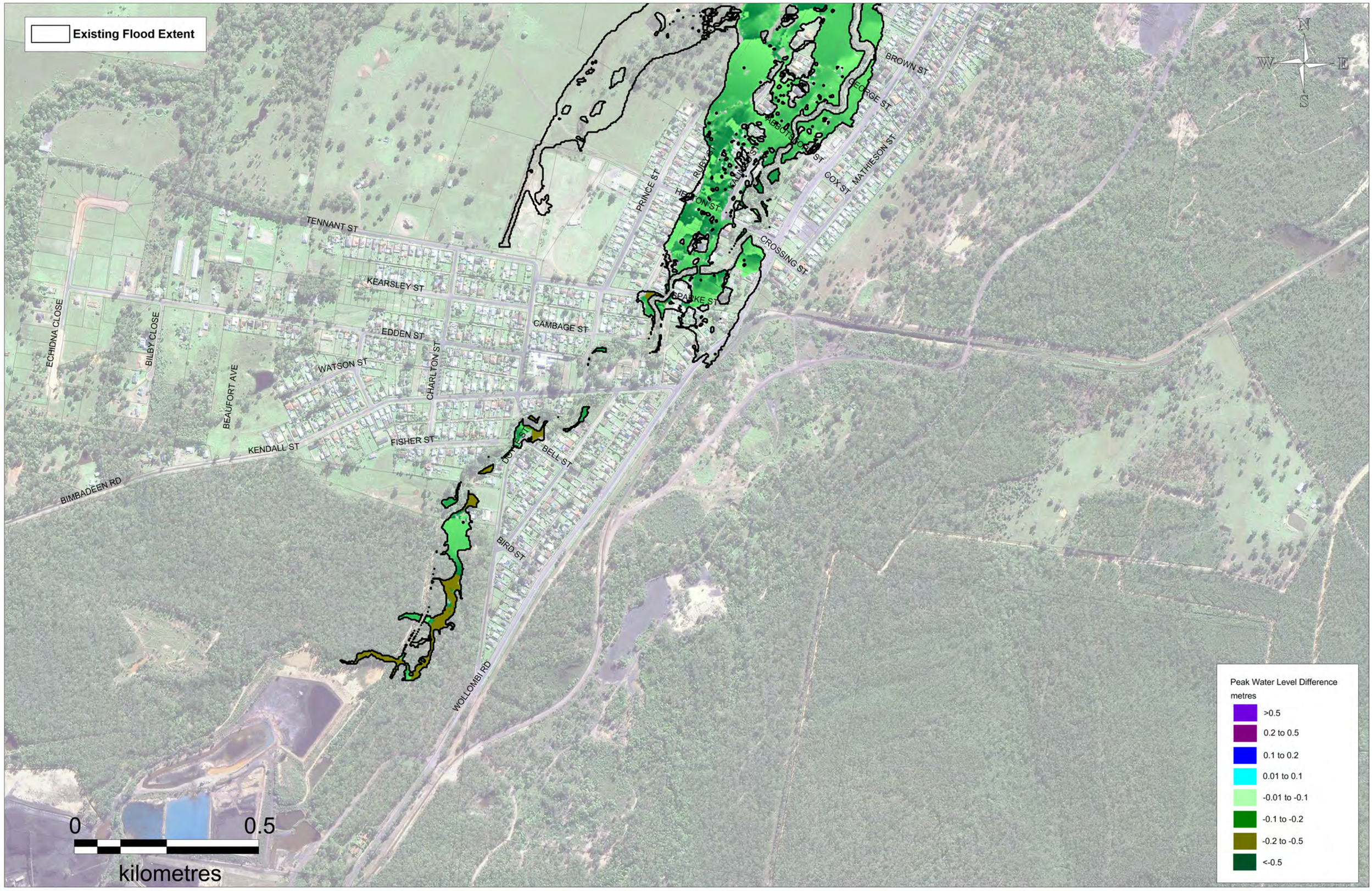
FIGURE 11-38 : 10% AEP - PEAK WATER LEVEL DIFFERENCES
FM6 Results Less Existing Results

W4951
April 2015



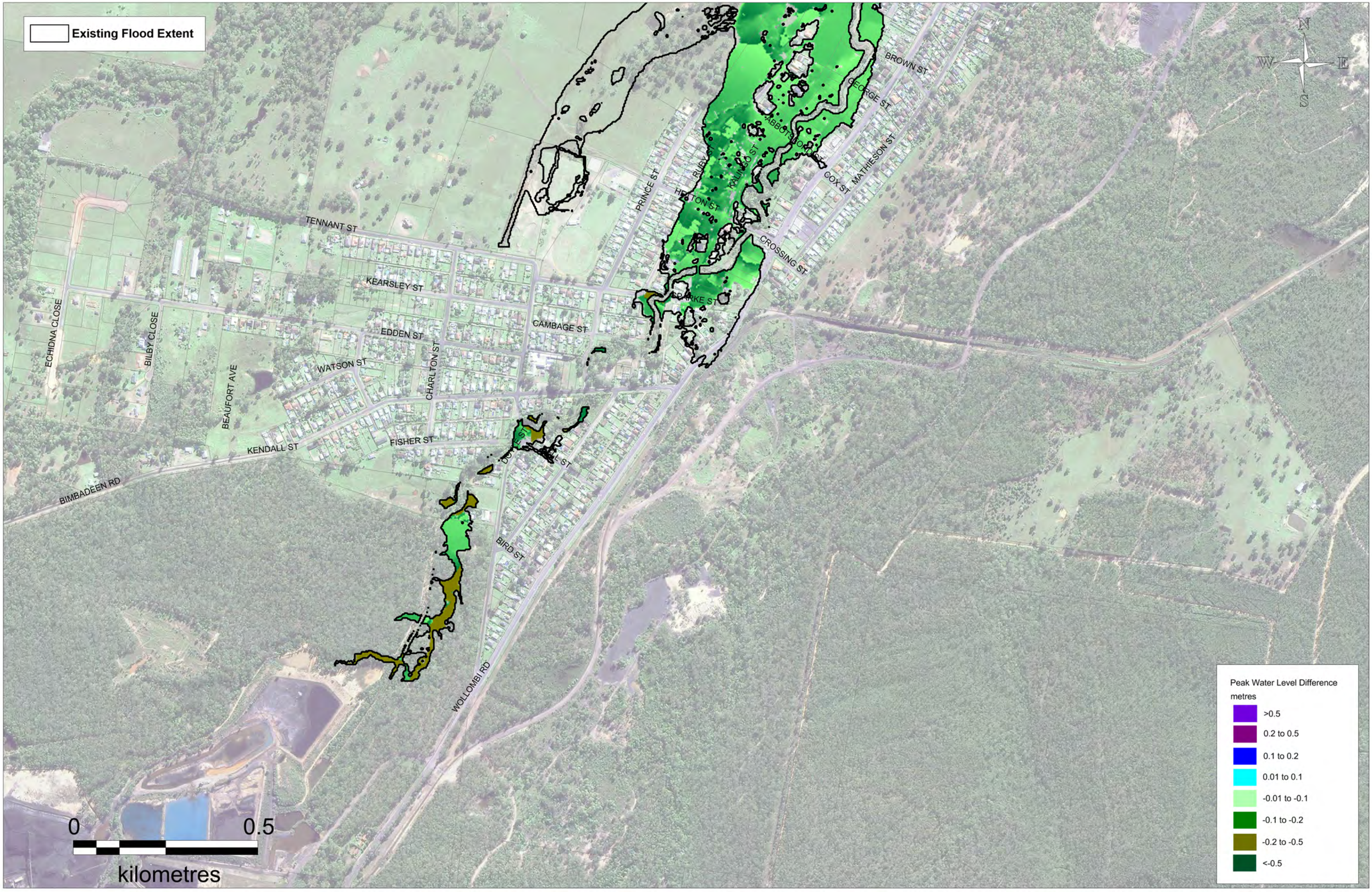
Cardno

FIGURE 11-39 : 5% AEP - PEAK WATER LEVEL DIFFERENCES
FM6 Results Less Existing Results



Cardno

FIGURE 11-40 : 2% AEP - PEAK WATER LEVEL DIFFERENCES
FM6 Results Less Existing Results



Cardno

FIGURE 11-41 : 1% AEP - PEAK WATER LEVEL DIFFERENCES
FM6 Results Less Existing Results

W4951
April 2015

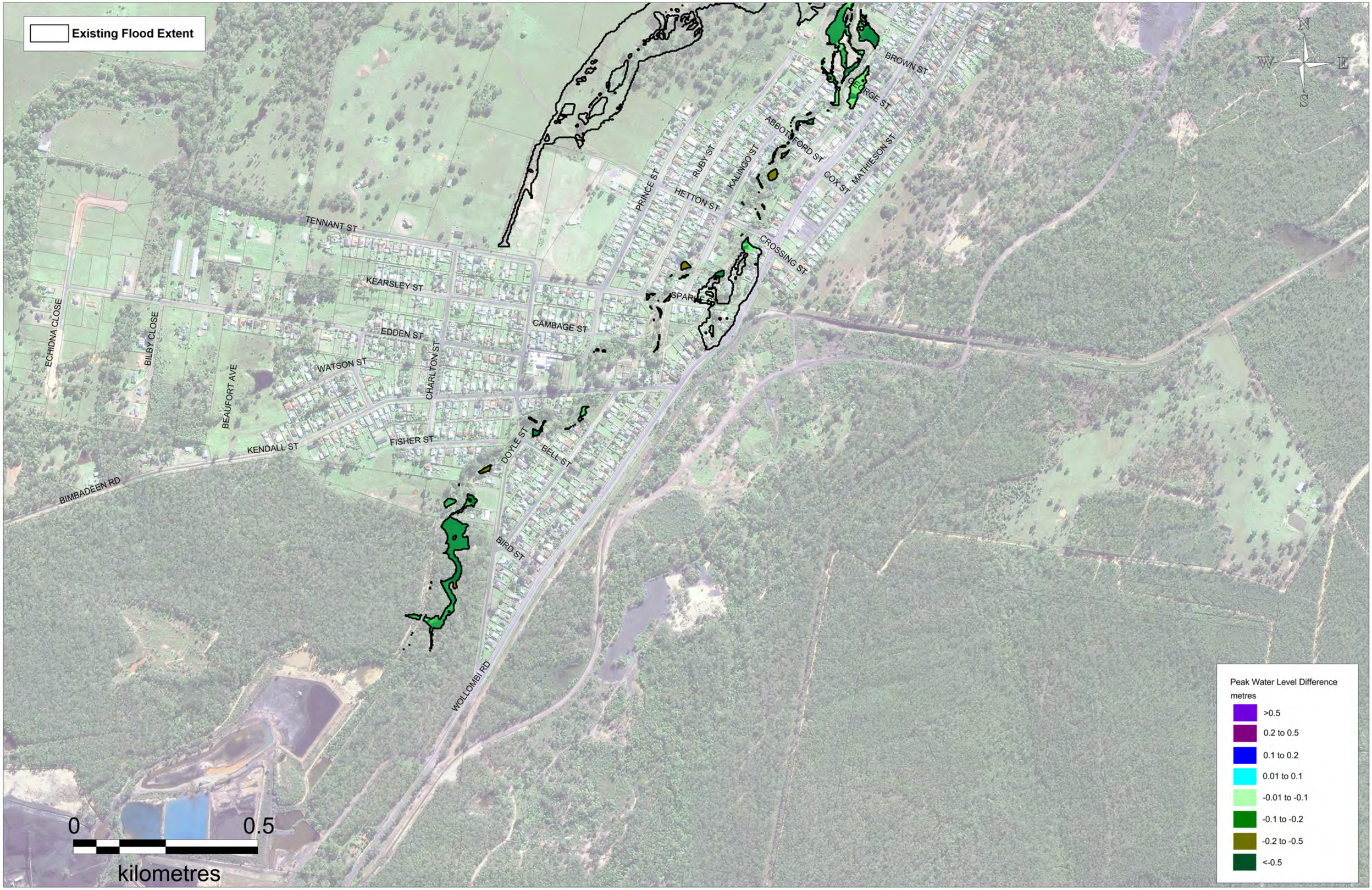


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FIGURE 11-42 : APRIL 2015 EVENT - PEAK WATER LEVEL DIFFERENCES
FM6 Results Less Existing Results

W4951
April 2015

Cessnock City (Black Creek)

APPENDIX B
CONSULTATION INFORMATION

Cardno
Shaping the Future

MEDIA RELEASE

Black Creek Floodplain Risk Management Study and Plan

Council is committed to comprehensive Floodplain Management in accordance with the process outlined in the NSW Government's 2005 *Floodplain Development Manual*. As part of this process, Cessnock City Council has engaged specialist flood consultants, Cardno, to prepare the Floodplain Risk Management Study and Plan for the Black Creek catchment. The Black Creek catchment comprises Black, Bellbird, Lavender, Limestone, Kearsley and Aberdare Creeks, its tributaries and incorporates Cessnock CBD.

Cessnock City Council has been working through the floodplain management process for Black Creek catchment and has completed the Black Creek Flood Study (2010), which provides a description of flood behaviour in the catchment and defines the flood extents for a range of storm events. In conjunction with Council, Cardno will be seeking to build upon this earlier work by undertaking some further investigations on flooding in the catchment including potential impacts of climate change.

The main objectives of the study and plan will be to identify options to mitigate and manage flood risk. This will involve consideration of options that seek to:

- Modify flood behaviour (e.g. levees, upgrade of stormwater systems);
- Mitigate the impact of flooding on existing properties (e.g. via floor raising);
- Control future development in the floodplain; and
- Guide emergency management when a flood occurs.

An Information Brochure has been prepared to outline the current investigations and potential flood damage reduction options for the Black Creek catchment. A copy of the brochure can be obtained at the following locations during ordinary office and library hours:

- Cessnock City Council offices, 62-78 Vincent Street, Cessnock; and
- Cessnock Library, 65-67 Vincent Street, Cessnock.

The brochure is also available for download from Council's website. Interested members of the community are invited to forward any comments or suggestions for other flood management measures which may be worthy of consideration. Comments can be submitted in writing by no later than 31st July, 2012 to the:

General Manager
Cessnock City Council
PO Box 152
CESSNOCK NSW 2325

Or via e-mail at: council@cessnock.nsw.gov.au

Further opportunity for comment will be provided via a community forum and during the public exhibition period of the Draft Floodplain Risk Management Study, which will be advertised on Council's website and in the local press.

The floodplain management process is part of the NSW State Government's Floodplain Management Policy. The project is jointly funded under the Floodplain Management Program between Office of Environment and Heritage and Cessnock City Council. The Management Plan is expected to be completed mid 2013.

ENDS

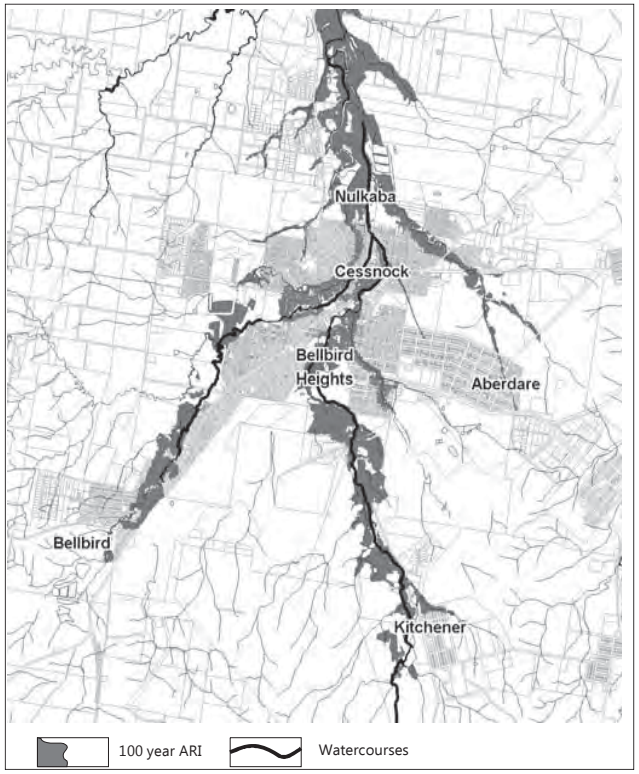
Glossary

Culvert – a drain or covered channel that passes under a road or railroad.

Levee Banks – An embankment usually constructed from earth or concrete built along the banks of a river to help prevent overflow of its waters.

Retarding/Detention Basin - A naturally occurring or constructed depression in the land surface that detains stormwater runoff by allowing it to slowly drain out of the basin into the adjoining natural drainage line or creek.

Stormwater Harvesting - the collection, storage, treatment and use of stormwater runoff from urban areas.



If you have any further comments that relate to the Black Creek Floodplain Risk Management Study and Plan, please express them in the space below. Please feel free to attach additional pages if necessary.

Thank you for providing the above information. Please remember to return the completed survey in the reply paid envelope by 25 October 2013. A representative from Cardno may contact you in the near future to discuss your response.

YOUR PERSONAL INFORMATION WILL REMAIN CONFIDENTIAL

If you have any queries, please contact:

Peter Jennings
Cessnock City Council
P: (02) 4993 4119
F: (02) 4993 2503
E: peter.jennings@cessnock.nsw.gov.au

Kieran Geraghty
Cardno
P: (02) 9496 7700
F: (02) 9499 3902
E: kieran.geraghty@cardno.com.au

SEPTEMBER 2013

CESSNOCK CITY (BLACK CREEK) Floodplain Risk Management Study & Plan

Local Resident/Business/Land Owner Survey

*Note: information supplied will remain completely confidential.

Q1. Could you please provide us with the following details? We may wish to contact you to discuss some of the information you have provided us.

Name: .....

Address: .....

.....

Daytime Ph: .....

Email: .....

Q2. Is your property (please tick)

☐ Owner occupied ☐ Occupied by a tenant

☐ Business ☐ Other

Operating hours:

Q3. What type of structure is your property/business? (please tick)

☐ Freestanding house ☐ Apartment/ dual occupancy

☐ Caravan/mobile home ☐ Other (Please Specify)

Q4. How long have you lived, worked and/or owned your property? ..... Years .

Q5. How long have you lived in the Black Creek Study Area? ..... Years .

Q6. How many people live/work at your property? .....

Q 7. Number of permanent residents at this address aged:

☐ 0 - 4 years ☐ 5 - 24 years

☐ 25 - 64 years ☐ 65+ years

prepared for CESSNOCK

prepared by Cardno Shaping the Future

Our team appreciates the diverse effects of flooding – from its dynamic shaping of the environment through to its potential negative social and economic impact. With this knowledge we analyse and develop comprehensive plans.

Q 8. Have you ever experienced flooding since living/working in the Black Creek catchment? (please tick relevant boxes)

- ☐ Yes, floodwaters entered my house/business
- ☐ Yes, floodwaters entered my yard
- ☐ Yes, the road was flooded and I couldn't drive my car
- ☐ Yes, the creek broke its banks
- ☐ Yes, other parts of my neighbourhood were flooded
- ☐ No, I haven't experienced a flood (go to Q.11)

Q 9. If you have experienced a flood, how did the flooding affect you and your family/business? (please tick relevant boxes)

- ☐ Parts of my house/business building were damaged
- ☐ The contents of my house/business were damaged
- ☐ My garden, yard, and/or surrounding property were damaged
- ☐ My car(s) were damaged
- ☐ Other property was damaged (specify) .....
- ☐ I couldn't leave the house/business
- ☐ Family members/work mates couldn't leave/return to the house/business
- ☐ The flood disrupted my daily routine
- ☐ The flood affected me in other ways (specify) .....
- ☐ The flood didn't affect me

Q 10. Do you have any materials or photos you can provide to evidence the flooding you experienced? If yes, when did the flooding occur?

☐ Yes ☐ No

The flooding occurred on .....

Q 11. Do you think your property would be flooded sometime in the future? (please tick relevant boxes)

- ☐ No
- ☐ Yes, but only a small part of my yard
- ☐ Yes, most of my yard/outdoor areas of business could be flooded
- ☐ Yes, my house/office/business could flood over the floor

Q12. Where have you looked for information about flooding on your property? (please tick relevant boxes)

- ☐ Council's customer service centre
- ☐ Other information from Council (specify).....
- ☐ Viewed a Property Planning (Section 149) Certificate
- ☐ Information from a real estate agent
- ☐ Information from relatives, friends, neighbours, or the previous owner
- ☐ Other information (specify).....
- ☐ No information has been sought
- ☐ I do not believe my property is affected by flooding

If you answered yes to having looked for information on Council's website:

- ☐ What information have you looked for?
- ☐ Where were you able to find information?

Q13. As a local resident who may have witnessed flooding/drainage problems, you may have your own ideas on how to reduce flood risks. Which of the following management options would you prefer for the Black Creek catchment (1=least preferred, 5=most preferred)? Please also provide comments as to the location where you think the option might be suitable.

Proposed Option	Preference	Location/Other Comments?
Stormwater harvesting, such as rainwater tanks	1 2 3 4 5	
Retarding or detention basins; these temporarily hold water and reduce peak flood flows	1 2 3 4 5	
Improved flood flow paths	1 2 3 4 5	
Culvert/ bridge/pipe enlarging	1 2 3 4 5	
Levee banks (note Glossary on next page)	1 2 3 4 5	
Diversion of creeks and channels	1 2 3 4 5	
Environmental channel improvements, including removal of weeds & bank stabilisation	1 2 3 4 5	
Planning and flood-related development controls	1 2 3 4 5	
Education of community, providing greater awareness of potential hazards	1 2 3 4 5	
Flood forecasting, flood warning, evacuation planning and emergency response	1 2 3 4 5	
Other (please specify any options you believe are suitable). Please attach extra pages for other suggestions	1 2 3 4 5	

Alternatively you can provide comment using Floodengage (a trial floodplain risk management community engagement tool) at www.floodengage.com/cessnock

Q14. What do you think are the best ways to get input and feedback from the local community about this project? (please tick relevant boxes)

- ☐ Council's website ☐ Emails from Council
- ☐ Council's Floodplain Management Committee
- ☐ Formal Council meetings ☐ Information days in the local area
- ☐ Council's information page in the local paper
- ☐ Other articles in the local paper
- ☐ Community meetings
- ☐ Mail outs to all residents/business owners in the study area
- ☐ Other (specify).....

Q15. What is the main language spoken at home? English Other

Floodplain Risk Management Options

The following list of Floodplain Risk Management options presents some preliminary strategies that could be considered to minimise the risk and reduce the impact of flooding throughout the Black Creek catchment. These options will be considered in further detail during the preparation of the Management Study and Plan.

Examples of Flood Management Options	
	Description
Flood Modification Options	• Construction of levees where properties are most at risk • Upgrading of drainage systems i.e. construction of detention/retarding basins • Stabilisation works along drainage channels
Property Modification and Planning Control Options	• Building and development controls • Voluntary house raising program (for selected properties) • Voluntary house rebuilding subsidy scheme (for selected properties) • Voluntary property purchase program (for selected properties).
Emergency Response Modification Options	• Revision of the Local Disaster Plan (DISPLAN) • Public awareness and education—locality based flooding information for residents • Public awareness and education—flooding information for schools • Flood depth markers at major (flood affected) road crossings • Continuation of existing public awareness and education campaigns • Data collection strategies for future floods

Consultation

During the Floodplain Risk Management Study and Plan process, consultation will be undertaken with the community in order to establish a comprehensive list of management options.

Interested members of the community are invited to forward any comments or suggestions for other floodplain management measures which may be worthy of consideration at this early stage of the process. Comments can be submitted in writing by no later than 25 October 2013 to:

General Manager, Cessnock City Council
PO Box 152 Cessnock NSW 2325
or via email at: council@cessnock.nsw.gov.au

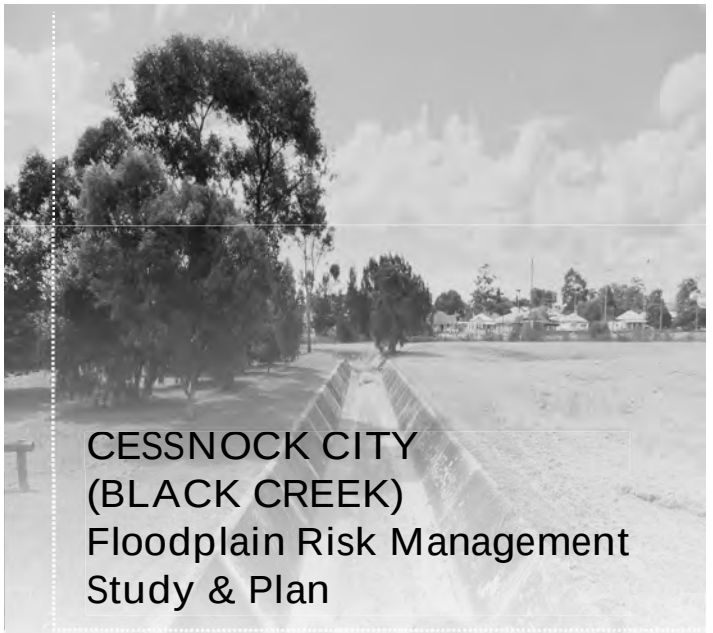
You will have further opportunities to comment on the direction of the project during the public exhibition periods of the Draft Risk Management Study and Plan. Any comments received during these periods will be taken into account before finalisation.

For further information regarding this project please see Council's website www.cessnock.nsw.gov.au, or contact either Cessnock City Council or Cardno via the details below.

Contact Us

Peter Jennings
Cessnock City Council
62-78 Vincent Street, Cessnock
P: (02) 4993 4119
F: (02) 4993 2503
E: peter.jennings@cessnock.nsw.gov.au

Kieran Geraghty
Cardno
Level 9, 203 Pacific Highway
St Leonards NSW 2065
P: (02) 9496 7700
F: (02) 9499 3902
E: kieran.geraghty@cardno.com.au



CESSNOCK CITY (BLACK CREEK) Floodplain Risk Management Study & Plan

Information Brochure

Cessnock City Council has engaged Cardno to assist with the preparation of the Black Creek Floodplain Risk Management Study and Plan.

The Risk Management Study and Plan follows from the Flood Study, completed in 2010, which identified the existing flooding behaviour in the Black Creek catchment. The purpose of this Risk Management Study and Plan is to identify and recommend appropriate actions to manage flood risks in the Black Creek catchment.

This brochure provides an introduction to the Risk Management Study and Plan and informs you of its objectives.

prepared for CESSNOCK CITY COUNCIL

prepared by Cardno Shaping the Future

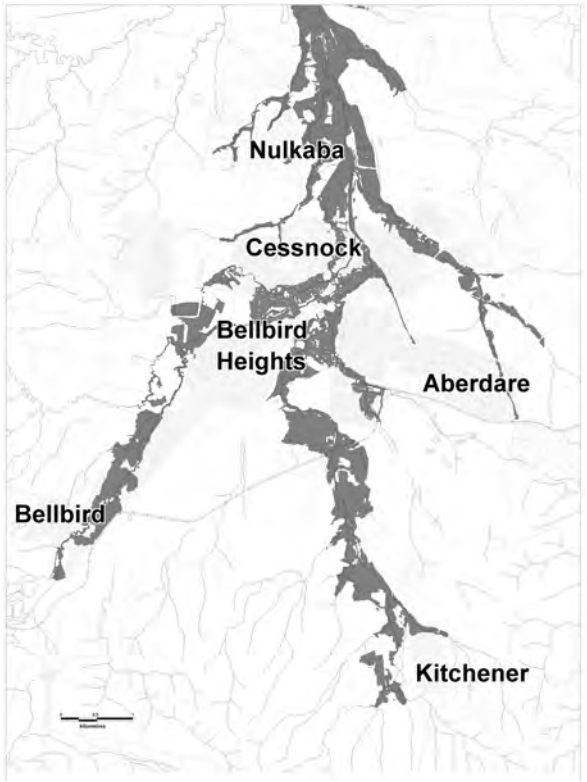
Existing Flooding Issues

Cessnock has experienced significant flooding in the past as outlined in the Flood Study (DHI Group, 2010).

The confluence of main creeks in the vicinity of the city and urbanised nature of the catchment affect flood behaviour.

Extensive flooding has been observed throughout the CBD, South Cessnock and Bellbird with adverse effects on property.

The expected flood extents for the 1 in 100 year event is shown below.

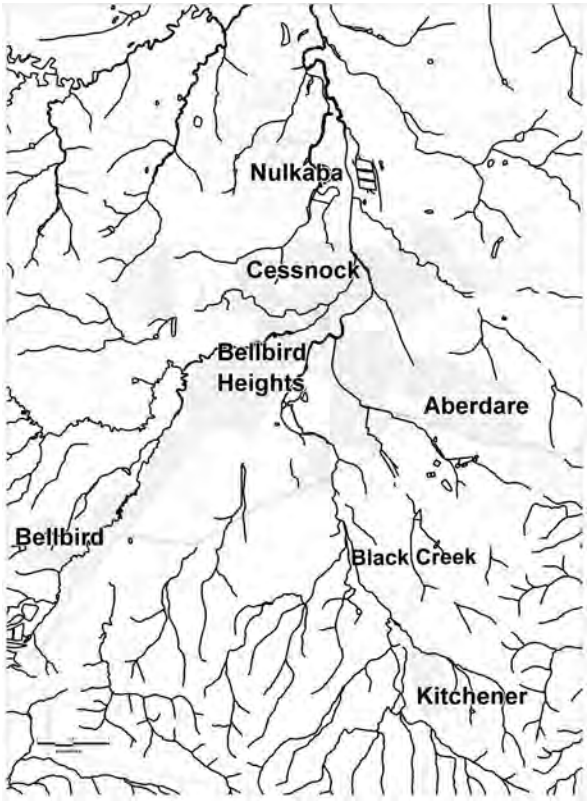


Study Area

The study area comprises Black Creek and other main creeks including Bellbird, Lavender, Limestone, Kearsley and Aberdare and is shown below.

The catchment is a combination of urban and rural with some bushland.

Flows are conveyed in natural channels in a northerly direction towards Cessnock where they enter a system of concrete lined channels in urban areas.



Floodplain Management Process

Council's Floodplain Risk Management Committee (the Committee) oversees the Floodplain Management process. The Committee meets regularly and includes representatives from Council, Office of Environment and Heritage (OEH), State Emergency Service (SES), Catchment Management Authority (CMA), and representatives of the local community.

Floodplain Risk Management Study and Plan Objectives

The objectives of the study and plan are:

Floodplain Risk Management Study

Find an appropriate mix of management measures and strategies to effectively manage the full range of flood risk in accordance with the NSW Government Floodplain Development Manual (2005) through an effective public participation and community consultation program. The information from this study will enable Council to formulate a Floodplain Risk Management Plan for the study area.

Floodplain Risk Management Plan:

Formulate a cost effective plan for the study area based on the findings of the Floodplain Risk Management Study and provide a priority program for implementation of the recommended works and measures in accordance with the Manual. The plan will detail how the existing and future flood risk within the study area will be managed.

Floodplain Risk Management Options

The following list of Floodplain Risk Management options presents some preliminary strategies that are being considered to minimise the risk and reduce the impact of flooding throughout the Black Creek catchment:

- A detention basin upstream of Cessnock.

- Channel widening and reshaping of Black Creek in vicinity of CBD

- A detention basin upstream of south Cessnock
- Channel widening within South Cessnock

Consultation

During the development of the Floodplain Risk Management Study and Plan, consultation will be undertaken with the community in order to discuss management options that have been identified and obtain feedback as part of the following process.

Draft Study and Plan considered by Floodplain Management Committee and Council (Mar/Apr 2015)

↓

Study and Plan on Public Exhibition and Community Workshop (April 2015)

↓

Review of Exhibition comments and Finalisation of Draft Study and Plan (May 2015)

↓

Adoption of Study and Plan by Council (June 2015)

Further advice will be provided through local media and our Website

Cessnock City Council
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62-78 Vincent Street
CESSNOCK NSW AUSTRALIA 2325

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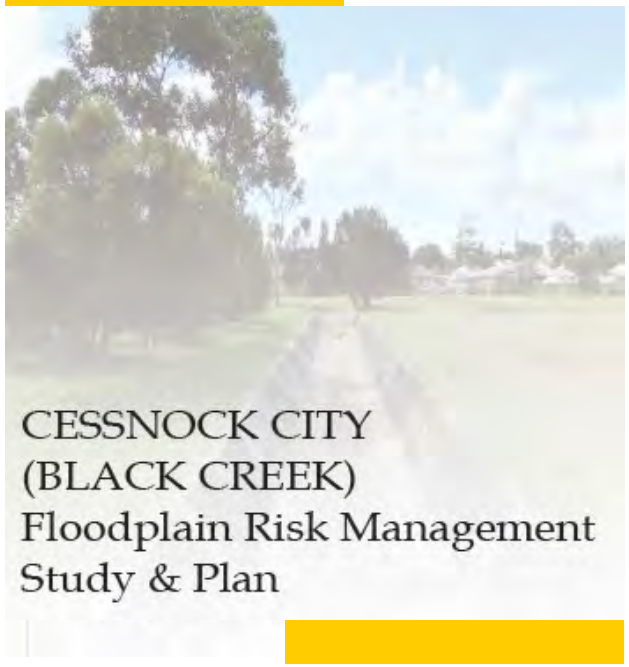
Fax: +61 (02) 4993 2500
email: council@cessnock.nsw.gov.au

Cessnock City Council



Cessnock City Council has engaged consultants Cardno to assist with the preparation of the Black Creek Floodplain Risk Management Study and Plan.

This follows on from the Flood Study completed in 2010, which identified the existing flood behaviour in the Black Creek catchment.

This brochure provides an update to the Plan and sets out the remaining steps for completion.

1. Formation of a Committee | 2. Data Collection | 3. Flood Study | 4. Floodplain Risk Management Study | 5. Floodplain Risk Management Plan | 6. Implementation of Plan

Existing Flood Issues

Cessnock has experienced significant flooding in the past as outlined in the Flood Study (DHI 2010).

The confluence of many creeks in the vicinity of the city, and urbanised development within the catchment affect flood behaviour.

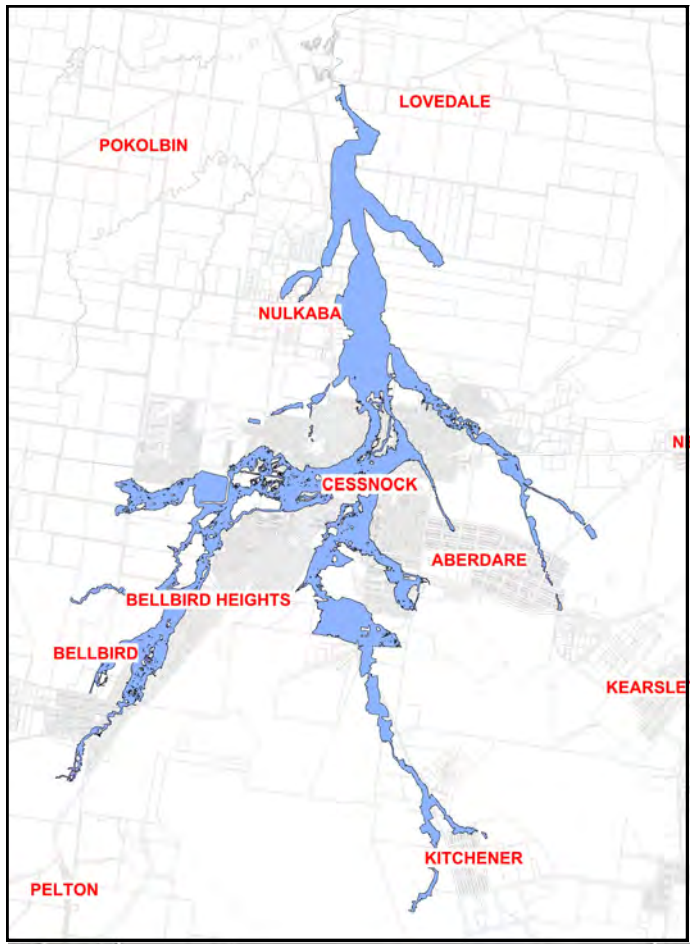
Vincent Street 1949

Extensive mainstream and localised flooding has been observed within the creeks and Hunter Water owned channels throughout the CBD, South Cessnock and Bellbird with adverse effects on property.

Oliver Street 2015

Study Area

The study area comprises Black Creek and other main creeks including Bellbird, Lavender and Kearsley and Aberdare as indicated on map below.



Floodplain Management Process

Council's Floodplain Risk Management Committee meets regularly and includes representatives from Council, Office of Environment & Heritage (OEH) , State Emergency Services (SES), Catchment Management Authority (CMA) and representatives from the community.

Floodplain Risk Management Study Objectives

The objectives of the Study are to :

- **Find an appropriate mix of management measures and strategies to effectively manage the full range of flood risk.**
- **Undertake a public participation and community consultation program.**
- **Formulate a Floodplain Risk Management Plan taking into consideration identified options for**

Floodplain Risk Management Plan Objectives

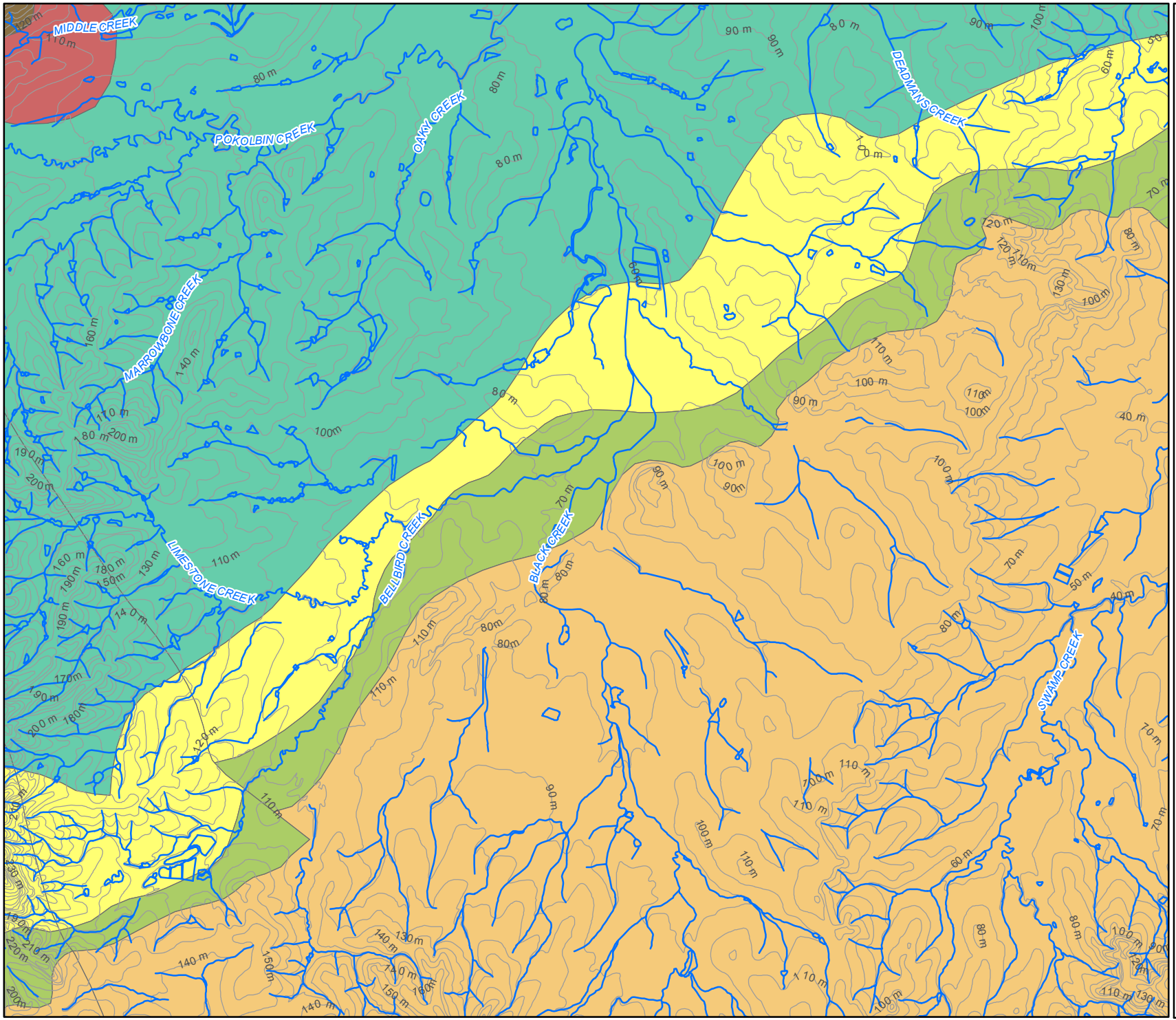
The objectives of the Plan are to :

- **Formulate a cost effective plan for the study area.**
- **Provide a priority program for implementation of the recommended works and measures.**
- **Detail how the existing and future risk within the study area will be managed.**

Cessnock City (Black Creek)

APPENDIX C
SOCIAL AND ENVIRONMENTAL ASSESSMENT

Cardno
Shaping the Future



Geology

BLACK CREEK FLOODPLAIN
RISK MANAGEMENT STUDY

Legend

- Watercourses
- 10m Topographic Contours
- Allandale Formation
- Branxton Formation
- Farley Formation
- Greta Coal Measures
- Rutherford Formation
- Sediments

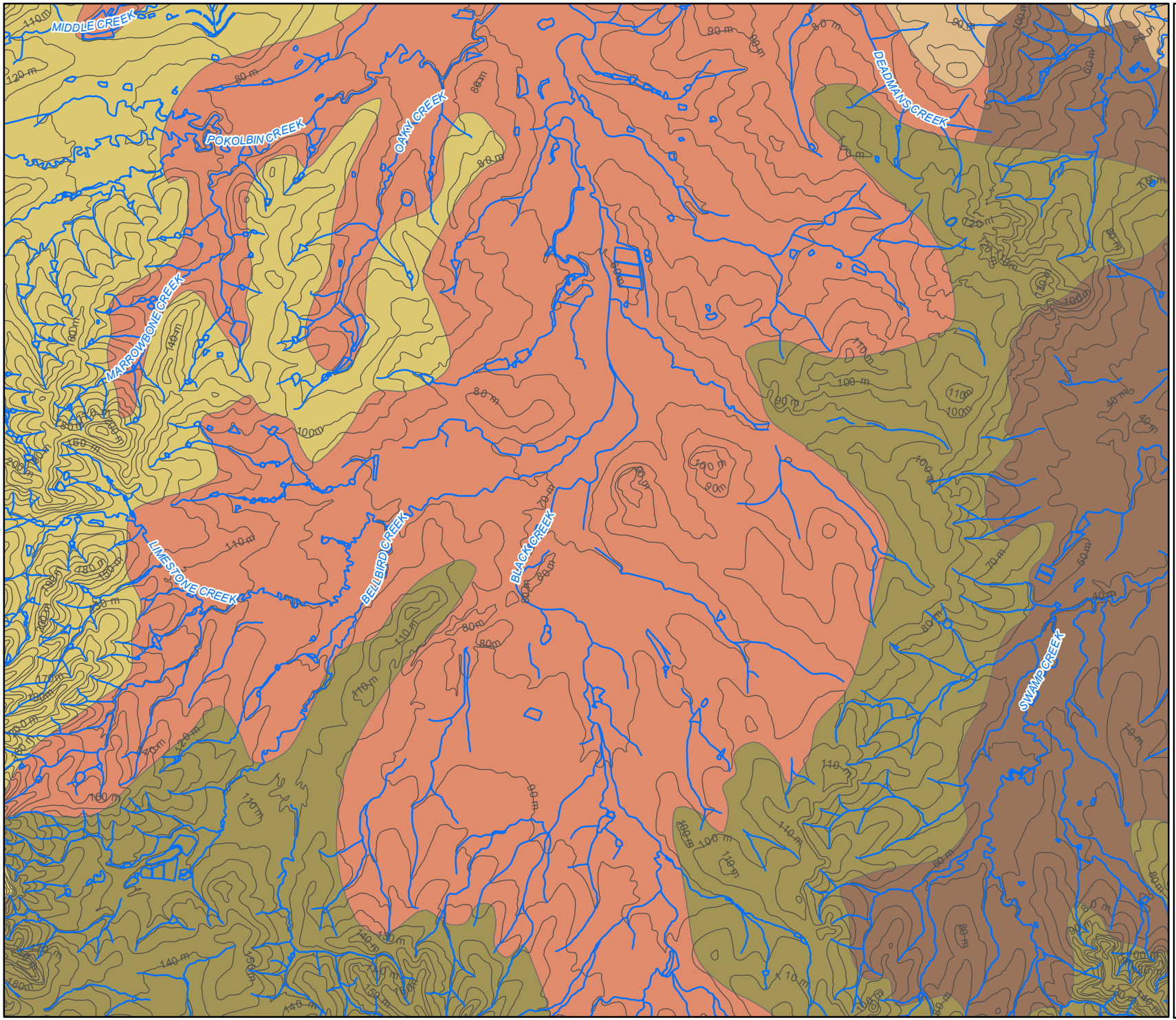
FIGURE 1

1:55,000 Scale at A4

Kilometers
0 0.25 0.5 1 1.5 2 2.5

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-04-30
Coordinate System: GDA 1994 MGA Zone 56
Project: W4951
Map: G1001_Geology.mxd 01
Data Source: Land and Property Information



Soil Landscapes

BLACK CREEK FLOODPLAIN
RISK MANAGEMENT STUDY

Legend

- Watercourses
- 10m Topographic Contours

Soil Landscapes

- Aberdare
- Branxton
- Neath
- Pokolbin
- Rothbury

N
W E
S

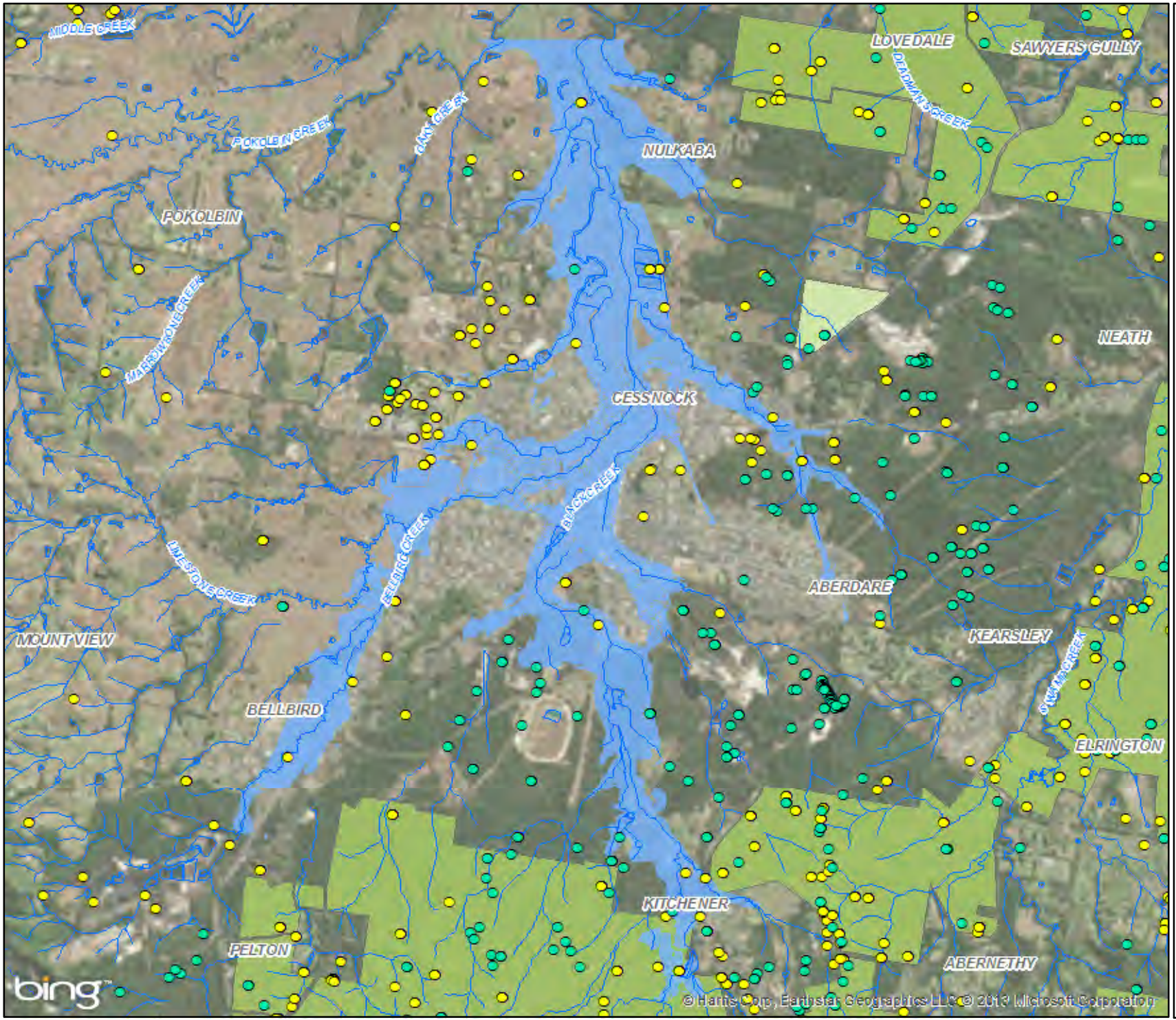
FIGURE 2

1:55,000 Scale at A4

Kilometers
0 0.25 0.5 1 1.5 2 2.5

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-04-30
Coordinate System: GDA 1994 MGA Zone 56
Project: W4951
Map: G1002_Soils.mxd 01
Data Source: Land and Property Information



Threatened Species

BLACK CREEK FLOODPLAIN
RISK MANAGEMENT STUDY

Legend

- Threatened Flora Records (NPWS Atlas, 2013)
- Threatened Fauna Records (NPWS Atlas, 2013)
- Watercourses
- PMF Extent
- State Forest
- Werakata State Conservation Area

N
W E
S

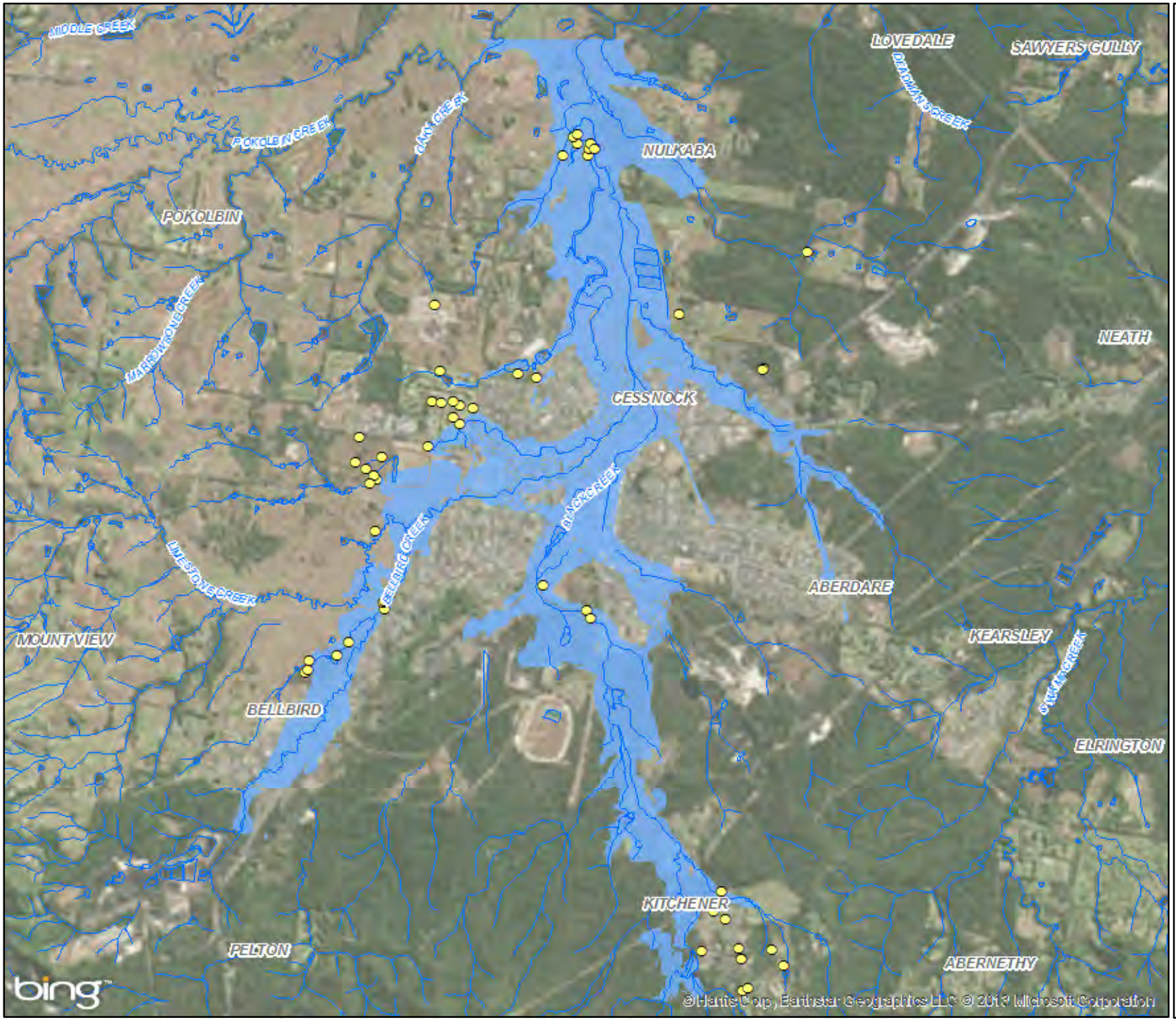
FIGURE 3

1:55,000 Scale at A4

Kilometers
0 0.25 0.5 1 1.5 2 2.5

Cardno

Date: 2013-05-14
Coordinate System: GDA 1994 MGA Zone 56
Project: W4951
Map: G1003_FloraFauna.mxd 01
Data Source: Land and Property Information and NPWS Atlas (Bionet)



Aboriginal Heritage

BLACK CREEK FLOODPLAIN
RISK MANAGEMENT STUDY

Legend

- Aboriginal Heritage Records (AHIMS, 2013)
- Watercourses
- PMF Extent

N
W E
S

FIGURE 4

1:55,000 Scale at A4

Kilometers
0 0.25 0.5 1 1.5 2 2.5

Cardno

Date: 2013-05-14
Coordinate System: GDA 1994 MGA Zone 56
Project: W4951
Map: G1004_Heritage.mxd 01
Data Source: Land and Property Information and the Aboriginal Heritage Information Management System

Fauna Records within the Black Creek Catchment (OEH, 2013a)

Family Name	Scientific Name	Common Name	TSC Act Status	EPBC Act Status
Acanthizidae	Acanthiza chrysorrhoa	Yellow-rumped Thornbill	P	
Acanthizidae	Acanthiza lineata	Striated Thornbill	P	
Acanthizidae	Acanthiza nana	Yellow Thornbill	P	
Acanthizidae	Acanthiza pusilla	Brown Thornbill	P	
Acanthizidae	Acanthiza reguloides	Buff-rumped Thornbill	P	
Acanthizidae	Acanthiza sp.	Unidentified Thornbill	P	
Meliphagidae	Acanthorhynchus tenuirostris	Eastern Spinebill	P	
Accipitridae	Accipiter cirrocephalus	Collared Sparrowhawk	P	
Accipitridae	Accipiter fasciatus	Brown Goshawk	P	
Acrobatidae	Acrobates pygmaeus	Feathertail Glider	P	
Acrocephalidae	Acrocephalus australis	Australian Reed-Warbler	P	
Ardeidae	Ardea ibis	Cattle Egret		M, Ma
Aegothelidae	Aegotheles cristatus	Australian Owlet-nightjar	P	
Psittacidae	Alisterus scapularis	Australian King-Parrot	P	
Agamidae	Amphibolurus muricatus	Jacky Lizard	P	
Anatidae	Anas castanea	Chestnut Teal	P	
Anatidae	Anas gracilis	Grey Teal	P	
Anatidae	Anas superciliosa	Pacific Black Duck	P	
Dasyuridae	Antechinus flavipes	Yellow-footed Antechinus	P	
Dasyuridae	Antechinus stuartii	Brown Antechinus	P	
Meliphagidae	Anthochaera carunculata	Red Wattlebird	P	
Meliphagidae	Anthochaera chrysoptera	Little Wattlebird	P	
Meliphagidae	Anthochaera phrygia	Regent Honeyeater	E4A,P	E
Motacillidae	Anthus novaeseelandiae	Australian Pipit	P	
Apodidae	Apus pacificus	Fork-tailed Swift		M, Ma
Accipitridae	Aquila audax	Wedge-tailed Eagle	P	
Ardeidae	Ardea ibis	Cattle Egret	P	M, Ma
Ardeidae	Ardea modesta	Eastern Great Egret	P	
Ardeidae	Ardea pacifica	White-necked Heron	P	
Artamidae	Artamus cyanopterus	Dusky Woodswallow	P	
Accipitridae	Aviceda subcristata	Pacific Baza	P	
Anatidae	Biziura lobata	Musk Duck	P	
Ardeidae	Botaurus poiciloptilus	Australasian Bittern		E
Cacatuidae	Cacatua galerita	Sulphur-crested Cockatoo	P	
Cacatuidae	Cacatua sanguinea	Little Corella	P	
Cacatuidae	Cacatua tenuirostris	Long-billed Corella	P	
Cuculidae	Cacomantis flabelliformis	Fan-tailed Cuckoo	P	
Cuculidae	Cacomantis pallidus	Pallid Cuckoo	P	
Cacatuidae	Callocephalon fimbriatum	Gang-gang Cockatoo	V,P,3	

Family Name	Scientific Name	Common Name	TSC Act Status	EPBC Act Status
Cacatuidae	Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo	P	
Cacatuidae	Calyptorhynchus lathami	Glossy Black-Cockatoo	V,P,2	
Scincidae	Carlia tetradactyla	Southern Rainbow-skink	P	
Centropodidae	Centropus phasianinus	Pheasant Coucal	P	
Alcedinidae	Ceyx azureus	Azure Kingfisher	P	
Cuculidae	Chalcites basalis	Horsfield's Bronze-Cuckoo	P	
Cuculidae	Chalcites lucidus	Shining Bronze-Cuckoo	P	
Vespertilionidae	Chalinolobus dwyeri	Large-eared Pied Bat, Large Pied Bat	V	V
Vespertilionidae	Chalinolobus gouldii	Gould's Wattled Bat	P	
Vespertilionidae	Chalinolobus morio	Chocolate Wattled Bat	P	
Chelidae	Chelodina longicollis	Eastern Snake-necked Turtle	P	
Anatidae	Chenonetta jubata	Australian Wood Duck	P	
Acanthizidae	Chthonicola sagittata	Speckled Warbler	V,P	
Psophodidae	Cinclosoma punctatum	Spotted Quail-thrush	P	
Cisticolidae	Cisticola exilis	Golden-headed Cisticola	P	
Climacteridae	Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V,P	
Pachycephalidae	Colluricincla harmonica	Grey Shrike-thrush	P	
Campephagidae	Coracina novaehollandiae	Black-faced Cuckoo-shrike	P	
Campephagidae	Coracina papuensis	White-bellied Cuckoo-shrike	P	
Campephagidae	Coracina tenuirostris	Cicadabird	P	
Corcoracidae	Corcorax melanorhamphos	White-winged Chough	P	
Climacteridae	Cormobates leucophaea	White-throated Treecreeper	P	
Corvidae	Corvus coronoides	Australian Raven	P	
Phasianidae	Coturnix ypsilophora	Brown Quail	P	
Artamidae	Cracticus nigrogularis	Pied Butcherbird	P	
Artamidae	Cracticus tibicen	Australian Magpie	P	
Artamidae	Cracticus torquatus	Grey Butcherbird	P	
Myobatrachidae	Crinia signifera	Common Eastern Froglet	P	
Scincidae	Cryptoblepharus virgatus	Cream-striped Shinning-skink	P	
Elapidae	Cryptophis nigrescens	Eastern Small-eyed Snake	P	
Scincidae	Ctenotus robustus	Robust Ctenotus	P	
Scincidae	Ctenotus taeniolatus	Copper-tailed Skink	P	
Anatidae	Cygnus atratus	Black Swan	P	
Alcedinidae	Dacelo novaeguineae	Laughing Kookaburra	P	
Neosittidae	Daphoenositta chrysoptera	Varied Sittella	V,P	
Pardalotidae	Dasyornis brachypterus	Eastern Bristlebird	E1	E
Dasyuridae	Dasyurus maculatus (SE mainland population)	Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population)	V	E

Family Name	Scientific Name	Common Name	TSC Act Status	EPBC Act Status
Elapidae	Demansia psammophis	Yellow-faced Whip Snake	P	
Colubridae	Dendrelaphis punctulatus	Common Tree Snake	P	
Nectariniidae	Dicaeum hirundinaceum	Mistletoebird	P	
Gekkonidae	Diplodactylus vittatus	Wood Gecko	P	
Scincidae	Egernia striolata	Tree Skink	P	
Scincidae	Egernia whitii	White's Skink	P	
Ardeidae	Egretta garzetta	Little Egret	P	
Ardeidae	Egretta novaehollandiae	White-faced Heron	P	
Accipitridae	Elanus axillaris	Black-shouldered Kite	P	
Charadriidae	Elseyornis melanops	Black-fronted Dotterel	P	
Meliphagidae	Entomyzon cyanotis	Blue-faced Honeyeater	P	
Cacatuidae	Eolophus roseicapillus	Galah	P	
Petroicidae	Eopsaltria australis	Eastern Yellow Robin	P	
Accipitridae	Erythrotriorchis radiatus	Red Goshawk	E	V
Cuculidae	Eudynamys orientalis	Eastern Koel	P	
Scincidae	Eulamprus quoyii	Eastern Water-skink	P	
Scincidae	Eulamprus tenuis	Barred-sided Skink	P	
Caprimulgidae	Eurostopodus mystacalis	White-throated Nightjar	P	
Coraciidae	Eurystomus orientalis	Dollarbird	P	
Falconidae	Falco berigora	Brown Falcon	P	
Falconidae	Falco cenchroides	Nankeen Kestrel	P	
Falconidae	Falco longipennis	Australian Hobby	P	
Falconidae	Falco peregrinus	Peregrine Falcon	P	
Pachycephalidae	Falcunculus frontatus	Eastern Shrike-tit	P	
Vespertilionidae	Falsistrellus tasmaniensis	Eastern False Pipistrelle	V,P	
Rallidae	Fulica atra	Eurasian Coot	P	
Scolopacidae	Gallinago hardwickii	Latham's Snipe	P	M, Ma
Rallidae	Gallinula tenebrosa	Dusky Moorhen	P	
Columbidae	Geopelia humeralis	Bar-shouldered Dove	P	
Columbidae	Geopelia striata	Peaceful Dove	P	
Acanthizidae	Gerygone albogularis	White-throated Gerygone	P	
Psittacidae	Glossopsitta concinna	Musk Lorikeet	P	
Psittacidae	Glossopsitta pusilla	Little Lorikeet	V,P	
Monarchidae	Grallina cyanoleuca	Magpie-lark	P	
Accipitridae	Haliaeetus leucogaster	White-bellied Sea-Eagle		M, Ma
Accipitridae	Haliastur sphenurus	Whistling Kite	P	
Elapidae	Hemiaspis signata	Black-bellied Swamp Snake	P	
Scincidae	Hemiergis decresiensis	Three-toed Earless Skink	P	
Accipitridae	Hieraaetus morphnoides	Little Eagle	V,P	
Apodidae	Hirundapus caudacutus	White-throated Needletail	P	M, Ma

Family Name	Scientific Name	Common Name	TSC Act Status	EPBC Act Status
Hirundinidae	Hirundo neoxena	Welcome Swallow	P	
Elapidae	Hoplocephalus	Broad-headed Snake	E1	V
Acanthizidae	Hylacola pyrrhopygia	Chestnut-rumped Heathwren	P	
Scincidae	Lampropholis delicata	Dark-flecked Garden Sunskink	P	
Scincidae	Lampropholis guichenoti	Pale-flecked Garden Sunskink	P	
Psittacidae	Lathamus discolor	Swift Parrot	E1,P	E, Ma
Columbidae	Leucosarcia picata	Wonga Pigeon	P	
Pygopodidae	Lialis burtonis	Burton's Snake-lizard	P	
Meliphagidae	Lichenostomus chrysops	Yellow-faced Honeyeater	P	
Meliphagidae	Lichenostomus fuscus	Fuscous Honeyeater	P	
Meliphagidae	Lichenostomus leucotis	White-eared Honeyeater	P	
Meliphagidae	Lichenostomus melanops	Yellow-tufted Honeyeater	P	
Meliphagidae	Lichenostomus penicillatus	White-plumed Honeyeater	P	
Myobatrachidae	Limnodynastes dumerilii	Eastern Banjo Frog	P	
Myobatrachidae	Limnodynastes dumerilii		P	
Myobatrachidae	Limnodynastes dumerilii		P	
Myobatrachidae	Limnodynastes ornatus	Ornate Burrowing Frog	P	
Myobatrachidae	Limnodynastes peronii	Brown-striped Frog	P	
Myobatrachidae	Limnodynastes	Spotted Grass Frog	P	
Hylidae	Litoria aurea	Green and Golden Bell Frog	E1	V
Hylidae	Litoria caerulea	Green Tree Frog	P	
Hylidae	Litoria dentata	Bleating Tree Frog	P	
Hylidae	Litoria fallax	Eastern Dwarf Tree Frog	P	
Hylidae	Litoria latopalmata	Broad-palmed Frog	P	
Hylidae	Litoria peronii	Peron's Tree Frog	P	
Hylidae	Litoria tyleri	Tyler's Tree Frog	P	
Hylidae	Litoria verreauxii	Verreaux's Frog	P	
Hylidae	Litoria wilcoxii		P	
Accipitridae	Lophoictinia isura	Square-tailed Kite	V,P,3	
Macropodidae	Macropod sp.	unidentified macropod	P	
Macropodidae	Macropus giganteus	Eastern Grey Kangaroo	P	
Macropodidae	Macropus robustus	Common Wallaroo	P	
Macropodidae	Macropus rufogriseus	Red-necked Wallaby	P	
Maluridae	Malurus cyaneus	Superb Fairy-wren	P	
Maluridae	Malurus lamberti	Variegated Fairy-wren	P	
Meliphagidae	Manorina melanocephala	Noisy Miner	P	
Meliphagidae	Manorina melanophrys	Bell Miner	P	
Meliphagidae	Meliphaga lewinii	Lewin's Honeyeater	P	
Meliphagidae	Melithreptus brevirostris	Brown-headed Honeyeater	P	

Family Name	Scientific Name	Common Name	TSC Act Status	EPBC Act Status
Meliphagidae	Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V,P	
Meliphagidae	Melithreptus lunatus	White-naped Honeyeater	P	
Meropidae	Merops ornatus	Rainbow Bee-eater	P	M, Ma
Phalacrocoracidae	Microcarbo melanoleucos	Little Pied Cormorant	P	
Petroicidae	Microeca fascinans	Jacky Winter	P	
Vespertilionidae	Miniopterus australis	Little Bentwing-bat	V,P	
Vespertilionidae	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V,P	
Myobatrachidae	Mixophyes iteratus	Giant Barred Frog, Southern Barred Frog	E1	E
Dicruridae	Monarcha melanopsis			
Scincidae	Morethia boulengeri	South-eastern Morethia Skink	P	
Molossidae	Mormopterus "Species 2"	Undescribed Freetail Bat	P	
Molossidae	Mormopterus "Species 4" (big penis)	Black-faced Monarch	P	M, ma
Molossidae	Mormopterus norfolkensis	Eastern Freetail-bat	V,P	
Molossidae	Mormopterus planiceps	Little Mastiff-bat	P	
Monarchidae	Myiagra cyanoleuca	Satin Flycatcher	P	M, Ma
Monarchidae	Myiagra rubecula	Leaden Flycatcher	P	
Vespertilionidae	Myotis macropus	Southern Myotis	V,P	
Meliphagidae	Myzomela sanguinolenta	Scarlet Honeyeater	P	
Myobatrachidae	Neobatrachus sudelli	Sudell's Frog	P	
Estrildidae	Neochmia temporalis	Red-browed Finch	P	
Strigidae	Ninox connivens	Barking Owl	V,P,3	
Strigidae	Ninox novaeseelandiae	Southern Boobook	P	
Strigidae	Ninox strenua	Powerful Owl	V,P,3	
Ardeidae	Nycticorax caledonicus	Nankeen Night Heron	P	
Vespertilionidae	Nyctophilus geoffroyi	Lesser Long-eared Bat	P	
Vespertilionidae	Nyctophilus gouldi	Gould's Long-eared Bat	P	
Cacatuidae	Nymphicus hollandicus	Cockatiel	P	
Columbidae	Ocyphaps lophotes	Crested Pigeon	P	
Gekkonidae	Oedura robusta	Robust Velvet Gecko	P	
Oriolidae	Oriolus sagittatus	Olive-backed Oriole	P	
Pachycephalidae	Pachycephala pectoralis	Golden Whistler	P	
Pachycephalidae	Pachycephala rufiventris	Rufous Whistler	P	
Pardalotidae	Pardalotus punctatus	Spotted Pardalote	P	
Pardalotidae	Pardalotus sp.	Unidentified Pardalote	P	
Pardalotidae	Pardalotus striatus	Striated Pardalote	P	
Pelecanidae	Pelecanus conspicillatus	Australian Pelican	P	
Petauridae	Petaurus breviceps	Sugar Glider	P	
Petauridae	Petaurus norfolcensis	Squirrel Glider	V,P	

Family Name	Scientific Name	Common Name	TSC Act Status	EPBC Act Status
Hirundinidae	Petrochelidon ariel	Fairy Martin	P	
Hirundinidae	Petrochelidon nigricans	Tree Martin	P	
Macropodidae	Petrogale penicillata	Brush-tailed Rock-wallaby	E1	V
Petroicidae	Petroica boodang	Scarlet Robin	V,P	
Petroicidae	Petroica rosea	Rose Robin	P	
Phalacrocoracidae	Phalacrocorax carbo	Great Cormorant	P	
Phalacrocoracidae	Phalacrocorax sulcirostris	Little Black Cormorant	P	
Phalacrocoracidae	Phalacrocorax varius	Pied Cormorant	P	
Columbidae	Phaps chalcoptera	Common Bronzewing	P	
Phascolarctidae	Phascolarctos cinereus	Koala	V,P	V
Meliphagidae	Philemon corniculatus	Noisy Friarbird	P	
Meliphagidae	Phylidonyris niger	White-cheeked Honeyeater	P	
Agamidae	Physignathus lesueurii	Eastern Water Dragon	P	
Threskiornithidae	Platalea flavipes	Yellow-billed Spoonbill	P	
Threskiornithidae	Platalea regia	Royal Spoonbill	P	
Psittacidae	Platycercus elegans	Crimson Rosella	P	
Psittacidae	Platycercus eximius	Eastern Rosella	P	
Meliphagidae	Plectorhyncha lanceolata	Striped Honeyeater	P	
Podargidae	Podargus strigoides	Tawny Frogmouth	P	
Agamidae	Pogona barbata	Bearded Dragon	P	
Pomatostomidae	Pomatostomus temporalis	Grey-crowned Babbler (eastern subspecies)	V,P	
Rallidae	Porphyrio	Purple Swamphen	P	
Rallidae	Porzana pusilla	Baillon's Crake	P	
Psittacidae	Psephotus haematonotus	Red-rumped Parrot	P	
Elapidae	Pseudechis porphyriacus	Red-bellied Black Snake	P	
Pseudocheiridae	Pseudocheirus peregrinus	Common Ringtail Possum	P	
Muridae	Pseudomys novaehollandiae	New Holland Mouse	P	V
Muridae	Pseudomys oralis	Hastings River Mouse	E1	E
Elapidae	Pseudonaja textilis	Eastern Brown Snake	P	
Myobatrachidae	Pseudophryne bibronii	Bibron's Toadlet	P	
Myobatrachidae	Pseudophryne coriacea	Red-backed Toadlet	P	
Psophodidae	Psophodes olivaceus	Eastern Whipbird	P	
Pteropodidae	Pteropus poliocephalus	Grey-headed Flying-fox	V,P	V
Ptilonorhynchidae	Ptilonorhynchus violaceus	Satin Bowerbird	P	
Typhlopidae	Ramphotyphlops wiedii	Brown-snouted Blind Snake	P	
Muridae	Rattus fuscipes	Bush Rat	P	
Muridae	Rattus lutreolus	Swamp Rat	P	
Rhinolophidae	Rhinolophus megaphyllus	Eastern Horseshoe-bat	P	
Rhipiduridae	Rhipidura albiscapa	Grey Fantail	P	

Family Name	Scientific Name	Common Name	TSC Act Status	EPBC Act Status
Rhipiduridae	Rhipidura leucophrys	Willie Wagtail	P	
Rhipiduridae	Rhipidura rufifrons	Rufous Fantail	P	M, Ma
Rostratulidae	Rostratula australis	Australian Painted Snipe	E1	V, M, Ma
Vespertilionidae	Scoteanax rueppellii	Greater Broad-nosed Bat	V,P	
Vespertilionidae	Scotorepens balstoni	Inland Broad-nosed Bat	P	
Vespertilionidae	Scotorepens orion	Eastern Broad-nosed Bat	P	
Vespertilionidae	Scotorepens sp.	Unidentified broad-nosed bat	P	
Cuculidae	Scythrops novaehollandiae	Channel-billed Cuckoo	P	
Acanthizidae	Sericornis frontalis	White-browed Scrubwren	P	
Acanthizidae	Smicrornis brevirostris	Weebill	P	
Dasyuridae	Sminthopsis murina	Common Dunnart	P	
Estrildidae	Stagonopleura guttata	Diamond Firetail	V,P	
Artamidae	Strepera graculina	Pied Currawong	P	
Podicipedidae	Tachybaptus novaehollandiae	Australasian Grebe	P	
Tachyglossidae	Tachyglossus aculeatus	Short-beaked Echidna	P	
Molossidae	Tadarida australis	White-striped Freetail-bat	P	
Estrildidae	Taeniopygia bichenovii	Double-barred Finch	P	
Threskiornithidae	Threskiornis molucca	Australian White Ibis	P	
Threskiornithidae	Threskiornis spinicollis	Straw-necked Ibis	P	
Scincidae	Tiliqua scincoides	Eastern Blue-tongue	P	
Alcedinidae	Todiramphus sanctus	Sacred Kingfisher	P	
Psittacidae	Trichoglossus chlorolepidotus	Scaly-breasted Lorikeet	P	
Psittacidae	Trichoglossus haematodus	Rainbow Lorikeet	P	
Phalangeridae	Trichosurus sp.	brushtail possum	P	
Phalangeridae	Trichosurus vulpecula	Common Brushtail Possum	P	
Turnicidae	Turnix varius	Painted Button-quail	P	
Myobatrachidae	Uperoleia fusca	Dusky Toadlet	P	
Myobatrachidae	Uperoleia laevigata	Smooth Toadlet	P	
Myobatrachidae	Uperoleia sp.		P	
Charadriidae	Vanellus miles	Masked Lapwing	P	
Varanidae	Varanus sp.	Unidentified Goanna	P	
Varanidae	Varanus varius	Lace Monitor	P	
Vespertilionidae	Vespadelus darlingtoni	Large Forest Bat	P	
Vespertilionidae	Vespadelus pumilus	Eastern Forest Bat	P	
Vespertilionidae	Vespadelus vulturnus	Little Forest Bat	P	
Vombatidae	Vombatus ursinus	Common Wombat	P	
Macropodidae	Wallabia bicolor	Swamp Wallaby	P	
Timaliidae	Zosterops lateralis	Silvereye	P	

P = Protected, V = Vulnerable, E1 = Endangered under the TSC Act, E = Endangered under the EPBC Act, TEC = Threatened Ecological Community E4 = Extinct, E4a = Critically Endangered, E2 = Endangered Population, M = Migratory

Flora Records within the Black Creek Catchment (OEH 2013a)

Family Name	Scientific Name	Common Name	TSC Act Status	EPBC Act Status
Orchidaceae	Acianthus fornicatus	Pixie Caps	P	
Apiaceae	Actinotus helianthi	Flannel Flower	P	
Adiantaceae	Adiantum aethiopicum	Common Maidenhair	P	
Myrtaceae	Angophora inopina	Charmhaven Apple	V	V
Proteaceae	Banksia spinulosa	Hairpin Banksia	P	
Proteaceae	Banksia spinulosa var. collina		P	
Rutaceae	Boronia polygalifolia	Dwarf Boronia	P	
Orchidaceae	Caladenia carnea	Pink Fingers	P	
Orchidaceae	Caladenia catenata	White Caladenia	P	
Orchidaceae	Caladenia spp.		P	
Orchidaceae	Caleana major	Large Duck Orchid	P	
Myrtaceae	Callistemon linearifolius	Netted Bottle Brush	V,P	
Casuarinaceae	Casuarina cunninghamiana subsp. cunninghamiana	River Oak	P	
Orchidaceae	Diuris aurea		P	
Myrtaceae	Eucalyptus glaucina	Slaty Red Gum	V,P	V
Myrtaceae	Eucalyptus parramattensis subsp. decadens	Earp's Gum, Earp's Dirty Gum	V,P	V
Scrophulariaceae	Euphrasia arguta			CE
Orchidaceae	Genoplesium fimbriatum	Fringed Midge Orchid	P	
Orchidaceae	Genoplesium rufum	Red Midge Orchid	P	
Proteaceae	Grevillea parviflora subsp. parviflora	Small-flower Grevillea	V,P	V
Proteaceae	Isopogon anemonifolius	Broad-leaf Drumsticks	P	
Proteaceae	Isopogon spp.		P	
Zamiaceae	Macrozamia communis	Burrawang	P	
Zamiaceae	Macrozamia flexuosa		P	
Zamiaceae	Macrozamia reducta		P	
Zamiaceae	Macrozamia spp.		P	
Myrtaceae	Melaleuca groveana	Grove's Paperbark	V,P	
Proteaceae	Persoonia levis	Broad-leaved Geebung	P	
Proteaceae	Persoonia linearis	Narrow-leaved Geebung	P	
Orchidaceae	Prasophyllum sp. Wybong	a leek-orchid		CE
Lamiaceae	Prostanthera cineolifera	Singleton Mint Bush	V,P	V
Orchidaceae	Pterostylis acuminata	Pointed Greenhood	P	
Orchidaceae	Pterostylis erecta	Erect Maroonhood	P	

Family Name	Scientific Name	Common Name	TSC Act Status	EPBC Act Status
Orchidaceae	Pterostylis gibbosa	Illawarra Greenhood, Rufa Greenhood, Pouched Greenhood	E1	E
Orchidaceae	Pterostylis revoluta		P	
Orchidaceae	Pterostylis spp.	Greenhood	P	
Asteraceae	Rutidosis heterogama	Heath Wrinklewort	V,P	V
Moraceae	Streblus pendulinus	Siah's Backbone, Sia's Backbone, Isaac Wood		E
Xanthorrhoeaceae	Xanthorrhoea fulva		P	
Xanthorrhoeaceae	Xanthorrhoea glauca subsp. glauca		P	
Xanthorrhoeaceae	Xanthorrhoea johnsonii	Johnson's Grass Tree	P	
Xanthorrhoeaceae	Xanthorrhoea spp.		P	

P = Protected, V = Vulnerable, E1 = Endangered, CE = Critically Endangered,

Items identified under NPWS Aboriginal Heritage Information Management System (OEH 2013b)

Family Name	Scientific Name	Common Name
37-6-0993	BBAS1	Artefact
37-6-0994	BBAS2	Artefact
37-6-1040	Mt View 1	Artefact
37-6-1041	Mt View 2	Artefact
37-6-1042	Mt View 3	Artefact
37-6-1043	Mt View 4	Artefact
37-6-1044	Mt View 5	Artefact
37-6-1126	Mt View IF2	Artefact
37-6-1127	Mt View IF3	Artefact
37-6-1216	Cessnock 2	Artefact
37-6-1217	Cessnock 1	Artefact
37-6-1373	Kitchener PAD 2	Potential Archaeological Deposit (PAD)
37-6-1386	HH 1	Artefact
37-6-1387	KS 1	Artefact
37-6-1388	KS 2	Artefact
37-6-1389	KS 3	Artefact
37-6-1390	KS 4	Artefact
37-6-1391	KS 5	Artefact
37-6-1392	KS 6	Artefact
37-6-1393	KS 7	Artefact
37-6-1680	NB 4	Artefact
37-6-1681	NB 5	Artefact
37-6-1682	NB 6	Artefact
37-6-1683	NB 7	Artefact
37-6-1695	NB 19	Artefact
37-6-1456	Kerlew 1	Artefact
37-6-1562	Kitchener Sub-Division (KSD2)	Artefact
37-6-1565	Kitchener Sub-Division (KSD1)	Artefact
37-6-1722	OGC 5	Artefact
37-6-1723	OGC 6	Artefact
37-6-1724	OGC 7	Artefact, Potential Archaeological Deposit (PAD)
37-6-1731	OGC 1	Artefact
37-6-1732	OGC 2	Artefact, Potential Archaeological Deposit (PAD)
37-6-1733	OGC 3	Artefact
37-6-1734	OGC 4	Artefact
45-3-3360	Former Aberdare Extended Colliery	Artefact
37-6-1839	AR1_	Artefact
37-6-1987	OGC PAD 2	Potential Archaeological Deposit (PAD)

Family Name	Scientific Name	Common Name
37-6-1988	OGC PAD 1	Potential Archaeological Deposit (PAD)
37-6-1906	Hunter TEC Ironbark Lane 1	Artefact
37-6-2096	SPC 1	Artefact
37-6-2097	SPC 2	Artefact
37-6-2098	SPC 3	Artefact
37-6-2099	SPC 4	Artefact
37-6-2100	SPC 5	Artefact
37-6-2104	SPC8	Artefact
37-6-2107	St Phillips PAD 2	Potential Archaeological Deposit (PAD)
37-6-2108	St Phillips PAD 3	Potential Archaeological Deposit (PAD)
37-6-2109	St Phillips PAD 4	Potential Archaeological Deposit (PAD)
37-6-1372	Kitchener PAD 1	Potential Archaeological Deposit (PAD)
37-6-1677	NB 1	Artefact
37-6-1678	NB 2	Artefact
37-6-1679	NB 3	Artefact
37-6-2276	Mount View Road AS01	Artefact
37-6-0948	C-IF-1 (Cessnock)	Artefact
37-6-2718	Kitchener Isolated Find 1	Artefact

Cessnock City (Black Creek)

APPENDIX D
MIKE FLOOD MODEL VALIDATION RESULTS

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Area	ID	Pt No	E	N	Surveyed Flood Mark (mAHD)	Accuracy	Cardno Flood Model (D09)					Comments
							J	K	Peak Depth (m)	Peak Level (mAHD)	Difference (m)	
Oliver branch of Kearsley Creek	23	2301	346502	6364850	71.063	High	1566	882	0.860	71.098	0.035	The modelled flood slope over this area is relatively flat grading down north-south, which is in accordance with the historic observations. However surveyed point 2405 suggests influence from localised effects.
	23	2305	346531	6364822	71.139	Medium	1576	872	1.045	71.101	-0.038	
	24	2405	346573	6364844	71.377	Medium	1589	880	0.877	71.100	-0.277	
	24	2401	346557	6364837	71.141	Medium	1584	877	1.000	71.101	-0.040	
	25	2501	346520	6364751	71.113	High	1572	849	0.787	71.106	-0.007	
	26	2601	346539	6364752	71.191	High	1578	849	0.709	71.107	-0.084	
	27	2701	346550	6364756	71.176	High	1582	850	0.710	71.106	-0.070	
	28	2801	346499	6364826	71.163	High	1565	874	0.936	71.100	-0.063	
	29	2901	346450	6364772	71.184	High	1548	856	0.557	71.105	-0.079	
Kearsley Creek @ Vincent St	31	3101	346132	6365299	70.126	Medium	1443	1032	0.514	70.162	0.036	The match between observed and modelled is relatively close, with the exception of points 3301 and 13001. These surveyed points are described as low to medium accuracy and are not consistent with the prevailing flood slope.
	31	3104	346119	6365319	70.055	Medium	1438	1038	0.183	70.118	0.063	
	32	3204	346068	6365297	70.040	High	1421	1031	0.436	70.082	0.042	
	32	3201	346073	6365305	70.028	High	1423	1034	0.474	70.095	0.067	
	33	3301	346065	6365266	70.537	Low	1420	1020	0.464	70.089	-0.448	
	129	12901	346101	6365352	70.214	High	1432	1049	0.399	70.108	-0.106	
	130	13001	346069	6365344	70.490	Medium	1422	1047	0.238	70.107	-0.383	
Mount View Detention Basin	111	11101	343954	6366283	79.877	High	716	1359	1.095	79.981	0.104	The model is over estimating by 0.1m, potentially from increased basin inflows which do not take into account the significant storages of the upstream catchment (30+ dams)
Bellbird Creek @ Sports Ave	30	3001	345045	6365868	73.977	High	1080	1221	0.227	74.296	0.319	Sports Avenue crossing forms a hydraulic control resulting in overland breakouts over the southern bank and north-east up Barrett/Condon Ave. However the historic observations are highly variable suggesting local effects (points 3001 and 11501 are adjacent to the crossing but over 0.6m different)
	113	11301	344991	6365842	74.071	Medium	1062	1213	0.323	74.386	0.315	
	115	11501	345085	6365861	74.594	Medium	1093	1219	0.375	74.230	-0.364	
	116	11601	345049	6366027	73.964	Medium	1081	1274	0.180	73.500	-0.464	
	117	11701	344978	6365937	74.243	High	1058	1244	0.120	74.022	-0.221	
Aberdare Creek @ Maitland Rd	118	11801	346752	6366492	68.664	Medium	1649	1429	0.047	68.450	-0.214	These points are subject to the Maitland Rd crossing performance and a blockage factor could be applied to achieve a closer match. However the validation was considered reasonable.
	121	12101	346668	6366491	67.867	Medium	1621	1429	0.313	67.741	-0.126	
Kearsley Creek @ Charlton St	123	12301	345982	6365441	69.512	Medium	1393	1079	0.865	69.790	0.278	These points are adjacent to car park areas. Modelling adopted a roughness representing full carparks (worst case) and hence are increased over observed
	124	12401	345999	6365491	69.155	High	1398	1095	1.108	69.781	0.626	
Barrett / Condon / Hunters Ave Overland	112	11201	345129	6366207	72.739	High	1108	1334	0.269	72.612	-0.127	As flooding of this area is relatively low depth overland flowpaths through fully urbanised residential, localised effects such as fences, walls and kerbs etc. can have significant effects that cannot be modelled at this detail. In any case the model generally achieves a reasonable match.
	122	12201	345119	6365998	73.555	Medium	1105	1265	0.070	73.344	-0.211	
	126	12601	345459	6366055	71.741	Medium	1218	1284	0.520	71.755	0.014	
	128	12801	345476	6366087	71.503	High	1224	1294	0.084	71.651	0.148	
	131	13101	345133	6366038	72.975	High	1110	1278	0.106	73.075	0.100	
	136	13601	345053	6366180	73.250	Medium	1083	1325	0.134	73.242	-0.008	
	133	13301	345352	6366080	71.955	Medium	1183	1292	0.144	71.886	-0.069	
	134	13401	345336	6366076	71.920	Medium	1177	1290	0.105	71.957	0.037	
	135	13501	345471	6366107	71.797	Medium	1222	1301	0.076	71.591	-0.206	

Cessnock City (Black Creek)

APPENDIX E
PRELIMINARY STRUCTURAL FLOOD MITIGATION OPTIONS

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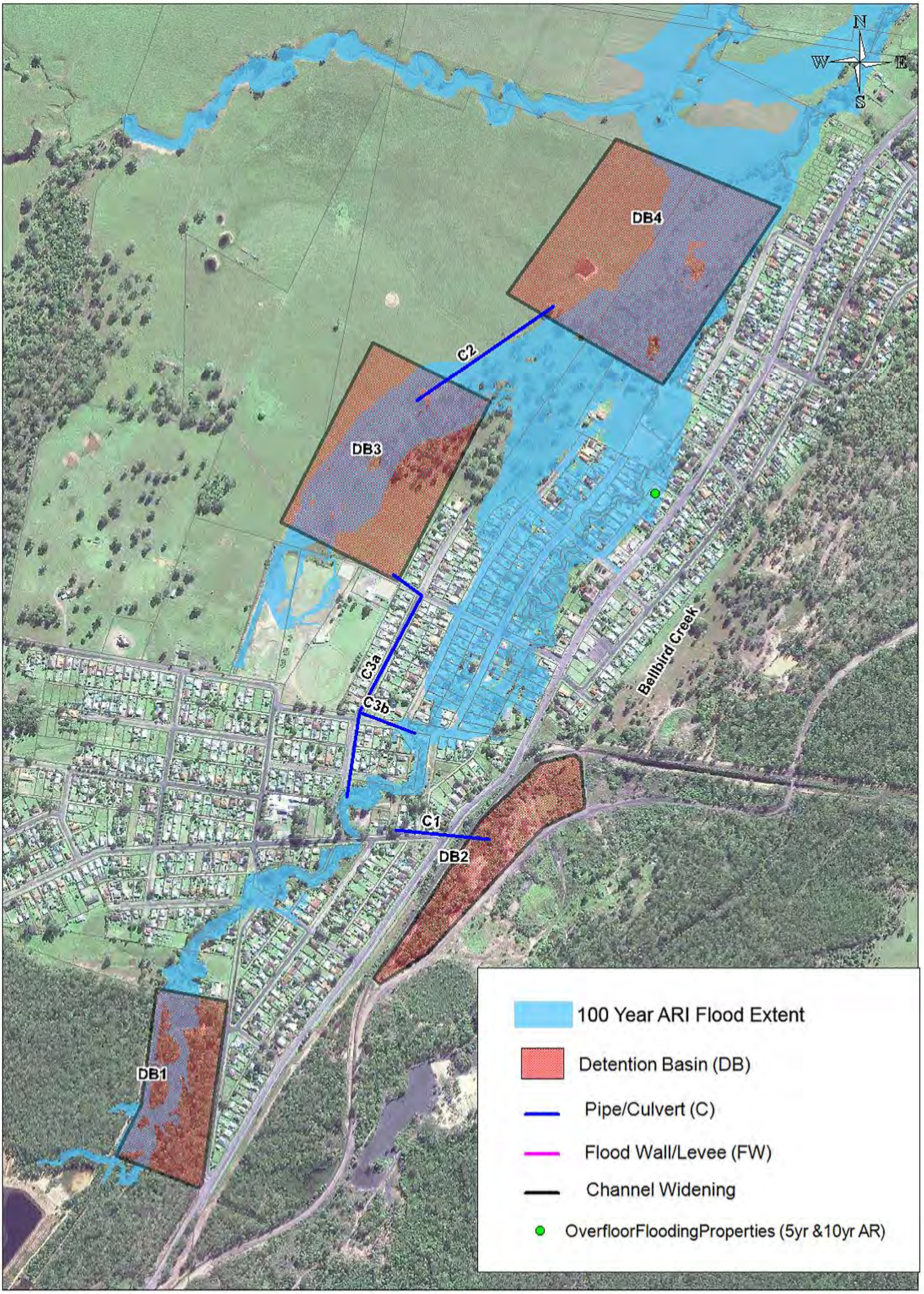


Figure 1
Options (DB1-DB4 & C1 - C3)

Cardno

W4951
March 2013

Black Creek FRMSP
Preliminary Flood Mitigation Options

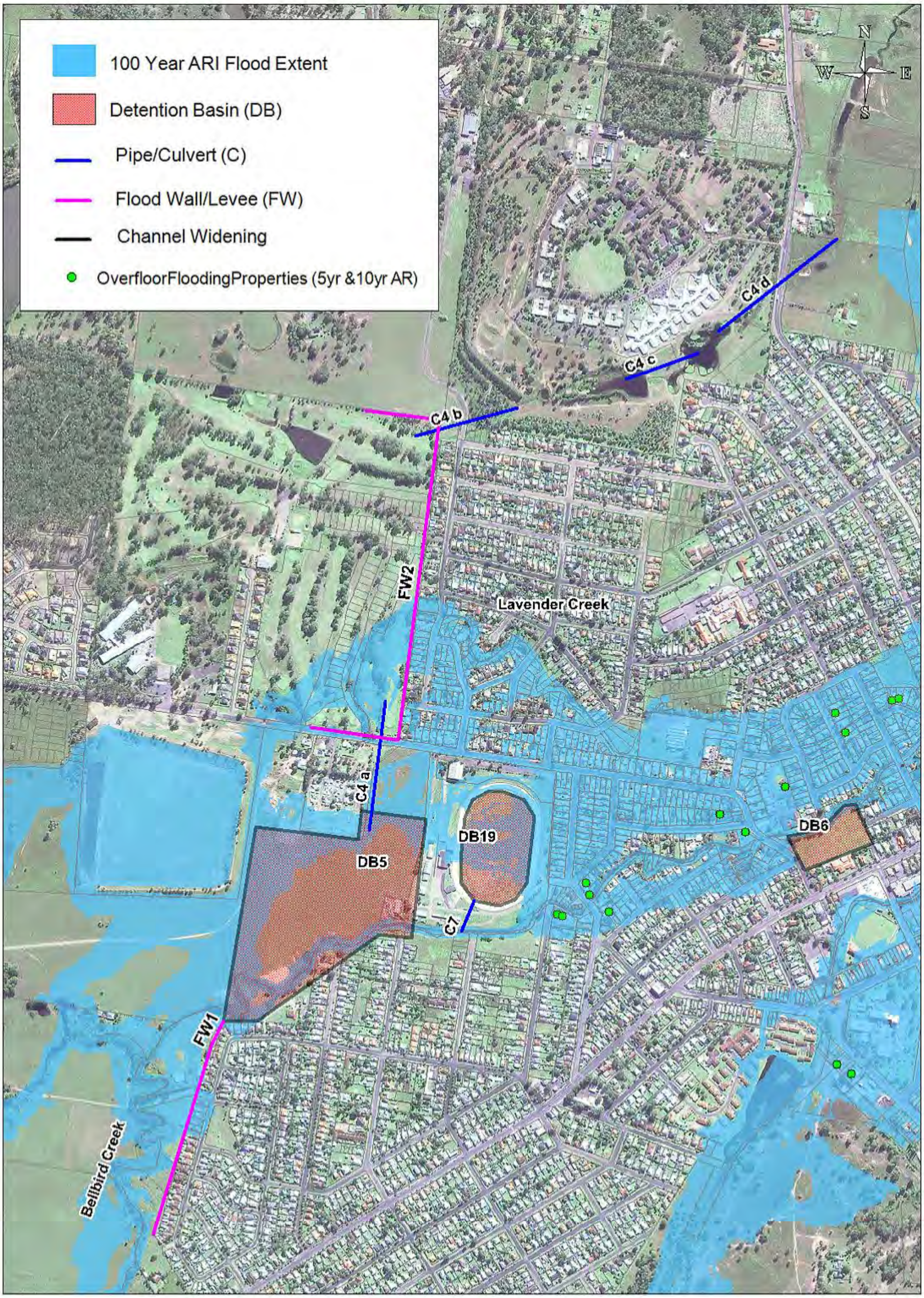


Figure 2
Options (DB5, DB6, DB19 & FW1-FW2 & C4,C7)

Cardno

W4951
March 2013

Black Creek FRMSP
Preliminary Flood Mitigation Options

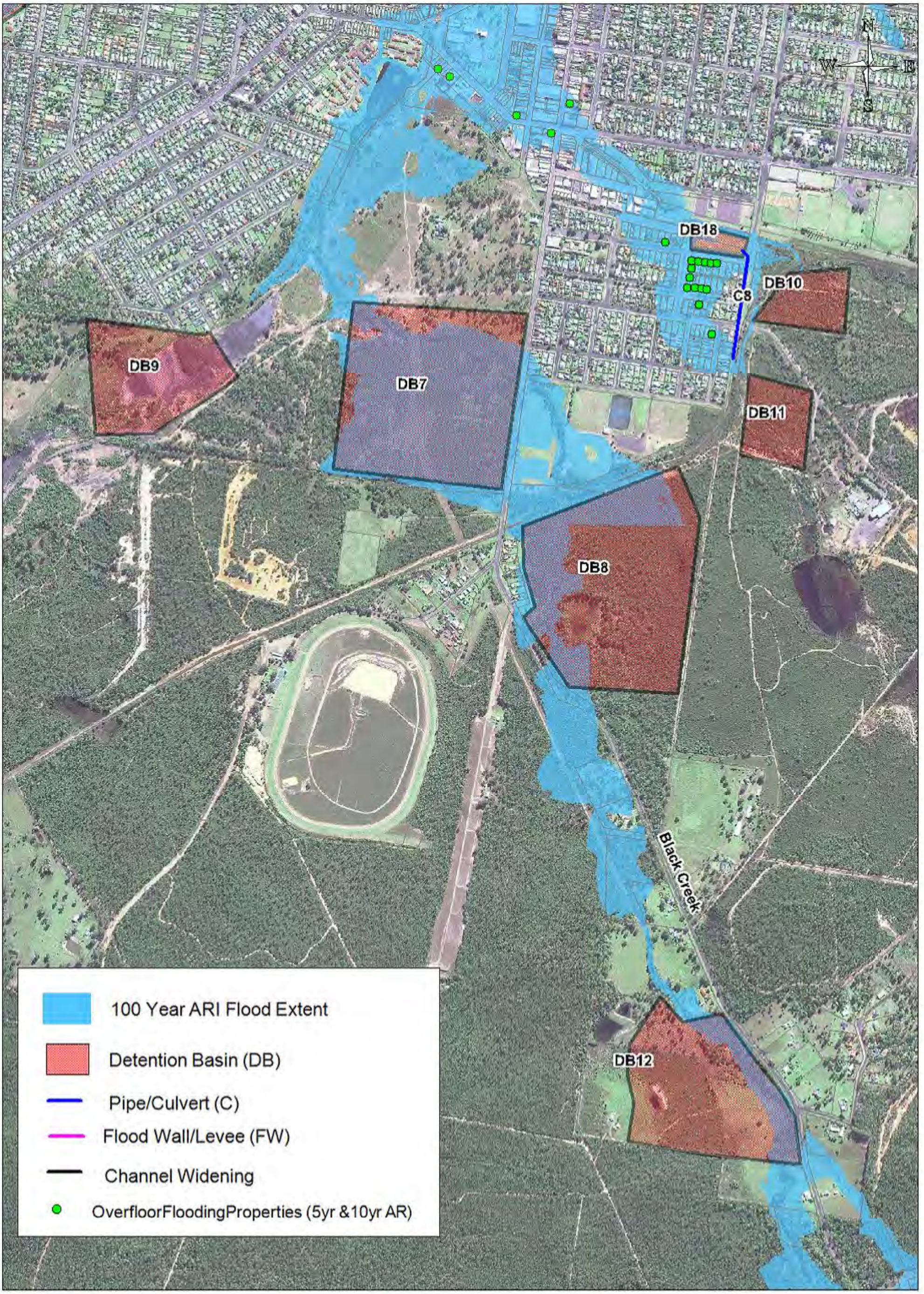
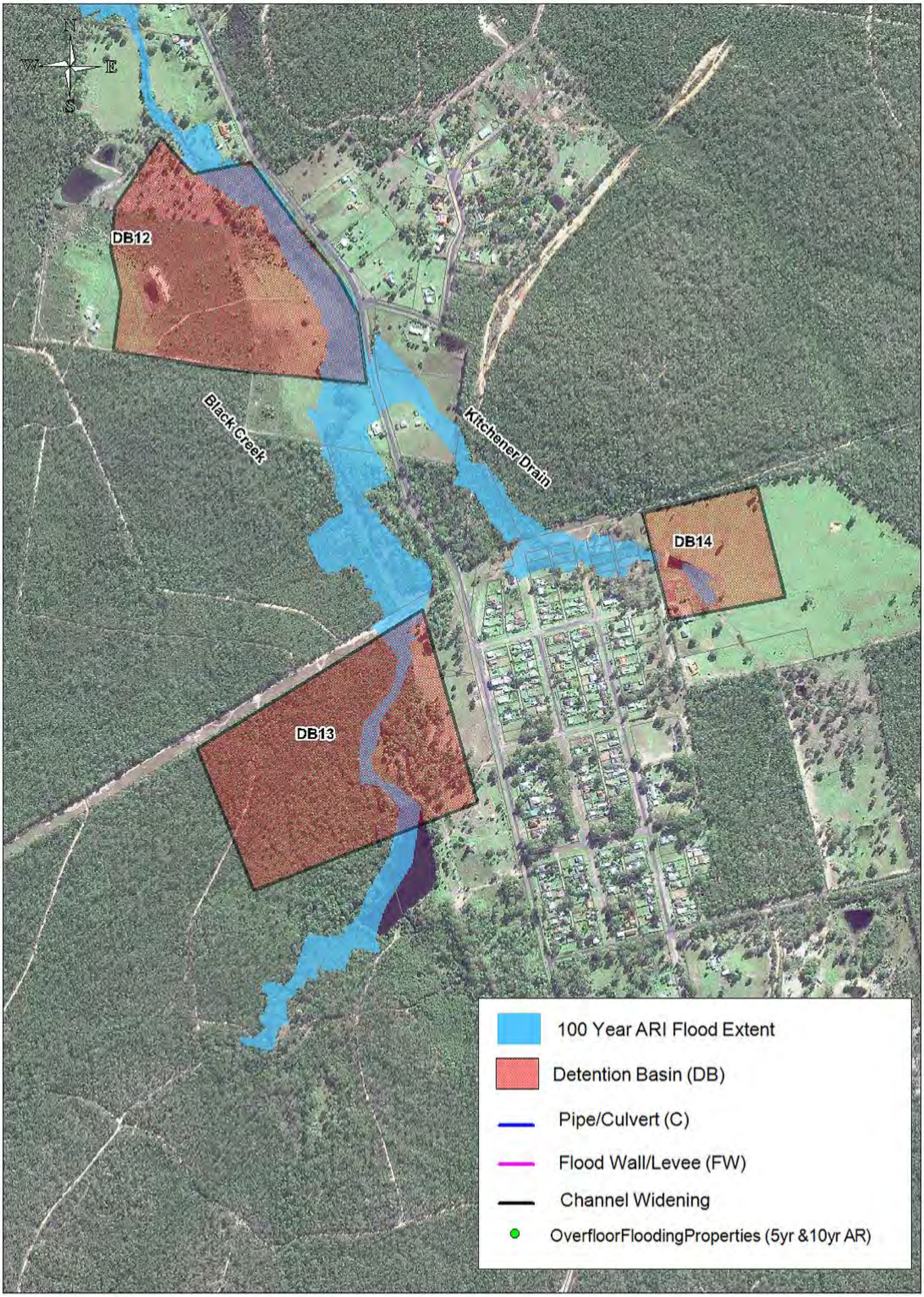


Figure 3
Options (DB7 - DB12, DB18, C8)

Cardno

W4951
March 2013

Black Creek FRMSP
Preliminary Flood Mitigation Options



Cardno

W4951
March 2013

Black Creek FRMSP
Preliminary Flood Mitigation Options

Figure 4
Options (DB12 - DB14)

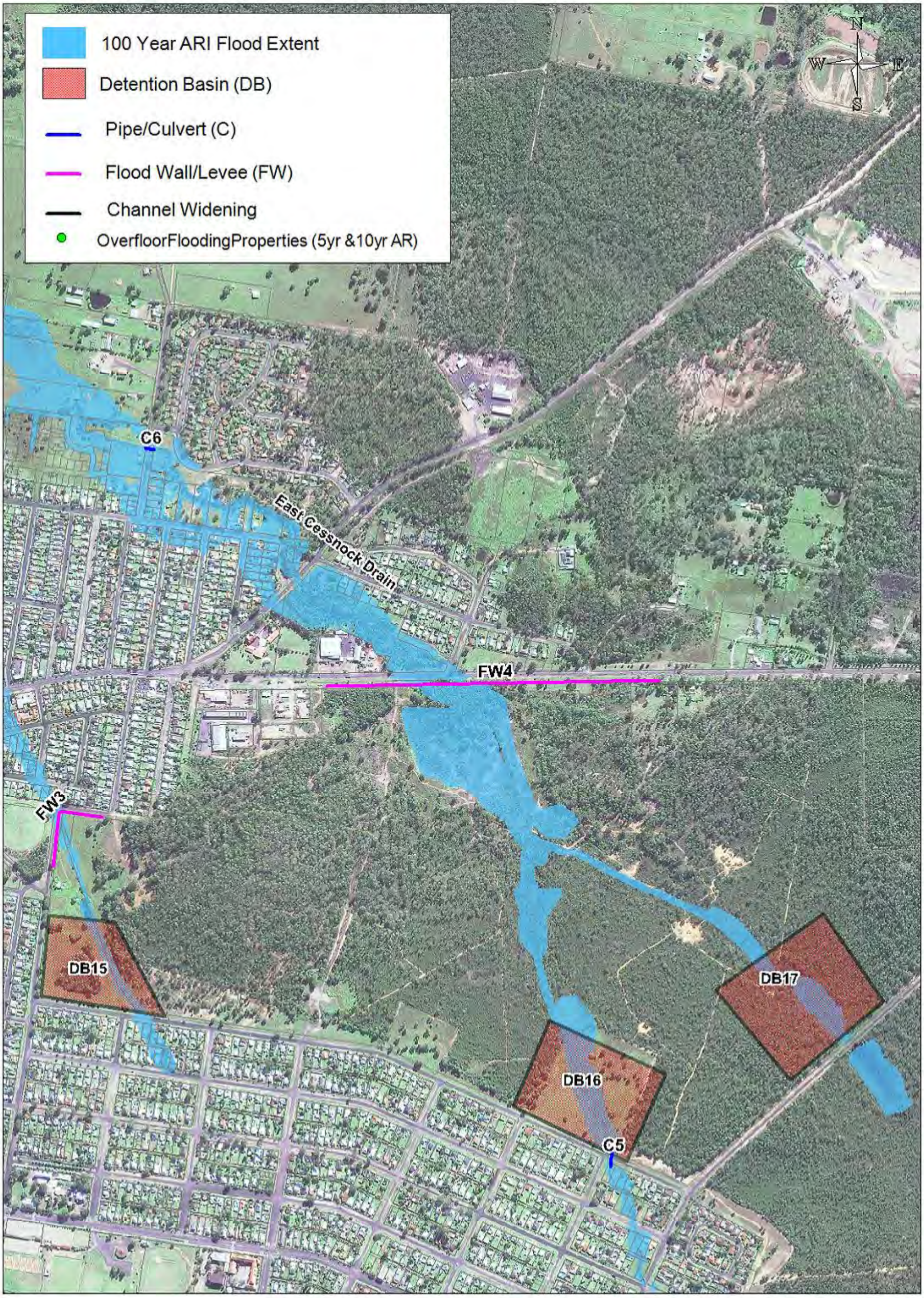


Figure 5
Options (DB15 - DB17 & FW3-FW4 & C5, C6)

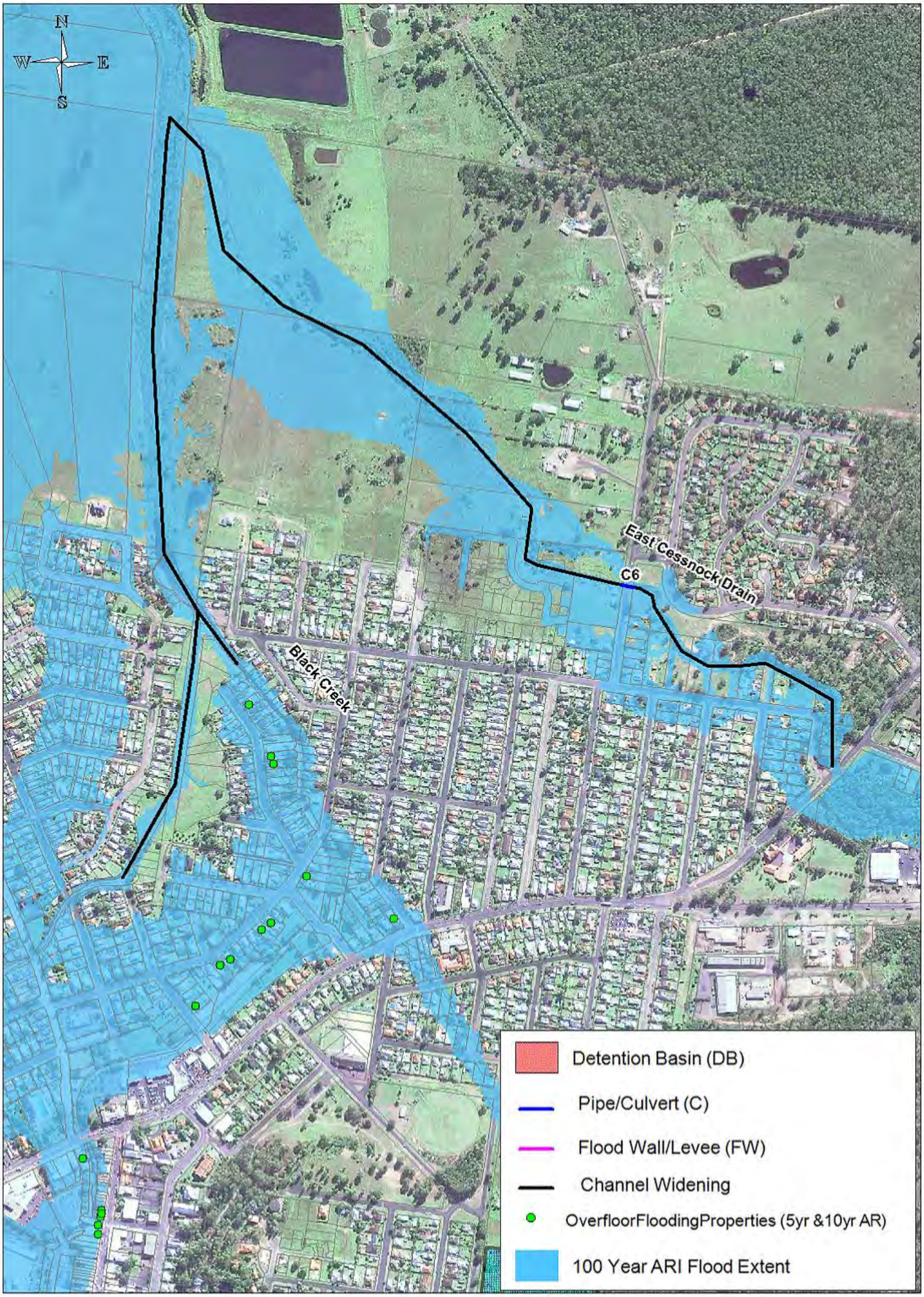


Figure 6
Options - Channel Widening & C6

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W4951
March 2013

Black Creek FRMSP
Preliminary Flood Mitigation Options

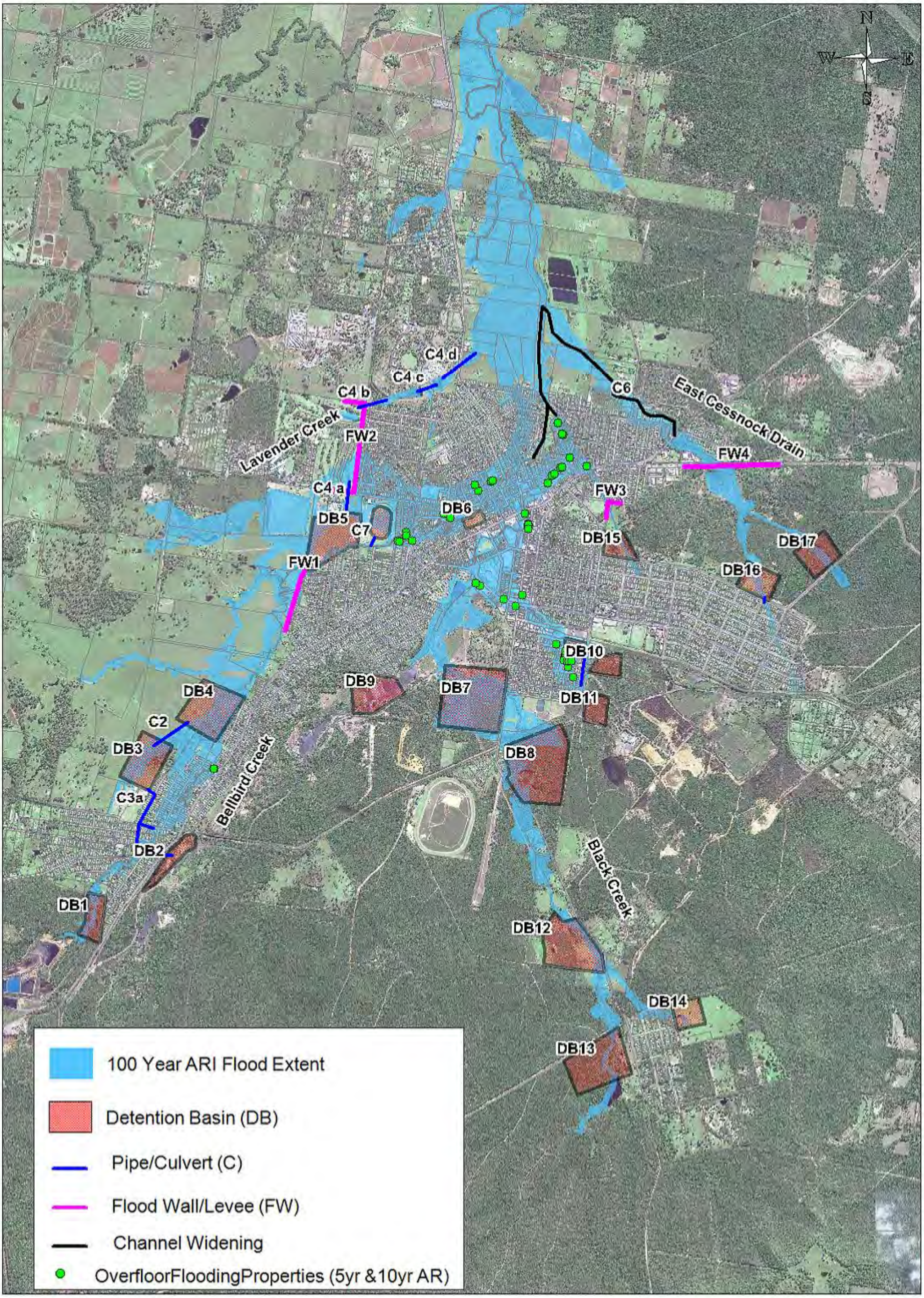

Figure 7
All Options

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Black Creek FRMSP
Preliminary Flood Mitigation Options

Cessnock City (Black Creek)

APPENDIX F
MULTI CRITERIA ASSESSMENT

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Option ID	Reference	Description	B/C	Estimated Capital Cost ($)	Estimated Maintenance Cost ($)	AAD	Economic			Social			Environment				Score	Overall Rank
							50%			25%			25%					
							Benefit Cost Ratio	Capital Cost	Operating Cost Estimate	Compatibility with Council Policies & Plans	Reduction in Social Disruption	Community & Stakeholder Support	Compatibility with Water Quality Objectives[1]	Groundwater	Heritage	Fauna/Flora Impact - Including Street Trees		
							50.0%	30.0%	20.0%	40.0%	30.0%	30.0%	25.0%	25.0%	25.0%	25.0%		
							25.0%	15.0%	10.0%	10.0%	7.5%	7.5%	6.3%	6.3%	6.3%	6.3%		
FM1	Structural Option - Detention Basins	Combination of four options - Detention Basin (DB7) west of Vincent Street and Baddely Park, Detention Basin (DB8) east of Quorrobolong Road and south of railway, Detention basin (DB12) west of Quorrobolong Road and Mountain View Place and Detention basin (DB13) West of Stanford Street, Kitchener	0.03	$70,315,800	$703,158	$2,244,065	0	-2.0	-2.0	0	0	1	0	0	0	-1	-0.49	**11**
FM2	Structural Option - Detention Basins	Combination of three options - Detention Basin (DB6), Local Bund (Bellbird Creek) and Channel Reshaping (Bellbird Creek)	0.00	$19,646,400	$196,464	$2,458,701	0	-2.0	-2.0	-1	-1	0	-1	-1	0	-1	-0.86	**13**
FM3	Structural Option - Culvert Upgrades and Channel Widening	Combination of three options – Culvert Upgrades (Wollombi Road, Doyle Street and Henderson Street), Channel Widening (Black Creek) Channel Reshaping (Black Creek)	0.03	$19,726,500	$197,265	$2,373,869	0	-2.0	-2.0	0	-1	0	0	0	0	0	-0.58	**12**
FM4	Structural Option - Channel Widening	Channel Widening (Oliver Street Channel) – From Sixth Street to Edgeworth Road	0.04	$2,322,600	$23,226	$2,411,670	0	0.0	0.0	0	-1	0	0	0	0	0	-0.08	**10**
FM5	Structural Option - Bund/Flood Wall	Proposed bund/flood wall east of Sixth Street properties and railway line	8.88	$690,700	$6,907	$1,913,429	2	1.0	1	1	1	1	0	0	0	0	1.00	**3**
FM6	Structural Option - Detention Basin	Detention basin (DB1) Bellbird Creek - Austar Coal Mine site	0.54	$7,278,900	$72,789	$2,094,194	1	-1.0	-1	0	0	1	0	0	0	0	0.08	**9**

Non-Structural Options																		
Option P3	House Raising	All houses that are inundated in the 10% AEP (32 houses) would be raised to the 5% AEP level	1.47	$2,560,000	$0	$2,200,764	2	0	2	0	0	1	0	0	0	0	0.78	**5**
Option P4	House Rebuilding	utilising the subsidy for house raising described above for reconstruction instead	1.47	$2,560,000	$0	$2,200,764	2	0	2	0	0	1	0	0	0	0	0.78	**5**
Option P5	Voluntary Purchase	Overfloor Flooding Properties in a 20% AEP Flood Event	0.53	$5,400,000	$0	$2,267,260	1	-1	2	0	0	1	0	0	0	0	0.38	**8**
Option P6	Land Swap	Council swaps a parcel of land in a non-flood prone area (e.g. an existing park) for the flood prone land with the appropriate transfer of park facilities to the acquired site (20% AEP)	3.16	$900,000	$0	$2,267,260	2	0	2	1	1	1	0	0	0	0	0.95	**4**
Option P7	Council Redevelopment	Council would still purchase the affected properties in a 20% AEP, it would redevelop these properties in a flood compatible manner and re-sell them with a break even objective	0.63	$4,500,000	$0	$2,267,260	1	0	2	0	0	1	0	0	0	0	0.53	**7**
Option EM4	Public awareness and education	Flood awareness for people residing in the floodplain.			$5,000		0	2	2	2	2	2	0	0	0	0	1.00	**1**
Option EM5	Flood warning signs at critical locations	Flood warning signs within the floodplain			$1,000		0	2	2	2	2	2	0	0	0	0	1.00	**1**

Cessnock City (Black Creek)

APPENDIX G
APRIL 2015 FLOOD EVENT

Cardno
Shaping the Future

Our Ref: W4951_L001_RevB
Contact: David Whyte

25th February 2016

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Cessnock City Council
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(peter.jennings@cessnock.nsw.gov.au)

RE: APRIL 2015 FLOOD EVENT – FLOOD MODEL VALIDATION & MITIGATION OPTIONS ASSESSMENT

Dear Peter,

We are pleased to provide you the following report which refers to the Flood Model Validation and Mitigation Options Assessment using the April 2015 Flood Event. This report details the rainfall data sourced for this flood event and summarises the comparison between the recorded flood levels and the modelled results. All the preferred structural mitigation options in the Floodplain Risk Management Study and Plan were assessed for the April 2015 Storm.

1. Historical Rainfall Data

There are three rainfall stations (pluviograph data) close to the catchment which were operational during the April 2015 event. They are listed below in **Table 1-1**.

Table 1-1 Rain Gauges

Station No.	Station Name	Location		Type	Source*	Operational during April 2015 event?	Gauge within Catchment
		Lat.	Lon.				
61260	Cessnock Airport AWS	32.79° S	151.34° E	Pluvio	BOM	Yes	No
61412	Cooranbong (Lake Macquarie AWS)	33.09° S	151.46° E	Pluvio	BOM	Yes	No
61250	Paterson (Tocal AWS)	32.63° S	151.59° E	Pluvio	BOM	Yes	No

**BOM = Bureau of Meterology,*

Rainfall data from the Cessnock Airport AWS (station 61260) was used for modelling the historical event as it is the evident choice in terms of proximity. The locations of the rain gauges are shown in Error! Reference source not found.. The recording interval for these gauges was 1 minute, which is suitable for the purposes of modelling the historical event. The Cessnock Airport AWS gauge

provides a reasonable representation of spatial variation in rainfall in the area, although rainfall over the southern portion of the catchment is not well represented.

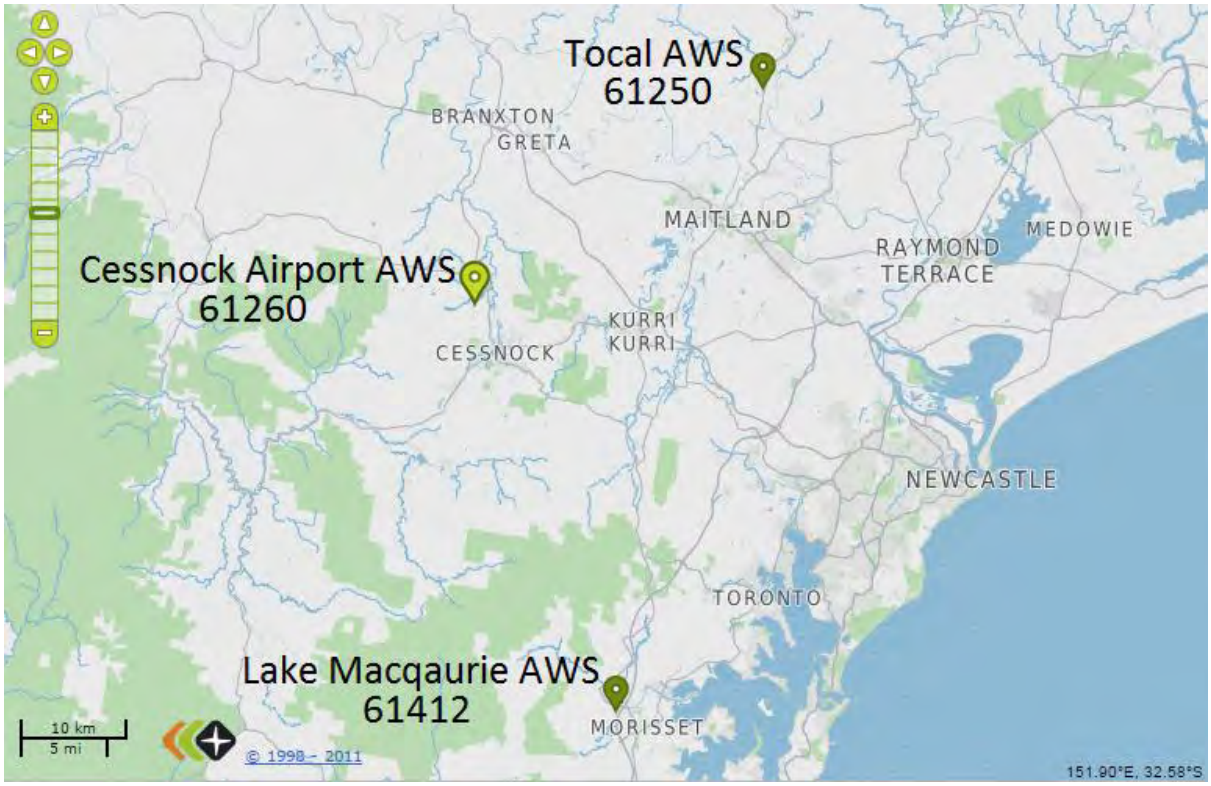

Figure 1-1 Location of Rain Gauges

The spatial variability of recorded rainfall between the stations is shown below in **Table 1-2**. There are also some observations missing from the datasets.

Table 1-2 Pluviograph Rainfall Data

Rainfall Station	Rainfall Total (mm)	Previous 24hr Rainfall (mm) to 9am					
		20/04/2015	21/04/2015	22/04/2015	23/04/2015	24/04/2015	25/04/2015
Cessnock Airport AWS (61260)	158	3	84.6	44	19.2	1.2	0
Observations Missing	5%	0%	0%	37%	1%	0%	0%
Lake Macquarie AWS (61412)	24.6	0.2	11.8	1	2.8	0.2	8.6
Observations Missing	0%	0%	0%	0%	0%	0%	0%
Tocal AWS (61250)	370.4	8.8	239.4	115.4	0.4	1.4	0.2
Observations Missing	14%	0%	0%	53%	42%	0%	0%

The majority of rainfall occurred on 20th and 21st April; **Figure 1-2** shows the comparison of pluviograph rainfall data. A massive 205.2 mm at Tocal AWS over a 3 hour period from 7-10am on 21st April is seen on the plot. **Table 1-3** shows the total daily rainfall of the three rain gauges.

Table 1-3 Total Daily Rainfall to 9AM 21st and 22nd April 2015 for operational rain gauges

Station No.	Station Name	Data Authority	Total Rainfall on 21st April 2015 (9AM)	Total Rainfall on 22nd April 2015 (9AM)
61260	Cessnock Airport AWS	BOM	84.60	126.60
61250	Paterson (Tocal AWS)	BOM	242.60	178.0
61412	Cooranbong (Lake Macquarie AWS)	BOM	117.80	-

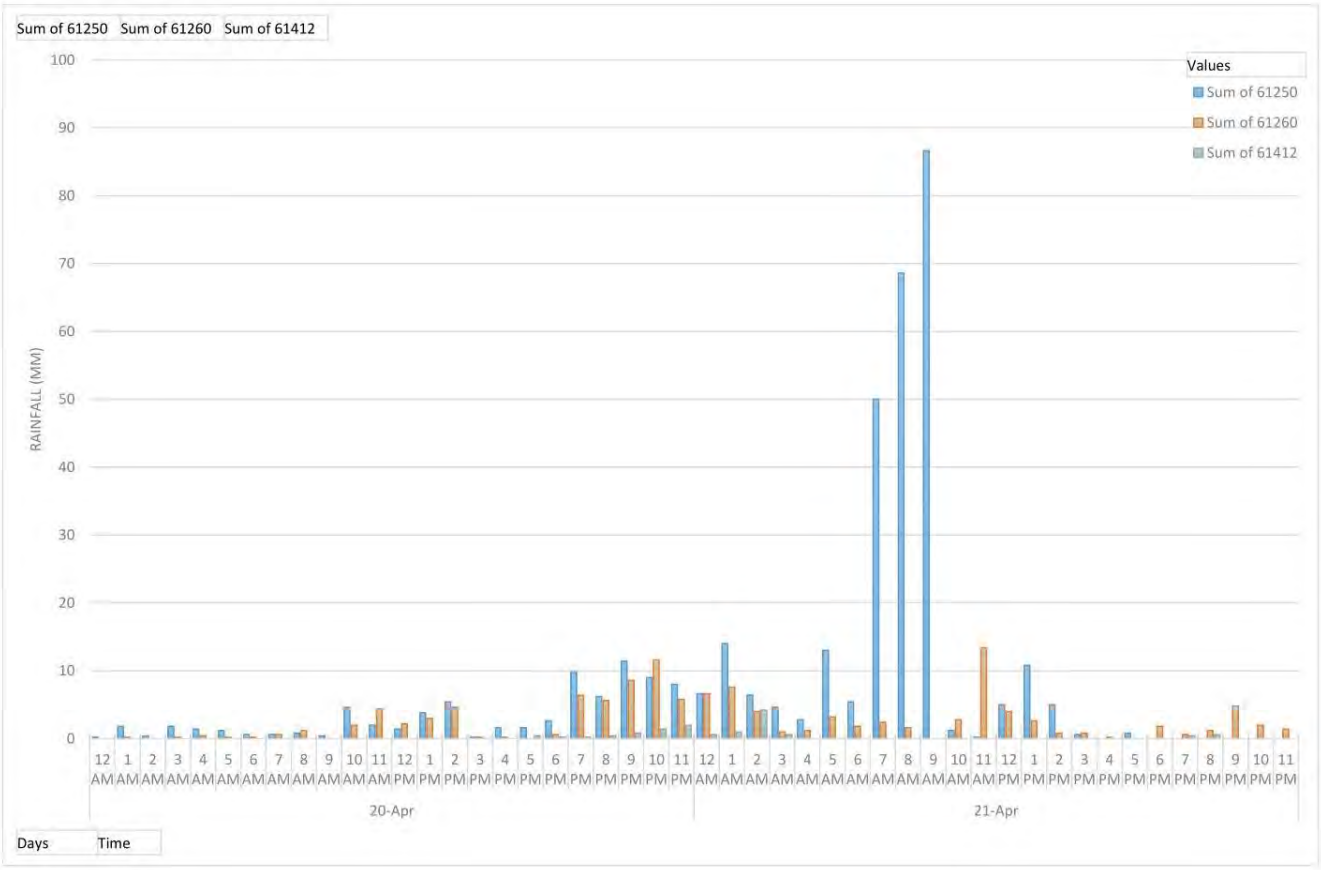

Figure 1-2 Comparison of Pluviograph Data

Figure 1-3 shows the comparison of Rainfall data for all the operational rain gauges. **Figure 1-4** provides an indication of the magnitude of the April 2015 event in relation to design storms.

As can be observed in **Table 1-2** and **Figure 1-3**, The Cessnock AWS station appears to be missing a reasonable amount of data on 21 April 2015. The AWS data does not correlate with the Cessnock Airport daily read gauge and the rainfall graph does not show the same pattern of intense rainfall in the morning of 21 April 2015 when compared with the other AWS stations.

The hydraulic model was originally run using the Cessnock AWS rainfall data, however, it was underestimating flood levels. Further, due to the missing data and the fact that the station is north of the Black Creek catchment, additional data was sought and rainfall pluviograph data was provided by Austar coal mine within the catchment. This data is also plotted in **Figure 1-3**.

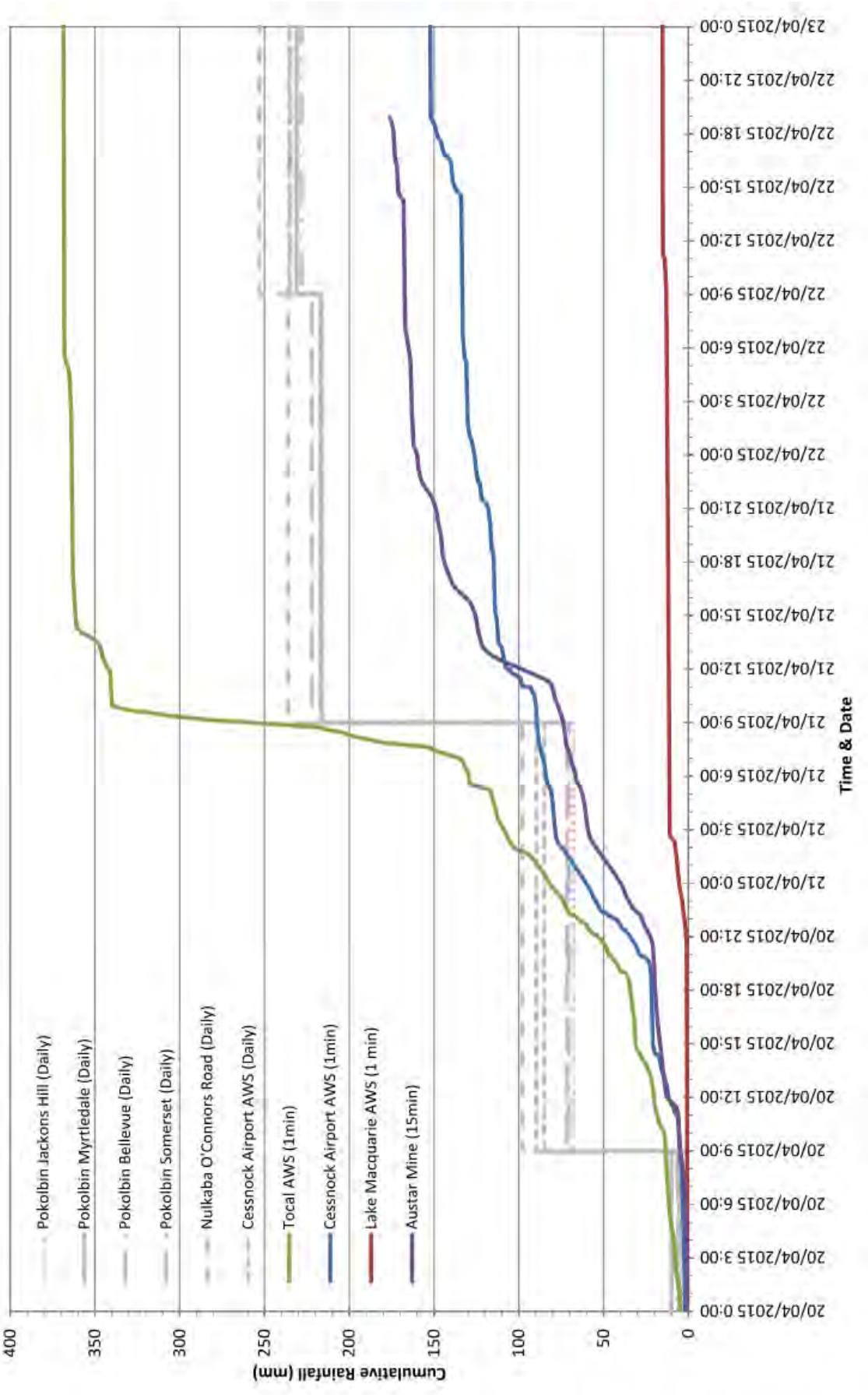

Figure 1-3 Comparison of Rainfall Data for Operational Rain Gauges

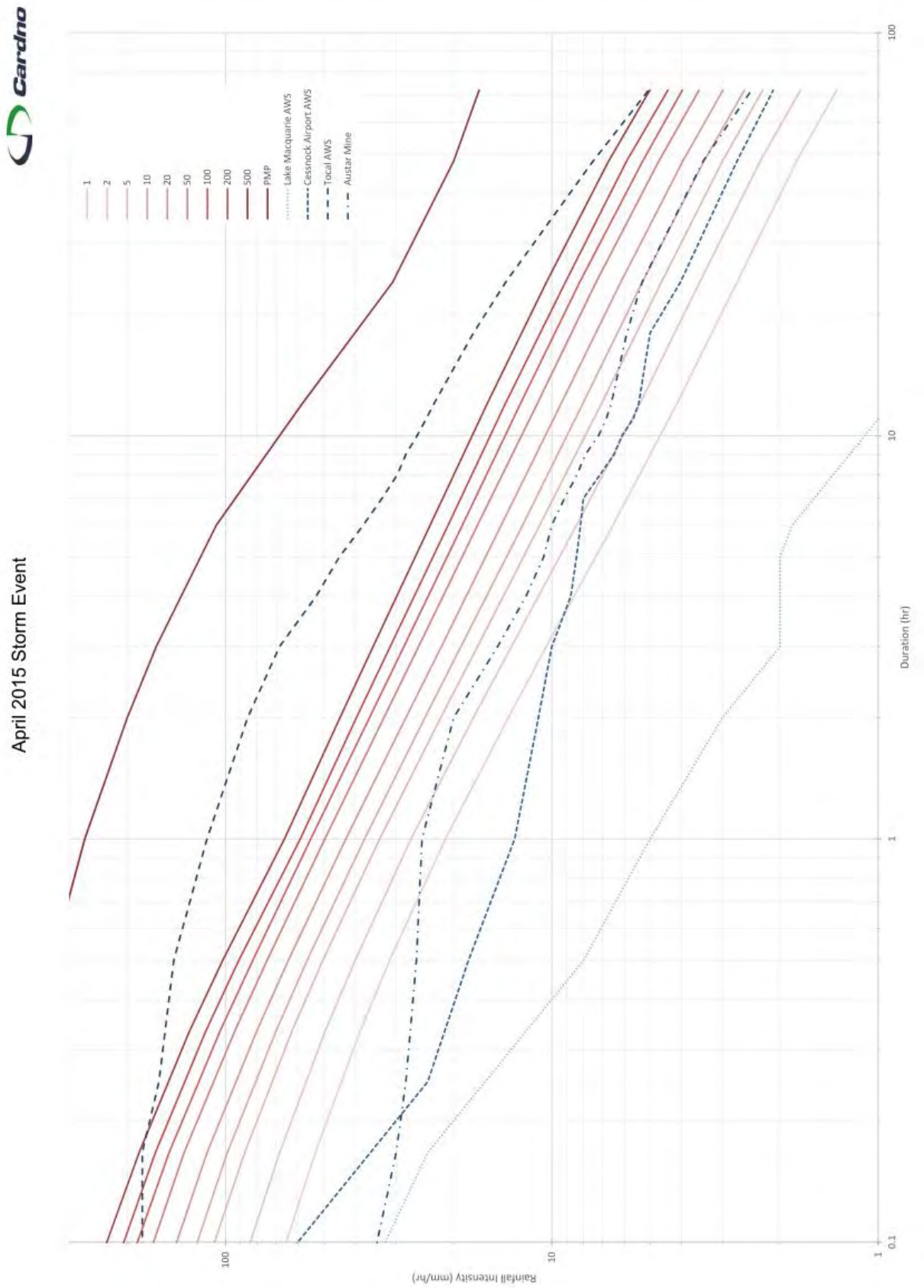

Figure 1-4 Comparison of April 2015 event in relation to Design Storms

2. Model Validation

2.1 Historical Event Validation

The April 2015 flood event identified seven locations with recorded flood levels within the catchment. The recorded values were largely observed flood levels or debris marks with an estimated depth. Flood levels were then estimated using the depth and available Airborne Laser Survey (ALS) data of ground levels.

This event was used for validation of the flood model used in the Floodplain Risk Management Study and Plan. **Figure 2-1** shows the identified locations with recorded flood levels.

The hydrology model was run using the recorded rainfall (pluviograph) data from the Austar Mine Gauge. The resulting flow hydrographs were extracted and used at the inflow locations for the flood model.

The hydraulic model was then run for the April 2015 event and **Table 2-1** summarises the comparison between the recorded flood levels and the modelled results. The modelled results show a reasonable correlation with the observed values, and differences can be explained by:

- unknown accuracy of the flood level observations, especially given that most values were an estimated depth based on a debris mark and not surveyed.
- rainfall gauge data used may not be accurate and may not represent the spatial variability of rainfall in the catchment and
- other conditions during the flood such as blockage of structures is unknown and cannot be replicated in the model.

The event model results were then compared with the design event results from the updated flood study modelling to determine the approximate recurrence interval of the event. The April 2015 event was found to have the closest comparison with the 10 Year ARI event (10% AEP) for most areas of the catchment.

Figure 2-2 shows the comparison between the April 2015 flood extent and the 10 Year ARI Flood Event (10% AEP).

There are some locations such as Bellbird Creek downstream and Lavender Creek for which the model results do not show any appreciable flooding during the event, with flows remaining in channel in these locations. As no flood level observations were available for these locations, this cannot be validated.

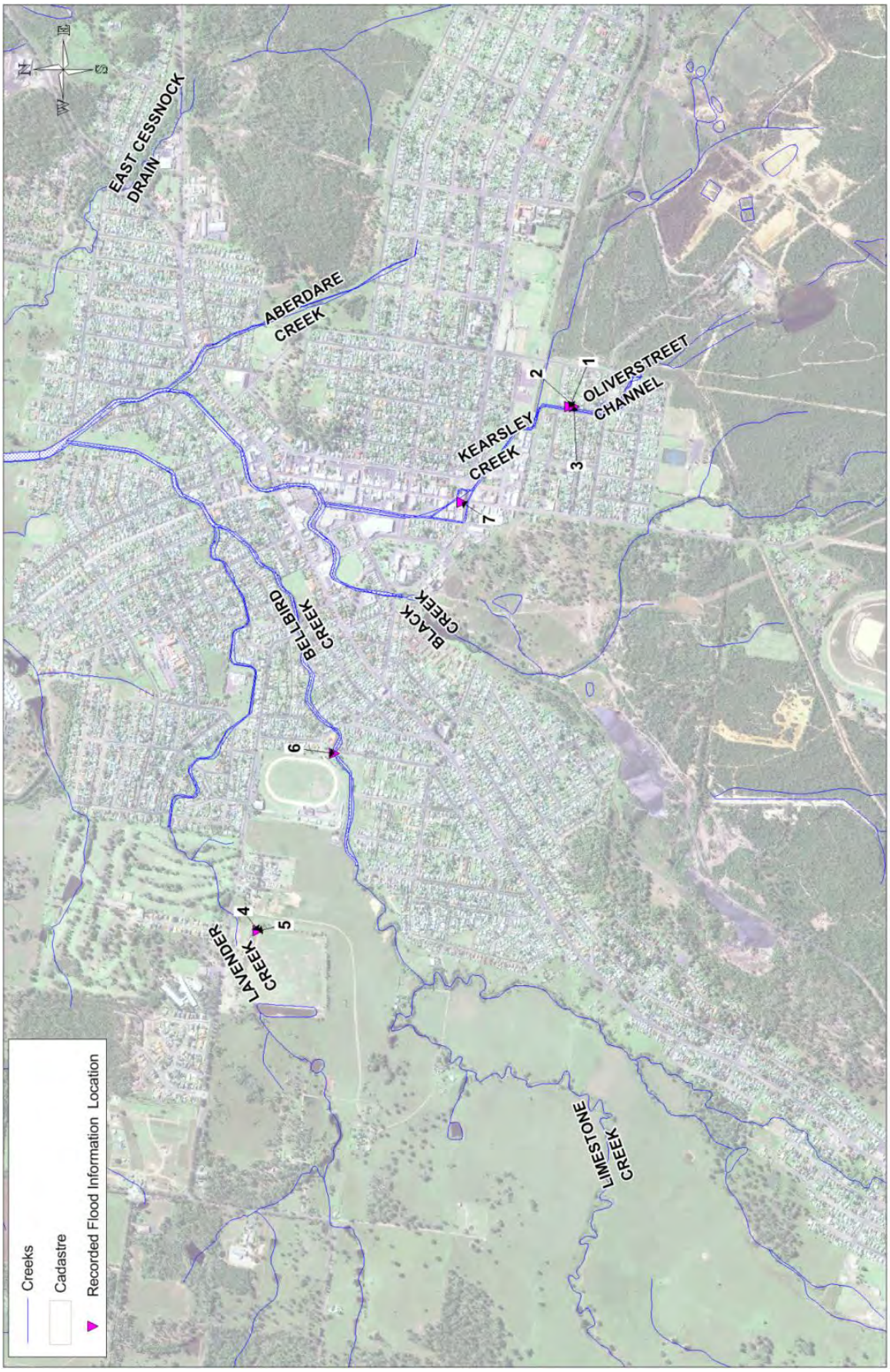

Figure 2-1 Historical Flood Level Information Locations

Table 2-1 Model Validation Results for the April 2015 Event

ID	Name	Historical Flood Level Location	Description	Observed Flood Level (mAHD)	Observed Flood Depth (m)	Modelled Flood Level (mAHD)	Modelled Flood Depth (m)	FRMSP Flood Level Difference	FRMSP Flood Depth Difference	Comments
1	WP15	Oliver Street, South Cessnock	Flooding in house		0.93		0.68		-0.25	Model is underestimating peak depths by 0.25 m
2	WP18	Oliver Street, South Cessnock	Flood marks on fence		1.00		0.79		-0.21	Debris lines in photos suggest peak depths of approximately 1.0 m. Model is underestimating 0.21 m
3	WP19	Oliver Street, South Cessnock	Flood marks on External Wall House		1.00		0.79		-0.21	Debris lines in photos suggest peak depths of approximately 1.0 m. Model is underestimating 0.21 m
4	WP70	Mt View Road, Cessnock	Debris Mark inside embankment, Mt View Detention Basin	78.70		78.63		-0.07		Debris marks from photos suggest depth of 2.8 m from flood indicators adjacent to outlet. Outlet invert is 75.86 mAHD and therefore peak WSL is approx. 78.7 mAHD. Model is underestimating 0.07 m.
5	WP82	Mt View Road, Cessnock	Debris Mark inside Basin embankment	78.70		78.63		-0.07		As Above
6	WP76	Vincent Street, Cessnock	Flooding in street (0.55m) Gutter invert		0.55				-0.55	Model indicates no flooding in this location, although the channel is at full capacity, and therefore any blockage or slightly reduced conveyance could produce observed levels. Model indicates the Charlton St carpark immediately downstream is flooding at the channel opening
7	WP81	Sports Avenue, Cessnock	Debris on Pedestrian Bridge (0.65 US, 0.35 DS)	73.85		74.02		0.17		Model is over-estimating by approximately 0.17 m. Localised effects (such as the bend location) may affect results

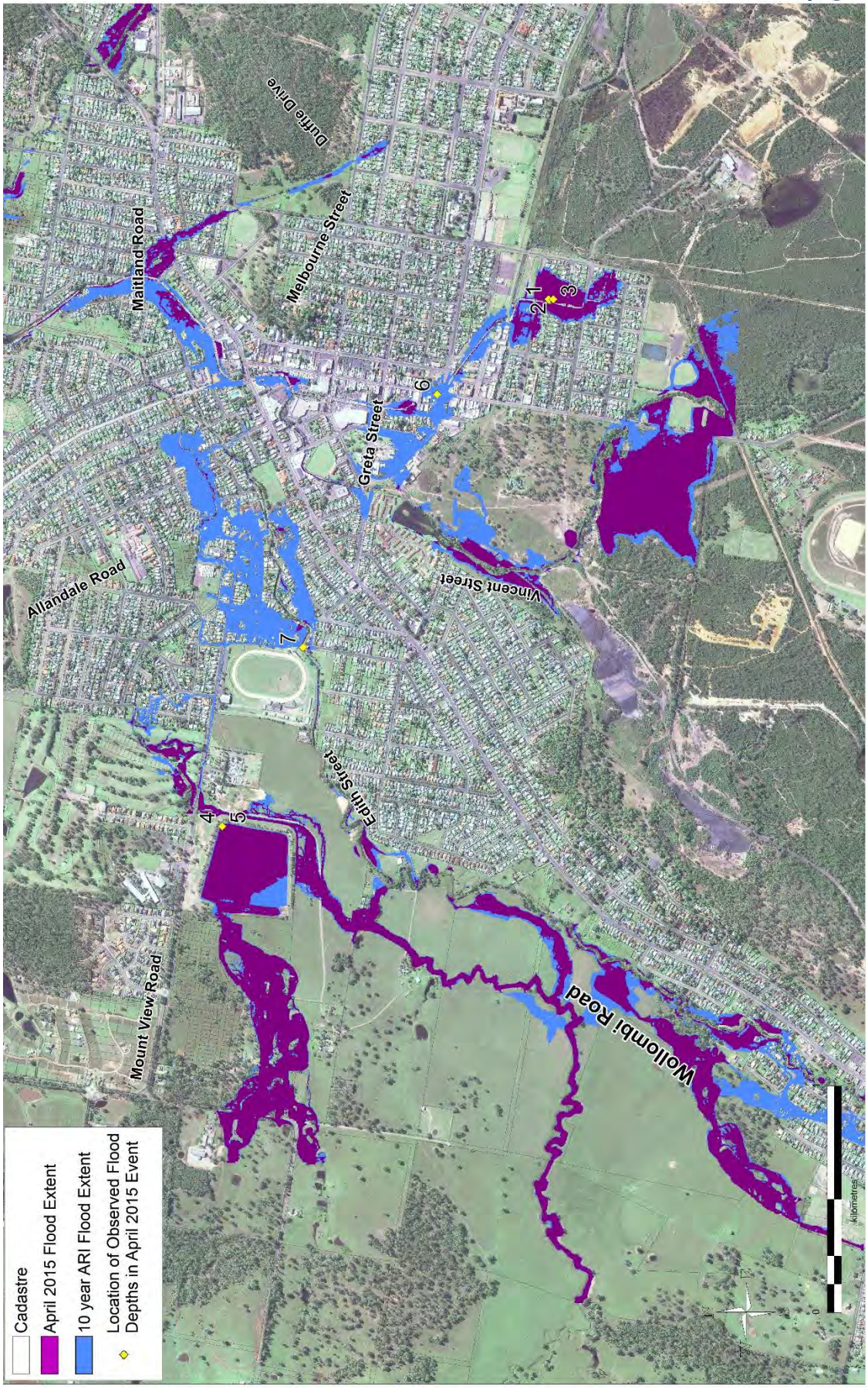

Figure 2-2 Flood Extent Comparison

3. Mitigation Options Assessment

The April 2015 flood event was used to assess the structural mitigation options identified in the Floodplain Risk Management Study and Plan. The options outlined below were run for the April 2015 event to provide context to the community as to the flood mitigation benefits that could have been expected if the mitigation options were implemented during the April 2015 event. The results of this analysis are summarised in **Table 3-1**.

Table 3-1 Structural Options Assessment for the April 2015 Event

Option ID	Option	Assessment Outcome	Option Layout and Water Level Impact Figure
FM2	Detention basin (DB6) adjacent to Bellbird Creek at 196 Wollombi Road Local bund on Bellbird Creek at end of Stephen Street Bellbird Creek channel reshaping from Stephen Street to confluence with Lavender Creek	For the April 2015 flood event negligible impacts in flood levels are observed on the north and western sides of Bellbird Creek. The bund at Stephen Street provides protection to residential properties in the 20% AEP event.	Figure 11-13
FM3	Widening of Black Creek channel from Wollombi Road to Ferguson Street Reshaping existing Black Creek channel downstream of Ferguson Street, provide flood walls on channel Culvert upgrades at Wollombi Road, Doyle Street and Henderson Street	Reduction in flood levels are observed up to 150mm upstream of Ferguson Street culverts. The proposed reshaping and floodwalls downstream of Ferguson Street result in minor changes to the flood levels.	Figure 11-20
FM4	Channel widening of existing Oliver Street Channel, South Cessnock	For the April 2015 event more conveyance is through the Oliver Street channel and reductions in levels up to 120mm are seen along Oliver Street.	Figure 11-27
FM5	Proposed bund east of Sixth Street and railway line, South Cessnock (variation to DB11)	The proposed bund upstream of the railway line results in significant reductions in flood levels up to 450-500mm at Oliver Street and Edgeworth Street. In frequent storms, properties on Oliver Street and Edgeworth Street would benefit from this option.	Figure 11-34
FM4 + FM5	Combination of Options FM4 and FM5	The proposed combination of FM4 and FM5 options results in reductions of flood levels in an order of 500mm at Oliver Street and adjacent properties. This is only a minor improvement from FM5 results.	Figure 11-35
FM6	Detention basin (DB1) Bellbird Creek - Austar Coal Mine site	The detention basin option at Austar Coal Mine site results in reduction of flood levels up to 200mm along the Bellbird Creek downstream of the Basin.	Figure 11-42

4. CONCLUSION

The validation modelling demonstrates that the model is providing a good representation of flood behaviour within the catchment and was able to reasonably replicate flood levels observed for the April 2015 event.

Flood Mitigation options modelling indicates that during an event similar to the April 2015 event, FM5 (a bund upstream of South Cessnock) could have reduced the level of flooding adjacent to Oliver Street drain by up to 450-500mm and prevented overfloor flooding to numerous properties. Other FM options either had a small or negligible benefit for reducing flooding during the April 2015 event.

Should you have any question or require any additional information, please to not hesitate to contact David Whyte on (02) 9496 7700.

Yours faithfully,

David Whyte
Manager – Water Engineering

For **Cardno (NSW/ACT) Pty Ltd**

Cessnock City (Black Creek)

APPENDIX H
COSTINGS- FLOOD MITIGATION OPTIONS

Cardno
Shaping the Future

Black Creek FRMSP

FM1
Cost Estimate

09.12.2015

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**5,558,600**
2.0	**DETENTION BASINS**				
2.1	DB7 - Excavate basin - cut / fill & regrade to suit new design levels, including disposal / provision of cut / fill	229000	cu. m	50	11,450,000
2.2	DB8 - Excavate basin - cut / fill & regrade to suit new design levels, including disposal / provision of cut / fill	222600	cu. m	50	11,130,000
2.3	DB12 - Excavate basin - cut / fill & regrade to suit new design levels, including disposal / provision of cut / fill	141540	cu. m	50	7,077,000
2.4	DB13 - Excavate basin - cut / fill & regrade to suit new design levels, including disposal / provision of cut / fill	148000	cu. m	50	7,400,000
	SUBTOTAL				**37,057,000**
	CONSTRUCTION SUB-TOTAL				**42,615,600**
3.0	**CONTINGENCIES**				
3.1	50% construction cost				**21,307,800**
	CONSTRUCTION TOTAL, excluding GST				**63,923,400**
	GST				**6,392,340**
	CONSTRUCTION TOTAL, including GST				**70,315,740**
	CONSTRUCTION TOTAL, rounded				**70,315,800**

DISCLAIMER:

1. This estimate of cost is provided in good faith using information available at this stage. This estimate of cost is not guaranteed.

Cardno (NSW) will not accept liability in the event that actual costs exceed the estimate.

NOTES:

1. Estimate does not include Consultant's fees, including design or project management

2. Assume existing drainage at sufficiently deep level to remain undisturbed.

3. Estimate / rates in 2015 dollars and does not allow for inflation

Black Creek FRMSP

FM2
Cost Estimate

09.12.2015

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**1,553,100**
2.0	**PROVISION OF BUND**				
2.1	Construct bund	225	lin. m	550	123,750
	SUBTOTAL				**123,750**
3.0	**DETENTION BASIN**				
3.1	DB6 - Excavate basin - cut / fill & regrade to suit new design levels, including disposal / provision of cut / fill	12600	cu. m	50	630,000
	SUBTOTAL				**630,000**
4.0	**CHANNEL WORKS**				
4.1	Convert trapezoidal channel to rectangular channel	12,000	sq. m	800	9,600,000
	SUBTOTAL				**9,600,000**
	CONSTRUCTION SUB-TOTAL				**11,906,850**
5.0	**CONTINGENCIES**				
5.1	50% construction cost				**5,953,425**
	CONSTRUCTION TOTAL, excluding GST				**17,860,275**
	GST				**1,786,028**
	CONSTRUCTION TOTAL, including GST				**19,646,303**
	CONSTRUCTION TOTAL, rounded				**19,646,400**

DISCLAIMER:

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NOTES:

1. Estimate does not include Consultant's fees, including design or project management
2. Assume existing drainage at sufficiently deep level to remain undisturbed.
3. Estimate / rates in 2015 dollars and does not allow for inflation

Black Creek FRMSP

FM3
Cost Estimate

09.12.2015

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**1,559,400**
2.0	**DRAINAGE**				
2.1	Supply, excavate, bed, lay, joint, backfill and provide connections for twin 2.36 X 0.9 m culvert	20	lin.m	6500	260,000
2.2	Supply, excavate, bed, lay, joint, backfill and provide connections for twin 3.8 X 1.8 m culvert	40	lin.m	12100	968,000
	SUBTOTAL				**1,228,000**
3.0	**CHANNEL WORKS**				
3.1	Channel widening from Wollombi Rd to Ferguson St	6,400	sq. m	800	5,120,000
3.2	Channel reshaping downstream of Ferguson St	5,060	sq. m	800	4,048,000
	SUBTOTAL				**9,168,000**
	CONSTRUCTION SUB-TOTAL				**11,955,400**
4.0	**CONTINGENCIES**				
4.1	50% construction cost				**5,977,700**
	CONSTRUCTION TOTAL, excluding GST				**17,933,100**
	GST				**1,793,310**
	CONSTRUCTION TOTAL, including GST				**19,726,410**
	CONSTRUCTION TOTAL, rounded				**19,726,500**

DISCLAIMER:

1. This estimate of cost is provided in good faith using information available at this stage. This estimate of cost is not guaranteed. Cardno (NSW) will not accept liability in the event that actual costs exceed the estimate.

NOTES:

1. Estimate does not include Consultant's fees, including design or project management
2. Assume existing drainage at sufficiently deep level to remain undisturbed.
3. Estimate / rates in 2015 dollars and does not allow for inflation

Black Creek FRMSP

FM4
Cost Estimate

09.12.2015

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**183,600**
2.0	**CHANNEL WORKS**				
2.1	Channel widening from Sixth Street to Edgeworth Road	1,530	sq. m	800	1,224,000
	SUBTOTAL				**1,224,000**
	CONSTRUCTION SUB-TOTAL				**1,407,600**
3.0	**CONTINGENCIES**				
3.1	50% construction cost				**703,800**
	CONSTRUCTION TOTAL, excluding GST				**2,111,400**
	GST				**211,140**
	CONSTRUCTION TOTAL, including GST				**2,322,540**
	CONSTRUCTION TOTAL, rounded				**2,322,600**

DISCLAIMER:

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NOTES:

1. Estimate does not include Consultant's fees, including design or project management
2. Assume existing drainage at sufficiently deep level to remain undisturbed.
3. Estimate / rates in 2015 dollars and does not allow for inflation

Black Creek FRMSP

FM5
Cost Estimate

09.12.2015

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**33,800**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing of vegatated areas	4615	sq. m	10	46,150
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	692.25	cu. m	25	17,306
2.3	Dispose of excess topsoil (nominal 10% allowance)	69.225	cu. m	60	4,154
	SUBTOTAL				**67,610**
3.0	**PROVISION OF BUND**				
2.1	Construct Bund - fill & regrade to suit new design levels, including provision of fill	4075.5	cu. m	50	203,775
3.2	Install overflow weir 6m in length	1	Item	10000	10,000
3.3	Supply, excavate, bed, lay, joint, backfill and provide connections for 0.45m dia. Low Flow Pipe	12	lin. m	925	11,100
	SUBTOTAL				**224,875**
4.0	**MINOR LANDSCAPING**				
4.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	4,615	sq. m	20	92,300
	SUBTOTAL				**92,300**
	CONSTRUCTION SUB-TOTAL				**418,585**
5.0	**CONTINGENCIES**				
5.1	50% construction cost				**209,292**
	CONSTRUCTION TOTAL, excluding GST				**627,877**
	GST				**62,788**
	CONSTRUCTION TOTAL, including GST				**690,665**
	CONSTRUCTION TOTAL, rounded				**690,700**

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NOTES:

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2. Assume existing drainage at sufficiently deep level to remain undisturbed.
3. Estimate / rates in 2015 dollars and does not allow for inflation

Black Creek FRMSP

FM6
Cost Estimate

09.12.2015

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item		
1.2	Provision of sediment & erosion control	1	item		
1.3	Construction setout & survey	1	item		
1.4	Work as executed survey & documentation	1	item		
1.5	Geotechnical supervision, testing & certification	1	item		
	SUBTOTAL (Assumed as 15% of works cost)				**575,400**
3.0	**DETENTION BASIN**				
3.1	Excavate basin - cut to suit new design levels, including disposal of cut	73000	cu. m	50	3,650,000
3.2	Construct embankments - fill & regrade to suit new design levels, including provision of fill	1200	cu. m	50	60,000
	SUBTOTAL				**3,710,000**
4.0	**DRAINAGE WORKS**				
4.1	Supply, excavate, bed, lay, joint, backfill and provide connections for Ø1.8m RCP including installation of headwalls and erosion protection as required	30	lin. m	4200	126,000
	SUBTOTAL				**126,000**
	CONSTRUCTION SUB-TOTAL				**4,411,400**
5.0	**CONTINGENCIES**				
5.1	50% construction cost				**2,205,700**
	CONSTRUCTION TOTAL, excluding GST				**6,617,100**
	GST				**661,710**
	CONSTRUCTION TOTAL, including GST				**7,278,810**
	CONSTRUCTION TOTAL, rounded				**7,278,900**

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NOTES:

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2. Assume existing drainage at sufficiently deep level to remain undisturbed.
3. Estimate / rates in 2015 dollars and does not allow for inflation