GRIFFITH CITY COUNCIL

GRIFFITH MAJOR OVERLAND FLOW
FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN FOR CBD CATCHMENTS

FINAL REPORT

JULY 2013

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Project Griffith Major Overland Flow Floodplain Risk Management Study and Plan for CBD Catchments	**Project Number** 112038
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FOREWORD

The NSW State Government‟s Flood Policy provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any 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 liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the Government through four sequential stages:

1. Flood Study

- Determine the nature and extent of the flood problem.

2. Floodplain Risk Management

- Evaluates management options for the floodplain in respect of both existing and proposed development.

3. Floodplain Risk Management Plan

- Involves formal adoption by Council of a plan of management for the floodplain.

4. Implementation of the Plan

- Construction of flood mitigation works to protect existing development, use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

The Griffith Major Overland Flow Floodplain Risk Management Study and Plan for the CBD Catchments constitutes the second and third stages of this management process. This study has been prepared by WMAwater for Griffith City Council (Council) and provides the basis for the future management of flood prone lands in the Griffith CBD catchment. It should be noted that this plan is in relation to major overland flows and a FRMP has already been adopted by Council concerning Main Drain J flooding.

This report has been prepared with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

EXECUTIVE SUMMARY

This Flood Risk Management Study and Plan (FRMS&P) focuses on the overland flow flooding issues within the Griffith urban area. The Study has been commissioned by Griffith City Council (Council) to assess and make recommendations for maintenance or reduction of flood risk within the Griffith CBD. This FRMS&P follows on from the Griffith CBD Catchment Overland Flow Flood Study prepared by WMAwater and adopted by Council in March 2012.

A floor level survey has been undertaken and used in producing a tangible flood damages assessment. The flood damages assessment was used to highlight key areas which should be prioritised in terms of providing flood relief and to assess the potential benefit of any relief works. Of the 216 properties surveyed (70 residential and 146 commercial), a total of 19 residential and 99 commercial or industrial properties are likely to be flooded above floor level in the 1% AEP event. For the same event, of the properties surveyed, 69 residential and 125 commercial or industrial properties are affected by over ground flooding. The estimated annual average damages per flood affected residential property up to the PMF event is $2,440 with 72 of the surveyed lots flood affected and 64 of these with building inundation above floor level. For commercial/industrial properties annual average damages per flood affected property up to the PMF event is $5,880 with 142 of the surveyed lots subject to flood affectation and 138 of these liable to above floor flooding.

The Flood Study identified a number of key areas where flooding was an issue. Yambil Street, Burrell Place, Cutler Avenue, Noorla Street and Lenehan Road were all highlighted as flooding hot-spots. For the purpose of this FRMS&P the total study area was divided into a number of sub-areas based on their flooding characteristics, previously identified hot-spot areas and type of land use. Six sub-areas were identified and referred to as; the CBD area; Industrial Zone; Crossing Street area; Junction of Wakaden and Ulong Streets; Hyandra Street area; and, Noorla Street Residential area.

As part of this FRMS&P the hydraulic model was used to assess where improvements made to the drainage system could effectively reduce flood depths and potential flood damages to properties. Drainage modification options investigated included a combination of upgraded pipe networks, installation of retention basins and open channel improvements. Each of the options was considered in terms of the impact of flood levels and tangible flood damages for each of the previously identified flooding hot-spots and the sub-areas.

All options were assessed using the 1% AEP flood event (100-year ARI). A number of options would provide benefits to different areas reducing flood levels and flood associated damages and further discussion with Council will be undertaken to identify the high priority areas or options.

The Flood Liable Lands Policy, Floor Heights Policy and OSD Policy have all been reviewed. Recommendations have been made, especially in relation to identifying the Flood Planning Area

(FPA) and setting the Flood Planning Level (FPL) and building floor levels. This matter will require further discussion with Council engineers and planners to finalise an appropriate FPA, FPL and building floor level requirements.

The draft Plan has been endorsed by Council and the Floodplain Management Committee and was held on public exhibition for community feedback before a this final Flood Risk Management Plan was issued.

1. INTRODUCTION

1.1. Study Area

Griffith is located approximately 450 km north of Melbourne and 560 km west of Sydney in the heart of the Murrumbidgee Irrigation Area (MIA). The CBD and residential areas of Griffith are located at the base of the McPherson Ranges. Griffith and its surrounding villages of Yenda, Yoogali, Hanwood, Bilbul and Beelbangera lie within the Main Drain J catchment, which together with its network of drainage channels delivers runoff to Mirrool Creek. A plan of the study area is shown as Figure 1.

The Griffith CBD catchment has an area of approximately 9 km^2. The upper part of the catchment is steep and covered in scattered timber and bushland. South of the bushland area the urban area begins and continues south to Wakaden St and the Temora-Roto Railway Line. This area is predominantly low density residential development. Griffith CBD lies the south of the railway line, and is characterised by commercial and light industrial land uses. At the downstream extents of the CBD is the Main Canal which is raised above normal ground levels and is consequently a substantial obstruction to overland flow. Existing land use of the Griffith CBD catchment is shown in Figure 2 based on the LEP land use zones.

The City of Griffith is not located on the banks of a major river system and therefore does not experience mainstream flooding as occurs at other centres within the Murrumbidgee River catchment for example Wagga Wagga. However, Griffith and its surrounding areas are affected by high volume rainfall events and also from flooding from the Main Drain J system.

1.2. The Floodplain Risk Management Process

As described in the Floodplain Development Manual (Reference 6), the floodplain risk management process is formed of sequential stages;

- Data Collection;
- Flood Study;
- Floodplain Risk Management Study;
- Floodplain Risk Management Plan; and
- Plan Implementation.

The first key stage of the process has been undertaken with the completion of the Griffith CBD Catchment Overland Flow Flood Study (Reference 1) which was adopted by Griffith City (Council) on 27 March 2012. Following this, this Floodplain Risk Management Study and Plan for the CBD catchment has been prepared to;

- Define true hazard / hydraulic categories;
- Identify over floor flood liability;
- Identify how, going forward, flood risk can be managed;
- Discuss results of the Study findings for SES response; and
- Identify the options for floodplain risk management with particular regard to the local

overland flooding problems in the CBD area of Griffith.

The floodplain risk management process is also being undertaken for the wider area with the Griffith Floodplain Risk Management Study and Plan for the Main Drain J Catchment (Reference 2) completed in 2011 although following the floods of March 2012[1] this document is now subject to review as per the recommendations of the Floodplain Development Manual (Reference 6). Notable outcomes of the study included recommendation of a Flood Liable Lands Policy and an On-site Detention Policy.

1.3. Previous Studies

A number of previous studies have been reviewed ranging from detailed drainage studies of the CBD area through to investigations of a broader area covering the Main Drain J system. Key studies include;

- Griffith Flood Study, 1992, Water Studies Pty Ltd (Reference 9);
- Yambil Street Drainage Investigation, 2001, BEL Group (Reference 4);
- Drainage Investigation Canal Underpass Capacity and Ulong/Kooyoo Upgrades, 2002, BE Group (Reference 5);
- Griffith CBD Flood Study, 2002, Environmental Resources Management Australia (Reference 8);
- Griffith Flood Study, 2006, Patterson Britton & Partners (Reference 3);
- Griffith Floodplain Risk Management Study and Plan, 2011, Worley Parsons Services (Reference 2); and
- Griffith CBD Catchment Overland Flow Flood Study, 2012, WMAwater (Reference 1).

Most of the previous studies noted above have been summarised in the Overland Flow Flood Study, 2012 (Reference 1). Those which have not, or are of importance to this study are detailed below.

1.3.1. Yambil Street Drainage Investigation, 2001

This study (Reference 4) was commissioned by Council to investigate potential solutions to existing flood problems at a commercial property located at the intersection of Yambil and Ulong Streets. An ILSAX model was developed for a portion of the drainage system and analysis was carried out.

The report highlighted that the existing Yambil St drainage system did not meet Council"s current stormwater design guidelines. The capacity of the system was largely restricted by the existing adverse gradients and reliance on piped flow solely until such time as Jondaryan Avenue is overtopped. The flat gradients of the system reinforce the need for regular maintenance to prevent blockage of the pipes and loss of capacity.

Further to this investigation built improvements were made to the Yambil Street drainage system

[1] The recent March 2012 Main Drain J event was an extreme flood event; at least a 2% AEP event but possibly as large as a 1% AEP event when compared against rainfall IFD data.

and completed in 2012.

1.3.2. Drainage Investigation Canal Underpass Capacity and Ulong/Kooyoo Upgrades, 2002

This study (Reference 5) was commissioned by Council to assess the capacity of the irrigation canal underpass that drains the Yambil St system and to determine the pipe sizes required to run under the Kooyoo St intersection for the proposed roundabout. The focus of the latter was subsequently shifted to the Ulong St intersection as this roundabout would be built first.

DRAINS was used as the hydrologic and hydraulic modelling tool for the Yambil St drainage system capacity assessment and upgrade. It was identified that the inverted siphon at DC „S‟ has the capacity to take up to the 2% AEP peak flow without surcharging the upstream pit, as determined by the 2002 Griffith Flood Study (Reference 8). Also it was found that the Yambil Street sub-surface drainage system has a capacity to convey only 1 in 1 year peak flow or less, compared to Council‟s adopted policy at the time requiring this system to have a capacity of 5% AEP. The lack of inlet capacity further impedes surface runoff from getting into the piped system.

1.3.3. Griffith Flood Study, 2006

The 2006 Flood Study (Reference 3) was undertaken for the Main Drain J catchment. Although it mainly focused on the flood behaviour of the Main Drain J system, the flood study also looked at areas of the Griffith CBD which have experienced flooding but which are not strictly located on the floodplain of the Main Drain J system. The study recognised the two different flooding mechanisms in the catchment and established two hydraulic models; one broad-scale model for the Main Drain J catchment and a second more detailed model for the urban sections of Griffith from the McPhersons Range to the Main Branch Canal. The models were developed independently and concurrent flooding of the Main Drain J system as well as the Griffith CBD catchment (as a result of overland flow) was not investigated.

This Flood Study formed the framework for the subsequent Floodplain Risk Management Study and Plan (Reference 2). The study defined existing flood behaviour within the floodplain of the Main Drain J system and highlighted those areas where the greatest flood damage is likely to occur.

1.3.4. Griffith Floodplain Risk Management Study and Plan for Main Drain J Catchment, 2011

The Griffith FRMS&P for the Main Drain J catchment (Reference 2), based upon the findings from the 2006 Flood Study (Reference 3), was completed in 2011. This study assessed a range of options to mitigate flooding within the lower CBD however concluded that works would be costly and provide marginal benefits when considered in the larger context of flood damages throughout the Main Drain J catchment. Through the FRMP process, Council developed and adopted its Flood Liable Lands and On-site Stormwater Detention Polies (see Section 2.3.1).

As part of the Study, a DRAINS model was developed to investigate options for diverting flows from the CBD area, for example Yambil Street via a new siphon under the Main Canal. This option was implemented and built works were completed in 2012.

It should be noted that the Study and Plan was adopted before the March 2012 event occurred in the Main Drain J catchment. During 3rd to 4th March heavy rainfall occurred on the catchment which resulted in flooding in Griffith, firstly via a Main Drain J event then secondly, due to flooding in the larger Mirrool Creek catchment. This event is thought to be in the order of a 2%-1% AEP flood. The Study will be reviewed as per NSW Floodplain Development Manual (Reference 6).

1.3.5. Griffith CBD Catchment Overland Flow Flood Study, 2011

The CBD Overland Flow Flood Study (Reference 1) looked in detail at the CBD catchment and overland flow problems whereas previous studies generally considered the wider Main Drain J catchment area. The study investigated the 5-year ARI, 10%, 5%, 2%, 1% 0.5% AEP and PMF events. Hydrologic and hydraulic models were developed using WBNM, DRAINS and TUFLOW. Preliminary hydraulic categories for the 5% and 1% AEP event were determined as was provisional hazard mapping. The study highlighted Yambil Street, Burrell Place, Cutler Avenue, Noorla Street and Lenehan Road as flooding hot-spots within the CBD catchment area.

The Study estimated that 52 residential and 116 commercial properties could be flood liable, though not necessarily above floor, in the 1% AEP event. At the time of the Flood Study floor levels were not available to accurately define over floor flooding of buildings. A floor level survey has been undertaken as part of this FRMS&P to more accurately assess the number of properties affected by over-floor flooding (see Section 4.1).

The study identified that within the study area there are at least two different flooding issues. Some residents, especially in the upper areas, experience relatively brief and shallow inundation of their properties and access roads and this causes concern. Generally runoff spills over from the road into the individual properties as the local drainage systems (pits, pipes, basins, etc) struggle to cope with runoff. For other residents, the railway or canal embankments impede the downstream flow of floodwaters causing subsequent inundation of properties.

1.4. Flood Study Review and Update

The Overland Flow Flood Study (Reference 1) described in Section 1.3.5 above and which forms the first stage of the floodplain risk management process for the CBD study area was adopted by Council in March 2012.

A range of storm durations were modelled for the study catchment and it was found that the critical storm durations for the 1% AEP and PMF design events are two and one hours respectively. Design floods information for the 5-year ARI, 10%, 5%, 2%, 1%, 0.5% AEP events and the PMF were established. Flood depth, level, velocity, provisional hazard and provisional hydraulic category maps were presented. The study found that flood levels, and therefore depths, do not differ significantly between events particularly for the upper catchment area. This has specific implications for the establishment of the Flood Planning Level (FPL) in that the 1% AEP flood level plus 0.5 m will generally exceed the PMF level.

The Flood Study established the following key issues;

- There is little difference between peak levels for the range of design events modelled;
- Water is attenuated by the presence of obstructions to flow including the railway and Main Canal embankments;
- The capacity of the inverted siphons beneath the Main Canal is largely restricted by the upstream drainage system to deliver flow; and
- Flooding hot-spots were identified - key locations of concern include; Yambil Street; Wakaden Street; Noorla Street; Cutler Avenue; and Lenehan Road.

The study also considered the potential effects of climate change by modelling rainfall increases of 10%, 20% and 30% on the 1% AEP flood event. A 10% increase in design rainfall intensity resulted in approximately 0.1 m increase in peak flood levels and a 20% increase in rainfall intensity lead to a 0.2 m increase in flood level and 30% to 0.3 m. Furthermore, a 30% increase in rainfall would be effectively a 0.2% AEP (500-year ARI) event based on current IFD data.

In addition to modelling climate change predictions the study also looked at future development modelling scenarios for four new developments including the Rural Fire Services (RFS) centre on Wakaden Street, Woolworths on Burrell Place, a new Medical Centre on Kooringal Avenue and Griffith Mall on corner of Yambil Street and Jondaryan Avenue. It was found that most of these developments have minimal impact on the 1% AEP flood levels with the exception of the RFS site which appears to have altered the overland flow paths albeit with minor impacts on 1% AEP flood levels.

The Flood Study concluded that certain areas are flood liable for events as small as the 20% AEP event. These areas include Yambil Street, Noorla Street, Cutler Avenue and Lenehan Road. Ultimately, in order to address these issues either runoff must be attenuated upstream or conveyance at, and downstream, of the hot-spots must be improved.

The key outcomes of the Flood Study which are to be discussed, considered or managed in this Study and Plan are:

- The implications for the Flood Planning Level (FPL) due to there being little difference between flood levels/depths for different design events;
- The areas identified as being flooding hot-spots;
- Establish the “true” hydraulic category and hazard definitions;
- Formal quantitation of flood risk by flood damages assessment;
- Identify mitigation measures to address the adverse impacts of new developments; and
- Identify risk management measures to reduce flood costs to properties within the Griffith CBD catchment by either structural or non-structural measures.

The hydraulic models developed for the 2012 Flood Study (Reference 1) have been reviewed and fully updated to incorporate new major developments within the Griffith CBD catchment including;

- Rural Fire Services (RFS) centre located on Wakaden Street;
- Woolworths on Burrell Place;
- New medical centre on Kooringal Avenue; and
- Griffith Central shopping mall located at the corner of Yambil St and Jondaryan Ave.

As reported in the Flood Study (Reference 1), although changes occur to the existing overland flow paths as a result of these developments, the redistribution of flow is localised and impact on flood levels is not significant.

Since the completion of the Flood Study, a new siphon outlet has been constructed underneath the Main Supply Canal along Ulong St and a flood detention basin built on Bromfield St at the previous Griffith Arboretum, as part of flood mitigation Option S2 from the 2011 Griffith FRMS&P (Reference 2). The model was updated based on revised survey details of the mitigation works provided by Council and the model extent extended to include the drainage channel in Merrigal St (a sub-branch of DC „R") where water stored in the basin will be discharged to. This will also facilitate the assessment of downstream flood impacts, if any, of mitigation works proposed for the CBD area.

In addition to Option S2, modelling of Option S5 is also required by Council whereby the existing trunk drainage line along Yambil St from Ulong St to Bonegilla Rd will be upgraded. This was modelled as part of the Mitigation Options proposed and discussed in Section 6. Several pipes omitted in the previous modelling were also included to provide connectivity for the flood detention basins proposed as part of the Mitigation Options.

The updated hydraulic model from the Flood Study which incorporates the aforementioned changes was then utilised in the assessment of the flood mitigation measures proposed in Section 6. All results reported herein are based on inclusion of these changes.

2. BACKGROUND

2.1. Study Area

2.1.1. Land Use

The land zones as identified in the Griffith LEP 2002 are shown as Figure 2. Generally residential development is located to the north of the railway and commercial and industrial uses to the south of the railway, and north of the Main Branch Canal. The Main Branch Canal, which carries irrigation water from the Murrumbidgee River to Griffith and surrounding area, is aligned parallel to the main street of the CBD; Banna Avenue. The study area is highly developed with relatively little space for further greenfield development and any development tends to be infill development.

2.1.2. Social Characteristics

Information is available from the 2006 census to understand the social characteristics of Griffith. At the time of writing this report, some information from the 2011 census has been released, although not all. Understanding the social characteristics of the area can help in ensuring that the right risk management practices are adopted. Of note is the percentage of population who are not fluent in English which is useful to understand when considering flood awareness education or when issuing evacuation orders. The 2011 census identifies that in Griffith City 21% of people speak a language other than English at home.

Based on the 2006 census, as 2011 data is not yet available for this subject, data shows that a large number of people moved to the area with the 5-year period prior to the census. For the general commercial/industrial area of the CBD (along and south of Banna Avenue) between 45% and 55% of residents in the area moved in the 5-years prior. North of this in the predominantly residential area, this figure applied to around 30% of the residents. This is interesting to show the frequency of change of residents. Generally residents who have lived in the same place for many years will generally have a better understanding of existing flood risk.

2.1.3. Drainage System

The CBD catchment is drained primarily by a sub-surface pipe system with natural earth drainage channels located downstream of the Main Branch Canal and in the western section of the catchment. The drainage network necessarily has a limited capacity and as a result parts of the CBD area are prone to inundation, even in smaller rainfall events. In periods of flooding overland flow paths exist which comprise Noorla Street, Jondaryan Avenue, Crossing Street and Lenehan Road. Otherwise flood water must either flow over the Main Canal or drain via the pit and pipe systems over an extended time.

Key components of the drainage system include a number of inverted siphons which convey controlled discharges from the CBD catchments upstream of the irrigation canal embankments to the lower downstream sections of the Main Drain J catchment.

Table 1 below describes the drainage arrangements to the various siphons. These siphons (also indicated on Figure 1) do not always have sufficient capacity to pass the full peak discharges from the upper sections of the catchment. Therefore the excess flood waters build up behind the canal embankments forming temporary storage areas as discussed in Section 3.1. This means that peak flood levels tend to be dominated by high volume events. With the exception of DC “U” and DC “McPherson S”, the siphons are connected to a pipe drainage system upstream.

Table 1: Siphon Details

Name	Size	Details
DC “McPherson S”	Twin 1500mm diameter pipe inverted siphons	Drains runoff from the McPhersons Range beneath the Main Branch Canal into DC “McPherson S”
DC “Industrial S”	Twin 1800mm diameter pipe inverted siphons	Drains runoff from the McPhersons Range and the eastern section of the Griffith CBD beneath the Main Branch Canal into DC “Industrial S”
DC “S”	Twin 1800mm diameter pipe inverted siphons	Drains runoff from the McPhersons range and the central sections of Griffith CBD beneath the Main Branch Canal into DC “S”
DC “U”	Twin 1200mm and twin 750mm diameter pipe inverted siphons	Drains runoff from the McPhersons Range and Mayfair beneath the Lake View Branch Canal into DC “U”
DC “R”	Twin 1050 diameter pipe siphon	Part of the Yambil Street drainage upgrade which drains runoff primarily from the western section of the Griffith CBD beneath the Main Branch Canal and discharges eventually into DC “R”

In the past, frequent flooding has occurred throughout the commercial areas of Griffith including Yambil Street, even in small rainfall events less than the 6 month ARI for example. Studies have indicated that this flooding has been due to a combination of catchment runoff, blockage and/or insufficient capacity of the sub-surface drainage systems and the associated siphon drainage systems, as well as the elevated railway and canal embankments that impede downstream overland flow paths. Within the study area flows are predominantly distributed and shallow at the upstream or northern sections of the CBD catchment and runoff generally ponds behind the various embankments that tend to be aligned normal to general flow direction such as the Main Canal and railway line, before being gradually discharged through the siphon outlets located under the Main Canal at the downstream boundary of the study area. The Flood Study (Reference 1) also found that the actual flow at the siphons was largely restricted by the upstream drainage system. The modelling undertaken as part of this study found that four of the siphons were inlet controlled whilst the recently constructed DC “R” siphon is outlet controlled due to the surcharge pit located downstream.

Council recently constructed new drainage works including a new siphon, DC “R”, along Ulong Street in an attempt to alleviate the flooding problems around Yambil Street. Hydraulic models have been updated to include this upgrade.

2.1.4. Sub-Areas

For the purpose of this FRMS&P the study area has been divided into a number of sub-areas. The sub-areas have been identified based on their flooding characteristics and the type of land use. The areas are described below and also identified on Figure 1.

CBD Area

This area generally comprises the mainly commercial CBD area including Banna Avenue, Banna Lane, Yambil Street and Canal Street between Daines Street on the west to Jondaryan Avenue to the east. The sub-area includes the new Griffith Central Shopping Centre. A total of 107 commercial and 19 residential buildings were surveyed for floor levels in this area.

Industrial Zone

The industrial zone comprises the area to the north and south of Burley Griffin Way as it becomes Banna Avenue. It is bounded by the railway to the north and Main Canal to the south. A total of 23 buildings were surveyed. All properties in this area were of industrial use.

Crossing Street Area

This area include properties either side of Crossing Street on Wakaden St and Banna Avenue, including the new Rural Fire Services centre. A total of four residential buildings were surveyed for flood levels along with ten commercial/industrial buildings and the new Rural Fire Services centre.

Junction of Wakaden and Ulong Streets

This area includes the new Woolworths supermarket and is generally centred around the junction of Ulong Street, Burrell Place and Wakaden Street. Three commercial buildings, including Woolworths, and five residential buildings were surveyed for floor levels.

Hyandra Street Area

This area comprises the retirement village, and several adjacent buildings including the dental and medical surgery. The sub-area is on a steep gradient from north-west to south-east and the Flood Study identified that some of the area is subject to hydraulic classification as a floodway through the area (see Section 3.2). Floor level survey of the sub-area included the doctors" surgery, buildings associated with the retirement village and five residential dwellings.

Noorla Street Residential Area

This area comprises residential properties on Noorla Street and also some on Parkinson Crescent. A drainage channel runs parallel with the Main Canal and Noorla Street. When the capacity of this drain is exceeded there is flooding on Noorla Street and into the surrounding area. Twenty-five residential buildings were surveyed for floor levels.

Other Areas

Seven residential buildings in other areas were also included in the floor level survey where the Flood Study identified localised flooding.

2.2. Historical Flood Issues

The CBD areas that have suffered the most flooding lie around Yambil Street with many businesses here reported to have been flooded at some point. Properties at the lower end of Banna Avenue to the east have been reported to have had flooded basements in the past. Recent rainfall events have also indicated some localised flooding at various locations including the intersection of Wakaden and Crossing Streets, Wakaden Street with Burrell Place and Ulong Street and Wakaden Street with Hickey Crescent junction. Noorla Street was significantly flood affected in October 2010.

2.2.1. Notable Events

March 1989

The Overland Flow Flood Study (Reference 1) describes the March flood of 1989 when 103 mm of rainfall fell in 15 hours. It was found that peak levels for the 1989 event are comparable to those of the 10% AEP design event. The urban area of Griffith suffered some flooding and it is generally thought that most of the flooding within the urban area was a result of the existing drainage system having insufficient capacity in combination with blockage by debris.

October 2010

The October 2010 event is notable in terms of its magnitude. The severity of this event was compounded by the fact that the catchment was already saturated with the occurrence of rainfall two days previous. Widespread flooding was reported by Council along Noorla Street and rainfall records show the total daily rainfall exceeded 60 mm. The 2010 event was found to be in the order of a 5-year ARI event (Reference 1).

March 2012

During late February and early March 2012, persistent, widespread and heavy rainfall was experienced throughout much of New South Wales (NSW). During this period Griffith experienced major flooding from local creeks and drainage canals as well as from levee failure. The Northern branch canal failed on the western (Yenda) side. A number of gauges in the vicinity of Griffith experienced rainfall depths exceeding 1% AEP depths for one, two and three day rainfall totals. A natural disaster declaration was announced for Griffith Shire on the 8th March 2012 which was one of 62 natural disaster declarations made throughout the state as a result of this rainfall event.

Hundreds of residences and commercial buildings were inundated throughout Griffith as a result of this rainfall event. Flooding in Main Drain J had flood depths and extents comparable to the 1% AEP event. In addition to this, Mirrool Creek to the east and south of Griffith experienced flooding to levels not seen since 1931. Yenda was the worst affected area due to failure of the Northern Branch Canal which allowed flood waters to flow uncontrolled into a region completely reliant on a drainage system designed only for local runoff and irrigation flows. The Mirrool Creek event and subsequent levee failure at Yenda caused flood water depths in excess of one meter and inundated over 600 properties. Thousands of people were evacuated throughout the Griffith region.

Although areas surrounding Griffith were significantly affected, the CBD of Griffith was left relatively unscathed. Several roads into the Griffith urban area were cut off but access was still available to the CBD via other routes. No evacuation order was issued for Griffith City.

2.3. Legislative and Planning Context

2.3.1. Existing Council Policy

Council is in the process of preparing a new Local Environmental Plan (LEP) and Development Control Plan (DCP) which consolidates all existing DCPs into one Comprehensive DCP. This study will contribute to both of these in regards to flooding. In the meantime policy in regards to flooding will continue to be guided by the existing LEP and DCP along with a number of newer Council Policies. These policies will eventually be incorporated into the Comprehensive DCP. The Plans and Polices have been discussed below and later have been reviewed in regards to flood risk management to identify where improvements might be made (see Section 5.6.3).

Griffith Local Environmental Plan, 2002

This planning instrument details land zoning and various planning restrictions. Clause 26 of the Plan specifically applies to flood liable land.

Planning restrictions set out in Clause 26 stipulate that consent will not be granted for development within flood liable land unless the following have been considered;

- A survey of land level relative to the flood level;
- Loss of life or property from flooding;
- Impediments to floodway systems;
- Effect of development on adjoining land;
- Limits on the intensity of development of flood liable land in urban areas;
- Provision of services; and
- Effect of development on water table.

Under this Clause, Flood Liable Land is defined as “land likely to be inundated in a 1 in 100 year flood”. Although this definition is within a legislated document, it is considered to be out of date and will be updated later in 2013 as Council amend the LEP (see section 5.6.3). In the interim, the requirements of Clause 26 in the 2002 LEP are considered in the development assessment process. However, it is also Council policy to in parallel implement the definition of Flood Liable Land within the Floodplain Development Manual (Reference 6) and under Council‟s Flood Liable Lands Policy (see below) which defines the flood liable (or prone) land being land susceptible to flooding by the PMF event. As the Flood Liable Lands Policy represent more recent and up-to date controls relating to flood liable (prone) lands which were created to satisfy an overarching NSW Government Flood Policy, it is Council practice to supplement Clause 26 with these controls when required.

Griffith Development Control Plan

Council is presently amending the LEP 2002 and, at the conclusion of the process, Council will be required to create a DCP. In the interim Council is not able to create any new DCPs and can only update the existing plans which include:

- DCP No. 1 – Non-urban Development;
- DCP No. 3 – Industrial Development;
- DCP No. 5 – Wyangan Avenue Residential Precinct;
- DCP No. 6B – Pioneer Precinct;
- DCP No. 11 – Urban Subdivisions;
- DCP No. 17 – Siting and Development of Public Open Space;
- DCP No. 19 – Mixed Development;
- DCP No. 20 – Parking;
- DCP No. 21 – Residential Development;
- DCP No. 22 – Exempt and Complying Development; and
- DCP No. 25 – Public Notification.

The majority of these DCPs are dated between 1998 and 2004. As such, controls relating to flooding are limited and for some areas out of date and the adopted Flood Liable Lands Policy is presently used as a primary form of flood related assessment criteria for development applications and inquiries. The controls adopted as part of the Flood Liable Lands Policy will form a chapter in the upcoming comprehensive DCP.

Flood Liable Lands Policy, 2011

Council‟s Flood Liable Lands Policy was adopted in October 2011 following the Main Drain J catchment FRMS&P (Reference 2). As previously stated, the Flood Liable Lands Policy has been adopted as Council Policy and is currently used by Council as an interim set of guidelines until incorporated into the Comprehensive DCP. With an aim to reduce impacts of flooding and flood liability on individual owners and occupiers as well as to reduce public and private losses resulting from floods, the Flood Liable Lands Policy presents a set of assessment criteria which are to be met by all new development. It also requires that new development assess potential life threatening situations arising from flooding up to the PMF.

The Policy is applicable to all flood prone land; that is land subject to flood inundation up to the PMF event as defined in the Floodplain Development Manual (Reference 6). For any development on or adjacent to flood prone land, Council‟s existing flood studies should be used to determine the relevant flood levels as well as the hydraulic category and hazard for the site. Development controls set within the Policy vary dependent on the land use of the development and the category of the floodwaters that impact on it.

The Policy adopts the 1% AEP (100-year ARI) flood level plus a freeboard of 0.5 m as the Flood Planning Level (FPL). For residential development finished floor levels of habitable rooms should be at least equal to the FPL. For other land uses alternate FPLs can apply dependent on the land use and therefore their vulnerability to flooding. The policy stipulates that for commercial and industrial properties at least 25% of the floor area is to be at or above the FPL whilst the remainder of the floor must be above the 1% AEP flood level. However, the policy recognises that this may not always be viable due to other constraints and therefore in some circumstances a minimum floor level above 5% AEP (20-year ARI) flood level may be permitted provided it is justified by the need to achieve mobility access standards and comply with existing street frontages.

Any critical utilities, where loss of these services during flooding would present an unacceptable risk, should be constructed away from flood prone land where possible. However in instances where location within flood prone land is unavoidable they should be constructed to be flood free during the PMF event by flood proofing methods such as land raising.

As well as specifying finished floor levels, the Policy requires that flood proofing for all new development, residential or commercial and industrial, is applied up to the FPL. Flood proofing measures are set out within the Policy applying to all potentially flood affected development. Flood proofing measures can include installing electrical features above the FPL, suitable structural design, construction materials and method of construction, and storage of large floatable objects such as vehicles, containers and bins.

The responsibility lies on the applicant to prove that any development within a designated flood storage area will not cause a loss in flood storage or result in adverse flood impacts. Excavation or other works will be allowed to compensate for this where practicable. The Policy also notes that existing overland flow paths should not be impeded. To comply, some development will require a Flood Impact Assessment report. Overall, the Policy ensures that new development will not increase demand on emergency services in the event of a flood and to ensure that safe site access and egress may be achieved.

The Policy also considers the flood risk from developments such as car parks and fences in that proposals for car parks should ensure that vehicles do not becoming moving debris during floods and fences should not impede flood flows or cause increases in flood velocities or other adverse impacts of flooding. Details are also given for other land uses.

The Policy is clear in identifying the development controls and conditions for consent which apply to different land uses and to areas subject to varying categories of flow, for example whether development lies within a flood storage, flood fringe or floodway defined area. It describes supporting information to be submitted with an application. This Policy is well prepared and comprehensive although largely based on fluvial flooding (Main Drain J catchment) as opposed to pluvial flooding (overland flood flows). It notes that this current study is ongoing and will be incorporated once complete, therefore following the outcomes of this Study and Plan there may be scope to update the Flood Liable Lands Policy.

With regards to the recommended FPLs, for much of the CBD catchment a floor level of 0.5 m above the 1% AEP flood level could be higher than the PMF flood level in terms of the overland flow flooding. This will need consideration when identifying appropriate flood risk management measures (see Section 5.6.1).

Buildings – Floor Heights Policy

This Policy should be read in conjunction with the Flood Liable Lands Policy described above. Its main objective seeks to ensure buildings in flood liable areas are designed and constructed above the 1% AEP flood level in order to avoid flood damage and ensure an acceptable level of risk to occupants. It gives no definition of flood liable areas and it is assumed that this would be as defined in the Floodplain Development Manual (Reference 6).

The Policy ensures that, within flood prone areas, the minimum height for habitable rooms should be greater than 0.5 m above the 1% AEP flood level as determined by the August 2006 Flood Study (Reference 3). It also notes where no study is available a minimum floor height of 0.41 m above ground level should be achieved. It is not clear where this value of 0.41 m comes from however, or how flood liable land is defined where there is no hydraulic modelling, although it is likely the 0.41 m is relating to older controls in the Building Code Australia.

On-Site Detention (OSD) Policy

This Policy was formalised as part of and included in the Griffith Floodplain Management Study (Reference 2) and adopted in October 2011. The primary aim of the OSD Policy is to ensure that new developments and redevelopments do not increase the volume or peak discharge of run-off within a catchment or modify the temporal distribution of stormwater discharge whereby flood levels are adversely affected at downstream locations. Any effects are considered with reference to the 1% AEP storm event. A key objective of the policy is to restrict peak flows from developments to which OSD restrictions apply, for all events up to and including the 1% AEP event to estimated peak flows under pre-development conditions. It also seeks to improve the existing flood issue where possible and create a sustainable storm water management system including Water Sensitive Urban Design (WSUD) techniques. The Policy requirements generally apply to all types of development and re-development on both flood liable and flood-free sites.

In catchment areas to the north of the Main Branch Canal, the Policy specifies a maximum discharge from the site of 65 l/s/ha for the critical 1% AEP storm. OSD is required to attenuate flows back to this rate. Ponding of pedestrian areas, parkways and drives, gardens, private courtyards, paved recreation in common areas can all be used to provide on-site detention. The Policy provides guidelines to assist in determining depths and frequencies dependent on the storage area type. For example pedestrian areas should not flood to a depth more than 0.05 m in a 1% AEP flood event whilst gardens would be allowed to flood up to 0.6 m in such an event.

In areas south of the Main Branch Canal the Policy recognises that it may be beneficial to allow runoff to discharge freely from the site and sites will be assessed on a case by case basis.

The Policy is useful in assuring on-site attenuation is provided to prevent an increase in runoff rates downstream as a result of future development. The beneficial effect of this is that peak flow rates at the siphons and the backing up of flood water behind them will not be exacerbated.

Land Use Strategy (LUS) – Beyond 2030

Council has adopted a new strategic land use planning document which will guide the preparation of the LEP and Comprehensive DCP. The mapping, controls and findings of the Main Drain J FRMS&P (Reference 2) were used to ensure growth areas were not located within constraint areas and to ensure that existing built up areas which have been identified as flood prone land are not further intensified. Following the adoption of this FRMS&P document, the LUS will be further amended to include the relevant mapping and findings for the CBD catchments.

2.3.2. Local Flood Plan and Emergency Response Protocols

Griffith Local Flood Plan (2008)

The Local Flood Plan (Reference 14) is a sub-plan of the Local Disaster Plan (DISPLAN). This Local Flood Plan sets out the responsibilities of various parties including, but not limited to, members of the SES, BoM, Australia Rail Track Corporation, Local Caravan Park Proprietors and some private companies, Council, NSW Fire Brigades and NSW Police Force, and the Transport Services Co-ordinator.

The Local Flood Plan states that it is the responsibility of the Griffith SES Local Controller, with the assistance of the Council and others to ensure that the residents of the LGA are aware of the flood threat in their vicinity and how to protect themselves from it. Public education methods are discussed in detail in Section 5.5.3.

The current plan has four nominated evacuation centres including the Police and Citizens club (PCYC) on Olympic Street in the Griffith CBD within the study area. The Southside Leagues Club and Griffith Ex-servicemen"s Club both located south of the Main Canal are also nominated evacuation centres.

2.4. Community Consultation

One of the central objectives of the Floodplain Risk Management Study process is to actively liaise with the community throughout the process, keep them informed and address their needs.

2.4.1. Previous Community Consultation

A consultation program was undertaken as part of the Main Drain J Flood Risk Management Study (Reference 2) to understand the views of the local community on the suitability of the floodplain management options proposed. Although this study covered a wider area, some people within the CBD area were involved.

As part of the Overland Flow Flood Study (Reference 1) a community survey was carried out to assess the awareness of the 2010 flood event and to find out who had been impacted. Results of the survey did not identify a huge flood problem necessarily but identified residents were more concerned over storm water type issues; for example, no complaints about over floor inundation were received. Survey results suggested that rainfall events that cause drainage issues occur fairly often. It also identified that two types of flooding were occurring where some residents, particularly in the upper catchment areas, experienced relatively brief and shallow inundation of properties and access roads whilst for other residents the railway or canal embankments caused backwater flooding to occur. Backwater flooding has been far deeper and more persistent. The survey also highlighted that some residents believe Council is failing to meet its planning/infrastructure provision obligations in regard to the drainage issues in Griffith.

2.4.2. Consultation as Part of this Study

As part of the current Study a floor level survey was been undertaken for a number of properties (see Section 4.1). As part of the survey process, each of the surveyed properties was given an information sheet informing them of the Flood Risk Management process and ongoing study (Appendix B).

Griffith Floodplain Risk Management Committee

A Floodplain Risk Management Committee (FRMC) has been formed with the purpose to raise and discuss issues related to the floodplain risk management process. It also allows community input throughout the process from start to finish. The committee includes Councillors, Council engineers and Planners, members of the SES, OEH and community representatives. During preparation of the draft Plan, WMAwater held several meetings with and presentations to the committee.

Presentation to Council

An initial presentation to Council was given in July 2012 setting the way forward from the Flood Study to a final Flood Risk Management Plan. The presentation also reiterated the hot-spots identified in the Flood Study and suggested some potential relief solutions. These are discussed further in Section 6. Further presentations to Council and the FRMC were given in November 2012 and the latest in March 2013.

Community Newsletter

A community newsletter (Appendix B) was made available in the Griffith library and Council offices. In association with the release of the newsletter, Council issued a media release and provided further information regarding the CBD floodplain risk management study to the community through local newspaper, television and ABC radio.

Public Exhibition

The report was made available for the community during a 28 day public exhibition period. The community were invited to examine the report and make any comments or suggestions. No formal submissions from the community were received.

Current Flood Policy Review

This draft FRMS&P report includes a review of current flood policy. With the knowledge of the findings from the CBD Flood Study and discussion with Council there is scope for flood policy to be improved. The policy review is currently underway and will be presented to Council and the Floodplain Risk Management Committee (FRMC) through the consultation process.

3. EXISTING FLOOD ENVIRONMENT

The Flood Study (Reference 1) details the flooding patterns in Griffith for a range of design events based on hydrologic and hydraulic modelling. The hydraulic model has been updated since the Flood Study was finalised to take account of development changes. Differences in flood levels between model versions are trivial relative to any applicable freeboard (i.e. a freeboard of 0.5 m).

The modelling results show that the difference in peak flood levels between design events up to the 1% AEP event is generally less than 0.5 m for events and less than 1 m for events up to the PMF. This relatively small flood range experienced is typical of many urban catchments with limited upstream catchment area. Although residences and businesses in the area are liable to regular over ground inundation, the risk of over floor inundation and to life associated with flooding is generally lower due to the limited flood range (the differences in flood level of different design events).

3.1. Flood Mechanisms

Previous investigations indicate that certain sections of the pipe network have only limited flow capacity. Accordingly, during larger volume floods the majority of runoff is predicted to be discharged overland. Compounding this flood dynamic is that several man-made features, such as the Main Branch Canal and Temora-Roto Railway, are aligned normal to the direction of the overland flow. The Main Branch Canal acts as a barrier to floodwaters due to its elevated position above ground levels. Furthermore, the main CBD street, Banna Ave, is an elevated part of the CBD and lies between the Main Canal and the Temora-Roto railway lines, creating another obstruction to overland flow. As a result, the Railway Line, Banna Ave and Main Canal impede the path of overland flow leading to localised ponding upstream.

Areas upstream of the canal embankments generally experience flooding from backing up of floodwaters where, at the downstream, flow of floodwaters is impeded. This type of flooding has been observed on a number of occasions in the past, particularly in the relatively flat CBD area where floodwaters build up behind the Main Branch Canal (e.g. Yambil Street) relying on an inadequate pit and pipe system for relief. Floods of this nature generally occur as a result of thunderstorms which are characterised with short, high intensity rainfall bursts but can also be generated from longer rainfall events. During such events, the sub-surface drainage system is either blocked or running full such that flood water ponded in Yambil St is unable to enter the system and be discharged downstream.

3.2. Hydraulic Categories

The 2005 NSW Government"s Floodplain Development Manual (Reference 6) defines three hydraulic categories which can be applied to define different areas of the floodplain; namely floodway, flood storage or flood fringe.

Floodways
"those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels."

Flood Storage Areas
"*those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.*"

Flood Fringe
"the remaining area of flood prone land after floodway and flood storage areas have been defined".

There is no precise definition of these 3 categories or accepted approach to differentiate between the various classifications. The delineation of these areas is somewhat subjective based on knowledge of an area, hydraulic modelling and previous experiences. Based on previous experience and literature review (Reference 15), the Flood Study (Reference 1) defined hydraulic categories as:

Floodway:		Velocity x Depth > 0.25 m^2/s AND Velocity >0.25m/s
	OR	Velocity > 1m/s
Flood Storage:		Land outside the floodway where Depth > 0.5m
Flood Fringe		Land outside the floodway where Depth < 0.5m

It should be noted that the hydraulic categories applicable will vary for different probability design events.

From the outputs of the Flood Study (Reference 1) as amended, utilising the criteria as described above, most of the flooding within the CBD area can be defined as Flood Fringe with small localised areas of Floodway (Cutler Avenue, Goondooloo Street and near Noorla Street) and Flood Storage (Banna Avenue, Lenehan Road). There is little difference between the provisional hydraulic classifications in the 5% AEP event when compared to the 1% AEP event due to the small difference in flood levels between design events. These are shown in Figure 3.

3.3. Flood Hazard Classification

Flood hazard is a measure of the overall adverse effects of flooding and the risks they pose. The 2005 NSW Government"s Floodplain Development Manual (Reference 6) describes two *provisional flood hazard* categories; High and Low, based on the product of the depth and velocity of floodwaters. The provisional hazard categories are only based on depth and velocity and do not take into account any other factors which may influence the flood hazard (Figure L2 of the Floodplain Development Manual); hence they are a provisional hazard estimates only with "true" hazard to be defined through the process of the current study. The boundary of the provisional High and Low hazard classification will change according to the magnitude of the flood in question.

Provisional hazard was established as part of the Flood Study (Reference 1) based on the Floodplain Development Manual criteria (Appendix L of the Floodplain Development Manual). For the study area hazard was considered to be generally low in the 1% AEP event with some localised spots of high hazard where there is deeper flooding or higher velocity flooding such as where flow is restricted abound buildings for example.

To assess the full flood hazard all adverse effects of flooding have to be considered. As well as considering the provisional (hydraulic) hazard it also incorporates threat to life, danger and difficulty in evacuating people and possessions and the potential for damage, social disruption and loss of production including those detailed in Table 2.

High Hazard - *an area or situation where there is possible danger to personal safety, evacuation by trucks is difficult and able-bodied adults would have difficulty in wading to safety. There could also be potential for significant structural damage to buildings.*

Low Hazard - *people and possessions can still be evacuated by trucks if necessary and able-bodied adults would have little difficulty wading to safety.*

The classification is a qualitative assessment based on a number of factors as listed in Table 2.

The size or magnitude of the flood can affect depths and velocities. However, due to the nature of the flooding in Griffith there is not a significant difference between flood levels of design events. Therefore the hazard is likely to be affected more by other criteria.

The rate of rise of flood waters is more applicable for fluvial flooding scenarios. However, the rate of onset of flooding can influence flood warning and evacuation times. The faster the onset of flooding the more difficult warning becomes and the quicker evacuation may need to occur. Due to the nature of overland flow flooding, there is little warning time in Griffith before the onset of flooding.

The community of Griffith CBD has some flood awareness. Recent flooding events such as occurred in March 2012, the completion of the wider area Flood Risk Management Plan and community consultation undertaken as part of this and as part of the current flood risk management process (of which this report forms part) has raised awareness of the flood problem. The awareness of the community has a high weight in considering flood hazard as a more aware community will be able to better prepare and therefore potentially evacuate before hazards become high. On the other hand, with approximately only 450 mm rainfall per annum (on average) and relatively dry seasons, it is not likely that people will persist in their flood awareness.

Table 2: Hazard Classification

Criteria	Weight [1]	Comment
Size of the Flood	Medium	Relatively low flood hazard is associated with more frequent minor floods while the less frequent major floods are more likely to present a high hazard situation.
Depth & Velocity of Floodwaters	Medium	The provisional hazard is the product of depths and velocity of flood waters. These can be influenced by the magnitude of the flood event.
Rate of Rise of Floodwaters	Low	Rate of rise of floodwaters is relative to catchment size, soil type, slope and land use cover. It is also influenced by the spatial and temporal pattern of rainfall during events.
Duration of Flooding	Medium	The greater the duration of flooding the more disruption to the community and potential flood damages. Permanent inundation due to sea level rise is of indefinite duration.
Flood Awareness and Readiness of the Community	High	General community awareness tends to reduce as the time between flood events lengthens and people become less prepared for the next flood event. Even a flood aware community is unlikely to be wise to the impacts of a larger, less frequent, event.
Effective Warning & Evacuation Time	Medium	This is dependent on rate at which waters rise, an effective flood warning system and the awareness and readiness of the community to act.
Effective Flood Access	High	Access is affected by the depths and velocities of flood waters, the distance to higher ground, the number of people using and the capacity of evacuation routes and good communication.
Evacuation Problems	Medium	The number of people to be evacuated and limited resources of the SES and other rescue services can make evacuation difficult. Mobility of people, such as the elderly, children or disabled, who are less likely to be able to move through floodwaters and ongoing bad weather conditions is a consideration.
Provision of Services	Low	In a large flood it is likely that services will be cut (sewer and possibly others). There is also the likelihood that the storm may affect power and telephones. Permanent inundation from sea level rise may lead to permanent loss of services.
Additional Concerns	Low	Floating debris, vehicles or other items can increase hazard. Sewerage overflows can occur when river levels are high preventing effective discharge of the sewerage system.

[1] Relative weighting in assessing the hazard for Griffith.

For the majority of residents, as floodplain extents are not vast, there should be easily available vehicular access to dry higher ground. The vehicular and pedestrian access routes are all along sealed roads and present no unexpected hazards if the roads have been adequately maintained.

At depths of 0.3 m wading should be possible for most mobile adults. This obviously could be more of an issue for children, elderly or disabled people. The majority of flood prone properties in Griffith do have access with flood depths of 300mm or less. Larger vehicles can easily travel through water at this depth and aid evacuation.

Evacuation problems could also be exacerbated by the time of day during which flooding occurs. For example flooding of the industrial and commercial CBD area overnight is less likely to require evacuation although evacuation at his time may be more difficult for residential areas. Likewise, evacuating a busy CBD during business hours can be more problematic due to larger numbers of people.

The impact of debris is unlikely to be a significant factor due to the low flood depths and/or velocities. However, there is always concern over floating debris causing injury to wading pedestrians or structural damages to property.

The flood hazard for the study area varies by location based on the relative depths, velocities and effective flood access. Flood hazards for different areas, taking into account the provisional flood hazard and the criteria discussed above, are summarised in Table 3 below and are also shown in Figure 4.

Table 3: Flood Hazards from CBD Flooding for 1% AEP event

Location	Flood Hazard	Comment
CBD area	Low	Low provisional hazard
Industrial Area	Low	Low provisional hazard
Crossing Street Area	Low	Low provisional hazard
Junction of Wakaden and Ulong Sts	Low	Low provisional hazard
Noorla Residential Area	Low	Low provisional hazard
Hyandra St Area	Low	Low provisional hazard
Other Areas	Low	Low provisional hazard

Based on the above assessment, the flood hazard would be low for all areas. There may be some very localised areas subject to higher hazard where flood velocities are high, such as near obstructions to flow or culverts and drains that would not be identified at the current scale of the result mapping.

In floods greater than the 1% AEP the hazard will increase as the depth increases. For the majority of areas, the flood level will increase gradually, and as such, residents will be able to evacuate to higher ground. However, in a PMF event there are likely to be areas of high hazard where evacuation could become difficult due to flood depths and velocities (Figure 5). Flood Emergency Response Planning classifications are considered in Section 3.7.

3.4. Impacts of Flooding on Residential Properties

Residential properties suffer damages from flooding in a number of ways. Direct damages include loss of property contents or damage to the structure of the property. Indirect damage costs can be incurred by property occupiers from having to move away from the property while repairs are being made.

Impact of flooding on residential properties is considered in further in greater detail in Chapter 4.

3.5. Impacts of Flooding on Commercial and Industrial Activities

A large number of commercial and industrial properties in Griffith have the potential to be affected by flooding, either directly by flood damage or indirectly by loss of business due to restricted customer and/or employee access. One of the major components of indirect flood losses to the commercial and industrial sector is the loss of production and trade.

The duration of flooding and flood depths can affect businesses differently. For example shorter duration flooding may allow businesses to re-open to trade again. If the short duration flooding is deep and causes property and stock damage then it may take some time for businesses to re-open. On the other hand through some long duration but shallow flooding businesses may still be able to operate. Some businesses are also able to operate temporarily from a different location, often albeit at a reduced capacity, such as the majority of office type businesses. Whether staff are able to get to work or have had home flooding issues also plays a part in recovery for commercial practices. The type of business also plays a major part in the impacts of flooding for example a high quality goods electrical store may suffer more damages in terms of loss of stock compared to a stationery store.

Floor levels of commercial properties tend to be closer to the ground than residential properties and therefore can suffer higher flood damages. Results of the floor level survey undertaken for this FRMS&P show that 79% of the commercial and industrial properties surveyed have a floor level less than 0.3 m above ground level compared to only 20% of residential properties surveyed.

Where sufficient warning is available businesses may be able to move stock and assets to higher levels to prevent flood damages. However, depending on the type of commercial or industrial activity this may not always be possible. Furthermore, in Griffith CBD due to the nature of overland flooding the onset is usually concurrent with rainfall and therefore there is little warning time to move stock and assets.

As re-development occurs measures to mitigate the impacts of flooding can be incorporated into building design encouraged through planning controls, for example flood proofing (as discussed in Section 5.4.2) which can reduce impacts over time.

A flood damages assessment is detailed in Section 4.

3.6. Impacts of Flooding on Public Infrastructure

Public sector (non-building) damages include; recreational/tourist facilities; water and sewerage supply; gas supply; telephone supply; electricity supply including transmission poles/lines, sub-stations and underground cables; roads and bridges including traffic lights/signs; and costs to employ the emergency services and assist in cleaning up. Public sector damages can contribute a significant proportion to total flood costs but are difficult to accurately calculate or predict.

Costs to Councils from flooding typically comprise;

- Clean-up costs;
- Erosion and siltation;
- Removing fallen trees;
- Inundation of Council buildings;
- Direct damage to roads, bridges and culverts;
- Removing vehicles washed away;
- Assistance to ratepayers;
- Increases in insurance premiums;
- Closures of streets;
- Loss of working life of road pavements; and
- Operational costs in the lead up to and during flood events.

Within the Griffith area damage to irrigation infrastructure could also be a significant cost.

3.7. Flood Emergency Response Planning

To assist in the planning and implementation of response strategies, the SES in conjunction with OEH has developed guidelines to classify communities according to the impact that flooding has upon them. These Emergency Response Planning (ERP) classifications (Reference 13) consider flood affected communities as 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, resupply and rescue. Based on the guidelines, communities are classified as either; Flood Islands; Road Access Areas; Overland Access Areas; Trapped Perimeter Areas or Indirectly Affected Areas and when used with the SES Requirements Guideline (Reference 13). The ERP classification can identify the type and scale of information needed by the SES to assist in emergency response planning (refer to Table 4).

Table 4: Emergency Response Planning Classifications of Communities

	Response Required		
Classification	**Resupply**	**Rescue/Medivac**	**Evacuation**
High flood island	Yes	Possibly	Possibly
Low flood island	No	Yes	Yes
Area with rising road access	No	Possibly	Yes
Area with overland escape routes	No	Possibly	Yes
Low trapped perimeter	No	Yes	Yes
High trapped perimeter	Yes	Possibly	Possibly
Indirectly affected areas	Possibly	Possibly	Possibly

Key considerations for flood emergency response planning in these areas include;

- Cutting of external access isolating an area;
- Key internal roads being cut;
- Transport infrastructure being shut down or unable to operate at maximum efficiency;
- Flooding of any key response infrastructure such as hospitals, evacuation centres, emergency services sites;
- Risk of flooding to key public utilities such as gas, power, sewerage; and
- The extent of the area flooded.

Flood liable areas of Griffith have been classified according to the ERP classification above. As the classifications take account of flood extents and do not regard flood depths it was seen as unsuitable to use the full flood extent for Griffith where, using the above classification, areas surrounded by less than only 0.1 m of water could be classified as flood islands when in reality most people could move through this water without problem. Therefore before assessing the ERP classifications flood depths less than 0.3 m were removed from the PMF flood extents. ERP classifications for the study area are shown in Figure 6.

3.8. Flood Awareness and Flood Warning

The flood awareness of the community and the available flood warning time are important factors in reducing the likely flood damages. The questionnaire undertaken as part of the FRMS&P for Main Drain J catchment (Reference 2) shows that the population is generally aware of flood risk. However for the CBD area Flood Study (Reference 1) the survey results show that 159 of the 205 respondents did not indicate that they were aware of any previous flooding.

A relative lack of awareness combines with a very short warning time. Fortunately however, the overall low hazard category of the flooding means ultimately that flood risk is also low despite the relatively low awareness and negligible warning time.

There is no specific flood warning system for the Griffith urban area. The nature of overland flood flows generally does not allow sufficient time for warning. Therefore as warning times are limited a stronger emphasis should be put on community flood awareness.

3.9. Implications of Future Development

Future development can cause hydrological impacts such as increased runoff due to increased area of impermeable land cover. Appropriate land zoning, planning and development controls can reduce these impacts. For example, Council"s recently developed OSD policy is specifically designed to mitigate the impact of urbanisation on runoff volumes and rates. Councils new LUS and land zoning in the LEP due later this year should take into account appropriate land uses in flood prone areas. Good planning controls will mean that as areas regenerate they may become more flood compatible as developers are required to consider runoff from sites and impacts on overland flow paths and flood storage areas.

4. FLOOD DAMAGES

Flood impact can be quantified in the calculation of flood damages. Flood damage calculations do not include all impacts associated with flooding. They do however, provide a basis for assessing the economic loss of flooding and also a non-subjective means of assessing the merit of flood mitigation works such as retarding basins, levees, drainage enhancement etc. The quantification of flood damages is an important part of the floodplain risk management process. By quantifying flood damage for a range of design events, appropriate cost effective management measures can be analysed in terms of their benefits (reduction in damages) versus the cost of implementation. The cost of damage and the degree of disruption to the community caused by flooding depends upon many factors including;

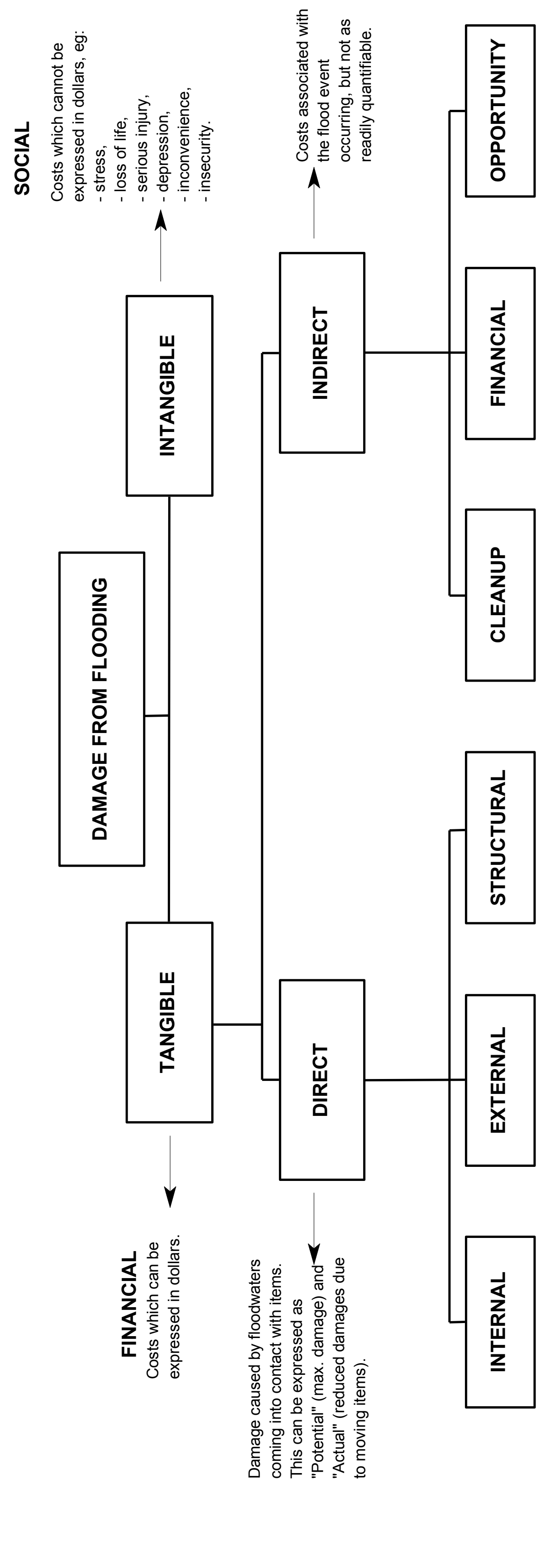
- The magnitude (depth, velocity and duration) of the flood;
- Land use and susceptibility to damages;
- Awareness of the community to flooding;
- Effective warning time;
- The availability of an evacuation plan or damage minimisation program;
- Physical factors such failure of services (sewerage), flood borne debris, sedimentation; and
- The types of asset and infrastructure affected.

The estimation of flood damages tends to focus on the physical impact of damages on the human environment but there is also a need to consider the ecological cost and benefits associated with flooding. Flood damages can be defined as being tangible or intangible. Tangible damages are those for which a monetary value can be easily assigned, while intangible damages are those to which a monetary value cannot easily be attributed. Types of flood damages are shown on Table 5 over.

The damages assessment does not only look at potential costs due to flooding but also identifies when properties are likely to become flood affected by either flooding on the property or by over floor flooding. Figure 7 shows when properties first become flood affected (when floodwaters first encroach onto the lot) and Figure 8 identifies in which design event buildings are first flooded above floor level.

Generally properties within the CBD and industrial area are likely to become inundated above floor level in smaller events than compared to other areas primarily due to the commercial and industrial development generally having lower floor level than residential dwellings. For example, although the majority of properties surveyed in the Noorla Street area are affected by flooding in the 1% AEP event they do not become flooded above floor level until at least the 0.2% AEP event. On the other hand, properties in the CBD may be affected by flooding in the 20% AEP event and are first flooded above floor level in events not much greater than this.

Table 5: Flood Damages Categories (including damage and losses from permanent inundation)



	INTERNAL	EXTERNAL	STRUCTURAL	CLEANUP	FINANCIAL	OPPORTUNITY
RESIDENTIAL	Contents of Buildings: Clothes, Carpets, Furniture, Valuables, Fittings, Appliances	External Items: Vehicles, Laundries, Caravans, Sheds, Tools, Gardens, Fences	Physical Damage to Buildings: Gyprock, Cupboards, Scour of Footings, Houses becoming buoyant (floating off footings)	Clean Carpets, Walls, Clothes; Re-instate Furniture; Remove Mud and Debris	Loss of wages, Living costs (temporary accomodation and food), Time to repair/replace damaged items	Not Applicable
RURAL	Contents of Buildings: Clothes, Carpets, Furniture, Valuables, Fittings, Appliances	External Items: Vehicles, Sheds (stables/barns), Machinery, Tools, Fences, Feed storage, Saddles, Crops &/or Stock, Irrigation Systems	Physical Damage to Structures: Damage to Homestead, Sheds, Access tracks, Protection levees	Clean Homestead and Out-buildings; Remove Debris; Dispose of affected crops &/or stock	Loss of Farm Production and Income, Re-instatement of Pastures, Supplementary feeding of stock (by hand or outside agistment), Stock movement/ transport, Living costs (temporary accomodation and food)	Sowing or harvesting of Crops, Sale of Stock (at depreciated value or dependent on market influences)
COMMERCIAL	Contents of Buildings: Products, Stock, Fittings, Tools, Machinery, Raw Materials	External Items: Vehicles, Machinery, Display, Raw Materials/Stockpiles, Fences	Physical Damage to Buildings	Dispose of damaged products, stock, materials; Cleaning and Re-instatement	Loss of Productivity and Income, Bank Interest Charges	Loss of existing &/or Potential Trade
PUBLIC AUTHORITIES	Contents of Public Buildings and Facilities	Public Property and Facilities: Parks, Signs, Machinery, Equipment	Physical Damage to Infrastructure: Electricity, Water, Telephone, Gas, Road & Rail Transport Links	Remove Mud & Debris from Facilities, Public & Private Property Repairs (temporary & permanent)	Disruption of Services, Community Service Relief Grants	Provision of Public Service

4.1. Tangible Flood Damages

Tangible flood damages are comprised of two basic categories; direct and indirect damages (Table 5). Direct damages are caused by floodwaters wetting goods and possessions thereby damaging them and resulting in either costs to replace or repair or in a reduction to their value. Direct damages are further classified as either internal (damage to the contents of a building including carpets, furniture), structural (referring to the structural fabric of a building such as foundations, walls, floors, windows) or external (damage to all items outside the building such as cars, garages). Indirect damages are the additional financial losses caused by the flood for example the cost of temporary accommodation, loss of wages by employees etc.

Given the variability of flooding and property and content values, the total likely damages figure in any given flood event is useful to get a feel for the magnitude of the flood problem, however it is of little value for absolute economic evaluation. However, considering damages estimates is useful when studying the economic effectiveness of proposed mitigation options. Understanding the total damages prevented over the life of the option in relation to current damages, or to an alternative option, can assist in the decision making process.

The standard way of expressing flood damages is in terms of average annual damages (AAD). AAD is equal to the damage caused by all floods over a period of time divided by the number of years in that period and represents the equivalent average damages that would be experienced by the community on an annual basis. This means that the smaller floods, which occur more frequently, are given a greater weighting than the rare catastrophic floods.

A flood damages assessment was undertaken as part of the FRMS&P (Reference 2) for the Main Drain J catchment. This split the Main Drain J catchment into several areas and estimated damages for each. A value of $237,000 for the 1% AEP event was estimated for direct and indirect tangible damages occurring in the Griffith CBD. However, the assessment did not use a floor level survey but assumed that finished floor levels were 0.3 m above ground level based on ALS data. Furthermore, properties were defined as commercial or residential based on aerial photography. Although this approach was suitable for looking at a wider catchment and comparing different sub-areas of the Main Drain J catchment a more detailed approach is required for assessing the CBD area alone.

In order to quantify the damages caused by inundation for existing development a floor level survey was undertaken. As part of this floor level survey work an indicative ground level was recorded for use in the damages assessment. This was used in conjunction with the flood level information for design events as established in the Flood Study (Reference 1) and amended as part of this Study to take into account the recent changes in the floodplain. For the damage calculations, a selected set of properties was used with these properties identified as located within the 1% AEP flood extent and their floor levels subsequently surveyed. It should be noted that as damage calculations have been based on those residential properties identified as being located within the 1% AEP flood extent it is possible that some buildings beyond this extent may be inundated in larger events and are not accounted for in damage calculations. Therefore damage calculations for the PMF event are likely to be underestimated. It was not considered viable to survey all properties within the PMF extent for the purpose of damage calculations as this would involve surveying virtually every property within the study area at a significant cost for little return.

The flood damages assessment was undertaken for existing development in accordance with current OEH guidelines (Reference 7) and the Floodplain Development Manual (Reference 6). The damages were calculated with use of a number of height-damage curves which relate the depth of water above the floor with tangible damages. Each component of tangible damages is allocated a maximum value and a maximum depth at which this value occurs. Any flood depths greater than this allocated value do not incur additional damages as it is assumed that, by this level, all potential damages have already occurred.

Damages were calculated for residential and commercial\industrial properties and the process and results are described in the following sections. This flood damages estimate does not include the cost of restoring or maintaining public services and infrastructure. It should be noted that damages calculations do not take into account the thresholds into any basements or cellars or the basements or cellars themselves. Therefore where properties have basements damages can be under estimated.

Total damage refers to the total damage estimated for a given flood event. Average damage per property is the total damage estimated for a particular flood event divided by the number of properties flood affected in this event; either by flooding on the yard and/or above floor level of a building. These are useful to compare damages likely to occur as a result of a particular design event and identify whether there are high damages for smaller events or just the larger less frequent events. It is also very useful to consider both total AAD for the sub-area and AAD per flood affected property. The AAD per flood affected property is the average AAD for each property affected by flooding whether that flooding is over building floor level or only within the property boundary such as flooding of a yard. Total AAD gives an indication of the total costs of flooding within a sub-area while AAD per property gives an idea of the costs to individual property owners. It may be that total AAD is low as there are few properties in a sub-area although AAD per property can be high as all of these properties are significantly flood affected. On the other hand, it may be that total AAD is high as there are a large number of flood affected properties in a sub-area but AAD per property could be low as these properties are only subject to minor flooding which may not be above building floor levels. Therefore in comparing sub-areas total AAD gives an idea of where flooding could have significant costs but AAD per property is better at assessing the cost (and therefore benefit of any improvements) to individual properties. Council may want to focus mitigation works in areas subject to a high total AAD or may wish to focus in areas where the AAD per property is high.

4.1.1. Residential Properties

The flood damages assessment was undertaken for existing development in accordance with OEH guidelines (Reference 7). For residential properties, external damages (damages caused by flooding below the floor level) were set at $8,375 and additional costs for clean-up as $5,000. For additional accommodation costs or loss of rent a value of $825 was allowed assuming that the property would have to be unoccupied for up to three weeks. Internal (contents) damages were allocated a maximum value of $60,000 occurring at a depth of 2 m above the building floor level (and linearly proportioned between the depths of 0 to 2 m). Structural damages vary on whether the property is slab/low set or high set. For the purpose of this study, any property with a floor level of 0.5 m or more above ground level was assumed to be high set. For two storey properties, damages (apart from external damages) are reduced by a factor of 70% where only the ground floor is flooded as it is assumed some contents will be on the upper floor and unaffected and that structural damage costs will be less. In some instances external damage may occur even where the property is not inundated above floor level and therefore tangible damages include external damages which may occur with or without house floor inundation.

The residential damages are summarised in Table 6 and a further breakdown by sub-areas is provided in Table C1 in Appendix C.

Overall for residential properties in Griffith CBD there is little difference in the average tangible damages per property for all the design events analysis up the 1% AEP. This is representative of the relatively small differences in flood level between the design flood events. Average damage per property increased at events larger than the 1% AEP when more properties become flooded above floor level.

Details of residential damages for each of the sub-areas are described below. Tables showing the breakdown of damages per event and per sub-area are included in Appendix C. Note that the terminology used refers to a property or lot being the land within the ownership boundary. Flooding of a property does not necessarily mean flooding above floor level of a building on that property/lot.

Table 6: Potential Residential Damages for Griffith CBD

TOTALS FOR STUDY AREA				
Event	Total Number of Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Damaged Property
20% AEP	40	10	$ 965,600	$ 24,140
10% AEP	56	14	$ 1,330,100	$ 23,750
5% AEP	63	15	$ 1,463,620	$ 23,230
2% AEP	70	17	$ 1,696,930	$ 24,240
1% AEP	70	23	$ 1,886,780	$ 26,950
0.5% AEP	70	27	$ 2,018,220	$ 28,830
0.2% AEP	70	28	$ 2,188,290	$ 31,260
PMF	72	64	$ 4,037,380	$ 56,070
		Average Annual Damages	**$ 175,670**	**$ 2,440**

NOTE: Properties affected are those where there is flooding above ground level within the property boundary (ie the lot). This does not necessarily mean that any buildings on the property are flooded.

Noorla Street Area

The Flood Study (Reference 1) identified Noorla Street area as a key hot-spot for flooding. In this area of the 25 properties surveyed, no buildings would become flooded above floor level until the PMF event. Buildings are raised on average 0.6 m above the ground levels (see Photograph 1). However, all of the properties (lots) surveyed would become affected by the 5% AEP (20-year ARI) event, with 10 residences affected in the 5-year ARI event. Properties are considered affected when flood levels are higher than ground levels on the property. Nonetheless, although buildings may not be flooded above floor level, depths of up to a metre could occur in the 1% AEP event on Noorla Street itself affecting property access/egress. AAD per property for the Noorla Street area up to the PMF is $2,490. Total damages per property for each design event remain similar around $15,370 to $20,760 between the 5-year and 0.2% AEP per property. This is mainly due to the small flood range (i.e. the difference in flood levels occurring during each design event (see Section 3)). Average damage per property increases to $52,620 for the PMF event when properties are likely to become flooded above floor level. Although this area has the highest total AAD at $62,280 this area also has the highest number of residential properties flood affected and the mid-range AAD per property of $2,490 is a result of those properties having buildings only becoming flooded above floor level in the PMF event. Therefore, although there are a large number of properties affected by flooding, AAD per property is not as high as in other sub-areas such as the Crossing Street and Hyandra Street sub-areas.

Photograph 1: Residential Property on Noorla Street with Floor Level Above Ground Level

CBD Area

Although properties in this area are predominantly commercial, 19 of the 126 properties surveyed in the CBD area were residential. Of these residential properties none of the buildings became flooded above floor level until the 5% AEP when one building was flooded above floor level by depths of less than 0.05 m. All properties were flood affected by the 2% AEP event with the potential for external structural damage. AAD per property for residential lots in the CBD totalled approximately $1,340. This figure is lower than the AAD seen at Noorla Street due to the shallower flood depths occurring in the CBD at events below the 2% AEP event compared to the flood depth for smaller events at Noorla Street. Within the CBD area, average damage per property increases as the magnitude of the flood event increases. Total AAD for the sub-area was approximately $25,520 which is less than half of that of the Noorla Street sub-area as the total number of properties flood affected is less. Although more residential buildings are flooded above floor level in the smaller events within the CBD sub-area, AAD per property was also lower than that of the Noorla Street sub-area as less properties overall are flood affected in the smaller events.

Wakaden and Ulong Street Junction

A total of five residential properties are flood affected in the PMF, four of which have buildings flooded above floor level. In events smaller than this none of the surveyed buildings are identified as being flooded above floor level, however, four lots are flood affected which gives potential for structural damages. Average damages per property for the range of design events assessed are between $15,600 and $16,390 for events up to and including the 0.2% AEP, again representative of the small difference in flood levels. The AAD per property of $1,290 is low compared to the other sub-areas due to the fact that none are flood affected above floor level until the PMF event.

Hyandra Street area

In undertaking the flood damage calculation, the retirement village community hall was assumed to be a residential building as it was considered the multiplier applied to commercial and industrial buildings (see Section 4.1.2) would significantly over estimate damages for this type of use. All other buildings in the retirement village were also considered residential. Five additional residential dwellings were also surveyed in this area. Of the 12 residential properties surveyed all but one were affected by the 5-year ARI event with five flooded above floor level and four of these being in the retirement village. This increases to nine buildings flooded above floor level by the 1% AEP flood event and all being flooded above floor level in the PMF.

Average total damage per properties is high ranging from $35,640 in the 5-year ARI event to $59,850 in the PMF event with AAD per property being $3,690. This is the highest AAD per property for all the sub-areas, mainly due to the fact the area is subject to flooding during the more frequent smaller events.

Crossing Street Area

Of the four residential properties surveyed in the Crossing Street sub-area, all four are affected by all the modelled design flood events. However over floor flooding only occurs at two of the properties for events smaller than the PMF. As all properties are flood affected, AAD per property is relatively high at $3,050. However, total AAD for this area is generally lower than other areas, at $12,200 due to there being fewer properties in the sub-area.

Other Areas

A total of seven other residential properties were also surveyed, all of which are flood affected at the 5-year ARI event and above. Three of these properties are flood affected above floor level in the 5-year ARI event and all seven are flooded above floor level from the 10% AEP event.

Summary

Table 7 summarises AAD for each sub-area as total AAD and also AAD per property. The worst affected sub-area in terms of AAD per property is Hyandra Street where the retirement village, and adjacent residential properties are significantly affected. Although Noorla Street does not have the highest AAD per property, more residential properties are affected (but not necessarily flooded above floor) in this area and therefore total AAD is highest. Properties in this sub-area are affected by all design floods but with over floor flooding only occurring in the PMF. In terms of the residential damages assessment, although it is beneficial to consider potential mitigation works for all sub-areas, it is considered that the Hyandra Street and Noorla Street sub-areas should be the highest priority having the highest AAD per property and total AAD respectively of all the sub-areas assessed.

Table 7: Annual Average Potential Residential Damage (up to PMF)

Sub-Area	Total Properties Affected	Flooded Above Floor Level	Total Annual Average Damages	AAD Per Flood Affected Property
Noorla St Area	25	21	$ 62,280 (1)	$ 2,490 (4)
CBD Area	19	19	$ 25,520 (3)	$ 1,340 (5)
Industrial Area	0	0	$ -	$ -
Junction of Wakaden and Ulong	5	4	$ 6,450 (6)	$ 1,290 (6)
Hyandra Street Area	12	12	$ 44,280 (2)	$ 3,690 (1)
Crossing St Area	4	4	$ 12,208 (5)	$ 3,052 (3)
Other	7	4	$ 24,940 (4)	$ 3,560 (2)
TOTAL	**72**	**64**	**$ 175,670**	**$ 2,440**

NOTE: Properties affected are those where there is flooding above ground level within the property (lot) boundary. This does not necessarily mean that any buildings on the property are flooded.

Rankings of sub-areas in terms of Total AAD and AAD per damages property is includes in brackets.

4.1.2. Commercial and Industrial Properties

The tangible flood damage to commercial and industrial properties is more difficult to assess. Costs vary dependent on the use of the property; for example a small stationery shop may not incur costs as high as an electrical store. No specific guidance is available for assessing flood damages to non-residential properties. Therefore for this Study, commercial and industrial damages were calculated using the methodology for residential properties and a multiplier factor applied. Although this is not strictly transferable to non-residential properties it is considered a good tool for creating comparable damage figures. The damages value figure should not be taken as an actual likely cost rather it is useful when comparing potential management options and for benefit-cost analysis.

As it is usual that commercial and industrial damages are higher than residential damages a multiplier was applied to the total damage per property for each event. For example, following the Sydney floods of 1986 a survey of damaged properties was undertaken and the result analysed (Reference 10). It was found that the commercial and industrial damages were between 3 and 27 times higher than residential damages. The amount varied considerably per catchment and depending on the number and type of businesses, size of business, location of properties and extents of development with the floodplain. A number of assumptions were also made in calculating the damages for the Sydney 1986 flood such as assuming commercial indirect losses to be 55% of direct losses whilst this was only assumed at 15% for residential properties. Where there was a higher ratio of commercial to residential properties flooded, such as the Georges River catchment, the average damage for commercial and industrial properties was three times higher than that for residential properties. After the Nyngan floods of 1990 the average damage to commercial properties was estimated to be approximately 4.4 times higher than the average damage to residential properties (Reference 11). Of damage to commercial properties indirect financial damages was a major component accounting for 70% of commercial damages. This reflected the long period during which commercial establishments were not trading or trading at reduced levels; a total of ten weeks. Due to the very different nature of flooding in Nyngan and Griffith, it is not expected that flooding in the Griffith CBD would cause such elongated periods where trading was not possible. Based on this, a multiplier of three was applied to the residential damages calculation for commercial and industrial damages where they were flooded above floor level. The multiplier used is mainly to take account of the higher costs that businesses would incur compared to residential dwellings when flooded above floor level. Commercial and industrial properties would face greater costs per property through, for example, higher value building contents or loss of business through having to close for a period. Flooding below floor level uses the same damages curve as the residential properties.

Commercial and industrial damage estimates are more uncertain and larger than residential damages. Commercial and industrial damage estimates can vary significantly depending on;

- Type of business – stock based or not;
- Duration of flooding – affects how long a business may be closed for not just whether the business itself if closed but when access to it becomes available;
- Ability to move stock or assets before onset of flooding - some large machinery will not be able to moved and in other instances there may be no sufficient warning time to move stock to dry locations; and
- Ability to transfer business to a temporary location.

Costs to business can occur for a range of reasons, some of which will affect some businesses more than others dependent on the magnitude of flooding and the type of businesses. Common flood costs to businesses are;

- Removal and storage of stock before a flood if warning is given;
- Loss of production – caused by damaged stock, assets and availability of staff;
- Loss of stock and/or assets;
- Reduced stock through reduced or no supplies;
- Trade loss – by customers not being able to access the business or through business closure;
- Cost of replacing damages or lost stock or assets; and
- Clean-up costs.

The results of the damages assessment for commercial properties is summarised in Table 8. More detailed damages for each of the sub-areas can be found in Appendix C. Details of commercial damages each of the sub-areas are described below. Tables showing the breakdown of damages per event, per sub-area are included in Appendix C. Note that the terminology used refers to a property or lot being the land within the ownership boundary. Flooding of a property does not necessarily mean flooding above floor level of a building on that property/lot.

AAD for the surveyed commercial and industrial properties is nearly five times greater than for residential properties ($175,670 for residential compared to $834,680 for commercial) reflecting the higher costs that commercial and industrial properties are likely to incur compared to residential properties and the greater number of commercial properties affected in Griffith. On a per property basis AAD is approximately 2.4 times higher largely due to the three times multiplier factor used to convert residential costs estimates into ones suitable for commercial properties.

Table 8: Potential Commercial and Industrial Damages for Griffith CBD

TOTALS FOR STUDY AREA				
Event	Total Number of Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Damaged Property
20% AEP	33	11	$ 1,741,850	$ 52,780
10% AEP	64	19	$ 2,698,130	$ 42,160
5% AEP	100	42	$ 6,192,710	$ 61,930
2% AEP	120	75	$ 10,711,220	$ 89,260
1% AEP	125	100	$ 14,993,890	$ 119,950
0.5% AEP	130	109	$ 16,802,420	$ 129,250
0.2% AEP	134	119	$ 19,262,220	$ 143,750
PMF	142	138	$ 29,902,310	$ 210,580
Average Annual Damages			**$ 834,680**	**$ 5,880**

NOTE: Properties affected are those where there is flooding above ground level within the property (lot) boundary. This does not necessarily mean that any buildings on the property are flooded above floor level.

CBD Area

This sub-area has the largest number of commercial properties and therefore highest total AAD of $545,910. The AAD per property is $5,250. Of the 107 commercial properties surveyed, 104 are affected by the PMF. Floor levels of commercial buildings are typically lower to the ground than those of residential properties. The average height of the floor levels above ground in the CBD is 0.2 m with a small step or gradual incline into the buildings (see Photograph 2).

Photograph 2: Commercial Properties on Yambil Street

Nearly 25% of buildings are affected by above floor flooding by the 5% AEP event with this figure rising to approximately 50% and 75% for the 2% AEP and 1% AEP events respectively.

In this area however, it should not just be the direct flood cost to property that is considered but also the indirect effects for the overall CBD. Properties which may not be directly flood affected (and therefore have not been surveyed) may still be indirectly affected by closures of roads or of businesses which they operate with.

Industrial Area

The types of commercial activity in this area are predominantly industrial. All of the 23 surveyed properties were flooded above floor level in the PMF. All properties are flood affected by events greater than the 1% AEP event with 19 of these having buildings flooded above floor level. At

$114,880 average damage per property for the 5-year ARI event is higher than other areas (although total damages are lower) reflecting that the affected properties in the 5-year event are also affected above building floor level. AAD per property, $7,360, was in the upper half of the sub-areas assessed whilst total AAD of $169,250 is lower than that of the CBD as there are significantly less properties in the sub-area.

Crossing St Area

Total AAD for the sub-area is $86,500 whilst AAD per property is $7,860. These values are representative of there being fewer total number of properties in this sub-area while the AAD per property suggests higher damages at lower flood level; during the more frequent but less extreme flood events. The new Rural Fire Service Centre which was included in the modelling update for this FRMS&P is subject to some inundation for all design events modelled within the lot. However the floor level of the lowest building on the site is not inundated until the 0.5% AEP event and the second and third buildings with higher floor levels are not affected above floor level until the PMF. Of the 11 commercial properties surveyed, eight are flood affected in the 1% AEP event with five of these subject to flooding above building floor level.

Junction of Wakaden and Ulong Streets

This area includes two commercial properties and the new Woolworths supermarket. While Woolworths is set high and is not flood affected, other properties in this area are. Total AAD for the sub-area is low due to there being fewer properties in this sub area than the others, however, AAD per property is $8,740 which is the highest of all the sub-areas in Griffith. This is skewed by the relatively lower floor and ground level of Griffith Motorcycles which may suffer significant flood depths of over 0.7 m in the 1% AEP event.

Hyandra Street Area

The only surveyed commercial properties located within this sub-area are the Griffith Dental and Medical centre. The Dental and Medical centre could be subject to over floor flooding in events as small as the 5-year ARI event although only by a nominal 0.05 m in all events up to the 0.2% ARI. It should be noted that although flood levels will be 0.05 m flood waters may not necessarily find a means of ingress into the building although damage calculations assume that as soon as flood levels are above floor level then there is internal damage to the building. Flood depths over floor of 0.3 m (300 mm) are likely in the PMF. The AAD is $6,800.

Other areas

No commercial and industrial properties outside the sub-areas already discussed were surveyed or considered affected by flooding.

Summary

Table 9 shows the breakdown of PMF flood damages for the sub-areas. The CBD and industrial areas are the most flood affected in terms of total AAD. In terms of the commercial damages assessment, although it is beneficial to consider potential mitigation works for all sub-areas, it is considered that the CBD sub-area and Industrial Zone sub-area should be the highest priority having the highest AAD and a significantly higher total AAD than the other sub-areas. The junction of Wakaden and Ulong Street sub-area should also be a key area for mitigation to be considered due to the high AAD per flood affected property.

Table 9: Annual Average Potential Commercial and Industrial Damage (up to PMF)

Sub-Area	Total Properties Affected	Flooded Above Floor Level	Total Annual Average Damages	AAD Per Flood Affected Property
Noorla St Area	0	0	$ -	$ -
CBD Area	104	102	$ 545,910 (1)	$ 5,250 (4)
Industrial Area	23	23	$ 169,250 (2)	$ 7,360 (3)
Junction of Wakaden and Ulong	3	2	$ 26,220 (4)	$ 8,740 (1)
Hyandra Street Area	1	1	$ 6,800 (5)	$ 6,800 (5)
Crossing St Area	11	10	$ 86,510 (3)	$ 7,860 (2)
Other	0	0	$ -	$ -
TOTAL	**143**	**138**	**$ 834,690**	**$ 5,880**

NOTE: Properties affected are those where there is flooding above ground level within the property (lot) boundary. This does not necessarily mean that any buildings on the property are flooded.
Rankings of sub-areas in terms of Total AAD and AAD per damages property is includes in brackets.

4.2. Intangible Flood Damages

The intangible damages associated with flooding, by their nature, are inherently more difficult to estimate in monetary terms. In addition to the tangible damages discussed above, additional costs/damages are incurred by residents affected by flooding, such as stress, risk/loss to life, injury, loss of sentimental items etc. It is not possible to put a monetary value on the intangible damages as they are likely to vary dramatically between each flood (from a negligible amount to several hundred times greater than the tangible damages) and depend on a range of factors such as the size of flood, the individuals affected, and community preparedness. However, it is still important that the consideration of intangible damages is included when considering the impacts of flooding on a community.

Post flood damages surveys have linked flooding to stress, ill-health and trauma for the residents. For example the loss of memorabilia, pets, insurance papers and other items without fixed costs and of sentimental value may cause stress and subsequent ill-health. In addition flooding may affect personal relationships and lead to stress in domestic and work situations. In addition to the stress caused during an event (from concern over property damage, risk to life for the individuals or their family, clean up etc.,) many residents who have experienced a major flood are fearful of the occurrence of another flood event and the associated damage. The extent of the stress depends on the individual and although the majority of flood victims recover, these effects can lead to a reduction in quality of life for the flood victims.

During any flood event there is the potential for injury as well as loss of life due to causes such as drowning, floating debris or illness from polluted water. Generally, the higher the flood velocities and depths the higher the risk. The Griffith study area generally is classified as low hazard within the built up areas. However, there will always be local high risk (high hazard) areas where flows may be concentrated around buildings or other structures within low hazard areas.

The intangible flood damages for Griffith CBD are likely to be less than the intangible damages for the Main Drain J catchment due to the nature of the flooding. The scale of the flooding in the Griffith urban area is, by comparison, more indicative of nuisance flooding and as such intangible damages would likely be limited. Some more vulnerable people such as the elderly and disabled may have more concerns over flooding. Likewise business owners may also have greater concerns due to flood exposure.

5. FLOODPLAIN RISK MANAGEMENT MEASURES

The FRMS aims to identify and assess risk management measures which could be put in place to mitigate flooding risk and reduce flood damages. The risk management measures should be assessed against the legal, structural, environmental, social and economic conditions or constraints of the local area. The 2005 NSW Government‟s Floodplain Development Manual (Reference 6) separates risk management measures into three broad categories.

5.1. Risk Management Measures Categories

Flood modification measures modify the physical behaviour of a flood including depth, velocity and redirection of flow paths. Typical measures include flood mitigation dams, retarding basins, on-site detention, channel improvements, levees or floodways. Pit and pipe improvement and even pumps may also be considered in some cases.

Property modification measures modify the existing land use and development controls for future development. This is generally accomplished through such means as flood proofing, house raising or sealing entrances, strategic planning such as land use zoning, building regulations such as flood-related development controls, or voluntary purchase.

Response modification measures modify the response of the community to flood hazard by educating flood affected property owners about the nature of flooding so that they can make better informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community and provision of flood insurance.

Table 10 below provides a summary of floodplain risk management measures that could be considered for the Griffith CBD.

Table 10: Flood Risk Management Measures

Flood Modification	Property Modification	Response Modification
Flood mitigation dams	Land zoning	Community awareness/preparedness
Retarding basins	Voluntary purchase	Flood warning
Bypass floodways	Building & development controls	Evacuation planning
Channel modifications	Flood proofing	Evacuation access
Levees	House raising	Flood plan / recovery plan
Temporary defences	Flood access	Flood insurance

5.1.1. Relative Merits of Management Measures

A number of methods are available for judging the relative merits of competing measures. The benefit/cost (B/C) approach has long been used to quantify the economic worth of each option enabling the ranking against similar projects in other areas. A B/C ratio is the benefits expressed in monetary terms, compared to the actual likely cost of achieving those benefits. It is a standard method for using the time value of money to appraise long-term projects of the reduction in flood damages (benefit) compared to the cost of the works. Generally the ratio expresses only the reduction in tangible damages as it is difficult to accurately include intangibles (as discussed in Section 4.2).

The potential environmental or social impacts of any proposed flood mitigation measure must be considered in the assessment of any management measure and these cannot be evaluated using the classical B/C approach. For this reason a matrix type assessment has been used which enables a value (including non-economic worth) to be assigned to each measure.

Multi-variate decision matrices are recommended in the Floodplain Development Manual (Reference 6) and therefore it is also a recommendation of this report that multi-variate decision matrices be developed for specific management areas, allowing detailed benefit/cost estimates, community involvement in determining social and other intangible values, and local assessment of environmental impacts.

5.1.2. Management Matrix

The criteria assigned a value in the management matrix are;

- Risk to life;
- Impact on flood behaviour (reduction in flood level, hazard or hydraulic categorisation) over the range of flood events;
- Number of properties benefited by measure;
- Technical feasibility (design considerations, construction constraints, long-term performance);
- Community acceptance and social impacts;
- Economic merits (capital and recurring costs versus reduction in flood damages);
- Financial feasibility to fund the measure;
- Long term performance;
- Environmental and ecological benefits;
- Impacts on the State Emergency Services;
- Political and/or administrative issues; and
- Long-term performance given the potential impacts of climate change.

The scoring system for the above criteria is provided in Table 11 and largely relates to the impacts in a 1% AEP event. The matrix below is designed to set out a general scheme to illustrate how a local matrix might be developed. These criteria and their relative weighting may be adjusted in the light of community consultations and local conditions.

Tangible costs and damages are also used as the basis of B/C analysis for some measures.

Table 11: Matrix Scoring System

SCORE:	-3	-2	-1	0	1	2	3
Impact on Flood Behaviour	>100mm increase	50 to 100mm increase	<50mm increase	no change	<50mm decrease	50 to 100mm decrease	>100mm decrease
Number of Properties Benefited	>5 adversely affected	2-5 adversely affected	<2 adversely affected	none	<2	2 to 5	>5
Technical Feasibility	major issues	moderate issues	minor issues	neutral	moderately straight-forward	Straight-forward	no issues
Community Acceptance	majority against	most against	some against	neutral	minor	most	majority
Economic Merits	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Financial Feasibility	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Environmental & Ecological Benefits	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Impacts on SES	major disbenefit	moderate disbenefit	minor disbenefit	neutral	minor benefit	moderate benefit	major benefit
Political / administrative Issues	major negative	moderate negative	minor negative	neutral	few	very few	none
Long Term Performance	major disbenefit	moderate disbenefit	minor disbenefit	neutral	positive	good	excellent
Risk to Life	major increase	moderate increase	minor increase	neutral	minor benefit	moderate benefit	major benefit

5.2. Measures Not Considered

Mitigation Dams

Large flood mitigation dams within the catchment are not viable on economic, social and environmental grounds. They are rarely used as a flood mitigation measure for existing development or in urban areas on the account of the likely low benefit cost ratio due to high construction costs, significant land demand, environmental damage and risk of failure. Often a considerable volume of water needs to be impounded in order to create a reduction in flood level downstream. They are more relevant when considering river flooding rather than overland flood flows. Mitigation dams would not be appropriate in Griffith due to the nature of the overland flooding.

Voluntary Purchase of Buildings

Generally, Government funding is only available for voluntary purchase of buildings that are frequently flooded in a high hazard area. However, as the flood depth above floor level is so shallow alternative means such as flood proofing would be more beneficial in terms of benefit/cost ratio. In Griffith most residential dwellings are in low hazard areas. No buildings have been identified as being suitable for voluntary purchase.

5.3. Flood Modification Measures

The purpose of flood modification measures is to modify the behaviour of the flood itself by reducing flood levels or velocities by excluding water from areas under threat.

5.3.1. Levees and Bunds

DESCRIPTION

Levees involve the construction of raised embankments between the watercourse and flood affected areas so as to prevent the ingress of floodwater up to a design height. Levees usually take the form of earth embankments but can be replaced by concrete walls where there is limited space or other constraints. They are commonly used on large river systems but can also be found on small creeks in urban areas.

Flood gates can be considered as a separate modification measure or as part of a levee design. They are commonly installed on drainage systems within a levee area and allow local runoff to be drained from an area, such as an area behind a levee, to the river but prevent water from entering or exiting when river levels are elevated. Pumps are generally also associated with levee designs. They are installed to remove local runoff behind levees when flood gates are closed or if there are no flood gates. Unless designed for the PMF, levees will be overtopped. Under overtopping conditions the rapid inundation combined with intense development as people build behind a levee as they feel flood protected, may produce exacerbated risk relative to a scenario in which the levee was not there.

DISCUSSION

An advantage of levee systems (this includes the levee and any drains, gates or pumps associated with its function) is a low maintenance cost although the levee system needs to be inspected on a regular basis for erosion or failure. In addition there is ongoing maintenance for grass cutting, vegetation trimming. The annual cost of inspections will generally be small (often less than $10,000 per annum per levee). However this amount can vary considerably depending upon the complexity and size of the structure.

Constructing a levee can cause additional flooding behind the levee due to local runoff within the protected area being unable to drain. In addition, as the levee causes a displacement of water from one area of the floodplain to another they should be carefully modelled and designed using hydraulic modelling techniques so as to ensure the construction does not increase flood risk to an adjacent area.

Unless the levee system is constructed to above the PMF level it will be overtopped. Should this occur the damages are likely to be higher as the population will be less flood aware, having built up a false sense of security living behind a levee. Many residents consider that following construction of a levee the existing flood related planning controls (minimum floor level, structural integrity certificate) should be relaxed. However, many experts consider that this should not be the case unless the levee is built to the PMF level and the risk of failure is nil, although achieving zero failure risk is impossible. The general opinion is that a levee should reduce flood damages to existing development but should not be used as a means of protecting new buildings with a reduction in flood related development control standards of the day.

There is currently an informal levee upstream of residential properties at the escarpment. The levee prevents runoff from the escarpment flowing into residential backyards adjoining the hill. Site inspection of this levee identified that there are places where it is lower than in others;

possibly where residents have tried to solidify or improve protection of their own property. It is recommended that Council formalise the levee as a flood management asset with an appropriate easement. Routine maintenance should be undertaken to ensure that the levee retains its structural integrity. Residents living near the levee should be made aware of its purpose and the importance of not modifying it.

The road level along Noorla Street is more or less at the same level as the top of the Noorla Street channel banks. Flooding of the road as the capacity of this channel is exceeded is common. Therefore, raised banks, or bunds (small levees) along the channel banks, parallel with Noorla Street, could prevent waters spilling from the channel and flooding Noorla Street (albeit for smaller events only). A small levee bank could also prevent runoff from the Noorla Street area reaching the channel however provisions would need to be made to allow free drainage to the channel.

SUMMARY

The current levee on the upstream side of residential properties at the escarpment will need ongoing maintenance and checks to ensure it continues to function to afford flood protection to properties. It is suggested that Council take responsibility for the levee, adopting it as a formal flood management asset, to maintain a consistent approach. The out-of-the way location of this relatively important flood protection infrastructure may lead to an out-of-sight out-of-mind response to its maintenance. For this reason regular maintenance of the levee should be included in the final adopted Flood Risk Management Plan.

5.3.2. Temporary Flood Barriers

DESCRIPTION

Temporary flood barriers include demountable defences, wall systems and sandbagging which is deployed before the onset of flooding.

DISCUSSION

Demountable defences can be used to protect large areas and are often used as a means to assist in current mitigation measures rather than as sole protection measures. For example they are best used to fill in gaps in levees or raising them as the risk of levee overtopping develops. The effectiveness of these measures relies on sufficient warning time and the ability of a workforce to install. They are more likely to be used for fluvial flooding from rivers which have sufficient warning time and are not a suitable technique for overland flooding such as in the study area.

Sandbagging, often used in conjunction with plastic sheeting, however, can be a more appropriate solution for dealing with flooding in smaller areas and at individual properties. However, again this relies on warning time and availability of sandbags and people to place them. Although sandbagging can be used to prevent ingress of flood waters into a property or access area it is not recommended as the primary risk management solution. Sandbagging should only be used in instances where additional temporary flood protection is required and should only be deployed when safe to do so. Recent experience from the March 2012 flood tells us that whilst sandbags and plastic sheeting seldom prevent the ingress of floodwaters entirely, they can substantially decrease the depth of over floor flooding and decrease foulness of floodwaters, thus aiding the clean up process.

SUMMARY

Large temporary barriers would not be an effective solution for the Griffith CBD due to the rapid and distributed nature of the flooding. The use of sandbagging to protect individual areas or properties is an option to consider although this is not a permanent method and therefore works best as a secondary option. Furthermore, due to the nature of the overland flooding occurring in Griffith CBD little to no warning time is available for sandbagging or other temporary barriers and therefore these measures should not be relied on.

5.3.3. Retarding Basins

DESCRIPTION

Retarding basins are often used in developing catchments. These measures are appropriate for use in controlling flooding in small catchments or to mitigate the effects of increased runoff caused by development. Retarding basins store runoff temporarily and then release it at a slower rate. Although they do not reduce the total volume of runoff, they do reduce the rate at which runoff occurs, thus reducing downstream flood levels. Communal retarding basins are generally used in conjunction with large scale development to allow for communal mitigation of runoff. They can also be used in general urban drainage systems for example, some Council‟s use of playing fields for retention of flows during flood events.

DISCUSSION

These systems are easier to implement as new development comes forward when Council can put the responsibility on the developer to provide appropriate drainage systems. However, it is also possible for systems to be retrofitted such as Council‟s recent upgrade to the Yambil Street drainage systems where the siphon beneath the Main Branch Canal was upgraded and a retarding basin constructed downstream of the embankment to attenuate the additional flows passed downstream.

Like the rest of the drainage system retarding basins have maintenance requirements. Regular checks and maintenance will be required by Council.

Large retarding basins can also be a safety hazard particularly when full. Appropriate safety controls such as fencing and signage should be included as part of the overall asset and should also be subject to routine checks and maintenance.

SUMMARY

Several potential locations where retarding basins could be installed to enhance the current drainage system were investigated including upgrading the current basin on Noorla Street, and new basins on Lenehan Road, Railway Street, Apex Park and Crossing Street. These are discussed further in Section 6.

5.3.4. On-Site Detention (OSD)

DESCRIPTION

Generally where retarding basins are used on large developments to restore lost catchment storage, on-site detention is used for the same purpose albeit on individual lots. OSD does not necessarily mean surface water must be attenuated in a basin; storage areas can include flooding above ground to shallow depths over paved areas, such as parking areas, or garden features. Storage can also be provided in underground systems.

OSD does not just apply to areas within a flood prone area but to all areas as it ultimately reduces the rate of runoff reaching downstream areas.

DISCUSSION

Council adopted an OSD Policy in October 2011 following the Main Drain J FRMS&P (Reference 2). This Policy, discussed in Section 2.3.1, requires that runoff from new developments is restricted back to the pre-development 1% AEP peak flow.

Although OSD can prevent development from exacerbating flood risk, it is not without its issues. The OSD systems will require maintenance. Lack of maintenance can allow blockages to form and therefore ponded water does not drain away and can even cause increased damage to property. Care should be taken when considering OSD depths and locations in relation to property and property access. Also provisions need to be made should the property ownership change. The new owners will need to be made aware of the OSD system on their property and their responsibility to maintain it. As OSD infrastructure tends to be on private property and falls under the responsibility of the property owner to maintain there is a risk of lack of maintenance, particularly in rental properties. Therefore Council needs to maintain a register of all OSD features within the LGA and undertake regular inspections to ensure they maintain full function over time.

As noted above, finished floor levels of properties should be considered where OSD is installed. If water storage is allowed above ground near to the building care should be taken in setting floor levels so that in case of failure of the system the surcharges would not adversely affect the property. The freeboard given in setting the Flood Planning Level (FPL) is usually suitable for this.

SUMMARY

Providing OSD on all new developments should be encouraged and can have beneficial effects in preventing increases in urban flooding in the future. The OSD Policy adopted by Council is generally supported. However, to aid developers Council should provide advice on appropriate OSD and also required the long term maintenance of it be considered.

5.3.5. Catchment Treatment and WSUD

DESCRIPTION

Catchment treatment is linked with OSD and modifies the runoff characteristics of the catchment to reduce flows. For an urban catchment, this involves planning to maximise the amount of pervious area, maintaining natural channels where practical and the use of Water Sensitive Urban Design (WSUD). These measures can reduce the volumes of storm water runoff in relatively small, frequent events, typically up to about 20% AEP (5-year ARI) events but they have less effect in larger, less frequent events. These measures can be effective on small catchments but have a negligible impact on large catchments.

DISCUSSION

Smaller systems such as community gardens in public areas can be encouraged through local planning. By increasing permeable surface area such schemes can reduce runoff and may be suitable in mitigating areas of localised flooding. By enforcing simple policies such as standard treatment within public space such as kerbside catchment treatment and limiting imperviousness of proposed development unless accompanied by offset works, Council can implement measures that will reduce flood volumes and hence reduce flooding. However, the effects of small scale catchment treatment and WSUD features are hard to quantify exactly through hydraulic modelling and depend on a range of factors such as permeability of soil, antecedent conditions, intensity of rainfall, size of the garden etc.

SUMMARY

As a general concept, catchment treatment techniques and WSUD should be encouraged for example, OSD, limiting on-site imperviousness for developments, controls on land use, along with water quality and other environmental controls as these approaches provide significant benefits to local drainage and overland surface water flooding.

5.3.6. Channel Modifications

DESCRIPTION

Channel modification includes a range of measures from straightening, concrete lining, removal of structures, dredging and vegetation clearing. In some instances „naturalising" the channel upstream can reduce peak levels downstream by slowing flows and making better use of flood storage.

DISCUSSION

In Griffith the majority of drainage comprises below ground systems although there are two channels used to convey flow; by Noorla Street and to the east of the orchard near Ortella Street. Noorla Street capacity is exceeded in events less than the 5-year ARI. Modifications to increase the capacity of the channel may be possible. However, if the channel bed was to be lowered consideration would need to be given to providing suitable channel depths whilst still providing a hydraulic gradient and also tying in with current infrastructure invert levels.

SUMMARY

Hydraulic modelling has been used to consider a number of channel modifications to the drains in Griffith. This has been detailed further in Section 6.

5.3.7. Drainage Network Modifications

DESCRIPTION

Modification of the existing drainage network is a possible mitigation measure in an urban catchment. Modifications can be made to increase the capacity of the system by installing larger or more pipes within the network or by providing areas for attenuation to hold back volumes of flood water and release at a slower rate such as detention basins (see Section 5.3.3).

DISCUSSION

Generally given the focus of a Flood Study on a 1% AEP event and the fact that drainage systems are typically designed for the 10% ARI event or less, drainage network modifications cannot radically change flood levels and hence it can be difficult to support on an economic basis. However, in specific circumstances and particularly where there is flooding in the smaller design events, such as occurs in Griffith, this can be a useful measure.

Council have already completed an upgrade to the drainage in the western section of Yambil Street area comprising a new siphon beneath the Main Canal and retarding basin downstream of the embankment to attenuate the additional flows passed forward.

Council have recently completed an upgrade of the drainage in the western section of Yambil Street area, between Daines St and Ulong St. The works comprised construction of new twin 1050 mm siphons beneath the Main Canal to provide an additional outlet for floodwaters from the Yambil Street area to be discharged downstream of the embankment. Floodwaters are first discharged into a newly constructed flood detention basin downstream of the Main Canal on Bromfield Street and subsequently flow to the drainage channel in Merrigal St, a sub-branch of DC „R". These mitigation works were proposed as part of Option S2 of the Griffith FRMS&P.

As well as adding retention basins to the drainage network other measures include upgrading drainage by installing larger pipes and more gullies/pits to convey more peak flows thus allowing stormwater to be removed from the flooded areas more quickly. Potential areas for upgrade include further works in Yambil Street as well as Crossing and Wakaden Streets, Lenehan Road and Blumer Avenue.

SUMMARY

By increasing drainage capacity larger volumes of surface water can be drained away more quickly although flood levels for the 1% events will not tend to radically improve as the design capacity of drainage systems is usually less than for the 10% AEP event and the Flood Study generally focuses on the 1% AEP event in relation to flood risk. Several drainage upgrade options were considered and have been modelled. Further discussion on these is included in Section 6.

5.3.8. Drainage Network Maintenance

DESCRIPTION

As identified in the Main Drain J FRMS&P (Reference 2), the responsibility for stormwater and drainage infrastructure located within the Griffith CBD catchment including the inverted siphons lies with Council. The introduction of maintenance protocols or policies would ensure that these assets are effectively managed and maintained such that they will perform as required particularly on those rare occasions when they are needed.

DISCUSSION

The 2001 Flood Plan (Reference 2) and 2006 Flood Study (Reference 3) both raised the issue of maintenance of drainage channels and pipes, with the 2006 Study suggesting that this was a key issue raised by the local community through consultation. Council is generally responsible for controlling stormwater drainage infrastructure within the study area with Murrumbidgee Irrigation being responsible for wider drainage infrastructure. A Memorandum of Understanding was recently entered into by Murrumbidgee Irrigation and Council to set out the acceptable maintenance on upgrade protocols and responsibility of the two bodies. Introducing further protocols or policies for maintenance would place more pressure on Council to fulfil their responsibility for this.

Maintenance includes regular inspections of drainage channels, pipes and structures to identify the need for removal of blockages or repair of damaged infrastructure. Installation of trash screens on some structures would help in the prevention of blockage by not allowing rubbish to enter the drainage systems in the first place. Trash screens at the entrance to drainage systems can have the effect of preventing flows from entering the systems if they become blocked so will need to be maintained to prevent adverse effects. However, these are generally considered better than trash screens at the outfall of the drainage system which would cause trash to build up within the system and be harder to clear.

The inverted siphons are key features of the Griffith CBD catchment drainage system as they convey discharge from the CBD catchments upstream of the Main Canal embankments to the Main Drain J. Hence, in any larger flood event greater that 5-year ARI, any damage or blockages to the siphons will lead to undesirable consequences for the area upstream of the Main Canal, i.e. the southern area of the CBD including the main flood hotspots in this area such as Yambil Street. This is highlighted in Table 12 where up to a 370 mm increase in the 1% AEP peak flood level can be expected at Yambil St, Canal St and Lenehan Rd when the siphons were modelled as fully blocked, while up to 50 mm increase in the 1% AEP peak flood level can be expected along Noorla St. The increased flood extents are shown in Figure 9, which largely affect the immediate areas upstream of the Canal. Therefore, regular maintenance of these siphons by Council is vital to ensure existing flood risks are not exacerbated.

Table 12: Impact to 1% AEP Peak Flood Level for Different Siphons Blockage Scenario

I.D. #	Location	Base Case – Siphons Blocked at 25% (mAHD)	Impact of Siphons Blocked at 100% (m)
1	Nelson Dr Basin	127.14	0.00
2	U/S of Railway near Dickson Rd	127.85	0.00
3	U/S of Railway near Ortella St	128.47	0.00
4	U/S of Goondooloo St/Cutler Ave culv	129.29	0.00
5	3 Ways Intersection	126.18	+0.05
6	Noorla St near Basin	126.20	+0.05
7	Noorla St/Parkinson Cres Inter. - NW	126.25	+0.04
8	Noorla St/Parkinson Cres Inter. - SE	126.28	+0.03
9	U/S of Noorla St adj Parkinson Cres	126.50	+0.01
10	Noorla St/Lawson Cres Inter.	126.47	+0.01
11	Noorla St/Goondooloo St Inter.	126.50	+0.01
12	Wakaden St/Burrell Pl Inter.	127.30	0.00
13	Ulong St near Railway	126.82	+0.01
14	Yambil St near Ulong St Inter.	125.45	+0.37
15	Canal St near Ulong St Inter.	125.45	+0.37
16	Banna Ave/Kooyoo St Inter.	126.12	+0.01
17	Banna Ave/Jondaryan Ave Inter.	125.82	+0.03
18	Yambil St near Jondaryan Ave Inter.	125.45	+0.36
19	Canal St near Jondaryan Ave Inter.	125.45	+0.36
20	Land adj to Crossing St N of Railway	127.54	0.00
21	Crossing St S of Railway	126.44	+0.01
22	Banna Ave/Lenehan Rd Inter.	126.14	+0.14
23	Lenehan Rd	125.93	+0.35
24	McCudden St/Poole St Inter.	128.37	0.00
25	Garfitt Pl Basin	127.41	+0.01
26	Dunbar Park Basin	126.84	0.00

SUMMARY

A drainage infrastructure maintenance program has been proposed and outlined in the Griffith FRMS&P (Reference 2). Proper ongoing maintenance is a challenge for Council. Scheduled observation of drainage asset conditions and procedures regarding cleaning out and/or repair of blocked and/or damages infrastructure would also assist.

5.4. Property Modification Measures

Property modification measures refer to the modifications to existing development and/or development controls on property and community infrastructure for future development.

In terms of construction standards there are currently no technical standards for new buildings in flood prone areas within Australia. However, the Australian Building Codes Board have developed a draft standard and accompanying handbook which it is expected to be adopted in the National Construction Code in 2013. This draft code will include consideration of appropriate materials, electrical, plumbing and drainage installation as well as setting floor levels. Once released the code should be compared against Council‟s current planning controls to ensure no contradiction.

5.4.1. House Raising

DESCRIPTION

House raising has been widely used throughout NSW to eliminate or significantly reduce flooding of habitable floors particularly in lower hazard areas of the floodplain, albeit in limited overall numbers. However it has limited application as it is not suitable for all building types being more suitable for non-brick single storey buildings. House raising is unlikely to be approved in high hazard areas.

DISCUSSION

The benefit of house raising is that it eliminates above floor flooding and consequently reduces flood damages. House raising also provides a safe refuge during a flood, assuming that the building is suitably designed for the water and debris loading. However the potential risk to life is still present if residents choose to enter floodwaters or are unable to leave the house during a medical emergency, or larger floods than the design flood occurs particularly in high hazard areas.

Property raising is not an option for any commercial or industrial properties as most are brick on concrete structure. Many of the residential properties in Griffith are brick structure and therefore difficult to raise. It may be possible to raise some houses of timber construction however other measures of flood proofing area considered more cost effective due to the shallow depths of flooding occurring for most design events up to an including the PMF.

SUMMARY

House raising is not considered to be the most cost effective option for the type of flooding in Griffith. Flood proofing is more appropriate and cost effective for flooding at shallow depths. In addition many of the flood affected properties are brick construction and therefore difficult and to raise. It is not viable to raise commercial properties in the CBD due to their construction, the street scene setting/character and access requirements.

Current planning controls are in place that stipulate any new residential development should be above the flood planning level (1% AEP flood level plus 0.5 m) to ensure community flood risk is not increased in the future. Planning controls are also in place setting floor levels for commercial property (see Sections 2.3.1 and 5.6.1).

5.4.2. Flood Proofing

DESCRIPTION

An alternative to house raising for buildings that are not compatible or not economically viable, is flood proofing or sealing off the entry points to the building. This measure has the advantage that it is generally less expensive than house raising and causes less social disruption. Flood proofing requires sealing of doors and possibly windows (new frame, seal and door); sealing and re-routing of ventilation gaps in brick work; sealing of all underfloor entrances and checking of brickwork to ensure there are no gaps or weaknesses in mortar. It is generally only suitable for brick buildings with concrete floors and it can prevent ingress from outside depths of up to one meter. Greater depths may cause structural problems unless water is allowed to enter. Generally an existing house can be sealed for approximately $10,000. New development and extensions allow the inclusions of flood appropriate materials and designs meaning the actual cost of flood proofing can be significantly less when compared to buildings requiring retro-fitting of flood proofing measures.

Flood proofing should also consider suitable electrical installation to as to avoid the risk of electrocution. A minimum aim should be to have all properties in flood hazard areas to, at least, be fitted with a circuit breaker although ideally for all new development all unsealed electrical circuits should be at the Flood Planning Level (FPL).

Additionally, flood proofing can involve the raising of easily damage/high cost items such as commercial stock, equipment and machinery. New buildings should have floor levels above the flood planning level.

Alternatively, temporary flood proofing can also be achieved by the use of sandbags in conjunction with plastic sheeting or private flood gates which fit over doors, windows and vents and are deployed by the occupant before the onset of flooding (see Photograph 3).

Photograph 3: Flood Gate at Front Door of Residential Property

DISCUSSION

Permanent flood proofing measures are more suitable for commercial and industrial buildings where there are only limited entry points and aesthetic considerations are less of an issue. Also there are issues of compliance with other regulations such as fire safety and maintenance issues as well as access issues. However flood compatible building or renovating techniques should be employed for extensions or renovations where appropriate. Guidelines are provided in a booklet *"Reducing Vulnerability to Flood Damage"* prepared in 2006 for the Hawkesbury-Nepean Floodplain Management Steering Committee (Reference 12).

The use of temporary measures such as flood gates which occupants fit over their doors and other possible water inlets can be useful in areas where there is frequent shallow flooding.

These methods are better used when flooding is of short duration otherwise people may become stranded in their homes. Alternatively they can be used to make a property more flood resistant before evacuation. However, temporary flood proofing measures rely on sufficient warning time to be effective so that they can be installed before the onset of flooding. If used, it could be recommended that temporary measures could be deployed following a BoM flood watch being issued for the region. However the effectiveness relies on the user understanding how and when to deploy.

Minimising the chance of electrocution by turning off the electricity supply during a flood should be standard practice for both residents and commercial owners during floods. The risk of electrocution can also be reduced by installing electrical circuits above, at least, the flood planning level.

SUMMARY

Flood proofing is a good solution to reducing flood risk to commercial and industrial properties. Flood proofing techniques, be they permanent or temporary, could be utilised for the properties in the industrial area. They are more likely to be effective for the more frequently flooded properties as infrequency of use will lead to the system being poorly maintained leading to a greater chance of failure during a flood event. Temporary flood proofing techniques may be deployed in the CBD area although lack of warning time may limit their efficiency. This is a good technique to use where stock, machinery or other goods cannot be moved before the onset of flooding and also suitable where flood depths may be shallow but have potential to cause significant damages.

5.4.3. Minor Property Adjustments

DESCRIPTION

In overland flow areas minor property adjustments can be made to manage overland flow passing through private property. Such adjustments can include amendments to fences, construction of fences which act as deflector levees, modifying gardens, changing easements etc all of which can affect the local continuity of overland flow paths.

DISCUSSION

Property adjustments can be used to manage overland flows through private property and minimise impacts on dwellings by helping to divert local overland flows away from dwellings and access points. However, due to the shallow and diffuse nature of flooding in Griffith this option is not applicable as changes will have negligible benefits.

It is difficult for Council to enforce property adjustments and furthermore the issue can be complicated by requirements of S149 certificates. In addition, adjustments on one property may have knock on effects on adjoining properties, or require modifications on neighbouring properties to be effective.

SUMMARY

Although minor property adjustments can have localised benefits, it is not recommended that Council specifically encourage or become involved in this. With the distributed nature of the overland flooding benefits are likely to be minor and the complexity of Council managing such as scheme can outweigh the benefits.

5.5. Response Modification Measures

Flood response measures encompass various means of modifying the response of the population to the flood threat.

5.5.1. Flood Warning and Evacuation

DESCRIPTION

Flood warning can significantly reduce damages and risk to life and studies have shown that flood warning systems generally have high benefit/cost ration if sufficient warning time is provided.

Flood warning and the implementation of evacuation procedures by the SES are widely used throughout NSW to reduce flood damages and protect lives. The Bureau of Meteorology (BoM) is responsible for flood warnings on major river systems and the SES is disseminating these warning to the local community. Adequate warning gives residents time to move goods and cars above the reach of floodwaters and to evacuate from the immediate area to designated evacuation points or flood free ground. The effectiveness of a flood warning scheme, known as the effective flood warning time, depends on;

- The maximum potential warning time before the onset of flooding;
- The actual warning time provided before the onset of flooding. This depends on the adequacy of the information gathering network and the skill and knowledge of the operators; and
- The flood awareness of the community responding to a warning.

DISCUSSION

For overland flow flooding providing a flood warning is more difficult than for area impacted by mainstream floods. For river systems, predictions of potential peak flood height and timing are possible with a high degree of reliability afforded by upstream gauges. However, predicting urban overland flow peak flood levels is not necessarily practicable. Overland flooding usually occurs soon after, or at the same time, as intense rainfall. Spatial differences in the rainfall patterns may go undetected by the sparse rainfall gauge network. Furthermore the extent of flood levels can vary over the study area. Therefore, weather warnings are often more useful with regard to providing warning to residents and businesses. Weather warnings issued by BOM can advise if flooding is expected.

This Study has found that over floor flooding does occur for some properties. Furthermore, there are some properties that may not be directly affected by flooding but will become flood islands during flooding and therefore a decision needs to be made whether to evacuate these people or allow them to remain in their homes.

The greatest improvement in the accuracy of any flood warning predictions generally only occurs following major flood events. It is imperative therefore that a post flood assessment report be prepared following each future flood event.

Currently Council make flood warnings available through the Flood Watch section on their website. This was updated during the wider area flooding of March 2012. Given the speed with which floods can occur a more realistic system may be the additional service of communication of flood risk via SMS alerts.

SUMMARY

Due to the nature of flooding in the study area flood warnings are difficult. In addition there would be little time for evacuation. Severe weather warnings should be used as a caution to potential onset of flooding. These are available through BOM and can also be made available on Council‟s website and through SMS alerts.

5.5.2. Flood Emergency Management

DESCRIPTION

As mentioned above, it may be necessary for some residents to evacuate their homes in a major flood. This would usually be undertaken under the direction of the lead agency under the DISPLAN, the SES. Some residents may choose to leave on their own accord based on flood information from the radio or other warnings, and may be assisted by local residents. The main problems with all flood evacuations are;

- They must be carried out quickly and efficiently;
- There can be confusion about „ordering‟ evacuations, with rumours and well-meaning advice taking precedence over official directions which can only come from the lead agency, the SES;
- They are hazardous for both rescuers and the evacuees;
- Residents are generally reluctant to leave their homes, causing delays and placing more stress on the rescuers, and
- People (residents and visitors) do not appreciate the dangers of crossing floodwaters.

For this reason, the preparation of a Community Flood Emergency Response Plan (CFERP) helps to minimise the risk associated with evacuations by providing information regarding evacuation routes, refuge areas, what to do/not to do during floods etc. It is the role of the SES to develop a CFERP for vulnerable communities.

DISCUSSION

Griffith Local Flood Plan was last updated in 2008 with findings from the Main Drain J Flood Study. Despite the lack of flood warning available a plan can still be highly beneficial and could be further updated with information from this Study.

From the Flood Study (Reference 1) and assessment undertaken in this Study it is identified that there are some low lying parts of the CBD which would benefit from evacuation, particularly the Yambil Street area.

Although flood warning is limited, a local disaster plan should be continually updated to include the latest information on design flood levels and details on roads, properties, and other facilities which would be flood affected.

SUMMARY

The SES should ensure that a Local Flood Plan is prepared for the Griffith urban area. This should also take into account those properties not directly flood affected but which may have had access cut and become flood islands. This Flood Plan should be regularly kept up to date and should include feedback from the March 2012 event and the recommendations of this Study once finalised.

5.5.3. Community Awareness Programme

DESCRIPTION

The success of any flood warning system and the evacuation process in reducing flood losses and damages depends on;

- *Flood Awareness*: How aware is the community of the flood threat? Has it been adequately informed and educated?
- *Flood Preparedness*: How prepared is the community to react to the threat of flooding? Do they (or the SES) have damage minimisation strategies (such as sand bags, raising possessions) which can be implemented?
- *Flood Evacuation*: How prepared are the authorities and the residents to evacuate households to minimise damages and the potential risk to life during a flood? How will the evacuation be done, where will the evacuees be moved to?

Public information and the level of public awareness is key in reducing flood damages and losses. A more aware community will suffer less losses and damage than an unprepared community.

DISCUSSION

The level of flood awareness within a community is difficult to evaluate. It will vary over time and depends on a number of factors including frequency and impact of previous floods, history of residence, and whether an effective community awareness program has been implemented.

Families who have owned properties for a long time will have established a considerable depth of knowledge regarding flooding and a relatively high level of flood awareness. A community which consists predominantly of short lease rental homes will have a low level of flood awareness. Also it is very likely that new residents will be aware from advice at the time of their property purchase (Section 149 certificate) or from neighbours after they move in.

Generally community awareness will decline as the time since the last flood increases. Community awareness can be raised as a result of community flood or climate change awareness programs albeit temporarily and without the same consensus an actual flood brings. A community with high flood awareness will suffer less damage and disruption during and after a flood because people are aware of the potential of the situation. On river systems which regularly flood, there is often a large, local, unofficial warning network which has developed over the years and residents know how to effectively respond to warnings by raising goods, moving cars, lifting carpets, etc. Photographs and other sentimental or non-replaceable items are generally put in safe places. In more frequently flooded areas, some residents may have developed storage facilities which are flood compatible. However, this is not the case within the Griffith urban area.

A major hurdle is often convincing residents that major floods will occur in the future. Many residents hold the false view that once they have experienced a large flood then another will not occur for a long time thereafter. History shows that, in contrast, actual flood events tend to cluster into a period of several years over 20-50 year cycles. Residents should be made aware that within Griffith, significant damage can occur even in the smaller, more frequent flood events.

Community information can simply be provided in an information brochure mailed to residents for them to keep available. This would include such things as identifying the risk, the procedures to be followed in an emergency evacuation, details of the local evacuation centre and evacuation routes telephone numbers etc. Further community awareness options are detailed in Table 13.

Following flooding it is important to collect available information but to also let the community know that Council is aware of the problems and are managing it. Council staff should meet with affected community members following flooding, particularly those properties in the main CBD area such as Yambil Street. Ongoing post flood data collection by Council in conjunction with the SES should occur after every flood event to enable improved understanding of the flooding situation and ensure data is always the most recent to allow better decision making for flood management.

SUMMARY

For risk management to be effective it must become the responsibility of the whole community. It is difficult to accurately assess the benefits of an awareness program but it is generally considered that the benefits far outweigh the costs. The perceived value of the information and level of awareness diminishes as the time since the last flood increases.

As time passes since the last significant flood, the direct experience of the community with historical floods will diminish. It is important that a high level of awareness is maintained through implementation of a suitable Flood Awareness Program that would include Floodsafe brochures as well as advice provided on Council‟s and SES‟s websites. These need to be updated on regular basis.

Table 13 provides examples of possible further education methods that may be developed and supported by Council.

Table 13: Community Flood Awareness Methods

Method	Comment
Letter/pamphlet from Council	These may be sent (annually or biannually) with the rate notice or separately. A Council database of flood liable properties/addresses makes this a relatively inexpensive and effective measure. The pamphlet can inform residents of ongoing implementation of the Risk Management Plan, changes to flood levels, climate change or any other relevant information.
Council website	Council should continue to update and expand their website to provide both technical information on flood levels as well as qualitative information on how residents can make themselves flood aware. This would provide an excellent source of knowledge on flooding as well as on issues such as climate change. It is recommended that Council"s website continue to be updated as and when required.
Community Working Group	Council should initiate a Community Working Group framework which will provide a valuable two way conduit between the local residents and Council.
School project or local historical society	This provides an excellent means of informing the younger generation about flooding and climate change. It may involve talks from various authorities and can be combined with topics relating to water quality, estuary management, etc.
Historical flood markers and flood depth markers	Signs or marks can be prominently displayed on telegraph poles or such like to indicate the level reached in previous floods. Depth indicators advise of potential hazards, particularly to drivers. These are inexpensive and effective but in some flood communities not well accepted as it is considered that they affect property values.
Articles in local newspapers	Ongoing articles in the newspapers will ensure that the flood and climate change issues are not forgotten. Historical features and remembrance of the anniversary of past events are interesting for local residents.
Collection of data from future floods	Collection of data (including photographs and recorded flood levels) assists in reinforcing to the residents that Council is aware of the problem and ensures that the design flood levels are as accurate as possible.
Types of information available	A recurring problem is that new owners consider they were not adequately advised that their property was flood affected on the 149 Certificate during the purchase process. Council may wish to advise interested parties, when they inquire during the property purchase process, regarding flood information currently available, how it can be obtained and the cost. This information also needs to be provided to all visitors who may rent for a period. Some Councils have conducted "briefing" sessions with real estate agents and conveyancers.
Establishment of a flood effects database and post flood data collection program	A database would provide information on a number of issues such as which houses require evacuation, which public structures will be affected (eg. telephone or power cuts). This database should be reviewed after each flood event. This database should be updated following each flood with input from the community.
Flood preparedness program	Providing information to the community regarding flooding helps to inform it of the problem and associated implications. However, it does not necessarily adequately prepare people to react effectively to the problem. A Flood Preparedness Program would ensure that the community is adequately prepared. The SES would take a lead role in this.
Develop approaches to foster community ownership of the problem	Flood damages in future events can be minimised if the community is aware of the problem and takes steps to find solutions. The development of approaches that promote community ownership should therefore be encouraged. For example residents should be advised that they have a responsibility to advise Council if they see a problem such as blockage of drains or such like. This process can be linked to water quality or other water related issues including estuary management. The specific approach can only be developed in consultation with the community.

The specific flood awareness measures that are implemented will need to be developed by Council taking into account the views of the local community, funding considerations and other awareness programs within the LGA. The details of the exact measures would need to be developed in consultation with affected communities.

5.6. Planning and Future Development Control Measures

5.6.1. Flood Planning Area

DESCRIPTION

A Flood Planning Area (FPA) map is a required outcome of the FRMS&P. The FPA is an area to which flood planning controls are applied. It is important to define the boundaries of the FPA to ensure flood related planning controls are applied where necessary and not to those lots unaffected by flood risk. It is also important to define the FPA on criteria as per the NSW Floodplain Development Manual (2005).

DISCUSSION

Typically, and as per the Floodplain Development Manual (NSW, 2005), the FPA will be based on the flood extent formed by the 1% AEP mainstream flooding event plus freeboard (typically 500 mm) and therefore extended further than the extents of the 1% AEP event. The FPA as per the Floodplain Development Manual (2005) is appropriate for areas of mainstream flooding; that is flooding from rivers and other watercourses. It is not appropriate for areas subject to flooding from overland flows which often do not reach the depths that could occur from mainstream flooding and additionally, where depths do not tend to increase significantly for rarer events. This is particularly an issue in areas such as the Griffith CBD catchment where the 1% AEP flood level plus 500 mm freeboard is consistently higher than the PMF flood level. To define the FPA using the 1% AEP flood level with 500 mm freeboard results in a FPA which encompasses the entirety of the Griffith urban area (within the bounds of the study area).

It would be overly conservative to define a FPA significantly larger extent than the PMF which would effectively force flood risk related planning controls on properties not subject to any flood risk. Therefore **use of the 1% AEP event flood levels plus 500 mm freeboard is NOT recommended.**

Current thinking and emerging policy for defining the FPA in areas subject to overland flow recommends the following approach:

- All flood depths less than 200 mm are discounted as "drainage". That is it is considered too unsubstantial to be called flooding, given the relatively shallow depth.
- Unless on a defined watercourse flooding is described as "major overland flow" and not "mainstream" flooding. As flood liability is due to major overland flows and not mainstream flooding, only those lots which are impacted by substantial floodwaters are selected for inclusion in the FPA.
- For mainstream flooding areas, which do not occur in the Griffith CBD, add a freeboard to the 1% AEP flood level and create an extent based on this defining the FPA. In some areas a 300 mm freeboard may be more appropriate than a 500 mm freeboard.

To define a reasonable FPA for Griffith CBD catchment, where a reasonable FPA is where the properties "tagged" are substantially flood liable and uncontrolled development of them would lead to flooding problems being shifted onto adjoining parties, the recommended approach above was taken. ***Where flooding is based on overland flow rather than mainstream flooding the FPA is defined as those properties within the 1% AEP flood extent where a depth of greater than 200 mm covers more than 20% of the property.***

The criteria used for lot selection is that 20% or more of the lot is impacted by floodwaters by depths over 200 mm. In regard to selected lots in Yambil Street, Council should exclude them from the FPA. Firstly the properties (and land use zone) are mainly commercial, secondly development is already close to 100% and thirdly it is debateable whether the flood affectation in Yambil Street is actually a flooding or stormwater problem. Should Council tag properties on the basis of a perceived drainage problem and owners link Section 149 notation to ongoing insurance issues or deflated property prices, then owners will obviously call on Council to fix the drainage system and remove the burden of being declared flood liable from property owners. A simple inclusion in the DCP for the Yambil St area could see floor levels set appropriately with respect to flood liability without the complications and potential agitation caused by adding the properties to the FPA. Figure 10 shows the properties selected by the above criteria.

SUMMARY

Defining the FPA is crucial as the FPA is a key concept referred to in the LEP. The FPA is defined on the basis of the Floodplain Development Manual (NSW, 2005). However, the use of the 1% AEP event plus freeboard event to define the FPA is a straightforward process where mainstream flooding dominates only. Griffith CBD is not subject to mainstream flooding, rather it is subject to overland flow flooding. Therefore the 1% AEP event plus 500 mm freeboard criteria is not appropriate.

Due to the nature of flooding in the Griffith urban area it is recommended that Council consider adoption of an alternate method of establishing the FPA for areas affected by overland flow rather than the current 1% AEP plus 0.5 m freeboard. We would recommend that Council consider adoption of the FPA as all **properties subject to inundation in the 1% AEP flood event, excluding depths less than 200 mm, AND where lot inundation is greater than 20 percent of the lot area with the exception of properties in the Yambil Street area.**

5.6.2. Flood Planning Levels

DESCRIPTION

Flood Planning Levels (FPLs) are an important development control in floodplain risk management. The Floodplain Development Manual (Reference 6) provides a comprehensive guide to the purpose and determination of FPLs. The FPL provides a development control measure for managing the future flood risk and is derived from a combination of flood level results from a flood event of specific probability and freeboard. In determining a suitable FPL Council should consider the impacts of restricted development in a flood prone area with the benefits of a reduction in damage, frequency and danger to life caused by flooding.

Defining the appropriate FPL involves trading off the social and economic benefits of a reduction in the frequency, inconvenience, damage and risk to life caused by flooding against the social, economic and environmental costs of restricting land use and development in flood prone areas and of implementing management measures. FPLs are generally required to be defined or applied for the following broad use land categories including; residential; commercial and industrial; community services such as schools, community halls; critical services such as hospitals, police stations, Council Offices; recreation facilities; caravan parks; additions or extensions to existing structures; and public utilities such as electricity, water, sewer, telephone infrastructure.

The Floodplain Development Manual (Reference 6) states that in general the FPL for a standard residential development would be the 1% AEP event plus a freeboard, typically 0.5 m. Developments more vulnerable to flooding (hospitals, electricity sub-stations, senior"s housing) must consider rarer events greater than the 1% AEP when determining their FPL and usually consider the PMF. However, the FPL does not address the full range of issues when considering flood risk such as access and failure of essential services.

DISCUSSION

The FPL can be varied depending on the use, and the vulnerability of the building/development to flooding. For example residential development could be considered more vulnerable due to people being present whilst commercial development could be considered less vulnerable, or it could be accepted that commercial property owners are willing to take a higher risk. Likewise, critical services such as hospitals, fire stations and other services which would need to operate during a flood event would be considered more vulnerable to flood damage and could be stipulated to have higher FPLs; or even better to be situated outside of the floodplain where possible. Flood proofing a building can be considered where raising floor levels is not an option or feasible and can be appropriate for the less vulnerable commercial and industrial developments. Whilst raising the floor levels will ensure that the floors are not flooded in the design there is still the issue of whether adequate services (sewer, roads) can be provided and that the lot will be suitable for habitation (i.e not permanently or regularly inundated so as to make the land unsuitable).

The FPL can also be used to set requirements for flood proofing a building. New developments and re-developments should have requirements to locate unsealed electrical circuits at least above the designated FPL for the area to reduce risk of electrocution.

According to the Floodplain Development Manual (Reference 6) the purpose of the freeboard is to provide reasonable certainty that the reduced flood risk exposure provided by selection of a particular flood as the basis of a FPL is actually provided given the following factors;

- Uncertainties in estimates of flood levels;
- Differences in water level because of local factors;
- Increases due to wave action;
- The cumulative effect of subsequent infill development on existing zoned land; and
- Climate change.

Current FPL considerations take into account the different vulnerability of different land uses and make suitable controls. However, in areas prone to overland flooding a 0.5 m freeboard that tends to the 1% AEP plus 0.5 m FPL being higher than the PMF, can be excessive.

While the 1% AEP flood level is often adopted with a 0.5 m freeboard for a FPL this is not always appropriate, such as when considering the shallow overland flooding in Griffith. A range of factors should be considered in selecting the appropriate FPL including social, economic, ecological and cultural factors as well as risk to life and property and flood behaviour.

SUMMARY

There is a need to update the current FPL used in the Griffith CBD in areas subject to overland flow flooding. In areas where the 1% AEP flood level plus a 0.5 m freeboard is higher than the PMF, adopting the 1% AEP flood level plus 0.5 m would be an unjustifiable control. This is generally applicable to the area north of the railway. For these areas it may be appropriate to use the PMF flood level as the FPL or use a lower freeboard. A freeboard of 0.3 m would be suitable for future rainfall increases and localised variability in flood level not identified by flood modelling. Alternatively where the PMF is less than the 1% AEP level plus 0.5 m then, if depths in the 1% AEP event are less than 0.5 m, the freeboard can be equal to the flood depth. For depths over 0.5 m the freeboard should be 0.5 m. For the area of the CBD south of the railway but upstream of the Main Canal the 1% AEP plus 0.5 m FPL could be appropriate given the current flooding situation with flood water being held back behind the Canal. However, Council may want to consider that should significant improvements be made to the siphons draining this area there may be an opportunity to reduce the FPL. Therefore options need to be considered for the FPL.

As with defining the boundaries of the FPA, Council"s Planners and Engineers should consider the implications of a FPL higher than the predicted PMF. The benefits and consequences of different criteria for setting both the FPA and FPL should be considered together as it is important both are compatible.

5.6.3. Update LEPs and DCP

Updated and relevant planning controls are important in flood risk management. Appropriate planning restrictions, ensuring that development is compatible with flood risk, can significantly reduce flood damages. Planning instruments can be used as tools to guide new development away from high flood risk locations and ensure that new development does not increase flood risk elsewhere. They can also be used to develop appropriate evacuation and disaster management plans to better reduce flood risks to the existing population.

This Study includes a draft review of the current planning controls with regard to flooding in Griffith. This is for future discussion with Council so that the methods of current practices can be better understood by WMAwater and suitable recommendations can be made based on the technical outcome of the Study and local knowledge of Council.

Local Environmental Plan

The Griffith LEP is to be updated in 2013 using the NSW Planning and Infrastructure"s Standard Instrument format. The Standard Instrument does not include a specific land use zone classification for flood prone land, rather permits a Flood Planning Map to be included as a layer imposed across all land zones. The Flood Planning map will be based on both the Main Drain J Flood Study (Reference 3) and the CBD Overland Flow Flood Study (Reference 1) model as amended for this FRMS&P to incorporate updates to the development in the floodplain.

The Flood Planning map will not provide precise depths of overland flow but rather will indicate areas which have been determined to be flood prone and reference that these areas are subject to the controls of the Flood Prone Land Policy. Provided below is an example of the clause related to Flood Planning in the Standard Instrument which has been adopted by other Council‟s in their LEPs:

Flood Planning:

1) The objectives of this clause are as follows:
    a. To minimise the flood risk to life and property associated with the use of land,
    b. 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.
    c. To avoid significant adverse impact on flood behaviour and the environment.
2) This clause applies to:
    a. Land that is shown as "Flood Planning Area" on the Flood Planning Map, and
    b. Other land at or below the Flood Planning Level.
3) Development consent must not be granted to development on land which this clause applies unless the consent authority is satisfied that the development;
    a. Is compatible with the flood hazard of the land, and
    b. Is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties; and
    c. Incorporates appropriate measures to manage risk to life from flood, and
    d. 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
    e. Is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.
4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0), published in 2005 by the NSW Government, unless it is otherwise defined in this clause.
5) In this clause:
    a. "Flood Planning Level" means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 meter freeboard.
    b. "Flood Planning Map" means the [Council Name] Local Environmental Plan 201(x) Flood Planning Map.

This FRMS&P recommends when updating the LEP that the following are also carefully considered:

- Re-define the FPA for the CBD area – it is recommended that all properties subject to inundation in the 1% AEP flood event, excluding depths less than 200 mm, AND where lot inundation is greater than 20 percent of the lot area with the exception of properties in the Yambil Street area are included within the FPA.
- Identify Flood Prone Land from fluvial flooding (Main Drain J catchment) and overland flow flooding (such as in the CBD) separately to allow different floor level controls.
- Note that all development in the zone will be subject to the Flood Prone Land Policy.

Flood Prone Land Policy

- To be updated with reference to the CBD Overland Flow Flood Study (Reference 1).

- Differentiate between areas flooded by overland flows and from the Main Drain J catchment.
- Identify different FPLs for those properties affected by overland flows and not affected by fluvial flooding. Perhaps even split the overland flood area into different "flood precinct" with different FPL controls as appropriate depending on area within Griffith.
- Allow lower floor levels for less vulnerable properties such as commercial and industrial developments and set development controls for flood proofing measures.

Floor Heights Policy

- Incorporate this Policy within the Flood Prone Land Policy to avoid confusion or conflict between two.
  OR
- Remove reference to particular flood studies. This can cause issues when Flood Studies are updated. Instead add comment to refer to Council‟s current flood studies or similar.
- Definition of Flood Prone Land is not included. Include this as per the definition in Floodplain Development Manual (Reference 6) which included flood affected land up to the PMF.
- Need to identify how flood prone land is mapped. Either include a current map based on both the Main Drain J Flood Study (Reference 3) and the CBD Overland Flow Flood Study (Reference 1) or, refer to Council‟s current flood studies and/or LEP.

On-Site Detention Policy

- Responsibility for maintenance and compliance is placed on the site owner – this is noted on S149 certificates.
- Council to keep record of all OSD features in the LGA and undertake regular audits.

Other Planning or Controls

- Review emergency response protocols and provision of recommendations to updates of the SES local flood plan.
- Identify policies for drainage maintenance of drains and channels. Determination of protocols for ownership maintenance and development / upgrade of infrastructure.
- Review and reissue S149 certificates.

5.6.4. Modification to the S149 Certificates

DESCRIPTION

Councils issue planning certificates to potential purchasers under Section 149 of the Environmental Planning and Assessment Act of 1979. The function of these certificates is to inform purchasers of planning controls and policies that apply to the subject land. A certificate issued under Section149(2) provides information about the zoning of the property, the relevant state, regional and local planning controls and other property affectations such as land contamination and road widening. A certificate issued under Sections 149(2) and 149(5) provides both the information available in a Section 149 (2) certificate and additional information such as advice from other authorities, subdivision history and easements where Council has information available. While the certificate will state all the relevant planning instruments that apply to the property, it does not specify specific development standards or terms of the instruments. Planning certificates are an important source of information for prospective purchasers on whether there are flood related development controls on the land. They need to rely upon the information under both Section 149(2) and 149(5) in order to make an informed decision about the property. It should be noted that only Part 2 is compulsory when a house is purchased and thus detail in Part 5, which provides additional details, may not be made known to the purchaser unless it is specifically requested. Under Part 2 Council is required to advise if it is aware of the flood risk as it is of any other known risk (bush fire, land slip etc.).

DISCUSSION

Because of the wide range of different flood conditions across NSW, there is no standard way of conveying flood related information. As such, Councils are encouraged to determine the most appropriate way to convey information for their areas of responsibility. This will depend on the type of flooding, whether from major rivers or local overland flooding, and the extent of flooding (whether widespread or relatively confined). It should be noted that the Section 149 certificate only relates to the subject land and not any specific building on the property.

The information provided under Part 2 of the certificate is determined by legislation, under the Environmental Planning as Assessment Act 1979, as amended, and the Environmental Assessment and Planning Regulation, 2000, and unless specifically included by the Council provides no indication of the extent of flood inundation. Under Part 5, which provides further details, there is scope for providing this additional type of information. There can be a general perception from the public that insurance companies, lending authorities or other organisations may disadvantage flood liable properties that have only a very small part of their property inundated by floodwaters. Some Councils have addressed this concern by adding information onto Part 5 to show the percentage of the property inundated as well as floor levels and other flood related information. In addition the hazard category could be provided and also advice regarding climate change increases in flood level.

SUMMARY

As Council information for S149 Certificates and Development Restriction Certificates is obtained mainly from computerised databases and maps, Council should investigate ways to make property-based flooding information more accessible via its web-site.

Data from the hydraulic modelling used in this FRMS&P should be incorporated into Council‟s Section 149 planning controls. All residents should be advised by personalised mail from Council if their land is affected. Council should determine the appropriate event for advising residents that the same criteria is used as in establishing the FPA.

6. AREA SPECIFIC MANAGEMENT OPTIONS

As part of the floodplain risk management study process a number of flood modification measures specific to certain areas of the study area were identified. These were assessed using the hydraulic model from the Flood Study and updated to include changes to the floodplain since its completion and assessed on their viability to mitigate flooding and reduce flood damages. All options were assessed using the 1% AEP flood event. Results of each of the modelled options can be seen in Appendix D. Flood damages assessment for the mitigation scenarios were undertaken to compare with the existing scenario and can be seen in Appendix C. Damages calculations were only undertaken for Options C, H, G, P and F as these were considered the options most likely to be brought forward. However, should Council desire, other options can be considered within the damage calculations. The following sections identify the areas in which specific flood mitigation options were considered, the impacts of these options with regard to flood levels for the 1% AEP flood event and an assessment of the feasibility of each option. Each of the options is briefly summarised below and details on upgrades to pipe sizes and volumes of attenuation basins in included as Appendix D.

Option A – Noorla Street channel improvements
This option widens and dredges the channel running parallel with Noorla Street to increase capacity and conveyance (Figure D1).

Option B – Yambil Street upgrade with additional pipe upgrade to DC "R"
Option B includes the drainage upgrade on Yambil Street as per option S2 from the Main Drain J FRMS&P (Reference 2). An additional pipe upgrade to DC "R" was introduced to allow the discharge of more flows from the Yambil Street area and the Bromfield Street basin (Figure D2).

Option C – Noorla Street retention basin improvements
This option seeks to increase the capacity of the existing retention basin at the corner of Noorla Street and Dickson Road. The size of the basin was increased and a bund was placed around the perimeter of the bushlands to allow controlled overtopping of floodwaters onto the road (Figure D3).

Option D – Retention basin at Crossing Street
This option includes installation of a retention basin on the currently vacant land at Crossing Street north of the railway line to attenuate overland flows before they enter the drainage system (Figure D4).

Option E – Retention basin at Apex Park
This option includes a retention basin in Apex Park to attenuate flows before they pass through the Hyandra Street area floodway (Figure D9).

Option F – Wakaden and Yambil Streets drainage upgrade
This option increases the capacity of Wakaden Street and Yambil Street drainage systems. This results in greater discharge of flow to the siphons and to relatively quicker removal of flood waters (Figure D5).

Option G – Crossing and Yambil Street Upgrade
Option G comprises an upgrade of the Yambil Street drainage as per Option H with additional upgrades to Crossing Street drainage. Similar to Option F this option discharges more flows to the siphons (Figure D6).

Option H – Yambil Street upgrade
This comprises option S5 from the Main Drain J FRMS&P (Reference 2). Previous studies have determined that the existing trunk drainage system is not capable of conveying runoff during a 1-year ARI storm event without surface water ponding. This option includes an upgrade of the trunk drainage line along Yambil Street from Ulong Street to Bonegilla Road. No changes were made to the siphons (Figure D7).

Option N – Retention basin on Lenehan Road
This option includes the construction of a retention basin on the currently vacant land east of Lenehan Road and connects it to the main trunk system (Figure D11).

Option P – Retention Basin on Railway Street
A retention basin situated at the corner of Railway and Ulong Streets was included in the hydraulic model. The basin would attenuate flows upstream of the local drainage system, therefore spreading the volume of floodwater over a longer time period and reducing peak flows entering the drainage system and subsequently Yambil Street (Figure D8).

Option Q – Lenehan Road and Blumer Avenue drainage upgrade
Option Q increases the drainage capacity in Lenehan Road and Blumer Avenue (Figure D10).

6.1. CBD Area

DESCRIPTION

Five options to provide flood alleviation for the CBD area were assessed:

- Yambil Street upgrade only (Option H);
- Crossing and Yambil Street Upgrade (Option G);
- Yambil Street upgrade with additional pipe upgrade to DC "R" (Option B);
- Wakaden Street and Yambil Street Drainage upgrade (Option F); and
- Retention basin at Railway Street (Option P).

DISCUSSION

Of the five options to relieve CBD area flooding, hydraulic modelling identified that Option F has the most beneficial impacts reducing flood levels at the Wakaden Street and Ulong Street intersection by 40 mm (Wakaden and Ulong Street junction sub-area) and a significant 170 mm reduction in flood levels along Yambil Street could be achieved for the 1% AEP event. However, as a result of the increased capacity upstream more flows are discharged through siphons DC “R” and DC “S” thus creating adverse impacts to areas downstream of the Main Canal. This will need to be considered in detailed design. A damages assessment shows that the total damage for the 1% AEP event is reduced by $5,177,320 for commercial properties in the CBD area and by $235,580 for residential properties in the area. Average damage per flood affected commercial property is reduced by $49,390 from $119,740 to $70,350 and for residential properties by $9,990 from $25,240 to $15,240. This is largely due to a significant reduction in the number of buildings which would no longer be flooded above floor level. Where currently 73 commercial buildings are flooded over floor in the 1% AEP event scenario this is reduced to 39 with Option F. For residential buildings the number flooded over floor reduces from eight to two. Of all the options investigated, option F was the most effective in terms of damages per affected property at the 1% AEP event.

Option H alone provides some benefits to commercial properties by reducing flood levels in Yambil Street by 60 mm. This option increased flows through siphon DC “R” but reduced flows through siphon DC “S”. This option could be undertaken alone or as part of a wider upgrade scheme. If a wider upgrade scheme is proposed of which option H is part then it would be advisable to undertake Option H first to provide some flood relief benefits whilst the rest of the upgrade is being undertaken. Total damages for the 1% AEP event are reduced by $1,837,650 for commercial properties and $126,950 for residential properties.

Option B considered the Yambil Street upgrade as per Option S2 of The Main Drain J FRMS&P (Reference 2). However it also includes an additional pipe upgrade to siphon DC “R”. Modelling showed that the basin is not fully utilised when a larger downstream conveyance is provided. Option B also has the impact of a significant 1.3 m drop in levels in Bromfield Street basin, the new basin installed by Council in 2012, and more flows discharged downstream with a more sustained hydrograph and higher peak outflow volume of water discharged downstream with a higher peak. This could have major adverse impacts downstream. To assess this fully the hydraulic model would need to be extended further downstream. Restricting the outlet of Bromfield Street basin may limit the downstream impact by retaining more water in the basin and allowing a slower discharge of attenuated water.

Some flood relief is provided to commercial properties on Yambil Street and residential properties along Canal Street by Option P; installation of a retention basin upstream at Railway Street. This option delayed and reduced the flood peak for flows crossing Banna Avenue. The largest benefit is the localised 100 to 130 mm reduction in flood levels occurring at Ulong Street (Wakaden and Ulong Sub-area) and Railway Streets and up to 75 mm drop in flood levels for Yambil Street. Option P reduced flood damages by slightly more that Option H, with a $2,531,240 reduction in total damages to commercial properties and $235,580 in total damages to residential damages.

An upgrade to the Yambil Street drainage system in conjunction with an upgrade to the Crossing Street system, Option G, has benefits for the CBD, Crossing Street and Industrial sub-areas. In Yambil Street flood levels are reduced by up to 90 mm whilst levels near Crossing Street are reduced by 70 mm and up to 85 mm on Lenehan Road. However, as with most scenarios, more flows are passed downstream through the siphons potentially creating adverse impacts. Option G gives similar benefits in term of damages as Option P, with a $2,705,060 in reduction of total damages to commercial properties and $153,320 for residential properties.

CONCLUSIONS

Option B could be considered further but is likely to require significant works, involving further modelling and refinement to the option. However, the reduction of Yambil Street flood levels is offset, relative to Option H or F in that adverse downstream impacts are expected.

Option F has significant benefits for commercial properties along Yambil Street. There are potential downstream impacts through more pass forward flows which would need to be investigated further. Option H, which can be undertaken as a stand-alone option or as part of other options including F and G, gives decent benefits for properties on Yambil Street and, if brought forward as part of other options could be completed first to provide some benefits while the rest of the improvements are being implemented.

In addition Option G has benefits to more than one area although for Yambil Street not as substantial as the results of Option F.

6.2. Industrial Zone

DESCRIPTION

Four options were assessed for the industrial zone sub-area, two of which Options D and G have other beneficial impacts in other areas as discussed earlier. The options investigated were;

- Retention basin at Crossing Street (Option D);
- Crossing and Yambil Streets drainage upgrade (Option G);
- Additional drainage and basin on Lenehen Road (Option N); and
- Lenehan Road and Bulmer Avenue drainage upgrade (Option Q).

DISCUSSION

As previously noted Options D and G both have positive benefits in reducing flood levels for the industrial area with peak levels being reduced by 35 mm and 85 mm on Lenehan Road respectively. These options also have positive impacts for other areas within the study area with Option G reducing total damages for the 1% event by up to $208,260. Although damages are reduced, the number of flood affected properties is only reduced by two.

Option N was considered to provide minimal benefits with levels reduced by up to 27 mm. Less flows were discharged through siphon DC “S” but the residual flow after the peak subsides is much higher.

Option Q was the most beneficial for Lenehan Road giving reductions in flood levels of up to 125 mm. Peak levels on Blumer Avenue and surrounds drop by up to 165 mm. However, there are significant adverse impacts downstream of the Main Canal.

CONCLUSIONS

Options D and G produce more positive impacts that are more substantial than Option N and also have positive impacts for more than one area. They are therefore worth considering further.

6.3. Crossing Street Area

DESCRIPTION

Two options were investigated for the Crossing Street area including;

- Retention basin at Crossing Street (Option D); and
- Crossing Street and Yambil Street upgrade (Option G).

DISCUSSION

Of the two options modelled, Option G has the most beneficial impacts for the Crossing Street, Industrial and CBD sub-areas. The increased pipe capacity causes a reduction in flood levels of up to 70 mm in the swale adjacent to Crossing Street upstream of the railway embankment. Due to the reductions in flood levels less flow overtops the railway embankment reaching Banna Avenue and the industrial area. Flood levels in Lenehan Road (Industrial Area) are also reduced by 35 mm. Levels also drop in Yambil Street in the CBD sub-area due to the improved Yambil Street drainage.

Although Option G reduced flood levels there was no change to the number of flood affected residential properties or residential damages for the 1% AEP event. Total damages for commercial properties was reduced by only $29,130 although there was no change in the number of flood affected commercial properties or buildings flooded above floor level.

Option D reduces flood levels by up to 40 mm in the depression upstream of the railway line. As with Option G, this reduction means that less flows overtop the railway line to Banna Avenue as well as reduced flows into the Industrial zone sub-area.

CONCLUSIONS

Both options are beneficial with improved flood levels not limited to the Crossing Street sub-area with Option G having the largest improvement. For further improvements, Options G and D could be considered in conjunction with each other.

6.4. Junction of Wakaden and Ulong Streets

DESCRIPTION

Two options for this area were considered. Both were carried out in conjunction with improvements for the CBD area;

- Retention Basin at Railway Street (Option P); and
- Wakaden and Yambil Streets drainage upgrade (Option F).

DISCUSSION

These options are considered in more detail in Section 6.1. In relation to the Wakaden and

Ulong Street sub-area, Option P reduced peak flood levels at Ulong Street near Railway Street by up to 130 mm however had no benefit for properties on Wakaden Street or Burrell Place. The greatest benefits are quite localised to the retention basin. Option F reduced peak flood levels by up to 40 mm at the junction of Wakaden and Ulong Streets although had no impact on reducing flood liable properties or total flood damages. Neither Option P or F gave any benefits in terms of the number of properties affected in the sub-area. Option P gave a decrease in total damages was $80,900 for commercial properties but none for residential properties. Option F gave no reduction in estimated damages.

CONCLUSION

Upgrading drainage on Wakaden Street and Ulong Street, in conjunction with the Yambil Street upgrade, reduces peak flood levels in the sub-area. However for the four properties on Ulong Street the Railway Street drainage basin has the largest positive impact. Both options also have positive impacts for the CBD sub-area. There could be scope to assess both options P and F together.

6.5. Noorla Street Residential Area

DESCRIPTION

Two options for Noorla Street sub area were considered which attempt to improve conveyance in the existing channel as well as storage in the existing retention basin on the corner of Noorla Street and Dickson Road. The options considered were;

- Channel improvements (Option A);
- Retention basin improvements (Option C); and
- Both options A and C in combination.

DISCUSSION

A drainage channel runs parallel with Noorla Street and the Main Canal which is prone to exceedance in events as low as the 5-year ARI event. A drainage basin is located near the corner of Noorla Street and Dickson Road which attenuates runoff before discharging t to the drain (Photograph 4).

Photograph 4: Noorla Street Drain and Basin

Channel widening and dredging, Option A, has some beneficial impact with the biggest reduction in flood levels on Noorla Street between Bowditch Place and Lawson Crescent with reductions of up to 260 mm in peak levels. Although this does not significantly reduce flooding for any flood affected properties, this option does mean that flood depths on Noorla Street are reduced and allows improved flood access for residents on Noorla Street and Lawson Crescent. Further west on Noorla Street, peak flood levels are reduced by 10-20 mm at the junction with Dickson Road.

As the Noorla Street channel is a dirt channel maintenance issues need to be considered. During a recent site inspection it looks like there were several areas of the channel where the banks had become unstable and fallen in. Over time this has the effect of widening but shallowing of the channel. For this option to work ongoing maintenance of the channel will be required.

Option C caused a 40 to 45 mm reduction in peak flood levels at the junction of Noorla Street and Dickson Road as well as a reduction in flood levels on Noorla Street to north of the southern entrance to Parkinson Crescent. Flood levels in the basin increase having potential impacts on several properties on Parkinson Crescent which back onto the basin as the higher waters may encroach onto these properties. Controlled overtopping of the bund was assumed for the 1% AEP event with the option available to increase the basin outlet capacity to allow more water to be discharged to the open channel across Noorla Street. Although the options at Noorla Street may have reduced flood levels and improved access to properties significantly there was no difference in the number of properties affected and flood damages for the 1% AEP event.

Combining both Options A and C, understandably has a greater beneficial impacts, resulting in a drop of flood levels by some 60 mm to 70 mm at Dickson Road and Noorla Street junction and by 320 mm further east on Noorla Street.

CONCLUSION

Of the two options, increasing the capacity of the existing basin would have the most beneficial impact; although not reducing the number of properties flood affected or total estimated damage figures. It would improve access to these properties in the instance of flooding and enable safer evacuation. Channel maintenance would improve access during flooding for some, but not all properties.

6.6. Hyandra Street Area

DESCRIPTION

Overland flow waters flows spill over Noorebar Avenue from Apex Park and through the retirement village off Hyandra Street. To try to reduce the flows a retention basin was placed in Apex Park with an outfall to the existing drainage system in Noorebar Avenue and Hyandra Street;

- Retention basin in Apex Park (Option E)

DISCUSSION

Impacts were negligible with changes in peak flood levels of less than 10 mm therefore no benefit is provided by the retention basin. Furthermore, there were minor localised adverse impacts on the drainage system downstream where pits downstream surcharge when the pipes are at full capacity.

CONCLUSION

The basin is unlikely to be a potential option to investigate further and costs of construction may be high for minimal to no benefit. Further improvements may be possible in this area by upgrading the drainage network around Hyandra Street area.

As Hyandra Street is a significant area in terms of flooding, particularly in the smaller events (see Section 4.1.1) other options for the area should be investigated. Given the sensitivity of the retirement village to flood flows and the shallow nature of floodwaters, it may be of some benefit to consider low bunding (flower bed, small hump in driveway) to direct flows to the road network. Modelling could assist in determining potential impacts on adjoining property.

6.7. Comments

Each of the options will benefit different areas. Discussion need to be had with Council and through community consultation to identify which of the options and which of the sub-areas should be prioritised based on the reduction in number of properties and damages.

Although the majority of the options investigated provide benefits to areas upstream of the main Canal, increased flows downstream of the canal can result as the upstream improvements allow water to flow through the system quicker. The increases in flow are expected to be small and have nominal effect on flood levels however should be investigated further before a decision is made to construct any of the options. A review of the Main Drain J FRMS&P is due and this will include integration of the CBD hydraulic model into the wider study area. It is recommended therefore that all CBD options are trailed within this review to assess the impact downstream.

7. FLOODPLAIN RISK MANAGEMENT PLAN FOR GRIFFITH CBD CATCHMENTS

7.1. Introduction

The recommended Floodplain Risk Management Plan for the Griffith CBD catchments has been prepared in accordance with the NSW Floodplain Development Manual (Reference 6) and:

- Is based on a comprehensive and detailed evaluation of all factors that affect and are affected by the use of flood prone land; and
- Provides a long-term path for the future development of the community.

Griffith is located approximately 450 km north of Melbourne and 560 km west of Sydney in the heart of the Murrumbidgee Irrigation Area (MIA). The CBD and residential areas of Griffith are located at the base of the McPherson Ranges (see Figure 1). Griffith and its surrounding villages of Yenda, Yoogali, Hanwood, Bilbul and Beelbangera lie within the Main Drain “J” catchment, which together with its network of drainage channels delivers runoff to Mirrool Creek.

The Griffith CBD catchment has an area of approximately 9 km^2. The upper part of the catchment is steep and covered in scattered timber and bushland. South of the bushland area the urban area begins and continues south to Wakaden St and the Temora-Roto Railway Line. This area is predominantly low density residential development. Griffith CBD lies the south of the railway line, and is characterised by commercial and light industrial land uses. At the downstream extents of the CBD is the Main Canal which is raised above normal ground levels and is consequently a substantial obstruction to overland flow.

The City of Griffith is not located on the banks of a major river system and therefore does not experience mainstream flooding as occurs at other centres within the Murrumbidgee River catchment for example Wagga Wagga. However, Griffith and its surrounding areas are affected by high volume rainfall events and also from flooding from the Main Drain J system.

In the past, frequent flooding has occurred throughout the commercial areas of Griffith including Yambil Street, even in small rainfall events less than the 6 month ARI for example. Studies have indicated that this flooding has been due to a combination of catchment runoff, blockage and/or insufficient capacity of the sub-surface drainage systems and the associated siphon drainage systems, as well as the elevated railway and canal embankments that impede downstream overland flow paths. Within the study area flows are predominantly distributed and shallow at the upstream or northern sections of the CBD catchment and runoff generally ponds behind the various embankments that tend to be aligned normal to general flow direction such as the Main Canal and railway line, before being gradually discharged through the siphon outlets located under the Main Canal at the downstream boundary of the study area. The Flood Study (Reference 1) also found that the actual flow at the siphons was largely restricted by the upstream drainage system.

7.2. Floodplain Risk Management Measures Considered

A matrix of possible management measures was prepared and evaluated taking into account a range of parameters. This process eliminated a number of risk management measures (refer to Section 5.2) including:

- Flood mitigation dams – not viable on economic, social and environmental grounds; and
- Voluntary purchase of flood affected buildings – flood depth above floor level generally shallow and most residential dwellings are in low hazard areas.

The full range of measures was evaluated in Section 5 and the outcomes are summarised in Table 14.

Table 14: Summary of Management Measures Investigated in Study

MEASURE	PURPOSE	COMMENT
FLOOD MODIFICATION:		
Maintenance of levee structure at upstream escarpment (Section 5.3.1)	To prevent runoff from escarpment from entering residential properties	Recommend that Council take responsibility and adopt the levee as a formal flood management asset
Temporary flood barriers (Section 5.3.2)	To prevent ingress of floodwaters from entering properties	Effectiveness relies on sufficient warning time and ability of a workforce to install
Construction of new retarding basins or enlargement of existing basins (Section 5.3.3)	To mitigate runoff increased caused by development and to provide additional floodplain storage	Possible for systems to be retrofitted to existing drainage and require regular checks and maintenance
On-Site detention (OSD) (Section 5.3.4)	Policy adopted to restrict development from exacerbating existing flood risk	Council needs to maintain a register of all OSD features and undertake regular inspections
Catchment treatment and WSUD (Section 5.3.5)	To modify runoff characteristics from catchment to reduce flows and to improve runoff quality	Should be encouraged to limit on-site imperviousness for developments and providing water quality and environmental controls
Channel modifications (Section 5.3.6)	To increase channel capacity to convey flow	Important to ensure a hydraulic gradient is provided and tying in with current infrastructure invert levels
Drainage network modifications (Section 5.3.7)	To increase the capacity of the drainage systems or to attenuate flows for slow release via detention basins	Drainage system typically designed for smaller flood events and as such any modifications do not change flood levels drastically. Also need to consider potential downstream impacts with increased catchment outflows
Drainage network maintenance (Section 5.3.8)	To ensure drainage assets are effectively managed and maintained and perform as required	A maintenance programme has been proposed in Griffith FRMS&P
PROPERTY MODIFICATION:		
House raising (Section 5.4.1)	To eliminate or reduce flooding of habitable floors	Not the most cost effective option for the type of flooding in Griffith and most properties are brick construction
Flood proofing (Section 5.4.2)	To reduce flood risk for frequently flooded properties	Suitable primarily for commercial and industrial properties
Minor property adjustments (Section 5.4.3)	To manage or later overland flow paths	Only provide localised benefits and unlikely to produce significant benefits to local overland flooding

RESPONSE MODIFICATION:		
Flood warning and evacuation (Section 5.5.1)	To reduce flood damages and to protect lives	Flood warning is difficult due to the nature of flooding in the study area with little time for evacuation
Flood emergency management (Section 5.5.2)	To minimise risk associated with evacuations	A Local Flood Plan should be prepared and regularly updated to include recommendations from this Study once finalised
Community Awareness Programme (Section 5.5.3)	To maintain a level of flood awareness among the community	A suitable Flood Awareness Programme should be implemented as well as advice provided by Council and SES via suitable mediums

7.3. Proposed Floodplain Risk Management Measures in Plan

An assessment of all floodplain risk management measures was undertaken and the recommended measures are described below (in no particular order within each priority group). The priority ranking is based upon a combination of reduction in flood risk, ease of implementation and cost/funding implications.

7.3.1. High Priority

1. **Regular maintenance of levee structure at upstream escarpment**
    a. **Cost:** internally within Council
    b. **Responsibility:** Griffith City Council
    c. **Time frame:** ongoing

2. **Review OSD Policy to include recommendations on appropriate OSD, catchment treatment techniques and the use of Water Sensitive Urban Design (WSUD)**
    a. **Cost:** internally within Council
    b. **Responsibility:** Griffith City Council
    c. **Time frame:** 12 months

3. **Establish a drainage infrastructure maintenance programme as outlined in the Griffith FRMS&P (Reference 2)**
    a. **Cost:** internally within Council
    b. **Responsibility:** Griffith City Council
    c. **Time frame:** 12 months

4. **Update Flood Emergency Management to include feedback from March 2012 event**
    a. **Cost:** $20,000
    b. **Responsibility:** SES
    c. **Time frame:** June, 2013

5. **Establish FPA and FPL, update LEP and DCP, modification to S149 certificates**
    a. **Cost:** internally within Council
    b. **Responsibility:** Griffith City Council
    c. **Time frame:** 12 months

6. **Upgrade existing drainage network as per Options presented in Section 6**
    a. **Cost:** depends on options but generally high
    b. **Responsibility:** Griffith City Council
    c. **Time frame:** short to medium term

7. **Investigate the effectiveness of minor property adjustments particularly for the retirement village in the Hyandra Street area which are subject to overland flow flooding**
    a. **Cost:** low to investigate
    b. **Responsibility:** local residents
    c. **Time frame:** short term

7.3.2. Medium Priority

8. **Undertake modifications or improvements to Noorla St open channel**
    a. **Cost:** moderate
    b. **Responsibility:** Griffith City Council
    c. **Time frame:** short to medium term

9. **Evaluate whether a flood proofing scheme for frequently inundated properties in the CBD area will be supported by the community and if so establish such a scheme**
    a. **Cost:** low to evaluate, suitably only for commercial properties on a case by case basis
    b. **Responsibility:** local business owners
    c. **Time frame:** ongoing

7.3.3. Low Priority

10. **Deploy temporary flood barriers before the onset of flooding**
    a. **Cost:** low to moderate and only effective when sufficient warning time provided
    b. **Responsibility:** local community
    c. **Time frame:** ongoing

11. **Construct new retarding basins or enlarge existing basins as per Options presented in Section 6**
    a. **Cost:** depends on options but generally high
    b. **Responsibility:** Griffith City Council
    c. **Time frame:** medium to long term

12. **Evaluate whether a house raising scheme or similar will be supported by the community and a practical adaptation measure for flood affected properties and if so establish such a scheme**
    a. **Cost:** low to evaluate, approximately $60,000 to raise a non-brick house but highly variable
    b. **Responsibility:** Griffith City Council and local community
    c. **Time frame:** ongoing

13. **Establish a community flood awareness programme with a focus on evacuation and ensuring personal safety during floods**
    a. **Cost:** low
    b. **Responsibility:** Griffith City Council and SES
    c. **Time frame:** ongoing

8. ACKNOWLEDGMENTS

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- Residents of the Griffith City area,
- Griffith City Council,
- NSW Office of Environment and Heritage.

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Figures

FIGURE 1
STUDY AREA

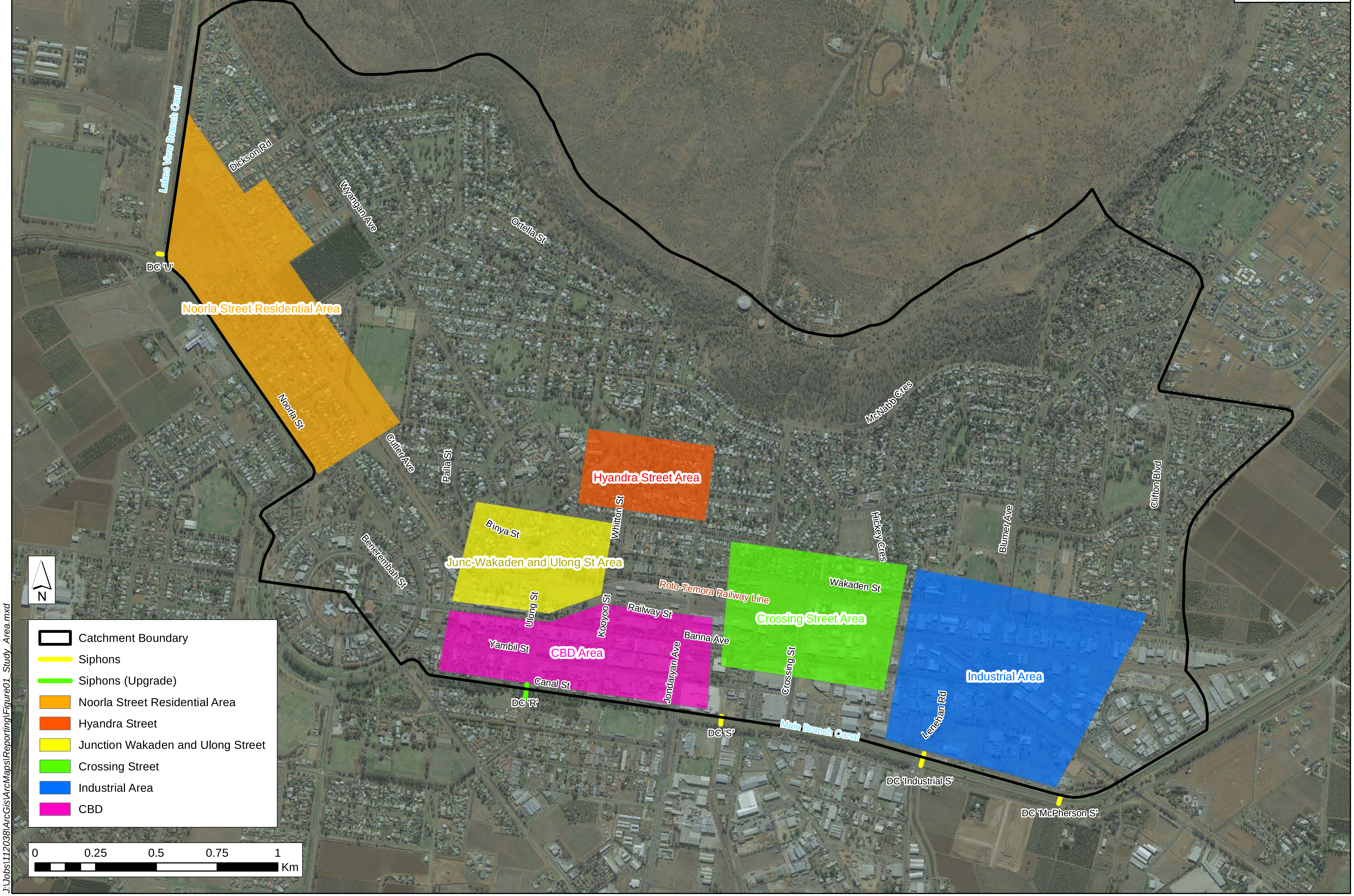

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FIGURE 2
EXISTING LAND USE

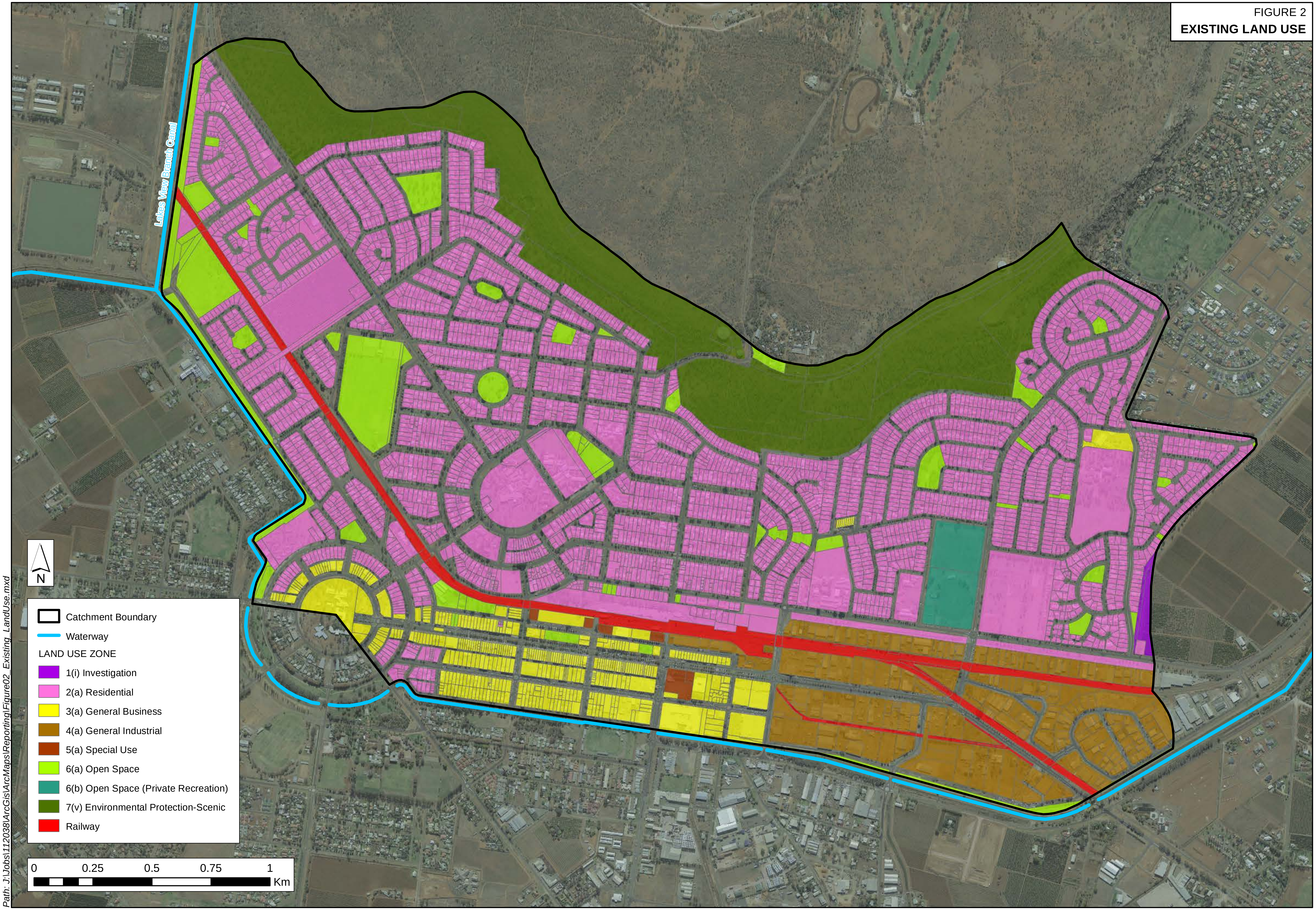

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FIGURE 3
HYDRAULIC CLASSIFCATION
1% AEP DESIGN FLOOD EVENT

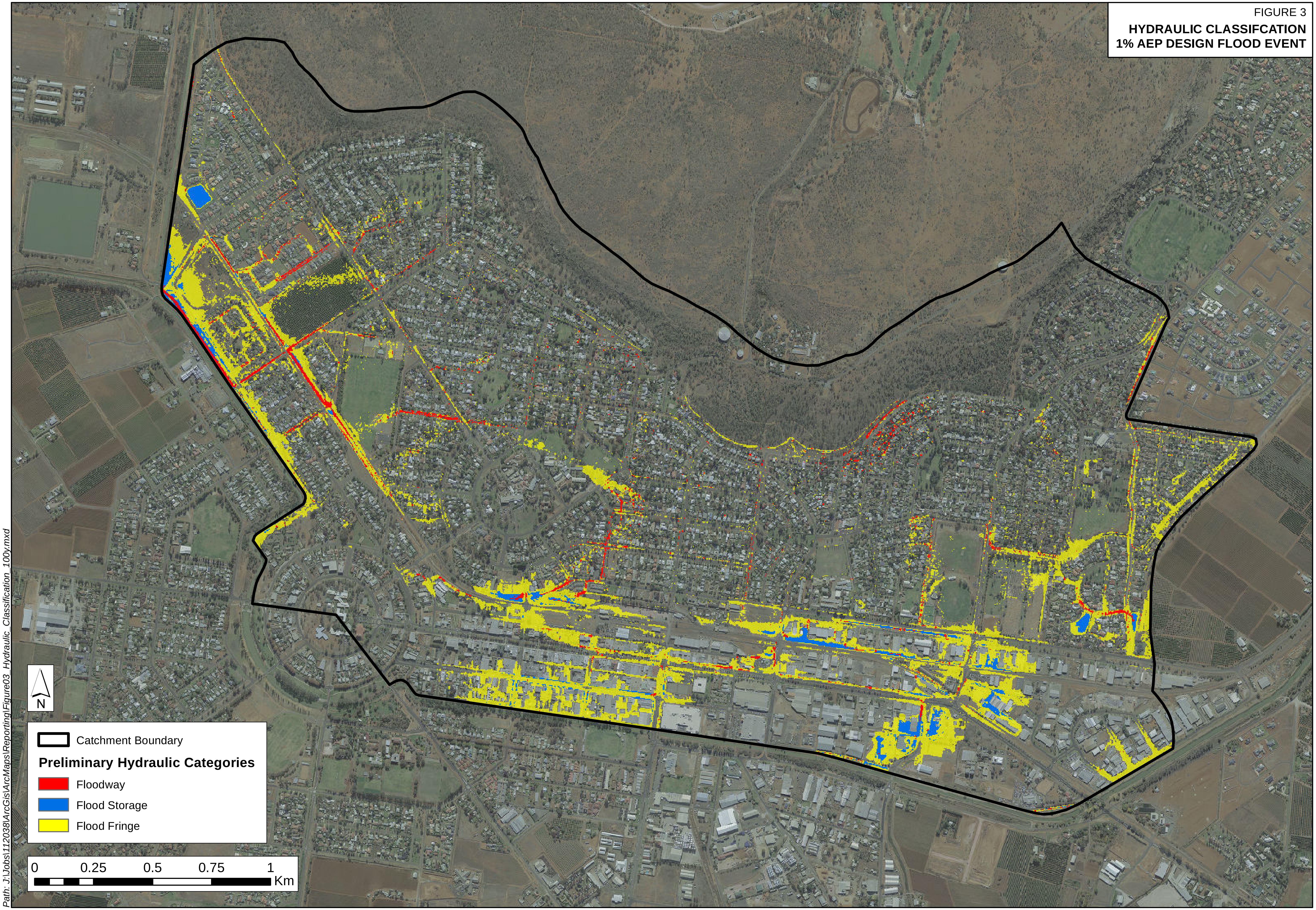

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FIGURE 4

FLOOD HAZARD

1% AEP DESIGN FLOOD EVENT

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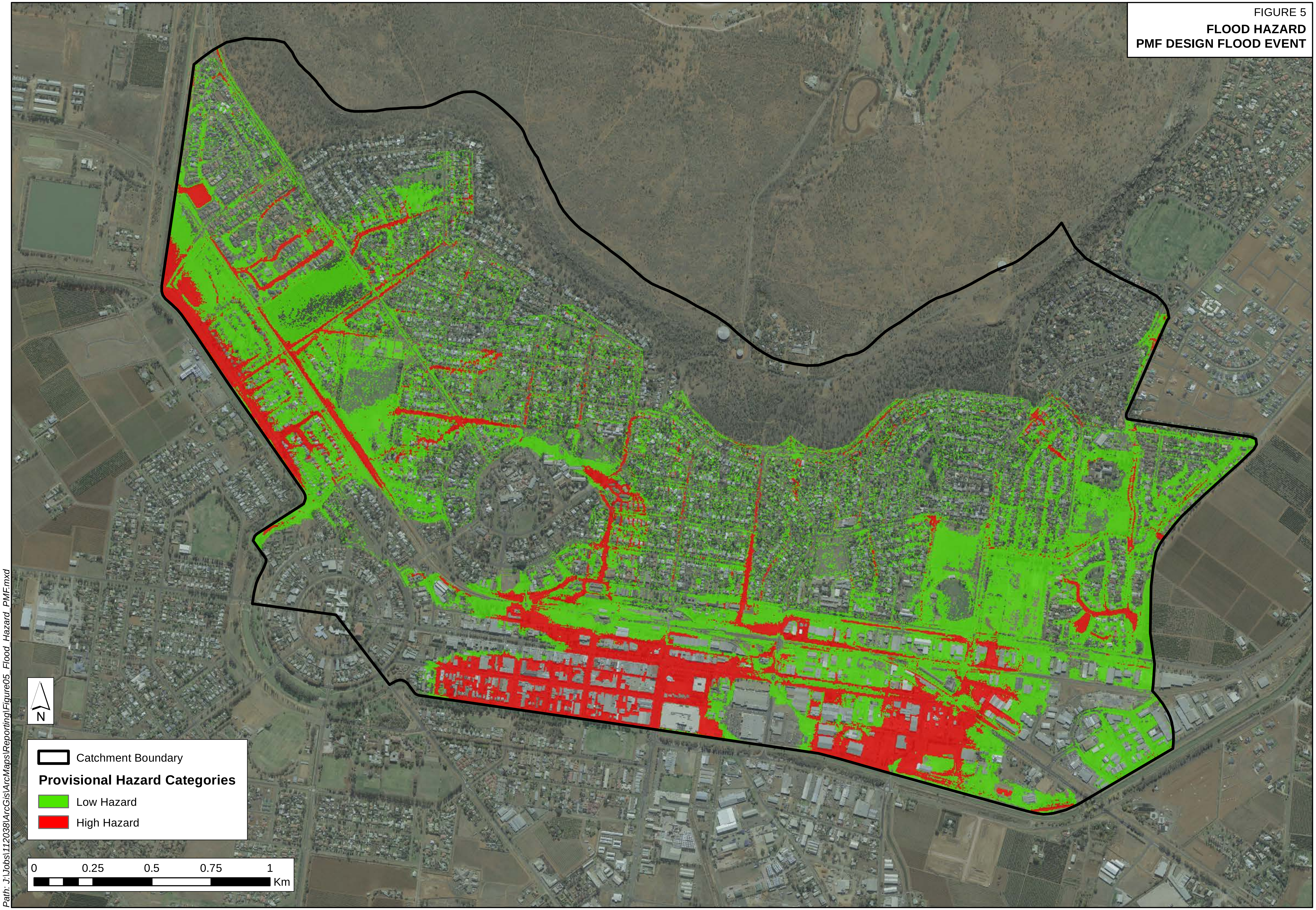

FIGURE 5
FLOOD HAZARD
PMF DESIGN FLOOD EVENT
N
Catchment Boundary
Provisional Hazard Categories
Low Hazard
High Hazard
0
0.25
0.5
0.75
1
Km
Path: J:\Jobs\112038\ArcGis\ArcMaps\Reporting\Figure05_Flood_Hazard_PMF.mxd

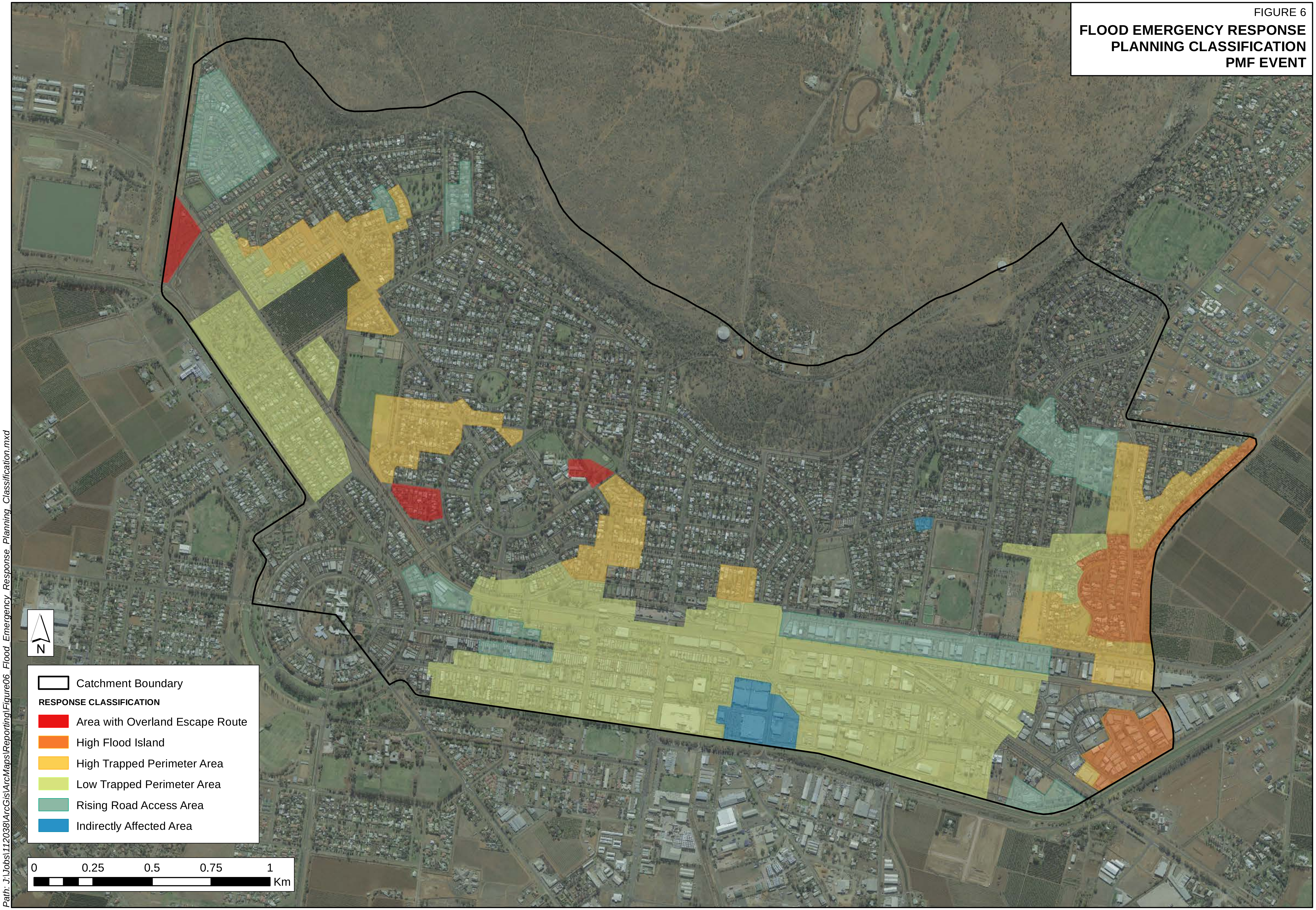

FIGURE 6
FLOOD EMERGENCY RESPONSE PLANNING CLASSIFICATION PMF EVENT

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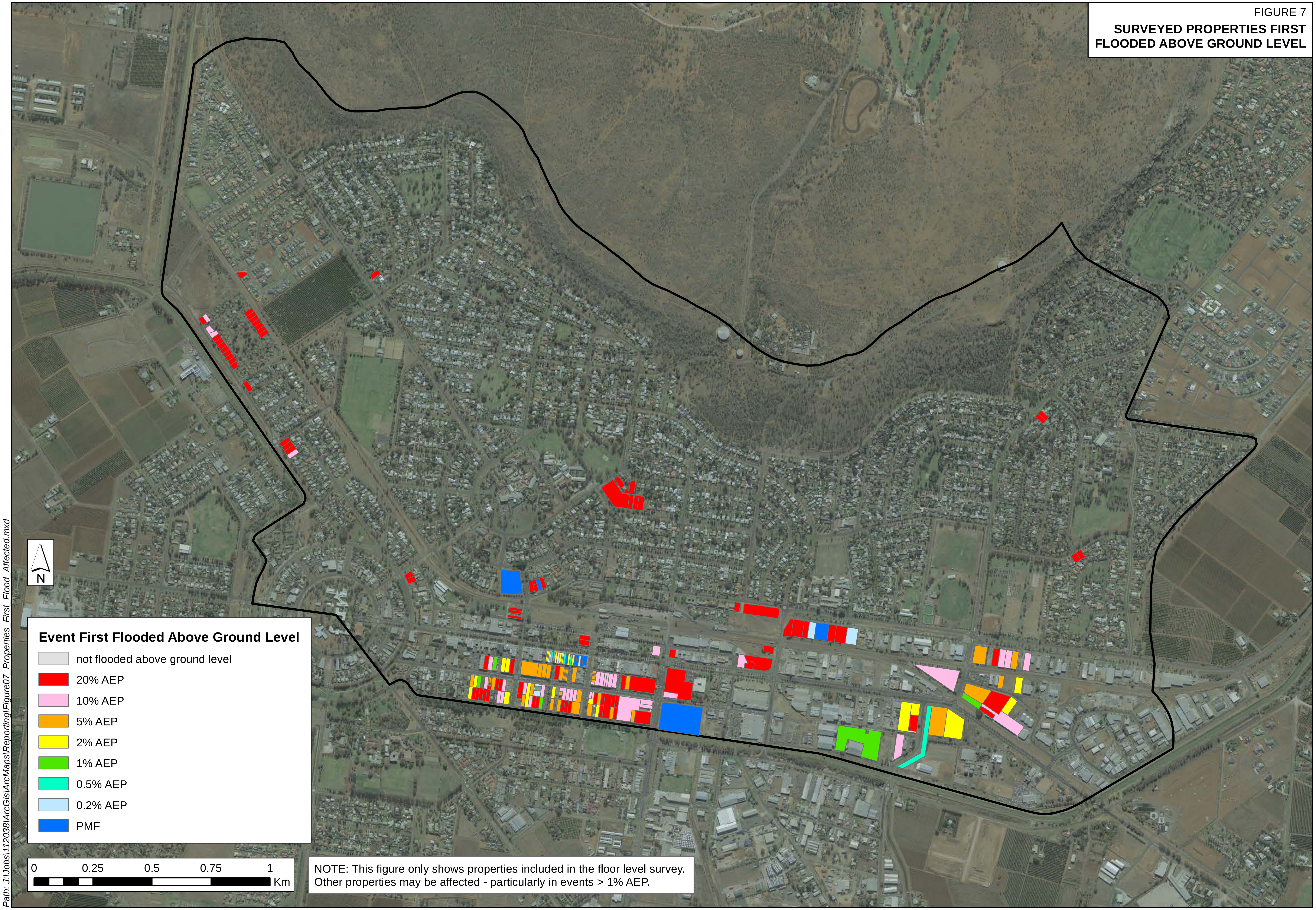
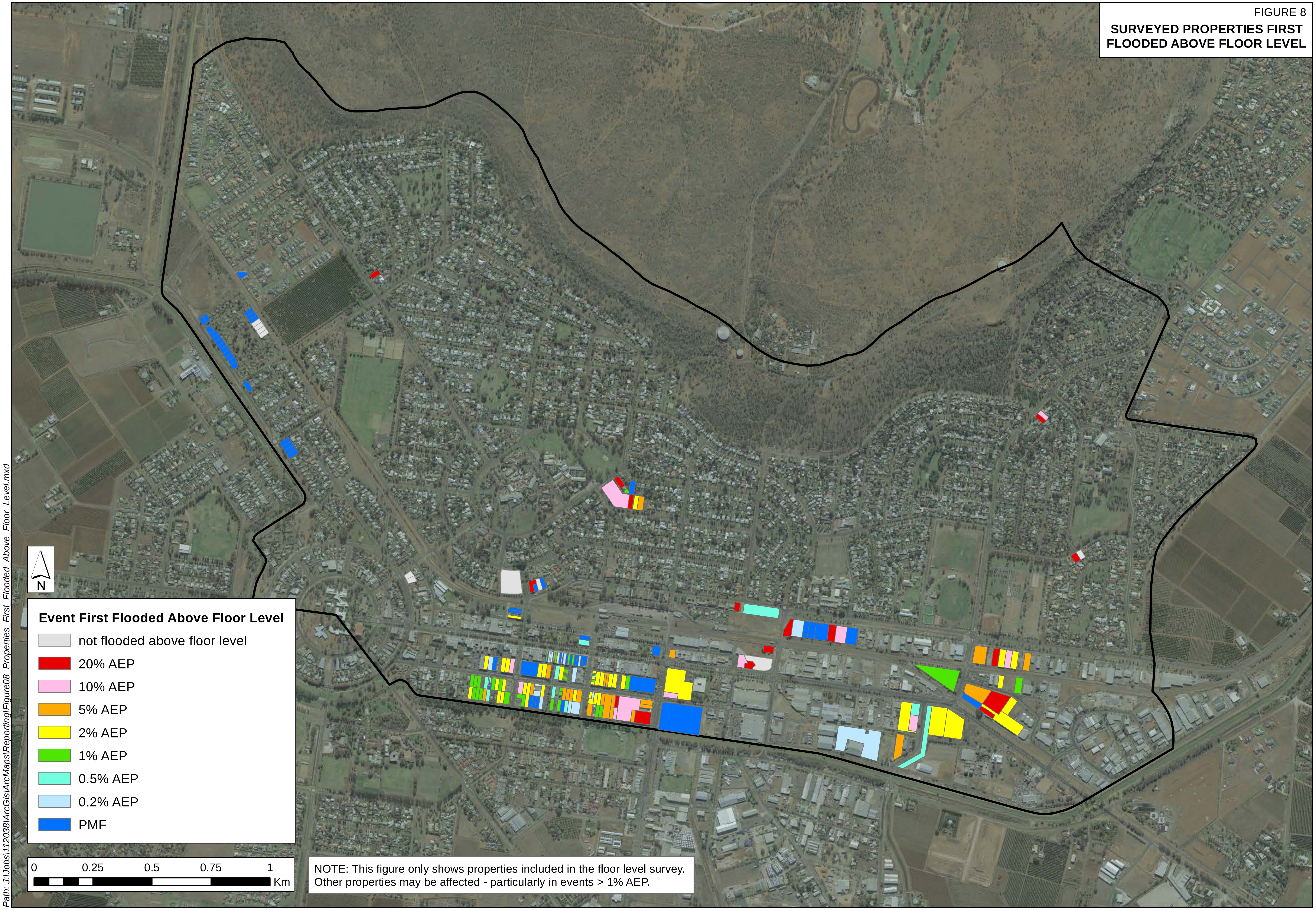
FIGURE 7

SURVEYED PROPERTIES FIRST FLOODED ABOVE GROUND LEVEL



NOTE: This figure only shows properties included in the floor level survey. Other properties may be affected - particularly in events > 1% AEP.

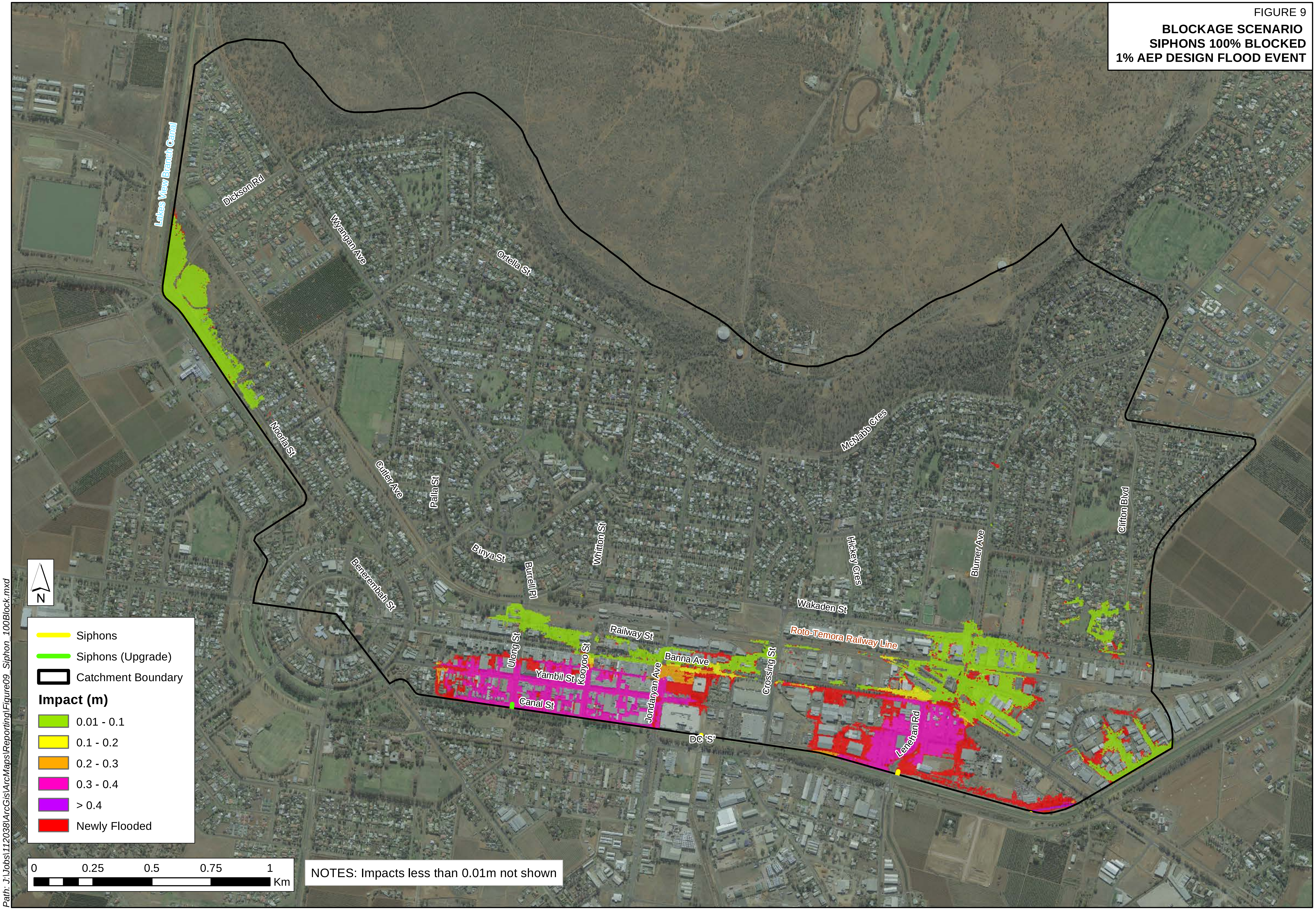
Path: J:\Jobs\112038\ArcGis\ArcMaps\Reporting\Figure07_Properties_First_Flood_Affected.mxd



Path: J:\Jobs\112038\ArcGis\ArcMaps\Reporting\Figure08_Properties_First_Flooded_Above_Floor_Level.mxd

FIGURE 9

BLOCKAGE SCENARIO SIPHONS 100% BLOCKED 1% AEP DESIGN FLOOD EVENT



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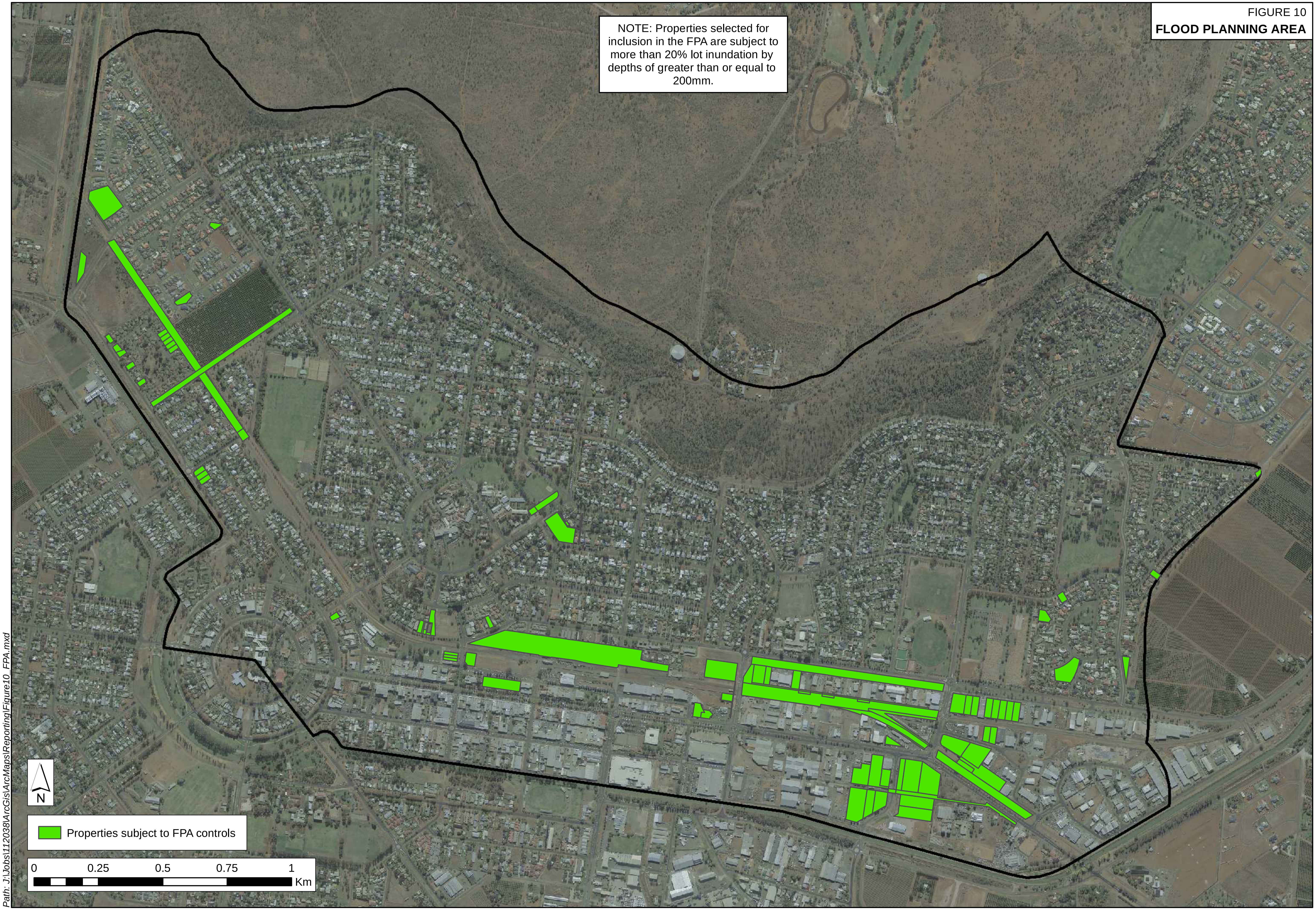

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Appendix A

APPENDIX A: GLOSSARY

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils — Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.

Annual Exceedance Probability (AEP) — The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).

Australian Height Datum (AHD) — A common national surface level datum approximately corresponding to mean sea level.

Average Annual Damage (AAD) — Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.

Average Recurrence Interval (ARI) — The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.

caravan and moveable home parks — Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.

catchment — The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.

consent authority — The Council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.

development — Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act).

infill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development.

new development: refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.

	redevelopment: refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.
disaster plan (DISPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.
effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
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 local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).
flood mitigation standard	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the

impacts of flooding.

floodplain Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.

floodplain risk management options The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.

floodplain risk management plan A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.

flood plan (local) A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.

flood planning area The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the flood liable land concept in the 1986 Manual.

Flood Planning Levels (FPLs) FPLs are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the standard flood event in the 1986 manual.

flood proofing A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.

flood prone land Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.

flood readiness Flood readiness is an ability to react within the effective warning time.

flood risk Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below.

existing flood risk: the risk a community is exposed to as a result of its location on the floodplain.

future flood risk: the risk a community may be exposed to as a result of new development on the floodplain.

continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.

flood storage areas Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood

	storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
major drainage	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves: ▪ the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or ▪ water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or ▪ major overland flow paths through developed areas outside of defined drainage reserves; and/or ▪ the potential to affect a number of buildings along the major flow path.
mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the

complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.

merit approach

The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State"s rivers and floodplains.

The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.

minor, moderate and major flooding

Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:

minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.

moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.

major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.

modification measures

Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.

peak discharge

The maximum discharge occurring during a flood event.

Probable Maximum Flood (PMF)

The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.

Probable Maximum Precipitation (PMP)

The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.

probability

A statistical measure of the expected chance of flooding (see AEP).

risk

Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to water level. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.

Appendix B

APPENDIX B: COMMUNITY CONSULTATION

Survey Information Sheet

GRIFFITH CBD FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

This sheet has been provided as background to the floor level survey currently being undertaken by Peter Bolan and Associates – Registered Surveyors. Should you require any further clarification please contact:
Mr Durgananda Chaudhary – Griffith City Council, Tel: 6969 4857; or
Mr Stephen Gray – WMAwater, Tel: 9299 2855, Email: gray@wmawater.com.au

Under the NSW Government's Flood Prone Land Policy, management of flood prone land is primarily the responsibility of Councils.

In March 2012 WMAwater Pty Ltd (Water and Environment Engineers) completed the Griffith CBD Flood Study. The flood study defined design floods for the Griffith CBD area. The study area incorporates urban areas of Griffith lying to the north of Main Canal.

The flood study was undertaken as part of the NSW Floodplain Risk Management Program. The Program seeks to define existing flood risk and provide a basis for that risk to be reduced or at the very least not made worse in the future as development occurs.

Under the Program the next step in the floodplain risk management process is to carry out a Floodplain Risk Management Study and Plan. This study will define over floor flood liability in the study area as well as look at how existing flood risk can be reduced via works and/or planning policy. Ultimately the study will put forward a plan for managing risk within the Griffith CBD study area.

Currently WMAwater are in the process of obtaining a floor level survey so as to assess over floor flood liability within the study area. It must be stressed that it is not necessarily the case that any property for which floor level survey is obtained is liable to over floor flooding.

Should you have any queries in regard to this work then please do not hesitate to contact either Council or WMAwater on the above provided numbers.

Yours sincerely,

Stephen Gray
ASSOCIATE
WMAwater

Consultation Newsletter

Griffith CBD Floodplain Risk Management Study

The Floodplain Risk Management Process

Griffith City Council are the process of improving flood risk related development controls and is now looking in more detail specifically at the Griffith CBD area. This area is mainly subject to flooding from local overland flow following rainfall events rather than flooding from Main Drain J.

The Griffith CBD Overland Flow Flood Study which quantified existing flood risk for the CBD area was completed in early 2012. As the next stage in the floodplain management process, the Floodplain Risk Management Study is currently underway for the Griffith CBD area. Council have appointed WMAwater, a consultancy specialising in hydrology and floodplain management to undertake the Management Study.

The Management Study will identify existing flood risk within the CBD and help in Council's planning for the future. The Study will ultimately lead to a Management Plan setting out how Council will deal with future flood risk. The Plan will focus on ensuring that potential future development does not exacerbate existing levels of flood risk.

Community Consultation

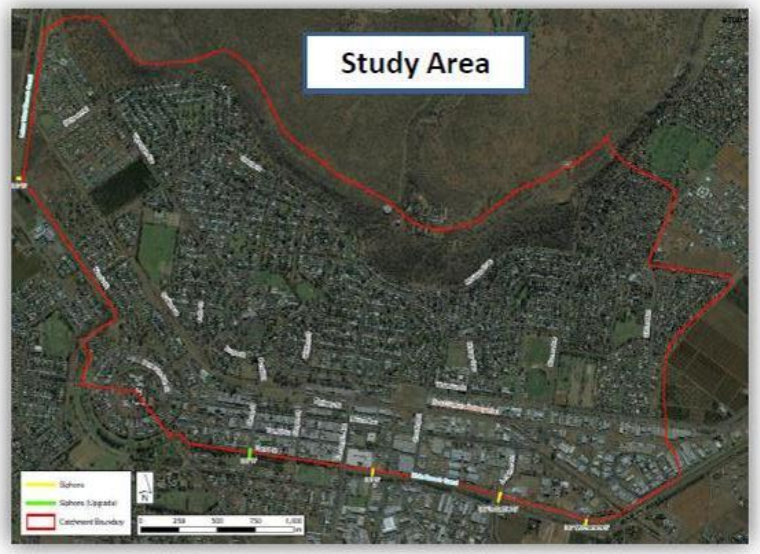
Community involvement in the study is important. For this reason a floodplain risk management committee is currently in operation. The committee has members, noted to the right, who are able to introduce suggestions from other residents. Feel free to contact them. At a later date the study will be placed on public exhibition and comments will be invited from the public.

Floor Levels Survey

A floor level survey has carried out for a number of residential and commercial properties. This has facilitated the calculation of flood damages and these estimates will in turn be used to assess the practicality of flood mitigation works.

Flood Emergency Planning

The study results are mapped flood depths and velocities. This information is useful in flood and emergency management planning such as identifying flooded roads, alternate evacuation routes. A key part of the work is liaising with the SES and updating their response plans to take into account any and all new information.



Further Information

If you have any questions or comments, please speak to Council Staff or your Community FRMC Representative.

Griffith City Council
Graham Gordon
02 6962 8100
Graham.Gordon@griffith.nsw.gov.au

Flood Risk Management Committee
Cr Bill Lancaster
blancaster@griffith.com.au

Peter Budd
architect@budd.net.au

Appendix C

APPENDIX C: FLOOD DAMAGES

Table C1: Residential Tangible Damages

CBD AREA – Residential Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
20% AEP	4	0	$ 33,500	$ 8,380
10% AEP	8	0	$ 94,970	$ 11,870
5% AEP	12	1	$ 128,470	$ 10,710
2% AEP	19	3	$ 295,180	$ 15,540
1% AEP	19	8	$ 479,460	$ 25,230
0.5% AEP	19	12	$ 588,090	$ 30,950
0.2% AEP	19	13	$ 719,250	$ 37,860
PMF	19	19	$ 1,292,200	$ 68,010
CBD area - Average Annual Damages			**$ 25,520**	**$ 1,340**

CROSSING STREET AREA – Residential Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
20% AEP	4	2	$ 79,500	$ 19,880
10% AEP	4	2	$ 106,470	$ 26,620
5% AEP	4	2	$ 106,470	$ 26,620
2% AEP	4	2	$ 106,470	$ 26,620
1% AEP	4	2	$ 106,470	$ 26,620
0.5% AEP	4	2	$ 122,130	$ 30,530
0.2% AEP	4	2	$ 122,130	$ 30,530
PMF	4	4	$ 218,290	$ 54,570
Crossing Street area - Average Annual Damages			**$ 12,210**	**$ 3,050**

WAKADEN AND ULONG JUNCTION – Residential Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
20% AEP	4	0	$ 62,410	$ 15,600
10% AEP	4	0	$ 62,410	$ 15,600
5% AEP	4	0	$ 62,410	$ 15,600
2% AEP	4	0	$ 63,990	$ 16,000
1% AEP	4	0	$ 63,990	$ 16,000
0.5% AEP	4	0	$ 65,580	$ 16,390
0.2% AEP	4	0	$ 65,580	$ 16,390
PMF	5	4	$ 204,940	$ 40,990
Wakaden and Ulong Junction - Ave Annual Damages			**$ 6,450**	**$ 1,290**

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NOORLA STREET AREA – Residential Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
20% AEP	10	0	$ 153,650	$ 15,360
10% AEP	22	0	$ 415,720	$ 18,900
5% AEP	25	0	$ 500,840	$ 20,030
2% AEP	25	0	$ 511,140	$ 20,450
1% AEP	25	0	$ 513,510	$ 20,540
0.5% AEP	25	0	$ 516,680	$ 20,670
0.2% AEP	25	0	$ 519,060	$ 20,760
PMF	25	21	$ 1,315,510	$ 52,620
Noorla St Area - Average Annual Damages			**$ 62,280**	**$ 2,490**

HYANDRA STREET AREA – Residential Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
20% AEP	11	5	$ 392,010	$ 35,640
10% AEP	11	8	$ 406,000	$ 36,910
5% AEP	11	8	$ 415,570	$ 37,780
2% AEP	11	8	$ 469,500	$ 42,680
1% AEP	11	9	$ 472,690	$ 42,970
0.5% AEP	11	9	$ 472,690	$ 42,970
0.2% AEP	11	9	$ 506,830	$ 46,080
PMF	12	12	$ 718,150	$ 59,850
Hyandra St Area - Average Annual Damages			**$ 44,280**	**$ 3,690**

OTHERS NOT INCLUDED IN SUB-AREAS – Residential Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
20% AEP	7	3	$ 244,520	$ 34,930
10% AEP	7	4	$ 244,520	$ 34,930
5% AEP	7	4	$ 249,860	$ 35,690
2% AEP	7	4	$ 250,650	$ 35,810
1% AEP	7	4	$ 250,650	$ 35,810
0.5% AEP	7	4	$ 253,040	$ 36,150
0.2% AEP	7	4	$ 255,440	$ 36,490
PMF	7	4	$ 288,300	$ 41,190
Other Properties - Average Annual Damages			**$ 24,940**	**$ 3,560**

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TOTALS FOR STUDY AREA – Residential Properties				
Event	**Total no. Properties Affected**	**No. of these Flooded Above Floor Level**	**Total Tangible Flood Damages**	**Average Tangible Damages Per Flood Affected Property**
20% AEP	40	10	$ 965,600	$ 24,140
10% AEP	56	14	$ 1,330,100	$ 23,750
5% AEP	63	15	$ 1,463,620	$ 23,230
2% AEP	70	17	$ 1,696,930	$ 24,240
1% AEP	70	23	$ 1,886,780	$ 26,950
0.5% AEP	70	27	$ 2,018,220	$ 28,830
0.2% AEP	70	28	$ 2,188,290	$ 31,260
PMF	72	64	$ 4,037,380	$ 56,070
		Average Annual Damages	**$ 175,670**	**$ 2,440**

Table C2: Commercial and Industrial Tangible Damages

CBD AREA – Commercial and Industrial Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
20% AEP	21	3	$ 499,100	$ 26,270
10% AEP	45	7	$ 1,073,840	$ 24,970
5% AEP	75	25	$ 3,873,870	$ 52,350
2% AEP	90	50	$ 7,242,370	$ 81,370
1% AEP	92	73	$ 11,016,220	$ 119,740
0.5% AEP	96	79	$ 12,391,950	$ 129,080
0.2% AEP	98	87	$ 14,212,580	$ 145,030
PMF	104	102	$ 22,986,040	$ 221,020
CBD area - Average Annual Damages			**$ 545,910**	**$ 5,250**

INDUSTRIAL ZONE – Commercial and Industrial Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
20% AEP	4	3	$ 459,510	$ 114,880
10% AEP	10	5	$ 648,350	$ 64,830
5% AEP	15	9	$ 1,291,000	$ 86,070
2% AEP	20	17	$ 2,264,850	$ 113,240
1% AEP	22	19	$ 2,758,880	$ 125,400
0.5% AEP	23	21	$ 3,118,630	$ 135,590
0.2% AEP	23	22	$ 3,579,900	$ 155,650
PMF	23	23	$ 4,580,820	$ 199,170
Industrial Zone - Average Annual Damages			**$ 169,250**	**$ 7,360**

CROSSING STREET AREA – Commercial and Industrial Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
20% AEP	7	3	$ 517,090	$ 73,870
10% AEP	8	5	$ 709,800	$ 88,720
5% AEP	8	5	$ 716,980	$ 89,620
2% AEP	8	5	$ 812,230	$ 101,530
1% AEP	8	5	$ 827,010	$ 103,380
0.5% AEP	10	6	$ 892,900	$ 111,610
0.2% AEP	10	7	$ 1,063,620	$ 106,360
PMF	11	10	$ 1,782,620	$ 162,060
Crossing Street area - Average Annual Damages			**$ 86,510**	**$ 7,860**

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WAKADEN AND ULONG JUNCTION – Commercial and Industrial Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
20% AEP	2	1	$ 199,060	$ 99,530
10% AEP	2	1	$ 199,060	$ 99,530
5% AEP	2	2	$ 243,780	$ 121,890
2% AEP	2	2	$ 324,680	$ 162,340
1% AEP	2	2	$ 324,680	$ 162,340
0.5% AEP	2	2	$ 331,860	$ 165,930
0.2% AEP	2	2	$ 339,040	$ 169,520
PMF	3	2	$ 390,480	$ 130,160
Wakaden and Ulong Junction - Ave Annual Damages			**$ 26,220**	**$ 8,740**

HYANDRA STREET AREA – Commercial and Industrial Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
20% AEP	1	1	$ 67,080	$ 67,080
10% AEP	1	1	$ 67,080	$ 67,080
5% AEP	1	1	$ 67,080	$ 67,080
2% AEP	1	1	$ 67,080	$ 67,080
1% AEP	1	1	$ 67,080	$ 67,080
0.5% AEP	1	1	$ 67,080	$ 67,080
0.2% AEP	1	1	$ 67,080	$ 67,080
PMF	1	1	$ 162,340	$ 162,340
Hyandra St Area - Average Annual Damages			**$ 6,800**	**$ 6,800**

TOTALS FOR STUDY AREA – Commercial and Industrial Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
20% AEP	33	11	$ 1,741,850	$ 52,780
10% AEP	64	19	$ 2,698,130	$ 42,160
5% AEP	100	42	$ 6,192,710	$ 61,930
2% AEP	120	75	$ 10,711,220	$ 89,260
1% AEP	125	100	$ 14,993,890	$ 119,950
0.5% AEP	130	109	$ 16,802,420	$ 129,250
0.2% AEP	134	119	$ 19,262,220	$ 143,750
PMF	142	138	$ 29,902,310	$ 210,580
Average Annual Damages			**$ 834,680**	**$ 5,880**

Table C3: Residential Tangible Damages For Options C, H, G, L, P and F – 1% AEP event

CBD AREA – Residential Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
EXISTING SCENARIO	19	8	$ 479,460	$ 25,230
OPTION C	19	8	$ 479,460	$ 25,230
OPTION H	19	6	$ 352,510	$ 18,550
OPTION G	19	5	$ 323,150	$ 17,010
OPTION P	19	5	$ 352,510	$ 18,550
OPTION F	16	2	$ 243,880	$ 15,240

CROSSING STREET AREA – Residential Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
EXISTING SCENARIO	4	2	$ 106,470	$ 26,620
OPTION C	4	2	$ 106,470	$ 26,620
OPTION H	4	2	$ 106,470	$ 26,620
OPTION G	4	2	$ 106,470	$ 26,620
OPTION P	4	2	$ 106,470	$ 26,620
OPTION F	4	2	$ 106,470	$ 26,620

WAKADEN AND ULONG JUNCTION – Residential Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
EXISTING SCENARIO	4	0	$ 63,990	$ 16,000
OPTION C	4	0	$ 63,990	$ 16,000
OPTION H	4	0	$ 63,990	$ 16,000
OPTION G	4	0	$ 63,990	$ 16,000
OPTION P	4	0	$ 63,990	$ 16,000
OPTION F	4	0	$ 63,990	$ 16,000

NOORLA STREET AREA – Residential Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
EXISTING SCENARIO	25	0	$ 513,510	$ 20,540
OPTION C	25	0	$ 513,510	$ 20,540
OPTION H	25	0	$ 513,510	$ 20,540
OPTION G	25	0	$ 513,510	$ 20,540
OPTION P	25	0	$ 513,510	$ 20,540
OPTION F	25	0	$ 513,510	$ 20,540

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HYANDRA STREET AREA – Residential Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
EXISTING SCENARIO	11	9	$ 472,690	$ 42,970
OPTION C	11	9	$ 472,690	$ 42,970
OPTION H	11	9	$ 472,690	$ 42,970
OPTION G	11	9	$ 472,690	$ 42,970
OPTION P	11	9	$ 472,690	$ 42,970
OPTION F	11	9	$ 472,690	$ 42,970

OTHERS NOT INCLUDED IN SUB-AREAS – Residential Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
EXISTING SCENARIO	7	4	$ 250,650	$ 35,810
OPTION C	7	4	$ 250,650	$ 35,810
OPTION H	7	4	$ 250,650	$ 35,810
OPTION G	7	4	$ 250,650	$ 35,810
OPTION P	7	4	$ 250,650	$ 35,810
OPTION F	7	4	$ 250,650	$ 35,810

TOTALS FOR STUDY AREA – Residential Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
EXISTING SCENARIO	70	23	$ 1,886,780	$ 26,950
OPTION C	70	23	$ 1,886,780	$ 26,950
OPTION H	70	21	$ 1,759,830	$ 25,140
OPTION G	70	20	$ 1,730,470	$ 24,720
OPTION P	70	20	$ 1,759,830	$ 25,140
OPTION F	67	17	$ 1,651,200	$ 24,640

Table C4: Commercial and Industrial Tangible Damages For Options C, H, G, L, P and F – 100year event

CBD AREA – Commercial and Industrial Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
EXISTING SCENARIO	92	73	$ 11,016,220	$ 119,740
OPTION C	92	73	$ 11,016,220	$ 119,740
OPTION H	91	63	$ 9,178,570	$ 100,860
OPTION G	90	60	$ 8,311,160	$ 92,350
OPTION P	91	59	$ 8,484,980	$ 93,240
OPTION F	83	39	$ 5,838,900	$ 70,350

INDUSTRIAL ZONE – Commercial and Industrial Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
EXISTING SCENARIO	22	19	$ 2,758,880	$ 125,400
OPTION C	22	19	$ 2,758,880	$ 125,400
OPTION H	22	19	$ 2,758,880	$ 125,400
OPTION G	20	17	$ 2,550,620	$ 127,530
OPTION P	22	19	$ 2,758,880	$ 125,400
OPTION F	22	19	$ 2,758,880	$ 125,400

CROSSING STREET AREA – Commercial and Industrial Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
EXISTING SCENARIO	8	5	$ 827,010	$ 103,380
OPTION C	8	5	$ 827,010	$ 103,380
OPTION H	8	5	$ 827,010	$ 103,380
OPTION G	8	5	$ 797,880	$ 99,730
OPTION P	8	5	$ 827,010	$ 103,380
OPTION F	8	5	$ 827,010	$ 103,380

WAKADEN AND ULONG JUNCTION – Commercial and Industrial Properties				
Event	Total no. Properties Affected	No. of these Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
EXISTING SCENARIO	2	2	$ 324,680	$ 162,340
OPTION C	2	2	$ 324,680	$ 162,340
OPTION H	2	2	$ 324,680	$ 162,340
OPTION G	2	2	$ 324,680	$ 162,340
OPTION P	2	2	$ 243,780	$ 121,890
OPTION F	2	2	$ 324,680	$ 162,340

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HYANDRA STREET AREA – Commercial and Industrial Properties				
Event	**Total no. Properties Affected**	**No. of these Flooded Above Floor Level**	**Total Tangible Flood Damages**	**Average Tangible Damages Per Flood Affected Property**
EXISTING SCENARIO	1	1	$ 67,080	$ 67,080
OPTION C	1	1	$ 67,080	$ 67,080
OPTION H	1	1	$ 67,080	$ 67,080
OPTION G	1	1	$ 67,080	$ 67,080
OPTION P	1	1	$ 67,080	$ 67,080
OPTION F	1	1	$ 67,080	$ 67,080

TOTALS FOR STUDY AREA – Commercial and Industrial Properties				
Event	**Total no. Properties Affected**	**No. of these Flooded Above Floor Level**	**Total Tangible Flood Damages**	**Average Tangible Damages Per Flood Affected Property**
EXISTING SCENARIO	125	100	$ 14,993,890	$ 119,950
OPTION C	125	100	$ 14,993,890	$ 119,950
OPTION H	124	90	$ 13,156,240	$ 106,100
OPTION G	121	85	$ 12,051,430	$ 99,600
OPTION P	124	86	$ 12,381,740	$ 99,850
OPTION F	116	66	$ 9,816,560	$ 84,630

ALL FLOOD DAMAGE CALCS - EXISTING SITUATION

Project Name	Griffith CBD FRMS&P
Job Number	112038
Case Description	Existing Situation
Freeboard necessary to give desired protection	0 m

Residential Type		
	1	Single Storey High Set
	2	Slab on Ground
	3	Two Storey
	4	Vacant

Commerical damages have been calcualted using residential damage curves and then the resulting damage multiplied by 3 where there is flooding above floor level.

ID and street name have been removed for privacy reasons.

Floods Assessed	
ARI Yrs	
100000	PMF
500	
200	
100	
50	
20	
10	
5	

y	PMF	500	200	100	50	20	10	5	0.00
AEP	0.001%	0.2%	0.5%	1%	2%	5%	10%	20%	0%
LookukUpCol FLOODLEVELS	10	9.00	8.00	7.00	6.00	5.00	4.00	3.00	0

Assume Damage is zero at what AEP: 0 year

Columns: ID or Survey No. | Type - Commercial or Residential | Street Name | Street Address | Number of Buildings | No of Storeys | Floor Types | Floor Level (m AHD) | "Protection Level" (Floor Level less Freeboard) (m AHD) | Ground Level (m AHD) | Type of Res (1-4) | Flood Level at Property (MAX FLOOD LEVEL ON SITE), m AHD for each AEP flood | Depth of Inundation above GROUND Level (m) for each AEP flood | Depth of Inundation above FLOOR Level (m) for each AEP flood | Depth of Inundation Above "Protection Level" (m) for each AEP flood | Flood Damages

Flood Damages

	PMF Damages, total for event, per property affected	PMF Properties Affected above floor level, damaged	AEP 0.20% Damages	AEP 0.20% Properties	AEP 0.5% Damages	AEP 0.5% Properties	AEP 1.0% Damages	AEP 1.0% Properties	AEP 2.0% Damages	AEP 2.0% Properties	AEP 5.0% Damages	AEP 5.0% Properties	AEP 10.0% Damages	AEP 10.0% Properties	AEP 20.0% Damages	AEP 20.0% Properties	AAD, total and per property
Total	$ 33,939,691	202	$ 21,450,507	147	$ 18,820,641	136	$ 16,880,668	123	$ 12,408,152	92	$ 7,656,334	57	$ 4,028,228	33	$ 2,707,445	21	$ 1,010,351
Average per property	$ 158,597	214	$ 105,150	204	$ 94,103	200	$ 86,568	195	$ 65,306	190	$ 46,971	163	$ 33,569	120	$ 37,088	73	$ 4,721
COMMERCIAL																	
Total for Event	$ 29,902,306	138	$ 19,262,219	119	$ 16,802,423	109	$ 14,993,888	100	$ 10,711,219	75	$ 6,192,710	42	$ 2,698,128	19	$ 1,741,848	11	$ 834,685
Average per Commercial property	$ 210,580	142	$ 143,748	134	$ 129,249	130	$ 119,951	125	$ 89,260	120	$ 61,927	100	$ 42,158	64	$ 52,783	33	$ 5,878
RESIDENTIAL																	
Total for Event	$ 4,037,385	64	$ 2,188,288	28	$ 2,018,218	27	$ 1,886,780	23	$ 1,696,933	17	$ 1,463,624	15	$ 1,330,100	14	$ 965,597	10	$ 175,667
Average per Resi Property	$ 56,075	72	$ 31,261	70	$ 28,832	70	$ 26,954	70	$ 24,242	70	$ 23,232	63	$ 23,752	56	$ 24,140	40	$ 2,440

[illegible]

Flood Damages: PMF – Damages, total for event, per property affected	PMF – Properties Affected above floor level, damaged	AEP 0.20% – Damages, total for event, per property affected	AEP 0.20% – Properties Affected above floor level, damaged	AEP 0.5% – Damages, total for event, per property affected	AEP 0.5% – Properties Affected above floor level, damaged	AEP 1.0% – Damages, total for event, per property affected	AEP 1.0% – Properties Affected above floor level, damaged	AEP 2.0% – Damages, total for event, per property affected	AEP 2.0% – Properties Affected above floor level, damaged	AEP 5.0% – Damages, total for event, per property affected	AEP 5.0% – Properties Affected above floor level, damaged	AEP 10.0% – Damages, total for event, per property affected	AEP 10.0% – Properties Affected above floor level, damaged	AEP 20.0% – Damages, total for event, per property affected	AEP 20.0% – Properties Affected above floor level, damaged	AAD, total and per property
$ 33,939,691	202	$ 21,450,507	147	$ 18,820,641	136	$ 16,880,668	123	$ 12,408,152	92	$ 7,656,334	57	$ 4,028,228	33	$ 2,707,445	21	$ 1,010,351
$ 158,597	214	$ 105,150	204	$ 94,103	200	$ 86,568	195	$ 65,306	190	$ 46,971	163	$ 33,569	120	$ 37,088	73	$ 4,721
$ 191,721	1	$ 22,830	0	$ 22,038	0	$ 21,246	0	$ 20,454	0	$ -		$ -		$ -		$ 904
$ 219,763	1	$ 155,164	1	$ 147,987	1	$ 67,084	1	$ 8,375	0	$ -		$ -		$ -		$ 1,868
$ 199,722	1	$ 159,718	1	$ 151,717	1	$ 50,572	0	$ 50,572	0	$ 25,205	0	$ 24,414	0	$ 24,414	0	$ 4,214
$ 191,721	1	$ 50,572	0	$ 25,205	0	$ 25,205	0	$ 24,414	0	$ 23,622	0	$ 22,830	0	$ 22,830	0	$ 2,611
$ 262,828	1	$ 183,875	1	$ 176,697	1	$ 169,520	1	$ 169,520	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 15,996
$ 241,295	1	$ 169,520	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ 67,084	1	$ -		$ -		$ 8,119
$ 241,295	1	$ 169,520	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ 67,084	1	$ 8,375	0	$ 8,375	0	$ 8,329
$ 226,940	1	$ 155,164	1	$ 147,987	1	$ 67,084	1	$ 8,375	0	$ -		$ -		$ -		$ 1,876
$ 241,295	1	$ 176,697	1	$ 169,520	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ -		$ -		$ 11,599
$ 248,473	1	$ 176,697	1	$ 169,520	1	$ 162,342	1	$ 162,342	1	$ 147,987	1	$ 67,084	1	$ 67,084	1	$ 13,427
$ 248,473	1	$ 176,697	1	$ 162,342	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ -		$ -		$ 11,578
$ 248,473	1	$ 169,520	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ 67,084	1	$ 8,375	0	$ -		$ 8,755
$ 255,650	1	$ 176,697	1	$ 162,342	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ 22,361	0	$ -		$ 13,262
$ 255,650	1	$ 176,697	1	$ 169,520	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ 67,084	1	$ -		$ 16,645
$ 255,650	1	$ 176,697	1	$ 169,520	1	$ 162,342	1	$ 162,342	1	$ 155,164	1	$ 67,084	1	$ 67,084	1	$ 13,722
$ 248,473	1	$ 176,697	1	$ 162,342	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ 22,361	0	$ 8,375	0	$ 12,836
$ 248,473	1	$ 176,697	1	$ 169,520	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ 22,361	0	$ 8,375	0	$ 12,865
$ 234,118	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ 67,084	1	$ 8,375	0	$ -		$ -		$ 4,045
$ 241,295	1	$ 169,520	1	$ 155,164	1	$ 155,164	1	$ 147,987	1	$ 22,361	0	$ 8,375	0	$ 8,375	0	$ 6,511
$ 231,726	1	$ 159,718	1	$ 50,572	0	$ 25,205	0	$ 24,414	0	$ 23,622	0	$ 22,830	0	$ -		$ 4,166
$ 234,118	1	$ 169,520	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ -		$ -		$ -		$ 5,429
$ 241,295	1	$ 169,520	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ 67,084	1	$ 8,375	0	$ -		$ 8,747
$ 226,940	1	$ 155,164	1	$ 147,987	1	$ 67,084	1	$ 22,361	0	$ 8,375	0	$ -		$ -		$ 2,490
$ 234,118	1	$ 162,342	1	$ 155,164	1	$ 155,164	1	$ 147,987	1	$ 8,375	0	$ 8,375	0	$ -		$ 6,345
$ 241,295	1	$ 169,520	1	$ 162,342	1	$ 155,164	1	$ 155,164	1	$ 22,361	0	$ 8,375	0	$ -		$ 7,102
$ 226,940	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 8,375	0	$ 8,375	0	$ -		$ 6,238
$ 226,940	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 67,084	1	$ 22,361	0	$ -		$ -		$ 4,551
$ 219,763	1	$ 155,164	1	$ 147,987	1	$ 67,084	1	$ 8,375	0	$ 8,375	0	$ -		$ -		$ 2,203
$ 219,763	1	$ 155,164	1	$ 147,987	1	$ 22,361	0	$ 8,375	0	$ 8,375	0	$ -		$ -		$ 1,868
$ 219,763	1	$ 147,987	1	$ 22,361	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ -		$ -		$ 1,243
$ 226,940	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 67,084	1	$ 8,375	0	$ -		$ -		$ 3,991
$ 226,940	1	$ 155,164	1	$ 147,987	1	$ 67,084	1	$ 8,375	0	$ 8,375	0	$ -		$ -		$ 2,211
$ 234,118	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ 67,084	1	$ 22,361	0	$ 8,375	0	$ -		$ 5,233
$ 234,118	1	$ 162,342	1	$ 155,164	1	$ 155,164	1	$ 147,987	1	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 5,927
$ 241,295	1	$ 169,520	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 147,987	1	$ 8,375	0	$ -		$ 12,324
$ 241,295	1	$ 169,520	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 147,987	1	$ 8,375	0	$ -		$ 12,324
$ 234,118	1	$ 162,342	1	$ 155,164	1	$ 155,164	1	$ 147,987	1	$ 8,375	0	$ 8,375	0	$ -		$ 6,345
$ 215,724	1	$ 23,622	0	$ 23,622	0	$ 22,830	0	$ 22,830	0	$ 22,038	0	$ 20,454	0	$ 18,870	0	$ 2,468
$ 226,940	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 67,084	1	$ 22,361	0	$ 8,375	0	$ 8,375	0	$ 4,742
$ 255,650	1	$ 169,520	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ -		$ 23,097
$ 191,052	1	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ -		$ 1,438
$ 219,763	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 22,361	0	$ 22,361	0	$ 11,746
$ 22,830	0	$ 20,454	0	$ 20,454	0	$ 20,454	0	$ 19,662	0	$ 19,662	0	$ 19,662	0	$ 19,662	0	$ 1,980
$ 198,230	1	$ 169,520	1	$ 169,520	1	$ 169,520	1	$ 169,520	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 16,513
$ 191,052	1	$ 162,342	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 147,987	1	$ -		$ 22,788
$ 191,052	1	$ 162,342	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 15,103
$ 176,697	1	$ 67,084	1	$ 22,361	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 1,207
$ 155,164	1	$ 8,375	0	$ -		$ -		$ -		$ -		$ -		$ -		$ 175
$ 155,164	1	$ -		$ -		$ -		$ -		$ -		$ -		$ -		$ 154
$ 176,697	1	$ 155,164	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 14,873
$ 169,520	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 67,084	1	$ 67,084	1	$ 22,361	0	$ 11,796
$ 162,342	1	$ 22,361	0	$ -		$ -		$ -		$ -		$ -		$ -		$ 217
$ 162,342	1	$ 147,987	1	$ 67,084	1	$ 67,084	1	$ 22,361	0	$ 8,375	0	$ 8,375	0	$ -		$ 2,713
$ 176,697	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 67,084	1	$ 8,375	0	$ -		$ 8,536
$ 176,697	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 67,084	1	$ 22,361	0	$ -		$ -		$ 4,483
$ 191,052	1	$ 162,342	1	$ 162,342	1	$ 155,164	1	$ 155,164	1	$ 147,987	1	$ 67,084	1	$ -		$ 16,462
$ 176,697	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 67,084	1	$ 22,361	0	$ 8,375	0	$ -		$ 5,111
$ 198,230	1	$ 169,520	1	$ 169,520	1	$ 162,342	1	$ 162,342	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 15,670
$ 183,875	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 67,084	1	$ -		$ -		$ 7,915
$ 176,697	1	$ 147,987	1	$ 147,987	1	$ 67,084	1	$ 67,084	1	$ 8,375	0	$ -		$ -		$ 3,317
$ 176,697	1	$ 147,987	1	$ 67,084	1	$ 67,084	1	$ 22,361	0	$ -		$ -		$ -		$ 1,764
$ 191,052	1	$ 162,342	1	$ 162,342	1	$ 155,164	1	$ 155,164	1	$ 147,987	1	$ -		$ -		$ 11,431
$ 212,585	1	$ 176,697	1	$ 176,697	1	$ 176,697	1	$ 169,520	1	$ 155,164	1	$ 155,164	1	$ 147,987	1	$ 16,520
$ 183,875	1	$ 155,164	1	$ 155,164	1	$ 147,987	1	$ 67,084	1	$ -		$ -		$ -		$ 3,642
$ 162,342	1	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ -		$ -		$ -		$ -		$ 279
$ 212,585	1	$ 183,875	1	$ 183,875	1	$ 176,697	1	$ 176,697	1	$ 162,342	1	$ 155,164	1	$ 155,164	1	$ 16,639
$ 191,052	1	$ 162,342	1	$ 155,164	1	$ 155,164	1	$ 147,987	1	$ 22,361	0	$ 8,375	0	$ -		$ 6,862
$ 234,118	1	$ 176,697	1	$ 169,520	1	$ 155,164	1	$ 155,164	1	$ 8,375	0	$ -		$ -		$ 5,954
$ 234,118	1	$ 183,875	1	$ 183,875	1	$ 169,520	1	$ 147,987	1	$ -		$ -		$ -		$ 5,658

ALL PROPERTIES - FLOOD DAMAGE CALCS - OPTIONS - 1% AEP EVENT

Project Name	Griffith CBD FRMS&P
Job Number	112038
Case Description	Options 1% AEP
Freeboard necessary to give desired protection	0 m

Residential Type		
	1	Single Storey High Set
	2	Slab on Ground
	3	Two Storey
	4	Vacant

Commerical damages have been calcualted using residential damage curves and then the resulting damage multiplied by 3 where there is flooding above floor level.

ID and street name have been removed for privacy reasons.

Floods Assessed	
ARI Yrs	
100000	PMF
500	
200	
100	
50	
20	
10	
5	

y	PMF	500	200	100	50	20	10	5	
AEP	0.00100%	0.2%	0.5%	1%	2%	5%	10%	20%	0%
LookukUpCol FLOODLEVELS	10	9.00	8.00	7.00	6.00	5.00	4.00	3.00	

Assume Damage is zero at what AEP: 0 year

y	PMF	500	200	100	50	20	10	5	0.00
AEP	0.001%	0.2%	0.5%	1%	2%	5%	10%	20%	0%
LookukUpCol FLOODLEV	10	9.00	8.00	7.00	6.00	5.00	4.00	3.00	0

Column headings: ID or Survey No. | Type - Commercial or Residential | Street Name | Street Address | Number of Buildings | No of Storeys | Floor Types | Floor Level m AHD | "Protection Level" (Floor Level less Freeboard) m AHD | Ground Level m AHD | Type of Res 1-4 | Flood Level at Property (MAX FLOOD LEVEL ON SITE) m AHD for each AEP flood: OPT F, OPT P, OPT L, OPT G, OPT H, OPT C | Depth of Inundation above GROUND Level (m) for each AEP flood: OPT F, OPT P, OPT L, OPT G, OPT H, OPT C | Depth of Inundation above FLOOR Level (m) for each AEP flood: OPT F, OPT P, OPT L, OPT G, OPT H, OPT C | Depth of Inundation Above "Protection Level" (m) for each AEP flood: OPT F, OPT P, OPT L, OPT G, OPT H, OPT C

Flood Damages

	OPTION F Damages, total for event, per property affected	OPTION F Properties Affected above floor level, damaged	OPTION P Damages, total for event, per property affected	OPTION P Properties Affected above floor level, damaged	OPTION L Damages, total for event, per property affected	OPTION L Properties Affected above floor level, damaged	OPTION G Damages, total for event, per property affected	OPTION G Properties Affected above floor level, damaged	OPTION H Damages, total for event, per property affected	OPTION H Properties Affected above floor level, damaged	OPTION C Damages, total for event, per property affected	OPTION C Properties Affected above floor level, damaged
	$ 11,467,762	83	$ 14,141,567	106	$ 16,880,668	123	$ 13,781,898	105	$ 14,916,062	111	$ 16,880,668	123
Average per property	$ 62,665	183	$ 72,895	194	$ 86,568	195	$ 72,157	191	$ 76,887	194	$ 86,568	195
COMMERCIAL												
Total for Event	$ 9,816,563	66	$ 12,381,741	86	$ 14,993,888	100	$ 12,051,432	85	$ 13,156,236	90	$ 14,993,888	100
Average per Commercial property	$ 84,626	116	$ 99,853	124	$ 119,951	125	$ 99,599	121	$ 106,099	124	$ 119,951	125
RESIDENTIAL												
Total for Event	$ 1,651,198	17	$ 1,759,826	20	$ 1,886,780	23	$ 1,730,466	20	$ 1,759,826	21	$ 1,886,780	23
Average per Resi Property	$ 24,645	67	$ 25,140	70	$ 26,954	70	$ 24,721	70	$ 25,140	70	$ 26,954	70
COMMERCIAL												
Average per Resi Property	$ 9,816,563 / $ 84,626	66 / 116	$ 12,381,741 / $ 99,853	86 / 124	$ 14,993,888 / $ 119,951	100 / 125	$ 12,051,432 / $ 99,599	85 / 121	$ 13,156,236 / $ 106,099	90 / 124	$ 14,993,888 / $ 119,951	100 / 125

ID or Survey No.	Type - Commercial or Residential	Street Name	Street Address	Number of Buildings	No of Storeys	Floor Types	Floor Level m AHD	"Protection Level" (Floor Level less Freeboard) m AHD	Ground Level m AHD	Type of Res 1-4	Flood Level at Property (MAX FLOOD LEVEL ON SITE) m AHD for each AEP flood						Depth of Inundation above GROUND Level (m) for each AEP flood						Depth of Inundation above FLOOR Level (m) for each AEP flood								Depth of Inundation Above "Protection Level" (m) for each AEP flood								Flood Damages OPTION F: Damages, total for event, per property affected	OPTION F: Properties Affected above floor level, damaged	OPTION P: Damages, total for event, per property affected	OPTION P: Properties Affected above floor level, damaged	OPTION L: Damages, total for event, per property affected	OPTION L: Properties Affected above floor level, damaged	OPTION G: Damages, total for event, per property affected	OPTION G: Properties Affected above floor level, damaged	OPTION H: Damages, total for event, per property affected	OPTION H: Properties Affected above floor level, damaged	OPTION C: Damages, total for event, per property affected	OPTION C: Properties Affected above floor level, damaged
											OPT F	OPT P	OPT L	OPT G	OPT H	OPT C	OPT F	OPT P	OPT L	OPT G	OPT H	OPT C	OPT F	OPT P	OPT L	OPT G	OPT H	OPT C			OPT F	OPT P	OPT L	OPT G	OPT H	OPT C			$ 11,467,762	83	$ 14,141,567	106	$ 16,880,668	123	$ 13,781,898	105	$ 14,916,062	111	$ 16,880,668	123
																																					Average per property		$ 62,665	183	$ 72,895	194	$ 86,568	195	$ 72,157	191	$ 76,887	194	$ 86,568	195
	C			1	1	S	125.83	125.83	125.19	1	125.29	125.38	125.45	125.36	125.39	125.45	0.1	0.19	0.26	0.17	0.20	0.26	-0.54	-0.45	-0.38	-0.47	-0.44	-0.38	0.00	0.00	-0.54	-0.45	-0.38	-0.47	-0.44	-0.38	0.00	0.00	$ 22,038	0	$ 22,038	0	$ 22,830	0	$ 22,038	0	$ 22,830	0	$ 22,830	0
	C			1 + Garage	1	S	125.25	125.25	125.1	2	125.29	125.38	125.45	125.36	125.39	125.45	0.19	0.28	0.35	0.26	0.29	0.35	0.04	0.13	0.20	0.11	0.14	0.20	0.00	0.00	0.04	0.13	0.20	0.11	0.14	0.20	0.00	0.00	$ 67,084	1	$ 147,987	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 155,164	1
	C			1	1	S	125.25	125.25	125.1	2	125.29	125.38	125.45	125.38	125.39	125.45	0.19	0.28	0.35	0.28	0.29	0.35	0.04	0.13	0.20	0.13	0.14	0.20	0.00	0.00	0.04	0.13	0.20	0.13	0.14	0.20	0.00	0.00	$ 67,084	1	$ 147,987	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 155,164	1
	C			2	1	S	125.19	125.19	125.08	2	125.29	125.38	125.45	125.38	125.39	125.45	0.21	0.30	0.37	0.30	0.31	0.37	0.10	0.19	0.26	0.19	0.20	0.26	0.00	0.00	0.10	0.19	0.26	0.19	0.20	0.26	0.00	0.00	$ 147,987	1	$ 155,164	1	$ 162,342	1	$ 155,164	1	$ 155,164	1	$ 162,342	1
	C			1	1	S	125.3	125.3	125.02	2	125.3	125.38	125.45	125.38	125.39	125.45	0.28	0.36	0.43	0.36	0.37	0.43	0.00	0.08	0.15	0.08	0.09	0.15	0.00	0.00	0.00	0.08	0.15	0.08	0.09	0.15	0.00	0.00	$ 22,361	0	$ 147,987	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 155,164	1
	C			1	1	S	125.36	125.36	125.01	2	125.3	125.38	125.45	125.38	125.39	125.45	0.29	0.37	0.44	0.37	0.38	0.44	-0.06	0.02	0.09	0.02	0.03	0.09	0.00	0.00	-0.06	0.02	0.09	0.02	0.03	0.09	0.00	0.00	$ 8,375	0	$ 67,084	1	$ 147,987	1	$ 67,084	1	$ 67,084	1	$ 147,987	1
	C			1	1	S	125.37	125.37	125.01	2	125.3	125.38	125.45	125.38	125.39	125.45	0.29	0.37	0.44	0.37	0.38	0.44	-0.07	0.01	0.08	0.01	0.02	0.08	0.00	0.00	-0.07	0.01	0.08	0.01	0.02	0.08	0.00	0.00	$ 8,375	0	$ 67,084	1	$ 147,987	1	$ 67,084	1	$ 67,084	1	$ 147,987	1
	C			1 + Garage	1	S	125.34	125.34	125	2	125.3	125.38	125.45	125.38	125.39	125.45	0.3	0.38	0.45	0.38	0.39	0.45	-0.04	0.04	0.11	0.04	0.05	0.11	0.00	0.00	-0.04	0.04	0.11	0.04	0.05	0.11	0.00	0.00	$ 22,361	0	$ 67,084	1	$ 147,987	1	$ 67,084	1	$ 67,084	1	$ 147,987	1
	C			1	1	S	125.34	125.34	125	2	125.3	125.38	125.45	125.38	125.39	125.45	0.3	0.38	0.45	0.38	0.39	0.45	-0.04	0.04	0.11	0.04	0.05	0.11	0.00	0.00	-0.04	0.04	0.11	0.04	0.05	0.11	0.00	0.00	$ 22,361	0	$ 67,084	1	$ 147,987	1	$ 67,084	1	$ 67,084	1	$ 147,987	1
	C			1	1	S	125.51	125.51	125.1	2	125.3	125.38	125.45	125.39	125.40	125.45	0.2	0.28	0.35	0.29	0.30	0.35	-0.21	-0.13	-0.06	-0.12	-0.11	-0.06	0.00	0.00	-0.21	-0.13	-0.06	-0.12	-0.11	-0.06	0.00	0.00	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0
	C			1	1	S	126	126	125.87	2	0	0.00	125.45	0.00	125.41	125.45	-125.87	-125.87	-0.42	-125.87	-0.46	-0.42	0.00	0.00	-0.55	0.00	-0.59	-0.55	0.00	0.00	0.00	0.00	-0.55	0.00	-0.59	-0.55	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	126.14	126.14	125.99	2	125.25	125.38	125.45	125.40	125.41	125.45	-0.74	-0.61	-0.54	-0.59	-0.58	-0.54	-0.89	-0.76	-0.69	-0.74	-0.73	-0.69	0.00	0.00	-0.89	-0.76	-0.69	-0.74	-0.73	-0.69	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	125.61	125.61	125.54	2	125.25	125.38	125.45	125.39	125.41	125.45	-0.29	-0.16	-0.09	-0.15	-0.13	-0.09	-0.36	-0.23	-0.16	-0.22	-0.20	-0.16	0.00	0.00	-0.36	-0.23	-0.16	-0.22	-0.20	-0.16	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	126.24	126.24	126.14	2	125.25	125.38	125.45	125.39	125.40	125.45	-0.89	-0.76	-0.69	-0.75	-0.74	-0.69	-0.99	-0.86	-0.79	-0.85	-0.84	-0.79	0.00	0.00	-0.99	-0.86	-0.79	-0.85	-0.84	-0.79	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	126.38	126.38	126.15	2	125.25	125.38	125.45	125.38	125.39	125.45	-0.9	-0.77	-0.70	-0.77	-0.76	-0.70	-1.13	-1.00	-0.93	-1.00	-0.99	-0.93	0.00	0.00	-1.13	-1.00	-0.93	-1.00	-0.99	-0.93	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	125.35	125.35	125.17	2	125.25	125.38	125.45	125.38	125.39	125.45	0.08	0.21	0.28	0.21	0.22	0.28	-0.10	0.03	0.10	0.03	0.04	0.10	0.00	0.00	-0.10	0.03	0.10	0.03	0.04	0.10	0.00	0.00	$ 8,375	0	$ 67,084	1	$ 147,987	1	$ 67,084	1	$ 67,084	1	$ 147,987	1
	C			1	1	S	126.31	126.31	125.5	1	125.25	125.38	125.45	125.38	125.39	125.45	-0.25	-0.12	-0.05	-0.12	-0.11	-0.05	-1.06	-0.93	-0.86	-0.93	-0.92	-0.86	0.00	0.00	-1.06	-0.93	-0.86	-0.93	-0.92	-0.86	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	125.36	125.36	125.15	2	125.25	125.38	125.45	125.38	125.39	125.45	0.1	0.23	0.30	0.23	0.24	0.30	-0.11	0.02	0.09	0.02	0.03	0.09	0.00	0.00	-0.11	0.02	0.09	0.02	0.03	0.09	0.00	0.00	$ 8,375	0	$ 67,084	1	$ 147,987	1	$ 67,084	1	$ 67,084	1	$ 147,987	1
	C			1	1	S	126.47	126.47	126.43	2	125.25	125.38	125.45	125.38	125.39	125.45	-1.18	-1.05	-0.98	-1.05	-1.04	-0.98	-1.22	-1.09	-1.02	-1.09	-1.08	-1.02	0.00	0.00	-1.22	-1.09	-1.02	-1.09	-1.08	-1.02	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	126.57	126.57	125.5	1	125.25	125.38	125.45	125.38	125.39	125.45	-0.25	-0.12	-0.05	-0.12	-0.11	-0.05	-1.32	-1.19	-1.12	-1.19	-1.18	-1.12	0.00	0.00	-1.32	-1.19	-1.12	-1.19	-1.18	-1.12	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	125.72	125.72	125.1	1	125.25	125.38	125.45	125.38	125.39	125.45	0.15	0.28	0.35	0.28	0.29	0.35	-0.47	-0.34	-0.27	-0.34	-0.33	-0.27	0.00	0.00	-0.47	-0.34	-0.27	-0.34	-0.33	-0.27	0.00	0.00	$ 22,038	0	$ 23,622	0	$ 23,622	0	$ 23,622	0	$ 23,622	0	$ 23,622	0
	C			1	1	S	126.69	126.69	126.58	2	125.25	125.38	125.45	125.38	125.39	125.45	-1.33	-1.20	-1.13	-1.20	-1.19	-1.13	-1.44	-1.31	-1.24	-1.31	-1.30	-1.24	0.00	0.00	-1.44	-1.31	-1.24	-1.31	-1.30	-1.24	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	125.78	125.78	125.2	1	125.25	125.38	125.45	125.38	125.39	125.45	0.05	0.18	0.25	0.18	0.19	0.25	-0.53	-0.40	-0.33	-0.40	-0.39	-0.33	0.00	0.00	-0.53	-0.40	-0.33	-0.40	-0.39	-0.33	0.00	0.00	$ 22,038	0	$ 22,830	0	$ 23,622	0	$ 22,830	0	$ 22,830	0	$ 23,622	0
	C			1	1	S	126.92	126.92	126.72	2	125.25	125.38	125.45	125.38	125.39	125.45	-1.47	-1.34	-1.27	-1.34	-1.33	-1.27	-1.67	-1.54	-1.47	-1.54	-1.53	-1.47	0.00	0.00	-1.67	-1.54	-1.47	-1.54	-1.53	-1.47	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	125.39	125.39	125.15	2	12.25	125.38	125.45	125.38	125.39	125.45	-112.9	0.23	0.30	0.23	0.24	0.30	-113.14	-0.01	0.06	-0.01	0.00	0.06	0.00	0.00	-113.14	-0.01	0.06	-0.01	0.00	0.06	0.00	0.00	$ -		$ 22,361	0	$ 147,987	1	$ 22,361	0	$ 22,361	0	$ 147,987	1
	C			1	1	S	125.58	125.58	125.49	2	125.24	125.38	125.45	125.38	125.39	125.45	-0.25	-0.11	-0.04	-0.11	-0.10	-0.04	-0.34	-0.20	-0.13	-0.20	-0.19	-0.13	0.00	0.00	-0.34	-0.20	-0.13	-0.20	-0.19	-0.13	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	127.16	127.16	126.96	2	125.24	125.38	125.45	125.38	125.39	125.45	-1.72	-1.58	-1.51	-1.58	-1.57	-1.51	-1.92	-1.78	-1.71	-1.78	-1.77	-1.71	0.00	0.00	-1.92	-1.78	-1.71	-1.78	-1.77	-1.71	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	127.13	127.13	125.55	1	125.24	125.38	125.45	125.38	125.39	125.45	-0.31	-0.17	-0.10	-0.17	-0.16	-0.10	-1.89	-1.75	-1.68	-1.75	-1.74	-1.68	0.00	0.00	-1.89	-1.75	-1.68	-1.75	-1.74	-1.68	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	126.07	126.07	125.27	1	125.24	125.38	125.45	125.38	125.39	125.45	-0.03	0.11	0.18	0.11	0.12	0.18	-0.83	-0.69	-0.62	-0.69	-0.68	-0.62	0.00	0.00	-0.83	-0.69	-0.62	-0.69	-0.68	-0.62	0.00	0.00	$ -		$ 20,454	0	$ 21,246	0	$ 20,454	0	$ 20,454	0	$ 21,246	0
	C			1	1	S	125.41	125.41	125.3	2	125.24	125.38	125.45	125.38	125.39	125.45	-0.06	0.08	0.15	0.08	0.09	0.15	-0.17	-0.03	0.04	-0.03	-0.02	0.04	0.00	0.00	-0.17	-0.03	0.04	-0.03	-0.02	0.04	0.00	0.00	$ -		$ 22,361	0	$ 67,084	1	$ 22,361	0	$ 22,361	0	$ 67,084	1
	C			1	1	S	126.38	126.38	125.87	1	126.29	126.31	126.38	126.38	126.39	126.38	0.42	0.44	0.51	0.51	0.52	0.51	-0.09	-0.07	0.00	0.00	0.01	0.00	0.00	0.00	-0.09	-0.07	0.00	0.00	0.01	0.00	0.00	0.00	$ 25,205	0	$ 25,205	0	$ 50,572	0	$ 50,572	0	$ 151,717	1	$ 50,572	0
	C			1	1	S	126.53	126.53	125.91	1	126.27	126.32	126.39	126.38	126.39	126.39	0.36	0.41	0.48	0.47	0.48	0.48	-0.26	-0.21	-0.14	-0.15	-0.14	-0.14	0.00	0.00	-0.26	-0.21	-0.14	-0.15	-0.14	-0.14	0.00	0.00	$ 23,622	0	$ 24,414	0	$ 25,205	0	$ 24,414	0	$ 25,205	0	$ 25,205	0
	C			1	1	S	125.02	125.02	125.02	2	125.34	125.39	125.45	125.39	125.42	125.45	0.32	0.37	0.43	0.37	0.40	0.43	0.32	0.37	0.43	0.37	0.40	0.43	0.00	0.00	0.32	0.37	0.43	0.37	0.40	0.43	0.00	0.00	$ 162,342	1	$ 169,520	1	$ 169,520	1	$ 169,520	1	$ 169,520	1	$ 169,520	1
	C			2 + Shed	1	S	125.22	125.22	125.14	2	125.32	125.38	125.45	125.37	125.40	125.45	0.18	0.24	0.31	0.23	0.26	0.31	0.10	0.16	0.23	0.15	0.18	0.23	0.00	0.00	0.10	0.16	0.23	0.15	0.18	0.23	0.00	0.00	$ 147,987	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1
	C			1	1	S	125.25	125.25	125	2	125.33	125.39	125.45	125.39	125.41	125.45	0.33	0.39	0.45	0.39	0.41	0.45	0.08	0.14	0.20	0.14	0.16	0.20	0.00	0.00	0.08	0.14	0.20	0.14	0.16	0.20	0.00	0.00	$ 147,987	1	$ 147,987	1	$ 155,164	1	$ 147,987	1	$ 155,164	1	$ 155,164	1
	C			1 + Shed	1	S	125.42	125.42	125.31	2	125.32	125.39	125.45	125.38	125.41	125.45	0.01	0.08	0.14	0.07	0.10	0.14	-0.10	-0.03	0.03	-0.04	-0.01	0.03	0.00	0.00	-0.10	-0.03	0.03	-0.04	-0.01	0.03	0.00	0.00	$ 8,375	0	$ 22,361	0	$ 67,084	1	$ 22,361	0	$ 22,361	0	$ 67,084	1
	C			2	1	s	125.12	125.12	124.95	2	125.33	125.39	125.45	125.39	125.41	125.45	0.38	0.44	0.50	0.44	0.46	0.50	0.21	0.27	0.33	0.27	0.29	0.33	0.00	0.00	0.21	0.27	0.33	0.27	0.29	0.33	0.00	0.00	$ 155,164	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1
	C			2	1	s	125.12	125.12	124.96	2	125.34	125.39	125.45	125.39	125.42	125.45	0.38	0.43	0.49	0.43	0.46	0.49	0.22	0.27	0.33	0.27	0.30	0.33	0.00	0.00	0.22	0.27	0.33	0.27	0.30	0.33	0.00	0.00	$ 155,164	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1
	C			2	1	S	125.18	125.18	125.13	2	125.34	125.39	125.45	125.39	125.42	125.45	0.21	0.26	0.32	0.26	0.29	0.32	0.16	0.21	0.27	0.21	0.24	0.27	0.00	0.00	0.16	0.21	0.27	0.21	0.24	0.27	0.00	0.00	$ 155,164	1	$ 155,164	1	$ 162,342	1	$ 155,164	1	$ 155,164	1	$ 162,342	1
	C			1	1	S	125.25	125.25	125.1	2	125.34	125.39	125.45	125.39	125.42	125.45	0.24	0.29	0.35	0.29	0.32	0.35	0.09	0.14	0.20	0.14	0.17	0.20	0.00	0.00	0.09	0.14	0.20	0.14	0.17	0.20	0.00	0.00	$ 147,987	1	$ 147,987	1	$ 155,164	1	$ 147,987	1	$ 155,164	1	$ 155,164	1
	C			1	1	S	125.17	125.17	125.11	2	125.34	125.39	125.45	125.39	125.42	125.45	0.23	0.28	0.34	0.28	0.31	0.34	0.17	0.22	0.28	0.22	0.25	0.28	0.00	0.00	0.17	0.22	0.28	0.22	0.25	0.28	0.00	0.00	$ 155,164	1	$ 155,164	1	$ 162,342	1	$ 155,164	1	$ 162,342	1	$ 162,342	1
	C			8	1	S	125.14	125.14	125.14	2	125.34	125.40	125.45	125.39	125.42	125.45	0.2	0.26	0.31	0.25	0.28	0.31	0.20	0.26	0.31	0.25	0.28	0.31	0.00	0.00	0.20	0.26	0.31	0.25	0.28	0.31	0.00	0.00	$ 155,164	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1
	C			1 + Garage	1	S	125.11	125.11	124.94	2	125.34	125.39	125.45	125.39	125.42	125.45	0.4	0.45	0.51	0.45	0.48	0.51	0.23	0.28	0.34	0.28	0.31	0.34	0.00	0.00	0.23	0.28	0.34	0.28	0.31	0.34	0.00	0.00	$ 155,164	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1
	C			1	1	S	125.18	125.18	124.95	2	125.34	125.39	125.45	125.39	125.42	125.45	0.39	0.44	0.50	0.44	0.47	0.50	0.16	0.21	0.27	0.21	0.24	0.27	0.00	0.00	0.16	0.21	0.27	0.21	0.24	0.27	0.00	0.00	$ 155,164	1	$ 155,164	1	$ 162,342	1	$ 155,164	1	$ 155,164	1	$ 162,342	1
	C			1	1	S	125.15	125.15	125.03	2	125.33	125.39	125.45	125.38	125.41	125.45	0.3	0.36	0.42	0.35	0.38	0.42	0.18	0.24	0.30	0.23	0.26	0.30	0.00	0.00	0.18	0.24	0.30	0.23	0.26	0.30	0.00	0.00	$ 155,164	1	$ 155,164	1	$ 162,342	1	$ 155,164	1	$ 162,342	1	$ 162,342	1
	C			1	1	S	125.35	125.35	125.21	2	125.33	125.39	125.45	125.38	125.41	125.45	0.12	0.18	0.24	0.17	0.20	0.24	-0.02	0.04	0.10	0.03	0.06	0.10	0.00	0.00	-0.02	0.04	0.10	0.03	0.06	0.10	0.00	0.00	$ 22,361	0	$ 67,084	1	$ 147,987	1	$ 67,084	1	$ 147,987	1	$ 147,987	1
	C			2	1	S	125.28	125.28	125.04	2	125.33	125.39	125.45	125.38	125.41	125.45	0.29	0.35	0.41	0.34	0.37	0.41	0.05	0.11	0.17	0.10	0.13	0.17	0.00	0.00	0.05	0.11	0.17	0.10	0.13	0.17	0.00	0.00	$ 67,084	1	$ 147,987	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 155,164	1
	C			1	1	S	125.55	125.55	125.02	1	125.32	125.38	125.45	125.37	125.40	125.45	0.3	0.36	0.43	0.35	0.38	0.43	-0.23	-0.17	-0.10	-0.18	-0.15	-0.10	0.00	0.00	-0.23	-0.17	-0.10	-0.18	-0.15	-0.10	0.00	0.00	$ 24,414	0	$ 24,414	0	$ 25,205	0	$ 24,414	0	$ 25,205	0	$ 25,205	0
	C			1	1	S	125.26	125.26	125.23	2	125.32	125.38	125.45	125.37	125.40	125.45	0.09	0.15	0.22	0.14	0.17	0.22	0.06	0.12	0.19	0.11	0.14	0.19	0.00	0.00	0.06	0.12	0.19	0.11	0.14	0.19	0.00	0.00	$ 147,987	1	$ 147,987	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 155,164	1
	C			1	1	S	125.23	125.23	125.02	2	125.32	125.38	125.45	125.37	125.40	125.45	0.3	0.36	0.43	0.35	0.38	0.43	0.09	0.15	0.22	0.14	0.17	0.22	0.00	0.00	0.09	0.15	0.22	0.14	0.17	0.22	0.00	0.00	$ 147,987	1	$ 147,987	1	$ 155,164	1	$ 147,987	1	$ 147,987	1	$ 155,164	1
	C			1	1	S	125.47	125.47	125.34	2	125.43	125.47	125.51	125.48	125.51	125.51	0.09	0.13	0.17	0.14	0.17	0.17	-0.04	0.00	0.04	0.01	0.04	0.04	0.00	0.00	-0.04	0.00	0.04	0.01	0.04	0.04	0.00	0.00	$ 22,361	0	$ 22,361	0	$ 67,084	1	$ 67,084	1	$ 67,084	1	$ 67,084	1
	C			1	1	S	125.36	125.36	124.97	2	125.42	125.47	125.51	125.48	125.51	125.51	0.45	0.50	0.54	0.51	0.54	0.54	0.06	0.11	0.15	0.12	0.15	0.15	0.00	0.00	0.06	0.11	0.15	0.12	0.15	0.15	0.00	0.00	$ 147,987	1	$ 147,987	1	$ 155,164	1	$ 147,987	1	$ 155,164	1	$ 155,164	1
	C			1	1	S	125.27	125.27	124.98	2	125.37	125.47	125.51	125.49	125.51	125.51	0.39	0.49	0.53	0.51	0.53	0.53	0.10	0.20	0.24	0.22	0.24	0.24	0.00	0.00	0.10	0.20	0.24	0.22	0.24	0.24	0.00	0.00	$ 147,987	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1
	C			1	1	S	125.4	125.4	124.99	2	125.45	125.47	125.51	125.49	125.51	125.51	0.46	0.48	0.52	0.50	0.52	0.52	0.05	0.07	0.11	0.09	0.11	0.11	0.00	0.00	0.05	0.07	0.11	0.09	0.11	0.11	0.00	0.00	$ 67,084	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1
	C			1	1	S	125.44	125.44	125.3	2	125.46	125.49	125.51	125.50	125.51	125.51	0.16	0.19	0.21	0.20	0.21	0.21	0.02	0.05	0.07	0.06	0.07	0.07	0.00	0.00	0.02	0.05	0.07	0.06	0.07	0.07	0.00	0.00	$ 67,084	1	$ 67,084	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1
	C			1	1	S	125.43	125.43	125.25	2	125.33	125.40	125.45	125.41	125.44	125.45	0.08	0.15	0.20	0.16	0.19	0.20	-0.10	-0.03	0.02	-0.02	0.01	0.02	0.00	0.00	-0.10	-0.03	0.02	-0.02	0.01	0.02	0.00	0.00	$ 8,375	0	$ 22,361	0	$ 67,084	1	$ 22,361	0	$ 67,084	1	$ 67,084	1
	C			1	1	S	125.45	125.45	125.24	2	125.32	125.38	125.45	125.37	125.40	125.45	0.08	0.14	0.21	0.13	0.16	0.21	-0.13	-0.07	0.00	-0.08	-0.05	0.00	0.00	0.00	-0.13	-0.07	0.00	-0.08	-0.05	0.00	0.00	0.00	$ 8,375	0	$ 8,375	0	$ 22,361	0	$ 8,375	0	$ 22,361	0	$ 22,361	0
	C			1	1	S	125.52	125.52	125.24	2	125.32	125.38	125.45	125.37	125.40	125.45	0.08	0.14	0.21	0.13	0.16	0.21	-0.20	-0.14	-0.07	-0.15	-0.12	-0.07	0.00	0.00	-0.20	-0.14	-0.07	-0.15	-0.12	-0.07	0.00	0.00	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0
	C			1	1	S	125.4	125.4	125.25	2	0	125.47	125.51	125.49	125.51	125.51	-125.25	0.22	0.26	0.24	0.26	0.26	0.00	0.07	0.11	0.09	0.11	0.11	0.00	0.00	0.00	0.07	0.11	0.09	0.11	0.11	0.00	0.00	$ -		$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1
	C			1	1	S	125.42	125.42	125.2	2	125.32	125.38	125.45	125.37	125.40	125.43	0.12	0.18	0.25	0.17	0.20	0.23	-0.10	-0.04	0.03	-0.05	-0.02	0.01	0.00	0.00	-0.10	-0.04	0.03	-0.05	-0.02	0.01	0.00	0.00	$ 8,375	0	$ 22,361	0	$ 67,084	1	$ 22,361	0	$ 22,361	0	$ 67,084	1
	C			1	1	S	125.31	125.31	124.98	2	125.32	125.38	125.45	125.37	125.40	125.45	0.34	0.40	0.47	0.39	0.42	0.47	0.01	0.07	0.14	0.06	0.09	0.14	0.00	0.00	0.01	0.07	0.14	0.06	0.09	0.14	0.00	0.00	$ 67,084	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1
	C			1	1	S	125.33	125.33	124.93	2	125.34	125.47	125.51	125.48	125.51	125.51	0.41	0.54	0.58	0.55	0.58	0.58	0.01	0.14	0.18	0.15	0.18	0.18	0.00	0.00	0.01	0.14	0.18	0.15	0.18	0.18	0.00	0.00	$ 67,084	1	$ 147,987	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1
	C			1	1	S	125.21	125.21	125.01	2	125.41	125.47	125.51	125.49	125.51	125.51	0.4	0.46	0.50	0.48	0.50	0.50	0.20	0.26	0.30	0.28	0.30	0.30	0.00	0.00	0.20	0.26	0.30	0.28	0.30	0.30	0.00	0.00	$ 155,164	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1
	C			1	1	S	125.21	125.21	125.01	2	125.41	125.47	125.51	125.49	125.51	125.51	0.4	0.46	0.50	0.48	0.50	0.50	0.20	0.26	0.30	0.28	0.30	0.30	0.00	0.00	0.20	0.26	0.30	0.28	0.30	0.30	0.00	0.00	$ 155,164	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1
	C			2	1	S	125.32	125.32	125.01	2	125.32	125.47	125.51	125.49	125.51	125.51	0.31	0.46	0.50	0.48	0.50	0.50	0.00	0.15	0.19	0.17	0.19	0.19	0.00	0.00	0.00	0.15	0.19	0.17	0.19	0.19	0.00	0.00	$ 22,361	0	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1
	C			1	1	S	125.89	125.89	124.93	1	125.43	125.47	125.52	125.48	125.52	125.52	0.5	0.54	0.59	0.55	0.59	0.59	-0.46	-0.42	-0.37	-0.41	-0.37	-0.37	0.00	0.00	-0.46	-0.42	-0.37	-0.41	-0.37	-0.37	0.00	0.00	$ 22,038	0	$ 22,830	0	$ 22,830	0	$ 22,830	0	$ 22,830	0	$ 22,830	0
	C			1	1	S	125.57	125.57	125.25	2	125.59	125.59	125.62	125.58	125.62	125.62	0.34	0.34	0.37	0.33	0.37	0.37	0.02	0.02	0.05	0.01	0.05	0.05	0.00	0.00	0.02	0.02	0.05	0.01	0.05	0.05	0.00	0.00	$ 67,084	1	$ 67,084	1	$ 147,987	1	$ 67,084	1	$ 147,987	1	$ 147,987	1
	C			2	1	s	125.2	125.2	125.13	2	125.43	125.47	125.51	125.47	125.51	125.51	0.3	0.34	0.38	0.34	0.38	0.38	0.23	0.27	0.31	0.27	0.31	0.31	0.00	0.00	0.23	0.27	0.31	0.27	0.31	0.31	0.00	0.00	$ 155,164	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1
	C			2	1	P	126.12	126.12	125.68	2	125.9	125.92	125.93	125.93	125.93	125.93	0.22	0.24	0.25	0.25	0.25	0.25	-0.22	-0.20	-0.19	-0.19	-0.19	-0.19	0.00	0.00	-0.22	-0.20	-0.19	-0.19	-0.19	-0.19	0.00	0.00	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0
	C			2	1	S	125.71	125.71	125.63	2	125.79	125.81	125.82	125.81	125.82	125.82	0.16	0.18	0.19	0.18	0.19	0.19	0.08	0.10	0.11	0.10	0.11	0.11	0.00	0.00	0.08	0.10	0.11	0.10	0.11	0.11	0.00	0.00	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1
	C			1	1	S	127.29	127.29	126.44	1	126.55	126.55	126.55	126.53	126.55	126.55	0.11	0.11	0.11	0.09	0.11	0.11	-0.74	-0.74	-0.74	-0.76	-0.74	-0.74	0.00	0.00	-0.74	-0.74	-0.74	-0.76	-0.74	-0.74	0.00	0.00	$ 20,454	0	$ 20,454	0	$ 20,454	0	$ 19,662	0	$ 20,454	0	$ 20,454	0
	C			1	1	S	126.01	126.01	126	2	126.39	126.39	126.40	126.36	126.40	126.40	0.39	0.39	0.40	0.36	0.40	0.40	0.38	0.38	0.39	0.35	0.39	0.39	0.00	0.00	0.38	0.38	0.39	0.35	0.39	0.39	0.00	0.00	$ 169,520	1	$ 169,520	1	$ 169,520	1	$ 162,342	1	$ 169,520	1	$ 169,520	1
	C			1	1	S	126.16	126.16	126.02	2	126.36	126.37	126.38	126.33	126.37	126.37	0.34	0.35	0.36	0.31	0.35	0.35	0.20	0.21	0.22	0.17	0.21	0.21	0.00	0.00	0.20	0.21	0.22	0.17	0.21	0.21	0.00	0.00	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1
	C			1	1	S	127.35	127.35	127.33	2	127.54	127.54	127.54	127.44	127.54	127.54	0.21	0.21	0.21	0.11	0.21	0.21	0.19	0.19	0.19	0.09	0.19	0.19	0.00	0.00	0.19	0.19	0.19	0.09	0.19	0.19	0.00	0.00	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 147,987	1	$ 155,164	1	$ 155,164	1
	C			3	1	S	127.55	127.55	127.3	2	127.49	127.49	127.49	127.43	127.49	127.49	0.19	0.19	0.19	0.13	0.19	0.19	-0.06	-0.06	-0.06	-0.12	-0.06	-0.06	0.00	0.00	-0.06	-0.06	-0.06	-0.12	-0.06	-0.06	0.00	0.00	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ 8,375	0
	C			1	1	S	127.82	127.82	127.61	2	127.6	127.60	127.60	127.60	127.60	127.60	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	0.00	0.00	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	127.79	127.79	127.7	2	127.62	127.62	127.62	127.62	127.62	127.62	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.17	-0.17	-0.17	-0.17	-0.17	-0.17	0.00	0.00	-0.17	-0.17	-0.17	-0.17	-0.17	-0.17	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	127.49	127.49	127.47	2	127.63	127.63	127.63	127.63	127.63	127.63	0.16	0.16	0.16	0.16	0.16	0.16	0.14	0.14	0.14	0.14	0.14	0.14	0.00	0.00	0.14	0.14	0.14	0.14	0.14	0.14	0.00	0.00	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1
	C			1	1	S	127.57	127.57	127.52	2	127.63	127.63	127.63	127.63	127.63	127.63	0.11	0.11	0.11	0.11	0.11	0.11	0.06	0.06	0.06	0.06	0.06	0.06	0.00	0.00	0.06	0.06	0.06	0.06	0.06	0.06	0.00	0.00	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1
	C			1	1	S	127.71	127.71	127.68	2	127.67	127.67	127.67	127.67	127.67	127.67	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	0.00	0.00	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			2	1	S	127.15	127.15	126.81	2	127.17	127.17	127.17	127.14	127.17	127.17	0.36	0.36	0.36	0.33	0.36	0.36	0.02	0.02	0.02	-0.01	0.02	0.02	0.00	0.00	0.02	0.02	0.02	-0.01	0.02	0.02	0.00	0.00	$ 67,084	1	$ 67,084	1	$ 67,084	1	$ 22,361	0	$ 67,084	1	$ 67,084	1
	C			1	1	S	127.12	127.12	127	2	127.24	127.24	127.24	127.24	127.24	127.24	0.24	0.24	0.24	0.24	0.24	0.24	0.12	0.12	0.12	0.12	0.12	0.12	0.00	0.00	0.12	0.12	0.12	0.12	0.12	0.12	0.00	0.00	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1
	C			1 + Shed	1	S	127.17	127.17	127.12	2	127.24	127.24	127.24	127.24	127.24	127.24	0.12	0.12	0.12	0.12	0.12	0.12	0.07	0.07	0.07	0.07	0.07	0.07	0.00	0.00	0.07	0.07	0.07	0.07	0.07	0.07	0.00	0.00	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1
	C			2	1	S	127	127	127	2	127.24	127.24	127.24	127.24	127.24	127.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.00	0.00	0.24	0.24	0.24	0.24	0.24	0.24	0.00	0.00	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1
	C			1	1	S	127.17	127.17	127	2	127.24	127.24	127.24	127.24	127.24	127.24	0.24	0.24	0.24	0.24	0.24	0.24	0.07	0.07	0.07	0.07	0.07	0.07	0.00	0.00	0.07	0.07	0.07	0.07	0.07	0.07	0.00	0.00	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1
	C			1	1	S	126.91	126.91	126.9	2	127.24	127.24	127.24	127.24	127.24	127.24	0.34	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33	0.33	0.33	0.33	0.00	0.00	0.33	0.33	0.33	0.33	0.33	0.33	0.00	0.00	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1
	C			1	1	S	127.12	127.12	127.07	2	127.26	127.26	127.26	127.26	127.26	127.26	0.19	0.19	0.19	0.19	0.19	0.19	0.14	0.14	0.14	0.14	0.14	0.14	0.00	0.00	0.14	0.14	0.14	0.14	0.14	0.14	0.00	0.00	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1
	C			1	1	S	126.87	126.87	126.58	2	126.92	126.92	126.92	126.92	126.92	126.92	0.34	0.34	0.34	0.34	0.34	0.34	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.00	$ 67,084	1	$ 67,084	1	$ 67,084	1	$ 67,084	1	$ 67,084	1	$ 67,084	1
	C			1	1	S	126.83	126.83	126.77	2	126.84	126.84	126.84	126.83	126.84	126.84	0.07	0.07	0.07	0.06	0.07	0.07	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.00	$ 67,084	1	$ 67,084	1	$ 67,084	1	$ 22,361	0	$ 67,084	1	$ 67,084	1
	C			2	1	S	126.6	126.6	126.53	2	126.83	126.83	126.83	126.81	126.83	126.83	0.3	0.30	0.30	0.28	0.30	0.30	0.23	0.23	0.23	0.21	0.23	0.23	0.00	0.00	0.23	0.23	0.23	0.21	0.23	0.23	0.00	0.00	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1
	C			1	1	S	126.36	126.36	126.32	2	126.83	126.83	126.83	126.81	126.83	126.83	0.51	0.51	0.51	0.49	0.51	0.51	0.47	0.47	0.47	0.45	0.47	0.47	0.00	0.00	0.47	0.47	0.47	0.45	0.47	0.47	0.00	0.00	$ 176,697	1	$ 176,697	1	$ 176,697	1	$ 176,697	1	$ 176,697	1	$ 176,697	1
	C			1	1	S	126.7	126.7	126.67	2	126.83	126.83	126.83	126.81	126.83	126.83	0.16	0.16	0.16	0.14	0.16	0.16	0.13	0.13	0.13	0.11	0.13	0.13	0.00	0.00	0.13	0.13	0.13	0.11	0.13	0.13	0.00	0.00	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1
	C			1	1	s	126.98	126.98	126.82	2	126.83	126.83	126.83	126.81	126.83	126.83	0.01	0.01	0.01	-0.01	0.01	0.01	-0.15	-0.15	-0.15	-0.17	-0.15	-0.15	0.00	0.00	-0.15	-0.15	-0.15	-0.17	-0.15	-0.15	0.00	0.00	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ -		$ 8,375	0	$ 8,375	0
	C			1	1	S	126.28	126.28	126.28	2	126.83	126.83	126.83	126.81	126.83	126.83	0.55	0.55	0.55	0.53	0.55	0.55	0.55	0.55	0.55	0.53	0.55	0.55	0.00	0.00	0.55	0.55	0.55	0.53	0.55	0.55	0.00	0.00	$ 176,697	1	$ 176,697	1	$ 176,697	1	$ 176,697	1	$ 176,697	1	$ 176,697	1
	C			1	1	S	126.62	126.62	126.49	2	126.83	126.83	126.83	126.81	126.83	126.83	0.34	0.34	0.34	0.32	0.34	0.34	0.21	0.21	0.21	0.19	0.21	0.21	0.00	0.00	0.21	0.21	0.21	0.19	0.21	0.21	0.00	0.00	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1
	C			3	1	S	125.69	125.69	125.48	2	125.93	125.93	125.93	125.85	125.93	125.93	0.45	0.45	0.45	0.37	0.45	0.45	0.24	0.24	0.24	0.16	0.24	0.24	0.00	0.00	0.24	0.24	0.24	0.16	0.24	0.24	0.00	0.00	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1	$ 155,164	1
	C			3	1	S	125.74	125.74	125.72	2	126.17	126.17	126.17	126.16	126.17	126.17	0.45	0.45	0.45	0.44	0.45	0.45	0.43	0.43	0.43	0.42	0.43	0.43	0.00	0.00	0.43	0.43	0.43	0.42	0.43	0.43	0.00	0.00	$ 169,520	1	$ 169,520	1	$ 169,520	1	$ 169,520	1	$ 169,520	1	$ 169,520	1
	C			1	1	S	125.6	125.6	125.48	2	125.93	125.93	125.93	125.85	125.93	125.93	0.45	0.45	0.45	0.37	0.45	0.45	0.33	0.33	0.33	0.25	0.33	0.33	0.00	0.00	0.33	0.33	0.33	0.25	0.33	0.33	0.00	0.00	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 162,342	1
	C			1	1	S	125.97	125.97	125.85	2	125.96	125.96	125.96	125.89	125.96	125.96	0.11	0.11	0.11	0.04	0.11	0.11	-0.01	-0.01	-0.01	-0.08	-0.01	-0.01	0.00	0.00	-0.01	-0.01	-0.01	-0.08	-0.01	-0.01	0.00	0.00	$ 22,361	0	$ 22,361	0	$ 22,361	0	$ 8,375	0	$ 22,361	0	$ 22,361	0
	C			1	1	S	125.85	125.85	125.79	2	125.96	125.96	125.96	125.89	125.96	125.96	0.17	0.17	0.17	0.10	0.17	0.17	0.11	0.11	0.11	0.04	0.11	0.11	0.00	0.00	0.11	0.11	0.11	0.04	0.11	0.11	0.00	0.00	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 67,084	1	$ 147,987	1	$ 147,987	1
	C			2	1	S	125.63	125.63	125.56	2	125.93	125.93	125.93	125.85	125.93	125.93	0.37	0.37	0.37	0.29	0.37	0.37	0.30	0.30	0.30	0.22	0.30	0.30	0.00	0.00	0.30	0.30	0.30	0.22	0.30	0.30	0.00	0.00	$ 162,342	1	$ 162,342	1	$ 162,342	1	$ 155,164	1	$ 162,342	1	$ 162,342	1
	C			2	1	S	126.13	126.13	125.91	2	125.93	125.93	125.93	125.87	125.93	125.93	0.02	0.02	0.02	-0.04	0.02	0.02	-0.20	-0.20	-0.20	-0.26	-0.20	-0.20	0.00	0.00	-0.20	-0.20	-0.20	-0.26	-0.20	-0.20	0.00	0.00	$ 8,375	0	$ 8,375	0	$ 8,375	0	$ -		$ 8,375	0	$ 8,375	0
	C			1	1	S	126	126	125.95	2	125.93	125.93	125.93	125.86	125.93	125.93	-0.02	-0.02	-0.02	-0.09	-0.02	-0.02	-0.07	-0.07	-0.07	-0.14	-0.07	-0.07	0.00	0.00	-0.07	-0.07	-0.07	-0.14	-0.07	-0.07	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	127.67	127.67	127.5	2	127.26	127.30	127.30	127.30	127.30	127.30	-0.24	-0.20	-0.20	-0.20	-0.20	-0.20	-0.41	-0.37	-0.37	-0.37	-0.37	-0.37	0.00	0.00	-0.41	-0.37	-0.37	-0.37	-0.37	-0.37	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	
	C			1	1	S	126.7	126.7	126.55	2	126.76	126.74	126.83	126.83	126.83	126.83	0.21	0.19	0.28	0.28	0.28	0.28	0.06	0.04	0.13	0.13	0.13	0.13	0.00	0.00	0.06	0.04	0.13	0.13	0.13	0.13	0.00	0.00	$ 147,987	1	$ 67,084	1	$ 147,987	1	$ 147,987	1	$ 147,987	1	$ 147,987	1
	C			1	1	S	127.2	127.2	126.97	2	127.74	127.74	127.74	127.74	127.74	127.74	0.77	0.77	0.77	0.77	0.77	0.77	0.54	0.54	0.54	0.54	0.54	0.54	0.00	0.00	0.54	0.54	0.54	0.54	0.54	0.54	0.00	0.00	$ 176,697	1	$ 176,697	1	$ 176,697	1	$ 176,697	1	$ 176,697	1	$ 176,697	1
	C			0	1	0	139.83	139.83	139.83	2	139.87	139.87	139.87	139.87	139.87	139.87	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.00	0.00	0.04	0.04	0.04	0.04	0.04	0.04	0.00	0.00	$ 67,084	1	$ 67,084	1	$ 67,084	1	$ 67,084	1	$ 67,084	1	$ 67,084	1
	C			3	1	S	128.21	128.21	127.96	2	128.17	128.17	128.17	128.15	128.17	128.17	0.21	0.21	0.21	0.19	0.21	0.21	-0.04	-0.04	-0.04	-0.06	-0.04	-0.04	0.00	0.00	-0.04	-0.04	-0.04	-0.06	-0.04	-0.04	0.00	0.00	$ 22,361	0	$ 22,361	0	$ 22,361	0	$ 8,375	0	$ 22,361	0	$ 22,361	0
	C			1	1	S	126.18	126.18	126.18	2	125.43	125.47	125.51	125.47	125.51	125.51	-0.75	-0.71	-0.67	-0.71	-0.67	-0.67	-0.75	-0.71	-0.67	-0.71	-0.67	-0.67	0.00	0.00	-0.75	-0.71	-0.67	-0.71	-0.67	-0.67	0.00	0.00	$ -		$ -		$ -		$ -		$ -		$ -	

Appendix D

FIGURE D1A
MITIGATION OPTION A
NOORLA ST CHANNEL IMPROVEMENTS

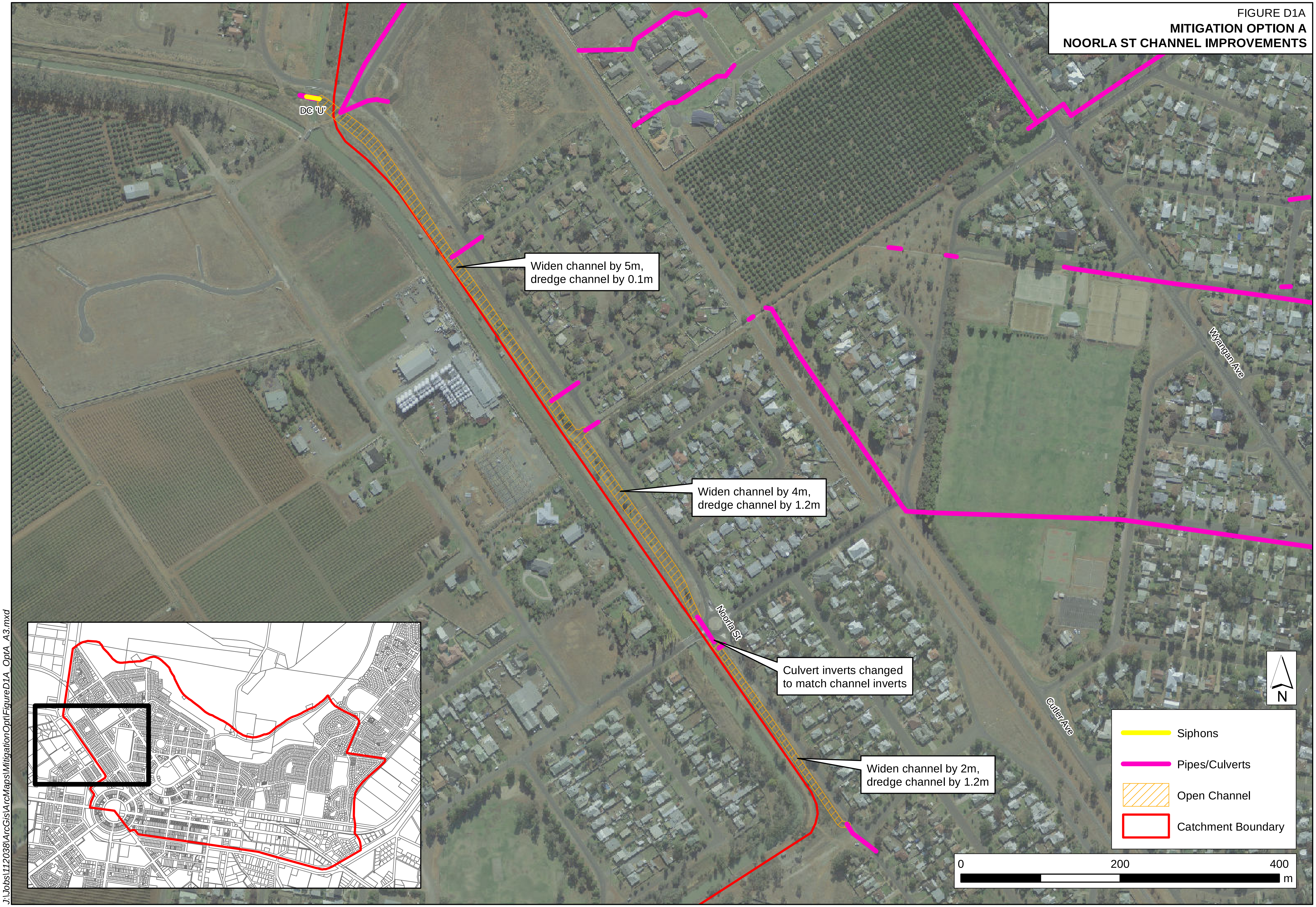
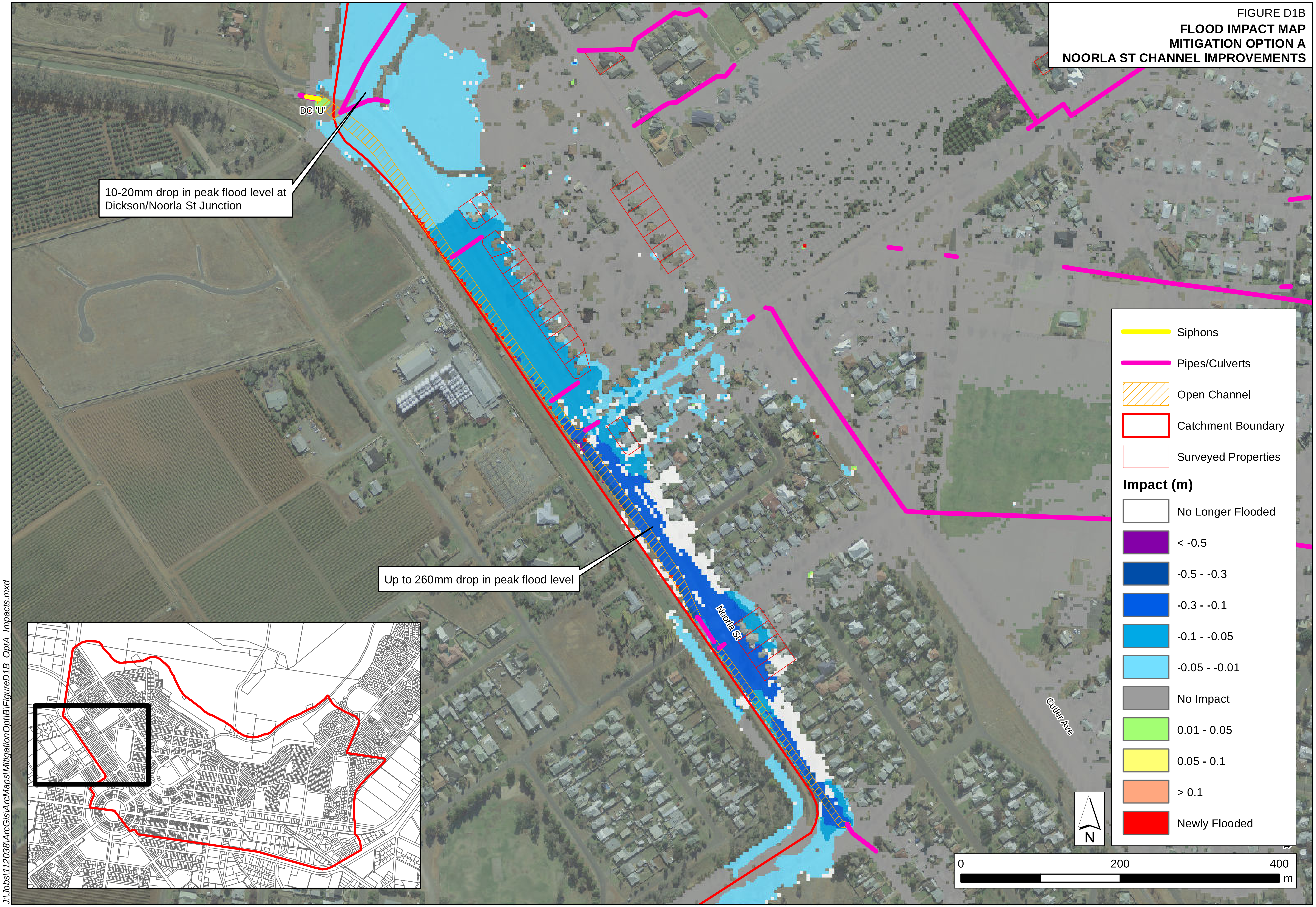


FIGURE D1B
FLOOD IMPACT MAP
MITIGATION OPTION A
NOORLA ST CHANNEL IMPROVEMENTS



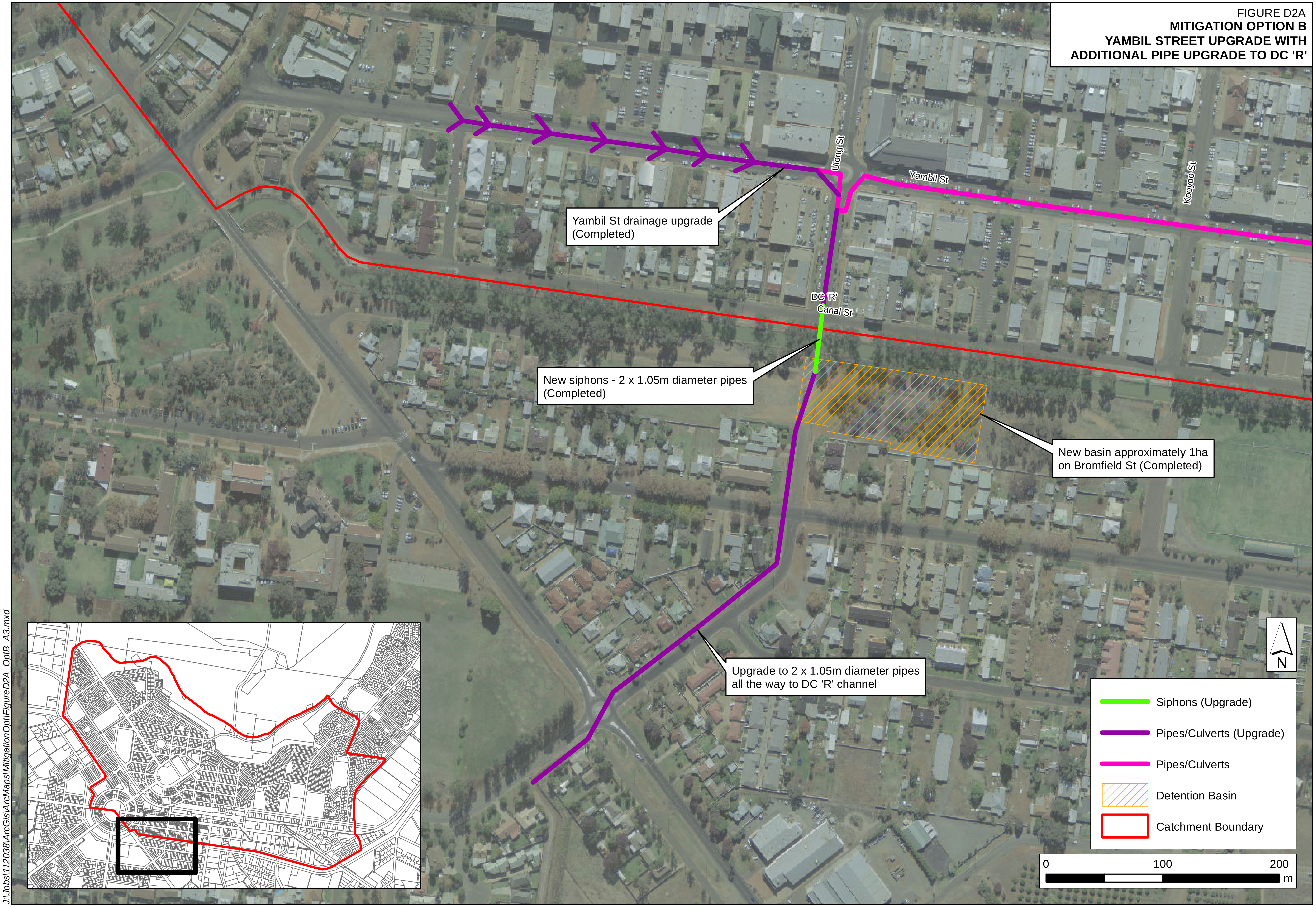


FIGURE D2A
MITIGATION OPTION B
YAMBIL STREET UPGRADE WITH
ADDITIONAL PIPE UPGRADE TO DC 'R'
Yambil St drainage upgrade
(Completed)
Ulong St
Yambil St
Kooyoo St
DC 'R'
Canal St
New siphons - 2 x 1.05m diameter pipes
(Completed)
New basin approximately 1ha
on Bromfield St (Completed)
Upgrade to 2 x 1.05m diameter pipes
all the way to DC 'R' channel
N
Siphons (Upgrade)
Pipes/Culverts (Upgrade)
Pipes/Culverts
Detention Basin
Catchment Boundary
0
100
200
m
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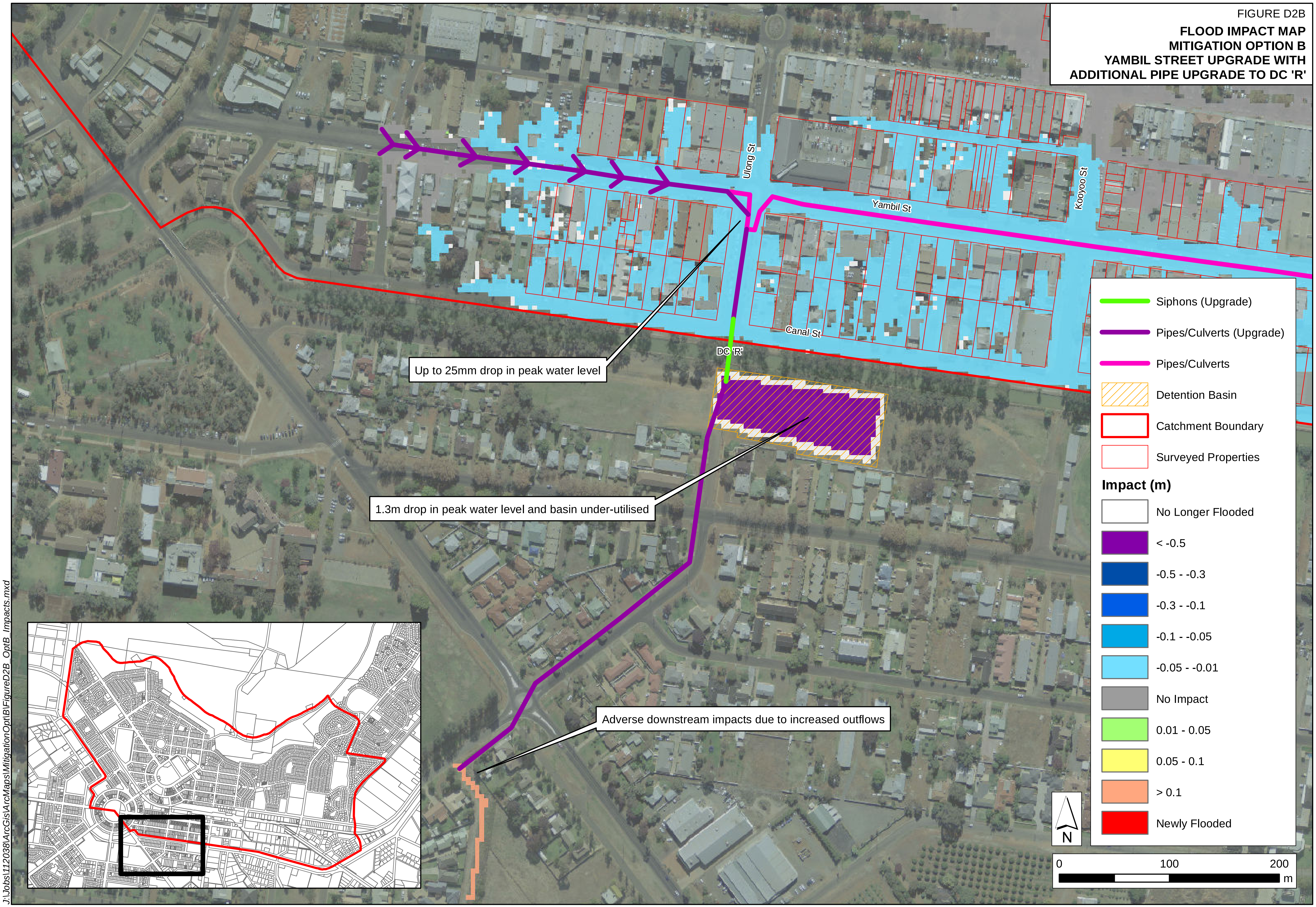
FIGURE D2B
FLOOD IMPACT MAP
MITIGATION OPTION B
YAMBIL STREET UPGRADE WITH
ADDITIONAL PIPE UPGRADE TO DC 'R'
Ulong St
Yambil St
Kooyoo St
Canal St
DC 'R'
Up to 25mm drop in peak water level
1.3m drop in peak water level and basin under-utilised
Adverse downstream impacts due to increased outflows
Siphons (Upgrade)
Pipes/Culverts (Upgrade)
Pipes/Culverts
Detention Basin
Catchment Boundary
Surveyed Properties
Impact (m)
No Longer Flooded
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.05
-0.05 - -0.01
No Impact
0.01 - 0.05
0.05 - 0.1
> 0.1
Newly Flooded
N
0
100
200
m
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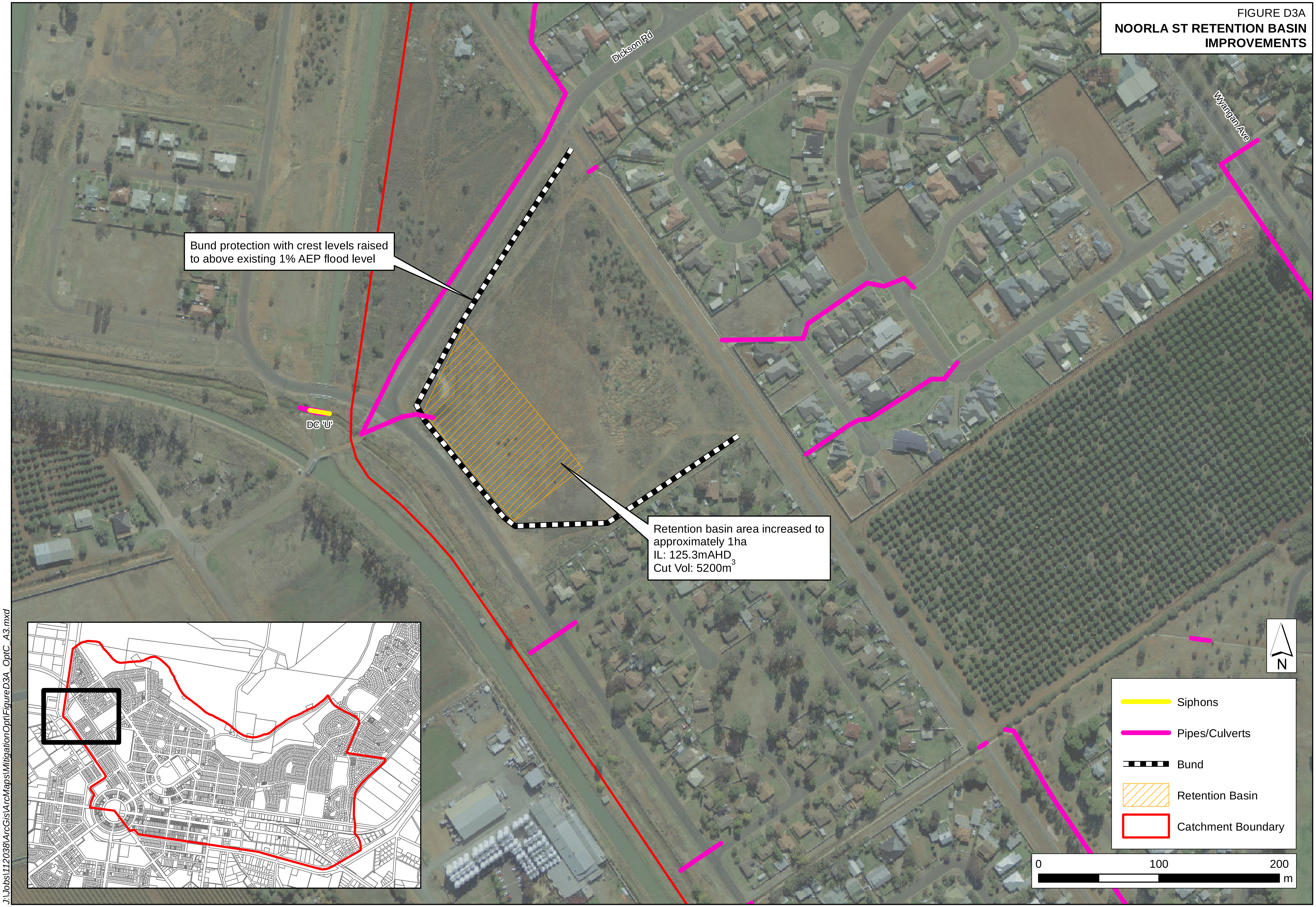
FIGURE D3A
NOORLA ST RETENTION BASIN IMPROVEMENTS



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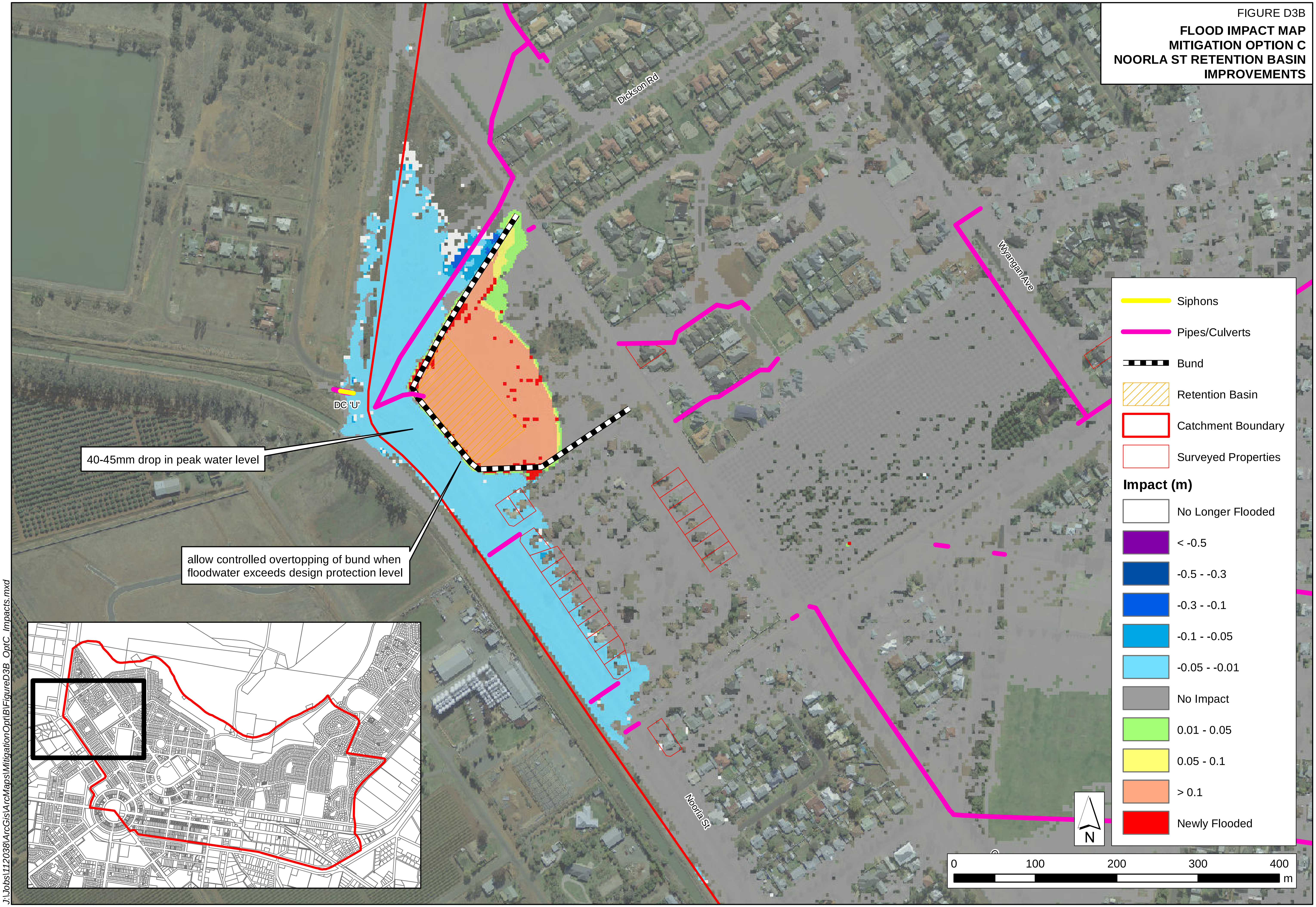

FIGURE D3B
FLOOD IMPACT MAP
MITIGATION OPTION C
NOORLA ST RETENTION BASIN
IMPROVEMENTS
Dickson Rd
Wyangan Ave
Noorla St
DC 'U'
40-45mm drop in peak water level
allow controlled overtopping of bund when
floodwater exceeds design protection level
Siphons
Pipes/Culverts
Bund
Retention Basin
Catchment Boundary
Surveyed Properties
Impact (m)
No Longer Flooded
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.05
-0.05 - -0.01
No Impact
0.01 - 0.05
0.05 - 0.1
> 0.1
Newly Flooded
N
0
100
200
300
400
m
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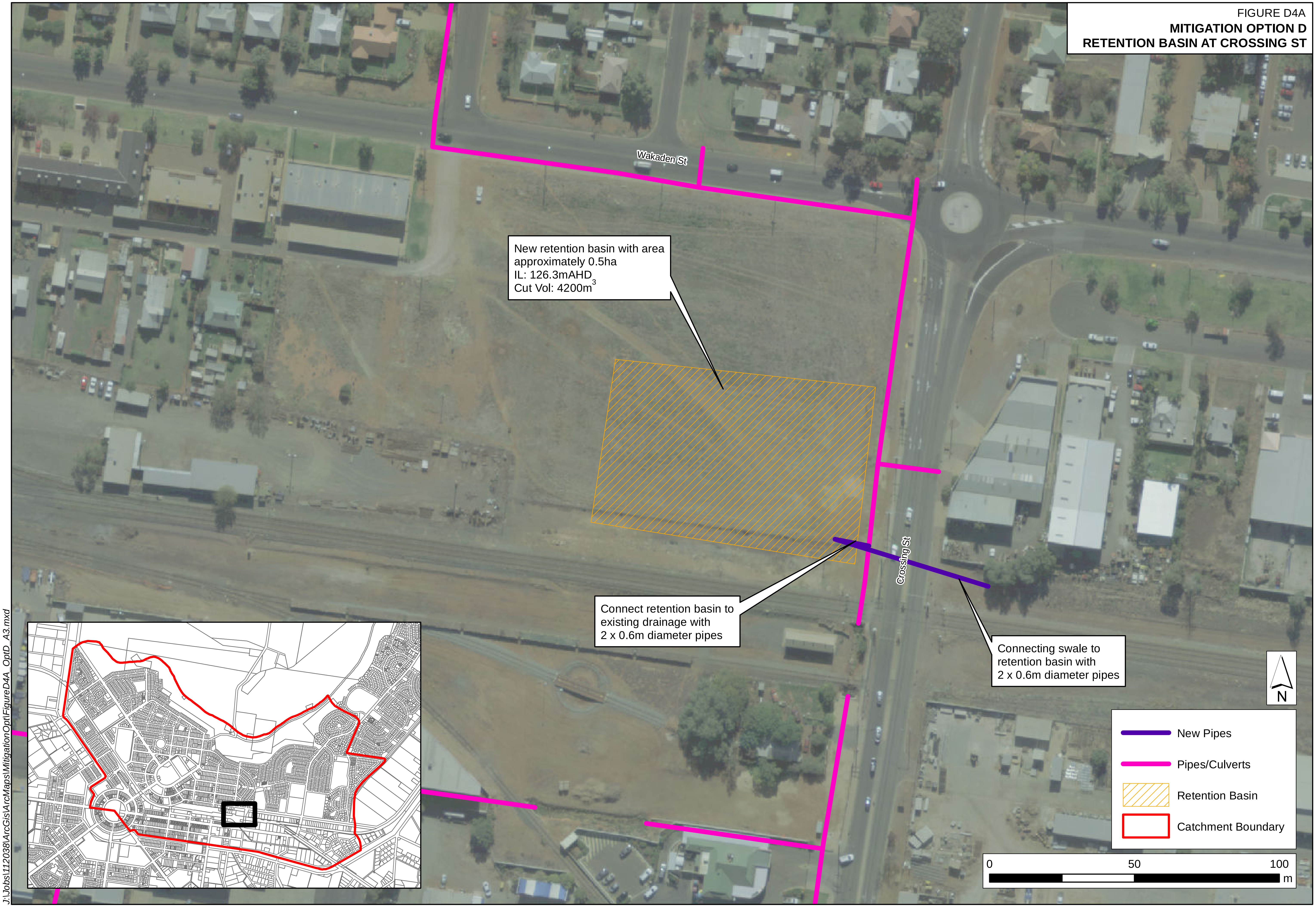


FIGURE D4A
MITIGATION OPTION D
RETENTION BASIN AT CROSSING ST
Wakaden St
Crossing St
New retention basin with area approximately 0.5ha
IL: 126.3mAHD
Cut Vol: 4200m3
Connect retention basin to existing drainage with 2 x 0.6m diameter pipes
Connecting swale to retention basin with 2 x 0.6m diameter pipes
N
New Pipes
Pipes/Culverts
Retention Basin
Catchment Boundary
0
50
100
m
J:\Jobs\112038\ArcGis\ArcMaps\MitigationOpt\FigureD4A_OptD_A3.mxd

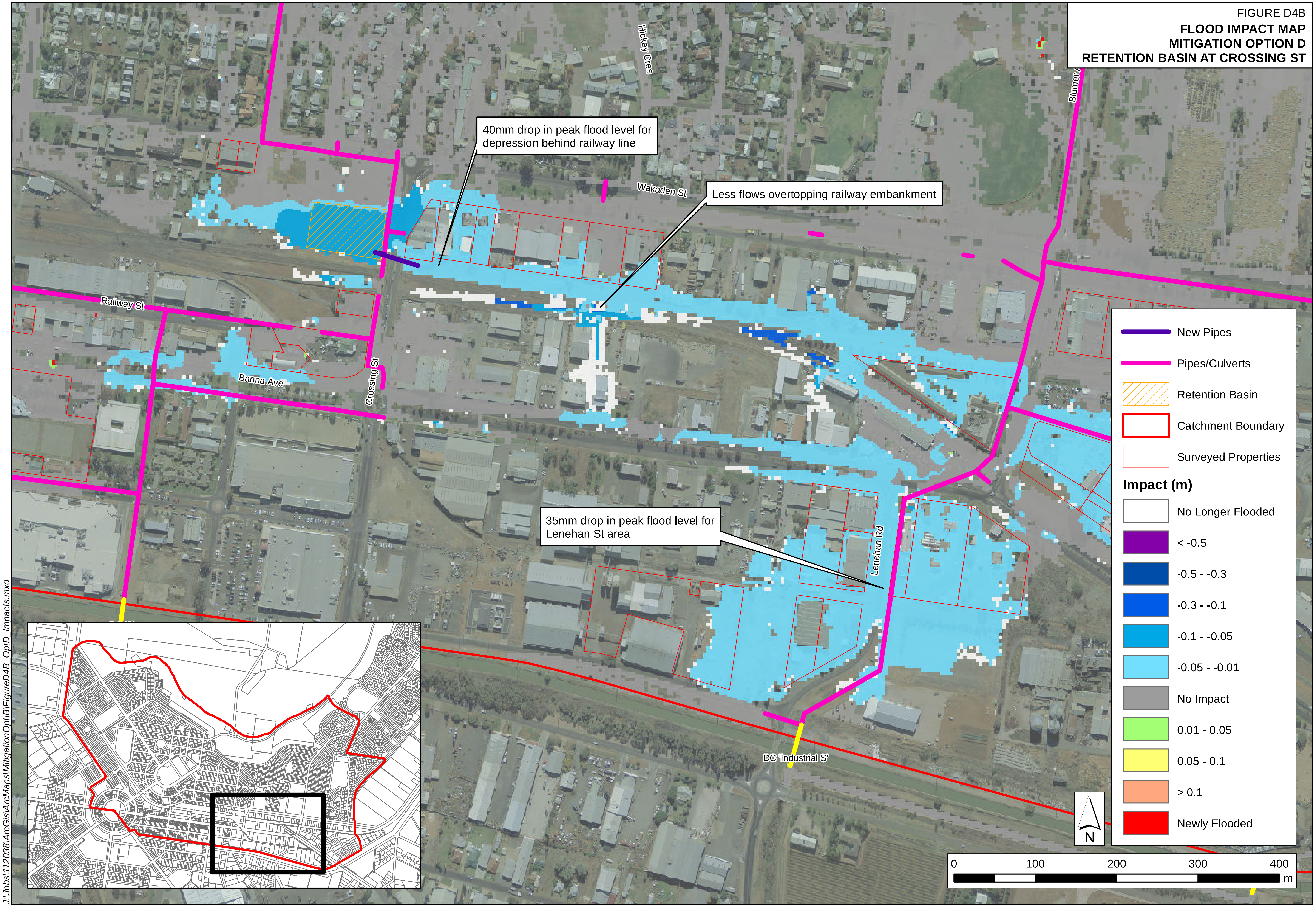
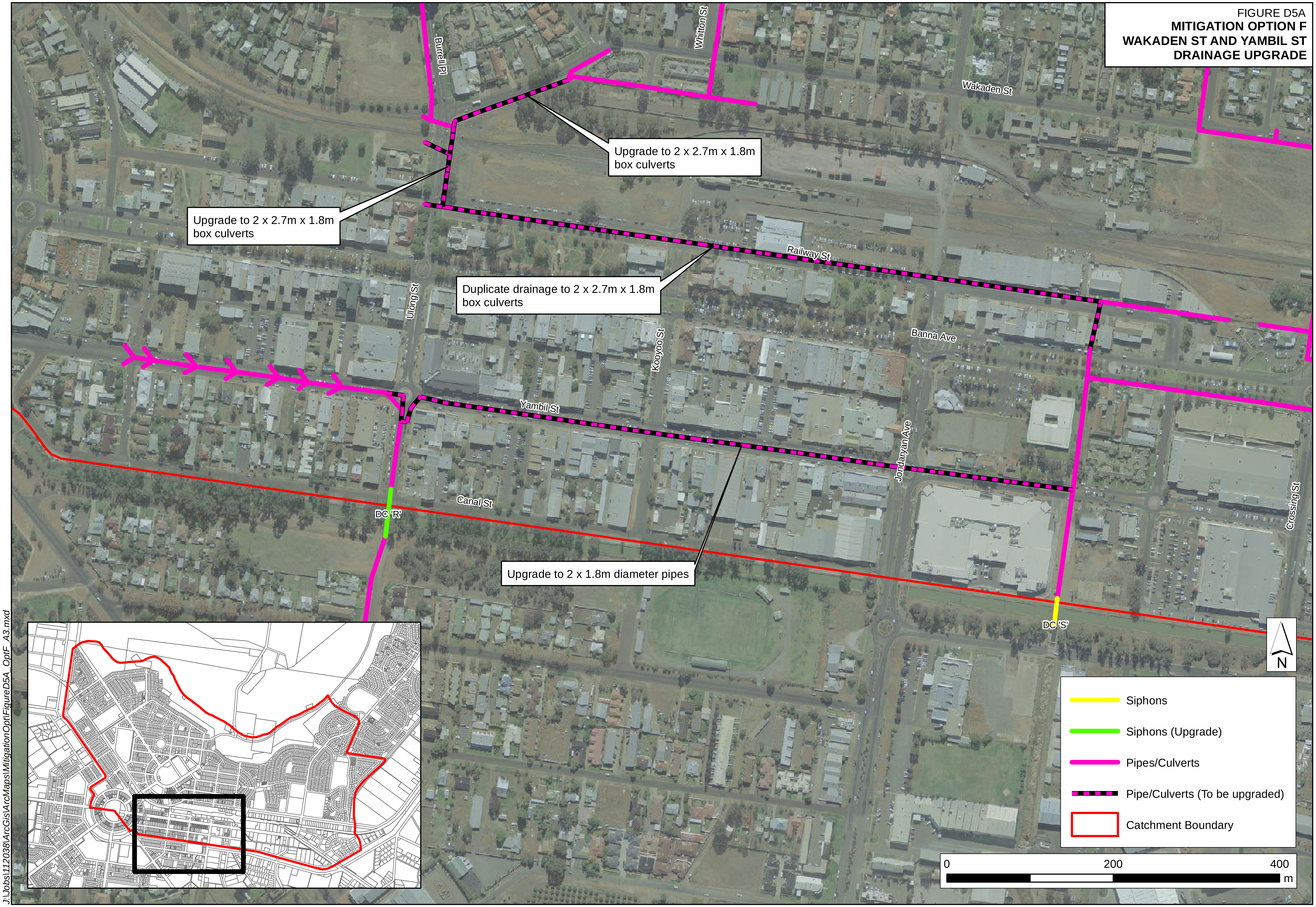


FIGURE D4B
FLOOD IMPACT MAP
MITIGATION OPTION D
RETENTION BASIN AT CROSSING ST

J:\Jobs\112038\ArcGis\ArcMaps\MitigationOpt\B\FigureD4B_OptD_Impacts.mxd



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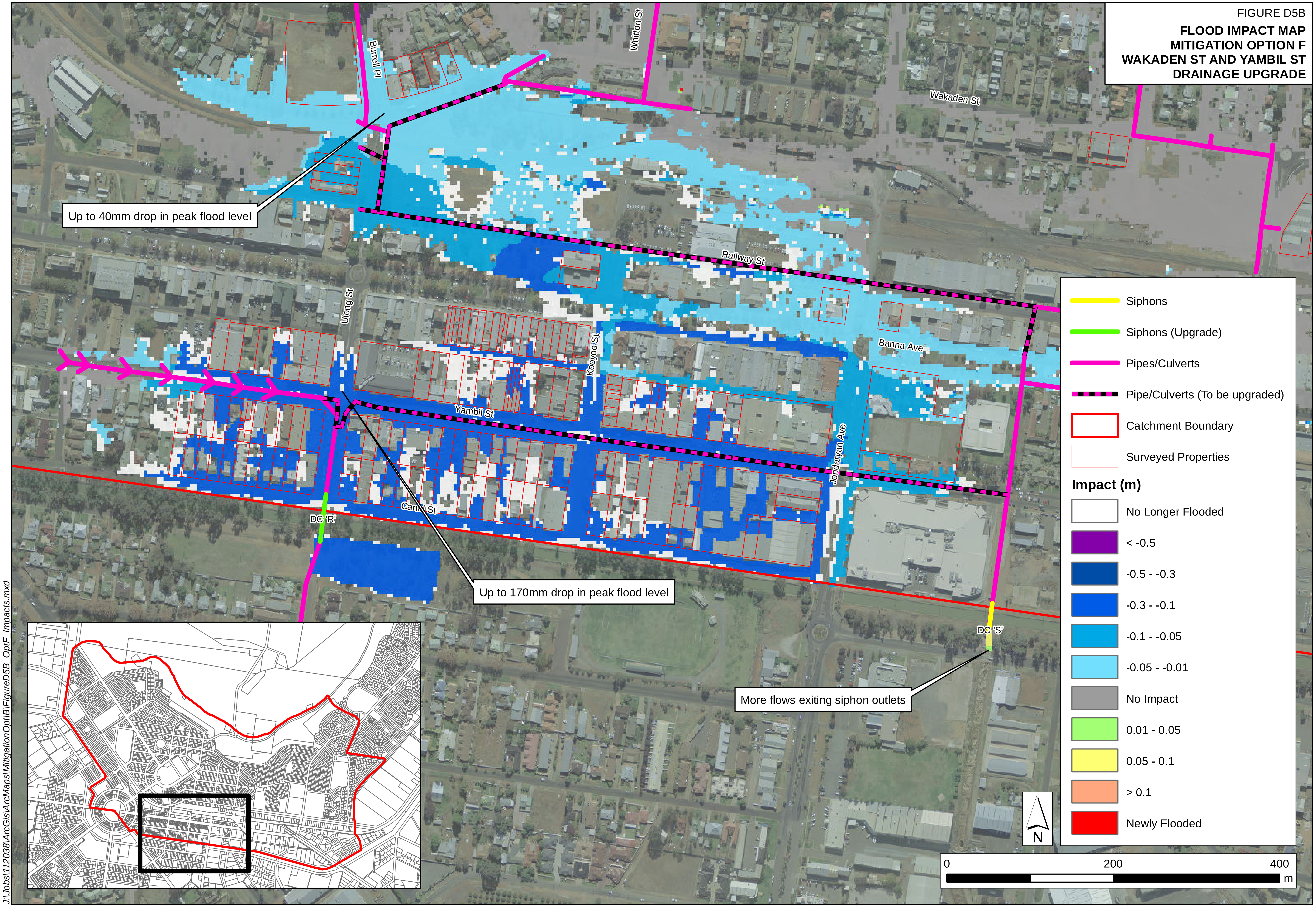
FIGURE D5B
FLOOD IMPACT MAP
MITIGATION OPTION F
WAKADEN ST AND YAMBIL ST
DRAINAGE UPGRADE
Burrell Pl
Whitton St
Wakaden St
Railway St
Banna Ave
Ulong St
Kooyoo St
Yambil St
Jondaryan Ave
Canal St
DC 'R'
DC 'S'
Up to 40mm drop in peak flood level
Up to 170mm drop in peak flood level
More flows exiting siphon outlets
Siphons
Siphons (Upgrade)
Pipes/Culverts
Pipe/Culverts (To be upgraded)
Catchment Boundary
Surveyed Properties
Impact (m)
No Longer Flooded
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.05
-0.05 - -0.01
No Impact
0.01 - 0.05
0.05 - 0.1
> 0.1
Newly Flooded
N
0
200
400
m
J:\Jobs\112038\ArcGis\ArcMaps\MitigationOpt\B\FigureD5B_OptF_Impacts.mxd

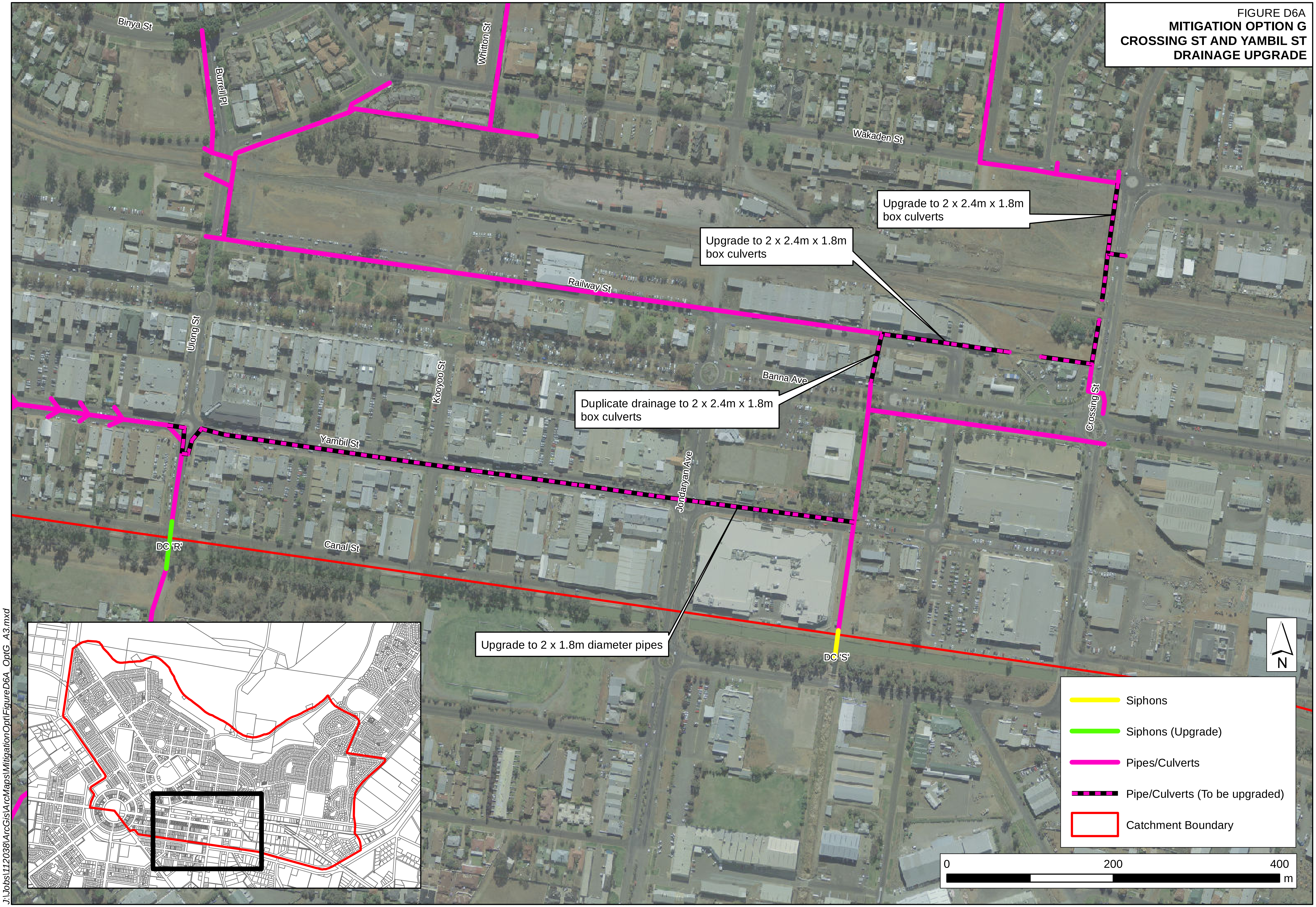

FIGURE D6A
MITIGATION OPTION G
CROSSING ST AND YAMBIL ST
DRAINAGE UPGRADE

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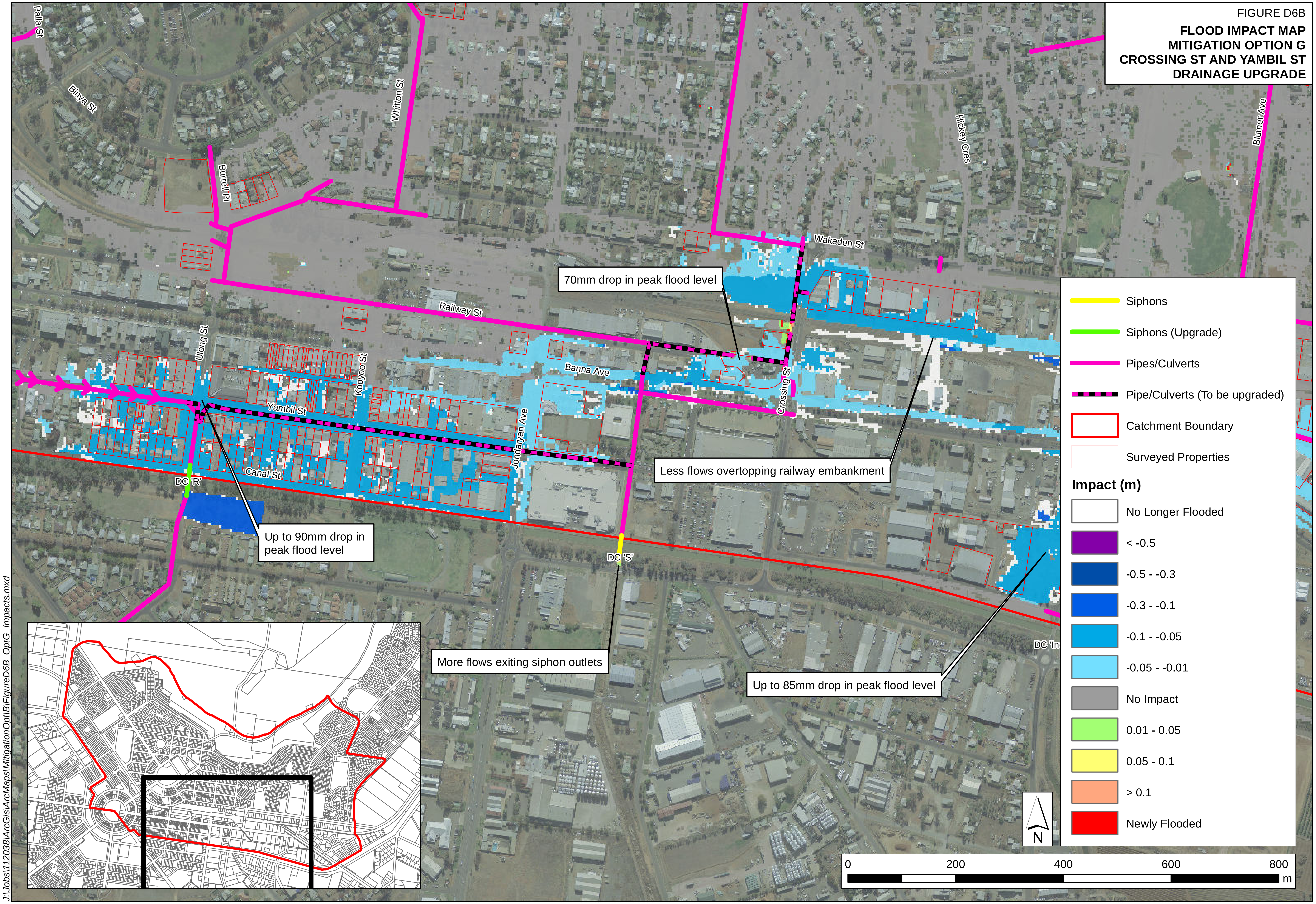

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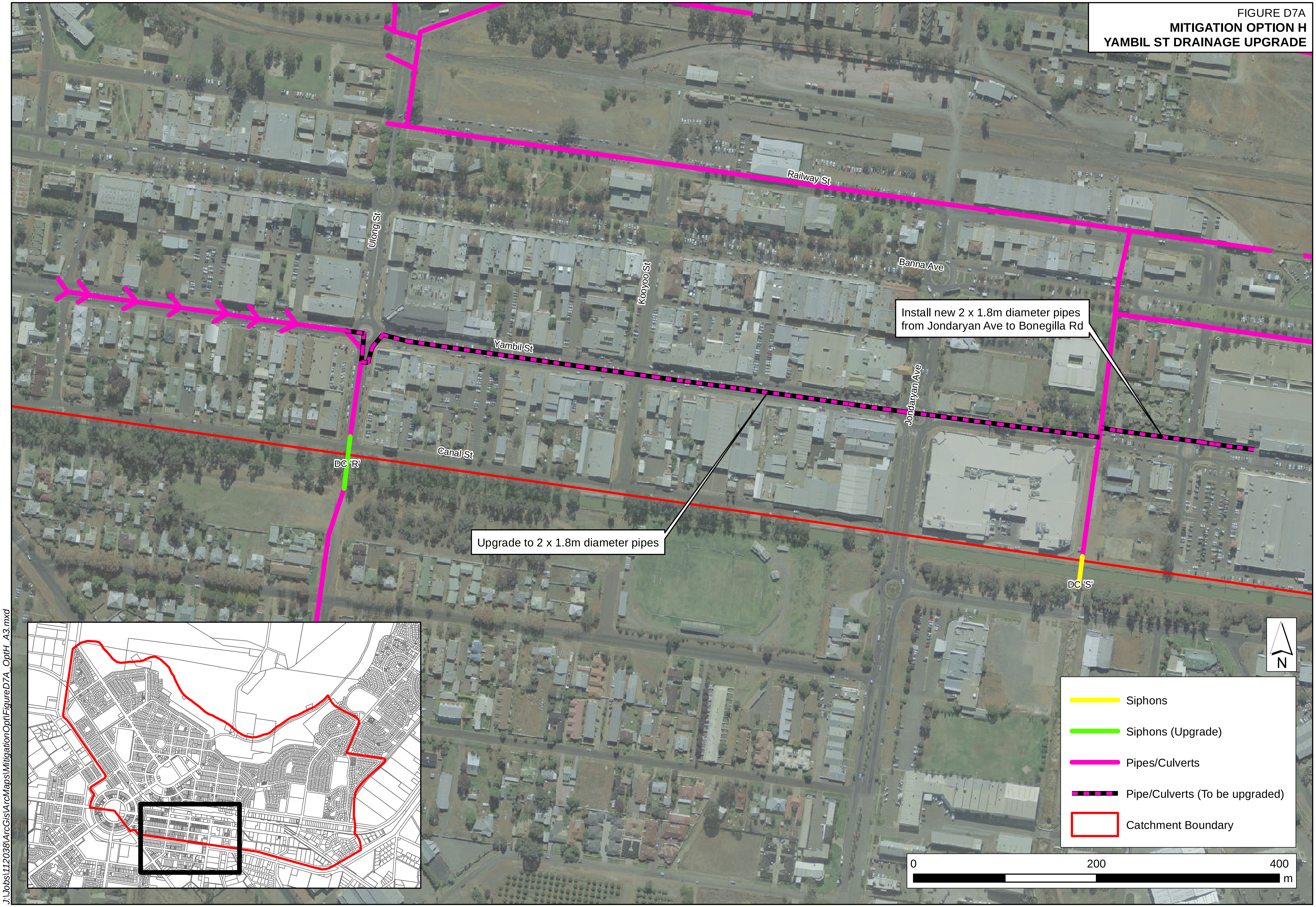
FIGURE D7A
MITIGATION OPTION H
YAMBIL ST DRAINAGE UPGRADE
Railway St
Banna Ave
Ulong St
Kooyoo St
Yambil St
Jondaryan Ave
Canal St
DC 'R'
DC 'S'
Install new 2 x 1.8m diameter pipes from Jondaryan Ave to Bonegilla Rd
Upgrade to 2 x 1.8m diameter pipes
N
Siphons
Siphons (Upgrade)
Pipes/Culverts
Pipe/Culverts (To be upgraded)
Catchment Boundary
0
200
400
m
J:\Jobs\112038\ArcGis\ArcMaps\MitigationOpt\FigureD7A_OptH_A3.mxd

FIGURE D7B
FLOOD IMPACT MAP
MITIGATION OPTION H
YAMBIL ST DRAINAGE UPGRADE

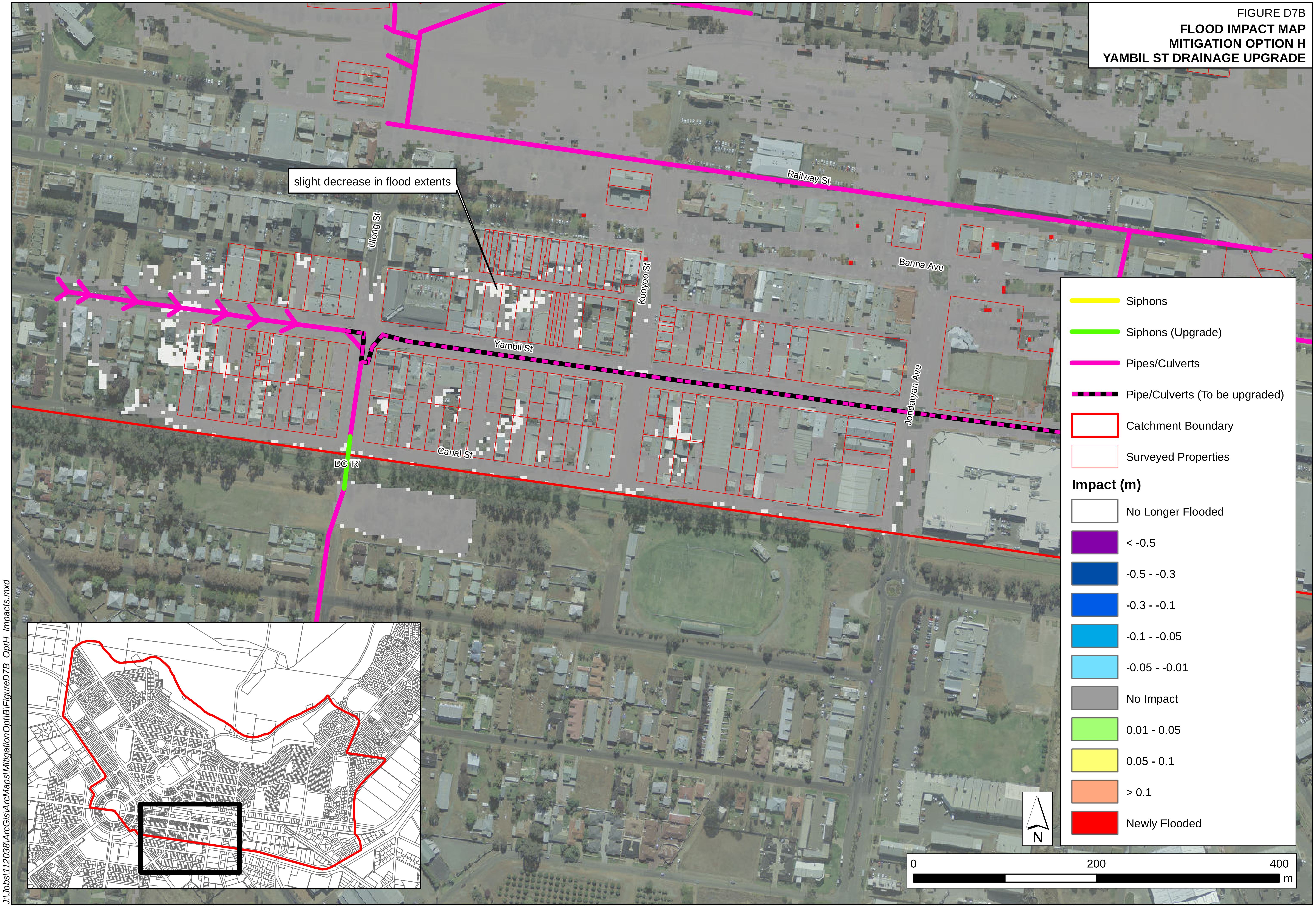

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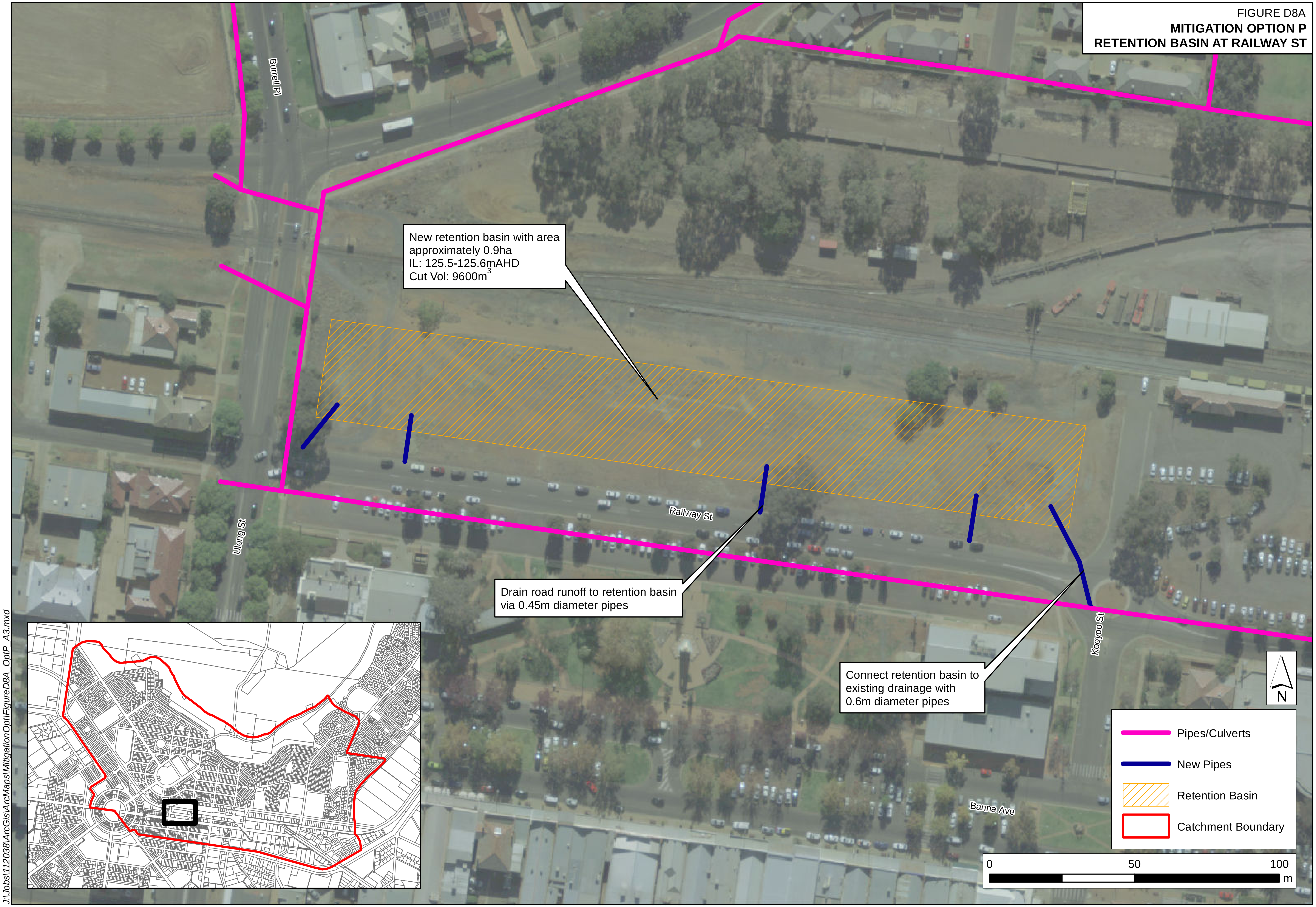
FIGURE D8A
MITIGATION OPTION P
RETENTION BASIN AT RAILWAY ST



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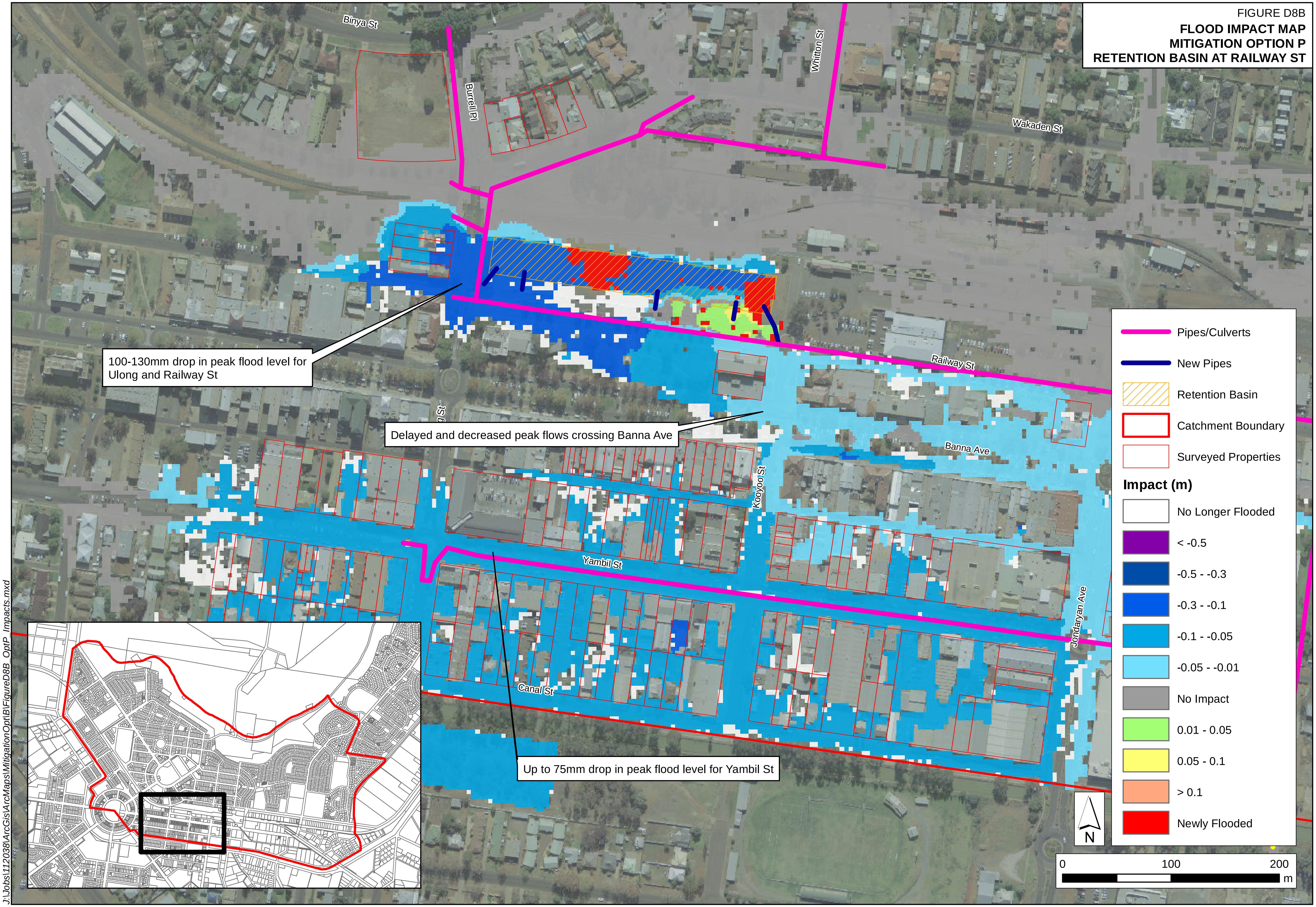

FIGURE D8B
FLOOD IMPACT MAP
MITIGATION OPTION P
RETENTION BASIN AT RAILWAY ST
Binya St
Burrell Pl
Whitton St
Wakaden St
Railway St
Banna Ave
Kooyoo St
Yambil St
Canal St
Jondaryan Ave
100-130mm drop in peak flood level for Ulong and Railway St
Delayed and decreased peak flows crossing Banna Ave
Up to 75mm drop in peak flood level for Yambil St
Pipes/Culverts
New Pipes
Retention Basin
Catchment Boundary
Surveyed Properties
Impact (m)
No Longer Flooded
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.05
-0.05 - -0.01
No Impact
0.01 - 0.05
0.05 - 0.1
> 0.1
Newly Flooded
N
0
100
200
m
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FIGURE D9A

MITIGATION OPTION E

RETENTION BASIN AT APEX PARK

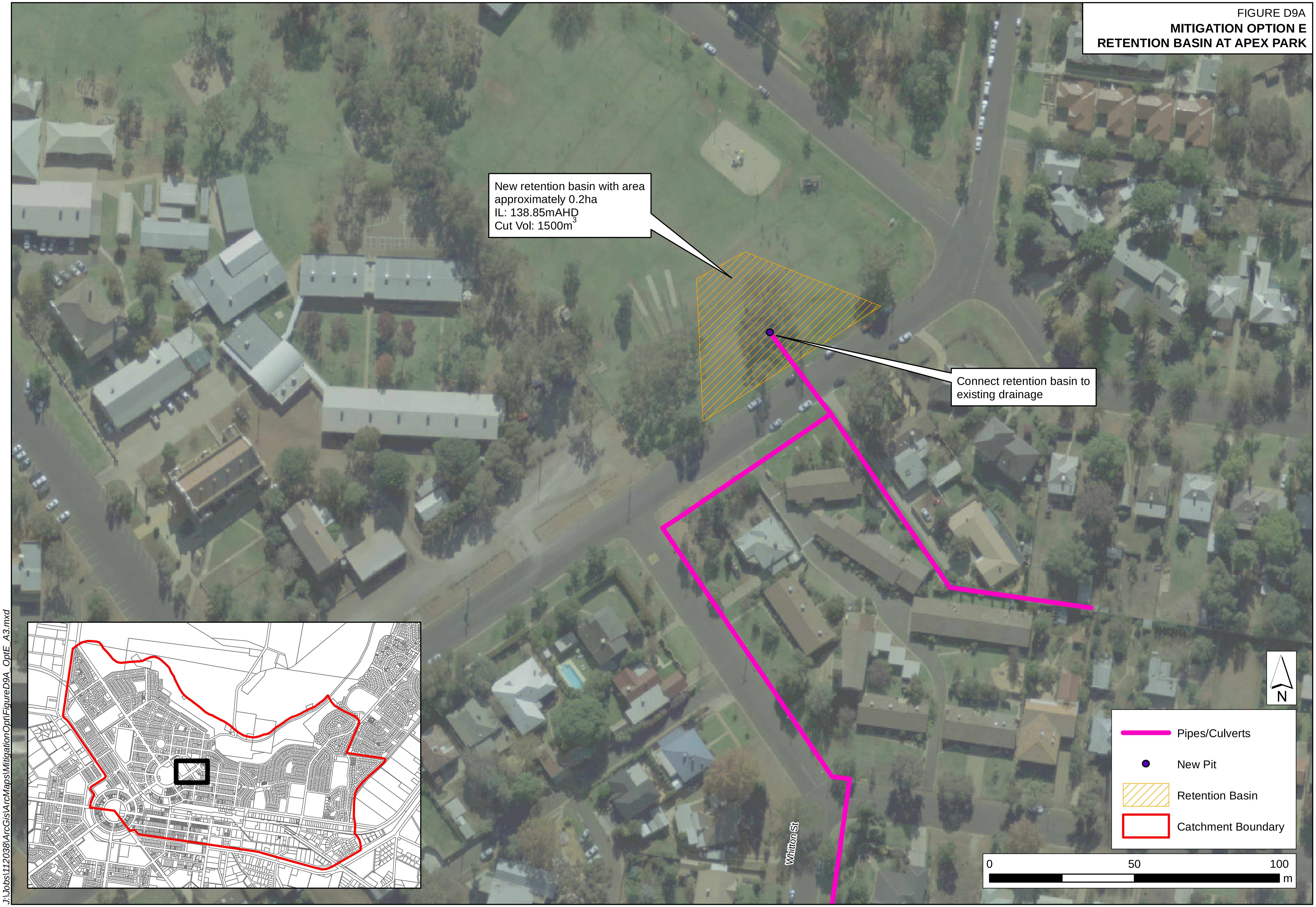

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FIGURE D9B
FLOOD IMPACT MAP
MITIGATION OPTION E
RETENTION BASIN AT APEX PARK

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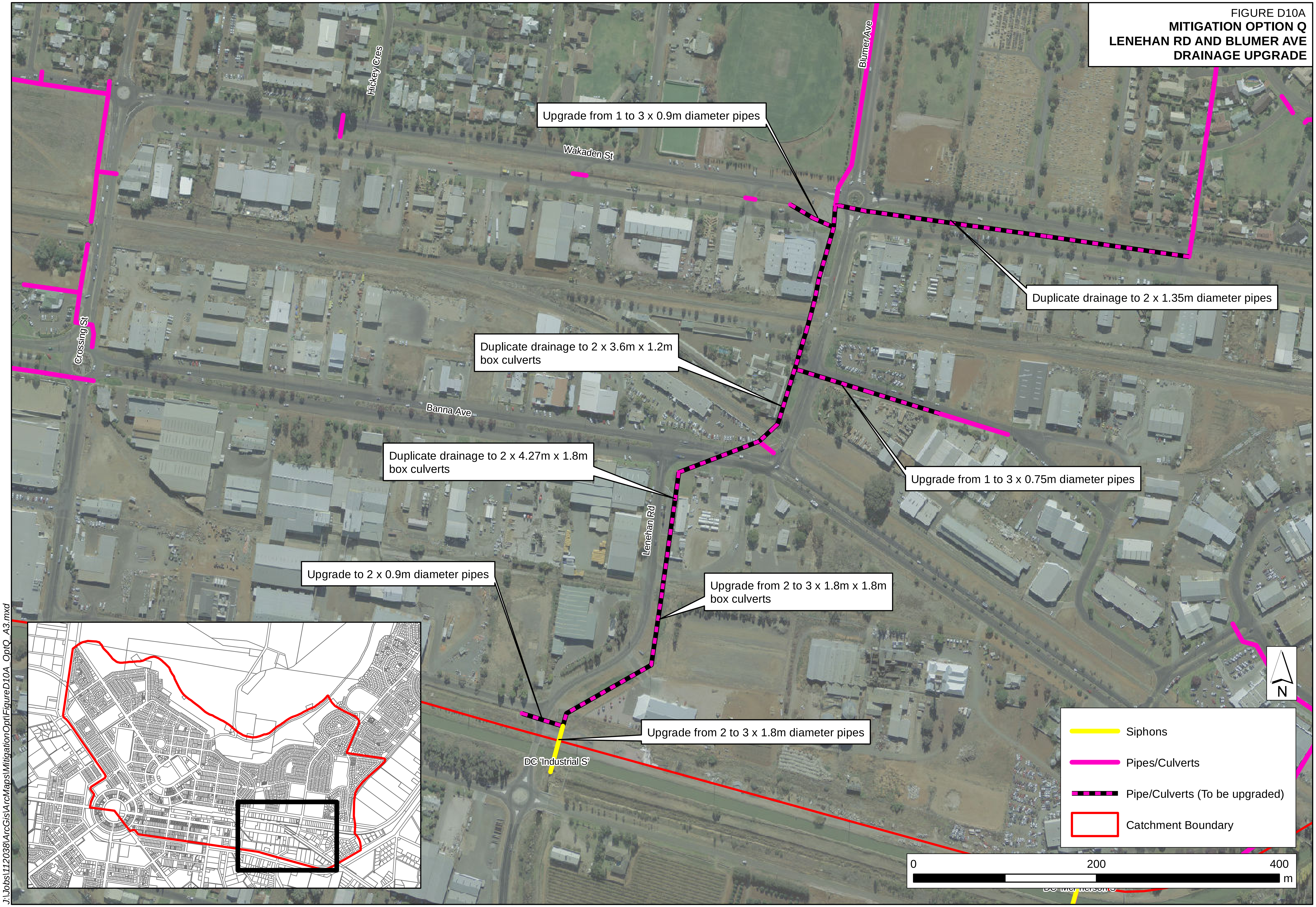
FIGURE D10A
MITIGATION OPTION Q
LENEHAN RD AND BLUMER AVE
DRAINAGE UPGRADE



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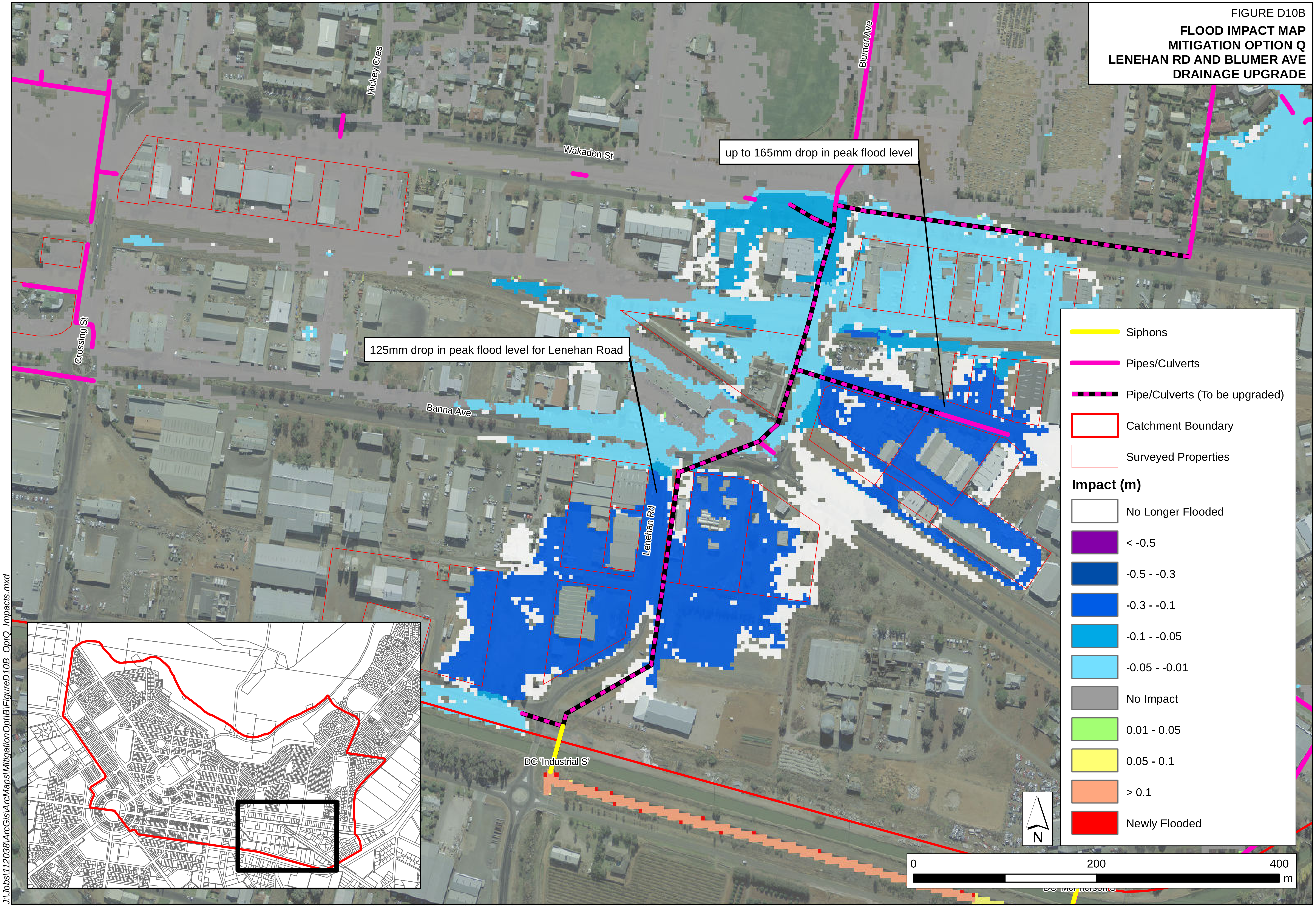
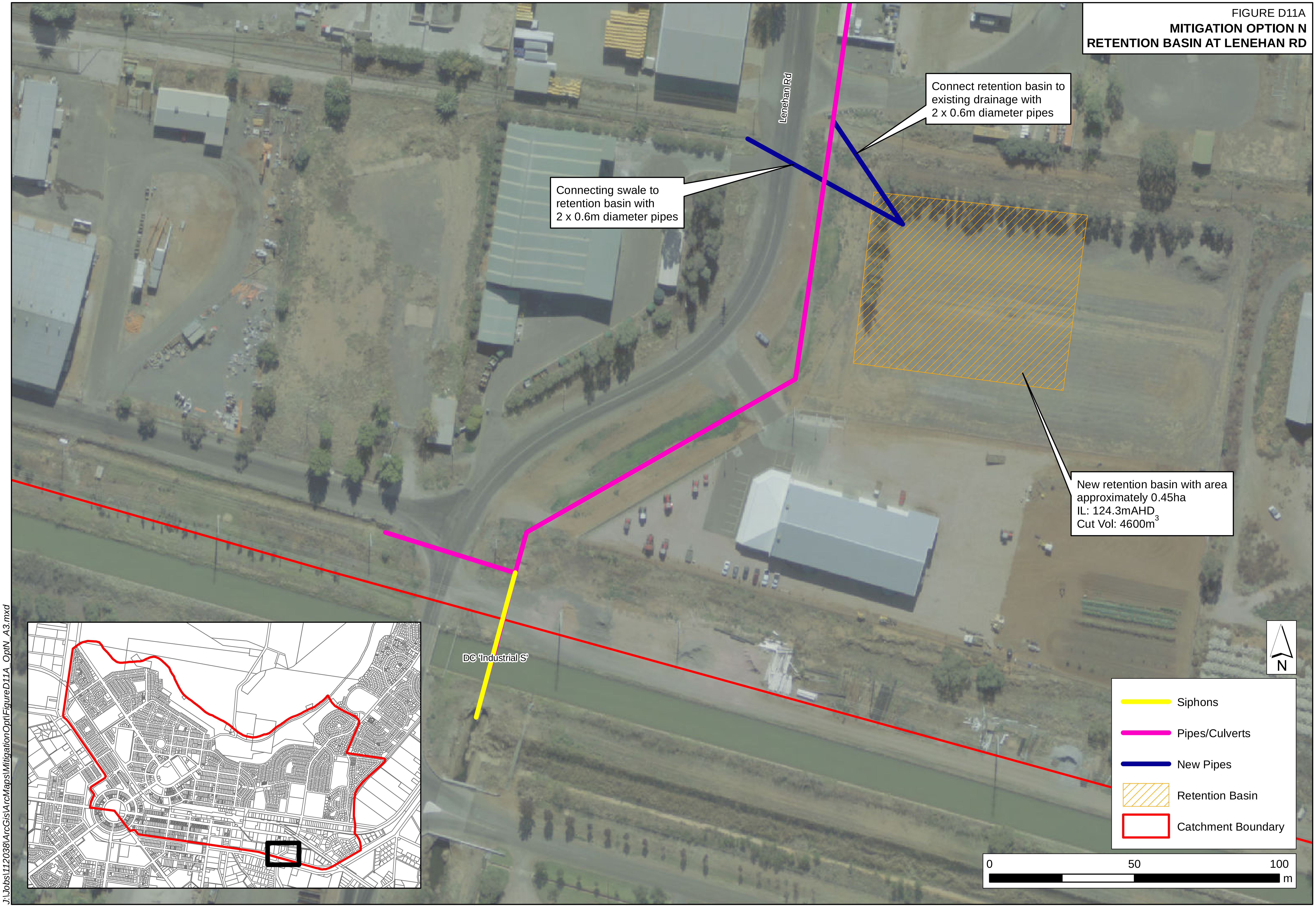


FIGURE D10B
FLOOD IMPACT MAP
MITIGATION OPTION Q
LENEHAN RD AND BLUMER AVE
DRAINAGE UPGRADE
up to 165mm drop in peak flood level
125mm drop in peak flood level for Lenehan Road
Hickey Cres
Blumer Ave
Wakaden St
Crossing St
Banna Ave
Lenehan Rd
DC 'Industrial S'
Siphons
Pipes/Culverts
Pipe/Culverts (To be upgraded)
Catchment Boundary
Surveyed Properties
Impact (m)
No Longer Flooded
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.05
-0.05 - -0.01
No Impact
0.01 - 0.05
0.05 - 0.1
> 0.1
Newly Flooded
N
0
200
400
m
J:\Jobs\112038\ArcGis\ArcMaps\MitigationOptB\FigureD10B_OptQ_Impacts.mxd

FIGURE D11A
MITIGATION OPTION N
RETENTION BASIN AT LENEHAN RD



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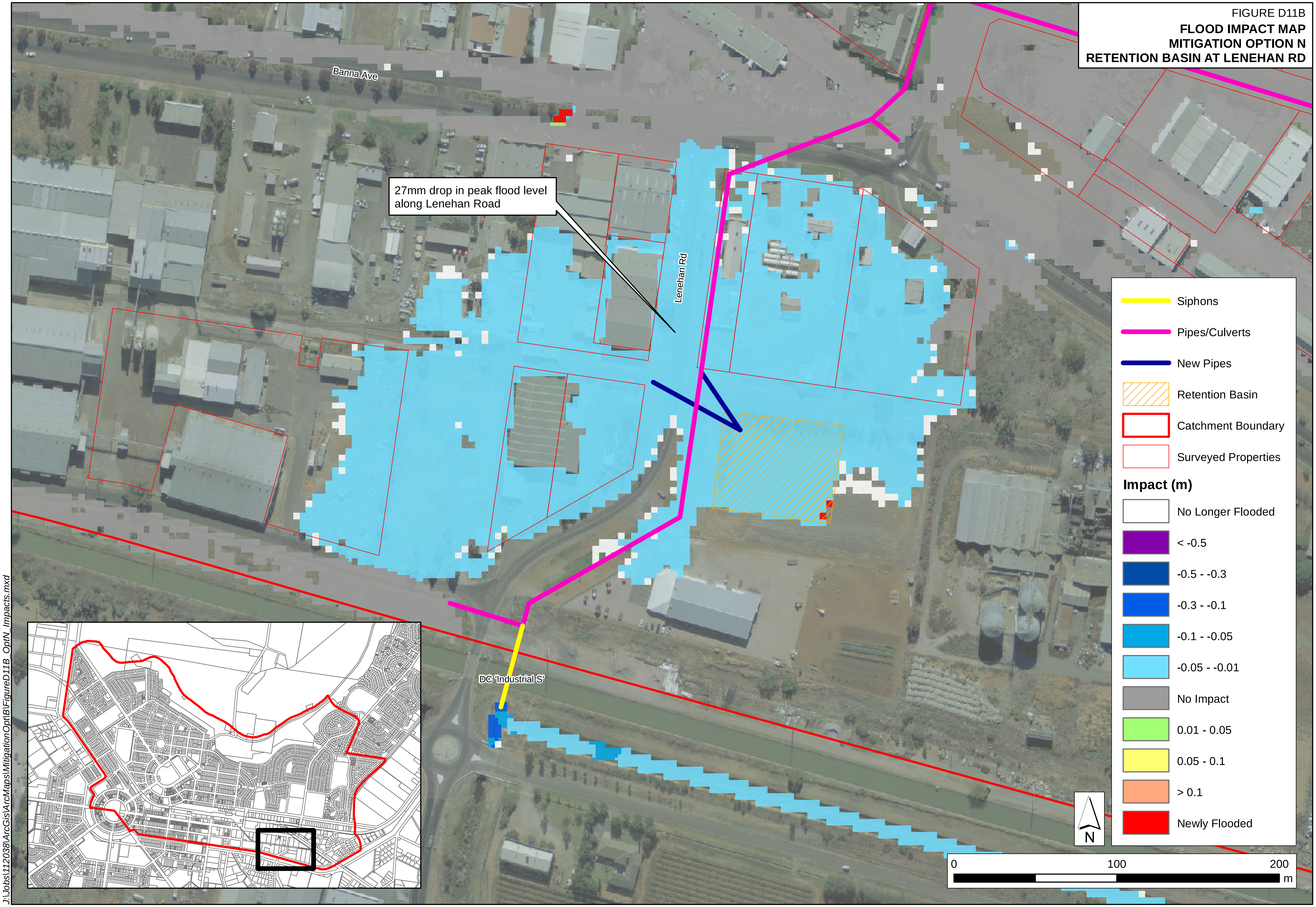
FIGURE D11B
FLOOD IMPACT MAP
MITIGATION OPTION N
RETENTION BASIN AT LENEHAN RD
Banna Ave
Lenehan Rd
27mm drop in peak flood level along Lenehan Road
DC 'Industrial S'
Siphons
Pipes/Culverts
New Pipes
Retention Basin
Catchment Boundary
Surveyed Properties
Impact (m)
No Longer Flooded
< -0.5
-0.5 - -0.3
-0.3 - -0.1
-0.1 - -0.05
-0.05 - -0.01
No Impact
0.01 - 0.05
0.05 - 0.1
> 0.1
Newly Flooded
N
0
100
200
m
J:\Jobs\112038\ArcGis\ArcMaps\MitigationOpt\B\FigureD11B_OptN_Impacts.mxd