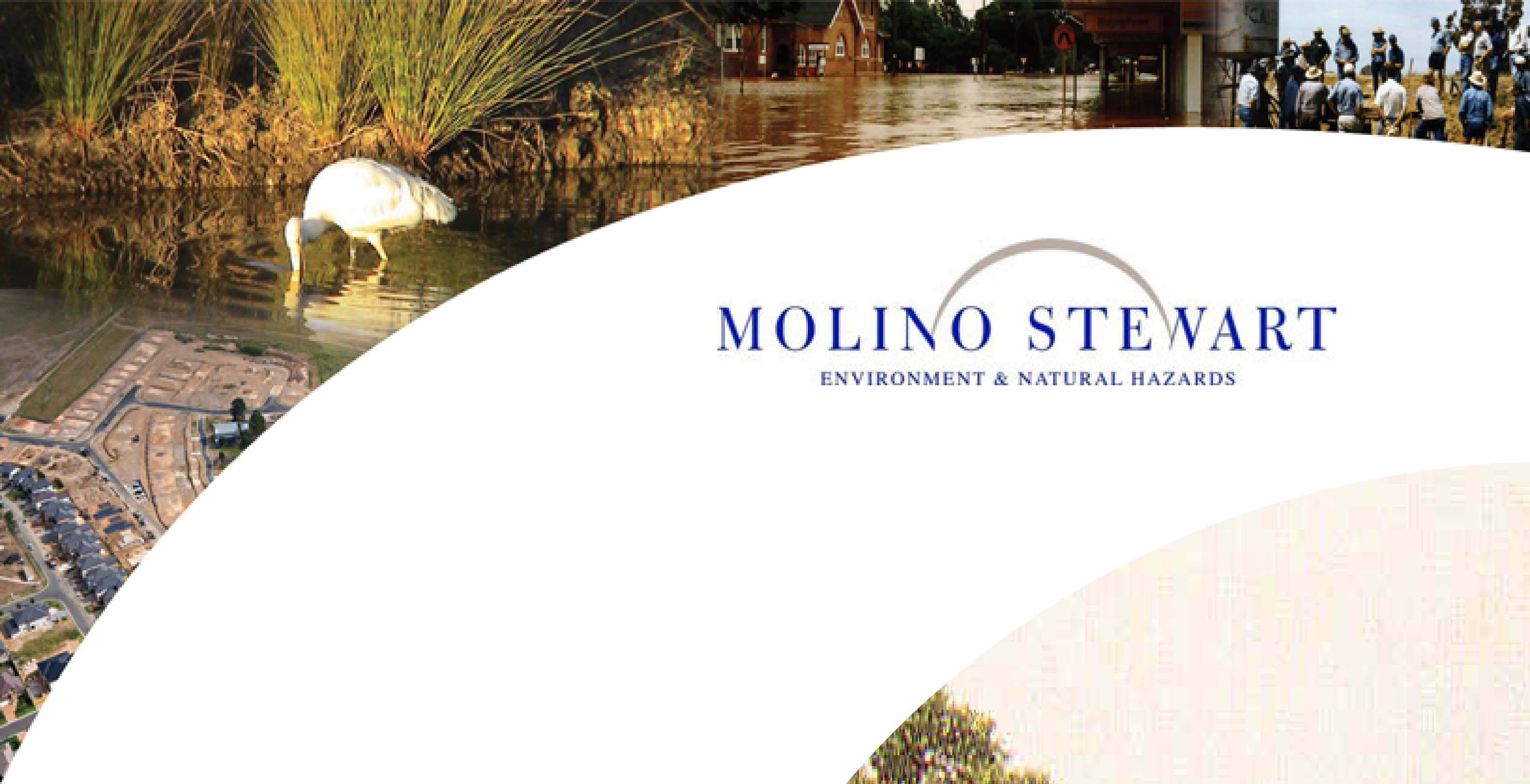

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Canley Corridor Floodplain Risk Management Study

Final Report

Canley Corridor Floodplain Risk Management Study

FINAL REPORT

for

Fairfield City Council

by

Molino Stewart Pty Ltd

ACN 067 774 332

OCTOBER 2015

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FOREWORD

In New South Wales the prime responsibility for local planning and the management of flood liable land rests with local government. To assist local government with floodplain management, the NSW Government has adopted a Flood Prone Land Policy in conjunction with the *Floodplain Development Manual*.

The Policy is directed at providing solutions to existing flood problems and to ensure that new development is compatible with the flood hazard and does not create additional flood problems.

The Policy sets out four sequential stages in the process of floodplain management:

Stage	**Summary**
1. Flood Study	Technical assessment to define the nature and extent of flooding.
2. Floodplain Risk Management Study	Comprehensive evaluation of management options with respect to existing and proposed development.
3. Floodplain Risk Management Plan	Formal adoption by Council of a management plan for floodplain risks.
4. Implementation of the Plan	Measures undertaken to reduce the impact of flooding on existing development, and implementing controls to ensure that new development is compatible with the flood hazard.

This *Floodplain Risk Management Study and Plan* (FRMS&P) constitutes the second and third stage of the management process for the Canley Corridor catchment. In broad terms, the *Floodplain Risk Management Study* has investigated what can be done to minimise the effects of flooding and has recommended a strategy in the form of the *Floodplain Risk Management Plan*.

Fairfield City Council commissioned Molino Stewart in 2012 to prepare this report. Council has obtained financial assistance from the NSW Government through the Office of Environment and Heritage (OEH) to undertake this project. This document does not necessarily represent the opinions of the NSW Government or OEH.

The assistance of Council's Floodplain Management Committee and officers from Fairfield City Council and OEH in preparing this document is gratefully acknowledged.

EXECUTIVE SUMMARY

Molino Stewart is a specialist Natural Hazard and Environmental Consulting company which was commissioned by Fairfield City Council (FCC), with financial assistance from the NSW State Government, to prepare a Floodplain Risk Management Study and Plan for overland flows through the Canley Corridor. The 258 hectare catchment covers approximately half of the suburbs of Cabramatta, Cabramatta West, Canley Heights and Canley Vale and drains in a north easterly direction to Orphan School Creek which is the main tributary of Prospect Creek.

The underground stormwater drainage system in the Canley Corridor was mostly designed when the area was developed after the Second World War using British design standards of the time. There were few local rainfall records and it was still not well understood just how much water could flow through catchments in the rarer storms which are much more intense in Australia than they are in Britain. This means that when stormwater runoff exceeds the capacity of the road and pipe drainage network the excess flows find the path of least resistance across the landscape, often through private properties and, in the more extreme events, through buildings.

FCC has been managing flood risks within the Fairfield LGA for many decades however the impacts from overland flows have not had as much attention as flooding from creeks until recent years. Overland flow management in Canley Corridor to date has included:

- Application of Council's Development Control Plan to ensure new development is compatible with flood risks
- Application of Council's on-site detention policy to minimise the increase in runoff from new development
- Some dividing fence modifications where these were obstructing significant overland flows.

The purpose of the study was to determine what other measures need to be put in place to manage overland flows through the catchment. The study was overseen by Council's Floodplain Management Committee, which comprises councillors and staff from Council, officers from the Office of Environment and Heritage, the NSW State Emergency Service, neighbouring local councils and several community representatives. There has also been opportunity for residents within the study area to provide input to the investigation through the engagement process (see Chapter 7).

Principal Outcomes

The principal outcomes of this study include:

- A revision of the Flood Study with improved estimates of flood extents, levels, depths and velocities for the 5 year, 20 year and 100 year average recurrence interval (ARI) floods and probable maximum flood (PMF) (Chapters 3)
- Definition of the flood problem by construction of a property database and assessment of building inundation, road inundation, evacuation 'hot spots' and flood damages; about 48 houses and 19 commercial/industrial premises would be flooded above floor in the 100 year ARI event; the average annual damages is $3.8 million (Chapter 5)
- Mapping of the High, Medium, Low and Very Low flood risk precincts used for planning and development control
- A detailed evaluation of potential floodplain management measures (Chapter 8), including flood modification measures, property modification measures and response modification measures
- A recommended Floodplain Risk Management Plan (FRMP) for the Canley Corridor floodplain (Chapter 9).

Floodplain Risk Management Plan

The draft Canley Corridor Floodplain Risk Management Plan is presented in Table 19 and Figure 38. The recommended measures have been selected from a range of available measures, after an assessment of the impacts on flooding, as well as economic, environmental and social considerations.

The recommended measures are summarised below:

Flood modification measures

- Maintain the flood model
- Update Council's Stormwater Drainage Policy
- Continue to maintain stormwater drainage assets
- Update Council's Urban Area On-Site Detention Policy
- Investigate a voluntary fencing modification program between Hughes Street and St Johns Road.

Property modification measures

- Seek to voluntarily purchase serious flood risk dwellings and co-ordinate it with FCC's Open Space Strategy
- Adopt a scheme to raise, redevelop or flood-proof houses flooded above floor in the 5 year, 20 year, or 100 year ARI events where it is economically worthwhile and practical to do so
- Revise Chapter 11 of Fairfield City Wide DCP including:
  - incorporation of a Very Low flood risk precinct
  - adoption of a 300mm freeboard
  - removal of the Zone of Significant Flow.

Response modification measures

- Update the Local Flood Plan
- Develop and implement a community education program
- Improve quality and availability of flood risk information at a property scale
- Encourage property owners and occupants to evaluate the benefits of flood insurance.

Funding

The total capital cost of implementing the Plan is about $10M, comprised mainly of the Voluntary Purchase / House Raising / Flood-Proofing Scheme ($7.8M).

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GLOSSARY AND ABBREVIATIONS

This Floodplain Risk Management Study utilises the terminology used in the NSW Floodplain Development Manual (2005). The following Glossary is drawn from that Manual.

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 (i.e., a one-in-20 chance) of a 500 m^3/s or larger events 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.
BoM	Bureau of Meteorology
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 DPI, as having the function to determine an application.
Development	Defined in Part 4 of the 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 re-zoning 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 re-zoning 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).
EP&A Act	The Environmental Planning & Assessment Act, the principal planning legislation in NSW.
EPI	Environmental Planning Instrument – a generic term for the suite of planning documents specified under the Environmental Planning & Assessment ACT and includes State Environmental Planning Policies (SEPP), Local Environmental Plans (LEP) and Development Control Plans (DCP).
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.
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 raise furniture, evacuate people and 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 PMF event. Note that the term flood liable land covers the whole floodplain, not just that part below the FPL (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 by the SES.
Flood planning area (FPA)	The area of land below the FPL and thus subject to flood related development controls.
Flood planning levels (FPLs)	Are the combinations of flood levels and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans.
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	Land susceptible to flooding by the PMF event. Flood prone land is synonymous with flood liable land.
Flood readiness	Readiness is an ability to react within the effective warning time. (see flood awareness)

Flood Refuge	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.
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: **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.
Flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often 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.
Freeboard	It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc.
Habitable room	In a residential situation: a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom.
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. Two levels of hazard are usually adopted in floodplain risk management planning: **High hazard:** possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty in wading to safety; potential for significant structural damage to buildings. **Low hazard:** should it be necessary, truck could evacuate people and their possessions; able-bodied adults would have little difficulty in wading to safety.
Hydraulics	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	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	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 purposes of this study, 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 0.3m (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 flowpaths through developed areas outside of defined drainage reserves; and/or • the potential to affect a number of buildings along the major flow path.
Minor, moderate and major flooding	Both the SES and the BoM 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 or the property or the response to flooding. There are three generally recognised ways of managing floodplains to minimise the risk to life and to reduce flood losses: • By modifying the response of the population at risk to better cope with a flood event (Response Modification); • by modifying the behaviour of the flood itself (Flood Modification); and • by modifying or removing existing properties and/or by imposing controls on property and infrastructure development (Property Modification).

Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood	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 viable 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	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 this context, 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.
SES	State Emergency Service
stage	Equivalent to water level (both 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 along a watercourse at a particular time.

1 INTRODUCTION

1.1 BACKGROUND

Fairfield City Council is responsible for local planning and floodplain management throughout the Fairfield Local Government Area (LGA). Council has been actively addressing flooding issues in both major streams and overland flow affected areas since the early 1980's and has a proactive, ongoing program of preparing and implementing Floodplain Risk Management Plans.

The watercourses in Fairfield City have a history of flooding. The Canley Corridor catchment forms part of the Orphan School Creek catchment which in turn is part of the larger Prospect Creek catchment. Major flooding occurred along Prospect Creek and Orphan School Creek in August 1986, April-May 1988 and February 2001. These floods caused serious financial losses and hardship to a large number of families and businesses in the area.

Two types of flooding are now recognised to affect properties in Fairfield City – mainstream flooding and local overland flooding. Mainstream flooding is considered to be the overtopping of a clearly defined watercourse (river or creek) or body of water (lake) with resulting inundation of the adjoining land. Local overland flooding usually arises from water flowing across normally dry land as a result of intense and heavy rainfall. It is in effect the rainfall runoff making its way across the ground on its way to a creek channel.

Generally, local overland flooding also occurs independently of these large flood events. These are usually flash flood events that happen within 20 minutes of a storm, therefore the response time can be quite different to larger duration storm events. These local overland floods can also cause damage to property and infrastructure and place lives at risk. Furthermore, because overland flows occur through areas which are not defined watercourses, they often have more development in the frequently flooded flow paths than say development along a creek's immediate floodplain. This means that damages from overland flows can happen much more frequently than damages from mainstream flooding and potentially have a cumulative impact as significant as the larger mainstream floods.

To address this, Council undertook the Fairfield City Overland Flood Study (FCS and SKM, 2004) to achieve a range of objectives, including a ranking of drainage areas in terms of severity of flooding for further investigation.

The Canley Corridor catchment area was the first of the identified areas where a detailed Flood Study (FCS and SKM, 2009) was undertaken using state-of-the-art hydraulic modelling techniques. The modelling is further discussed in Section 3.1.

Council now proposes to develop a floodplain risk management plan to address overland flooding in the Canley Corridor catchment in accordance with the NSW Floodplain Development Manual. This Plan would set out a suite of measures to manage overland flood risk in the catchment and would complement other floodplain risk management plans already developed for Fairfield Council.

1.2 THE STUDY AREA

The study area is located in Fairfield City approximately 32 kilometres south west of the Sydney CBD. The study area is shown on Figure 1.

The Canley Corridor catchment drains in a north easterly direction to Orphan School Creek which is the main tributary of Prospect Creek. The 258 hectare catchment covers approximately half of the suburbs of Cabramatta, Cabramatta West, Canley Heights and Canley Vale. Land uses are predominantly residential and commercial. The catchment area is largely low density residential with significant areas of high density residential development east of a line formed by Sackville Street, St Johns Road and Gladstone Street.

For the most part, development has occurred in a grid of streets running north to south and east to west though the newer areas of Cabramatta West are less regimented. Housing is dominated by single storey cottages, with new two storey houses or duplex developments steadily growing in number throughout the low density area. The lower catchment includes a range of commercial areas, separated from Orphan School Creek by an open space corridor.

The Canley Vale local town centre is located along Canley Vale Road, between Railway Parade and Phelps Street. It is adjacent to the Canley Vale railway station. It is characterised by district strip retailing surrounded by both apartments and single residential dwellings. Duplexes are also common in this area. Buildings are a variety of styles, heights, sizes and materials and in various states of repair.

The Canley Heights local town centre starts at the intersection of the Cumberland Highway and runs along Canley Vale Road in an easterly direction. It is very similar in nature to the Canley Vale town centre in building style and usage however it is much less flood affected.

A noticeable feature of the development in the area is the residential block size. North of St Johns Road and east of Sackville Street, block sizes are generally 12.66m wide and 36.21m deep whereas south of St Johns Road, block sizes are 20.7m wide and 81.1m deep. Block sizes in Cabramatta West are highly mixed.

1.3 CONTEXT OF STUDY

The continuing occurrence of flooding across NSW has highlighted the importance of managing the risks associated with flooding. In NSW Government Flood Policy is directed at providing solutions to existing flooding problems in developed areas, and ensuring that new developments are compatible with the flood hazard and do not exacerbate existing flooding or create additional flooding problems in other areas. Under the Policy, the management of flood prone land is primarily the responsibility of local government. To facilitate this, the NSW Government published in 2005, the "Floodplain Development Manual: the management of flood liable land" (the Manual) to provide guidance to Councils in the implementation of the Policy. The NSW Government also provides funding in support of floodplain management programs.

The Manual describes a floodplain risk management process comprising the sequential stages shown in Table 1.

In March 2012, Fairfield City Council (Council) engaged Molino Stewart to prepare the Canley Corridor Floodplain Risk Management Study & Plan (FRMS&P). BMT WBM was engaged by Molino Stewart as a sub-consultant to review and update the existing Canley Corridor flood model and model proposed flood mitigation options for the FRMS&P.

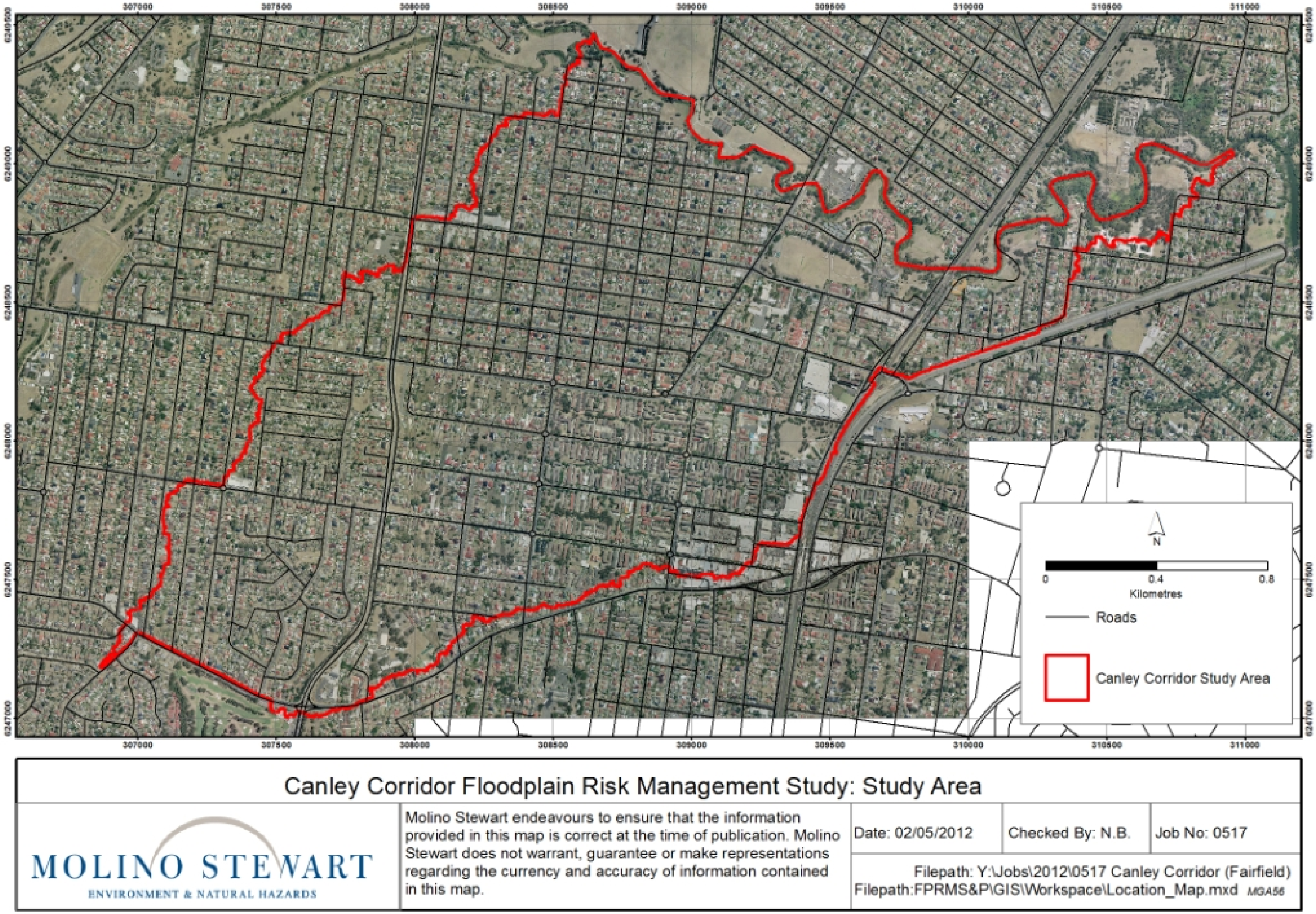


Figure 1: Study Area

Table 1: Floodplain Risk Management Process

Stage	**Activity**
1 Flood Study	Determines the nature and extent of the flood problem for the full range of flood events
2 Floodplain Risk Management Study	Evaluates management options for the floodplain with respect to both existing and future development.
3 Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of management for the floodplain.
4 Implementation of the Plan	Involves implementation of flood risk management measures, where viable, to protect existing development. Uses planning controls to ensure that future development is compatible with flood hazards.
5 Review of Plan	Review of plan to ensure it remains current and appropriate. A review is normally carried out after 5 - 10 years, subject to the implementation of the Plan or the occurrence of flooding.

The FMRS&P brings together the relevant data from previous flood studies into a comprehensive set of management measures for Council. This report pertains to Stage 2 and Stage 3 of the NSW Floodplain Risk Management Process with the Floodplain Risk Management Plan constituting the final chapter of the document.

The overall objective of this Study is to develop sufficient and reliable information to assist in the development of a Floodplain Risk Management Plan for the study area that addresses the existing, future and ongoing flood risks in accordance with the Manual. This will ensure that the following broad needs are met:

- Reduce the flood hazard and risk to people and property in the existing community
- Protect, maintain and, where possible, enhance the creek and floodplain environment, and
- Ensure floodplain risk management decisions integrate the social, economic and environmental considerations.

Fairfield City Council has prepared this document with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government.

1.4 STUDY METHODOLOGY

To meet the overall objective of the project the following steps were undertaken:

- The flood model for Canley Corridor was reviewed and updated so that overland flow behaviour could be understood;
- Flood hazards for people and property caused by the full range of overland flows from the most common floods through to the Probable Maximum Flood (PMF), which is the largest flood that could conceivably occur, were estimated using the most recent published research into flood hazards;

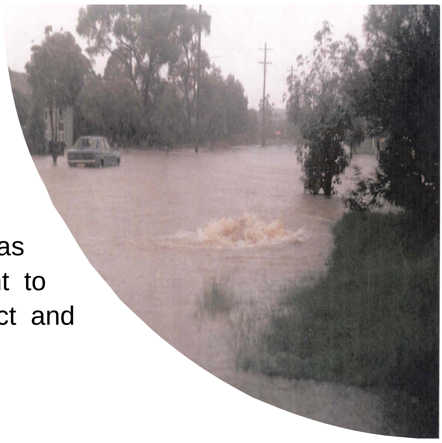
- The extent of development and the population at risk in areas of significant flood hazard were estimated from recent airphotos and street photography, floor level surveys of highest risk properties and census data;
- The vulnerability of the property and the people that could be exposed to flood hazards were determined from street photography and census data;
- The consequences of flooding for people and property, should they be flooded, and the probability of that occurring were calculated by using spatial analysis software which combined flood modelling, terrain, property and census data. This defined the flood risks and included an estimate of the direct and indirect financial losses likely to be suffered in each flood event;
- The latest information from the CSIRO and the Department of Environment and Heritage was used to estimate how the flood risks might evolve as a result of climate change;
- Council's existing environmental planning policies and instruments and long term planning strategies for the study area, which have the potential to influence future flood risk, were reviewed
- Flood Emergency planning for the study area and available flood warnings and resources for flood response were determined in consultation with the NSW SES and Fairfield City Council;
- Community understanding of their flood risks was determined through surveys and focus groups;
- Works, measures and restrictions which may be able to be implemented to reduce the social, environmental and economic impacts of flooding now and in the future were identified in consultation with the community;
- The effectiveness, practicality, benefits, costs and impacts of the identified works, measures and restrictions were identified;
- Community and other stakeholder opinion about the flood risks and the identified potential flood mitigation options was sought;
- An objective and transparent process was used for selecting, from the full range of flood mitigation options, a suite of mitigation options to be implemented;
- A plan for implementing the preferred suite of mitigation options was developed.

1.5 REPORT FORMAT

This report presents the Floodplain Risk Management Study for local overland flooding in the Canley Corridor catchment. The report includes the sections shown in Table 2.

Table 2: Outline of Report

Chapter	Outline of Content of Section
2. Catchment Characteristics	Describes the natural, built and social characteristics of the catchment
3. Flood Studies	A discussion on the past Flood Studies, the Modelling Review, Design Event Modelling, Flood Mapping, Floodplain Classification and a Climate Change Assessment.
4. Urban Planning Context	This Section contains reviews of existing NSW Legislation and Policy, Regional Environmental Plans, Local Environmental Planning Instruments, Development Control Plans and Planning Certificates under Section 149 as they apply to Canley Corridor
5. Flood Impacts	A description of flood depths, velocities and hazards for the full range of floods and their impacts on property, heritage items and biodiversity.
6. Emergency Management	A discussion on the roles of the relevant agencies, a review of the current Fairfield Local Flood Plan and the role of the community in emergency management.
7. Community and Stakeholder Engagement	Provides details of the Community Engagement Plan and the results of Agency and Community consultations.
8. Floodplain Risk Management Options	This Section contains a detailed discussion on Property Modification Measures, Flood Modification Measures and Response Modification Measures that may be applicable in the study area. It evaluates the options and then shortlists the most appropriate options for further inclusion in the Floodplain Management Plan.
9. Floodplain Risk Management Plan	This Section covers the detailed assessment of the selected options against social economic and environmental, as well as flood criteria.
10. References	This section contains a comprehensive list of references used to undertake this project.



2 CATCHMENT CHARACTERISTICS

This chapter describes the natural and developed features of the catchment as well as socio-economic profile of those who live and work in the catchment to provide some context for the flood studies and how flooding can have direct and indirect impacts on people and property

2.1 TOPOGRAPHY

The Canley Corridor catchment is located on the Cumberland Plain, which has a predominantly flat topography and Wianamatta shale derived clay soils (Fairfield City Council, 2010). The catchment drains from the south west to the north east towards Orphan School Creek which is a tributary of Prospect Creek. The highest elevation in the catchment is about 40m above sea level along its south western ridgeline which Cabramatta Road West runs along next to Cabramatta Golf Course. The lower parts of the floodplain along Orphan School Creek are about 10m above sea level and the creek itself is three or four metres deep from the top of the bank to the bed of the creek.

The upper parts of the catchment are steeper and the overland flow paths are well defined along clear depressions in the landscape. Lower in the catchment the terrain is flatter which means that the floodwaters spread out over a wider area with no clearly defined flow path. In the lower parts of the catchment street layout becomes a more dominant factor in determining flow paths than does underlying topography

2.2 BIODIVERSITY ASSETS

It is important to understand the biodiversity assets within a catchment because they may:

- be adversely impacted by flooding;
- affect flood behaviour by impeding flood flows;
- be a constraint to implementing some flood mitigation options
- be able to be enhanced when implementing some flood mitigation options

Comprehensive clearing of the catchment for residential, commercial and industrial development has resulted in a dramatic reduction in natural areas. Figure 2 shows the areas of remnant vegetation within the Canley Corridor Catchment as identified by a recent survey (Ecological Australia, 2010), which are all remnants of Cumberland Plain Woodland.

Existing biodiversity assets within the catchment include:

- the Orphan School Creek riparian corridor which includes alluvial woodland and in which three threatened plant species and two threatened fauna species have been found in or near the Canley Corridor Catchment section of the creek;
- Cooks river Castlereagh Ironbark Forest which is an endangered ecological community at the state level; and
- Shale Plains Woodland which is a critically endangered ecological community at both the state and national level.

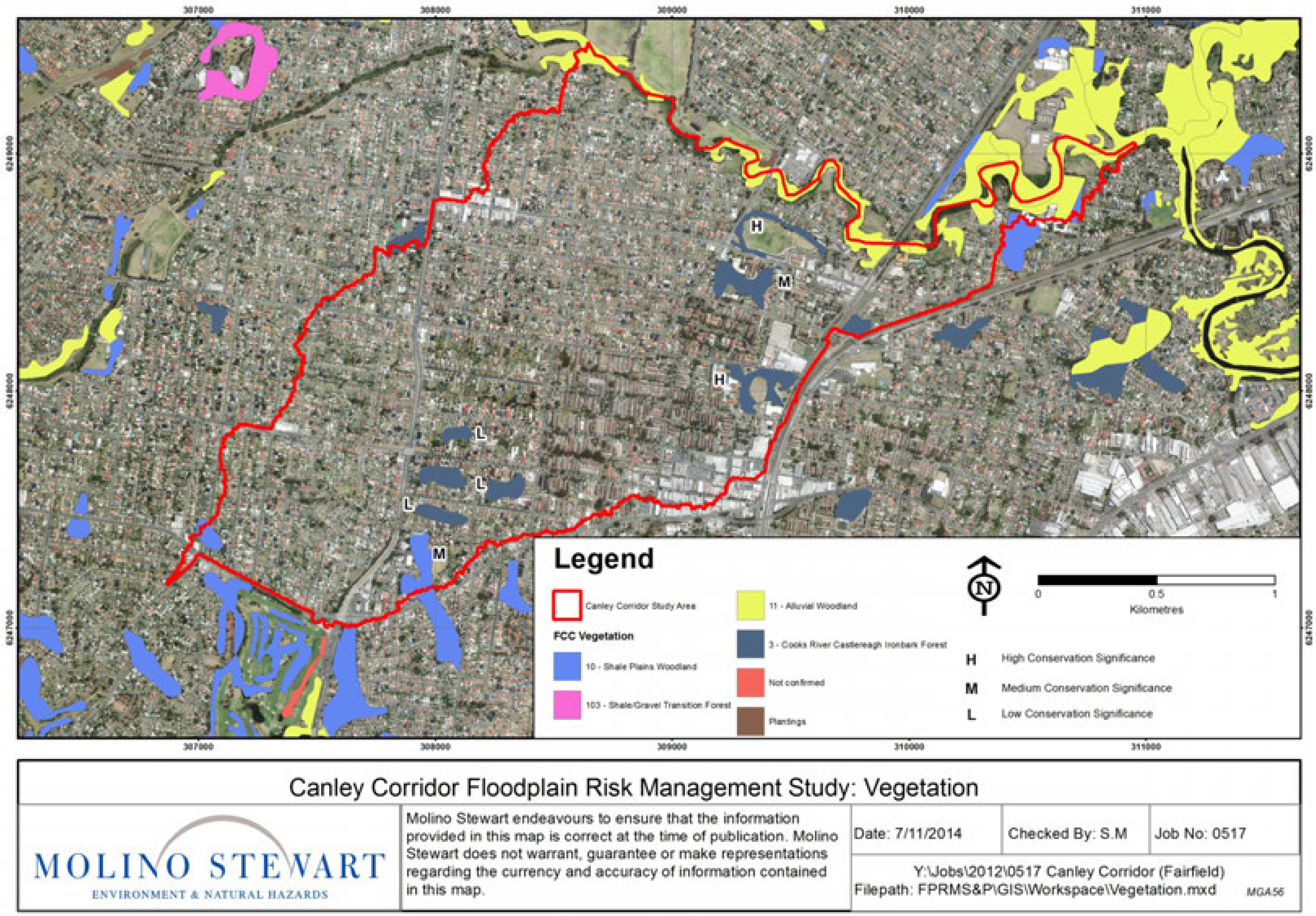


Figure 2: Remnant Vegetation in Canley Corridor

Their condition influences their conservation significance. Specific areas in the catchment identified as having high, moderate or low conservation significance (Ecological, 2010) include:

- Adams Park – tree lined boundary - high conservation significance;
- Cabra-Vale Park - high conservation significance;
- Canley Vale Primary School - moderate conservation significance;
- Cabramatta West Primary School - moderate conservation significance
- Private land between Hughes and John Street - low conservation significance;
- Private land between John and Gilbert Street - low conservation significance; and
- Private land between Gilbert and Broad Street - low conservation significance.

2.3 URBAN DEVELOPMENT

The remnant woodlands which are described in the preceding section would have originally covered the whole of the Canley Corridor Catchment which was part of the traditional lands of the Cabrogal tribe for thousands of years. The catchment was part of a 13,000 acre land grant created by Governor King in 1803 for agriculture to support a male orphan school (Bubacz, 2007). Later in the 1800s it was subdivided and Sir Henry Parkes built a mansion near the railway line between Fairfield and Cabramatta. He named it Canley Grange after his birthplace in Warwickshire, England.

Cabramatta and Canley Vale were regarded as a single community and from the 1920's it was known as Cabravale. In 1899, the municipality of Cabramatta and Canley Vale, which had been established in 1892, was redivided, and the two separate wards were gazetted on 8th January 1900. In 1948, they became part of the Fairfield local government area. Canley Vale's first public school opened in 1884 (Vance, 1991).

By 1943 significant subdivision had occurred and most of the road network which exists today had been constructed for anticipated urban development. As can be seen in Figure 3, which is an air photo from this time, housing was concentrated around the streets close to Cabramatta railway station but after the Second World War urban development took off and continued through until the late 1970s. Through this period residential buildings were mostly small detached houses on large blocks and during the 1950s and 1960s the majority of these were of fibro or weatherboard construction. Commercial development occurred around the centres of Canley Heights, Canley Vale and Cabramatta.

Since that time urban consolidation and redevelopment has taken place with there now being:

- a large precinct close to the railway line with many residential flat buildings or townhouse developments;
- attached or detached dual occupancy dwellings on some of the larger lots
- large houses replacing the original small house either through extension or complete reconstruction, often in brick.

The current land use zonings are shown in Figure 4 which suggests that the catchment landuse will continue to be predominantly residential but:

- Further townhouse development could occur east of Sackville St between Pevensey St and Orphan School Creek
- Residential flat buildings could occur close to Canley Heights town centre with townhouse development occurring several blocks back from that.

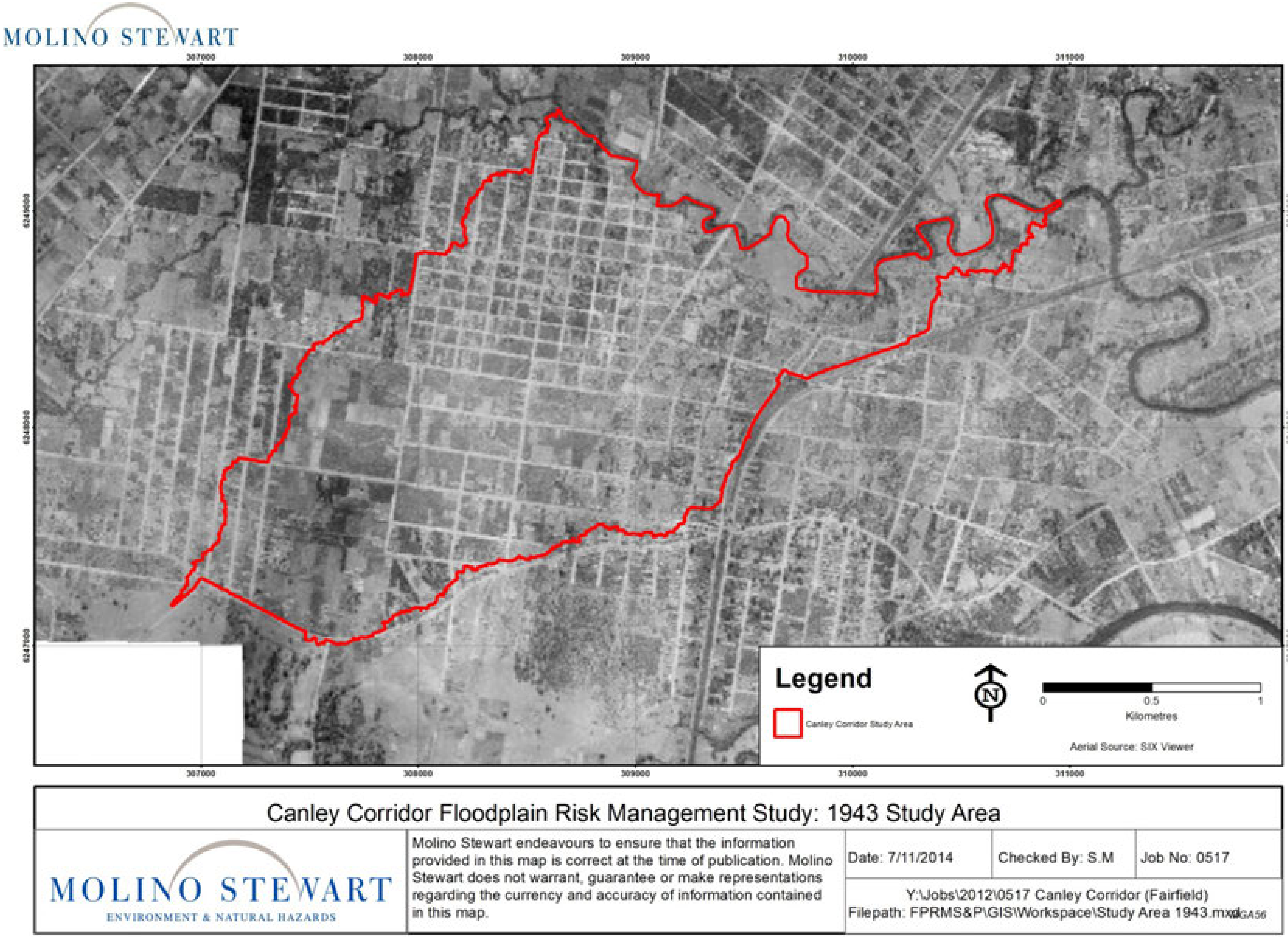
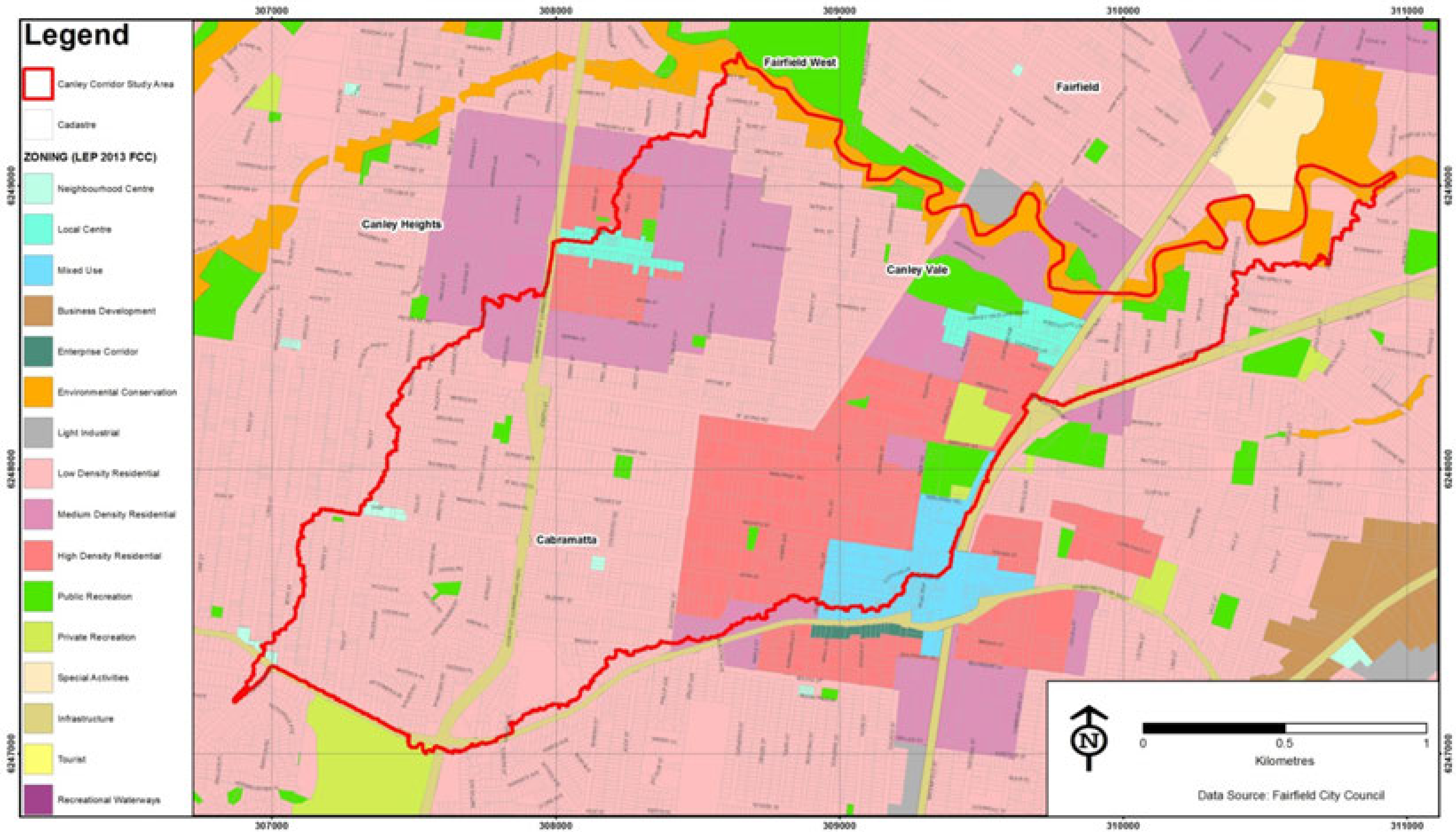


Figure 3: Canley Corridor Catchment 1943



Canley Corridor Floodplain Risk Management Study: Land Zoning

MOLINO STEWART ENVIRONMENT & NATURAL HAZARDS	Molino Stewart endeavours to ensure that the information provided in this map is correct at the time of publication. Molino Stewart does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.	Date: 7/11/2014	Checked By: S.M	Job No: 0517
		Y:\Jobs\2012\0517 Canley Corridor (Fairfield) Filepath: FPRMS&P\GIS\Workspace\Zoning.mxd MGA56		

Figure 4: Current Landuse Zoning

2.4 HERITAGE VALUES

Heritage consists of those places and objects the community has inherited from the past and have indicated a desire to hand on to future generations. Our heritage gives us a sense of living history and provides a physical link to the work and way of life of earlier generations. It enriches our lives and helps us to understand who we are today.

Although the Canley Corridor was occupied by Aboriginal people for many thousands of years, and was the traditional lands of the Cabrogal tribe, the extensive urban development which has taken place in the past 70 years has removed most traces of Aboriginal occupation. A search of the Aboriginal Heritage Information Management System (AHIMS) revealed that there are records of three indigenous heritage items on the northern boundary of the catchment in the public reserves along Orphan School Creek.

They consist of an open campsite, an open campsite with a scarred tree, and an undefined artefact. Their recorded locations are shown in Figure 5. It is not known whether they are still extant or have been removed. These locations are more affected by flooding from Orphan School Creek than overland flows from Canley Corridor.

The Canley Corridor catchment also includes sites of non-indigenous heritage significance, not only for the immediate catchment area but also for the wider Sydney basin. The non-indigenous heritage sites within the catchment area are listed in Table 3 and Table 4. These sites have been extracted from the Australian Heritage Places Inventory, items listed under the NSW Heritage Act, items listed by State Agencies and items/locations listed in the various LEPs. These sites are also shown on Figure 5.

The vast majority of the heritage listed sites shown here are above the 100 year ARI flood level however they are affected, to varying degrees, by floods up to the PMF. They will need to be considered, where relevant, to flood mitigation options.

Canley Vale (Orphan School Creek) Viaduct 1891 is also affected by flooding from Orphan School Creek.

Table 3: Items listed by Local Government and State agencies under s.170 NSW State agency heritage register.

Item Name	**Address**	**Suburb**
Canley Vale (Orphan School Creek) Viaduct 1891	Orphan School Creek; Railway Parade	Canley Vale

Table 4: Items listed Fairfield LEP

Item Name	**Address**	**Suburb**
Corner Shop	2 Canley Vale Road	Canley Vale
Westacott Victorian Cottage	110 Railway Parade	Canley Vale
Church	136 John Street	Cabramatta
Kwan Yin Temple	2 Second Avenue	Canley Vale
Railway Viaduct Stuart & Canley Vale Rd	Railway Parade	Canley Vale

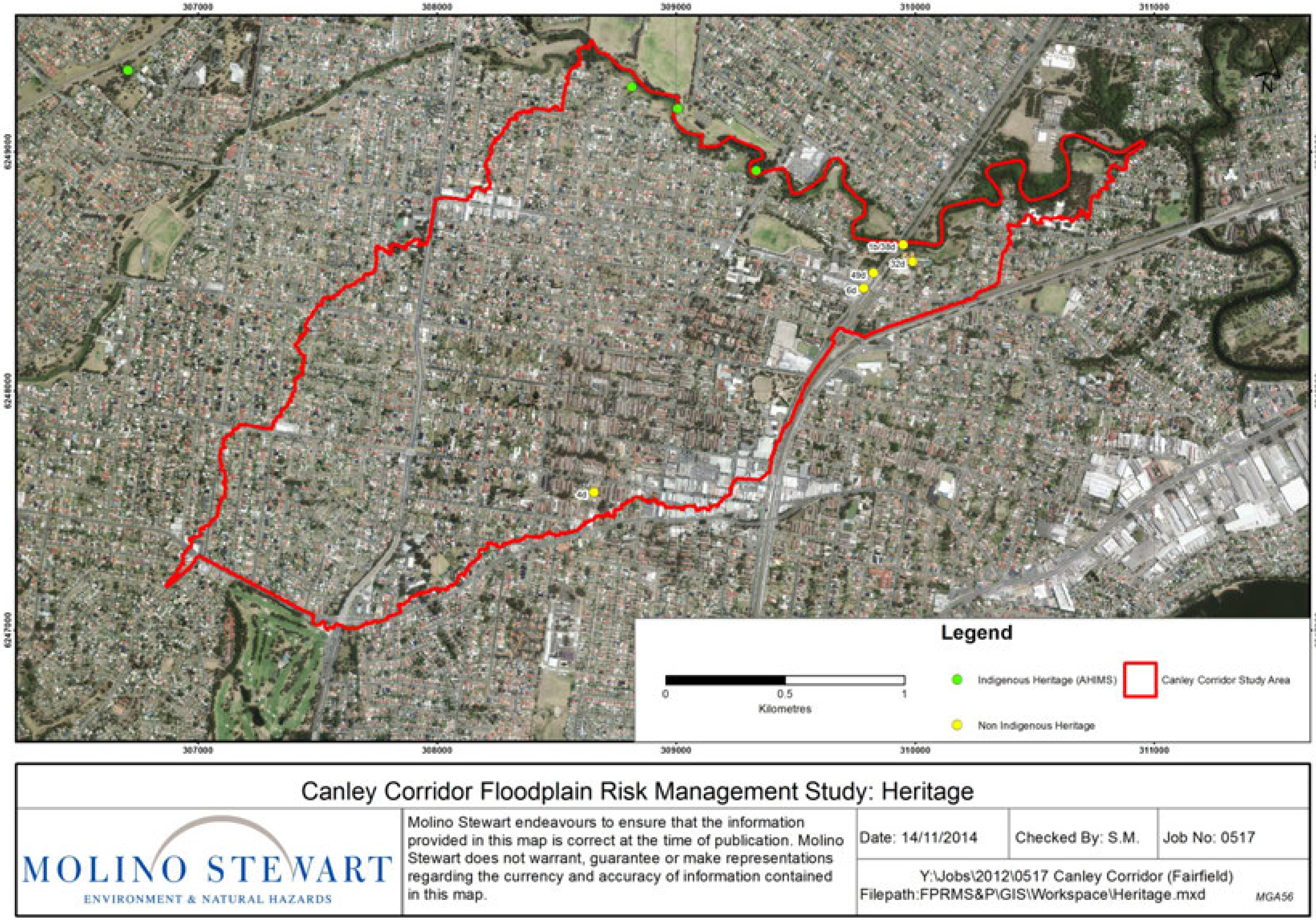


Figure 5: Heritage Properties in Canley Corridor

2.5 SOCIAL PROFILE

2.5.1 Background

A general understanding of the makeup of the community potentially affected by flooding is an essential factor in the development of floodplain management measures. For example, if the community features a number of languages or has little formal education then methods of communication and education in relation to flooding must reflect that. If the internet is not widely used, then a "social media" campaign to raise awareness may not be as effective as planned. Age and income can be indicators of vulnerability during response and recovery.

Accordingly, a limited social profile of the community in the Canley Corridor catchment was developed from the 2011 Census data and is detailed in Appendix A along with a comparison to data for Fairfield LGA and Sydney.

Census data is not defined by the catchment boundary; it utilises statistical areas that, in many cases, extended beyond the study area boundary (see Figure 6). Although data is collected in smaller areas, referred to as Mesh Blocks, the information is not reported at a Mesh Block level, other than dwelling and population counts, for privacy reasons.

For this study, the statistical areas used were:

- Cabramatta - Lansvale
- Cabramatta West - Mount Pritchard
- Canley Vale - Canley Heights

Once the individual data for each statistical area had been accessed, an area wide average was calculated to provide a picture of the social profile of the study area. This picture is not comprehensive and greater detail can be obtained from the Census website:

http://abs.gov.au/websitedbs/censushome.nsf/home/quickstats.

Fairfield City Council also has specially assessed data relating to the LGA; this can be found at:

http://profile.id.com.au/fairfield.

2.5.2 Statistics of Interest

The following is a brief discussion of a selection of statistics which may have relevance to:

- Vulnerability to flood impacts
- Ability to receive information before, during or after a flood
- Ability to comprehend communications in relation to flooding including planning controls, resilience education, flood warnings, emergency response orders and recovery actions
- Ability to recover from flooding

While there is some variation between the statistical areas, the variation is not great and the following discussion is likely to be a reasonable reflection of the floodplain as a whole.

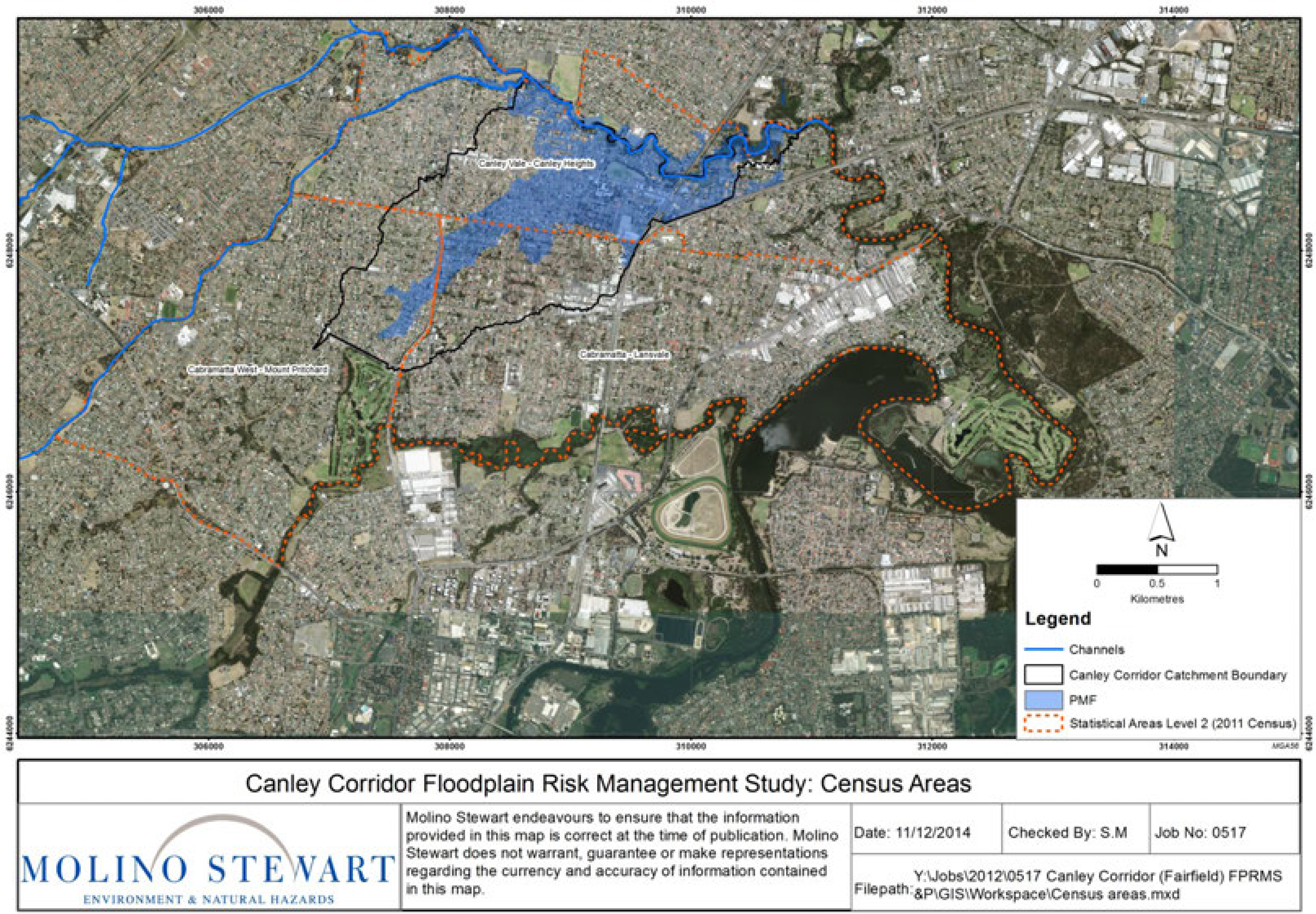


Figure 6: Census Statistical Areas - Fairfield

a) Age and Household Structure

The study area has a relatively young profile compared to the Sydney Average, with 62.75% of the population under 44 years of age and 88.7% under 64 years of age. This is shown in Table 5. However, the 11% of the population that is 65 or over may be particularly vulnerable to the impacts of flooding, have communication challenges and find it difficult to recover after a flood. This will be particularly the case if they live alone as 17% of the population does.

Table 5: Age Distribution - Three Tributaries catchment

Age Group	Percentage
0-19 years	28.63
20-44 years	34.60
45-64 years	24.50
65-84 years	10.70
85- and over	1.53

b) Cultural and Linguistic Diversity

About 60% of the population was born outside of Australia with Chinese and Vietnamese being the predominant ancestries. Only about 21% of the households speak English alone and about 77% of households speak two or more languages at home. This means that there are at least 2% of households which do not speak English.

The languages other than English with the greatest usages are Vietnamese, Cantonese, Arabic and Khmer. Any communications with these communities will need to not only recognise this linguistic diversity but also any potential cultural barriers to communication.

c) Education

Nearly 10% of the population have never attended school and a further 12% did not complete more than the equivalent of Year 8 education. Of the 23% who have some form of tertiary education, almost half of them have vocational training.

This means that a significant proportion of the population might not be literate, even in their first language let alone in English. It will be important that the means of communication and the terminology used to describe technical concepts is appropriate to the ability of the community to comprehend the information.

d) Employment and Income

About half the population participate in the labour force and about 10% of the population is unemployed. Median weekly household incomes are around $1,000 per week which puts them about $10,000 p.a. below the NSW state median. This may affect the ability of some people to participate in property modification options, to take flood preparedness actions or to recover following a flood.

e) Home Ownership

About one third of the dwellings in the catchment are rented with the remainder owner occupied with about half of these owned outright by the owners and the others mortgaged. About one quarter of detached dwellings are rented and about half of the townhouses and residential flats are rented. Home ownership could be relevant to willingness to participate in property modification options.

f) Internet Access

The internet access data is only provided across the entire Fairfield LGA and thus some caution is required in applying this data too specifically to the study area.

However, the general trend is that approximately 25% of all residences do not have an internet connection and where there is a connection, it is most likely to be broadband – it is not stated whether that connection is cable or wireless nor the length of time connected. Thus, while there is a significant movement to provide flood education and warning messages by internet, there remains a sizable proportion of the community for whom more conventional methods of engagement will continue to be required. The results are detailed in Table 6.

The census results are somewhat contradicted by the results published in the recent report "Community Flood Education and Awareness in Fairfield City" (Molino Stewart, 2012) in which with 60% of respondents to a Council survey indicated that they had no internet access. This does indicate that emphasis should be placed on communication methods for flood education and flood warning on methods other than websites, especially in areas where there are significant older populations where 'traditional' communication means such as newspapers and radio should be used in flood education.

Table 6: Internet Access (Fairfield LGA) by Dwelling Structure

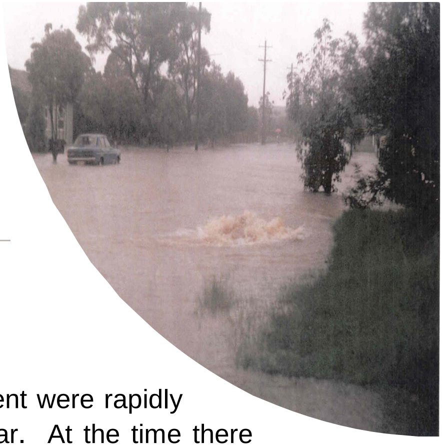
	Separate house	Semi-detached, row or terrace house, townhouse etc.	Flat, unit or apartment	Other dwelling	Not stated	Total
No Internet connection	9,435	2,026	2,582	63	12	14,118
Type of Internet connection:						
Broadband	27,675	4,616	3,119	80	35	35,525
Dial-up	1,091	230	214	3	3	1,541
Other	1,163	259	306	3	3	1,734
Total	*29,929*	*5,105*	*3,639*	*86*	*41*	*38,800*
Internet connection not stated	1,981	458	467	14	0	2,920
Total	**41,345**	**7,589**	**6,688**	**163**	**53**	**55,838**

(a) Where a dwelling has more than one type of Internet connection, only one is recorded.

(b) Excludes 'Visitors only' and 'Other non-classifiable' households.

2.5.3 Conclusion

The social profile is limited in its extent and it is acknowledged that there are a number of other ways of describing the community such as level of interconnectedness, socio-economic disadvantage, relationship to government/authority, level of flood awareness, etc. that are important in understanding the community's receptivity to floodplain risk management options such as flood emergency response, flood modification and property modification. However, for the purposes of a floodplain risk management study and plan, which identifies options and recommends further actions, the profile as developed is suitable. Depending on the type of option selected, a more comprehensive social profile may or may not be needed.



3 FLOOD STUDIES

3.1 OVERLAND FLOW LEGACY

As with many areas of Sydney, the suburbs within the Canley Corridor catchment were rapidly converted from farmland to urban development following the Second World War. At the time there were few local rainfall records and engineering design calculations were done with a slide rule. Most of the drainage network would have been designed using British design standards of that time.

As development continued into the 1960s and 1970s flow estimation and design techniques improved but it was still not well understood just how much water could flow through catchments in the rarer storms which are much more intense in Australia than they are in Britain. It is only in the last few decades that this has been properly appreciated and the rainfall data and computer technology has been available to better understand and estimate the full range of rainfall and runoff which is possible.

However, even in new subdivisions it is not economically feasible or socially desirable for stormwater pipes to be built large enough to take runoff from every possible storm. Rather, pipes are designed to take the frequent events and excess flow finds its way overland to the main watercourses. In older suburbs, such as those in the Canley Corridor catchment, no formal provision was made in urban designs for designated overland pathways for flows to follow in the biggest storms.

This means that runoff finds its own way across the landscape following the path of least resistance which includes the original swales and dips in the landscape as well as those created by the construction of roads and houses. This often results in roads becoming torrents which can divert down driveways and through private property including yards, garages, houses and shops which are at lower parts of the local landscape.

Over time these overland flooding problems have been made worse by the intensification of development. When the drainage network in the Canley Corridor was first designed and built the roads were unsealed, the housing blocks were large and the houses were small. This meant that there were large areas for the rainfall to soak into the ground before the ground became saturated and the excess rainfall became overland flow. Over time roads have been sealed, land has been subdivided and small houses have been replaced with larger houses, townhouses and home units. This has increased the amount of runoff for any particular storm event and the pipes fill more frequently and overland flooding occurs more often.

Canley Corridor has had little opportunity to adapt to this increase in runoff because the lower parts of the catchment were developed first and development has progressively spread further up into the catchment. This has meant it has not been possible to increase the size of the pipes in the extensive network which is under the established areas (including under some buildings) to take the additional runoff from new areas.

3.2 MODERN FLOOD MODELLING

Since the 1980s, computer based flood models have been increasingly used to better understand flood behaviour for both main channel flooding and for overland flows. The modelling is done in two steps:

- **Hydrology modelling** – this is used to estimate how often it rains, how much rain falls and how much of the rain becomes runoff. There are various models able to do this, ILSAX, XP-RAFTs and DRAINS being some which are commonly used for this purpose in small urban catchments in Australia.
- **Hydraulic modelling** – takes the runoff from the hydrology modelling and calculates how it will move across the landscape and through the drainage network including how fast, deep and

broad it will flow. Early computer models were only able to model the flow in on dimension (along a pipe, drain on landscape low point) but new models are capable of modelling flow in two dimensions which more accurately models how flows spread across the landscape. DRAINS, XP-RAFTS, HEC-RAS and TUFLOW are all capable of undertaking hydraulic modelling.

3.3 PREVIOUS FLOOD STUDIES

As noted in Section 1.1, Fairfield City Council had been addressing flood issues since the 1960's however the primary focus was on mainstream flooding. Overland flows were usually addressed as part of stormwater drainage design. The concept of local overland flooding was first officially introduced in the NSW Floodplain Management Manual in 2001 and it became incumbent on Councils to consider the impacts of overland flooding.

Shortly afterwards Fairfield City Council undertook the Fairfield City Overland Flood Study (Fairfield Consulting Services and SKM, 2004) to achieve a range of objectives, including a ranking of drainage areas in terms of severity of flooding for further investigation. Canley Corridor was identified as a high priority for further investigation.

Prior to the 2009 Canley Corridor Overland Flood Study (SKM and FCS), the only previous overland flood analysis of the study area was the "Canley Vale-Cabramatta Drainage Investigation" undertaken by Dalland & Lucas Pty Ltd in 1990. That study was undertaken in response to redevelopment in the previous 10 years, as well as the State Government's release of a medium density development policy to encourage the re-development of large residential blocks with existing services. A computer model (ILSAX) was built for the existing drainage system. Due to a lack of gauged information, the model was not calibrated, but default parameters were chosen based on other catchment areas within the Sydney area. The study determined pipe hydraulic grade lines and overland discharges for a range of flood return periods and durations. Locations were identified where the quantity of overland flow exceeded the capacity of the conventional drainage systems and where measures may be required to address this. The study recommended that Council utilise the ILSAX model to determine the permissible site discharge for all new developments so that the quantity of overland flow does not exceed existing flows and that further investigation is undertaken of other measures to reduce the quantity of overland flow.

In August 2005 Council commissioned Sinclair Knight Merz (SKM) to undertake an Overland Flood Study for the Canley Corridor area. The aim of the study was to define flood behaviour, identify properties at risk of flooding and to map the flood risk.

The Canley Corridor Overland Flood Study was initially completed in October 2008, and then adopted by Council with updates to the flood mapping in December 2009. The flood study was prepared in accordance with the NSW Government's Flood Prone Land Policy as documented in the 2005 Floodplain Development Manual (FDM).

Since it was the first detailed overland flow flood study to be carried out by Council, tests were carried out on the sensitivity of overland flood modelling to different assumptions about the capacity of the existing stormwater drainage system, and the conclusions used to establish a methodology for future overland flood studies.

A two-dimensional hydraulic TUFLOW model of the study area was developed. The TUFLOW model represented the topography of the study area using a 2 metre grid, buildings as solid objects in the floodplain and Orphan School Creek at the downstream end as a one-dimensional element. The TUFLOW model did not incorporate any fences although the impact of fences was investigated as part of sensitivity testing.

The TUFLOW model relies on inflows from the hydrologic and stormwater system models developed for the study area. Three different hydrological and stormwater models were developed using DRAINS or XP-RAFTS software to compare modelling approaches. The study selected the preferred "limited" DRAINS hydrologic and stormwater system model, representing larger sized pipes in the stormwater network as well as areas of known localised flooding named “hot spots”, for the design event modelling of the flood study.

The TUFLOW model also relies on boundary conditions from additional existing hydrologic and hydraulic models. Inflows for Green Valley Creek, Orphan School Creek and local sub-catchment inflows to Orphan School Creek within the hydraulic model extent, but beyond the study area extent were sourced from the 2008 Orphan School Creek, Green Valley Creek and Clear Paddock Creek (Three Tributaries) XP RAFTS flood model (SKM, 2008). The downstream boundary of the hydraulic model at Orphan School Creek was sourced from the Prospect Creek Flood Study (Bewsher Consulting, 2006).

Catchment flows and flood levels were subsequently calculated for the 5, 20 and 100 year ARI and PMF events for a range of storm durations.

Fence lines were not included in the model, as accurate representation of fences would have required considerable extra work beyond the study scope. However, a sensitivity test on the 100 year storm was carried out to assess the potential impact of “solid” fences in the upper catchment. Lengths of continuous and solid (brick or “Colorbond”) fencing in the upper catchment were represented as solid boundaries, that would retain water up to 1.0 metre depth and then overflow freely. These blockages were found to significantly increase water levels, particularly in areas where most of the flow is conveyed across properties rather than along streets. The increased water level was found to be directly related to the assumed depth at which the fence overflows or fails.

Preliminary Flood Risk Precinct maps were produced as the key output from this study. These maps were based on the modelling of the 100 year ARI and PMF events, and use Council’s Development Control Plan flood risk precinct categories. This mapping identified areas of:

- **High Risk Precinct** in the middle of the catchment around McBurney Road, along Freeman Avenue adjacent to Orphan School Creek, and along major overland flow paths on Railway Parade and Sackville Street;
- **Medium Risk Precinct** running from southwest to northeast from Cabramatta Road, across the Cumberland Highway, and covering much of the Canley Vale Road East and Sackville Street area;
- **Low Risk Precinct** following the outline of the Medium Risk Precinct closely, although extending significantly beyond the Medium Risk Precinct between Canley Vale Road East, Gladstone Road and Sackville Street, and in localised areas on either side of Railway Parade.

Peak flood depths on most properties were less than 0.5 metres, although there were some areas in the upper catchment where depths are between 0.5 metres and 1.0 metre. Similarly, flow velocities across most properties were generally below 0.5 metres per second, although higher velocities were seen in many streets and across some upper catchment properties.

A “Zone of Significant Flow” was delineated where it is important that overland flow paths are kept clear. It contains much of the 100 year ARI extent in the upper catchment, where flowpath blockage caused by fences, large buildings and debris can significantly increase water levels and divert water onto nearby properties.

A review of the modelling and revisions to ensure the flood model is “fit-for-purpose” were undertaken as part of the Floodplain Risk Management Study which this report details. That review is described in the following section.

3.4 FLOOD MODELLING REVIEW AND UPDATE

3.4.1 Overview

A review of the Canley Corridor DRAINS and TUFLOW models was undertaken in 2013 which identified a number of improvements which could be made to the hydrologic and hydraulic modelling of the catchment. Evaluation of these issues for the current Floodplain Risk Management Study suggested that the model would benefit from some modification to reflect current best practice in modelling approaches to overland flows as well as using new, more accurate data, which had become available.

A number of model modifications were implemented including:

- Updates to the one dimensional (1D) representation for Orphan School Creek and Green Valley Creek;
- Representing building footprints by applying locally higher hydraulic roughness values to allow water to flow through the building once it reaches the floor level, better representing realistic flood behaviour;
- Revision of the two dimensional (2D) model domain to incorporate the laser measured (LiDAR) digital elevation model (DEM) in a more flexible arrangement such that any new DEM can be efficiently incorporated at a later date;
- Conversion of the existing DRAINS pipe network to a now dynamically linked TUFLOW elements; and
- Changes to the hydrological and tail water inputs from the various sources.

The model review, model modifications and their impact on design flood levels, revised design event modelling and mapping and the additional climate change assessment conducted are detailed in Canley Corridor, Flood Study Review and Update (BMT WBM, 2014) included as Appendix B.

The following sections summarise the design event modelling and the results of the modifications and the impacts on the overall floodplain management approach in the Canley Corridor.

3.4.2 Design Event Modelling

The updated Canley Corridor TUFLOW model (as described above) has been used to simulate the 5, 20 and 100 year ARI and PMF design events for numerous standard durations. The TUFLOW model sources inflow hydrographs from the Canley Corridor DRAINS model, Three Tributaries TUFLOW model and Three Tributaries RAFTS model, along with sourcing the downstream boundary tailwater level representative of Prospect Creek from the Three Tributaries TUFLOW model.

The combination of ARIs and durations for the local catchment (i.e. Canley Corridor), the various inflow hydrograph sources and the downstream boundary have been based on recent advice from Fairfield City Council and the specific combinations used in the original SKM flood study for Canley Corridor. The adopted combinations ensure that consistency is maintained between the Canley Corridor study area and other overland flow catchments within Fairfield City which assumes:

- a concurrent flood in Prospect Creek which is of the same ARI as the event in the local catchment, with the exception of the local catchment PMF which has a 100 year ARI concurrent event;
- a concurrent flood in Orphan School Creek (i.e. Three Tributaries catchment) which is of the same ARI as the event in the local catchment, with the exception of the local catchment PMF which has a 100 year ARI concurrent event.

Outputs from the revised Canley Corridor modelling provide flood levels and extents for the overland flow flooding mechanism and does not replace flood levels derived from mainstream flooding in areas which are subject to both overland flooding and mainstream flooding.

3.4.3 Impact of Modifications

The revised Canley Corridor TUFLOW model was run for four design events and the results compared with the results from the 2009 Canley Corridor Overland Flood Study TUFLOW model. The differences between the peak water level results for the 100 year ARI and PMF design events are shown in Figure 3-4 and Figure 3-5 of the Flood Study Review and Update (FSRU) report.

The revised Canley Corridor TUFLOW model results for the study area are generally comparable with those of the 2009 model for the 100 year ARI design event and generally slightly lower for the PMF design event. Notable differences between the results are as follows:

- An increase in peak water level of up to 0.20 m in a localised area near the confluence of Orphan School Creek and Green Valley Creek for the 100 year ARI and PMF event which can be attributed to the dynamic interaction between the drainage network and Orphan School Creek
- An increase in peak water level of up to 0.20 m within the flooded extent west of Sackville Street between Canley Vale Road and St Johns Road for the PMF event.
- Decreases in peak water levels of up to 1.2 m along Orphan School Creek and Green Valley Creek. This can be attributed to the reduction in discharge in both creeks arising from updated Three Tributaries TUFLOW modelling. A major development in the Three Tributaries modelling is the inclusion of various detention basins in the modelling, resulting in an attenuation of flow at the upstream extent of the Canley Corridor TUFLOW model. This is discussed further in the Three Tributaries Floodplain Risk Management Study and Plan report.
- A comparison between the hydrographs being applied at the upstream of Orphan School Creek and Green Valley Creek for the 90 minute, 100 year ARI design event is provided in Figure 3-6 and Figure 3-7 of the FSRU. The revised model applies lower peak flows to the upstream of both of the creeks which has resulted in these lower peak water levels along Orphan School Creek which forms the downstream extent of the Canley Corridor study area.
- For both design events compared, the revised Canley Corridor TUFLOW model produces water levels up to 1.2 m higher along Orphan School Creek at the downstream boundary. This has resulted from correction of the timing of the downstream boundary tailwater level outlined in Section 3.5 of the FSRU. The original TUFLOW model applied a constant water level of 1.3 m AHD for the 100 year ARI design events for storm durations greater than 1 hour. The revised TUFLOW model applies a dynamic water level boundary reaching 4.73 m AHD for the same design events. The correction made to the timing of the hydrographs has resulted in the Prospect Creek water levels being correctly represented with higher water levels being applied.

The variations in results across the study area can be attributed to the changes made to the TUFLOW model. The changes incorporated into the model as a result of the review have resulted in a robust and fit for purpose tool for the purpose of undertaking a Floodplain Risk Management Study. The model did not warrant any recalibration (given the lack of calibration data) or any additional sensitivity checks The TUFLOW model can be readily adapted and modified to incorporate new data in the future (e.g. change of land use, new development).

It should be noted that the flood modelling represents the expected runoff from the catchment based on the level of development and the amount of impervious surfaces throughout the catchment at the time that the model was developed. Future development may increase the area of impervious surfaces. Although Council's On-site Detention Policy is designed to ensure major redevelopment does not increase peak stormwater discharges, multiple small increases in impervious surfaces through the construction of larger houses, larger driveways and paving of yards can lead to uncontrolled increases in peak overland flows for a given storm event.

3.5 FLOOD MAPPING

3.5.1 Mapping Methodology

The updated TUFLOW model calculates flow behaviour on 2 metre intervals and outputs results on a 1 metre grid over the study area. These results include flood levels, flood depths, and flow velocities at regular time intervals throughout the flood simulation, as well as peak values. These grids can be interrogated at any point within the study area using a GIS database, such as MapInfo.

An envelope approach has been used for mapping purposes where the peak of peaks results from all simulated model durations are calculated for each design ARI event. This accounts for the variation in critical storm duration across the catchment.

3.5.2 Design Flood Maps

The design flood maps for local catchment flooding events are presented in Appendices A to D of the FSRU:

- Peak flood levels for the 5, 20, 100, year ARI and PMF (Figures A-1 to A-4 of the FSRU);
- Peak flood depths for the 5, 20, 100, year ARI and PMF (Figures B-1 to B-4 of the FSRU);
- Peak flow velocities for the 5, 20, 100, year ARI and PMF (Figures C-1 to C-4 of the FSRU); and
- Flood hazard categories for the 5, 20, 100, year ARI and PMF (Figures D-1 to D-4 of the FSRU).

The flood mapping of all design storm events, using the same methodology and criteria as the original modelling, has been provided to Council digitally for incorporation into their GIS database.

Flood hazard categorisation in the flood modelling was based on peak depth and velocity criteria as outlined in the *Floodplain Development Manual* (NSW Government, 2005). Subsequently, hazard mapping was updated based on more recent research which is summarised in the current review draft of Australian Rainfall and Runoff (Smith and Cox, 2013).

3.6 HYDRAULIC, HAZARD & RISK CATEGORIES

While mapping flood extents, depths and velocities is useful, some form of classification of flood behaviour is useful in determining what risks flooding poses and what are appropriate land uses in the floodplain. Two such ways of doing this is by means of hydraulic classification and hazard classification.

3.6.1 Hydraulic Categories

Hydraulic classification divides the floodplain according to its hydraulic function. The NSW Floodplain Development Manual (2005) recommends three hydraulic categories: floodway; flood storage and flood fringe.

It is not feasible to provide explicitly quantitative criteria for defining floodways, flood storage areas and flood fringe areas, as the significance of such areas is site specific. Generally, the following definitions are applied:

- Floodways are areas conveying a significant proportion of the flood flow and where partial blocking will adversely affect flood behaviour to a significant and unacceptable extent.

- Flood storage areas - those areas outside floodways which, if completely filled with solid material, would cause peak flood levels to increase anywhere by more than 0.1 m and/or would cause the peak discharge anywhere downstream to increase by more than 10%.
- Flood fringe - the remaining area of land affected by flooding, after floodway and flood storage areas have been defined. Development in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels.

In Canley Corridor, in floods up to the 100 year ARI flood, there are very few areas that would fall within the flood storage criteria and this hydraulic category can be ignored for the majority of flood events. Extreme floods may create localised floodways however as their likelihood is so small, basing any planning decision on these floods, other than for emergency planning, is not justified. Therefore this form of hydraulic classification of the floodplain was not undertaken for Canley Corridor as it does not provide a meaningful delineation of the floodplain for floodplain management purposes in this instance.

The Fairfield City Wide Development Control Plan (FCC, 2013a) does define a zone of significant flow which is the area of the floodplain where a significant discharge of water occurs during floods. Should the area within this boundary be fully or partially blocked by buildings or fences, a significant distribution of flood flows or increase in flood levels would occur. This in a sense is a floodway within an overland flow catchment.

3.6.2 Provisional Hazard Categories

While the flood modelling report classified flood hazard as high or low in accordance with the depth and velocity combinations used to develop provisional flood hazards categories in the NSW Floodplain Development Manual (2005), for the purposes of the Canley Corridor Floodplain Risk Management Study consideration was given to a more a finely divided category classification which matches recent published data.

Figure 7 shows five categories of provisional flood hazard in accordance with the stability of people in floodwaters which is an important consideration in areas subject to overland flows. This is from published research as part of the current review of Australian Rainfall and Runoff (Smith and Cox, 2013).

It should be noted that the “low hazard for children category” may not be a low hazard for infants, frail or older people or people with physical or mental disabilities. Australian Rainfall and Runoff (ARR) recommends against locating facilities for such people (aged care facilities, retirement villages, preschools, child care centres etc.) in areas which can be subject to any flooding.

The ARR paper (Smith and Cox, 2013) also provides guidance on flood hazard based on vehicle stability as shown in Figure 8. It suggests that flood depths greater than 300mm are sufficient for small vehicles to become unstable and for velocities greater than 1 metre per second they can become unstable in shallower water. Any cars, even four wheel drives, can become unstable when velocities exceed 3 metres per second.

Other research indicates that similar criteria can be developed based on building stability. Figure 9 shows a similar diagram for building stability. Figure 10 shows a consolidated hazard diagram taking into consideration stability of people, vehicles and buildings.

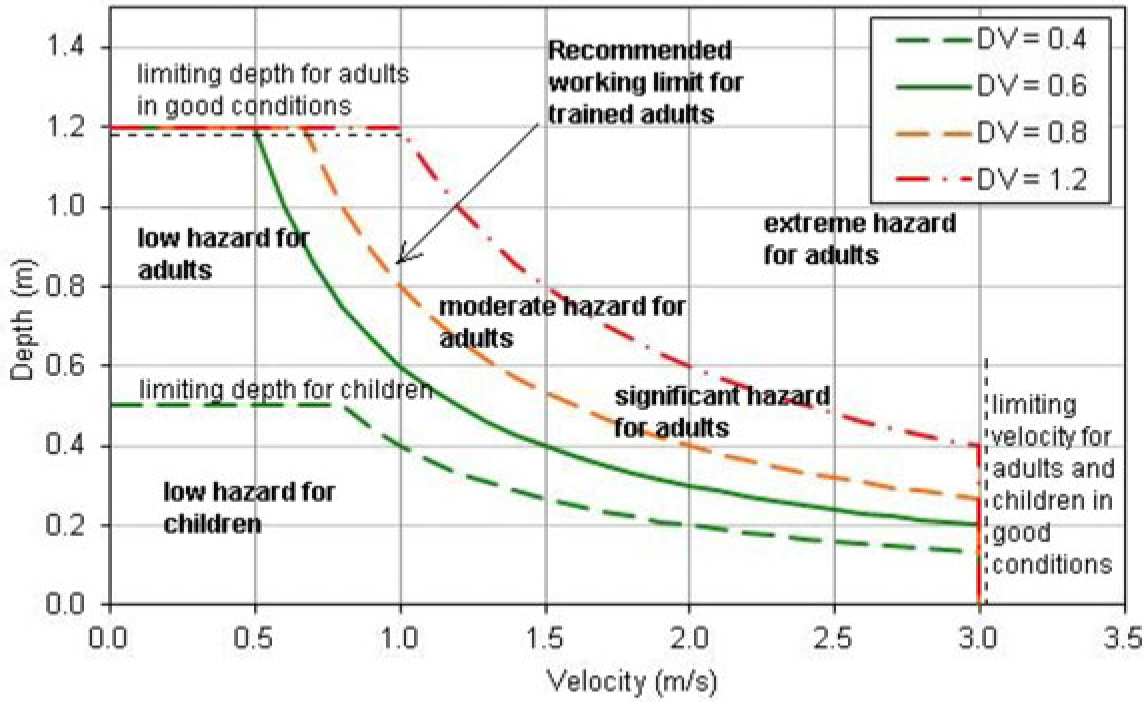


Figure 7: Provisional Hydraulic Hazard Categories based on Safety Criteria for People

Source: Smith and Cox (2009)

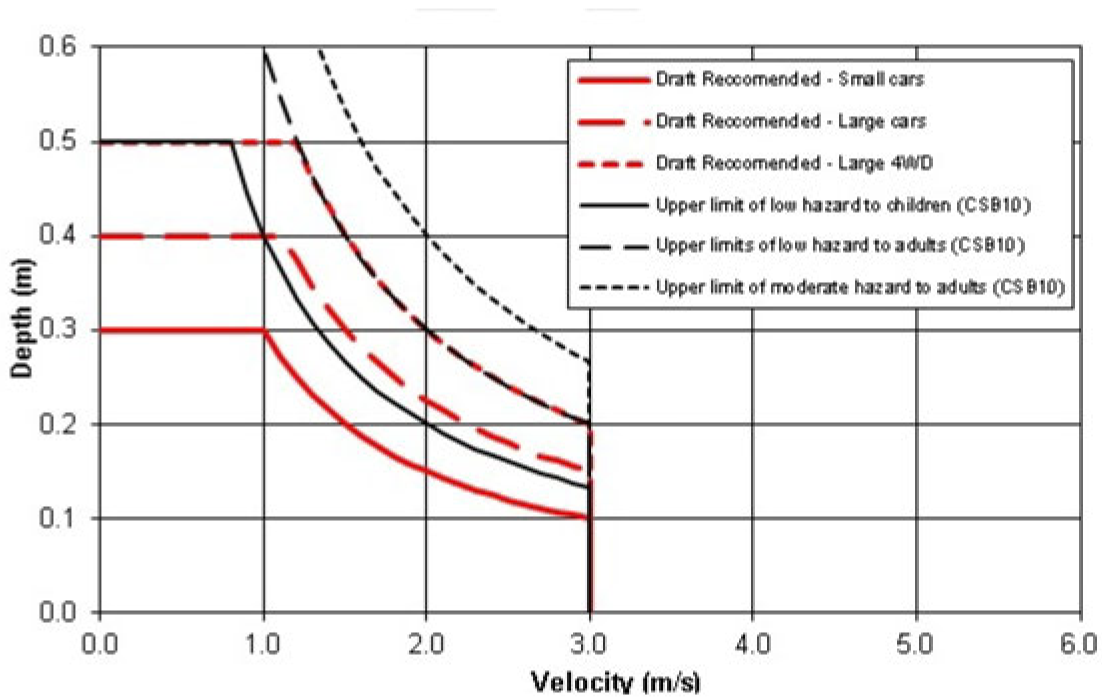


Figure 8: Provisional Hydraulic Hazard Categories based on Safety Criteria for vehicles

Source: Smith and Cox (2009)

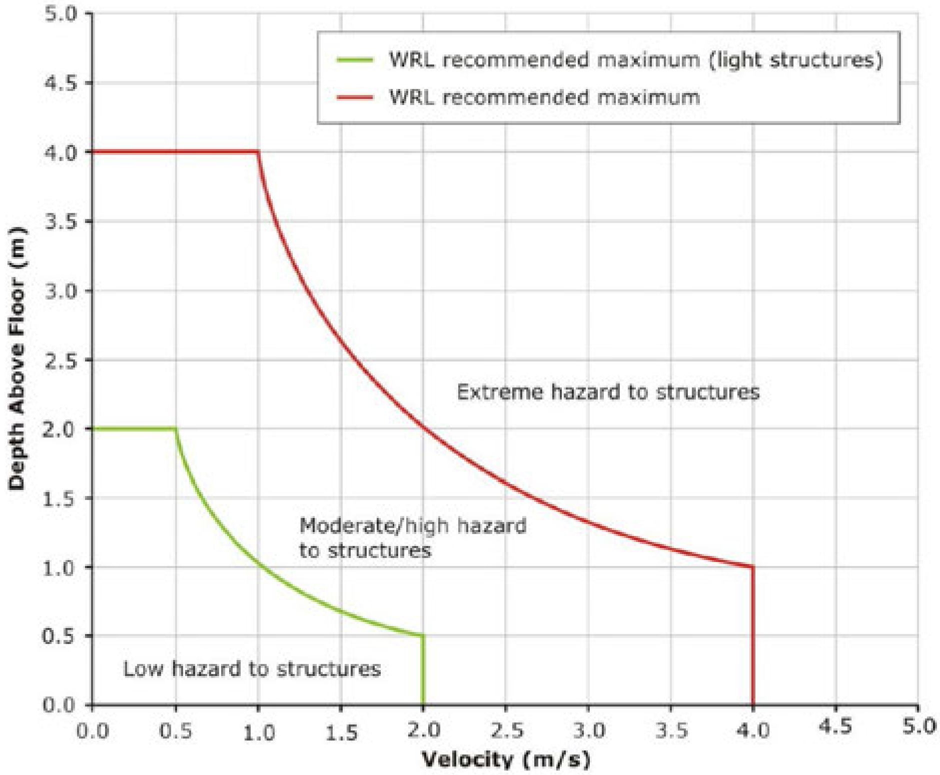


Figure 9: Provisional Hydraulic Hazard Categories based on Building Stability

Source: McLuckie et al. (2014)

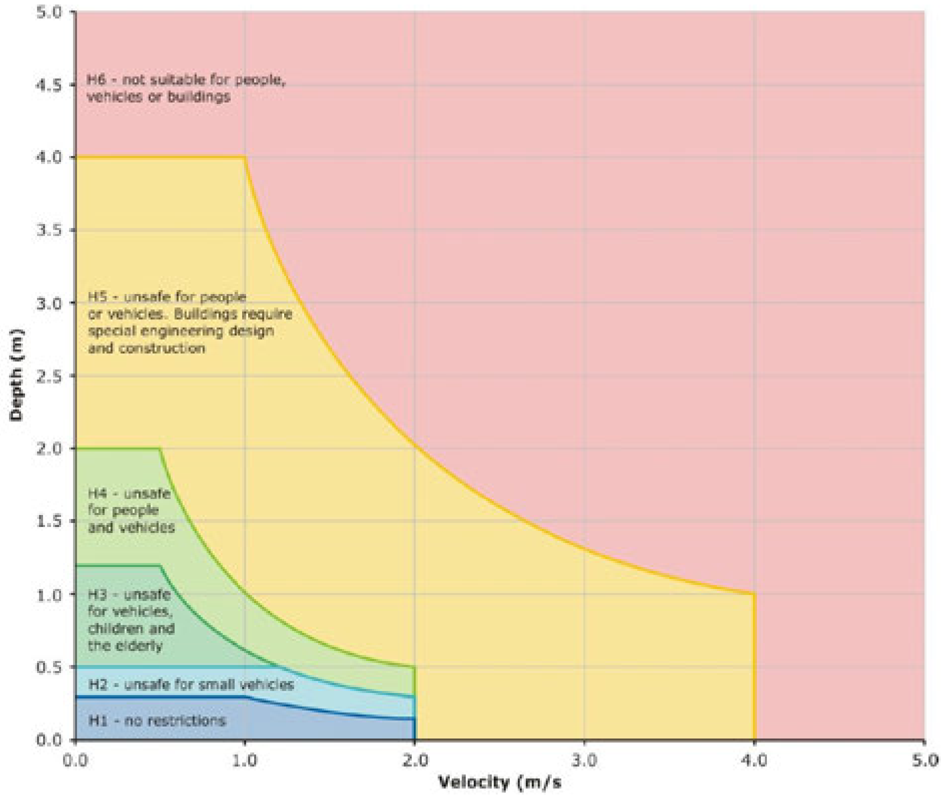


Figure 10: Provisional Hydraulic Hazard Categories based on Combined flood hazard curves

Provisional flood hazard categorisation based around depth and velocity combinations does not consider a range of other factors that influence flood hazard. Therefore provisional hazard categorisation should be used with the following factors to determine true hazard categories:

- Extent of flood;
- Effective warning time;
- Flood preparedness;
- Rate of rise of floodwaters;
- Duration of flooding;
- Evacuation problems;
- Effective flood access; and
- Type of development.

3.6.3 Flood Risk Precincts

The flood study review (see Section 3.4) provides a short discussion on the division of the floodplain into three provisional flood risk precincts: high, medium and low. The three (provisional) flood risk precincts are based on definitions outlined in the Fairfield City Wide Development Control Plan (2013a) summarised in Table 7. Fairfield City Council also defines a *Zone of Significant Flow* which is described in Table 7.

Table 7: Provisional Flood Risk Categorisation for Fairfield City Council

Flood Risk Category	**Description**
High Flood Risk	Land below the 100 year flood that is either subject to high hydraulic hazard or where there are significant evacuation difficulties
Medium Flood Risk	Land below the 100 year flood level that is not subject to high hydraulic hazard and where there are no significant evacuation difficulties
Low Flood Risk	All other land within the floodplain (i.e. within the PMF extent) but not identified as either in a high flood risk precinct or medium flood risk precinct
Zone of Significant Flow	The area of the floodplain where a significant discharge of water occurs during floods. Should the area within this boundary be fully or partially blocked, a significant distribution of flood flows or increase in flood levels would occur.

Appendix E of the FSRU presents the Provisional Flood Risk Precinct Map for the Canley Corridor catchment. It has been derived by compilation of the design flood conditions for catchment runoff events only, excluding Orphan School Creek flooding. It is noted that potential evacuation constraints have not been taken into account as this will be considered as part of the floodplain risk management study. The previously identified Zone of Significant Flow has not been included in the provisional flood risk precinct map at this stage and its application to floodplain management is discussed in the consideration of floodplain risk management options (see Section 8.4).

3.7 CLIMATE CHANGE ASSESSMENT[1]

There is increasing evidence that the earth's atmospheric and ocean temperatures have increased over the last century and that accumulation of greenhouse gases in the earth's environment may accelerate this process. Future climate change can potentially affect flood behaviour through:

- Increased sea levels; and
- Increased severity of storms and other weather systems.

The NSW Government has previously advocated sea level rise planning benchmarks to be considered in all coastal and flood hazard assessments (NSW Government, October 2009 and NSW Government, August 2010). The NSW sea level rise planning benchmarks are an increase above 1990 mean sea levels of 40cm by 2050 and 90cm by 2100. The NSW Government has since ceased to advocate these sea level rise planning benchmarks but they remain the best available estimates for accounting for sea level rise due to climate change however, as a previous study (Floodmit, 2011) has determined, sea level rise will not affect flooding in the upper reaches of Orphan School Creek nor will it affect flood levels in the Canley Corridor catchment. Sea level rise has therefore not been adopted in this study.

The impact of climate change on rainfall is less certain. Evidence to date suggests that whilst mean annual rainfall over Australia is likely to reduce, the intensity of extreme daily rainfall could increase. The CSIRO predicts the effects of climate change to result in increases in rainfall of up to 12% by 2070 (CSIRO, February 2007).

Climate change sensitivity assessments in NSW are often conducted by considering the impact of an increase in rainfall intensity on flooding. As the Canley Corridor TUFLOW model utilises inflow hydrographs from a variety of sources it was not possible to directly model an increase in rainfall intensity. As an alternative, the inflow hydrographs from the various sources (Canley Corridor DRAINS model, Three Tributaries TUFLOW model and Three Tributaries RAFTS model) were increased. Note a percentage increase applied to inflow hydrographs is not equivalent to an equal percentage increase in rainfall intensity as the relationship is very rarely linear in nature. In reality the impact of an increase in rainfall intensity on rainfall runoff is dependent upon the many and varied catchment characteristics that can influence runoff volumes following rainfall.

For this assessment, a sensitivity assessment for the Canley Corridor catchment was undertaken to estimate the potential impact of a 10%, 20% and 30% increase in rainfall runoff (as applied to the inflow hydrographs) on stormwater flooding. The assessment was undertaken for the 100 year ARI design event simulating the range of standard durations modelled from 5 minutes to 120 minutes. The downstream water level boundary condition representative of Prospect Creek was not modified from the design event.

The peak water level results for each of the climate change scenarios were compared to 100 year ARI design event as illustrated in Figures F-1 to F-3.

Typical flood level increases of 0.05m, 0.10m and 0.15m for the 10%, 20% and 30% scenarios are evident across the majority of the Canley Corridor catchment. The largest increases in peak water levels are evident along Orphan School Creek. These increases range from approximately 0.20m, 0.35m and 0.55m for the 10%, 20% and 30% scenarios upstream of the railway line.

Similar increases in flood levels are apparent at the intersection of Sackville Street and Freeman Avenue with increases ranging from 0.15m, 0.35m and 0.35m for the 10%, 20% and 30% scenarios. Smaller increases are evident in other areas such as in Canley Vale shopping strip where increases are less than 0.10m even in the 30% scenario. These increases are so small because the overland flow areas are generally broad and flat and in most areas the depth of flows are relatively shallow.

[1] Much of this discussion is based on Practical Consideration of Climate Change, published by NSW Department of Environment & Climate Change (now OEH) in 2007.

The results of the climate change analysis highlight that peak flood level conditions in the Canley Corridor study are not particularly sensitive to the impacts of climate change and represent at most about 10% of the current freeboard of 0.5m which is provided for in existing planning controls.

4 URBAN PLANNING CONTEXT

4.1 OVERVIEW

The management and development of flood prone land must be undertaken within the current NSW legislative, policy and planning framework. A brief summary of relevant legislation and policy as well as recent reforms by the NSW Government on flood related development controls are provided in this section. Fairfield City Council's compliance with this legislation and policy is also discussed.

This Chapter also provides a brief overview of current town planning initiatives in Fairfield LGA with potential to impact up floodplain management.

4.2 NSW ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979

4.2.1 Background

The *Environmental Planning and Assessment Act 1979* (EP&A Act) creates the mechanism for development assessment and determination by providing a legislative framework for development and protection of the environment from adverse impacts arising from development. The EP&A Act outlines the level of assessment required under State, regional and local planning legislation and identifies the responsible assessing authority.

Prior to development taking place in New South Wales a formal assessment and determination must be made of the proposed activity to ensure it complies with relevant planning controls and, according to its nature and scale, conforms with the principles of environmentally sustainable development.

4.2.2 Section 117 Directions of the Environmental Planning and Assessment Act 1979 – Direction No. 4.3 (Flood Prone Land)

Pursuant to the *EP&A Act*, Section 117 Direction No 4.3 (Flood Prone Land) was issued on the 19 July 2007 by the Minister for Planning replacing all existing directions previously in operation. The later Directions allow the Minister for Planning to provide instructions to councils regarding the principles, aims, objectives or policies to be achieved in the preparation of draft Local Environmental Plans (LEPs).

Direction No. 4.3 – Flood Prone Land applies to councils that contain flood prone land within their local government area and any draft LEP that creates, removes or alters a zone or provision that affects flood prone land.

Key objectives of Direction 4.3 are:

- To ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005 (including the Guidelines or Development Controls on Low Flood Risk Areas); and
- To ensure that the provisions of an LEP on flood prone land are consistent with flood hazard and includes consideration of the potential flood impacts both on and off the subject land.

Under Direction 4.3, amongst a range of requirements, Councils must not include provisions in draft LEPs that apply to the flood planning area which:

- permit development in floodway areas;

- permit development that will result in significant flood impacts to other properties;
- permit a significant increase in the development of that land;
- are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services; or
- permit development to be carried out without development consent except for the purposes of agriculture (not including dams, drainage canals, levees, building or structures in flood ways or high hazard areas), roads or exempt development.

Councils are able to vary these requirements if they can satisfy the Director General (or the officer of the Department nominated by the Director General) of any particular inconsistency with the Flood Prone Land Direction.

The directive makes reference to Guidelines on Development Controls on Low Flood Risk Areas which were issued at the same time and which provide more prescriptive details regarding planning controls. The Guidelines are discussed in more detail in Section 4.4.2.

4.2.3 Environmental Planning and Assessment Amendment (Flood Related Development Controls Information) Regulation 2007

Schedule 4, clause 7A of the Environmental Planning and Assessment Regulation 2000 (EP&A Act Regulations) was amended in 2007 to include references to flood related development and is referred to as the Environmental Planning and Assessment Amendment (Flood Related Development Controls Information) Regulation 2007. This amendment requires councils to distinguish where flood related development controls are for nominated types of residential development and all other development. Nominated residential development includes dwelling houses, dual occupancies, multi dwelling housing and residential flat buildings, however does not include group homes or seniors living.

4.3 STATE ENVIRONMENTAL PLANNING POLICIES (SEPP)

4.3.1 SEPP (Exempt and Complying Code) 2008

SEPPs are the highest level of planning instrument and generally will prevail over LEPs. *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* defines development which is exempt from obtaining development consent and other development which does not require development consent if it complies with certain criteria.

The SEPP defines ‘Flood Control Lots’ as property where ‘flood-related development controls apply’ i.e. this would have a notation on its Section 149 Certificate. These development controls may apply through an LEP or DCP. Exempt development is not permitted on Flood Control Lots but some complying development is allowed on Flood Control Lots.

Complying development is permitted on Flood Control Lots where a Council or professional engineer can certify that the part of the lot proposed for development is not a:

- flood storage area;
- floodway area;
- flow path;
- high hazard area; or
- high risk area (see Clause 3.36C).

The SEPP specifies various controls in relation to floor levels, flood compatible materials, structural stability, flood affectation, safe evacuation, car parking and driveways (see Clause 3.36C).

Flood control lots have not been specifically defined as part of the FRMS&P. However there is sufficient information to define flood control lots based on hazard and risk categories.

4.3.2 SEPP (Infrastructure) 2007

As it affects flooding in the Canley Corridor catchment, this SEPP identifies development which is permissible without consent which includes – flood mitigation work (Division 7) and stormwater management systems (Division 20). It also includes provision under – Clause 15 for consultation on flooding

SEPP (Infrastructure) 2007 prevails over Fairfield LEP 2013 and allows Council to undertake stormwater and flood mitigation work without development consent and for it to be assessed under Part5 of the EP&A Act 1979.

4.4 NSW FLOOD RELATED POLICIES & PLANNING CONTROLS

4.4.1 Floodplain Development Manual

The Floodplain Development Manual 2005 (the Manual) was gazetted on the 6 May 2005 and relates to the development of flood liable land. It incorporates the NSW Flood Prone Land Policy, which aims to reduce the impacts of flooding and flood liability on individual owners and occupiers of flood prone property and to reduce private and public losses resulting from floods. To implement this policy and achieve these objectives, the Manual develops a merit based framework to assist with floodplain risk management. The Manual indicates that responsibility for management of flood risk remains with local government. It assists councils in their management of the use and development of flood prone land by providing guidance in the development and implementation of local floodplain risk management plans.

The Manual builds upon and replaces the 2001 Floodplain Management Manual. Key changes include outlining altered agency roles in floodplain risk management and clarifying the State Government's position on development standards.

4.4.2 Guidelines on Development Controls on Low Flood Risk Areas

The Guidelines on Development Controls on Low Flood Risk Areas – Floodplain Development Manual (the Guidelines) were issued on 31 January 2007 as part of Planning Circular PS 07-003 at the same time as the S117 Directive described in Section 4.2.2. The Guidelines are intended to be read as part of the Floodplain Development Manual. They have been created to supply additional guidance on matters within the Manual, including determining the appropriate flood planning level (FPL) for councils and appropriate flood related development controls on residential development in low flood risk areas. Strategic consideration of a number of key issues which must be addressed include safety to existing and future occupants of flood prone land, management of the potential damage to property and infrastructure and the cumulative impacts of development.

The Guidelines do not strictly conform with the Manual’s merit based approach to selection of appropriate flood planning levels (FPLs) however they recognise the need to consider the full range of flood sizes, up to and including the probable maximum flood (PMF) and the corresponding risks associated with each flood.

The Guidelines have caused significant consternation amongst Councils and floodplain managers generally in that they state:

- "unless there are exceptional circumstances, councils should adopt the 100-year flood as the FPL for residential development"; and
- "unless there are exceptional circumstances, councils should not impose flood related development controls on residential development on land above the residential FPL (low flood risk areas)".

Fairfield Council, in light of its past flood history, local flood behaviour, associated flood hazards and particular historic floods made an application to the relevant government agencies for the granting of these exceptional circumstances. On 9 May 2013, the Director-General of the Department of Planning and Infrastructure advised FCC that the exceptional circumstance application has been approved. This means that Fairfield City Council has been permitted to continue to impose development controls on residential development which is above the 1 in 100 year ARI flood level as per its practice from before the issuing of the S117 Directive.

Accordingly, Clause 6.4 has been included in the Fairfield LEP 2013 to enable this. This clause is not part of the standard LEP template adopted by Councils throughout NSW.

There remains a likelihood that this particular directive and guidelines may be repealed at some date in the near future as part of the current government's review of planning legislation and procedures.

4.4.3 NSW State Flood Plan

The NSW State Flood Plan is a sub-plan of the State Disaster Plan (DISPLAN). The aim of the DISPLAN is to set out the mitigation, preparation, warning, response and recovery arrangements for flooding in New South Wales and the responsibilities of agencies and organisations with regard to these functions.

A sub-plan of the NSW State Flood Plan, the Fairfield Local Flood Plan 2010, is most applicable to the Canley Corridor catchment and is discussed in detail in Section 6.

4.5 REGIONAL ENVIRONMENTAL PLANS (REPS)

It should be noted that as of 1 July 2009, Regional Environmental Plans (REPs) are no longer part of the hierarchy of environmental planning instruments in NSW. Accordingly, all existing REPs are now deemed to be State Environmental Planning Policies (SEPPs).

Greater Metropolitan Regional Environmental Plan No 2 – Georges River Catchment applies to the Catchment, which is part of the region declared under the Act and known as the Greater Metropolitan Region. The Catchment consists of parts of Bankstown City, Blacktown City, Campbelltown City, Camden, Canterbury City, Fairfield City, Holroyd City, Hurstville City, Kogarah, Liverpool City, Rockdale City, Sutherland, Wollondilly and Wollongong City local government areas that are within the Georges River Catchment. The catchment map indicates the boundary of the Catchment.

Greater Metropolitan Regional Environmental Plan No 2 – Georges River Catchment aims to protect the water quality of the Georges River and its tributaries and the environmental quality of the whole catchment. The objectives of the plan are to be achieved through coordinated land use planning and development control. The plan establishes the framework within which local, State and Federal agencies will consult so that there is a consistent approach to planning and development within the catchment. Practice has shown that this plan is no longer fully taken into consideration during the landuse planning and development assessment process.

The following considerations are included in the assessment for land which is subject to flooding:

- the benefits of periodic flooding to wetland and other riverine ecosystems;
- the pollution hazard posed by development on flood liable land in the event of a flood; and

- the cumulative environmental effect of development on the behaviour of flood water and the importance of not filling flood prone land.

4.6 LOCAL ENVIRONMENTAL PLANNING

In accordance with Standard Instrument (Local Environmental Plans) Order 2006, a Fairfield Local Environmental Plan (LEP) was prepared by Council and approved on 17 May 2013.

Land use planning decisions within the Fairfield LEP 2013 are based on a "best fit" transfer from the former Fairfield LEP 1994. Some areas have been rezoned to accommodate higher density housing.

Part 6 of the LEP allows Council to include clauses that address local circumstances within the City. It details specific local provisions for the following issues:

- Earthworks
- Flood planning
- Floodplain risk management
- Terrestrial biodiversity
- Riparian land and watercourses
- Landslide risk
- Infrastructure development—Council
- Essential services

It is noted that Flood Planning and Floodplain Risk Management are addressed amongst a range of specific local provisions in clause 6.3 and 6.4 respectively and reproduced below.

6.3 Flood planning [local]

(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 impacts on flood behaviour and the environment.

(2) This clause applies to land at or below the flood planning level.

(3) Development consent must not be granted to development on land to 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 NSW Government's Floodplain Development Manual [ISBN 0 7347 54756 0] published in 2005, by the NSW Government, unless it is otherwise defined in this clause.

(5) In this clause:

flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

6.4 Floodplain risk management [local]

(1) The objectives of this clause are as follows:

(a) in relation to development with particular evacuation or emergency response issues, to enable evacuation of land subject to flooding in events exceeding the flood planning level,

(b) to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

(2) This clause applies to land between the flood planning level and the level of a probable maximum flood, but does not apply to land subject to the discharge of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

(3) Development consent must not be granted to development for the following purposes on land to which this clause applies unless the consent authority is satisfied that the development will not, in flood events exceeding the flood planning level, affect the safe occupation of, and evacuation from, the land:

(a) caravan parks,

(b) commercial premises,

(c) correctional centres,

(d) emergency services facilities,

(e) group homes,

(f) hospitals,

(g) industries,

(h) residential accommodation,

(i) residential care facilities,

(j) tourist and visitor accommodation.

(4) In this clause:

flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

probable maximum flood has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0), published in 2005 by the NSW Government.

The inclusion of Clause 6.4 in the LEP was based on the Department of Planning and Infrastructure's acceptance of Council's case for exceptional circumstances lodged in April 2011. It is a significant moment for floodplain risk management in Fairfield as it allows Council to manage the risks associated with flooding up to the PMF, not just to an arbitrarily chosen Flood Planning Level. It recognises that there are a very large number of residential, commercial and other property uses potentially affected by flooding above that arbitrary line and up to the PMF event.

4.7 LOCAL DEVELOPMENT CONTROLS

4.7.1 Fairfield City Wide Development Control Plan 2013

Chapter 11 of Fairfield City Wide DCP 2013 entitled "Flood Risk Management" outlines the context, background and controls necessary for addressing existing flood risk (flood modification measures) and future flood risk (development controls).

The criteria for determining applications for proposed development that is potentially affected by flooding are structured in recognition that different controls are applicable to different types of land uses and levels of flood risk.

The method by which it is determined which controls apply to proposed development involves:

- firstly, identifying the land use category of the development (from Schedule 2 at the end of Chapter 11);
- secondly, determine which flood risk precinct the land is located within (refer to Clause 11.7 and relevant flood risk mapping); and
- then apply the controls outlined under Clause 11.8.

Clause 11.8 states:

The development controls apply to all land within a Flood Risk Precinct described above. The type and stringency of controls have been graded relative to the severity and frequency of potential floods, having regard to categories determined by the relevant Floodplain Risk Management Study and Plan or, if no such study or plan exists, council's interim considerations. The categories applicable to each floodplain are depicted on the planning matrices contained in the following schedules at the rear of Chapter 11:

- Schedule 4 –Georges River (south of the Hume Highway) Floodplain;
- Schedule 5 – Cabramatta Creek Floodplain; and
- Schedule 6 – All Other Floodplains including areas affected by local overland flow.

Note: The controls applying to "all other floodplains" are interim only until catchment specific Flood Risk Management Plans are prepared as required by the FDM.

It should be noted that development proponents can choose to either meet the prescriptive controls in the matrices (refer Section 11.8.3) or meet the performance criteria (refer Section 11.8.2). In the vast majority of cases, development proponents choose to comply with the prescriptive controls.

Clause 11.9 provides specific requirements for fencing in the floodplain, while Clause 11.10 identifies special considerations which will apply only to some development in specific circumstances.

The Canley Corridor Floodplain Risk Management Study relates to a floodplain that is neither Georges River (south of the Hume Highway) Floodplain nor Cabramatta Creek. Accordingly, "Schedule 6 - All Other Floodplains" category currently applies with the specific rider that the controls as published are interim until catchment specific Floodplain Risk Management Plans are prepared as required by the Floodplain Development Manual (FDM). Accordingly, an evaluation of the viability of the controls outlined within Schedule 6 is undertaken later in Section 8.4.2 of this report.

4.7.2 Canley Corridor Local Town Centres DCP No.37 2013 Version 1 (2013 – Amendment 5)

Within the Canley Corridor Local Town Centres DCP, Section 2.4.2 addresses drainage and flooding as follows:

> *The major drainage system in the City consists of 97km of waterway, and part of Orphan School Creek forms the northern boundary of the Canley Corridor. Some land in the Canley Corridor is affected by either a low, medium or high risk of flooding as well as being subject to overland flooding.*
>
> *Overland flow paths are critical. Designs must ensure that movement of water during storm events continues to occur in a safe and effective manner with minimal risk to users of the centre or property within it.*
>
> *This flood-affected land, upon redevelopment must address any flood related concerns along with provision of engineer's analysis, reports and requirements to proposed developments. Details of how proposed development will meet any flood issues must be provided, also with extraction of water from basement or semi-basement car parks. Appropriate and sustainable water management measures should be considered to ensure flooding and drainage does not become a problem.*
>
> *Council is reviewing all flood liable land in accordance with the New South Wales Flood Plain Management Manual. Flood studies are being undertaken by Council and once complete, information will be made available to assist in the assessment and viability of development sites affected either by creek flooding or overland flow paths. Contact Council's Catchment Management Branch for more information.*

This DCP is less prescriptive than the City-wide DCP and it will be necessary for Council to ensure that both documents are referred to in development considerations. This is discussed further in the consideration of Property Modification Measures (Section 8.4.2).

4.7.3 Planning Certificates under Section 149

Council has a detailed process for responding to requests made under both Section 149 (2) and 149 (5) of the EP&A Act. This process has been in use for a significant period and there has generally been minimal complaint about if from either the community or real estate professionals. This is not to say the type of information which they include and the way it is communicated cannot be improved.

Section 149 (2)

The information provided in response to requests under Section 149 (2) of the EP&A Act comprises the issue of a general statement regarding flood related development, then a range of mainstream flood risk categories within various risk precincts and then, if applicable, a range of overland flood risk categories within various risk precincts. Copies of the wording and information issued in response to requests under this section are attached at Appendix C.

Section 149 (5)

If further flooding information is available under Section 149 (5), this information is provided in a “Flood Information Sheet” that provides information on flood levels for a range of flood events, under either mainstream flooding or local overland flooding, or both, depending on circumstances. Information on flooding in Canley Corridor is currently extracted from the 2009 flood model

The Section 149 (5) Certificate must be purchased from Council and the relevant S149(5) certificate would include the Flood Information Sheet. It also includes the same information regarding the flood risk precincts as is provided in the Section 149(2) certificate.

A copy of the type of information conveyed in response to requests under this section is attached at Appendix C.

4.7.4 Section 94 Development Contributions

Section 94 of the EP&A Act enables councils to collect contributions from developers for the provision of infrastructure which will be necessary as a consequence of development. This can include roads, drainage, open space and community facilities. Each Council must develop a Section 94 Contributions Plan(s) which demonstrates a quantifiable link between the development intensification and the need for the additional infrastructure as well as a detailed costing of such infrastructure and formulae to be used to determine contributions from each type of development.

Fairfield City Council's current Section 94 contributions plan includes provision for the acquisition of land for public open space but does not include provisions for stormwater management works.

4.7.5 Stormwater Drainage Policy

The objectives of this policy are to:

- Provide clear guidelines to Council's customers of requirements for stormwater drainage and civil works;
- Ensure that developments meet all relevant standards for the disposal of stormwater and that developments do not increase the hazard to persons or property;
- Cater for minor and major stormwater systems;
- Provide latitude for merit based assessment of stormwater issues; and
- Expedite the assessment of development applications with respect to stormwater drainage.

It is not intended that this policy will cover all situations and does not absolve the designer of the necessity to plan for specific site requirements. It is also not the intention of this policy to encompass the growing field of water sensitive urban design (WSUD). It is envisaged that WSUD principles will be included as part of a future update and expansion of the stormwater drainage policy.

This policy should be read in conjunction with relevant standards, instruments and policies, including:

- Australian Standard AS 3500.3.2;
- Australian Rainfall & Runoff;
- Building Code of Australia Housing Provisions 1996;
- Fairfield City Council's On-Site Detention Handbooks;
- Fairfield City Council's Local Environmental Plan 1994;
- Fairfield City Council's Road and Drainage Specification Associated With Subdivision or Other Development;
- Fairfield City Council's Flood Plain Management Policy; and
- Fairfield City Council's Development Control Plans, Policies and Guidelines relevant to the proposed development.

Currently the policy is applied on a site-by-site basis to infill development within the CC catchment. Any stormwater drainage work proposed as part of new development needs to be consistent with both this policy, the OSD policy and flood related development controls in the DCP.

Given the passage of time since this policy was developed, its upgrading and updating will form a specific recommendation within the Floodplain Risk Management Plan.

4.7.6 Urban Area On-Site Detention Code

The Urban Area On-Site Detention (OSD) Code was originally prepared in 1994 and has been updated, in part, since with the most recent Handbook on the Code dated 1997. The objectives of the Code are:

- To minimise increases in the frequency and/or severity of surcharging of the local drainage system resulting in downstream flooding problems;
- To minimise increases in flood levels on the major trunk drainage networks and on the creek systems;
- To emphasise that OSD drainage requirements within Fairfield City's urban area need to be integrated with the architectural design and layout of the development in order that adequate storage areas can be located in the very early stages of the building design process; and
- To provide developers with information relating to the location of overland flow paths for stormwater flows in excess of the capacity of the in-ground system for storm events up to the 100 year Average Recurrence Interval (ARI) storm.

OSD is to be applied to the following developments ultimately draining to the Georges River:

- All multi-unit residential development;
- All industrial developments where the impervious area is increased (not required in Wetherill Park Industrial Area); and
- All commercial developments where the impervious area is increased.

OSD may also be required for single dwelling development, including dual occupancies, and the redevelopment of multiple parcels of land which Council considers likely to produce excessive stormwater runoff. However, if a significant portion of the site is affected by a major overland flowpath, the emphasis shifts from OSD to safely conveying flows through the site and applying other controls to minimise flood damage, e.g. elevating flood levels.

The Code also provides data on "Permitted Site Discharge", Ponding Depths, Freeboard and the application of the Code within the overall Development Approval Process.

The Code as it currently stands does not control the cumulative impacts of runoff created by small residential building extensions or increased paved areas on properties.

Given the passage of time since this code was developed, its upgrading and updating will form a specific recommendation within the Floodplain Risk Management Plan.

4.8 STRATEGIC PLANNING

There are some strategic planning documents which are of relevance to Canley Corridor and options which may be available for managing overland flows. Of specific relevance are the following.

4.8.1 Draft Fairfield Residential Development Strategy

The population of Sydney will increase by 1.3 million people by 2031, meaning an additional 545,000 homes are needed. The State Government has set a target of 24,000 additional dwellings in Fairfield City by 2031 to help accommodate Sydney's growth.

Council has a long-term plan that will allow more people to live around town centres and areas that have good public transport and are close to railway stations.

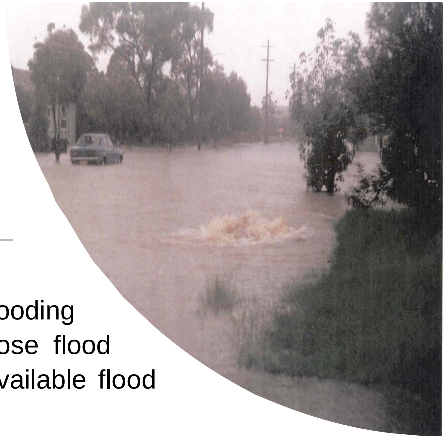
A draft residential development strategy report was prepared in 2009 for areas east of the Cumberland Highway and included draft planning visions for Canley Heights, Canley Vale and Cabramatta (Hassell, 2009). Investigations identified local road and traffic issues in Canley Vale and Cabramatta which would need to be resolved before further urban consolidation would be possible in these areas. The urban consolidation vision for Canley Heights is reflected in the rezoning of land as part of the LEP 2013.

Other areas which were part of the 2009 study were included in the public exhibition of the Draft Residential Strategy East which came off public exhibition in October 2014. It does not apply to any areas within the Canley Corridor Catchment although there are areas in the eastern part of the floodplain which are zoned for higher density residential development and are not completely redeveloped.

4.8.2 Open Space Strategy

The Fairfield Open Space Strategy (Clouston Associates, 2007) identifies the open space needs within Fairfield LGA and divided the LGA into Place Management Areas (PMAs) for the purposes of analysis. Canley Corridor is within the Cabramatta PMA and was identified as an area of highest open space need. Amongst the report's recommendations was:

Implement a program to make good the shortfall in passive open space provision in the Middle Distance Areas (including the suburbs of Cabramatta, Cabramatta West, Canley Vale, Fairfield Heights) in the short term by improvement of existing facilities and links … however there is an ongoing need for more open space in middle distance areas.



5 FLOOD IMPACTS

The flood modelling described in Chapter 2 was used to assess the impacts of flooding on people and property in the Canley Corridor. This Chapter describes those flood impacts and where possible quantifies them. It refers to a selection of the available flood mapping. The full set of flood maps can be found in Appendix B.

5.1 FLOOD BEHAVIOUR

5.1.1 Frequent Floods

Figure 11 shows the depth of flooding across the catchment in a 5 Year ARI flood, the most common flood which has been modelled. In such an event it is anticipated that most of the overland flows would concentrate in the natural topographic depression of the upper catchment and flow from southwest to north east towards Orphan School Creek.

While these flows in the upper reaches and along the fringes of the overland flow area would mostly be less than 300mm deep there are some depressions in the landscape which will fill with water up to 600mm deep.

North of St Johns Road the flows spread out more and are generally less than 300mm deep but are flowing across a wider area. As the flows get closer to Orphan School Creek they remain shallow but tend to be more concentrated within the road reserves and parks rather than private property.

The lowest sections of Freeman Avenue, which is close to the creek, could get up to 800 mm deep. It is also noted that even in such a small event vehicular evacuation from Freeman Avenue, which includes a nursing home at its eastern end, would be cut off because of the depth of flooding across the road. The only safe access would be along a pedestrian path which connects Freeman Avenue to Canley Vale Road to the south.

In addition to the main overland flow path described above, there is also:

- some local overland flows which flow directly to the creek in the northern part of the catchment at less than 300 mm deep
- flows which accumulate on the western side of the railway line (up to 700mm deep) before flowing north towards the creek with some of the flow crossing the railway north of Pevensey St and finding a path toward the creek east of the railway line.

While flood depth is an important consideration in assessing flood impacts, flood velocity is also important. The combined effect of depth and velocity is used to define hydraulic hazard (see Section 3.6) and this can be used to evaluate flood impacts.

The peak flood hazard for the 5 Year ARI event is shown in Figure 12 and, apart from the few locations where the depth exceeds 500mm, the flood hazard is generally very low and does not pose a risk to people who may be walking or driving through it. Even in the most hazardous areas the water would pose a low risk to able bodied adults.

In the 20 Year ARI event the area subject to overland flows is slightly more extensive as are the areas which are more than 500mm deep and which could pose a low risk to adults. What does start to happen in this size flood is that the velocity of water running along some of the streets north of St Johns Road begins to enter the low hazard for adults category which would be sufficient to cause some cars to float. Greater lengths of Freeman Avenue and Railway Parade would be non-trafficable.

In this event it would take less than an hour after the beginning of the storm for Freeman Avenue to be cut off and it is likely to be cut for three or four hours.

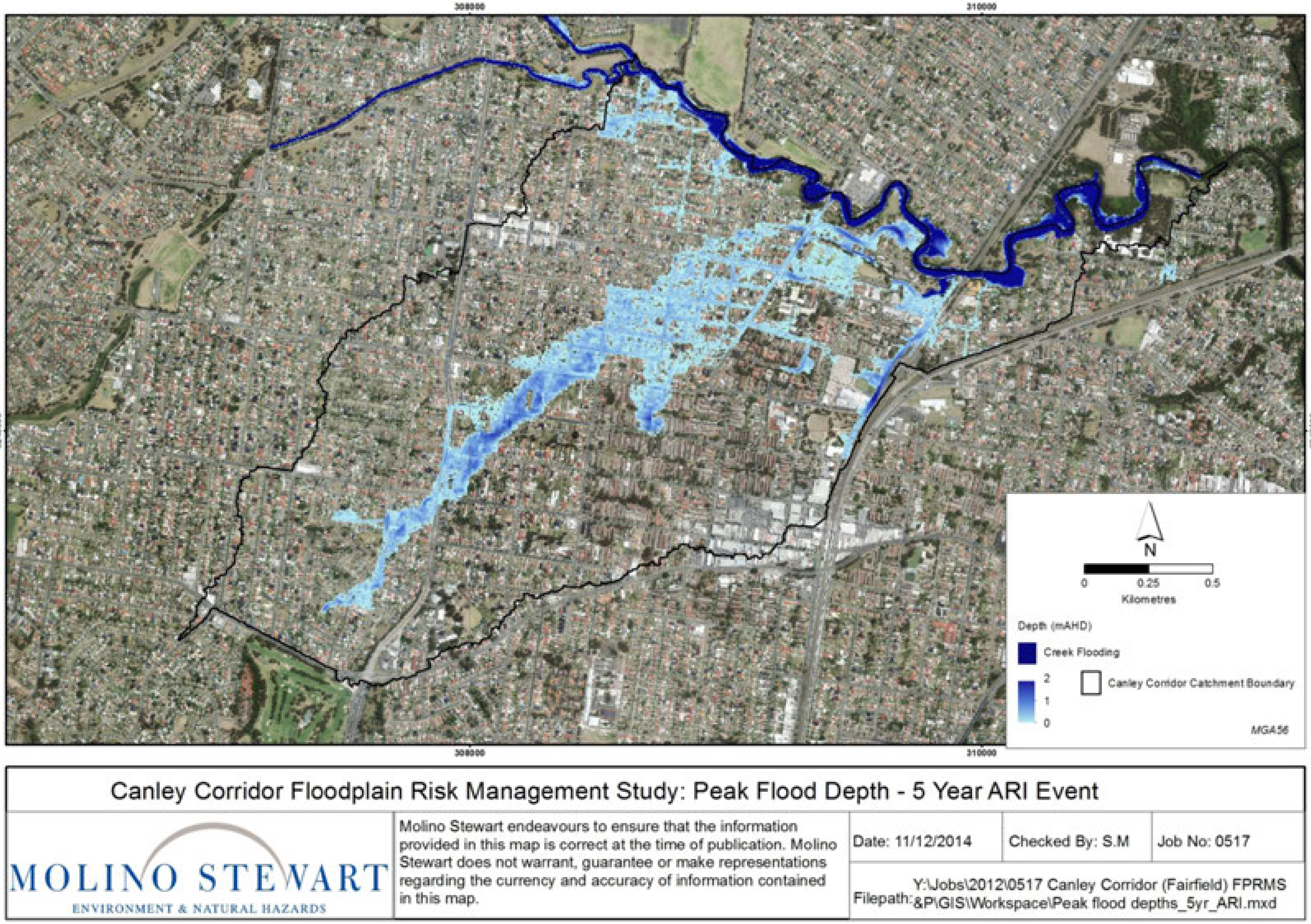
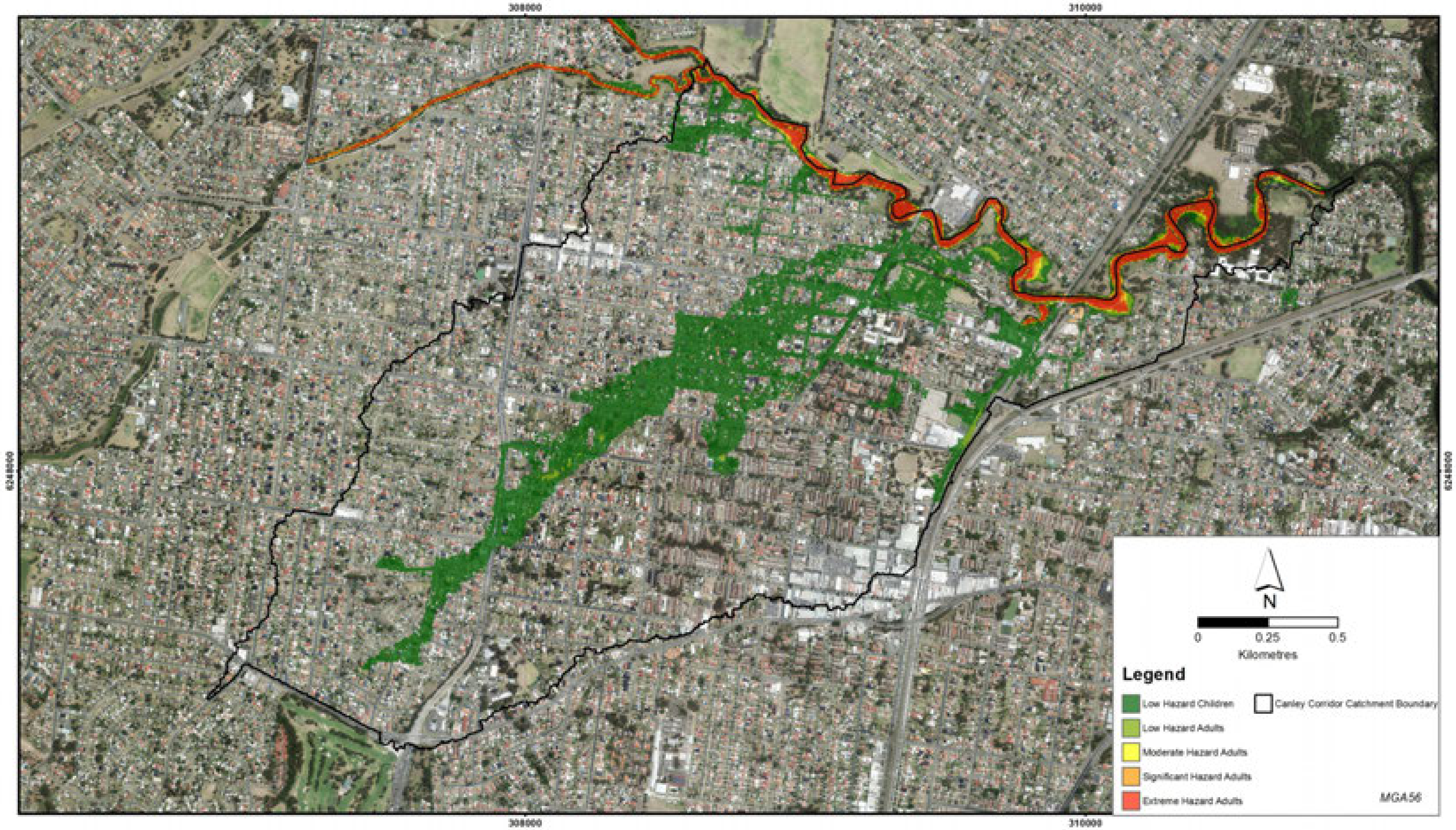


Figure 11: Peak Flood Depths – 5 Year ARI Event



Canley Corridor Floodplain Risk Management Study: Peak Flood Hazard - 5 Year ARI Event				
MOLINO STEWART ENVIRONMENT & NATURAL HAZARDS	Molino Stewart endeavours to ensure that the information provided in this map is correct at the time of publication. Molino Stewart does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.	Date: 11/12/2014	Checked By: S.M	Job No: 0517
		Filepath: Y:\Jobs\2012\0517 Canley Corridor (Fairfield) FPRMS &P\GIS\Workspace\Peak flood depth_and hazards.mxd		

Figure 12: Peak Flood Hazard – 5 Year ARI Event

5.1.2 Infrequent Floods

The flood hazard in a 100 Year ARI flood is shown in Figure 13 which demonstrates that the area flooded is slightly more extensive than a 5 year ARI flood but for the most part the flooded areas are not hazardous to adults.

There is a section of floodplain between McBurney Road and Hughes Street where flood hazard is higher. This is as a result of increasing depth in a low lying, possibly remnant stream area rather than any high velocity of flow in the area. This is the "Zone of Significant Flow" previously identified by Council and this classification is assessed in more detail in Section 8.4.

What Figure 14 also shows is that the velocities along many of the streets north of St Johns Road would make them dangerous to drive along because cars could float or be pushed along by the floodwaters.

All of Freeman Avenue would be flooded and most of it would be hazardous for adults to walk along it. In a flood rising as quickly as this design flood event Freeman Avenue would be non-trafficable within 30 minutes and would remain so for three or four hours.

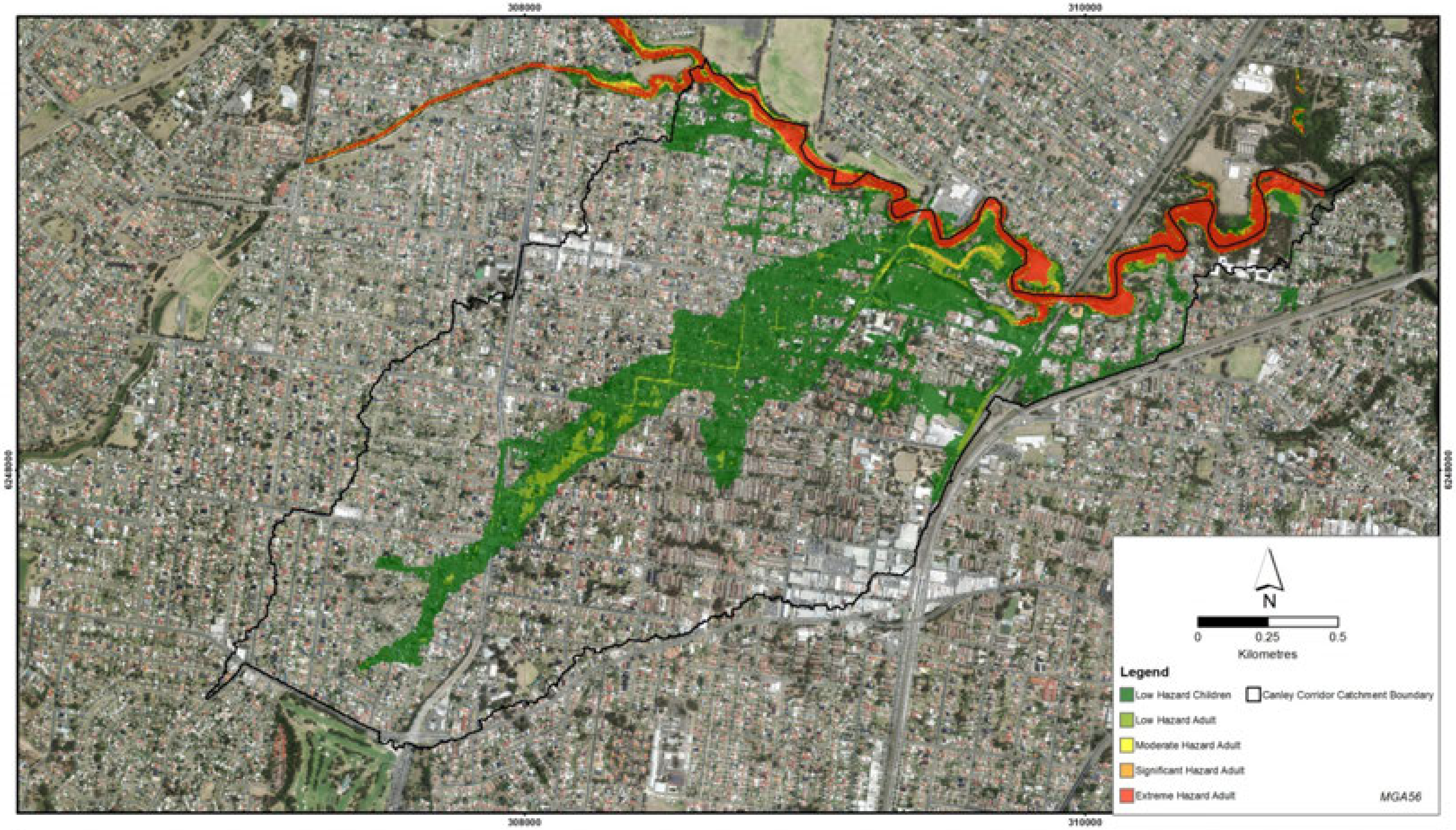
The highest risk areas for the 100 year ARI event are essentially close to Orphan School Creek and in the parklands that border the creek, where depth is significant, in a number of the roadways especially Freeman Avenue and Railway Parade and in the remnant stream that drains from Adams Park, currently sealed and used as a car park for the Canley Vale shopping precinct.

5.1.3 Extreme Floods

In the most extreme events many parts of the catchment would be extremely hazardous and it could be fatal for people to drive or walk through the floodwaters (Figure 14). West of the Cumberland Highway the most hazardous areas are quite confined and are generally along residential property boundaries but there would be a section of the Cumberland Highway from John St to Hughes St which would be extremely hazardous.

Large areas of residential lots, in some cases whole lots, would be exposed to extremely hazardous flows between John St and Derria St. North and east of this area, and in the other parts of the catchment, the most hazardous locations tend to be along the roads or within public open space with the residential land classified as low hazard for adults. The two exceptions are some houses on the southern side of Freeman Avenue and a block of home units in Railway Parade South of Pevensey St.

In the more extreme events it could take less than 30 minutes after the start of the storm for streets to be too dangerous to travel on but even these large events can be expected to dissipate within three or four hours.



Canley Corridor Floodplain Risk Management Study: Peak Flood Hazard - 100 Year ARI Event

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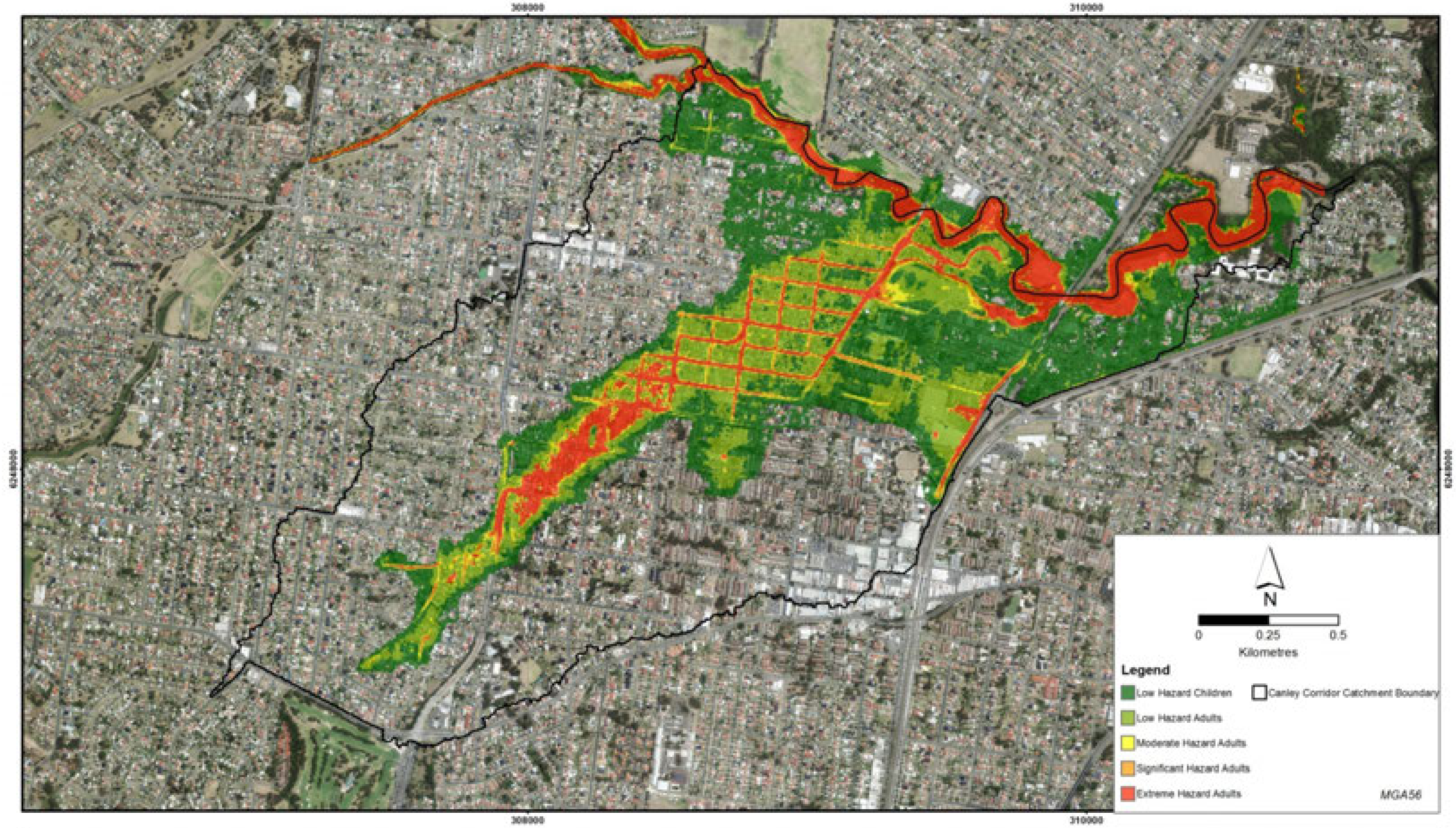
		Filepath: Y:\Jobs\2012\0517 Canley Corridor (Fairfield) FPRMS &P\GIS\Workspace\Peak flood depth_and hazards.mxd		

Figure 13: Peak Flood Hazard – 100Year ARI Event



Canley Corridor Floodplain Risk Management Study: Peak Flood Hazard - PMF ARI Event

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		Filepath: Y:\Jobs\2012\0517 Canley Corridor (Fairfield) FPRMS &P\GIS\Workspace\Peak flood depth_and hazards.mxd		

Figure 14: Peak Flood Hazard – PMF Event

5.1.4 Effects of Buildings and Fences

A computer flood model presents an idealised representation of flood behaviour which is usually sufficient for making floodplain management decisions. In overland flood studies consideration needs to be given to the impacts which obstructions to flow, such as buildings and fences, can have on flood depths and velocities.

For this particular study it was assumed that all buildings would create a solid obstruction to the flow. That is, no water would flow under the buildings or through the buildings. Even though this was the assumption, the model was not constructed with the individual buildings as solid blocks but rather the average roughness of the ground surface was increased in the model to account for the effect that the buildings would have on slowing down the flow of water. The model then represents flows across the flow paths as a smooth surface with an even distribution of velocities. In reality flood levels will be higher on the upstream side of a building and lower on the downstream side with localised increases in velocity where the water passes between buildings.

Fences have not been included in the model. It has been assumed that fences do not create an impediment to flow. This is not the case in reality but the effect that fences have on flow will vary considerably depending on their orientation, permeability and strength. Solid fences which are constructed perpendicular to the flow will impede flow the most and water will build up behind them. This will increase flood depths and hazards upstream and decrease them downstream of the fence. That is, until the depth of water upstream of the fence exerts so much force on the fence that it fails (Figure 15).

Figure 15: Damaged Fencing, Malta Street, Fairfield East

These impacts were tested using the hydraulic model for the flood affected area between Hughes Street and McBurney Road, Canley Heights, with the results shown in Appendix D. Figure 16 shows the impact of fencing on flood depth in the 100 year ARI event. The modelling established that fences can significantly impact the peak flood levels, velocities and flood hazard in the immediate area, in particular:

- Flood levels are increased up to 0.5m or more on the upstream side of the fences and decreased downstream of the fences initially
- Velocities and flood hazard are increased suddenly downstream as a result of the fence failure.
- There is only a relatively small area that was not previously impacted by flooding, that becomes flooded

The more impervious the fence, the less flow will pass through or under it. This means that solid brick and Colorbond fences will have a greater impact than paling fences and lapped paling fences will have a greater impact than standard paling fences than will staggered paling fences. Furthermore, paling fences are more likely to fail at a lower depth than that Colorbond or brick fences which means that they release a smaller flood wave. These are generalised observations and the actual effects will depend on the quality of the fence construction.

Fences with gaps under them, openings in them or which are of a mesh construction are far less impervious but even these can become clogged with debris and eventually fail.

5.1.5 Real Floods

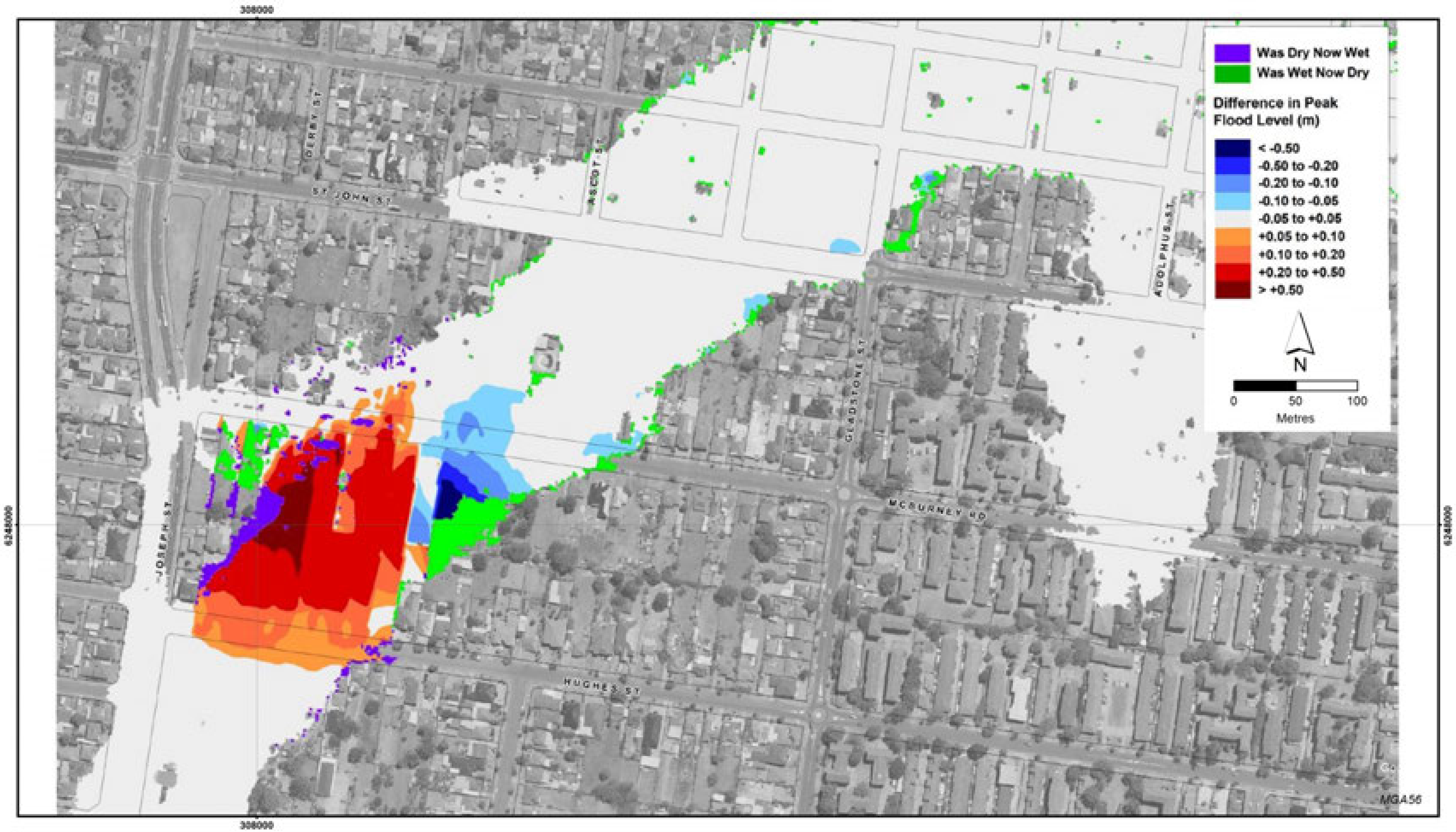
Design flood events are an idealised representation of both rainfall and flood behaviour. They assume an even rainfall distribution across the catchment and a stepped change in rainfall intensity over time for a critical duration which will give the largest flows at the point of interest in the catchment for a particular storm return period. They also assume a particular degree of catchment saturation before the rainfall begins. This is the standard methodology recommended in Australian Rainfall and Runoff (Pilgrim, 1977) and is used for all flood modelling throughout Australia.

Real storms and floods will behave more randomly. Storms which cause overland flooding could occur from an intense thunderstorm after days of hot, dry weather or could be a period of intense rainfall after many days of rain. In either case the same intensity and duration of storm could result in very different peak flows. Similarly, the distribution of rainfall in time and space across the catchment can mean that the flood hazards in one part of the catchment will match those of a frequent event and in another part those of an infrequent event even though they have been caused by the same storm.

Variations in rainfall patterns can also mean that a particular flood hazard condition can be reached more quickly or more slowly than suggested by the design flood event which has that hazard condition.

As already explained, obstructions caused by buildings, fences and debris blockages can also change flood depths, velocities and hazards locally.

The variability of actual conditions compared to those in the model does not in any way invalidate the modelling. What it highlights is that the model results are indicative of realistic flood behaviour but possible variations around that behaviour must be taken into consideration when selecting appropriate flood mitigation options.



Canley Corridor Floodplain Risk Management Study: Impact of Fencing on Flood Depth in 100 Year ARI Event				
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Figure 16: Impact of Fencing on Flood Depth in 100 Year ARI Event

5.2 IMPACTS ON PROPERTY

5.2.1 Overview

The depths and velocities anticipated from overland flows in the Canley Corridor are not expected to create significant damage to public infrastructure such as roads, railways and utilities.

Flood depths or more than 300mm are likely to cause some damage to cars and exposure to more than 500mm depth of flooding could result in cars being written off. The number of vehicles damaged by flooding will depend on the time of day that flooding occurs, the number of vehicles parked in the path of damaging flooding water and the actions of drivers. Some drivers may take the opportunity to move their parked cars to higher ground while others driving through the area may try and drive through hazardous floodwaters. Because it is difficult to estimate the number of vehicles which could be damaged and most vehicles are insured against flood damage, the cost of motor vehicle damage has not been estimated.

Detailed estimates were made, however, of the impacts and costs of flooding on residential and commercial premises. Damage estimates are used later to assess the relative merits of various floodplain risk management measures.

5.2.2 Residential Flood Damages

There are a total of 1,335 residential properties within the PMF flood extent. Floor levels for residential buildings were provided by Council and these were compared to ground levels at the property as extracted from the LiDAR surveyed ground levels also provided by Council. Where reported floor levels were less than 100mm above the reported ground level, Google Street View was used to check the property and, if warranted, a corrected floor level was entered based on the estimated height of the floor above the ground.

The flood levels for the events provided (5, 20 and 100 Year ARI and the PMF) were then extracted at each residential building location and the depth of above ground and above floor flooding was calculated. Where above floor flooding was estimated to occur in the 100 year ARI flood, Google Street View was used to check whether that particular property had been redeveloped after the Council floor level survey had been conducted. If redevelopment was apparent, the floor level was corrected to correspond to the current planning level which is 0.5m above the 100 Year ARI flood level.

The OEH Standard Residential Calculator (DECC, 2007) was used to estimate the direct residential damages in Canley Corridor. The calculator works on the basis of there being an average amount of damage external to a dwelling when a property is first flooded and then once flooding exceeds the floor level the damage increases with increasing flood depth until it reaches a depth above which no further damage occurs. There are different damage curves for low set single storey houses, high set single storey houses (i.e. those with ground floor levels more than 1.5m above ground level) and two storey houses which account for the different depths of flooding necessary for contents to be damaged. There are also factors included for decreasing the cost of damages to account for the time available to move building contents as well as inflation factors which account for the increased cost of labour and materials if flood damage is widespread.

The curve input values used for the Canley Corridor study are provided in Table 8. The same factors were used as in the Three Tributaries Floodplain Risk Management Study (Molino Stewart, 2014, in preparation) with the exception of:

- Typical Duration of Immersion – 2 hours rather than 6 hours

- Effective Warning Time – 0.5 hours rather than 2 hours
- Likely Time in Alternative Accommodation – 4 weeks rather than 8 weeks

There are numerous apartment blocks in the Canley Corridor and for the purposes of this assessment, each was assumed to be a high set house. Townhouses and villas were assumed to be two storey and lowset houses respectively. Each building was treated as a single dwelling for the damage estimations but any with expected above floor flooding in the 100 Year ARI flood were examined more closely during the option evaluations.

The OEH methodology estimates tangible direct residential damages which are caused by floodwaters coming in direct contact with assets. Tangible indirect damages are the costs and losses incurred as an indirect consequence of the flooding and can include clean-up costs, temporary accommodation, additional travel, lost income, health costs etc. A number of studies have found indirect damages to be worth about 15% of the direct damages while others which have counted clean-up costs as direct damages have estimated the indirect damages to be about 5% of direct damages (Sydney Water, 1995).

Given that the OEH methodology includes clean-up costs and alternative accommodation in the tangible damage estimates, additional indirect damages have been assumed to be worth 5% of the direct damages for this study.

Table 8: Input Variable for Damages Estimation

Input	Value	Explanation
Regional Cost Variation factor	1.0	Rawlinsons
Post late 2001 adjustments	1.66	Changes to average weekly earnings (AWE) from Nov 2001 to May 2014
Post Flood Inflation Factor	1.40	Regional city
Typical Duration of Immersion	2 Hours	Based on duration of significant flooding in 100 year ARI event
Building Damage Repair Limitation Factor	0.85	Short duration
Typical House Size	131 m^2	Sample of houses within catchment
Contents Damage Repair Limitation Factor	0.75	Short duration
Level of Flood Awareness	Low	*Community Flood Education and Awareness in Fairfield City* (MS,2013)
Effective Warning Time	0.5 Hours	Based on rate of rise of 100 year ARI event
Typical Table/Bench Height	0.90	Standard
External Damage	$6,700	Standard
Clean-up costs	$4,000	Standard
Likely Time in Alternative Accommodation	4 Weeks	Half Standard
Additional Accommodation Costs	$220/week	Standard

5.2.3 Commercial Damages

Commercial and Damages were calculated using the stage-damage curves developed by Water Studies (1992) and updated to 2014 values using the Consumer Price Index (CPI). These curves apply damage per square metre of floor area with increasing damage for increasing depth of flooding. There are separate damage curves for commercial premises with low, medium and high value depending on the type of contents. For example a shop selling garden statues would have low value flood damages while an electrical retailer would experience high damages for the same depth of flooding.

For commercial/industrial land uses, the type of activity was split into one of six codes provided by Council for the application of six different stage-damage curves:

- Commercial low (CL)
- Commercial medium (CM)
- Commercial high (CH)
- Industrial low (IL)
- Industrial medium (IM)
- Industrial high (IH)

Floor areas for each business were estimated by a combination of aerial photography and inspection of Google Street View.

Flood surfaces for the 20 year, 50 year and 100 year ARI floods and the PMF were used to extract flood levels at the tag point of each building in the database.

Indirect damages were estimated as 35% of the direct damages as per the ANUFLOOD method (Taylor, Greenaway and Smith, 1983).

5.2.4 Intangible Damages

Intangible flood damages are those damages which are caused by flooding but are not easily quantified in monetary terms. Direct intangible damages include such things as injury, loss of life, loss of pets and loss of memorabilia. Indirect intangible damages include things such as stress and anxiety, loss of business confidence and bankruptcy. While it is difficult to quantify these damages in monetary terms, the number of residential and business premises with above floor flooding is indicative of the relative magnitude of these damages between floods and the benefits of mitigation options in reducing such losses.

As loss of life and injury are intangible flood damages it is appropriate in this section to also discuss locations where the combination of flood hazards, other aspects of flood behaviour, the types of development and the vulnerability of the population can either increase or decrease the risk to life.

The rapid rise of flood waters in all events across the catchment means that flood warning and timely evacuation will be problematic. Evacuating into streets with a high flood hazard could increase risks to life as would trying to drive through those streets. The rectangular grid pattern of streets means that there are several locations where motorists may be tempted to try and drive through floodwaters.

There is a nursing home at the eastern end of Freeman Avenue which is occupied by particularly vulnerable people. The site itself is flood free in a 100 year ARI flood and only subject to low hazard flooding in a PMF. However, road access gets cut early and quickly even in a 5 year ARI event and although there is a pedestrian path linking it to Canley Vale Road, that is cut by low hazard flows in a 5 year ARI event and may be subject to moderate hazard flooding in a 100 year ARI event. This could compromise the ability of ambulance services reaching the facility in the event of a medical emergency.

5.2.5 Damages Summary

The number of properties flooded is provided in Table 9 and the cost breakdowns for each event and the total AAD are provided in Table 10.

Because floods occur randomly and the magnitude of damages is greater the rarer the flood, the concept of Annual Average Damage (AAD) has been developed to enable the economic evaluation of flooding and flood mitigation options. As the name implies, these are the average cost of damages if all the damages caused by the full range of floods were averaged over a long period of time, taking into account the number of times it is likely to occur on average over that time. For the purpose of estimating the AAD, the PMF was assumed to have an ARI of 1 in 100,000 and it was assumed that there would be no flood damages in a 1 Year ARI event.

These damages estimations will be used as the basis for the economic assessment of the selected floodplain risk management measures. It is noted that the more frequent events make the greatest contribution to the annual average damages which suggests that mitigation options which deal with frequent flooding impacts will be the most economically worthwhile.

Table 9: Flood Affected Properties

Event	Residential Properties with Above Ground Flooding	Residential Properties with Above Floor Flooding*	Commercial and Industrial Properties with Above Floor Flooding*
5 Year	323	7	13
20 Year	455	26	16
100 Year	586	48	19
PMP	1335	677	74

Table 10: Calculation of Average Annual Damage

Event	Residential Direct Damage ($m)	Residential Indirect Damage ($m)	Commercial and Industrial Direct Damage ($m)	Commercial and Industrial Indirect Damage ($m)	Total ($m)	Contribution to AAD ($m)
5 Year	$4.0	$0.2	$0.05	$0.02	$4.3	$1.1
20 Year	$6.0	$0.3	$0.6	$0.3	$7.2	$1.7
100 Year	$8.5	$0.4	$2.8	$1.4	$13.1	$0.4
PMP	$41.6	$2.1	$38.3	$19.1	$101.1	$0.6
					Total	$3.8

5.3 HERITAGE IMPACTS

Many of the listed heritage items in the catchment are affected by overland flooding. While the Railway Viaduct, which is listed at a state level, is affected by overland flows, it has been designed for these magnitudes of flows. It is more at risk from extreme mainstream flooding in Orphan School Creek. Similarly, the three indigenous heritage items, if they are still there, would be at greater risk from Orphan School Creek flooding than overland flows.

The Church in John St Cabramatta would not be affected by overland flows.

A 5 year ARI flood would flow through the grounds of the Kwan Yin Temple in Second Avenue and the Westacott Victorian Cottage in Railway Parade and would be at the door of the heritage listed shop at 2 Canley Vale Road. In a 20 year ARI event the water would be flowing between 100 and 200mm deep in front of the shop and cottage but given that they are virtually at footpath level, wash from a vehicle driving through the flood waters would be sufficient to push the water into the buildings if it is not already flowing into them. A 100 year ARI event would not flow much deeper near these buildings.

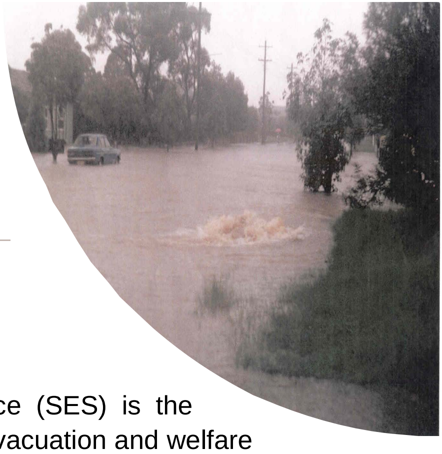
A PMF would definitely be flowing at a shallow depth through the shop and cottage but is only likely to flood the temple carpark, although that could be up to 800mm deep.

5.4 BIODIVERSITY IMPACTS

An area of low conservation significance area of Ironbark Forest on private land between Gilbert Street and John Street is within the overland flow pathway in a 5 year ARI event and would be subject to more hazardous flooding in rarer events. The same applies to the high conservation value remnant Ironbark Forest in Adams Park. A 20 year ARI event would begin to impinge on the high conservation Ironbark Forest in Cabravale Park and also on the moderate conservation value Ironbark Forest between Pevensey St and Canley Vale Road. These too would experience greater depths of flooding in less frequent floods.

Given that these are remnants of natural forests in a landscape which would have periodically flooded, the occasional flood for a few hours on average every five years or less frequently is unlikely to have a detrimental impact on the vegetation.

While this vegetation can be habitat for native fauna, the lack of natural ground cover in these areas means that any native animals living in these areas are likely to be arboreal and able to climb above the reach of what will be relatively shallow flooding, even in the PMF.



6 EMERGENCY MANAGEMENT

6.1 STATE EMERGENCY SERVICE

Under the *State Emergency Service Act, 1989,* the State Emergency Service (SES) is the designated combat agency for controlling floods, and to coordinate the rescue, evacuation and welfare of affected communities.

The SES is to protect people from risk to their safety and health, and to protect property from destruction or damage, arising from floods (SES Act, 1989).

Details of the roles and responsibilities of the SES (and other emergency services and affected parties) can be found in the State Flood Sub Plan, a Sub Plan of the New South Wales Disaster Plan (Displan).

For floods generally, the role of the SES covers prevention, preparedness, response and recovery.

6.1.1 Prevention

- Provide emergency management advice to councils in relation to the management of land which is subject to flooding;
- Contribute to the deliberations of Floodplain Risk Management Committees established by councils;

6.1.2 Preparedness

- Contribute to the identification of flood problems, specifically in relation to emergency management matters including warning, evacuation, rescue and resupply functions;
- Develop and maintain flood intelligence systems for the full range of flood types and severities;
- Lead in the preparation, maintenance and exercising of Flood Sub Plans at State, Region and Local levels;
- Ensure that SES Controllers, operations centre staff and field staff are appropriately trained and equipped for flood-related tasks;
- Ensure that appropriate agencies, organisations and officers are aware of and ready for tasks related to their agreed flood responsibilities;
- Prepare, coordinate and deliver awareness and educational materials and programs regarding flooding;
- Prepare prewritten Flood Bulletins for key gauges, flash flood environments and for areas downstream of deficient dams;
- Prepare systems for the communication of warnings and public information regarding flooding;
- Define and continually review the state's flood warning requirements in conjunction with the Flood Warning Consultative Committee, councils, the owners of dams classified as deficient and flood-affected communities;

6.1.3 Response

- Control flood operations;
- Coordinate the responses of agencies supporting flood operations;

- Ensure that relevant Emergency Operations Controllers and supporting agencies are briefed on flood operations, including relevant flood and dam failure warnings;
- Respond to indications of potential dam failure when Dam Failure Warning Systems are activated;
- Assist in the development of official flood warnings by providing data to the BoM from the SES network of river height gauges and those private gauges to which it has access;
- Coordinate the development and communication of SES Flood Bulletins to at risk communities, including:
    - Augmentation of official BoM flood warnings by assessing the likely consequences of flooding at the predicted heights and suggesting appropriate actions for people in areas expected to be affected and disseminating this information;
    - Livestock and Equipment Warnings when there is evidence of rises in levels below minor flood heights, and disseminate these within Region Flood Bulletins;
    - Local Flood Advices for communities for which the BoM does not issue official flood warnings, and disseminate these within Region Flood Bulletins;
- Coordinate reconnaissance of areas likely to be affected by floods;
- Coordinate the resupply of isolated communities and properties;
- Coordinate the evacuation and immediate welfare of people at risk;
- Coordinate flood rescue operations;
- Coordinate operations to protect property;
- Provide an information service to the community regarding flooding;
- Assist councils to organise temporary repairs or improvements to levees;
- Assist the NSW Police Force, RTA and councils with road closure and traffic control operations;
- Assist the Agriculture and Animals Services Functional area with fodder supply operations;
- Depending upon the scale of the event, establish a Joint Media Information Centre as near as is practicable to the areas affected by flooding;
- Coordinate the collection of flood intelligence and post impact data and make it available to recovery agencies;
- Establish a spatial information group if required to coordinate the collection; analysis; mapping and distribution of spatial information regarding flooding;
- Provide Situation Reports incorporating the activities of supporting agencies to all agencies listed under this Plan and to all state level supporting operations centres and relevant members of parliament;
- Provide information to Treasury on damage to public infrastructure for the purpose of Natural Disaster Relief and Recovery Arrangements;
- Provide immediate welfare support to evacuees;

6.1.4 Recovery

- Ensure that initial recovery operations are commenced;
- Coordinate the conduct of after action reviews / debriefs following flood operations;
- Ensure any recovery coordinating committee is briefed regarding the flood response phase and that appropriate information is provided to appropriate recovery agencies; and
- Participate in recovery committees as required.

6.2 BUREAU OF METEOROLOGY

Under the State Flood Sub Plan, the Bureau of Meteorology is responsible to:

- Assist the SES in the exercising of Flood Sub Plans;
- Act as the flood prediction agency;
- Develop warning systems in conjunction with the SES and other state and local agencies;
- Collect, collate and analyse rain and river data;
- Provide near real time rainfall and river level data on the internet;
- Contribute to flood education programs;
- Formulate and issue official forecasts and warnings for:
  - River basins (Flood Watches);
  - Key locations on rivers and creeks (Preliminary Flood Warnings and Flood Warnings);
  - Weather Forecast Districts (Regional Severe Thunderstorm Warnings and Severe Weather Warnings) and the Newcastle/Sydney/Wollongong area (Severe Thunderstorm Warnings); and
  - Coastal areas (large waves and storm surges).

The Bureau works closely with the Regional and Local SES to ensure the quality and accuracy of weather and flood warnings.

6.3 ROLE OF THE SES IN THE CANLEY CORRIDOR CATCHMENT

The Canley Corridor catchment falls within Sydney Southern Region SES operational region. This region can call on other Sydney regions as required as all regions will have received the same training and can operate as a larger unit if required.

The major issues for the SES in the Canley Corridor catchment are that the catchment essentially generates a flash-flood scenario i.e. the flood peaks less than 6 hours after commencement of rain, with its critical storm being approximately a 2 hour duration event. This scenario does not provide any sound basis for the Bureau to issue flood warnings, though there is some warning function for the Georges River. The Bureau will release Severe Thunderstorm Warnings and Severe Weather Warnings and these should be noted by the community.

As such, there is very little time for the SES, as well as potentially limited resources, to provide complex response activities in the highly built up catchment. Thus, the SES role in the catchment will very much concentrate on the prevention, preparedness and recovery functions as outlined above.

6.4 FAIRFIELD LOCAL FLOOD PLAN

The Fairfield Local Flood Plan is a sub-plan of the Fairfield Disaster Plan and deals specifically with flooding. Local flood plans are prepared by the State Emergency Service and describe agreed roles, responsibilities, functions, actions and management for the preparation for and conduct of flood operations. The plan is issued under the authority of the *State Emergency and Rescue Management Act 1999* and the *State Emergency Service Act 1989*. It has been accepted by the Sydney Southern SES Division Controller and the Fairfield City Local Emergency Management Committee.

As Part of the review of floodplain risk management measures in the Canley Corridor catchment, the Fairfield Local Flood Plan (2010) was reviewed and issues identified for future resolution. The NSW

SES has reported that these comments are being taken into consideration in the current review of the Fairfield Local Flood Plan.

During consultation the NSW SES acknowledged particular challenges with flooding in the Canley Corridor catchment. In particular:

- There are less than 50 volunteers and staff within the local unit servicing a population of more than 50,000 potentially affected by flooding within the whole of the Fairfield City LGA. Within Canley Corridor, it is estimated that 4,500 – 5,000 people may be affected by overland flows
- There are locations within the LGA where the flood hazards are significantly greater than those in Canley Corridor and these would need to be given priority
- It will be extremely difficult to call on neighbouring SES units as they are more than likely to be employed in similar flood emergencies in their areas and the short response time of the overland flooding means that would be insufficient time for responders from outside the LGA to arrive before the flooding had peaked
- The potential for high hazard floodwaters along the roads, particularly in the middle of the catchment, will make it dangerous for building occupants to leave or for SES personnel to try and reach them after a short time into the larger floods
- If resources can be deployed to provide timely evacuation of at-risk buildings, the attention would be focussed on Freeman Avenue, including the nursing home followed by the area between Hughes St and St Johns Road.

6.5 PERSONAL RESPONSIBILITY

A key concept which has been emphasised in reports from commissions of inquiry in Australia into natural disasters in recent years is the concept of shared responsibility (VBRC, 2009 and QGCI, 21012). This is the idea that all levels of government, including emergency services organisations, have a role in disaster mitigation and response but so to do communities and individuals.

In the case of Canley Corridor the small catchment, the rapid onset of flooding, the short flood durations, ill-defined flow paths and the potential significant localised effects of buildings and fences makes it impractical for:

- the Bureau of Meteorology to provide tailored, accurate and timely flood warnings
- the NSW SES to effect evacuations
- NSW Police to close flood affected roads

In these circumstances communities and individuals have to take a greater responsibility for appropriate flood preparedness and response.

6.1 PLANNED RESPONSE FOR FUTURE DEVELOPMENT

Redevelopment within Canley Corridor provides an opportunity to reduce risk to life from flooding and development controls play an important part in that.

A major point of contention in contemporary emergency management policy and practice relates to the advantages and disadvantages of evacuation compared to sheltering-in-place, particularly for flash flood catchments such as Canley Corridor. This has a significant bearing on what development controls are most appropriate to manage risk to life.

6.1.1 NSW SES Position

The NSW SES has prepared or contributed to a number of publications which address this subject (Opper and Toniato, (2008), Opper et al (2011), AFAC (2013)). The latter is a national guideline which the NSW SES endorses and can be summarised as:

- The safest place to be in a flash flood is well away from the affected area. Evacuation is the most effective strategy, provided that evacuation can be safely implemented. Properly planned and executed evacuation is demonstrably the most effective strategy in terms of a reliable public safety outcome.
- Late evacuation may be worse than not evacuating at all because of the dangers inherent in moving through floodwaters, particularly fast-moving flash flood waters. If evacuation has not occurred prior to the arrival of floodwater, taking refuge inside a building may generally be safer than trying to escape by entering the floodwater.
- Remaining in buildings likely to be affected by flash flooding is not low risk and should never be a default strategy for pre-incident planning. It is not equivalent to evacuation.
- The risks of ‘shelter-in-place’ include:
  - Floodwater reaching the place of shelter (unless the shelter is above the PMF level);
  - Structural collapse of the building that is providing the place of shelter (unless the building is designed to withstand the forces of floodwater, buoyancy and debris in a PMF);
  - Isolation, with no known basis for determining a tolerable duration of isolation;
  - People’s behaviour (drowning if they change their mind and attempt to leave after entrapment);
  - People’s mobility (not being able to reach the highest part of the building);
  - People’s personal safety (fire and accident); and
  - People’s health (pre-existing condition or sudden onset e.g. heart attack).
- For evacuation to be a defensible strategy, the risk associated with the evacuation must be lower than the risk people may be exposed to if they were left to take refuge within a building which could either be directly exposed to or isolated by floodwater.
- Pre-incident planning needs to include a realistic assessment of the time required to evacuate a given location via safe evacuation routes. This requires consideration of barriers to evacuation posed by available warning time, availability of safe routes and resources available.
- Successful evacuation strategies require a warning system that delivers enough lead time to accommodate the operational decisions, the mobilisation of the necessary resources, the warning and the movement of people at risk.
- Effective evacuation typically requires lead times of longer than just a couple of hours and this creates a dilemma for flash flood emergency managers. Due to the nature of flash flood catchments, flash flood warning systems based on detection of rainfall or water level generally yield short lead times (often as short as 30 minutes) and as a result provide limited prospects for using such systems to trigger planned and effective evacuation.
- Initiating evacuation of large numbers of people from areas prone to flash flooding based only on forecasts may be theoretically defensible in a purely risk-avoidance context but it is likely to be viewed as socially and economically unsustainable. Frequent evacuations in which no flooding occurs, which statistically will be the outcome of forecast-based warning and evacuation, could also lead to a situation where warnings are eventually ignored by the community.

Following a consultation with the NSW SES in relations to the Three Tributaries Floodplain Risk Study, the NSW SES wrote to Fairfield City Council to state its position (NSW SES, 2014) and in summary said:

- In the context of future development, self-evacuation of the community should be achievable in a manner which is consistent with the NSW SES’s principles for evacuation.

- Development must not conflict with the NSW SES's flood response and evacuation strategy for the existing community.
- Evacuation must not require people to drive or walk through flood water.
- Development strategies relying on deliberate isolation or sheltering in buildings surrounded by flood water are not equivalent, in risk management terms, to evacuation.
- Development strategies relying on an assumption that mass rescue may be possible where evacuation either fails or is not implemented are not acceptable to the NSW SES.
- The NSW SES is opposed to the imposition of development consent conditions requiring private flood evacuation plans rather than the application of sound land use planning and flood risk management.

Clearly, the NSW SES holds that evacuation is the preferred emergency response for floodplain communities, where this can safely be achieved. Late evacuation, through floodwater, may be a recipe for disaster and in that situation it might be safer to remain inside the building, though sheltering-in-place has a number of direct and indirect risks associated with it. Evacuating prior to flooding is therefore much preferred. Where current hydro-meteorological monitoring systems, communications systems, road infrastructure and expected community behaviours do not allow this, the SES advocates improvements to these so that evacuation can proceed safely. However, the AFAC (2013) guide makes clear that even with improvements in monitoring, insufficient time may be available to inform evacuation decisions with any confidence. If evacuations are ordered based only on predicted rainfall, the community may eventually come to ignore warnings.

6.1.2 FCC Position

Chapter 11 of Fairfield's City Wide DCP contains a number of provisions relating to response to flooding, which in effect sets out Council's current position.

One objective of the DCP is '*to minimise the risk to life by ensuring the provision of appropriate access from areas affected by flooding up to extreme events*'. Several performance criteria have bearing:

> *a) The proposed development should not result in any increased risk to human life.*
>
> *c) The proposal should only be permitted where effective warning time and reliable access is available for evacuation from an area potentially affected by floods to an area free of risk from flooding. Evacuation should be consistent with any relevant flood evacuation strategy.*
>
> *f) Procedures would be in place, if necessary, (such as warning systems, signage or evacuation drills) so that people are aware of the need to evacuate and relocate motor vehicles during a flood and are capable of identifying an appropriate evacuation route.*

Prescriptive evacuation controls vary from catchment to catchment. For residential uses in the Medium flood risk precinct in the Georges River floodplain, proponents need to demonstrate that:

> *Adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon the SES or other authorised emergency services personnel*
>
> and that:
>
> *The development is to be consistent with any relevant flood evacuation strategy or similar plan.*

For the Cabramatta Creek floodplain and other floodplains in the LGA, proponents need to demonstrate *either* an ability to evacuate *or* a safe refuge above the PMF:

> *Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest habitable floor level to an area of refuge above the PMF level, or a minimum of 20% of the gross floor area of the dwelling to be above the PMF level.*
>
> and that:

The development is to be consistent with any relevant flood evacuation strategy or similar plan.

If the proponent chooses to provide a PMF refuge, there is a condition that the building structure can withstand PMF inundation:

Applicant to demonstrate that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus freeboard, or a PMF if required to satisfy evacuation criteria (see below). An engineer's report may be required.

The *Prospect Creek Floodplain Management Plan Review* (Bewsher Consulting, 2010, p.80) recommended that the area of the Prospect Creek floodplain downstream of the Granville Railway Line should not have a shelter-in-place provision. This is because that area is largely influenced by flood behaviour within the Georges River, where the PMF can be many metres higher than the 100 year ARI event, limiting the practicality of providing a PMF refuge area within a building. Also, the duration of flooding typically exceeds 24 hours or longer, suggesting that the isolation risks are too great since power, water and sanitary services would likely be lost. Early evacuation is the preferred response strategy for all homes and businesses in that area. A specific matrix was prepared for the Prospect Creek floodplain including a revised evacuation control incorporating this spatial distinction in evacuation/isolation risks:

Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest habitable floor level to an area of refuge above the PMF level. In the case of property upstream of the Granville Railway Line, this refuge can be on site provided a minimum of 20% of the gross floor area of the dwelling is above the PMF level.

However, the current version of the DCP has not included the Prospect Creek matrix, so developments there would be assessed under the ‘other floodplains’ schedule.

6.1.3 Review

Flood behaviour in Canley Corridor is such that flooding can rise and peak within a couple of hours of the onset of rainfall. The further complication is that in many parts of the catchment it is the roads which will flood before buildings are threatened and even in the PMF many parts of the catchments are subject to low-hazard above ground flooding around buildings while the adjacent roads are unsafe for driving or walking through. Even where buildings are at risk of above floor flooding, only four would experience depths of more than 0.3m in a 100 Year ARI flood and only 10 would experience depths of more than 1.0m in a PMF with the maximum depth of above floor flooding be 1.2m. Such depths can be reduced by increasing the floor levels of dwellings.

Unless evacuation commences very early in a rainfall event, in most locations in the catchment it is safer to stay within buildings rather than evacuate through more hazardous flood waters in the street. The inescapably ‘flashy’ nature of flooding suggests that it will always be difficult to ensure everyone in the floodplain evacuates prior to flooding of evacuation routes. And while there is scope for strategically upgrading evacuation routes (see Section 8.4.1(d)) and for community education to promote appropriate behaviours such as early evacuation (see Section 8.5.4), floodplain managers need to recognise that the majority of floodplain occupants will be isolated in their buildings.

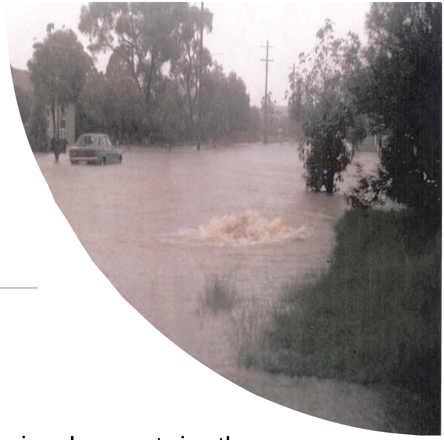
In the Consultant’s opinion, it is appropriate that both the Fairfield City Local Flood Plan and the Fairfield City Wide DCP recognise this for already developed areas and seek to minimise the risk to life in these circumstances. The 2005 edition of the LFP is appropriately pragmatic in including these clauses:

Evacuations should be completed before inundation occurs or evacuation routes are closed. However, this may not always be possible due to the short warning time generally available (3.12.2)

Where evacuation is considered too dangerous due to flooding of access routes, shelter in place should be recommended until flooding eases or rescue occurs (3.12.3)

However, similar caveats are evidently not located in Volume 1 of the 2013 edition of the LFP. It appears that NSW SES has adopted a harder line and no longer explicitly recognises that it may not be possible (indeed, it is not possible) to evacuate everyone within the affected area prior to flooding. Although wholesale evacuation is an understandable aspiration, the absence of an alternative – admittedly, not an equivalent risk-reducing option – means that the revised LFP is not practical for Canley Corridor. By excluding any concession for the likely situation wherein many people have not evacuated prior to flooding, the draft 2013 version is also arguably inconsistent with AFAC (2013, p.3), which states, 'if evacuation has not occurred prior to the arrival of floodwater, taking refuge inside a building may generally be safer than trying to escape by entering the floodwater'. Recommended amendments to the LFP are discussed in 8.5.2.

In the Consultant's opinion, and consistent with the Prospect Creek FMP Review, the provision of a shelter-in-place option for the Canley Corridor floodplain – which is upstream of the Canley Vale – Fairfield Railway – is appropriate in Council's DCP. This also recognises the typically short duration and low hazard of floods in this area, which suggests that isolation is likely to be limited to about a few hours in most events. As a way of reducing existing risks to life, shelter-in-place should at least be made available for the concessional development category. It is also defensible for existing residential areas where urban renewal is occurring.



7 COMMUNITY AND STAKEHOLDER ENGAGEMENT

7.1 GENERAL

The Floodplain Development Manual (2005) advises that broad community involvement in the preparation of a floodplain risk management plan, from the beginning, should produce the best prospect for community acceptance of, and commitment to, the resulting management plan. Current best practice sees that the most appropriate method of achieving this acceptance is, amongst other things, extensive community and stakeholder engagement.

Community engagement has been an essential component of the Canley Corridor FRMS&P. This has aimed to inform the community about the development of the floodplain management study and its likely outcomes. It has also aided learning about community flood awareness and preparedness. The engagement process has also provided an opportunity for the community to participate in the study by submitting ideas about potential floodplain management measures.

When the Canley Corridor Flood Study was prepared in 2009 it drew upon information provided by the community about historical flooding in the catchment. The completed study was placed on public exhibition and the community was invited to comment on the study.

Community members who had commented on the 2009 Flood Study were subsequently advised that the Canley Corridor Overland Flood Study had been adopted by Council and that the results were available from Council. They were also informed that a floodplain risk management study and plan, seeking the most appropriate means of managing the issues identified by the flood study, was being undertaken and that the communities were encouraged to be a part of this process.

To guide the engagement process for the Canley Corridor FRMS&P, a detailed Engagement Plan was developed in consultation with Council. This Plan was based on the Fairfield City Community Flood Education Project (Molino Stewart, 2012) and featured:

A **First Phase** where, through media announcements and community development networks, the community was invited to attend an information display at Council's Administration Centre. Letters were also written directly to every property owner with a property within the extent of the 100 Year ARI flood. The display featured maps, examples of potential management options, photos of floods, WaterRIDE presentation simulating floods and some summary text.

In addition to the display, a pre-arranged "script" of information and questions was used to seek feedback from communities as to their desires and outcomes sought from these studies. The "script" also included a "what happens next" scenario to create the feedback loop.

At the time of writing a **Second Phase** is planned that is designed to inform/remind the specific communities that the management studies for the Canley Corridor Overland Flow study area have been undertaken and will be placed on public exhibition and people have the opportunity to view and comment on the studies and the draft plan.

7.2 FLOODPLAIN MANAGEMENT COMMITTEE

The study has been overseen by the Fairfield Floodplain Management Committee. This committee comprises representatives from:

- Fairfield City Council;
- Office of Environment and Heritage (OEH);
- Fairfield State Emergency Service;

- Local residents; and
- Floodplain managers from neighbouring councils.

The Committee has met regularly to hear progress reports from Council staff and the consultant, and to provide direction as the study progressed. The Committee has provided a valuable mechanism for the views of many interested parties to be represented. The main agenda items at each meeting are summarised in Table 11.

Table 11: Meetings of the Floodplain Management Committee

Date of meeting	Main agenda items
12 Apr 2012	Debrief of March 2012 flood; general update
26 Jul 2012	Flood education and awareness project; community consultation
13 Mar 2013	General update
28 Aug 2013	Preliminary draft FRMS&P
23 Oct 2013	Options assessment
7 May 2014	General update
26 Nov 2014	Review of recommended options

7.3 COMMUNITY QUESTIONNAIRES AND INTERVIEWS

A round of Community Consultation was held between 18 November and 13 December 2013 as part of Phase 1 of the engagement plan. The Consultation process involved a letter to affected property owners and advertisements in local newspapers (see Appendix J). A detailed questionnaire was sent with the letter and there was an opportunity for residents to discuss issues with Council staff. There were 104 respondents to the survey/interview process that are affected by the Canley Corridor flooding and the following results reflect both the submitted questionnaires and the replies to an interview held for those that contacted Council.

7.3.1 General

94% of respondents were from residential dwellings and the remaining 3% were from commercial buildings (Figure 17). Most of the respondents owned the building they were in (87%), 3% rented, and 7% leased (Figure 18).

7.3.2 Flood Experience

Only 19% of respondents had experienced a flood previously, and even less had any records of flooding (4%). Only about one third of the respondents had seen or heard information about flooding (35%).

7.3.3 Flood Knowledge and Preparedness

Many of the respondents stated that they did not know how to protect themselves or their properties from flooding (63%). Only 4% of respondents reported having a written plan for flood emergencies.

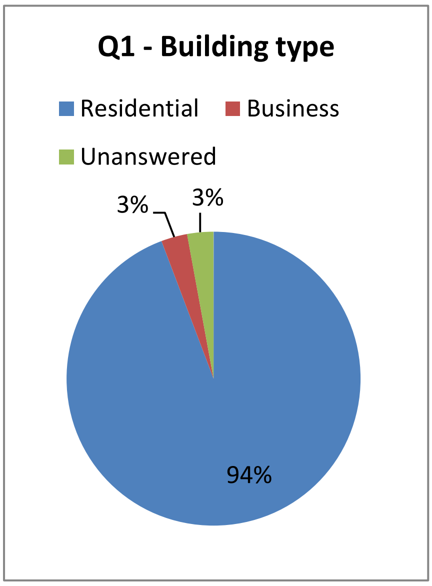


Figure 17: Building type

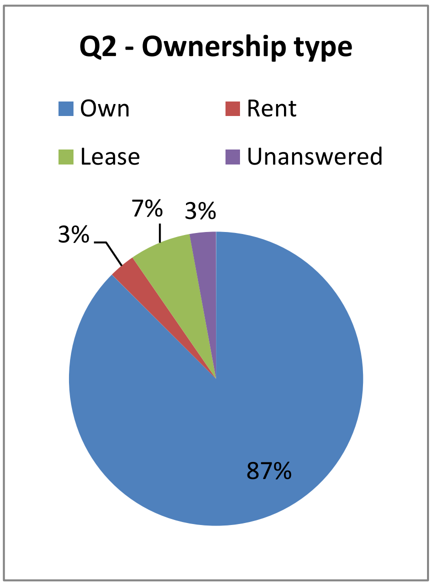


Figure 18: Property ownership type

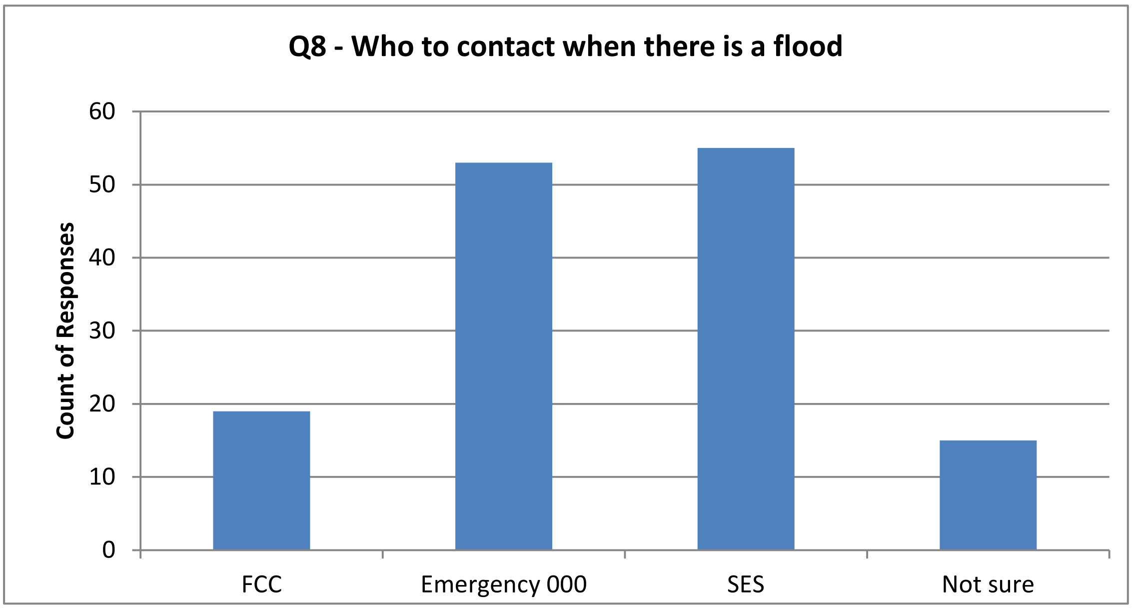
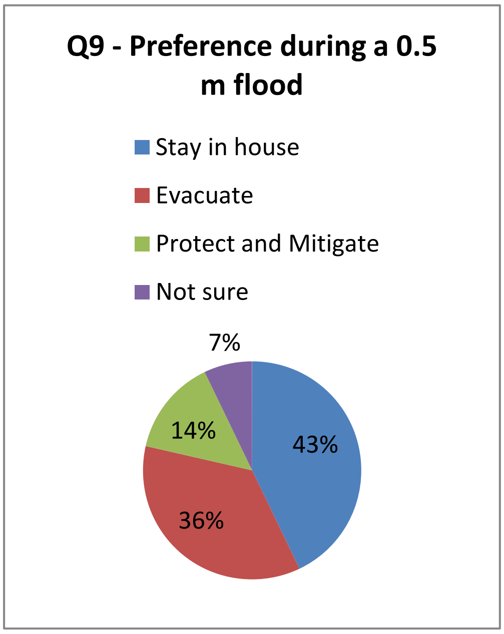


Figure 19: Who respondents think that they should contact if there is a flood

When asked who they thought they should contact in a flood, the most common answer given by respondents was, the SES (Figure 19). The next most common response was Emergency 000, the Council, and ‘not sure’. In this question 31% of respondents gave multiple answers, which could be an indication that the respondents did not know exactly who to contact and so would try at least two different sources to obtain information, or that they thought it would be appropriate to contact any of the organisations which they selected. The most common multiple answer was a combination of SES and Emergency 000. The second most common response was all three (FCC, SES and Emergency 000).

Almost half of the respondents stated that they would prefer to stay in their homes during a flood (48%). 29% stated that they would prefer to evacuate, and 23% were not sure what they would prefer to do.

Where further information was available, it was found that in a 0.5 m above ground flood, 43% of respondents would prefer to stay in their houses, 36% would evacuate, 14% would protect and mitigate, and 7% were not sure what they would prefer (Figure 20). In a 1 m flood, the respondents who would prefer to stay in their homes dropped to only 21%, the respondents who would evacuate increased to 72%, those who would protect and mitigate decreased to 0%, and those who were not sure what they would prefer decreased to 7% (Figure 20).



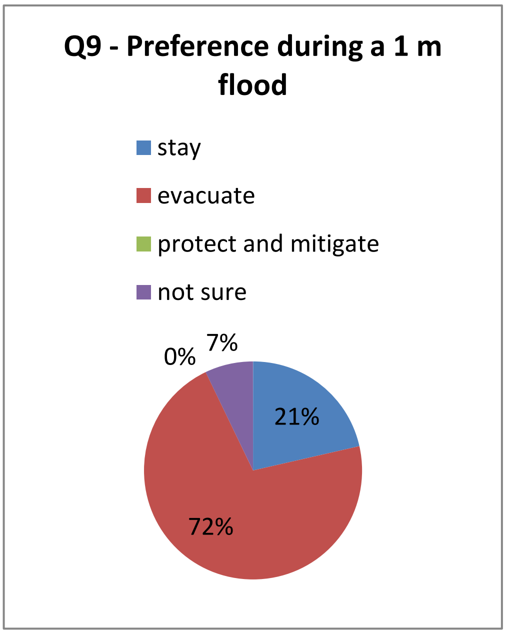


Figure 20: Preferred action to take during a flood

When asked what kind of assistance they would want council to provide to help them prepare for floods, the most common answer was a flood preparedness pack (69%), followed by online information (23%), workshop (13%), 'not sure' (13%), and then 'other' (9%)(Figure 21). Of the respondents who answered 'other', one respondent did not specify what other assistance they would like, and the remaining respondents each suggested something different (Table 12)

7.3.4 Responsibility for Floodplain Risk Management

Almost three quarters of respondents provided multiple answers when asked who they thought should be responsible for reducing flood risk (73%) (Figure 22). The most common answer included in the responses (both single and multiple) was FCC (93%). This was followed by the NSW Government, the SES, the landowner/resident, and then finally by 'someone else'. The most common response of 'someone else' was the responsibility to go to the Federal Government, followed by those responsible for development and development approval. The other response was 'emergency 000'.

Where multiple answers were provided, the most common combination was that of FCC and the NSW Government.

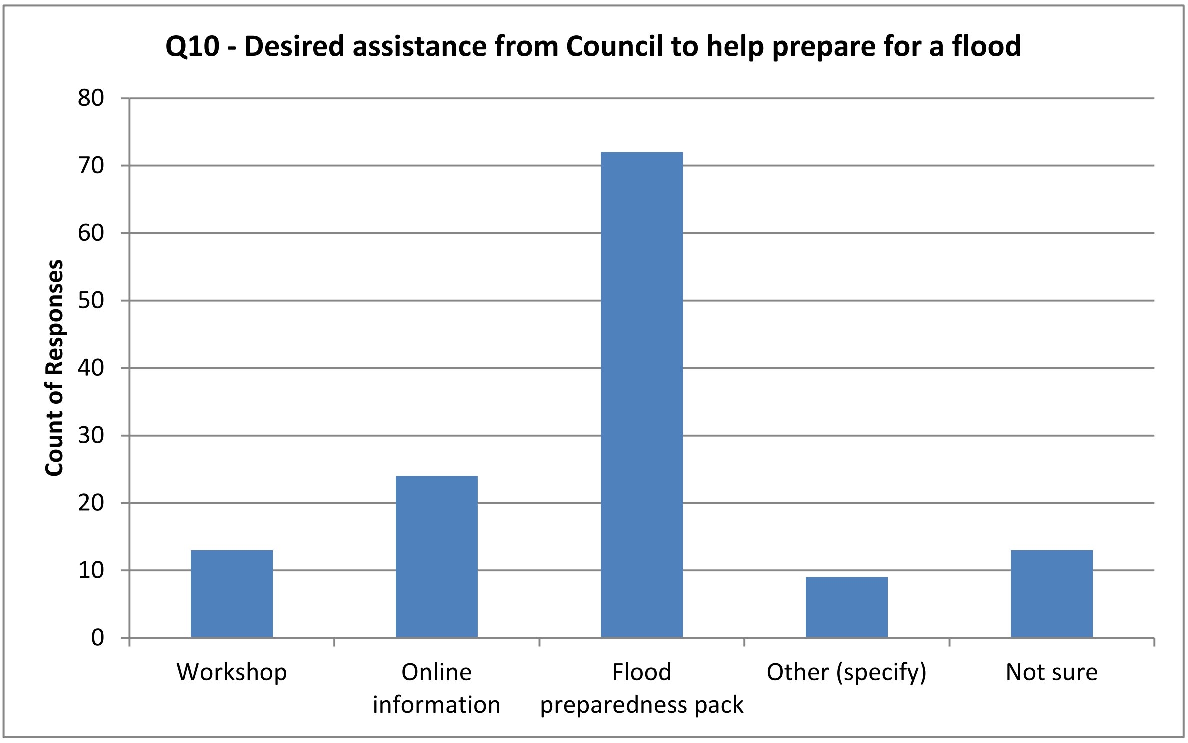


Figure 21: The kind of assistance that respondents would like to receive from Council to help prepare for a flood

Table 12: 'Other' assistance requested from council in response to question 10

'Other' assistance requested from Council
TV & radio
Just keep family safe
Rates notice
Letter
Contact SES
letter
Through rates notice for example
Something practical

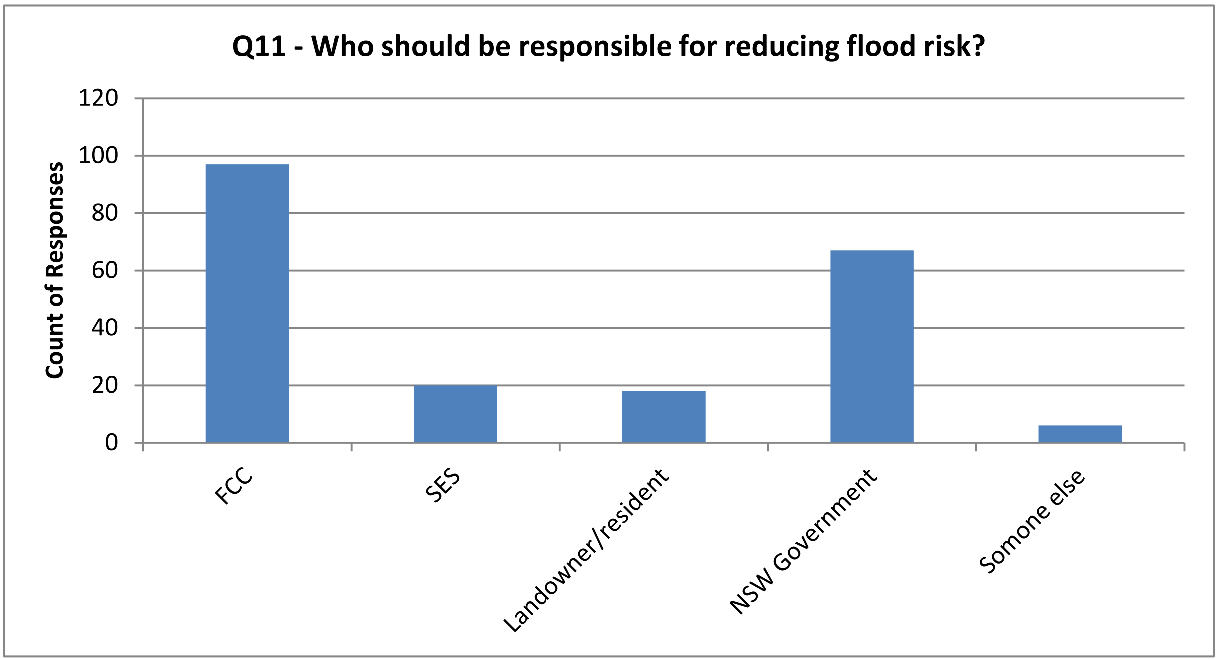


Figure 22: Who respondents think should be responsible for reducing flood risk

Most of the respondents indicated that they think that council is not spending enough on flooding controls and awareness (55%) (Figure 23).

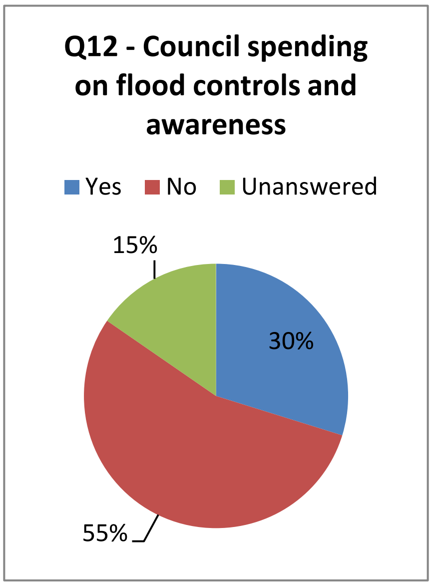


Figure 23: Future council flood control and awareness spending

7.3.5 Flood Mitigation Options

The proposed flood mitigation options were prioritised based on the sum of the priority values which it was assigned (where 1 is least preferred and 10 is most preferred) as shown in Table 13. The most preferred option was floodgates, followed by flow diversion, education, and redevelopment. The least preferred options were flood proofing, voluntary fence modification, non-voluntary fence controls, and stormwater drainage upgrade.

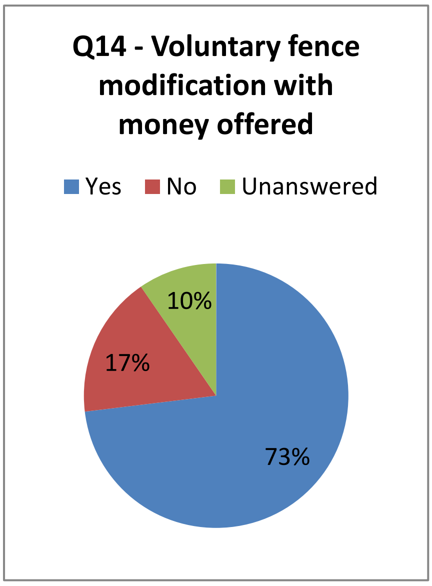
Table 13: Preference of respondents for proposed flood management options n

Option	Sum of all Responses	Rank	Average Response
Floodgates	745	1st	7.8
Flow diversions	725	2nd	7.6
Education	724	3rd	7.6
Redevelopment	703	4th	7.4
Development Controls	687	5th	7.3
On Site Detention	672	6th	7.1
Voluntary House Raising	621	7th	6.5
Local Flood Plan	614	8th	7.2
Flood proofing	614	9th	6.5
Voluntary fence modification	562	10th	5.9
Non-voluntary fence controls	473	11th	5.6
Stormwater Drainage Upgrade	52	12th	5.2

Most respondents indicated that they would consider voluntary fence modification if council offered money to assist with the cost of the modification (73%) (Figure 24). This number dropped to only 15% if money was no offered (Figure 24).

7.3.6 Additional Comments

Twenty-seven of the survey respondents made additional comments. A common response was that flooding had not occurred in the home of the occupant and they were sceptical that it would happen in the future.



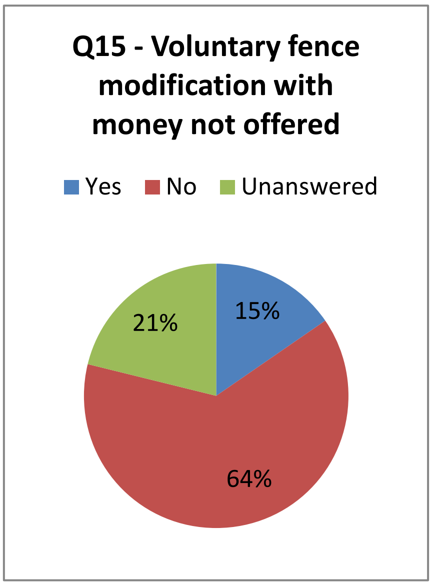


Figure 24: Willingness to modify fencing

7.4 IMPLICATIONS OF SURVEY

As noted above, only 19% of respondents had experienced a flood previously, and even less had any records of flooding. Only about one third of the respondents had seen or heard information about flooding (35%). In addition, 63% of the respondents stated that they did not know how to protect themselves or their properties from flooding. Only 4% of respondents reported having a written plan for flood emergencies. There was also confusion as to who should be contacted in a flood situation (far too many respondents only know the 000 emergency number rather than the SES number) and many residents preferred to stay and "fight" a flood rather than evacuate.

These responses, and those reported on another resident survey (Section 7.5), indicate a need for a targeted and specific education program for the residents of the Canley Corridor catchment.

Other responses that bear consideration in the floodplain risk management plan are:

- People are more aware of local drainage issues and nuisance flooding rather than major flooding being discussed here, simply because major flooding has not occurred recently;
- There is tendency for the community to focus on structural options such as flood gates and diversions as options to manage flooding, even though these have very little influence on the behaviour of major floods; and
- People appear to recognise the often uncontrolled increase in impervious areas (e.g. backyard paving) as a contribution to increasing flood risk.

7.5 COMMUNITY FLOOD AWARENESS

In addition to the survey above, Molino Stewart undertook a wider community survey as part of a "Community Flood Education and Awareness in Fairfield City" Project (Molino Stewart, 2012).

The findings of that survey reinforce the impression that there are low flood risk awareness and preparedness levels in the catchment (indeed, in Fairfield City). This appears to be comparable to other Sydney LGAs that have not experienced a major flood since a similar time to Fairfield City. The

Project also noted that there is a poor conversion rate between flood awareness and preparedness thus questioning this linkage.

The Project report indicated that the implication for a Flood Education and Awareness Action Plan is that it cannot be assumed that a concentration on awareness-raising education options will necessarily increase preparedness levels; there needs to be a focus on both.

It also noted that while flood experience is a major determinant of flood preparedness, the passing of time will result in a decrease in the numbers with flood experience due to population turnover. The implication for any Action Plan is the need to provide experiential learning options to provide 'real-life' situations, especially for the increasing number of people that have no flood experience.

The Project report concludes that the specific challenges of community flood education based on the demographics of this catchment, and the broader Fairfield City, should also be addressed in the Action Plan. These include catering for the large CALD communities (education options should provide information where possible in main non-English languages, community networks and leaders should be used to accommodate different cultural perspectives on flooding), low internet use (emphasis should be placed on communication methods other than websites), significant older populations ('traditional' communication means such as newspapers and radio should be used in flood education) and potentially significant numbers in the population who are neither literate in English or community languages (cannot solely rely upon written communication).

7.6 AGENCY CONSULTATION

Letters were sent to a range of government agencies seeking to ascertain whether they have any general or specific requirements that should be addressed in the course of the Study. The agencies contacted were those with an interest in the management of the floodplain, an interest in the infrastructure that crosses the floodplain or the environment of the floodplain. Agency responses are summarised in Table 14.

7.7 PUBLIC EXHIBITION

The final stage of the community engagement for this study was the public exhibition of the draft Canley Corridor FRMS&P. This document was placed on exhibition from 16 February to 20 March 2015.

Over 4,700 letters were issued to inform every resident and owner within the PMF extent of the exhibition, and to invite comments (See Appendix J). Council received 20 responses (19 telephone and one email). Some residents expressed scepticism about the flood risk affectation on their properties, and some expressed concern about the possible effect on their development proposals or property values. Council explained that recent flood history is not a sound indicator of the risk of large floods outside people's experience and that the evidence for any discounting effect on property values following the release of flood information was weak (see Yeo 2004 and Yeo et al., 2015). Several residents complained that the scale of the map was too small to see their individual property or that they needed labelling on the streets to locate their property on the maps. Some of these wanted to know if their property was in the areas identified for potential voluntary purchase. A few described localised property or street drainage maintenance which they thought would contribute to flooding.

Table 14: Input from Agencies

Agency	**Response**
Aquatic Habitat Protection Unit, Dept of Primary Industries	Orphan School Creek downstream of its junction with Green Valley Creek is designated key fish habitat,[1] which is to be conserved under the *Fisheries Management Act 1994*. It is important that flood mitigation structures are constructed outside of these waterways and seek to not impact upon any significant areas of riparian vegetation.
NSW Office of Water, Dept of Primary Industries	Any proposed mitigation works resulting from the study that impact on the creeks and its environment need to follow the guidelines available on the Office of Water website.[2]
Bureau of Meteorology	No general or specific requirements that need to be addressed in this study
NSW State Emergency Service	Section 6.1.1 articulates the NSW SES concerns with sheltering in isolated buildings during a flood as set out in a letter to Fairfield in early 2014. A meeting was held on 28 October 2014 with local regional and state representatives of the NSW SES to discuss the specific issues in Canley Corridor. Following public exhibition, the NSW SES reiterated its opposition to intensification of development in those parts of the Canley Corridor which could be isolated by floodwaters.
NSW Office of Environment and Heritage	The Waters, Wetlands and Coast Division provided input during the meetings of the Fairfield Floodplain Risk Management Committee. No input was received from the Ecosystems & Threatened Species and Planning Groups of the Metropolitan Branch of OEH.
Asset Management Division, Roads and Maritime Services	No issues identified.
Engineering and Projects Division, Railcorp	No issues identified by Sydney Trains or Transport NSW.
Government Property	No issues identified.
Greater Sydney Local Land Services	No input.
Sydney West Region, Department of Planning and Infrastructure	No input.
Emergency Information Coordination Unit, Land & Property Information	No input.
Housing NSW, within the Department of Finance & Services	No input.
SummitCare (owner of Canley Vale nursing home in Freeman Avenue)	SummitCare considers that the greater risk to patients is presented by the evacuation process rather than by inundation of the residential care centre.

[1] http://www.dpi.nsw.gov.au/fisheries/habitat/publications/protection/key-fish-habitat-maps
[2] http://www.water.nsw.gov.au/Water-Licensing/Approvals/Controlled-activities/default.aspx

8 FLOODPLAIN RISK MANAGEMENT OPTIONS

8.1 GENERAL

The floodplain risk management approach adopted in NSW divides flood risk into 3 types, existing, future and continuing risks, where:

- Existing flood risk is the risk a community is exposed to as a result of its location on the floodplain;
- Future flood risk is the risk a community may be exposed to as a result of new development on the floodplain.
- Continuing flood risk is the risk a community is exposed to after floodplain risk management measures have been implemented.

There are generally three recognised broad ways of managing floodplains to minimise the risk to life and to reduce losses to property due to flooding:

- By modifying the behaviour of the flood itself (**Flood Modification**). These measures are most applicable to addressing the existing flood risk and should not be used as a basis for introducing additional development to a floodplain;
- By modifying properties (**Property Modification**) to change the way in which flooding can impact on them. This can either involve removing or modifying existing properties to address existing flood risk or by imposing controls on future property and infrastructure development to address future flood risk. In some instances redevelopment can address both existing and future flood risks; and
- By modifying the response of the population at risk to better cope with a flood event (Response Modification). This measure is most frequently used to address existing and continuing flood risk and its application should never be the basis for introducing additional development to a floodplain.

The various options within these three broad categories are listed in Table 15 and are discussed in more detail in Sections 8.2-8.4).

Table 15: Floodplain Management Measures

Flood Modification	**Property Modification**	***Response Modification***
Detention Basins	Voluntary Purchase	Local Flood Plans
On Site Detention	Voluntary House Raising	Flood Prediction and Warning
Bypass Floodways	Flood Proofing of Buildings	Flood Education
Levees	Flood Access	Recovery Planning
Channel Modifications	Flood Planning Level	Insurance
Floodgates	Fencing Controls	Disaster Relief
Flow diversions	Land use controls	
Fence Raising Program	Site Filling/excavation	
	Large-scale re-development	

A fundamental principle of floodplain risk management is that management measures should not be considered in isolation. Rather, they must be considered collectively on a risk management basis that allows their interactions, their suitability and effectiveness, and their social, ecological and economic impacts to be assessed.

8.2 PAST AND CURRENT FLOODPLAIN MANAGEMENT PRACTICES

When urban development in the catchment accelerated after the Second World War, trunk stormwater drainage was installed and added to with little to no regard for existing watercourses or overland flowpaths. Most, but not all, of the pipes follow the road network layout with inlet pits from the road kerb and guttering directing surface drainage into the pipe below. Pipes range in diameter from small pipes less than 400mm diameter in the upper parts of the catchment to 1,800mm diameter pipes in the lower parts of the catchment. Some of the pipe drainage network runs through private properties, particularly in the upper parts of the catchment.

In the early decades of catchment development the drainage network was constructed in a somewhat piecemeal fashion. In many locations trunk drainage lines have been duplicated and additional inlet pits installed in an attempt to alleviate drainage problems as they arose, particularly as development higher up in the catchment directed more water into the drainage network which was already in place. There was no consideration given to the possibility of the increased impervious areas that we have today.

In recent decades a limited program of works and measures has been, or are being, undertaken by Council, or others, within the Canley Corridor catchment to reduce flood risk. These include:

- Ongoing cleaning of stormwater gully pits on a regular cycle and if notified by the community that a particular pit (or pits) has become obstructed by debris;
- Ongoing application of flood related development controls in accordance with the requirements of the relevant DCP or local plan including minimum floor levels and on-site detention provisions for major developments;
- Trial of a fence modification scheme between Hughes Street and McBurney Street, Cabramatta (see illustration in Section 8.3.6).
- Minor stormwater works, e.g. extension of stormwater pit and pipe network in new development areas.

These works and measures are very site specific and do not address the catchment wide issues. It must also be remembered that a solution for dealing with overland flows in one area may divert flows or exacerbate the problem elsewhere.

It should also be noted that there has been no major stormwater upgrade works, i.e. trunk drainage amplification, in the catchment since it underwent urban development decades ago. This action is considered later in Section 8.3.3.

Water quality improvement works have been undertaken at Adams Park and the Baramy Gross Pollutant Trap (GPT) to the north of Canley Vale shopping centre. These measures do not address floodplain risk management.

8.3 FLOOD MODIFICATION MEASURES

The purpose of flood modification measures is to modify the behaviour of the flood itself by reducing flood levels or velocities or by excluding floodwaters from areas under threat. It is essential that these measures are assessed, first, on an overall catchment basis, and second, from within the strategic framework of an overall floodplain management plan. If assessed individually or in isolation, there is the possibility that future land-use developments may reduce, if not eliminate, present mitigating effects. For example, detention basins must be assessed on a systems basis that incorporates the impact of future development and a range of flooding scenarios.

8.3.1 Flood Detention Basins

A detention basin is like a small dam that provides temporary storage for floodwaters. Detention basins are used as a means of controlling the peak discharge from urbanised areas. Some of these basins are becoming quite large, and in fact, they are more properly regarded as small dams and have to be designed as such.

Figure 25: Hassall Street Detention Basin in January 2001

In urban areas, detention basins are most suitable for small streams that respond quickly to rapidly rising flooding. Detention basins have a number of inherent disadvantages that should be carefully evaluated for each particular situation, for example:

- They require a substantial area to achieve the necessary storage;
- Where they involve multi-purpose uses (e.g. public recreation), safety aspects during flooding need to be addressed;
- Long duration or multi-peak storms (when the basin is filled in the first peak) can increase the likelihood of overtopping (when no alternative is available), or embankment breaching or failure (‘dam break’), and the resulting personal danger and damage; and
- They provide little attenuating effect when overtopping occurs.

Consequently, it is important that detention basins are properly designed (including consideration of alternative storm patterns and flood recurrence intervals), constructed and maintained. Risk is reduced by complementary works (bypass spillways) or specific land use planning measures (downstream flowpaths). It is noted that with appropriately designed outlet works, detention basins may act as sediment traps thereby improving urban water quality by reducing the concentration of solids.

There are some 20 flood detention basins in Fairfield City, most of them constructed in large park areas or open space adjacent to the City’s creeks, e.g., King Park, Chisholm Park and Basin C within Bonnyrigg Town Centre Park. There are 14 basins in the Three Tributaries main-catchment that collectively act to reduce downstream flood levels in Orphan School Creek and its main tributaries, reducing the impact of flooding in the areas most immediately located near those creeks. However, they do not provide any significant benefit to the upstream areas of the Canley Corridor catchment – that area is directly affected by the local overland flooding.

Given the level and extent of development in the Corridor and the lack of open space that may have met the first requirement above, detention basins are not generally relevant to this study area. However, there is one site in the study where a detention basin may result in a positive outcome for flooding – Cabra-Vale Diggers Park. This site could be used to manage flows from a side “tributary” that contributes to flooding, and closure, of Railway Street Cabramatta/Canley Vale.

The park would have to be significantly modified to act as a detention basin and there would need to be significant outlet works constructed both under Railway Street and also the Southern Railway, needing the co-operation of Rail Corporation NSW as this particular set of tracks carries not only suburban rail services but also major interstate freight services.

This potential basin was modelled in the updated Canley Corridor flood model. The results (Appendix E) indicate that the potential basin had minimal impact on flood levels (less than 0.05m) and did not affect the extent of flooding along Railway Parade. In a PMF, there would be some storage of water in the park however this would again have minimal impact on flood waters in Railway Parade where the flooding was far more dependent on all other flows rather than the flows from the small catchment commanded by the potential basin.

Any benefits gained from a basin at this location would be significantly exceeded by the costs and community disruption caused by its construction. Accordingly, flood detention basins are not further investigated in this Study.

8.3.2 On-Site Detention

An alternative to providing one or more large detention basins is to provide a number of smaller basins. This can be done through the construction of on-site detention (OSD) structures on private properties throughout the catchment. This is common practice in many local government areas around Australia, including Fairfield City.

OSD is a way of collecting rainwater that falls on a property, storing it temporarily and then releasing it slowly so that it does not worsen downstream flooding. OSD can be provided underground in storage tanks, on ground as ponding areas and above ground as rainwater tanks (if designed appropriately).

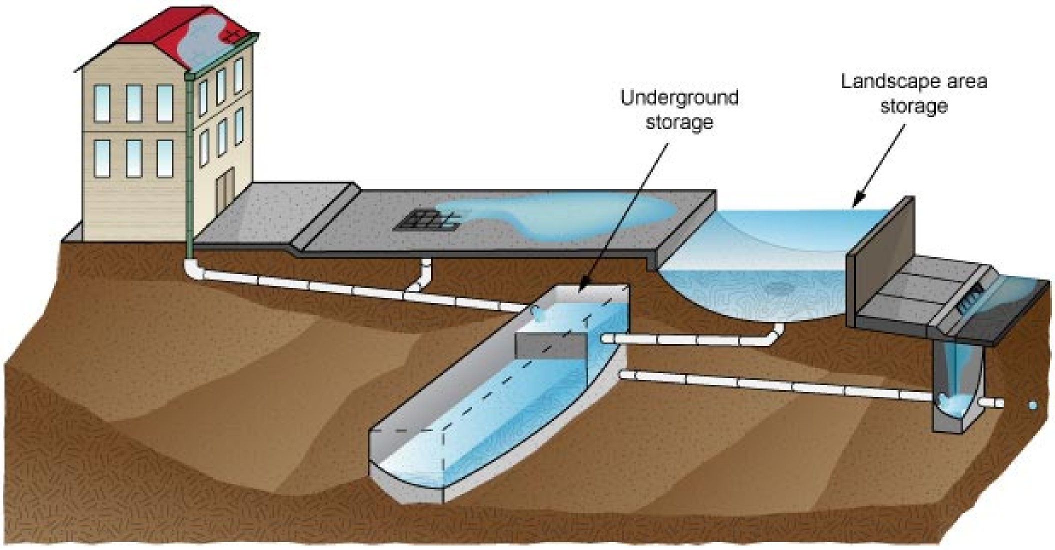


Figure 26: Illustration of OSD system

There is the potential for significant on-site detention in the Corridor, especially where there is large-scale redevelopment in the future (see Section 8.4.3).

The OSD policies for Fairfield City are contained in the following listed documents:

- Urban Area On-Site Detention Handbook, February 1997; and
- Stormwater Drainage Policy, September 2002.

The Handbook also details where the OSD Policy will be applied and, importantly, where it will not be applied. A Permissible Site Discharge (PSD) is stated, as is a ponding depth and freeboard.

The OSD policy does not apply to:

- an area where a significant portion of the site is affected by a major overland flow path as there would be limited opportunity on site for OSD;
- individual residential dwellings, whether they be extensions, reconstructions or dual occupancies unless Council anticipates they will produce excessive stormwater runoff; and
- driveways and paving of yards.

This means that there can continue to be uncontrolled increases in the impervious areas within the catchment with an accompanying increase in stormwater runoff in any particular event.

It should also be noted that that the current OSD policies applied in the catchment are not a process that necessarily makes flooding better, as can be achieved by major structural works, it prevents flooding from getting worse from the increment of development.

A policy to reduce flooding in larger events using on site detention works alone would not be practical and was not investigated further for the Canley Corridor catchment. It is understood that the development of catchment management plans for the Burns Creek and Smithfield catchments has included reviews of the OSD design criteria for those areas including the computer modelling of OSD as a means of reducing peak overland flows, not just preventing them from increasing.

As OSD is a practical means of managing future flood risks it has been carried through for more detailed consideration in Chapter 9. Any changes to OSD policy will need to be reflected in Council's Stormwater Drainage Policy which is more than 10 years old.

8.3.3 Underground Flood Storage

Underground flood storages can be used to manage flooding through the temporary storage of flood waters during a flood event, effectively reducing downstream flow rates. This mitigation option aims to reduce flood levels by increasing the capacity of the underground drainage network through the construction of additional underground storages (See Figure 27). They are essentially underground flood detention basins.

There were a range of potential sites that could have been considered for this option, particularly two existing open space sites[1] and also under some less trafficked roadways. One of the open space sites was discovered to be in the ownership of the NSW Land & Housing which, when contacted, did not want any work done on or under their land.

Accordingly, a trial run was undertaken with the hydraulic model, as reported in Appendix F however no significant benefit was determined as a result of the limited storage available with local reductions of flood levels of less than 0.01m in the immediate areas. No further investigations were carried out for this option.

[1] The park at the corner of Arbutus & Gladstone streets is owned by Council and is zoned "RE1 Public Recreation". The vacant lots on the corner of Kiora, Adolphus & Arbutus are all owned by NSW Land & Housing.

Figure 27: Forming underground storages

8.3.4 Stormwater Pits & Pipes

The capacity of the stormwater pit and pipe system in many catchments will be largely dependent on its age and original land uses. Many older pipe systems were originally designed for the most frequent floods with excess flows carried in the road reserve or overland flow paths. Generally, the pit and pipe system is expected to manage the more common storm events and when major events occur, these systems surcharge and overland flow occurs.

The pit and pipe system in the Canley Corridor catchment was designed for frequent floods (1 in 5 years ARI) and installed in the early 1960s. They were designed using the best rainfall estimation techniques available at the time but these significantly underestimated Australian rainfall variability. During this time, the catchment consisted of large residential blocks with minimal impervious surfaces and the stormwater system, consisting of the pipes system (the minor drainage system) and the road reserves (the major drainage system) could manage these more frequent storm events without significant impact on residential properties. With the passage of time and increased development, particularly the increased density of residences, increases in hard surfaces and heavier fencing, the pipe drainage system became less and less capable of managing the runoff from major storms.

Council currently maintains the existing stormwater systems through regular cleaning of stormwater pits and as-needs replacement of collapsed or broken pipes. Council will also undertake minor stormwater works such as small extensions of the pit and pipe network, driveway or footpath raising, etc. to alleviate localised nuisance flooding. Although this will assist in reducing the risk of nuisance flooding, these actions will make little difference to major overland flow behaviour (FCC, 2013b).

A significant proportion of community comment highlighted that the upgrading of the pits and pipes would be a significant contribution to improving the flood situation in the study area.

The upgraded hydraulic model was used to establish pipe capacities across the study area and assess whether any upgrades to the stormwater system would be a viable flood mitigation option. The pipe capacity assessment report is presented in Appendix G.

In summary, the modelling indicated that:

- The majority of the network is at-capacity (full) during the 5 year ARI event.
- The capacity of the drainage is greater in some locations at the upstream extremities of the network.
- There are no obvious bottlenecks in the drainage network.

Figure 28: Installation of new stormwater pipes in Smithfield

Whilst the results indicate some pipe capacity at the upstream extremities of the pipe network, it is likely that this result is due to the adopted modelling approach for the Canley Corridor Flood Study and subsequent revisions for the Floodplain Risk Management Study, whereby only pipes greater than 900mm diameter have been included in the stormwater network, with sub-catchment inflows lumped at drainage pits. In reality, runoff will enter the drainage network further upstream. It is therefore likely that the pipes at the upstream extremities of the modelled stormwater drainage network will be at-capacity (full) during a 5 Year ARI event.

These results indicate that there are not likely to be any viable flood mitigation options within the Canley Corridor study area related to:

- Increasing pit inlet sizes to direct more runoff into the stormwater drainage network; or
- Local pipe size increases to reduce bottlenecks in the stormwater drainage network.

The highly urbanised Canley Corridor catchment makes this option very expensive and potentially disruptive. For instance, it is estimated that upgrading 100m of pipeline from 900mm diameter pipes to 1200mm diameter pipes would cost some $300,000. Thus, to upgrade the pipes from the Cumberland Highway to Gladstone Street in Cabramatta, a distance of 540m, the cost would be $1.62

million. Construction would disrupt the street traffic for between 3 and 6 months. The "costs" associated with the disruption have not been estimated but could be 25% to 30% of the capital costs. Such an upgrade would increase the carrying capacity of the pipes by 80% but this would not be sufficient to fully contain the 20 Year ARI flows and would not make a significant difference to the overland flows in the larger events.

It is considered that pipe upgrading is not beneficial from either a flooding or economic standpoint and the limited benefits do not warrant further consideration of this option. However, the maintenance and cleaning of existing stormwater drainage assets is worthwhile to ensure that they are all working at maximum efficiency.

8.3.5 Bypass Floodways and Flow Diversions

Bypass floodways redirect a portion of the floodwaters or overland flows away from areas under threat from flooding, and so reduce flood levels along the channel or flow path adjacent to the diversion. Bypass floodways are more typically considered for mainstream flooding as opportunities for the construction of bypass floodways may be limited by existing development, the topography of the area, environmental considerations and the availability of land. They are also used, in limited applications, for road crossings of creeks – in Fairfield City, Orphan School Creek at Moonlight Road in Prairiewood and Cambridge Street (Cumberland Highway) in Canley Heights are examples of such applications.

Bypass floodways may exacerbate flood problems further downstream and, as they direct flows away from natural paths, may impact on channel form both upstream and downstream of the site of the works. Despite these shortcomings, bypass floodways can, on occasions, provide a useful management option.

Given the highly built up nature of the catchment, bypass floodways that attempt to convey all significant flows are considered unviable and will not be discussed further. However, an opportunity was identified to develop flow diversions through the developed areas using cross-streets, architectural mounding and "hard" fencing in particular locations.

This mitigation option aims to reduce flood levels by reducing overland flows through properties east of Adolphus Street by diverting this flow along new or enhanced flow paths that follow the street network. Street flows are to be diverted using speed humps to convey flows to connecting side streets which can then drain to Orphan School Creek.

The feasibility of this option requires proximity to both Orphan School Creek and the main flow path as well as an achievable fall in topography along the additional flow paths. The area bounded by Orphan School Creek, Adolphus Street, Canley Vale Road and Sackville Street was considered appropriate for a trial modelling of this option (Figure 29). The option would therefore aim to reduce floods levels in the immediate downstream areas. The detailed report is at Appendix H.

Testing of this option with the hydraulic model indicated that:

- There is some merit in pursuing this as an option for the Floodplain Risk Management Study, specifically in the area north of Buckingham Street, however more detailed testing is required regarding spacing of humps, road design criteria and localised flood level changes; and
- There is minor benefit along Canley Vale Road combined with an adverse impact between Buckingham Street and Earl Street as a result of the flow path improvements between Canley Vale Road and Buckingham Street.

This option was not considered further because of the practical difficulties in installing the speed humps at the necessary locations and the adverse impacts it would have on traffic.

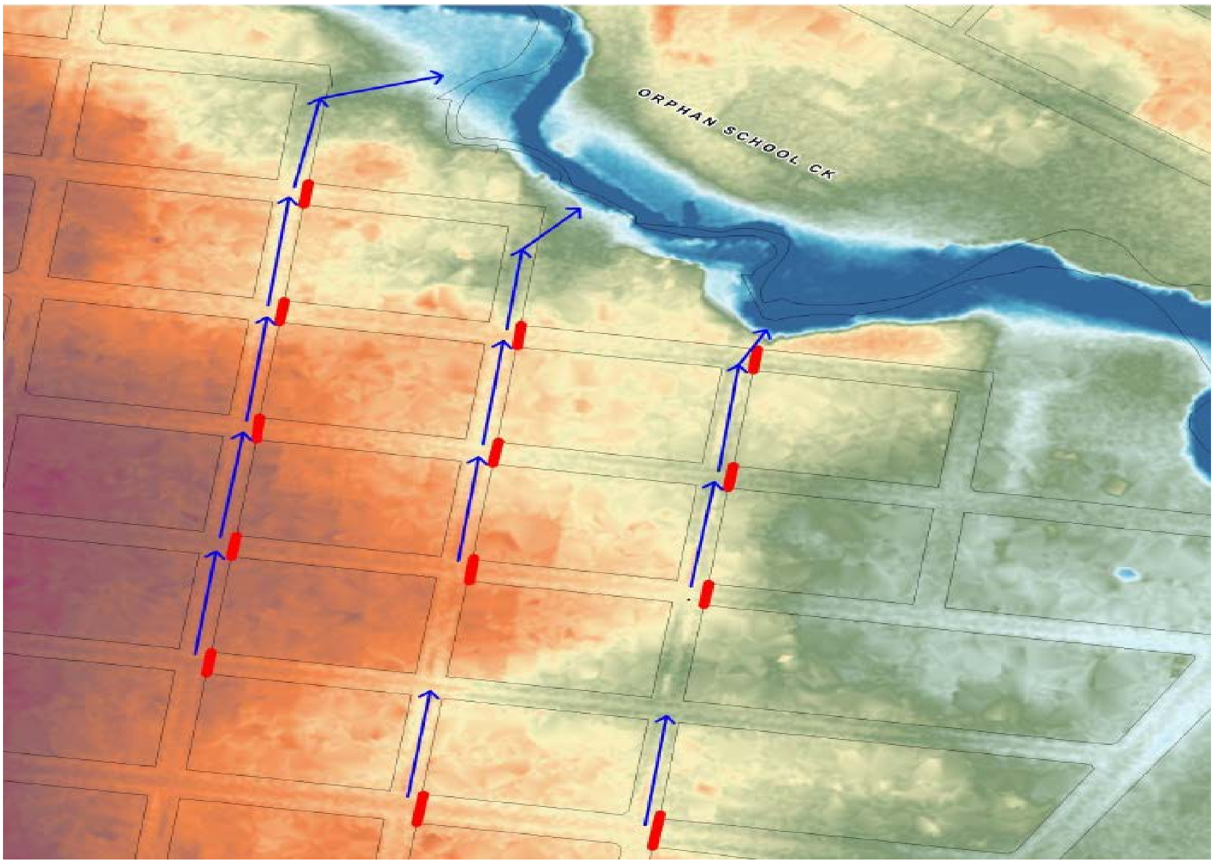


Figure 29: Flow diversion along streets in Canley Corridor

8.3.6 Levees

Levees are essentially a high wall of earthworks or concrete, or a combination of materials to suit a location, and are frequently the most economically attractive measure to protect existing development in flood prone areas from mainstream flooding. The extent, width and height or crest level of a levee is determined by a variety of factors that include:

- The economics of the situation (including the nature of development requiring protection);
- The physical limitations of the site;
- The level to which floods can rise relative to the ground levels in the area (important in safety considerations); and
- The visual impact of the levee.

The use of levees for flood risk management requires the consideration of a range of precautions, all of which are detailed in the Floodplain Development Manual (2005).

Levees have been used in Fairfield City, e.g. Tresalam Street at Mt Pritchard, however this is a mainstream flooding scenario. Levees are rarely used in overland flow situations due to lack of space, increase in downstream flood risk, cost and environmental constraints, amongst other considerations. Council does however construct bunds, which are essentially a very small levee, in open spaces to reduce the risk of nuisance flooding. Although bunds may be considered on an as-needs basis for this catchment, they are unlikely to be effective in controlling major overland flows. They are a partial solution and should be supplemented by comprehensive flood planning and readiness measures.

Given the highly built up nature of the catchment, levees are considered unviable and will not be discussed further.

8.3.7 Fence Modification

An important consideration in the management of overland flows is the location and type of boundary fencing that crosses or deflects overland flows. As noted in Section 5.1.4, fencing throughout the Canley Corridor catchment has a major impact on flood levels, flow paths and the general state of the catchment. The wrong type of fencing across an important flow path may result in significantly higher actual flood levels than may be predicted by a hydraulic model.

As such, fences pose a significant hazard to properties upstream, through raising flood levels, and to properties downstream from the resulting surge of water should the fence fail. This unpredictability of behaviour means that the fencing has not been modelled in detail in the hydraulic model. There are also so many different styles of fencing within the catchment – brick, paling, Colorbond or a combination thereof, that adopting a particular style or failure mode for modelling only really applies in the immediate area and not generally through the study area.

The impacts of fencing were tested using the hydraulic model for the flood affected area between McBurney and Hughes Streets, Canley Heights, with the results at Appendix D. Figure 16 shows the impact of fences on depth in a 100 year ARI event. The modelling established that the inclusion of fences in the TUFLOW modelling has significantly impacted the peak flood levels, velocities and flood hazard in the immediate area, in particular:

- Flood levels are increased on the upstream side of the fences (i.e. prior to failure of the fence segments); and
- Velocities and flood hazard are increased as a result of the fence failure.

The results highlight the need for fences to continue to be controlled by Council's development control plans and for a long-term fence raising/opening program to be developed in the area between Hughes Street and McBurney Road (see Figure 30).

Constructing fencing to allow this free flow of water in high flow areas offers benefits to the management of overland flows. The "open fencing" requirement can be met a number of ways, not just by opening a space underneath the fencing (usually sealed by wire or mesh), but also through vertical gaps, offset palings, or even collapsible fencing.

Section 11.9 in the 2013 Fairfield City Wide Development Control Plan, Chapter 11 – Flood Risk Management, Version 17 contains a specific fencing policy for new developments in flood prone land, including that in the Canley Corridor catchment. In non-flood affected areas, Council utilises the provisions of the Dividing Fences Act, 1991. Where Council should apply these controls is a matter of some conjecture, as the current high hazard/Zone of Significant Flow development controls do not normally allow development in those areas however the "2008 Code SEPP" and concessional development do allow such work. This is discussed in Section 8.4.2.

Council has previously undertaken fence raising, in association with the landholders (see Figure 31), to reduce the obstruction to flows caused by "hard" fencing[1]. This work mainly consisted of creating a mesh panel some 300 – 450 mm above the ground and allowing the solid fencing above that. It was planned to allow the free flow of water across properties however care was required to ensure that additional flows, or new flows, were not detrimental to the adjoining residences. This is particularly the case with low-set houses.

This is one of the principal concerns with the fence raising/opening option – the potential for litigation as a result of additional flows being experienced downstream in small events even though the purpose of the scheme is to prevent a sudden flood wave being released downstream should the fence fail in larger events. The legal complexities of such an issue are outside the remit for this study and need to be considered in any detailed planning for future application of any scheme to "raise/open fences".

[1] Undertaken under the auspices of the Western Sydney Drainage Initiative in the early 1990's in Shackel Avenue, Old Guilford, McBurney and Hughes Street Cabramatta and Moonshine Avenue Cabramatta West.

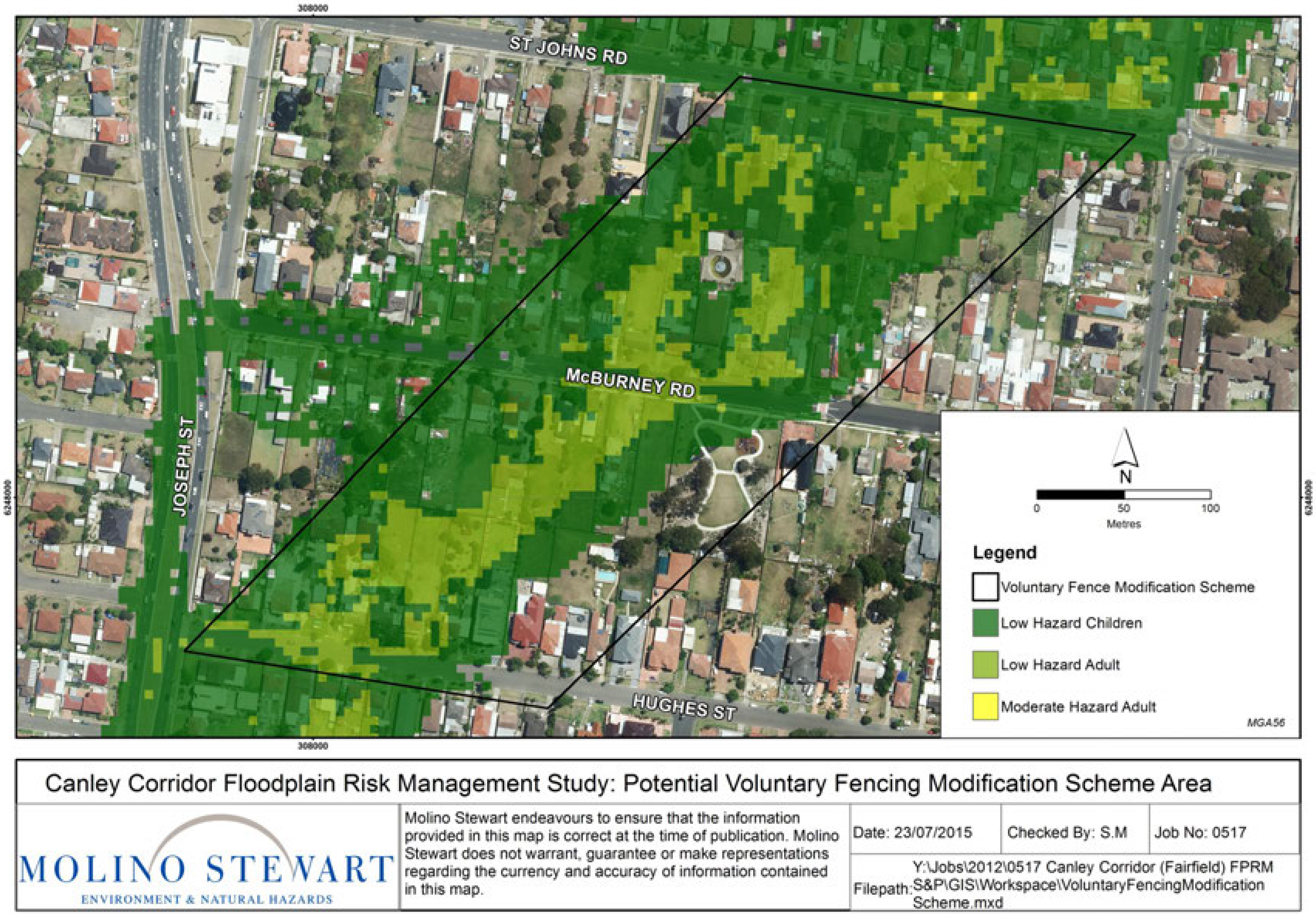


Figure 30: Potential Area for Voluntary Fencing Modification Scheme

Figure 31: Revised Fencing, McBurney Road, Cabramatta – 1993/4

The possibility of a fence raising program was discussed during the community consultation phase of the study. Most respondents indicated that they would consider voluntary fence modification if council offered money to assist with the cost of the modification (73%) however this dropped to only 15% if financial assistance was not offered.

The blocks between Hughes St and McBurney Road are approximately 80m by 20m which means the cost of about 90m of fencing needs to be paid for by each adjoining property. Standard Colorbond fencing currently costs less than $70/m installed. It would be reasonable to assume that a modified Colorbond fence with modifications as shown in Figure 31 might cost in the order of $10,000 per property. Fences are replaced more frequently than houses but metal or brick fences generally last considerably longer than a timber paling fence which may last only about 20 years. If a fence needed to be replaced then the cost of replacing it with a flood compatible fence might cost less than $3,500 more per property.

As with the legal implications of applying a fence raising/opening program, voluntary or financially assisted, there are flooding related issues that need very detailed consideration before a final plan can evolve.

For example, it may be found that, in the older areas, the residences are built low so that any additional flows may flood a residence that was previously not directly affected. That requires the cumulative impact of any fence raising/opening to be taken into account and a balance of benefits and costs established, especially if the work on the fences also requires some flood mitigation measure to be applied to an individual property or group of properties,

It could be expected that fence raising/opening would have a positive impact on benefit/cost calculations however the currently used formulae are not that sensitive to the depth of flooding or to the speed of inundation. The formulae are based on a specific depth, not how a flood may occur. Any estimation of benefit cost is thus hampered by those constraints and would need a significantly more detailed approach than usually applied to such options.

In addition to the already identified legal, flooding and financial issues, there are a range of other issues that require detailed consideration before a final program can be instituted. These issues include, in no priority order:

- The maintenance of the work, once completed, should financial assistance be provided –this is a Council responsibility, especially if government assistance is provided, based on the wording of the funding agreement with the Office of Environment & Heritage. The ability of this requirement to be passed to the resident, and future residents, needs to be clarified through legal advice;

- What costs will apply to any program - DA fees, construction costs, ongoing maintenance – and how might these be shared between Council and resident;
- Is a covenant under Section 88B of the Conveyancing Act 1919 needed to ensure long-term continuation of the fencing as built. An audit of the fences which were previously modified would inform this;
- What status does Council have in the contract to build the fencing (usually between contractor and resident) and do recent changes to the NSW Strata legislation regarding insurances for works change any status between resident, contractor and council; and
- What funding may be available and at what rate within the program. If funding is attracted from government sources, what priority may the program attract when compared to other programs (voluntary purchase, house raising etc) state-wide?

In addition to these concerns, there are specific concerns that Council needs to address if such a program is to be adopted. These include staff resourcing, particularly inspecting fences on a regular basis and ensuring compliance with the relevant development controls, the number of applications that can be handled, quantitatively and financially, the staff skills/knowledge required to administer the program and a listing of contractors for residents to source quotes.

All these issues need to be addressed in additional studies to ensure any such program reaches an efficient and effective outcome.

The application of development controls to fencing and the areas where it is to be applied are discussed in Section 8.4.2.

Figure 32: New development at 96 Canley Vale Road (cnr Sackville Street), Canley Vale

8.3.8 Channel Modifications

The hydraulic capacity of a creek or stormwater channel to discharge floodwater can be increased by widening, deepening or re-aligning the channel and by clearing the channel banks and bed of obstructions to flow. This option may have some benefits in a main stream situation, e.g. Orphan

School Creek, and it is understood that will be investigated as part of the development of the floodplain risk management plan for the Three Tributaries catchment.

The Canley Corridor does not have either a defined channel or a clearly defined major flow path that could be utilised as a "channel" in the usually accepted sense.

Given the level and extent of development in the Corridor, which has eliminated open areas, channelisation of flows is not relevant to this study area and is not discussed further.

8.3.9 Floodgates

Floodgates may be used to control flow down a floodway or to prevent flow along a small creek or drain or other waterway. In this study, the consideration of flood gates applies to the prevention of backwater flows into the drainage system from high water levels in Orphan School Creek.

Areas such as Freeman Avenue / Queen Street / Burdett Street in Canley Vale might benefit from floodgates but this is a benefit best investigated as part of the Three Tributaries Floodplain Risk Management Study as they would be controlling backwater flooding from Orphan School Creek.

Maintenance of floodgates is important to ensure that they operate satisfactorily when a flood comes and remain closed or open as required during non-flood times.

Figure 33: Floodgates - closed to exclude flows (left) and releasing stored water (right)

8.3.10 Summary of Flood Modification Measures

There are limited options for modifying flood behaviour in the Canley Corridor because it is a fully developed catchment with limited open space, an old drainage network and a broad area affected by shallow overland flows.

The one option which is worth evaluating for existing flood risks is the modification of fences through the area of highest flows between Hughes Street and McBurney Road, to ensure that fences are not causing a flow obstruction which increases flood depths and hazards upstream and downstream.

On-site detention is worthwhile for ensuring future flood risks do not increase and may be worth considering as a means of using future development to reduce existing flood risks.

8.4 PROPERTY MODIFICATION MEASURES

Property Modification Measures incorporate modifying or removing existing properties from flood affected areas and/or by imposing controls on future property and infrastructure development. These measures are aimed at steering inappropriate future development away from areas with a high potential for damage and ensuring that potential damage to existing developments likely to be affected by flooding is limited to acceptable levels by means of minimum floor levels, flood resistant building materials and design etc.

In this catchment, it is convenient to divide these measures into Works and Planning, as each sub-category has differing impacts and applications.

8.4.1 Property Modification - Works

Property Modification – Works include any measure that changes the character of an existing property or residence, including:

- Voluntary purchase (VP);
- Voluntary house raising (VHR);
- Flood proofing buildings; and
- Improved flood access.

The Office of Environment and Heritage has issued the following guidelines to guide the first two of these options:

- Floodplain Management Program Guidelines for voluntary purchase schemes (OEH, 2013a); and
- Floodplain Management Program Guidelines for voluntary house raising schemes (OEH, 2013b).

Property modification measure mainly target buildings which experience above floor flooding. Figure 34 shows the residential buildings which could experience above floor flooding in the 100 Year ARI flood or more frequent events in Canley Corridor. There are seven which could experience above floor flooding in the 5 Year ARI flood, a further 19 which could experience it in a 20 Year ARI flood and another 22 which could experience it in a 100 Year ARI flood. Most of these are free standing houses but some are duplexes and there are also some home unit and villa home complexes.

Throughout Australia today the 100 Year ARI flood is generally used as the planning benchmark for protecting residential buildings and contents from flood damage. In addition to the 48 houses shown in Figure 34, there are a further 629 residential buildings which could experience above floor flooding in a PMF. Reducing risk to life would be the main consideration in modifying buildings which would only experience above floor flooding in events larger than the 100 Year ARI event.

a) Voluntary Purchase

Voluntary Purchase (VP) is a recognised and effective floodplain risk management measure for existing properties. It can be an effective strategy where it is impractical or uneconomic to mitigate the high flood hazard to an existing property and it is more appropriate to cease occupation to meet the personal safety and flood loss reduction objectives inherent in a floodplain risk management strategy. It is likely to be a measure that complements an overall floodplain risk management strategy for an area rather than an option that reduces flood risk on its own. Under such circumstances, property should be purchased at an equitable price and only where voluntarily offered. Such areas should ultimately be rezoned to a flood compatible use such as public open space.

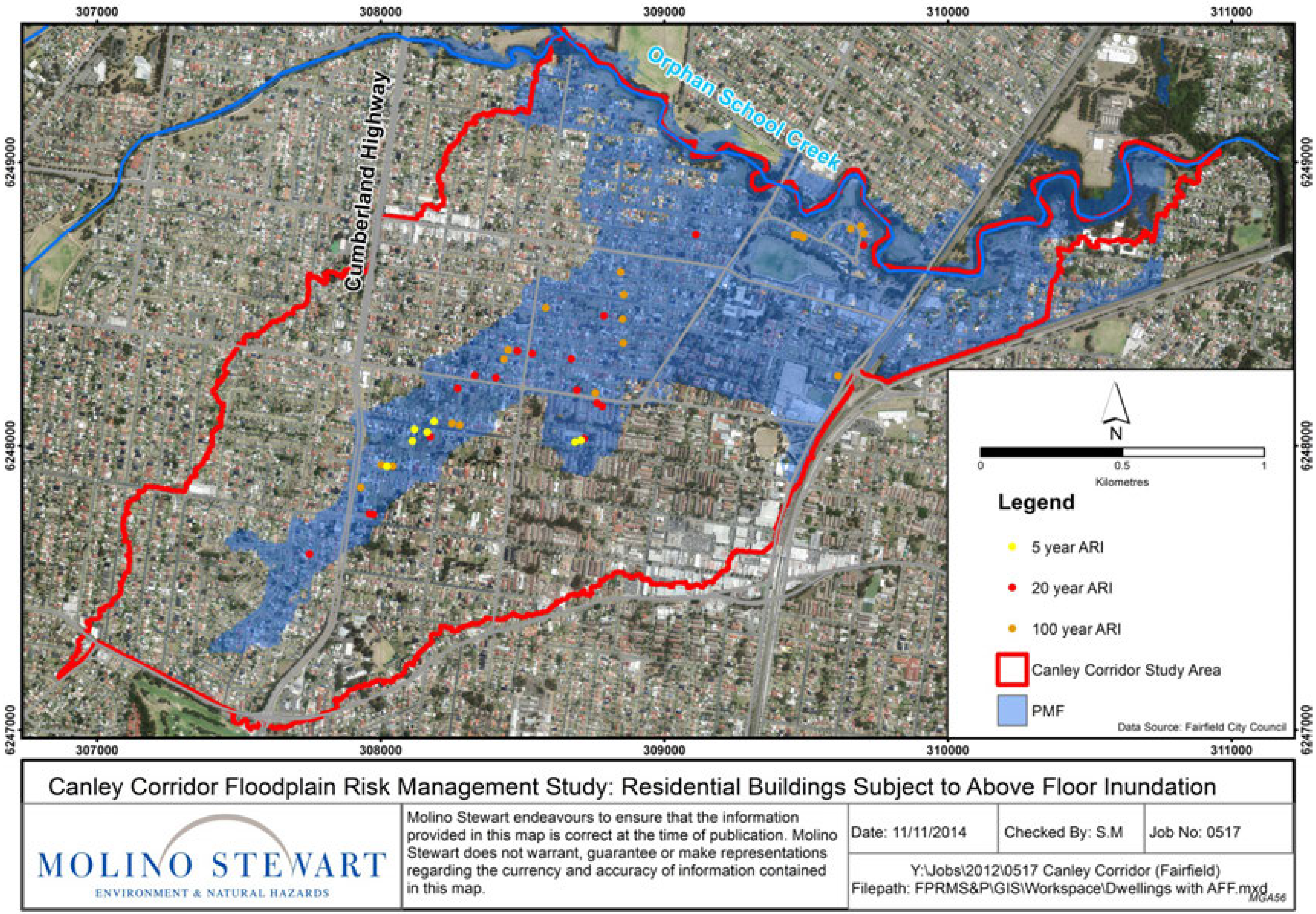


Figure 34: Properties at Risk of Above Floor Flooding up to the 100 year ARI Flood

VP is a risk management option that has been pursued by Council over many years, particularly in the suburbs of Lansvale and Canley Vale. Council has developed a set of criteria that govern the eligibility of properties to be purchased (Willing and Partners, 1990) and these criteria are adequate for the Canley Corridor catchment and may be used in conjunction with the OEH Floodplain Management Program - Guidelines for voluntary house raising schemes.

The areas of highest flood hazard within the residential areas are:

- In the deep water depressions in the section of floodplain between Hughes Street and Wyong St, Cabramatta; and
- The lowest lying blocks in Freeman Avenue, Canley Vale.

i) Hughes Street to Wyong Street

The Hughes Street to Wyong Street properties are large residential blocks. Many still have the original small houses on them while others have been redeveloped with either newer, larger houses, dual occupancies or duplexes.

Examination of the likely flood damages to houses with the greatest risk of above floor flooding in this area suggests that they would experience about $50,000 of damages in a 5 year ARI flood, rising to about $70,000 damages in a PMF. Taking into account the probabilities of the various events that could occur, this equates to average annual damages of about $31,000 in direct and indirect tangible damages. If these annual damages are assumed to occur every year for the next 50 years and the value of those damages are brought back to a single present value they would equate to about $430,000 (assuming a 7% discount rate). Small cottages on large blocks in Canley Vale are currently on the market for around $600,000. In other words it would be necessary to spend about $600,000 to avoid tangible damages worth about $430,000. On that basis alone voluntary house purchase is not economically worthwhile. It would be even less economically viable to purchase those properties with less chance of over floor flooding.

However, FCC's VP criteria recognise that there are additional considerations in determining eligibility for voluntary house purchase such as impediment of flows and risk to life. Of the seven residential buildings which can experience above floor flooding in the 5 Year ARI flood, four in McBurney Road and one in Hughes St can be surrounded by high hazard flood water and have evacuation difficulties. This would make them candidates for VP according to the criteria in the FCC guideline. It would cost about $3 million to purchase these five highest risk properties and the land would have to be left vacant. A further four houses in the area with significant flows which have evacuation problems would experience above floor flooding in the 20 Year ARI event and would cost about $2.4 million to acquire.

The remaining two buildings with a risk of above floor flooding in the 5 Year ARI event are home unit developments in a section of McBurney Road further to the east. Modelling suggests that a total of 16 ground floor units may be at risk but flooding is so minor in this area that the difference between the modelled 5 Year ARI and the 100 Year ARI is less than 100mm which is within the order of accuracy of the floor level estimates and it may be that these units are not even flooded in the 100 Year ARI event. There are no evacuation issues in this location and even in the PMF the flooding is low hazard for adults at worst. For all of these reasons it is not worth considering purchasing these properties.

The Federal and State government make funds available to local government to establish voluntary purchase schemes to acquire houses around the country with significant risk from natural hazards. The funds are limited and are made available on a priority basis. Funding is provided on a 2:1 ratio to council's own funds but there is only about $2m available to councils each year for all hazards across the whole State and it can take many years, if ever, for funds to become available. The NSW Government Guidelines for Voluntary Purchasing indicate that the State will not provide funds to voluntarily purchase dwellings constructed after the publication of the first NSW Floodplain Development Manual in 1986, which may be the case with a dual occupancy in Freeman Ave that was constructed in 2009.

It is noted that McBurney Park has been created by the purchase and demolition of similar houses to these for about $2 million in 2011. There is currently a vacant block next to the park and three of the houses with the highest flood risk are within four doors of the park and the one adjacent to the vacant block would experience above floor flooding in a 20 Year ARI event. Two of the dwellings are a dual occupancy on the one title and are of newer construction so it might cost say $900,000 to purchase that property and the vacant lot may cost $500,000. However it may be possible to spend less than $3.5 million to almost treble the size of McBurney Park while removing four of the highest risk dwellings from the floodplain. The combined benefit of the avoided flood tangible damages would be worth more than $1.0 million.

However, as already stated, the NSW Government Guidelines for Voluntary Purchasing are likely to make the dual occupancy property ineligible because they were built about 10 years ago, the vacant block would most definitely be ineligible as would the house which does not experience above floor flooding in the 100 year ARI flood. Therefore FCC would have to fully fund purchase of at least three of the five properties.

FCC has a Section 94 Contributions Plan (FCC, 2013) which identifies that nearly 15,000m^2 of new open space will be required in the Canley Heights, Canley Vale and Cabramatta areas to cater for the population growth from both the small scale intensification which is occurring in the low density residential zones and the medium and high density development which is proposed for Canley Heights. Developers will pay contributions for the purchase of land for this additional open space. The five properties identified above would amount to about 8,000m^2 of open space. It therefore may be possible to partly or fully fund voluntary purchase of four high risk dwellings through open space developer contributions which would be more expedient than seeking State and Federal Government funding and would cost FCC less. There are other town planning considerations which would need to be addressed in assessing the suitability of the land for additional open space but the option merits further consideration.

ii) Freeman Avenue

The Freeman Avenue issues are slightly more complex, especially as the area is also exposed to flooding from Orphan School Creek (considered in the Three Tributaries Floodplain Risk Management Study & Plan) and that there has been considerable redevelopment of older housing stock to modern townhouse/duplex development.

Most parts of Freeman Avenue have a low flood hazard based on hydraulic categorisation alone in both overland floods and main stream flooding. However, a 5 Year ARI flood would be sufficient to make the road impassable to vehicles and in a 100 Year ARI event it would be unsafe for adults to leave the area by foot towards Sackville Street. The three dwellings adjacent to the road low point would have above floor flooding in the 100 Year ARI flood which alone would not be sufficient for them to be considered for voluntary purchase. However, it will not be possible to evacuate by vehicle from these dwellings in a 5 Year ARI event, it may be unsafe to evacuate on foot in an event not much larger than a 20 year ARI event and two of these properties would be exposed to extreme hazard floodwater in a PMF. For these reasons two or three of these properties may be eligible for Voluntary Purchase. It is noted that these are all adjacent to Adam's Park.

While it would not be inequitable to purchase and demolish some remaining residences in Freeman Avenue, there are other social and environmental issues that need to be fully assessed before a comprehensive VP scheme is undertaken for the area. It is also noted that their current zoning and their size means that they are likely to eventually attract redevelopment.

iii) Other Areas

There are some additional properties which are in an area of high hazard, have evacuation difficulties or have a high probability of above floor flooding. However, FCC's VP Guideline requires a combination of these risks for a property to be eligible for Voluntary Purchase and none of these properties would meet the overall eligibility criteria.

b) Voluntary House Raising

Voluntary House Raising (VHR) is as an effective floodplain risk management measure for both riverine and overland flood conditions. It is generally undertaken to:

- Reduce the frequency of exposure to flood damage of the house and its contents by reducing the frequency of household disruption, associated trauma and anxiety, and clean up after floods;
- As a compensatory measure where flood mitigation works adversely affect a house which is generally considered part of the mitigation work rather than a separate VHR scheme.

VHR can be an effective strategy for existing properties in low flood hazard areas where mitigation works to reduce flood risk to properties are impractical or uneconomic. It should be part of an overall floodplain risk management strategy for an area rather than a stand-alone option as it does not deal with issues such as risk to life.

Not all houses are suitable for raising. Brick or brick veneer houses and houses built on concrete slabs are very difficult and costly to raise. Clad, timber-framed houses built on piers are most suitable for house raising which involves lifting the entire house up to a higher level at its current location. This gets the floor level above 1 in 100 year ARI event but does not stop property flooding. FCC already has a VHR scheme which has been operating for about 20 years and was established for houses affected by flooding from the Georges River.

In the FCC VHR Scheme there are three ways that a property may be raised:

- Owner raises existing house;
- Owner demolishes existing house and builds a new house to a higher floor level, as well as comply with other controls (floor level, habitable rooms, structural soundness, flood effects, etc.); or
- Council purchases and demolishes 'a difficult to raise' house and sells it on the market with conditions e.g. DA conditions (floor level, habitable rooms, structural soundness, flood effects, etc.) or positive covenants under Section 88B of the Conveyancing Act 1919.

As with voluntary purchase, the greatest flood mitigation benefits generally accrue to houses with the highest probability of above floor flooding although it is also sensitive to size of the house.

Two of the houses most eligible for voluntary purchase are also the ones most eligible for house raising. If each of these were lifted to above the 100 Year ARI flood level then each would have its total AAD would reduce from $31,000 to $18,000 a reduction of $13,000 which equates to a present benefit of $179,000 (over 50 years at a 7% discount rate). Currently FCC provides a full subsidy of $81,000 per house which is based on the estimated cost for raising small timber framed cottages such as these. At this cost raising these houses would be economically worthwhile. Both buildings appear to be reasonably well maintained but detailed inspections would be necessary to determine whether the buildings have sufficient future life in them and that there are no complications that would prevent it being a worthwhile undertaking

The remaining houses with the highest damages are brick homes in McBurney Road which would be prohibitively expensive to raise.

Of the additional 19 buildings which could experience above floor flooding in a 20 Year ARI event, four are units, six are two storey brick homes and two are single storey brick homes. The remaining seven are weatherboard or fibro cottages which may be suitable for raising. The one with the least annual average damages is near the park in McBurney Road and raising its floor level would only have a present benefit of $30,000 which would not make it economically worthwhile. At the other end of the scale there is a house in St Johns Road which may have a present benefit of $160,000. Raising the most at risk houses in Freeman Avenue may have a present benefit in the order of $30,000 each.

What must be taken into consideration, however, is that raising houses in the high hazard areas will simply reduce the probability of damage to property but only partly addresses risk to life because it still has people residing in areas where the flood depths and velocities can become hazardous. The PMF, however, is generally not more than 500mm higher than the 100 Year ARI flood level in these areas. Consequently there would be benefit in reducing risk to life point by raising eligible houses above the PMF rather than above the 100 Year ARI level plus freeboard if the former is higher. This is likely to only be marginally more expensive than raising these dwellings to above the current planning level.

Although it has been noted that some of the clad cottages which would benefit most from house raising appear to be well maintained, that is not the case with all of them and they are all more than 50 years old. This, and the large blocks on which they sit, makes them attractive for redevelopment and current planning controls would require new dwellings to have floor levels above the 100 Year ARI flood level. House raising now would be superfluous if it is intended to rebuild on these blocks in any case. Countering this is the consideration that in areas where flows are considerable it is difficult to increase the building footprints because it may push floodwaters onto neighbouring properties and so if small cottages can only be replaced with buildings with similar sized footprints or with costly underflow provisions the incentive for redevelopment may not be there.

The community survey suggested that close to 90% of dwellings are owner occupied. However, this is an average across the whole catchment and it is possible that a higher proportion of the older, small, clad cottages are rental properties. The owners may therefore be less interested in voluntary house raising if most of the contents at risk are not theirs.

c) Flood Compatible Buildings

This option refers to the design and construction of new buildings with appropriate flood compatible materials and re-configuration of existing buildings so that flood damage to the building itself (structural damage), and possibly its contents, is minimised should the building be inundated. A detailed discussion on these issues and methods to address potential flood damages can be found in *Reducing Vulnerability of Buildings to Flood Damages* (HNFMSC, 2006). It is not proposed to summarise this document in detail, other than to indicate that it provides specific and detailed information on house construction methods, materials, building style and design. The use of these guidelines can reduce structural damage due to inundation or higher velocities and facilitate the clean up after a flood, thus reducing the costs and shortening the recovery period.

The option to introduce flood compatible material to affected properties is most readily applied to new buildings where the type of materials used can be selectively chosen or specified in the Building Approval. The inclusion of such controls is addressed in Section 8.4.2.

The application of this option to existing dwellings is more problematic and may require some significant structural changes within a building, particularly with older housing stock that utilises plaster or wall-linings that is not as readily adapted to change as newer walls.

The existing scheme being implemented by Council to subsidise the incorporation of flood compatible material into affected residences, particularly those units or houses that cannot be raised, should continue. This would be on a voluntary basis and is a reflection of the indicated desire of the community, as determined through the community consultation, to stay in their homes under most flooding conditions and to only leave should flooding begin to reach 1.0m or more in depth. However, it must also be noted that there has not been significant uptake under the existing scheme but it is not known whether this is because it has not been well promoted.

d) Flood Access

Flood access relates to providing reliable vehicular and pedestrian access from flood affected areas to flood free areas. Flood access can be considered for both existing development and future development.

i) Existing Development

The majority of the Canley Corridor catchment has a rectangular gridded street pattern running roughly both north-south and east-west and the overland flows are moving diagonally through it. The exceptions are the crescents and cul-de-sacs in the upper catchment west of the Cumberland Highway, Equity Place near the Ex-Servicemen's Club and Freeman Avenue at the bottom of the catchment.

West of the Cumberland Highway and north of St Johns Road the deepest and fastest overland flow paths are along the roads. Between these areas the flows cross Hughes St and McBurney Road and make them hazardous for vehicular traffic in relatively common events.

This pattern of overland flows means that safe access between dwelling or businesses and flood free locations can be problematic. Furthermore, it has already been explained that there are no viable options for reducing the flows along these paths.

However, in the Canley Corridor catchment, where floods rise and fall in hours, isolation during a flood may be tolerable, particularly in the majority of areas where even in a PMF hazards are low outside of buildings and even lower inside of buildings.

The two areas where flood access is more of a concern are Freeman Avenue and the high hazard areas between Hughes St and St Johns Road.

The Freeman Avenue roadway gets inundated early in a flood and people will be trapped in the cul-de-sac, if not in their homes, by floodwaters. Most homes will experience low hazard flooding in a PMF from overland flows but the whole area is subject to extreme flood hazard from creek flooding. Furthermore, there is a nursing home in Freeman Avenue which means emergency access is even more important. There is a pathway from the high end of Freeman Avenue adjacent to the nursing home to Canley Vale Road. Options for improving this as a flood access and/or raising the lowest point in Freeman Avenue are being investigated as part of the Three Tributaries Floodplain Risk Management Study and are not discussed further here.

In the high hazard areas between Hughes Street and St Johns Road it is not safe to stay within buildings which experience above floor flooding at low levels but at the same time there will be limited opportunity to evacuate before the streets and even the yards of these properties become hazardous. Nothing can really be done to improve access in these areas because raising the roads would simply increase flood levels upstream.

ii) Future Development

Any future development in the Canley Corridor will be infill development. This could either take the form of replacement homes, duplexes or dual occupancies being constructed in the low density residential zone, townhouses being built in the medium density zone and apartments in the high density zone. Again the flows through the streets are the main constraint to access in these areas and there is little that can be done to improve it. In areas where the flood hazards are low, providing there is refuge within the new buildings above the PMF level, the need for flood free access outside the buildings is not essential.

Freeman Avenue and the area between Hughes Street and St Johns Road are the problematic areas and it would be prudent not to permit any intensified development in these areas unless the existing access problems can be addressed.

Should any areas be rezoned in the future for more intense development than currently permitted, this may provide an opportunity for streets to be modified or other access arrangements to be made which cross current cadastral boundaries. In this case access should be designed with reference to Designing Safer Subdivisions – Guidance on Subdivision Design in Flood Prone Areas written for the Hawkesbury-Nepean Floodplain Management Steering Committee (2006).

e) Summary of Property Modification - Works

Council has a number of programs in operation that fall within the Property Modification – Works category, particularly VP and VHR, as well as the associated flood compatible material installation program.

These programs were initially developed to address the mainstream flooding from Prospect Creek that affects existing development. The study has identified that there are properties in the Canley Corridor where it could be justified to include them in either the VP, VHR or flood compatible material installation programs. This may also be the case for properties in other overland flow catchments and those affected by local creek flooding, floodplain risk management studies for which are currently being undertaken or are to soon commence.

Therefore, it may be beneficial for Council to re-consider all of its property modification programs once all of the relevant mainstream and overland flooding studies and plans have been completed and a Council-wide plan can be developed which takes into account the relative merits of individual properties and the affordability of the programs to Council and the community. The use of S94 open space contributions for purchasing the vulnerable flood affected properties should be explored, particularly if they may not be eligible for financial assistance from the State and Federal governments.

There are limited opportunities to improve access during floods although road raising and/or the upgrading of the pedestrian path at Freeman Avenue should be investigated further. Unless the access situation at Freeman Avenue can be improved, no further infill development should be permitted there. No infill development should be permitted in the area between Hughes Street and St Johns Road due to increase of flood effects upstream, increasing the population at risk, increasing the value of property at risk and flood access constraints.

8.4.2 Property Modification - Planning

Planning measures govern what can be built on the floodplain and can impose controls on the design, construction and operation of new developments to minimise or negate the impacts of flooding. These measures are usually regulated through planning instruments such as state environmental planning policies (SEPPs), local environment plans (LEPs) and development control plans (DCPs) but may be articulated in principle in a higher order document such as a policy or strategy.

Planning measures can be used to ensure that future development does not detrimentally impact on flood behaviour but are also commonly used to ensure that the impacts of flooding on development are acceptable or at least tolerable.

a) State Environmental Planning Policy Exempt and Complying Development Codes

SEPPs are the highest level of planning instrument and generally will prevail over LEPs. *State Environmental Planning Policy Exempt and Complying Development Codes 2008* defines development which is exempt from obtaining development consent and other development which does not need development consent if it complies with certain criteria.

The SEPP defines ‘Flood Control Lots’ as property where ‘flood-related development controls apply’ i.e. this would have a notation on its Section 149 Certificate. These development controls may apply through an LEP or DCP. Exempt development is not permitted on Flood Control Lots but some complying development is allowed on Flood Control Lots.

Complying development is permitted on Flood Control Lots where a Council or professional engineer can certify that development is not a:

- flood storage area;
- floodway area;
- flow path;

- high hazard area; or
- high risk area

Currently Fairfield City Council does not explicitly map Flood Control Lots. Rather Flood Control Lots are defined by the application of Clauses 6.3 and 6.4 of the Fairfield LEP and the flood risk precincts defined by the Fairfield DCP. Similarly, not all of the flood constraints on complying development are mapped. In Canley Corridor high risk areas are mapped but none of the others are.

There would be benefit in publishing maps showing flood control lots as well as the constrained areas to assist both development proponents and council compliance officers. This would need to be done in a consistent way across the whole LGA and therefore should be done for all areas which have had Floodplain Risk Management Studies completed.

b) Local Environmental Plan and Flood Planning Level

The Fairfield Local Environmental Plan 2013 conforms to the NSW Standard LEP in most respects including Clause 6.3 which relates to flood planning. This clause applies to land at or below the flood planning level which it defines as “the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.” The clause prohibits development below the flood planning level unless the consent authority is satisfied that the impacts of the development on flooding and the impacts of flooding on the development and its occupants are addressed.

FCC successfully applied to have “exceptional circumstances” recognised in the LGA. This has allowed Fairfield City Council to continue to impose development controls on residential development which is between the flood planning level and the PMF. To this end Clause 6.4 was inserted in the LEP which states:

(1) The objectives of this clause are as follows:

(a) in relation to development with particular evacuation or emergency response issues, to enable evacuation of land subject to flooding in events exceeding the flood planning level,

(b) to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

(2) This clause applies to land between the flood planning level and the level of a probable maximum flood, but does not apply to land subject to the discharge of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

(3) Development consent must not be granted to development for the following purposes on land to which this clause applies unless the consent authority is satisfied that the development will not, in flood events exceeding the flood planning level, affect the safe occupation of, and evacuation from, the land:

(a) caravan parks,

(b) commercial premises,

(c) correctional centres,

(d) emergency services facilities,

(e) group homes,

(f) hospitals,

(g) industries,

(h) residential accommodation,

(i) residential care facilities,

(j) tourist and visitor accommodation.

In this clause:

***flood planning level** means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.*

***probable maximum flood** has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0), published in 2005 by the NSW Government.*

The intent of item (2) in the clause was to allow controls to be applied to certain developments on land above the flood planning level and below the PMF level quite separately to Clause 6.3 which applies to land below the flood planning level.

A key decision in a Floodplain Risk Management Study is the determination of the Flood Planning Level (FPL). The NSW Floodplain Development Manual states that "FPLs are the combinations of flood levels (derived from significant historical flood events or floods of specific ARIs) and freeboards selected for floodplain risk management purposes, as determined in risk management studies and incorporated in risk management plans."

The decision on the adopted FPL should be a merit based decision, taking into account the full range of flood sizes, up to and including the probable maximum flood (PMF) and the corresponding risks associated with each flood. However, the Manual notes that while there may be a few exceptions, it is neither feasible nor socially or economically justifiable to adopt the PMF as the basis for FPLs.

The standard LEP 2013 wording effectively bypasses the risk assessment process set out in the Floodplain Development Manual and sets a single FPL for residential development in all floodplains within an LGA and, as it is a standard clause, sets the same standard across every LGA in the State.

Using the 100 Year ARI flood to set the flood planning level for residential floor levels is a common practice throughout Australia and, given the relatively small increment of the PMF above the 100 Year ARI flood in the Canley Corridor, there is nothing to suggest that it should not be adopted to set the FPL for this catchment.

However, the freeboard which should be added to the 100 Year ARI level to determine the FPL could arguably be less than 0.5m in the Canley Corridor. Freeboard is an allowance that is included to allow for uncertainties and to ensure that a flood with a 100 Year ARI will not enter buildings constructed at the FPL. At the same time it must be recognised that any increment in floor height adds to the cost of a building and so such an increment is only justified if its benefits exceed its costs.

The uncertainties which can be accounted for in a freeboard include:

- Confidence limits in the flood modelling – the models are representations of reality and cannot account for all physical processes that occur during a flood.
- The models assume a smooth floodwater surface – actual flood surfaces are uneven due to hydraulic features such as waves, hydraulic jumps, water piling up on the upstream side of obstructions and forming eddies on their downstream sides.
- External forces can increase water levels – for example where there are wide areas wind can create waves or vehicles or boats travelling through the floodwaters can create waves.

Where flood waters are deep, flows are significant and/or the floodplain is wide, these uncertainties can add up to a few hundred millimetres and a freeboard of 0.5m can be justified in these locations.

In Canley Corridor the flows are not particularly high, depths in the 100 year ARI event are less than 1.0m deep and over most of the floodplain less than 0.5m deep. In such circumstances it is difficult to justify having a 0.5m freeboard, particularly when that exceeds the level of the PMF in much of the floodplain.

Another consideration in setting a FPL is the potential impacts of climate change. As explained in Section 3.7, even a 30% increase in the 100 Year ARI rainfall intensity is unlikely to result in more than a 0.15m increase in the flood level.

It should be noted, however, that the modelling does not make allowance for the impacts of fencing on upstream or downstream flood heights. Sensitivity testing in the upper reaches of the catchment showed that flood rises of 0.5m or more could be caused by fences (See appendix D) and this has prompted the recommendation that a fence modification scheme be adopted (Section 8.3.7).

In light of the above, the adoption of the 100 Year ARI plus a 0.3m freeboard should be sufficient to account for uncertainties in the flood level and future climate change provided that fences are modified through the areas with significant flow to ensure that impermeable fences do not contribute to excessive rises in flood heights upstream if they do not fail or sudden rises in flood heights downstream if they do.

However, this can only be done if the standard clause in the LEP is changed which would require the LEP to go through public exhibition and Department of Planning and Environment approval. The alternative therefore is to leave the LEP definition as it is and simply use the DCP to determine what controls apply above and below the defined flood planning level.

The DCP can therefore adopt a minimum floor level which is 0.3m above the 100 Year ARI flood level and not require a floor level control between 0.3m and 0.5m above the 100 Year ARI flood level. The LEP provides scope for this because it simply requires that development below the FPL satisfies Council's hazard and risk requirements.

c) Development Control Plan

Specific land use planning measures in relation to flooding are controlled by Section 11 of the Fairfield City Wide Development Control Plan 2013 (DCP). The DCP's stated object is to "supplement the statutory provisions contained in Fairfield Local Environmental Plan 2013."

The FCC DCP 2013 adopts a flood planning matrix based on earlier work on other floodplains in the LGA but that matrix identifies land use categories that are not defined in the new FCC LEP 2013. As a minimum, the flood planning matrix will need to be amended to reflect current flood information, current landuse category information and best practice floodplain risk management practices.

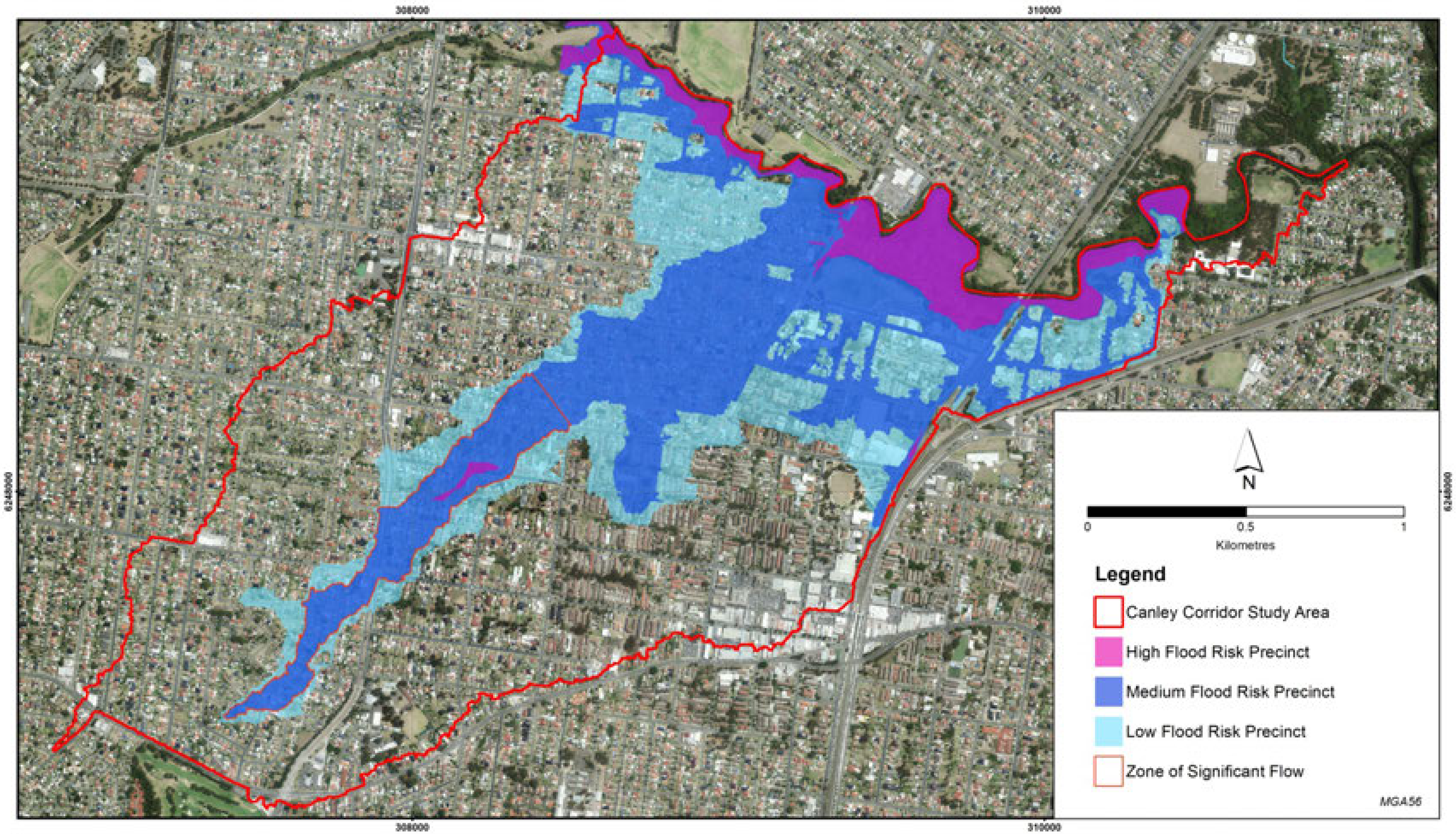
The FCC DCP 2013 adopts a flood planning matrix based on earlier work on other floodplains in the LGA. That matrix works around four sets of information:

- Flood Risk Precincts – it divides the floodplain up to the PMF into three precincts: High, Medium and Low based on the probability of flooding and the corresponding hydraulic hazard
- Landuse Categories – the matrix identifies land uses or development types which are not appropriate within particular Flood Risk Precincts and others which are appropriate subject to suitable planning controls
- Planning Considerations – the matrix lists matters which need to be managed to ensure that particular developments are designed, built and operated in a way which is appropriate to their flood risk.
- Planning Controls – these are a mix of prescriptive planning controls and objective based solutions which are to be applied to particular land uses within particular flood risk precincts to manage specific planning considerations

Consideration is given to the suitability of Chapter 11 of the Fairfield City Wide DCP to manage flood risk in the Canley Corridor floodplain.

i) Flood Risk Precinct Definition and Justification

As explained in Section 3.6, FCC has adopted three flood risk precincts and a zone of significant flow, (Figure 35) the descriptions of which are repeated in Table 16.



Canley Corridor Floodplain Risk Management Study: Flood Risk Precincts

MOLINO STEWART
ENVIRONMENT & NATURAL HAZARDS

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Figure 35: Existing Flood Risk Precincts

Table 16: Provisional Flood Risk Categorisation for Fairfield City Council

Flood Risk Category	**Description**
High Flood Risk	Land below the 100 year flood that is either subject to high hydraulic hazard or where there are significant evacuation difficulties
Medium Flood Risk	Land below the 100 year flood level that is not subject to high hydraulic hazard and where there are no significant evacuation difficulties
Low Flood Risk	All other land within the floodplain (i.e. within the PMF extent) but not identified as either in a high flood risk precinct or medium flood risk precinct
Zone of Significant Flow	The area of the floodplain where a significant discharge of water occurs during floods. Should the area within this boundary be fully or partially blocked, a significant distribution of flood flows or increase in flood levels would occur.

Council successfully petitioned the Department of Planning and Infrastructure for 'exceptional circumstances', enabling it to apply controls relating to emergency response, evacuation and structural soundness of buildings to ensure the safety of occupiers in the event of severe flooding, rarer than the 100 year ARI event. However, Council is not obliged to apply these controls everywhere in the floodplain, and recently has indicated a desire to consider whether flood risk considerations demand the application of planning and development controls to residential developments as far as the PMF extent, or whether there are some areas within the PMF extent where the flood hazard is such that controls on emergency response are not warranted.

In consultation with Council, this has resulted in the mapping of an additional flood risk precinct, the Very Low Flood Risk precinct. The intention is that planning and development controls would not need to be applied to residential developments in the Very Low Flood Risk precinct. Accordingly, Council requires confidence that residents could survive an extreme, low-probability flood by either evacuating to higher ground or by remaining in their house, even if that house – designed without necessarily meeting the planning and development controls applied to higher-level flood risk precincts – is flooded above floor.

For the purposes of mapping preliminary flood risk precincts in the Canley Corridor, the diagram in Figure 36 was used.

The preliminary High Risk Flood Risk precinct was defined as those areas which are unsafe for people (H4, H5, H6) in the modelled 100 Year ARI flood or with significant evacuation difficulties. The preliminary Very Low Flood Risk precinct was defined as the area with low hazard for children and buildings in the modelled PMF (H1, H2).

As it is proposed that no development controls will apply in the Very Low Flood Risk precinct, this precinct cannot include areas which would not satisfy the minimum floor level requirements. Accordingly, the Low Flood Risk precinct is proposed to be extended to include those areas less than 0.3m above the 100 Year ARI flood which would have otherwise be classified as Very Low Flood Risk based on hydraulic hazard alone.

The area around Freeman Avenue has been classified as a High Flood Risk precinct because it has evacuation challenges. Frequent overland flows from Canley Corridor catchment can prevent vehicular evacuation very early in a flood and although most of the area would not become highly hazardous in an extreme overland flow event, creek flooding would create significant hazards and are likely to coincide with overland flows.

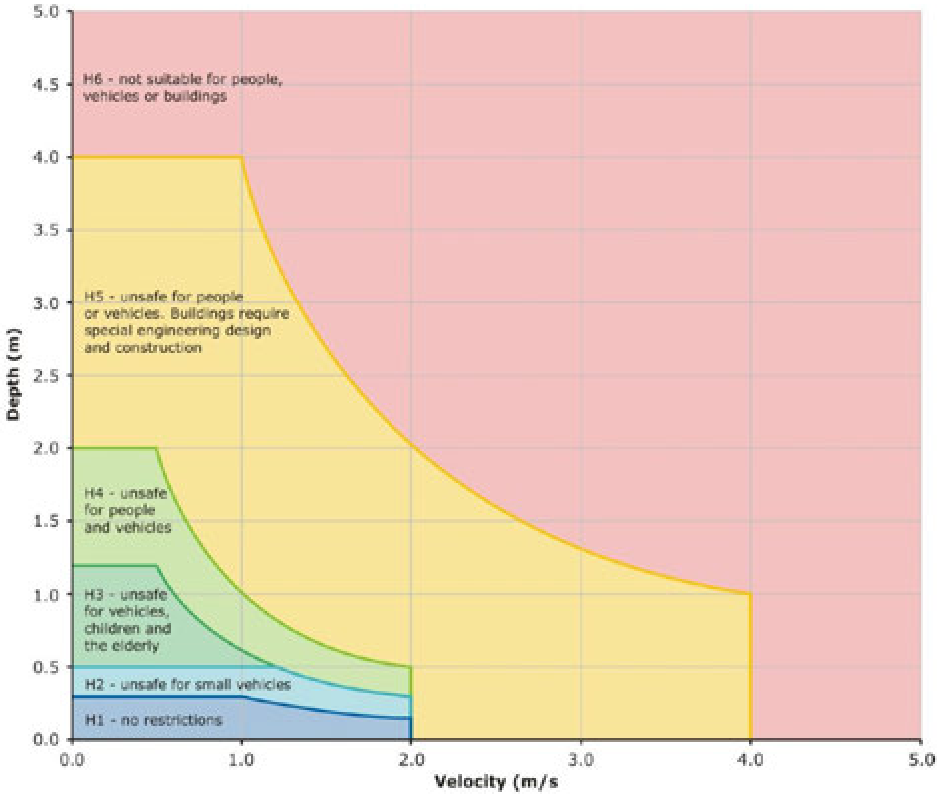


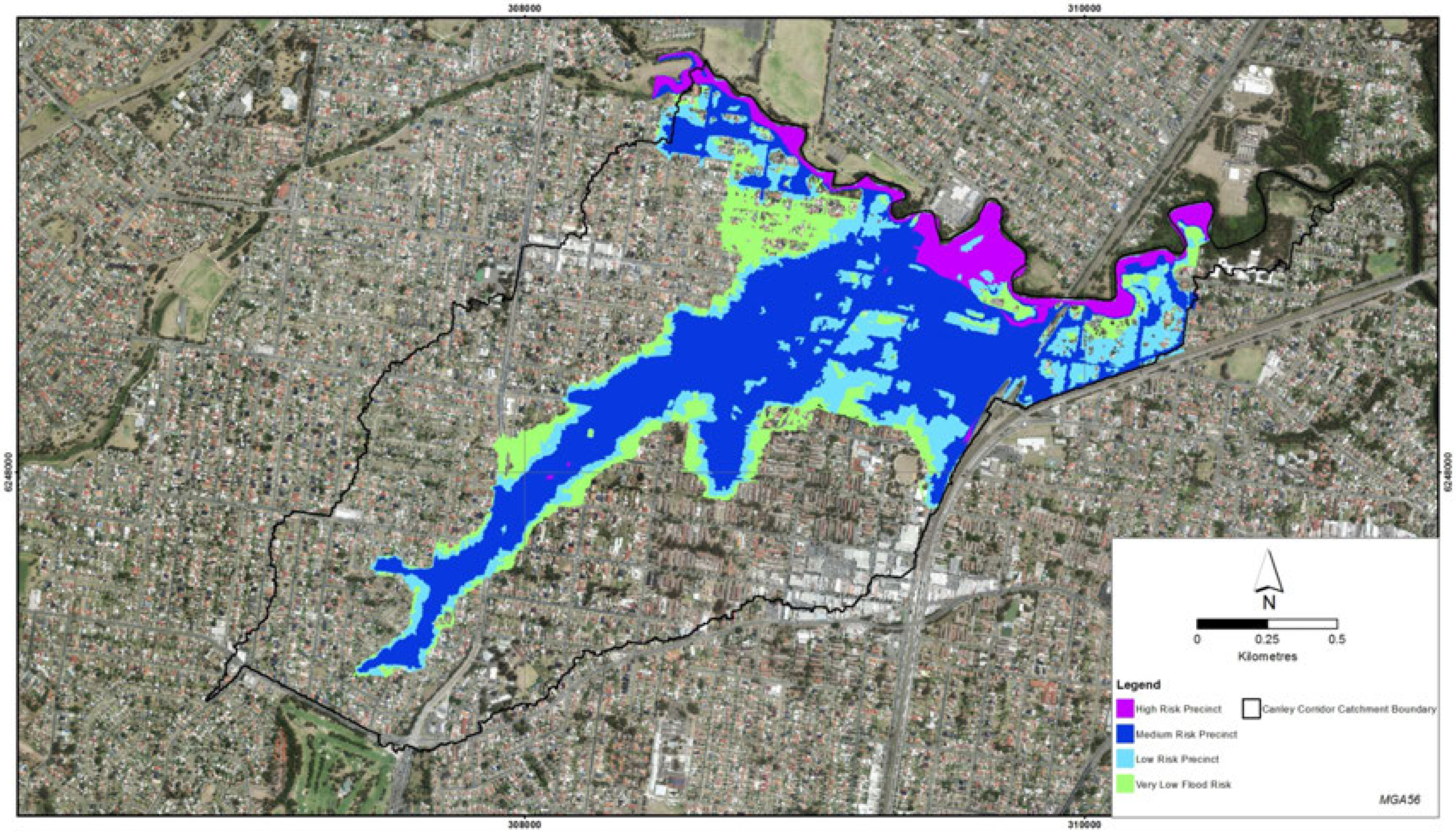
Figure 36: Hazard Criteria used for Preliminary Flood Risk Precinct Mapping

Taking all of the above into consideration the proposed map in Figure 37 has been created. The impact on the number cadastral lots affected by each risk precinct is summarise in Table 17.

Reducing the freeboard from 0.5m to 0.3m only results in a slight increase in the number of lots in the Medium Risk precinct despite the fact that the revised flood mapping shows a more extensive 100 Year ARI flood extent. Introducing the Very Low Risk precinct significantly reduces the number of lots in the

Table 17: Comparison of Lots Affected by Risk Precincts

Most Restrictive Risk Precinct Affecting a Cadastral Lot	**Number of Cadastral Lots Affected**	
	Existing Risk Precincts	**Proposed Risk Precincts**
High or Partly High	178	134
Medium or Partly or Medium	1,616	1,630
Low or Partly Low	811	422
Very Low or Partly Very Low	0	379
Total	**2,605**	**2,565**



Canley Corridor Floodplain Risk Management Study: Preliminary Risk Precinct Classification				
MOLINO STEWART ENVIRONMENT & NATURAL HAZARDS	Molino Stewart endeavours to ensure that the information provided in this map is correct at the time of publication. Molino Stewart does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.	Date: 04/02/2015	Checked By: S.M	Job No: 0517
		Filepath: Y:\Jobs\2012\0517 Canley Corridor (Fairfield) FPRMS &P\GIS\Workspace\Prelim Risk Precinct.mxd		

Figure 37: Preliminary Flood Risk Precinct Map

The existing risk precinct mapping includes a Zone of Significant Flow. This was identified on the basis that should the area within this boundary be fully or partially blocked, a significant distribution of flood flows or increase in flood levels would occur. The DCP planning matrix then stated that “any development inside this area will normally be unacceptable as it will reduce flood conveyance and increase flood effects elsewhere.”

There is merit in retaining the Zone of Significant Flow because it clearly delineates where blockage of conveyance would be a problem. However, the term and its definition is not only unique to Fairfield DCP but also only occurs in the Canley Corridor flood risk precinct maps. Furthermore, it would be possible to design and build structures in this area so that they did not block conveyance any more than existing structures and the DCP matrix provisions require that to be demonstrated in any case.

It should be noted that without the Zone of Significant Flow being mapped it may be more difficult to demonstrate that complying development in that area is not in a flood storage area, floodway area, flow path, high hazard area or high risk area

On balance it is recommended that the Zone of Significant Flow be deleted and the other DCP matrix provisions be relied upon to control development in this area.

The creation of a ‘Very Low’ flood risk precinct will require amending the DCP to include its definition and to vary the definition of the ‘Low’ flood risk precinct under clause 11.7, as follows:

Low Flood Risk Precinct

This has been defined as land within the floodplain (i.e. within the extent of the probable maximum flood - PMF), above the 100 year ARI floodplain up to the 100 year + 0.3 m or where flooding during a PMF would present a high hazard to children, whichever is the higher.

Note: The Low Flood Risk Precinct is where in the PMF, the depths and velocities are such that there is a significant hazard for children as defined in Australian Rainfall and Runoff Revision Project Book 9 Chapter 6 ‘Safety Design Criteria’ (draft) or where buildings would require special engineering design and construction as defined in ‘Updating National Guidance on Best Practice Flood Risk Management’ prepared by McLuckie et al. (2014). The Low Flood Risk Precinct is that area above the 100 year flood with a significant hazard to children or buildings in the PMF. Most land uses would be permitted within this precinct, subject to planning and development controls.

Very Low Flood Risk Precinct

This has been defined as land within the floodplain (i.e. within the extent of the probable maximum flood - PMF) but not identified within either the High Flood Risk, the Medium Flood Risk or the Low Flood Risk Precincts.

Note: The Very Low Flood Risk Precinct is where even in the PMF, the depths and velocities are such that there is a low hazard for children as defined in Australian Rainfall and Runoff Revision Project Book 9 Chapter 6 ‘Safety Design Criteria’ (draft) prepared by Grantley Smith and Ron Cox and a low hazard to buildings as defined in ‘Updating National Guidance on Best Practice Flood Risk Management’ prepared by McLuckie et al. (2014). The Very Low Flood Risk Precinct is that area above the 100 year flood with a low hazard to children and buildings in the PMF. Most land uses would be permitted within this precinct, without planning and development controls.

Changes would also have to be made to the wording of flood notations in S149 certificates to reflect the changes in the flood risk precinct definitions.

ii) Schedule 2 Land Use Categories

The Planning Matrix uses eight landuse categories

- Critical Uses and Facilities
- Sensitive Uses and Facilities
- Subdivision

- Residential
- Commercial and Industrial
- Tourist Related Development
- Recreation and Non-urban
- Concessional Development

Chapter 11 includes Schedule 2 which lists all of the land uses which fall within each of these categories.

The matrix lists critical uses and facilities as being unsuitable anywhere in the floodplain, sensitive uses and facilities being unsuitable in the medium flood risk precinct and all but recreation and non-urban, and concessional development being unsuitable in the low risk flood precinct.

Critical uses and facilities include emergency service facilities, hospitals and residential care facilities. Sensitive uses and facilities include seniors housing, child care centres, correctional facilities, education establishments, respite day care centres, liquid fuel depots, electricity generating works and public utility undertakings which are essential during or after a flood.

Concessional development is development which creates a subdivision, modifies a building or changes an existing use without significantly increasing flood risks.

In general the landuse categories and prohibitions are considered to be appropriate but consideration should be given to adding the following to the list of sensitive uses and facilities:

- Group homes – these often accommodate several people with physical, mental or behavioural disabilities which may create significant challenges in the occupants being able to respond safely and in a timely manner to a flood
- Hazardous and offensive industries and storage establishments – these store significant quantities of hazardous substances or pollutants which can be at risk of being released to the environment in the event of a flood.

iii) Planning Controls

A draft matrix including the new Very Low Flood Risk Precinct and removing the Zone of Significant Flow is presented in Table 18. This is amended from the existing Schedule 6 in Chapter 11 of the DCP.

Within the Very Low FRP:

- No controls are applied to Residential uses. As Residential uses are generally considered more sensitive than Commercial and Industrial, Tourist-Related and Recreation and Non-Urban uses, the latter uses are also exempt from any planning and development controls in this area of very low risk.
- For ‘Sensitive Uses & Facilities’ – including seniors housing and childcare centres – it is considered appropriate to condition development in a manner consistent with the Low FRP.
- ‘Critical Uses & Facilities’ – including emergency evacuation centres, emergency services facilities, hospitals and residential care facilities – remain marked as unsuitable land uses. Potentially these uses could be permitted with controls similar to those for Sensitive Uses & Facilities. However, in our opinion it remains appropriate to send a signal that best practice teaches that such critical uses are fundamentally incompatible uses for a floodplain, no matter how rare a flood’s occurrence.
- Concessional Development might be relevant for the Very Low FRP if there is an existing Sensitive Use, though perhaps not all the controls would be relevant.

Table 18: Draft Planning Matrix

*Schedule **

Canley Corridor Catchment

Planning & Development Controls

FIGURE*

Matrix of Prescriptive Controls for Canley Corridor

Template V4.0

Flood Risk Precincts (FRPs)

Very Low Flood Risk

Planning Consideration	Critical Uses & Facilities	Sensitive Uses & Facilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development
Floor Level		3						4,7
Building Components		2						1
Structural Soundness		3						2
Flood Effects		2	2					2
Car Parking & Driveway Access		1,3,5,6,7						6,7,8
Evacuation		2,3,4	5					2,3
Management & Design		4,5	1					2,3,5
Fencing								

Low Flood Risk

Planning Consideration	Critical Uses & Facilities	Sensitive Uses & Facilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development
Floor Level		3		2,6,7	5,6,7	2,6,7	1,6	4,7
Building Components		2		1	1	1	1	1
Structural Soundness		3		2	2	2	2	2
Flood Effects		2	2	2	2	2	2	2
Car Parking & Driveway Access		1,3,5,6,7		1,3,5,6,7	1,3,5,6,7	1,3,5,6,7	2,3,4,6,7	6,7,8
Evacuation		2,3,4	5	2,3	1 or 2, 3	2,3	4,3	2,3
Management & Design		4,5	1		2,3,5	2,3,5	2,3,5	2,3,5
Fencing								

Medium Flood Risk

Planning Consideration	Critical Uses & Facilities	Sensitive Uses & Facilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development
Floor Level				2,6,7	5,6,7	2,6,7	1,6	4,7
Building Components				1	1	1	1	1
Structural Soundness				2	2	2	2	2
Flood Effects			1	2	2	2	2	2
Car Parking & Driveway Access				1,3,5,6,7	1,3,5,6,7	1,3,5,6,7	2,3,4,6,7	6,7,8
Evacuation			5	2,3	1,3	2,3	4,3	2,3
Management & Design					2,3,5	2,3,5	2,3,5	2,3,5
Fencing			1	1	1	1	1	1

High Flood Risk

Planning Consideration	Critical Uses & Facilities	Sensitive Uses & Facilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development
Floor Level							1,6	4,7
Building Components							1	1
Structural Soundness							1	1
Flood Effects							1	1
Car Parking & Driveway Access							2,3,4,6,7	6,7,8
Evacuation							4,3	2,3
Management & Design							2,3,5	2,3,5
Fencing							2	2

COLOUR LEGEND: Not Relevant; Unsuitable Land Use

General Notes

1	*Freeboard* equals an additional height of 300mm.
2	The relevant environmental planning instruments (generally the Local Environmental Plan) identify development permissible with consent in various zones in the LGA. Notwithstanding, constraints specific to individual sites may preclude Council granting consent for certain forms of development on all or part of a site. This matrix identifies where flood risks are likely to determine where certain development types will be considered "unsuitable" due to flood related risks.
3	Filling of the site, where acceptable to Council, may change the FRP considered to determine the controls applied in the circumstances of individual applications.
4	Refer to Section 11.9 of the DCP for planning considerations for proposals involving only the erection of a fence. Any fencing that forms part of a proposed development is subject to the relevant flood effects and Structural Soundness planning considerations of the applicable landuse category.
5	Refer to Section 11.10 of the DCP for special considerations such as for house raising proposals and development of properties identified for voluntary acquisition.
6	Terms in italics are defined in the glossary of this plan and Schedule 2 specifies development types included in each land use category. These development types are generally as defined within Environmental Planning Instruments applying to the LGA.
7	From time to time, Council may adopt mapping showing the *Boundary of Significant Flow* and/or *Flood Storage Areas* for this floodplain. Refer to Council to find out if these areas have been defined and mapped for this floodplain.

Floor Level

1	All floor levels to be no lower than the 20 year flood level unless justified by site specific assessment.
2	*Habitable floor* levels to be no lower than the 100 year flood level plus *freeboard*.
3	*Habitable floor* levels to be no lower than the *PMF* level. Non-*habitable floor* levels to be no lower than the *PMF* level unless justified by a site specific assessment.
4	Floor levels to be no lower than the *design floor level*. Where this is not practical due to compatibility with the height of adjacent buildings, or compatibility with the floor level of existing buildings, or the need for access for persons with disabilities, a lower floor level may be considered. In these circumstances, the floor level is to be as high as practical, and, when undertaking alterations or additions, no lower than the existing floor level.
5	The level of *habitable floor areas* to be equal to or greater than the 100 year *flood* level plus *freeboard*. If this level is impractical for a development in a Business zone, the floor level should be as high as possible.
6	Non-habitable floor levels to be equal to or greater than the 100 year flood level plus freeboard where possible, or otherwise no lower than the 20 year flood level unless justified by site specific assessment.
7	A restriction is to be placed on the title of the land, pursuant to S.88B of the Conveyancing Act, where the lowest *habitable floor area* is elevated more than 1.5m above finished ground level, confirming that the undercroft area is not to be enclosed.

Building Components & Method

1	All structures to have *flood compatible building components* below the 100 year flood level plus *freeboard*.
2	All structures to have *flood compatible building components* below the *PMF* level.

Structural Soundness

1	Engineer's report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus *freeboard*, or a *PMF* if required to satisfy evacuation criteria (see below).
2	Applicant to demonstrate that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus *freeboard*, or a *PMF* if required to satisfy evacuation criteria (see below). An engineer's report may be required.
3	Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a *PMF* An engineers report may be required.

Flood Effects

1	Engineer's report required to certify that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood *conveyance*; and (iii) the cumulative impact of multiple potential developments in the floodplain.
2	The flood impact of the development to be considered to ensure that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood *conveyance*; and (iii) the cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required.
	Note: (1) If a *Flood Storage Area* has been defined for this floodplain, any filling of the floodplain inside this area (except where this occurs by compensatory excavation), will normally be unacceptable as it will reduce the volume of flood storage available on the floodplain and increase flood effects elsewhere. (3) Even where a *Flood Storage Area* has been defined, development outside this areas may still increase flood effects elsewhere and therefore be unacceptable.

Car Parking and Driveway Access

1	The minimum surface level of open car parking spaces or carports shall be as high as practical, and not below: (i) the 20 year flood level; or (ii) the level of the crest of the road at the location where the site has access; (which ever is the lower). In the case of garages, the minimum surface level shall be as high as practical, but no lower than the 20 year flood level.
2	The minimum surface level of open car parking spaces, carports or garages, shall be as high as practical.
3	Garages capable of accommodating more than 3 motor vehicles on land zoned for urban purposes, or *enclosed car parking*, must be protected from inundation by floods equal to or greater than the 100 year flood.
4	The driveway providing access between the road and parking space shall be as high as practical and generally rising in the egress direction.
5	Where the level of the driveway providing access between the road and parking space is lower than 0.3m below the 100 year flood, the following condition must be satisfied. The depth of inundation on the driveway during a 100 year flood shall not be greater than the larger of: (i) the depth at the road; and (ii) the depth at the car parking space. A lesser standard may be accepted for single detached dwelling houses where it can be demonstrated that risk to human life would not be compromised.
6	*Enclosed car parking* and car parking areas accommodating more than 3 vehicles (other than on Rural zoned land), with a floor level below the 20 year flood level or more than 0.8m below the 100 year flood level, shall have *adequate warning systems, signage and exits*.
7	Restraints or vehicle barriers to be provided to prevent floating vehicles leaving a site during a 100 year flood
8	Driveway and parking space levels to be no lower than the *design ground/floor levels*. Where this is not practical, a lower level may be considered. In these circumstances, the level is to be as high as practical, and, when undertaking alterations or additions, no lower than the existing level.
	Note: (1) A still water flood depth of 0.3m is sufficient to cause a small vehicle to float. (2) *Enclosed car parking* is defined in the glossary and typically refers to carparks in basements.

Evacuation

1	Reliable access for pedestrians or vehicles required during a 100 year flood.
2	Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest *habitable floor* level to an area of refuge above the *PMF level*, or a minimum of 20% of the gross floor area of the building to be above the *PMF level*.
3	The development is to be consistent with any relevant *flood evacuation strategy* or similar plan.
4	The evacuation requirements of the development are to be considered. An engineers report will be required if circumstances are possible where the evacuation of persons might not be achieved within the *effective warning time*.
5	Applicant to demonstrate that evacuation in accordance with the requirements of this DCP is available for the potential development flowing from the subdivision proposal.

Management and Design

1	Applicant to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken in accordance with this DCP.
2	*Site Emergency Response Flood Plan* required where floor levels are below the *design floor level*, (except for single dwelling-houses).
3	Applicant to demonstrate that area is available to store goods above the 100 year flood level plus *freeboard*.
4	Applicant to demonstrate that area is available to store goods above the *PMF* level.
5	No storage of materials below the *design floor level* which may cause pollution or be potentially hazardous during any flood.

A few minor amendments have been made to other text within the schedule:

- Under 'General Notes' the freeboard has been changed from 500mm to 300mm
- Under 'Car Parking and Driveway Access', best practice now indicates that when the water is not still, vehicles can float at depths as shallow as 0.1m (Figure 8). Nevertheless, it may be an unacceptable impost to make control no. 5 more conservative, so the note has been amended to indicate that the depth of 0.3m relates to a *still* water depth.
- Under 'Evacuation', because control no. 2 (which allows shelter-in-place) is currently permitted not only for 'dwellings', it seems appropriate to adopt the term 'buildings' in the text.

Whilst no change has been made, we note that Evacuation Control no. 1 (requiring reliable access in a 100 year event) is required for Commercial and Industrial uses in a Medium FRP, whereas a PMF refuge is an available alternative for Residential uses in a Medium FRP. This control can result in a significant impost on commercial and industrial developments including changes of use in existing buildings to only slightly more intense uses (hence, not qualifying for Concessional Development). The reason for this more conservative requirement for Commercial and Industrial uses (relative to Residential uses) is not obvious, and we suggest that consideration be given to applying the same Evacuation requirements required for Commercial and Industrial uses in the Low FRP, namely that *either* reliable access *or* shelter-in-place be provided for.

iv) Other Considerations

There are other matters which Council needs to consider before adopting a final matrix for Canley Corridor.

- While this draft matrix has been developed specifically for Canley Corridor, there must also be a consideration of how many separate matrices there should be for the LGA. There would be significant benefits in having a single matrix which applies to all overland flow areas and it would be even better if this could apply to creek flooding too.
- There is also consideration of what controls should apply where the overland flow areas overlap with mainstream flooding and how different freeboards in different catchments should be managed within the matrix approach. It is recommended a condition is added to all matrices stating that both mainstream and overland flooding must be addressed, but that the highest FPL is overriding.
- It is also noted that SEPP Exempt and Complying Development Codes 2008 prevails over the FC DCP and development which is defined as complying cannot be controlled by the DCP if it is in an area which is not in a flow path, a high hazard or high risk area. That means that complying development will be permissible in many flood affected areas within Canley Corridor which would otherwise be controlled by the controls in the matrix. Having said that, the SEPP specifies various controls in relation to floor levels, materials, flood affectation, reliable access, car parking and driveways. In this regard the SEPP can be regarded as a method of controlling concessional development. There may be benefit in making further amendments to the matrix to ensure that the definitions of complying development in the SEPP and concessional development in the DCP fully align and that the planning controls for concessional development and complying development are identical.
- There may be benefit in providing more guidance and references to assist developers in preparing appropriate documentation showing how they meet the flood-related development controls
- There is an argument for codifying what constitutes a significant adverse flood impact e.g. 10 mm rise if flood level outside a site boundary.

As such, the matrix remains a draft document and the recommendation in the Floodplain Risk Management Plan is that all Land-use considerations arising from flooding be considered on a city wide basis and floodplain type (mainstream or overland) rather than having different conditions and different applications for each catchment or study area.

8.4.3 Major Redevelopment

The flooding situation in the Canley Corridor catchment, when taken with the age and type of development, offers an opportunity for a major redevelopment of an area within the catchment. This option would see one or more town blocks between Hughes St and St Johns Road subject to rezoning to an R3 medium density residential zoning with a strip of public open space zoning in the area with the highest flood hazards.

This would create market conditions where:

- redevelopment would be accelerated
- new buildings would have their floors above the FPL and could be confined to areas with little or no flood risk
- private open space within the development could be conditioned to be in the areas of moderate flood risk
- an area of public open space could be created in the areas of highest flood risk
- there may be potential for creating some flood detention in the area of public open space which would mitigate flooding downstream
- developer open space contributions would pay for the purchase of the open space.

This option was explored and, while such development would be consistent with other urban consolidation which has taken place nearby, the following challenges were identified:

- the investigations for the Fairfield Residential Development Strategy identified the roads in this area as having capacity issues which would not support addition medium density development
- areas which have already been zoned for medium density or high density residential development have not been redeveloped at the rate forecast so there is not the market demand in the foreseeable future to drive the desired redevelopment.

For these reasons this option was not investigated further.

8.4.4 Summary of Property Modification Measures

Council should consider extending its existing voluntary purchase, voluntary house raising and flood compatible material installation programs to a selection of properties in Canley Corridor. This should be done in light of the results of mainstream and overland flooding studies and plans which are being undertaken elsewhere in the LGA. The use of S94 open space contributions for purchasing some vulnerable flood affected properties should be explored.

The upgrading of the pedestrian path at Freeman Avenue to improve flood evacuation should be investigated further.

No infill development should be permitted between Hughes Street and St Johns Road because of flood access constraints.

The current form of Section 11 of the FCC DCP should be maintained including the planning matrix but several amendments need to be made. This includes adopting a minimum floor level in Canley Corridor of the 100 Year ARI flood plus 300mm, introducing a Very Low Flood Risk Zone in which there are no planning controls on most development and aligning the DCP with the provision of the SEPP Exempt and Complying Development Codes 2008. Reference to the Zone of Significant Flow can be removed.

8.5 RESPONSE MODIFICATION MEASURES

8.5.1 Overview

Flood response measures encompass various means of modifying the response of the population to the flood threat. Planning for these measures should be incorporated in a local flood plan for the area, which is prepared by the NSW SES, with significant input from the Council. The local flood plan is complementary to the floodplain management plan and should incorporate information provided by the floodplain risk management study and the preceding flood study.

The development and implementation of effective flood response within the community is a means of reducing flood damages. Response modification measures, such as flood warning and evacuation procedures, can be of substantial benefit in their own right and may be implemented without reference to other risk management measures. Flood warning and evacuation plans can be very cost effective. In fact, they may, in some cases, be the only economically justifiable risk management measure.

8.5.2 Local Flood Plans

The SES, in association with Council and other relevant agencies, leads in the development of detailed local flood plans for areas with significant flood problems. These plans describe the various measures to be undertaken before, during and after a flood, including warning, evacuation, resupply and other procedures.

It is essential that the floodplain management measures adopted in the floodplain management plan are compatible with the local flood plan.

As indicated in Section 6.4, there are a number of issues that need to be addressed to bring the existing Local Flood Plan to reflect the situation in the Canley Corridor catchment, and Fairfield City as a whole. Given the importance of the Local Flood Plan in the Response Modification Measures, an immediate upgrade of the Flood Plan is an essential measure to be adopted in the Floodplain Risk Management Plan not least of which is to acknowledge that evacuation is not a practical option for most buildings and provision for shelter in place is appropriate for new developments.

8.5.3 Flood Forecast and Warning

The Bureau of Meteorology (BoM) has a system of weather data collection that allows flood levels to be forecast in non-flash flooding catchments. However, in the case of catchments affected by flash flooding such as Canley Corridor, it is not possible for the Bureau to provide any prediction and warning, other than a general severe weather warning, because the flood events occur so quickly after the onset of rainfall. The time of concentration in this catchment is approximately 2 hours and anything less than 6 hours is considered flash flooding.

A number of investigations have been undertaken into a refined flood warning system for metropolitan Sydney and other areas of the State subject to flash flooding. These include a very comprehensive study and plan prepared by the NSW Flood Warning Consultative Committee (1992) however that plan was rejected by government on financial grounds. More recently, both Pittwater Council and Newcastle City Council have installed flash flood warning systems however it should be noted that these systems have yet to be tested in a major event and may take some time to be calibrated against actual events and warning scenarios. Furthermore, these systems have been installed on creek systems which have catchments much larger than Canley Corridor.

Fairfield City Council has also investigated rainfall and flow gauging and its potential to be used, amongst other things, as part of a flash flood warning system. It received a Report in 2013. While that report recommended the installation of rainfall and flood gauges, its focus was on larger creek catchments where there could be effective warning time.

The area around Freeman Avenue may benefit from such a warning system but it would be warning residents of flooding from Orphan School Creek rather than overland flows from Canley Corridor.

The other part of the Canley Corridor which has the greatest need for flood warning is between Hughes Street and St Johns Road but this is so high in the catchment that flooding will be occurring shortly after intense rainfall has occurred.

In catchments as small as Canley Corridor the best flood forecasts that are currently available are severe weather warnings for the region accompanied by radar images of recent and current cloud density which can give an indication of the expected arrival and intensity of rainfall:

NSW SES has responsibility to issue flood bulletins which add local information to the broad scale warnings prepared by BoM where such information is available. The SES turns the predictions of flood levels at specified gauges into warnings about the consequences of predicted flooding, such as, closing of roads or water entering properties or otherwise affecting human interests and activities. The NSW SES is not able to undertake this role in a small flash flood catchment such as Canley Corridor, not only because there would not be specific forecasts issued by BoM but because there would not be sufficient time to add value to the forecasts and issue them.

There is a potential for modern technology to improve the warning dissemination process, e.g. text messages to potentially affected residents when there is either a severe weather warning or radar suggests that intense rainfall may be expected. The risk with doing this is that the monitoring systems are not sufficiently precise for such a small catchment and many false alarms could be issued just as actual floods could be missed.

8.5.4 Flood Education

Community engagement and education helps to build resilience to flooding through learning. There are four ways that community education can help communities, including residents and businesses, to improve their flood resilience:

- Learning to prepare for a flood;
- Learning how to respond to a flood;
- Learning how to recover from a flood; and
- Learning how to improve the situation after a flood.

Research shows that there are several psychological factors that must be addressed to increase flood preparedness through learning. These factors include perception of the flood risk, perception of the importance of the risk, whether people believe that they have control over circumstances, their assessment of their resources to enable an action (‘self-efficacy’) and their capacity for problem solving and to confront challenges. Even with these factors advanced it has been shown that people will only prepare appropriately if they trust the emergency authority (e.g. the SES). A recent flood experience is another factor that may increase people’s preparedness activities.

Preparedness covers learning how to prepare for, respond to and recover from a flood. In practice, preparation may involve a range of activities including residents and businesses flood proofing properties and having an emergency kit. Response learning can include how to respond to flood warnings and when and how to evacuate. Recovery learning can include the ways to clean up, resume functions and safety and health precautions.

A method to cover and integrate these preparedness activities is through the development of emergency plans for the different users e.g. residents, businesses, institutions. These emergency plans should link to local flood plans.

There are other aspects of resilience-building that can also be assisted through learning. The ability of a community to adapt to a flood event is also dependent on how its capabilities (e.g. leadership, networks) and all its systems (e.g. flood warning systems, recovery systems) operate. Learning can be conducted to further improve capabilities (e.g. training for emergency management volunteers, briefings for community leaders such as councillors) and systems (e.g. flood response drills, review of flood warning and communications).

It is important to learn immediately after a flood event to further build resilience to future flood events including by improving preparedness, capabilities and systems. Ways to conduct this learning include through community de-briefs, ongoing discourse (e.g. through the media) and reviews (e.g. by the SES).

Community flood education programs should consider all of the above in their design. As a flood can occur at any time, they should be ongoing as learning can be lost rapidly if they are not maintained.

Research has shown that flood education programs are most effective when they:

- Are participatory i.e. not totally consisting of top-down provision of information but where the community has input to the development, implementation and evaluation of education activities;
- Involve a range of learning styles e.g. experiential learning (e.g. field trips, flood commemorations), information provision (e.g. via pamphlets, DVDs, the media), collaborative group learning (e.g. scenario role plays with community groups) and community discourse (e.g. forums, de-briefs).
- Use volunteers to lead informal discussions in the community about flooding
- Are linked with structural and other non-structural floodplain management options (e.g. by encouraging the community having a say in structural infrastructure options, commenting on planning options).
- Are part of local flood plans.

This revised approach to flood awareness/education is detailed in “Community Flood Education and Awareness in Fairfield City” (Molino Stewart 2012) which sets out a comprehensive community flood education action plan. This action plan requires input from the Council and NSW SES, together with other emergency agencies, the community contact groups and the Floodplain Risk Management Committee.

The proposed Action Plan is summarised as:

- Regularly write to all flood-affected residents to reinforce that they live in a flood-prone area and encourage preparedness activities e.g. development of emergency plans
- Hold ‘meet-the-streets’ in high-risk areas to engage households re flooding and encourage street support networks
- Problem-solve flood scenarios with community groups
- Conduct emergency drills and exercises involving communities and emergency agencies
- Brief councillors about floodplain and emergency planning and provide them with information to speak to communities and answer enquiries
- Use print media, radio and social media to run flood stories to raise flood awareness
- Hold post-flood community de-brief meetings
- Engage with youth and multicultural networks about flood-related initiatives (e.g. flood studies, FRMPs) using Council’s reference groups
- Train and support local community leaders to help their communities prepare, respond and recover
- Use and/or hold community events (e.g. Council Open Day, centenary of the 1988 flood) to engage with communities about floodplain and emergency management

- Prepare a FloodSafe Guide for Fairfield City
- Prepare curriculum-based school teaching units for Primary and Secondary students related to aspects of flooding
- Encourage and support businesses to complete the Business FloodSafe emergency plans
- Erect signage in strategic locations to help raise awareness of flooding in the City
- Maintain and update local flood information links on Council's website

The details of the overall and targeted plans are specific matters for Council to determine in concert with the SES. It is recommended that specific content in relation to Canley Corridor needs to focus on:

- Having a personal flood response plan;
- Monitoring BoM severe weather warnings and rainfall radar;
- Sheltering in place; and
- Not trying to drive or walk through floodwater.

- Particular attention will need to be given to Freeman Avenue and the area between Hughes Street and St Johns Road.

8.5.5 Flood Risk Information

While Section 8.5.4 makes it clear that the publishing of flood information alone is not sufficient for people to be able to prepare flooding, information must be readily available if the other parts of a flood information plan are to be effective.

Currently the FCC Website has general information about flood preparation and action including the following flood preparation measures:

- Find out if your house or business could be affected by flooding
- Work out a safe route in case you need to evacuate
- Keep your local emergency numbers handy.
- Have an emergency kit prepared.

In relation to the first point there are currently three ways in which a person in Canley Corridor can find out if their house or business could be affected by flooding:

- They review flood risk precinct maps and flood study reports which are on the FCC website
- They review the Section 149(2) certificate which they received with their contract of sale when they purchased the property (if purchased after the adoption of the 2007 Canley Corridor Flood Study) . That will include general information about the types of flooding which could affect their property. Section 149(2) certificate wording is included in Appendix C.
- They purchase a Section 149(2) or 149(5) certificate. The section 149(5) certificate includes a “Flood Information Sheet” that provides information on flood levels on the property for a range of flood events,

Only the latter will gives specific information about flood levels for different events at the property. However, it has several drawbacks:

- There is an application process so that the information takes time to be received
- There is a $53 fee for a section 149(2) Certificate, and a $133 fee for a section 149(5) certificate
- They are usually only purchased when a property is being bought or sold and is therefore only acquired by the property owner who may not be the occupant who has to respond to the flood

- The flood information sheet only lists flood levels in m AHD which will not be meaningful unless the inquirer knows the ground and floor levels on their property
- The sheet only provides flood information for the property and there is no contextual information about flood behaviour on adjoining properties or areas.

There is therefore a need for more comprehensive, meaningful and site specific information to be freely available to all building occupants within Canley Corridor Catchment.

Other councils throughout Australia are doing this. Pittwater Council and Brisbane City Council have had free, on-line, property specific flood information available for some years. However, Moreton Bay Council has recently set the benchmark in terms of specific, comprehensive and comprehendible flood information which is searchable for free on-line at an individual property level by property descriptor, street address or via an interactive map called Flood Explorer. Importantly, it provides a Flood Check property report which includes a flood depth information across a property which is more meaningful to building occupants than flood level information. A detailed flood report can be downloaded with comprehensive information about every type of flooding which could affect the property; riverine; creek; overland flow; tidal.

Flood Explorer can be viewed at http://flood.moretonbay.qld.gov.au/floodexplorer/ and Appendix I includes a sample Flood Check property report printed for a property which is affected by riverine and creek flooding. It is estimated that to develop a similar system for Fairfield City would cost in the order of $200,000 to establish and $10,000 per annum to maintain.

Many councils are reluctant to make such detailed information freely available to everyone with the most common concerns given being:

- Property values will go down;
- Insurance premiums will go up;
- There will be community backlash;
- Council will be sued.
- The latter two points are often anticipated as a result of the first two.

The facts are:

- There is no evidence of property prices dropping significantly as a result of flood information being published (Yeo, 2004), particularly in large cities. What the evidence shows is that property prices decrease immediately after a flood but soon recover to pre flood values. This was most recently evidenced in Brisbane;
- Insurance premiums will reflect both the actual flood risk and uncertainties about the accuracy of those flood risk estimates. In the absence of published flood risk information, insurers will make their own assessment of flood risk and then add a premium margin to account for the uncertainties. Reported large increases in insurance premiums for flood coverage in recent years has not been due to the release of flood information but because flood insurance was not previously included in most residential property insurance policies. Insurers have already been conducting their own inquiries into which areas flood, their flood risk estimation techniques however are not as accurate as those employed by councils. The release of accurate flood risk information by councils are likely, on average, to push flood insurance premiums down not up;
- Pittwater Council and Brisbane Council have published this information for many years and, while there are complaints, they are occasional. Brisbane Council experienced many complaints following the 2011 Brisbane floods that the information on their website was not sufficiently comprehensive or detailed. Moreton Bay Council has had more than 40,000 on-line inquiries in the two years it has been operating its system and has only had a small percentage of complaints (less than 0.5% of all property flood inquiries are letters or telephone calls and only about 10 per year require significant time from Council personnel to deal with– S Roso pers comm.).
- The evidence is that “the risk of releasing reasonably accurate hazard information in a planned way is less than the risk of deliberately withholding it.” (Eburn and Handmer, 2012)

For the above reasons there is a strong case for FCC to improve the detail and quality of flood information which it releases and to make it more freely available to the community.

8.5.6 Personal Flood Planning

Consistent with the concept of shared responsibility, it is incumbent on those occupying the Canley Corridor to take responsibility for their own monitoring of flood potential and their response to actual flooding. Given the nature of the catchment it is unlikely that they will be able to rely on support from government agencies during a flood.

While the NSW SES preference is for building occupants to evacuate from properties at risk of flooding, they acknowledge that this must be done when it is safe to do so. In Canley Corridor the streets are generally more hazardous than the curtilage around buildings and, should floodwater enter buildings, in most locations it is unlikely to be of depths and velocities which are life threatening even in the most extreme events.

In these circumstances it is probably safer for people to shelter in place than try and leave a building and travel out of the floodplain. This is also the preference of the majority of respondents to the community surveys reported earlier (Section 7.3). The proposed planning controls will ensure that appropriate provisions are provided in redevelopments such that sheltering in place presents a tolerable risk to life.

8.5.7 Recovery Planning

The Local Flood Plan sets out the various responsibilities of agencies when dealing with post-flood recovery. The floodplain management plan needs to recognise these responsibilities however there needs to be a recognition that after a flood:

- Council and other agencies will need to restore or clean up their own assets. In the case of Canley Corridor, these will include the street drainage system, the parks and recreation areas and the streetscape. The drainage outlets to Orphan School Creek will also need to be assessed and cleaned as necessary;
- Residents and commercial operators will commence clean-up, with the expectation that Council will provide some assistance, even if only in disposing of waste materials and debris, in the residential clean-up after a flood (FCC, 2013b).
- Authorities such as Department of Community Services may provide some welfare services;
- Meetings to share flood experiences and subsequent problems could include trauma counselling to help people realise they are not alone in the floodplain; and
- The period after the flood is an opportunity to collect data that will help agencies and communities to better deal with the next flood event through an assessment of the level of community flood awareness, recalibration of flood models, re-estimation of potential flood damages based on actual flood damage data and assessment of communication protocols and the effectiveness of the education program.

The final stage of the recovery is, as set out in the Local Flood Plan, a full de-brief of all agencies and council(s) in the experiences of and results of the flood response actions. This is an essential step in upgrading and updating the Local Flood Plan to improve actions and reactions, that is, to raise the resilience of the community to flooding.

8.5.8 Disaster Relief

Major disaster relief or assistance usually comes about following the declaration of a disaster by either the State or Commonwealth governments – it is usually the State that makes the initial declaration and then, based on the size and extent of the disaster, the Commonwealth may also declare a disaster.

A NSW Disaster Declaration enables flood affected residents access to assistance under various NSW Natural Disaster Assistance Schemes including the following:

- Personal Hardship and Distress Assistance (see below)
- Primary Producers – Loans
- Primary Producers – Transport Subsidies
- Small Businesses
- Trustees of Parks and Reserves
- Sporting Clubs
- Churches and Voluntary Non-Profit Organisations
- Motor Vehicle Stamp Duty Relief
- The Natural Disaster Declaration also enables Council to claim for a fair and reasonable estimate for the cost of repair and restoration of public assets that have been damaged as a result of the natural disaster.

Payment for “Personal Hardship & Distress” is available through the NSW Department of Family and Community Services at all times and does not need a Disaster Declaration to be triggered (see NSW Disaster Assistance Guidelines, 2010 - http://emergency.nsw.gov.au/content.php/881.html)

Centrelink only becomes part of disaster amelioration process once the Commonwealth Attorney General declares a disaster. If there is a Commonwealth declaration, then Centrelink would be able to make payments under the Australian Government Disaster Recovery Program or the far less used Recovery Income Supplement (essentially income supplementation for disaster victims).

8.5.9 Insurance

Insurance is not strictly a response modification measure but is a means of mitigating the cost of the residual risk to property after all other mitigation measures have been implemented. Insurance can be taken out on private property as well as public infrastructure and buildings. It is available for residential, commercial and industrial property. However, the cost of insurance may be considered unaffordable by those who have to pay for it.

As explained in Section 8.5.5, flood insurance was not previously included in most residential property insurance policies and so there has been a negative reaction from community members to the increase in their insurance premiums when flood coverage has been included. However, premiums are reflective of the estimated annual average damages to a property from flooding and are a way to spread the financial burden across many years rather than have a single, unaffordable cost in a large flood.

Property owners in Canley Corridor, particularly for those properties in the highest risk areas where an infrequent flood could result in a single unaffordable flood loss, should be encouraged to evaluate the benefits of flood insurance. Council’s role would be to provide objective information about flood risks and costs for property owners to be able to make an informed choice.

8.5.10 Summary of Response Modification Measures

Undertaking Response Modification Measures involves people taking actions before, during and after a flood to reduce the risk to life and the risk to property.

The small catchment size and rapid flood rises in Canley Corridor make monitoring severe weather warnings and rainfall radar the best current flood warnings available for the catchment. In these circumstances shelter in place is the most practical and safest response to building occupants during a flood.

Accordingly, a community education program, prepared with the aim of response modification, is a recommended option as a major part of the Canley Corridor Floodplain Risk Management Plan. It is considered that the program model detailed in "Community Flood Education and Awareness in Fairfield City" (Molino Stewart 2012) should form the basis for this program.

Individual property owners would then be responsible for implementing a personalised flood plan. This personal plan, which can be based on information from Council and the NSW SES web-site[1] (subject to the resident having that access). This will need to be supported by more easily accessible and comprehendible flood information at a property scale.

This joint education approach with the Council does not reduce the responsibilities of the SES as the flood response agency. The SES will need to update its Local Flood Plan and areas of concern on the mapping and property identifications in this Report and to use that data to concentrate their limited resources where they will have the greatest benefit including in flood recovery.

Property owners and occupants in the highest flood risk areas should be encouraged to evaluate the benefits of flood insurance.

8.6 SUMMARY OF SHORTLISTED OPTIONS

Based on the discussions above, and earlier notes regarding longer-term actions within Council, the following actions are short-listed for incorporation into a Floodplain Risk Management Plan. They include a number of actions which Council is already undertaking. The priorities of these actions, their estimated costs, timing and responsibilities are presented in Chapter 9.

8.6.1 Flood Modification Measures

There are limited options for modifying flood behaviour in the Canley Corridor because it is a fully developed catchment with limited open space, an old drainage network and a broad area affected by shallow overland flows.

The following options were considered and found not to be viable:

- Flood Detention Basins
- Amplification of Stormwater Pits and Pipes
- Bypass Floodways
- Levees
- Channel Modifications
- Floodgates

Five options were found to be worth further investigation or implementation:

[1] www.ses.nsw.gov.au

- Maintain flood model – ensure that the flood model is kept up to date with changes in catchment conditions or information
- Update Stormwater Drainage Policy – This is more than 10 years old and should be reviewed to ensure that it is consistent with the DCP and OSD policies which themselves are recommended for review as part of the Floodplain Risk Management Plan
- Maintain stormwater assets – FCC currently has a program of stormwater asset maintenance including cleaning and repair. This should be continued.
- Update Urban Area On-Site Detention Code - Continuation of council's current on-site detention is worthwhile for ensuring future flood risks do not increase. It may need to be reviewed to determine if it needs to be extended to cover 'knock down and rebuild', small development and perhaps even paving of private open space as well as from intensification of development. It may also be worth considering as a means of using future development to reduce existing flood risks. The benefits and costs of extending on-site detention requirements are the subject of a separate study by Council
- Voluntary fencing modification program - the modification of fences through the areas between Hughes Street and St Johns Road, would ensure that fences are not causing a flow obstruction which increases flood depths and hazards upstream and downstream. The estimated cost is in the order of $10,000 per block to rebuild fences on blocks 80mx20m (assuming shared cost on dividing fences), this would add about $3,500 to cost of replacing fencing on these blocks with standard Colorbond. Costs would be less for smaller blocks

8.6.2 Property Modification

Property modification measures offer the greatest opportunity for reducing flood risk. They are however a long term endeavour that will depend on redevelopment rates plus interest of people in taking up incentives which are designed to accelerate change.

There would be benefit in rezoning the land bounded by St Johns Road, Cumberland Highway, Hughes St and Gladstone St to R4 as an extension of the R4 zone immediately to its east with a band of recreational land passing diagonally through it in the most hazardous parts. This was found to not be a viable option yet for several town planning reasons.

The study also investigated:

- Voluntary purchase (VP);
- Voluntary house raising (VHR);
- Flood proofing buildings; and
- Improved flood access.
- All appear to be worthwhile in particular locations subject to:
- Accurate checking of floor levels
- Structural quality and capability of building for house raising or flood proofing
- LGA-wide evaluation of potential properties to determine affordability and priority

It is noted that many of the eligible dwellings are prime candidates for redevelopment although their flood risks will limit options but redevelopment would provide opportunity for more flood compatible development.

Therefore the following are provisionally recommended subject to the additional investigations listed above:

- Voluntary purchase:

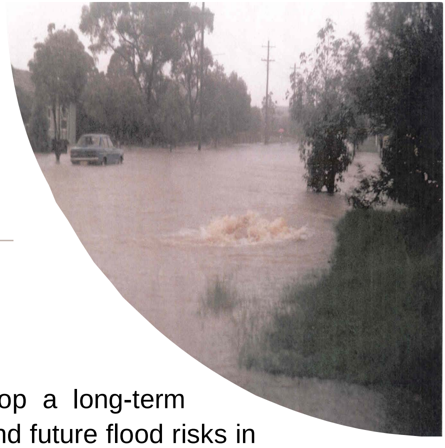
  - Based on the criteria outlined in the Lower Prospect Creek Floodplain Management Study (Willing and Partners, 1990), some dwellings within the study area are eligible
  - Consider 5 residential blocks adjacent to McBurney Park which are in an area with the highest flood hazard
- 3 dwellings on 2 blocks above floor flooding (AFF) in 5yr ARI
- 1 dwelling AFF in 20yr ARI
- 1 dwelling AFF in PMF
- 1 vacant block
- All extreme flood hazard in PMF
- Cost - $3.5m
- Benefits, $1.0m in avoided damages, reduced risk to life in 5 existing homes and a potential home site, McBurney Park almost treble current size in an area with recognised open space deficiency
  - Consider 3 residential blocks at the low point in Freeman Ave
- All three have not been redeveloped (virtually original cottages)
- Cannot evacuate by vehicle in 5yr ARI
- Cannot evacuate by foot in 20yr ARI
- AFF in 100yr ARI
- 2 have extreme flood hazard in PMF
- Currently in High Hazard Precinct so redevelopment limited even though R3 zone
- Cost - >$2.0m (valuation will be influenced by R3 zone)
- Benefits, $0.25m in avoided damages, reduced risk to life in 3 existing homes, extension to Adams Park
- Voluntary House Raising:
  - Direct raising of up to seven timber framed clad buildings with AFF in 20yr ARI if not eligible for VP
  - Raising subsidy during reconstruction to any buildings with AFF in 20yr ARI if not eligible for VP
  - Estimated cost of full payment/subsidy $81,000 per dwelling - 26 dwellings max (including potential VP dwellings) - $2.1m
  - Partial raising subsidy ($20,000/dwelling) during reconstruction to any buildings with AFF in 100yr ARI if in high hazard area – (9 properties including potential VP) - $0.2m
  - Consider raising to above PMF level as it is less than 700mm above 100yr ARI and often less than 300mm above 100yr ARI
- Flood Compatible Housing program:
  - Some houses not eligible for VP or VHR may benefit from flood proofing.
  - Costs and benefits would need to be estimated on a property by property basis
- Upgrade pedestrian access between Freeman Avenue and Canley Vale Road. Estimated to cost between $0.5m and $1.0m depending on width of construction, height of construction and services to be moved.

- Review DCP to ensure development controls are compatible with flood risk in particular:
  - Adopt a minimum floor level in overland flow area of 100yr ARI + 0.3m
  - Introduce a Very Low Flood Risk precinct where there are no development controls on residential, commercial and industrial development
  - Continue permitting a shelter in place approach
  - Add group homes to the list of sensitive uses
  - Ensure concessional development provisions are consistent with SEPP Exempt and Complying Development Codes SEPP
  - Maintain requirement with regard to flood affectation in development control matrix and consider how to ensure complying development is not permitted in the former zone of significant flow
  - Consider quantifying what constitutes a “significant adverse flood impact (e.g. 10 mm rise if flood level outside a site boundary) in development control matrix

8.6.3 Response Modification Measures

Response modification measures investigated included:

- Flood Forecasting and Warning
- Flood Response Planning
- Flood Education
- Recovery Planning
- Disaster Relief
- Insurance
- The following are recommended for implementation
- Update Local Flood Plan
- Develop and implement Community education program
- Improve quality and availability of flood risk information at a property scale
- Encourage property owners and occupants to evaluate the benefits of flood insurance



9 FLOODPLAIN RISK MANAGEMENT PLAN

9.1 OBJECTIVE

The overall objective of the Floodplain Risk Management Plan is to develop a long-term approach to flood management in Canley Corridor that addresses the existing and future flood risks in accordance with the general desires of the community and in line with the principles and guidelines laid out in the NSW Floodplain Development Manual.

This will ensure that the following broad needs are met:

- Reduce the flood hazard and risk to people and property, now and in the future;
- Protect, maintain and where possible enhance the floodplain environment; and
- Ensure floodplain risk management decisions integrate social, economic and environmental considerations.

9.2 RECOMMENDED MEASURES

The recommended measures for the plan have been selected from the suite of options which are discussed and evaluated in Chapter 8. The recommended measures are presented in Table 19 and summarised in Figure 38.

It should be noted that:

- Several of the actions involve maintaining existing policies and programs;
- Some of the actions involve some further investigation of an action before determining whether it is feasible and affordable to implement;
- Some of the actions rely upon completion of studies in other catchments; and
- Some of the actions would apply LGA wide or in other catchments in addition to Canley Corridor and the action needs to be taken over the wider area to encompass Canley Corridor.

9.3 PLAN IMPLEMENTATION

9.3.1 Costs

There are only four actions which would have a cost in addition to ongoing staffing costs within Council and the NSW SES. This includes:

- $5.5m for the voluntary purchase of 8 residential properties (5 residential blocks adjacent to McBurney Park and 3 residential blocks at the low point of Freeman Ave)
- $2.3m for the voluntary house raising program of 35 houses (26 at full subsidy and 9 at a partial subsidy). Some of these properties include potential voluntary purchase properties
- $0.5 to $1.0m for the upgrading of the pedestrian access from Freeman Avenue to Canley Vale Road although this need is driven more by creek flooding from Orphan School Creek than overland flows; and
- $40,000 to develop a city-wide Flood Education Plan and approximately $10,000 per year for its implementation; and
- $200,000 to develop a city-wide online flood information system and approximately $10,000 per year for its maintenance.

- $70,000 for specialist advice to update both the Stormwater Drainage Policy and Urban Area on Site Detention Policy.

9.3.2 Priorities

Priorities are defined as high, medium and low.

High priority measures have been so defined because they are either:

- Existing actions which need to be continued;
- Actions which can be undertaken within 12 months with minimal cost; or
- Have the potential to deliver high benefits for small costs
- Medium priority measures are those which:
- Are dependent on other investigations being completed which may take more than 12 months; or
- Have the potential to deliver moderate benefits compared to costs.
- Low priority measures are those which:
- Would not be able to be implemented for at least three years;
- Have the potential to deliver marginally greater benefits than costs

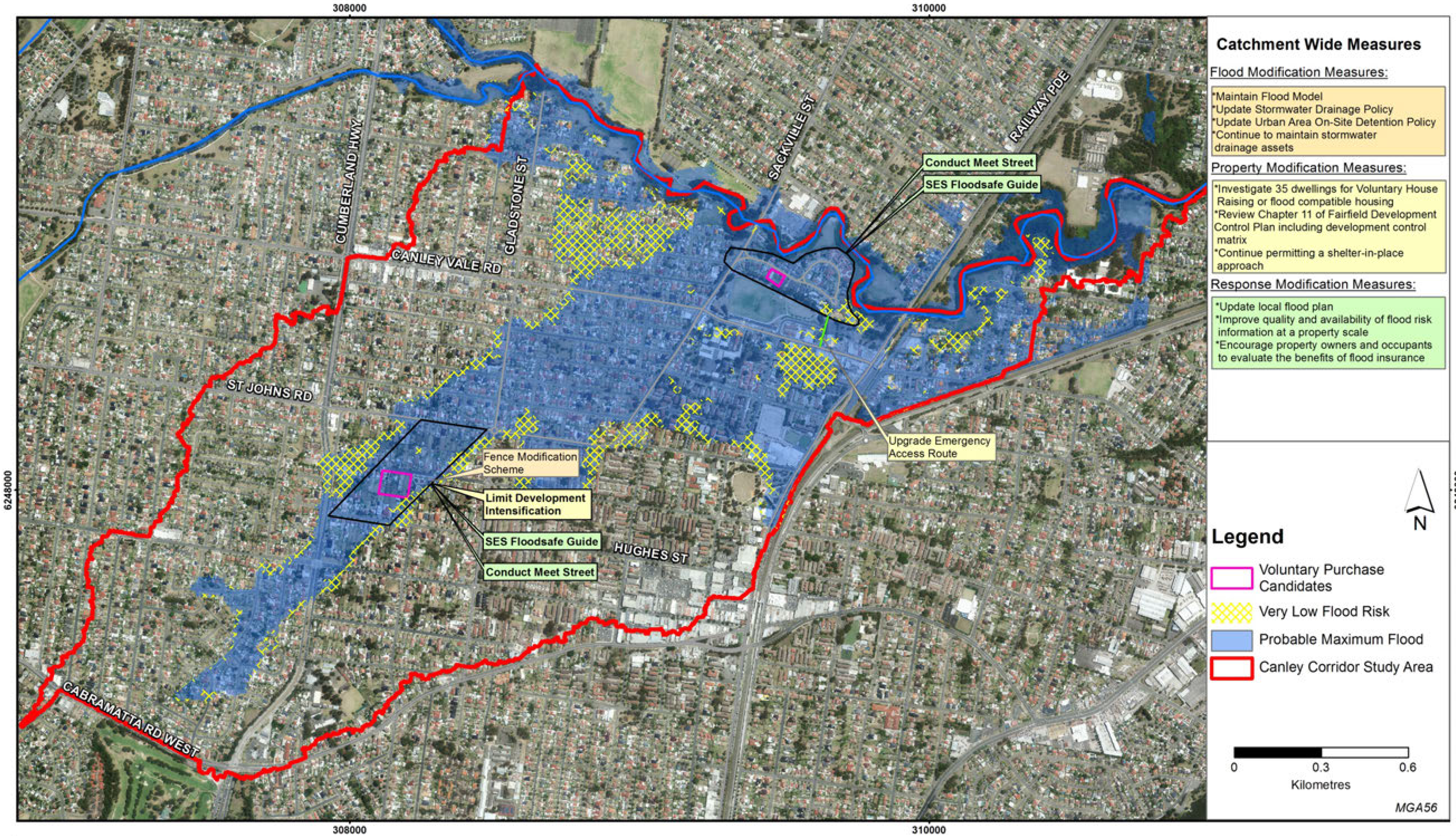
9.3.3 Resourcing

Plan implementation will be dependent on adequate resourcing of its implementation and maintenance. Resources may include financial and human resource and come from a number of sources. Potential contributors of resources include:

- Fairfield City Council – financial resources from capital and operating budgets, staff time;
- NSW State Government – financial grants for investigations, mitigations works and programs, NSW SES and OEH staff time;
- Commonwealth Government - financial grants for investigations, mitigations works and programs
- Developers – OSD construction and maintenance, Section 94 contributions for open space
- Community – volunteer time to NSW SES or to assist with development and implementation of community education plan

Table 19: Floodplain Risk Management Plan

Floodplain Management Measure	Implementation Responsibility	Initial cost	Ongoing cost	Priority	Resourcing	Comments
Flood Modification Measures						
Maintain Flood Model	*FCC*	*$0*	*minimal*	*Ongoing*	*FCC*	*Ongoing responsibility of FCC floodplain management staff*
Update Stormwater Drainage Policy	*FCC*	*$30,000*	*minimal*	*High*	*FCC*	*Project which can be undertaken in house by FCC staff with specialist advice*
Continue to maintain stormwater drainage assets	*FCC*	*$0*	*$0*	*Ongoing*	*FCC*	*Funded through existing asset management program*
Update Urban Area On-Site Detention Policy	*FCC*	*$40,000*	*$0*	*High*	*FCC*	*This is dependent on completion of an investigation project which has been commenced by FCC.*
Investigate voluntary fencing modification program	*FCC*	*$0*	*minimal*	*High*	*FCC*	*This requires further investigation by FCC staff to determine whether it would be acceptable to the community and what funding sources would be available.*
Property Modification Measures						
Voluntary Purchase	*FCC*	*$5.5*	*minimal*	*Medium*	*FCC, NSW Govt, Aust Govt*	*There are relatively few properties that could be purchased to reduce risk to life and property. When future floodplain risk management studies and plans are completed, any suggested VP should be amalgamated into one scheme. Investigate potential for S94 contributions for open space to be used for VP of high risk properties in Canley Corridor*
Voluntary House Raising	*FCC*	*$2.3*	*minimal*	*Medium*	*FCC, NSW Govt, Aust Govt*	*This option may be pursued for those properties not as severely affected by overland flooding. When future floodplain risk management studies and plans are complete, any suggested VHR should be amalgamated with this scheme.*
Flood Compatible Housing	*FCC*	*$unknown*	*minimal*	*Medium*	*FCC*	*Costs will need to be estimated on a property by property basis, and may also be dependent on a property's eligibility for the VHR scheme.*
Upgrade pedestrian access from Freeman Avenue to Canley Vale Road	*FCC*	*$0.5-$1.0m*	*minimal*	*High*	*FCC, NSW Govt, Aust Govt*	*This is driven more by flooding from Orphan School Creek than Canley Corridor*
Review DCP to ensure development controls are compatible with flood risk and other planning instruments.	*FCC*	*$0*	*minimal*	*Medium*	*FCC*	*Including adoption of 300mm freeboard and Very Low Flood Risk Precinct and removal of Zone of Significant Flow*
Response Modification Measures						
Update Local Flood Plan	*SES*	*$0*	*$0*	*High*	*SES, FCC*	*NSW SES to incorporate flood risk intelligence from Canley Corridor Floodplain Risk Management Study*
Develop and implement community education program	*SES, FCC*	*$40,000*	*$10,000*	*High*	*SES, FCC, NSW Govt, Aust Govt, community*	*This is the cost of a city-wide plan of which Canley Corridor would just be one part*
Improve quality and availability of flood risk information at a property scale	*FCC*	*$200,000*	*$10,000*	*Medium*	*FCC, NSW Govt, Aust Govt*	*This is the cost of a city-wide on-line flood inquiry system*
Encourage property owners and occupants to evaluate the benefits of flood insurance	*FCC*	*$0*	*minimal*	*High*	*FCC*	*This could be an element of the community education program*



Canley Corridor Floodplain Risk Management Study: Draft FRMP				
MOLINO STEWART ENVIRONMENT & NATURAL HAZARDS	Molino Stewart endeavours to ensure that the information provided in this map is correct at the time of publication. Molino Stewart does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.	Date: 12/03/2015	Checked By: S.M.	Job No: 0517
		Filepath: Y:\Jobs\2012\0517 Canley Corridor (Fairfield) FPRMS&P\GIS \Workspace\Draft FRMP.mxd		

Figure 38: Summary of Floodplain Management Plan

9.4 PLAN MAINTENANCE

A management plan is never truly finished.

Social and economic circumstances change and flooding behaviour may be substantially altered by future measures adopted in other areas of the catchment. A management plan represents the 'best' appraisal of existing and likely future circumstances at the time it is 'adopted'. For this reason management plans are not 'final' but rather 'adopted', that is, plans have been adopted for the immediate future. Management plans should be reviewed regularly (say every 5 years or after each major flood, or where circumstances change that impact on the relevance of the management plan) to ensure that their provisions remain appropriate.

The adopted management plan should be complementary to the Local Flood Plan. Existing, future and continuing flood risk cannot be effectively dealt with if this does not occur, or if the SES is left out of the overall management process. Review of either plan should not be undertaken without reference to the other plan and the relevant authority. Changes in the Floodplain Risk Management Plan should be reflected in the local floodplain risk management policy.

It is envisaged that the Plan would be implemented progressively over a 5 to 10 year timeframe. The timing of the proposed works will depend on the overall budgetary commitments of each Council, and the availability of funds from other sources (e.g. State Government, potential section 94 contributions etc.).

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APPENDIX A- 2011 CENSUS DATA

Demographics (percentage)	Averages	Cabramatta - Lansvale	Cabramatta West - Mount Pritchard	Canley Vale - Canley Heights	Fairfield LGA	Greater Sydney
Male	49.0	48.9	49.1	49	49.3	49.2
Female	51.0	51.1	50.9	51	50.7	50.8
Age group						
0-19 years	28.6	27.1	30.1	28.7	28	25.5
20-44 years	34.6	35.5	33	35.3	34.3	37.4
45-64 years	24.5	25.3	24	24.2	25.7	24.3
65-84 years	10.7	10.1	11.8	10.2	10.7	10.9
85- and over	1.5	1.9	1.2	1.5	1.3	1.8
Australian born	39.3	31.8	48.1	38.1	42.4	59.9
Foreign born	60.7	68.2	51.9	61.9	57.8	40.1
English only spoken at home	21.1	14.1	30.7	18.4	25.9	62.2
Households where two or more languages are spoken	77.1	84.6	66.6	80.2	75.2	35.5
Languages other than English (top responses)	87.7					
Vietnamese	32.2	36.4	25.5	34.8	19.1	1.9
Cantonese	10.4	12		8.7	5.0	3.0
Khmer	6.0	8.2	4.1	5.8	3.6	
Mandarin	4.3	4.7		3.9	2.7	3.1
Arabic	5.4		5.4		7.3	4.1
Italian	3.9		3.9		3.4	1.6
Serbian	3.4	2.8	4		2.2	
Assyrian					7.8	
Median weekly incomes - Personal	$345	$331	$364	$340	$369	$619
Dwellings - dwelling structure						

Demographics (percentage)	**Averages**	**Cabramatta - Lansvale**	**Cabramatta West - Mount Pritchard**	**Canley Vale - Canley Heights**	**Fairfield LGA**	**Greater Sydney**
Separate house	65.9	45.8	88.5	63.3	74	60.9
semi-detached, row or terrace house, townhouse etc	17.5	19.2	9.7	23.7	13.6	12.8
flat, unit or apartment	16.4	34.9	1.6	12.6	12	25.8
Dwellings - number of motor vehicles						
none	15.1	20.5	11.2	13.7	12	12.1
1 motor vehicle	37.8	41.3	34	38.2	33.9	38.4
2 motor vehicles	28.8	22.9	32.8	30.7	31.6	32.9
3 or more vehicles	13.3	9.4	17.6	12.9	18.2	13.6
Employment						
Worked full-time	56.9	54.5	58.4	57.7	58.8	62.1
Worked part-time	24.8	25.3	25.5	23.5	24.9	26.7
Away from work	6.7	6.9	6.5	6.7	6.6	5.5
Unemployed	11.6	13.2	9.6	12.1	9.7	5.7
People who reported being in the labour force, aged 15 years and over						
Occupation						
Labourers	18.9	21.6	16.5	18.6	14.8	7.3
Machinery Operators And Drivers	14.6	15.2	14.1	14.6	12.5	5.7
Technicians and Trades Workers	14.7	14.7	15.7	13.6	15.8	12.2
Clerical and Administrative Workers	12.7	10.6	14.6	12.8	15.2	16.2
Community and Personal Service Workers	9.1	9.4	8.7	9.3	8.7	8.8
Sales Workers	8.8	7.9	9.3	9.3	9.3	9

Demographics (percentage)	Averages	Cabramatta - Lansvale	Cabramatta West - Mount Pritchard	Canley Vale - Canley Heights	Fairfield LGA	Greater Sydney
Professionals	11.8	10.5	11.4	12.5	13	25.5
Managers	6.2	6.1	6.8	5.8	7.6	13.3
Household composition						
Family Households	79.6	76.7	80.7	81.5	82.3	73.1
Single (or lone) person	17.4	18.9	17.2	16.2	15.6	22.6
Group	2.9	4.3	2.1	2.3	2	4.3
Family Composition						
Couple family without children	22.7	22.8	23.2	22.1	23.3	33.5
Couple family with children	47.4	46.3	47.8	48.2	52	48.9
One parent family	27.3	27.7	27.3	26.9	22.6	15.7
Other family	2.6	3.1	1.8	2.8	2.1	1.9

APPENDIX B – FLOOD STUDY REVIEW & UPGRADE

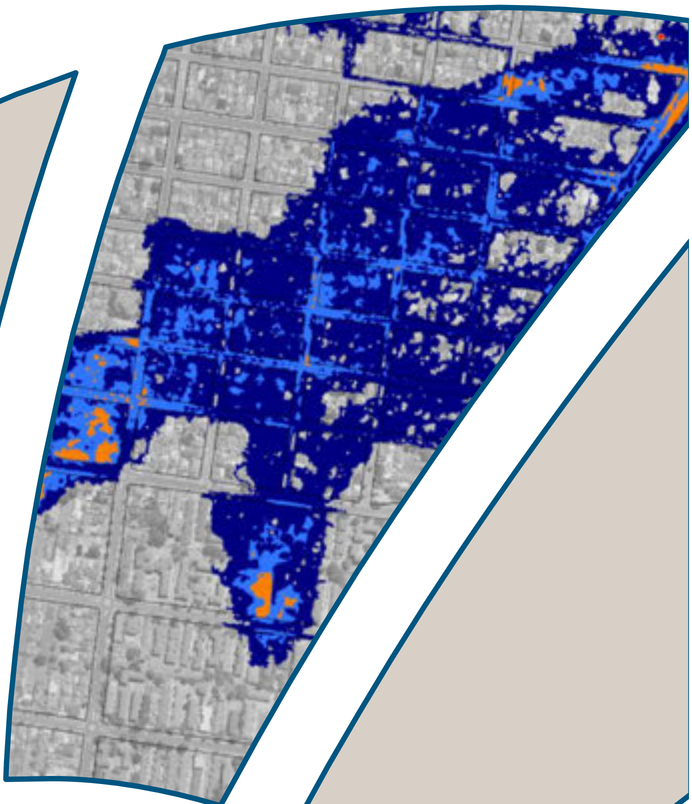
A part of BMT in Energy and Environment

Canley Corridor Flood Study Review and Update

Final Report:

R.S01272.001.0.FINAL.docx

January 2014



Canley Corridor
Flood Study Review and Update

January 2014

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Prepared For:	Molino Stewart Pty Ltd as part of the Floodplain Risk Management Study for Fairfield City Council
Prepared By:	BMT WBM Pty Ltd (Member of the BMT group of companies)

DOCUMENT CONTROL SHEET

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	Project Manager :	Simon Kovacevic
	Client :	Molino Stewart Pty Ltd
	Client Contact:	Neil Benning
	Client Reference	

Title :	Canley Corridor Flood Study Review and update Report
Authors :	Simon Kovacevic, Melanie Gostelow
Synopsis :	This report describes the flood study review undertaken for the Canley Corridor catchment in the Fairfield City Council area in NSW.

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1 BACKGROUND

In August 2005 Fairfield City Council (FCC) commissioned Sinclair Knight Merz (SKM) to undertake an Overland Flood Study for the Canley Corridor area. The aim of the study was to define flood behaviour, identify properties at risk of flooding and to map the flood risk.

The flood study was undertaken by SKM in association with Fairfield Consulting Services (FCS) and was completed in December 2009. The flood study was prepared in accordance with the NSW Government's Flood Prone Land Policy as documented in the 2005 Floodplain Development Manual (FDM).

As part of this study, hydrological and hydraulic models were developed to assess flooding behaviour due to stormwater runoff from the catchment.

A two-dimensional hydraulic TUFLOW model of the study area was developed. The TUFLOW model represented the topography of the study area using a 2 metre grid, buildings as solid objects in the floodplain and Orphan School Creek at the downstream end as a one-dimensional element. The TUFLOW model did not incorporate any fences although the impact of fences was investigated as part of sensitivity testing.

The TUFLOW model relies on inflows from the developed hydrologic and stormwater system model of the study area. One of the key objectives of this study was to test the sensitivity of overland flood modelling to different assumptions about the capacity of the existing stormwater drainage network. Three different hydrological and stormwater models were developed using DRAINS or XP-RAFTS software to compare modelling approaches. The study selected the preferred “limited” DRAINS hydrologic and stormwater system model, representing larger sized pipes in the stormwater network as well as areas of known localised flooding named “hot spots”, for the design event modelling of the flood study.

The TUFLOW model relies on boundary conditions from additional existing hydrologic and hydraulic models. Inflows for Green Valley Creek, Orphan School Creek and local sub-catchment inflows to Orphan School Creek within the hydraulic model extent, but beyond the study area extent were sourced from the 2008 FCC Orphan School Creek, Green Valley Creek and Clear Paddock Creek (Three Tributaries) XP RAFTS flood model (SKM, 2008). The downstream boundary of the hydraulic model at Orphan School Creek was sourced from the Prospect Creek Flood Study (Bewsher Consulting, 2006).

Subsequent to the 2009 overland flood study and as per the process outlined in the FDM, Fairfield City Council commissioned consultants Molino Stewart in 2012 to undertake the Floodplain Risk Management Study and Plan (FRMS&P) for the Canley Corridor study area. BMT WBM were engaged by Molino Stewart as a sub-consultant to review and update the existing Canley Corridor flood model and model proposed flood mitigation options for the FRMS&P.

A review of the Canley Corridor DRAINS and TUFLOW models was undertaken by BMT WBM in 2013 which identified a number of issues with the hydrologic and hydraulic modelling of the existing model. Evaluation of these issues for the current Floodplain Risk Management Study suggested that the model was not fit for purpose and required some modification.

Based on discussions with FCC, BMT WBM implemented a number of model modifications including:

- Updates to the 1D representation for Orphan School Creek and Green Valley Creek;
- Representing building footprints by applying locally higher hydraulic roughness values;
- Revision of the 2D model domain to incorporate the LiDAR DEM in a more flexible arrangement such that any new DEM can be efficiently incorporated at a later date;
- Conversion of the existing DRAINS pipe network to dynamically linked TUFLOW elements; and
- Changes to the hydrological and tailwater inputs from the various sources.

The following report outlines the model review, model modifications and their impact on design flood levels, revised design event modelling and mapping and the additional climate change assessment conducted.

2 MODEL REVIEW

2.1 Objective

The purpose of the model review is to review and update the existing Canley Corridor overland flood study model in order for it to be “fit for purpose” for the FRMS&P. Items considered in the review include:

- Consistency with other studies being undertaken by FCC;
- Adequate representation of hydrological and hydraulic features;
- Ability for the model to assess a range of flood mitigation options; and
- Flexibility of the model schematisation for use of the model by FCC in the future.

2.2 Review Data

The review of the Canley Corridor Flood Study modelling by BMT WBM has been based on the following information provided by Fairfield City Council.

- Canley Corridor Overland Flood Study (SKM & Fairfield Consulting Services, 2009)
- Flood Study for Orphan School Creek, Green Valley Creek and Clear Paddock Creek (SKM & Fairfield Consulting Services, 2008) - also referred to as "Three Tributaries"
- Review of Three Tributaries Flood Study (June 2012)
- Canley Corridor TUFLOW Model (Canley_LimMajObv1_[Event]y[Duration]loop1_ext.tcf)
- Canley Corridor DRAINS Model (Limited 900mm with extended area complete.drn)
- Three Tributaries XP-RAFTS Model (Tribs 1% 2hr.xp)
- Prospect Creek TUFLOW result files (PC_bc_Exg[Event]y[Duration]_01) from the Prospect Creek Flood Study Review (Bewsher Consulting, 2006)

2.3 Hydrology Review

Inflow hydrographs applied to the Canley Corridor TUFLOW model have been sourced from the Canley Corridor DRAINS model for the direct study area catchment and from the Three Tributaries XP-RAFTS Model for the surrounding and upstream sub-catchment areas, as shown in Figure 2-1.

The selected hydrological inputs for the Canley Corridor TUFLOW model aims to represent the 100 year average recurrence interval (ARI) and probable maximum flood (PMF) events for the Canley Corridor study area, with coincident 100 year flood hydrographs for Orphan School Creek and downstream Prospect Creek.

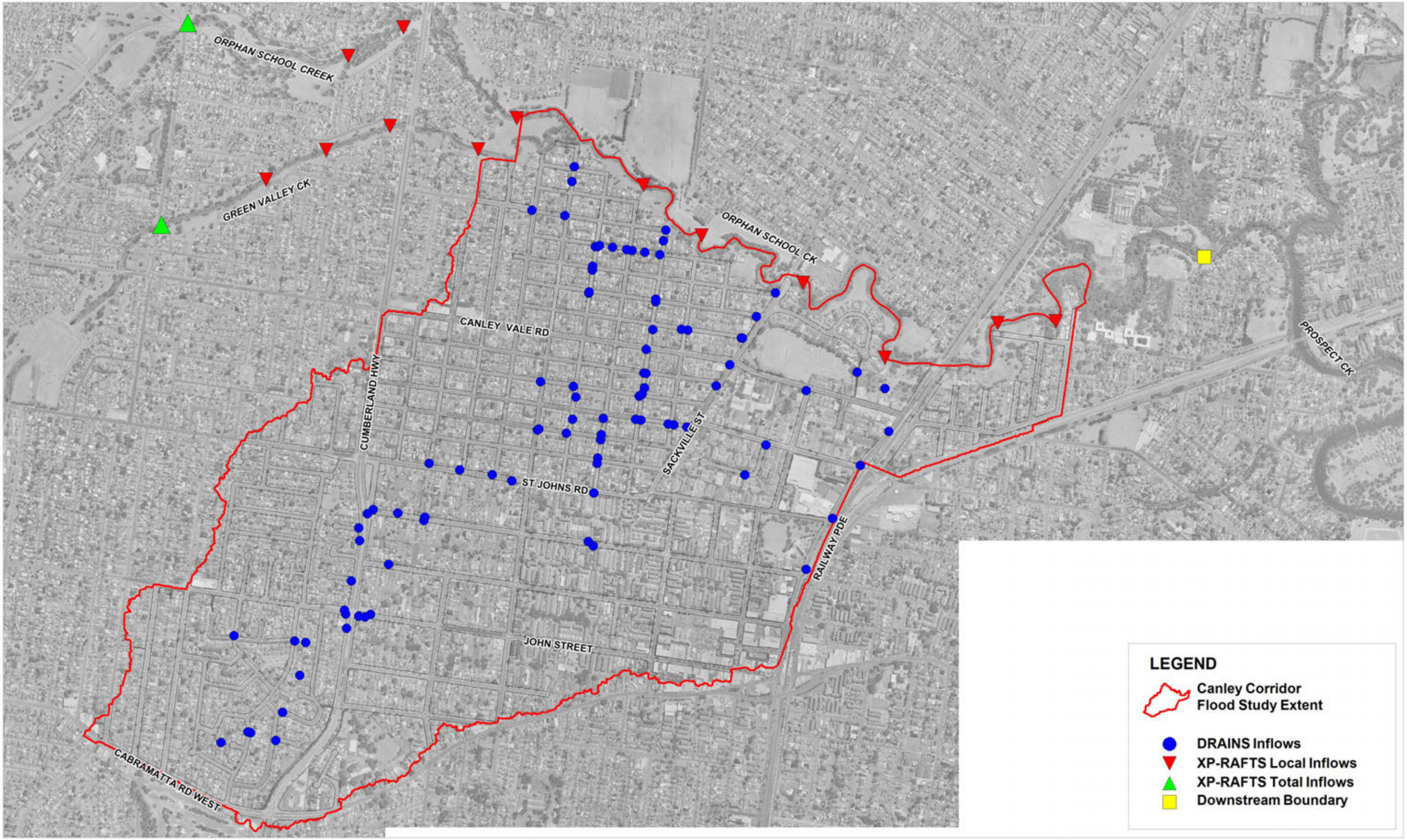
The hydrology model review indicates an inconsistent approach has been adopted for the derivation and application of flows to the hydraulic model, as discussed below.

2.3.1 Overlapping Sub-Catchments

A number of sub-catchments have been represented in both the DRAINS and XP-RAFTS model inflows, as shown in Figure 2-2, resulting in a local overestimation of flows in Orphan School Creek. Discharge from XP-RAFTS sub-catchments 2.04, 2.04C and 5.03 have been applied in the TUFLOW model as inflows within Orphan School Creek, representing the total flow from those sub catchments. Runoff from these particular sub-catchments which surcharges from the drainage network in the DRAINS model is also being applied in the TUFLOW model.

The XP-RAFTS derived flows do not take into account the volume of water that is transferred by the drainage network, as modelled in DRAINS. The XP-RAFTS flow hydrographs for these catchments will have magnitudes of flow and volume being applied in Orphan School Creek that are higher than what will realistically occur.

To ensure consistency across the Canley Corridor study area, the XP-RAFTS sub catchments were removed in the updated model in favour of the DRAINS model derived flows.



Title:
Canley Corridor TUFLOW Inflow Locations

Figure: 2-1

Rev: A

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Approx. Scale

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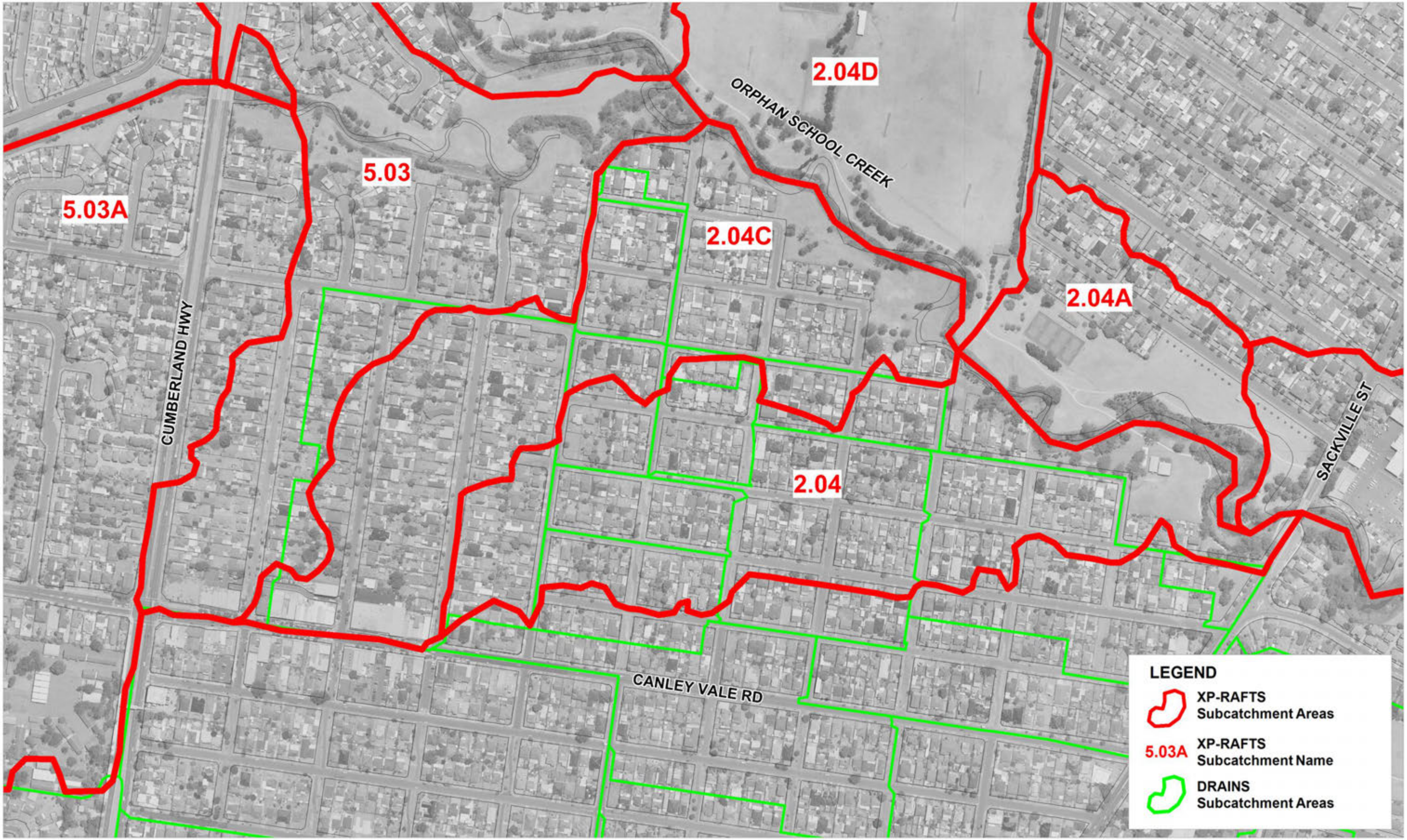

Title:
Overlapping Sub-catchment Areas in 2009 Model

Figure: 2-2

Rev: A

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Approx. Scale

BMT WBM
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2.3.2 DRAINS Model

The DRAINS model represents the study area sub-catchments and drainage network for pipe diameters 900mm and greater and at known problem areas or "hot spots". Overflows or surcharges from selected individual pits are used as TUFLOW inflow hydrographs. Based on the following issues the DRAINS model would most likely underestimate the hydrology of the Canley Corridor catchment in TUFLOW possibly underestimating the flood extent and depths across the study area.

- Several pit locations (in particular along the Cumberland Highway) in the DRAINS model provided do not match the inflow locations in the TUFLOW model as shown in Figure 2-3. This has been rectified with the inclusion of the pipe network in the TUFLOW model, as discussed in Sections 3.4 and 3.6.

- Flows discharging from the drainage network outlets to Orphan School Creek in the DRAINS model have not been applied in the TUFLOW model. In effect, the runoff collected and discharged from the drainage network is 'lost' from the TUFLOW model, underestimating flows in Orphan School Creek. This has been rectified by including these inflows in the TUFLOW model, as discussed in Section 3.6.

- Tailwater conditions representative of the water levels in Orphan School Creek have not been applied in the DRAINS model. The DRAINS model discharges flows from the drainage network freely to Orphan School Creek, assuming water levels in the creek are below the pipe invert levels. This approach is inconsistent with applying a coincident 100 year ARI event to Orphan School Creek in the Canley Corridor TUFLOW model using the XP-RAFTS model hydrographs. By assuming low water levels in the creek the DRAINS model overestimates the pipe network capacity during periods of high creek flow, therefore underestimating the overland flows through the Canley Corridor study area. Council indicated this tailwater approach was taken due to limitation of the DRAINS model. The DRAINS model produced significant instabilities when higher tailwater levels representative of flood levels in Orphan School Creek were applied. This has been rectified with the inclusion of the stormwater network within the TUFLOW model, as discussed in Section 3.4.

- When sections of the DRAINS model were rerun using version 2012.02 of the software, several overflows occurred which were not represented in the TUFLOW model. As a result water is "lost" from the TUFLOW model potentially underestimating the overland flows through the Canley Corridor study area. This has been rectified with the inclusion of the stormwater network within the TUFLOW model.

Title:
Inconsistent DRAINS Pit and TUFLOW Inflow Locations

Figure: 2-3

Rev: A

N

0 100 200m

Approx. Scale

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2.3.3 XP-RAFTS Routing

The 2009 Canley Corridor model uses both local and total hydrographs from the Three Tributaries XP-RAFTS model as TUFLOW inflow hydrographs.

The Three Tributaries model report states that only local hydrographs were used in the Three Tributaries TUFLOW model, and as such, all routing and attenuation within the Three Tributaries study area was achieved hydraulically in the TUFLOW model.

This has been rectified by extracting discharge hydrographs in Orphan School Creek and Green Valley Creek from the Three Tributaries model at locations matching the upstream extent of the Canley Corridor model, as discussed in Section 3.6.2.

2.4 Hydraulic Model Review

The TUFLOW model developed for the Canley Corridor Flood Study applies a 2D grid with a cell size of 2m linked with 1D representation of the Green Valley and Orphan School Creeks. As discussed in Section 2.3 inflow hydrographs are applied at point locations with a time-varying (dynamic) downstream water level boundary sourced from the Prospect Creek TUFLOW modelling.

The model review identified a number of specific problems with the existing model with respect to its use in the Canley Corridor Floodplain Risk Management Study, as discussed below.

2.4.1 Downstream Boundary Hydrograph Timing

The downstream water level boundary in the Canley Corridor TUFLOW model has been derived from the Prospect Creek hydraulic model. The specific 100-year ARI Prospect Creek storm durations that have been applied for specific Canley Corridor storm durations are summarised in Table 2-1.

Table 2-1 Downstream Boundary Storm Duration Combinations

Canley Corridor Storm Duration	Prospect Creek Storm Duration
> 1 hour	2 hours
≤ 1 hour	25 minutes

The various boundary conditions (inflows and water levels) applied in the existing Canley Corridor TUFLOW model all commence at time t=0.0h, with the exception of the Prospect Creek 100 year ARI 2 hours water level boundary. This particular time-series incorrectly commences at t=13.0h, the consequence of which is that the simulations for the Canley Corridor storm durations greater than 1 hour have been modelled with a fixed water level for the entire simulation. This water level is the value specified at t=13.0h. Because of this discrepancy, water levels in Orphan School Creek are significantly underestimated for the Canley Corridor 90 minutes and 2 hours design events, which were previously found to be the critical durations in the Canley Corridor Flood Study. This was rectified as discussed in Section 3.5.

2.4.2 1D Channel Representation

The adopted 1D channel representation of Orphan School Creek and Green Valley Creek has resulted in several surveyed cross sections being omitted from the model, as shown in Figure 2-4.

The model topography is also inconsistent across the TUFLOW 1D/2D domain, where 1D cross-sections have been artificially stretched to the 1D/2D boundary. As shown in Figure 2-5 the surveyed cross sections do not extend to the 1D/2D boundary. As a result the topography between the extents of the surveyed sections and the 1D/2D boundary isn't accounted for, the 1D/2D link across the topography is not consistent and gaps appear in the flood extent, as shown in Figure 2-6. This was rectified through the changes made to the TUFLOW model as discussed in Section 3.1.

2.4.3 Building Footprints

Building footprints have been removed from the 2D domain in the existing Canley Corridor TUFLOW model. By removing the 2D cells from the computation, the model does not account for the temporary flood storage as water enters buildings during large flood events. This approach results in "holes" in the 2D model results (including the flood extents, see Figure 2-6) where the building footprints are located. Furthermore, many of the building footprints defined for the 2009 SKM study span several adjacent buildings and do not account for the overland flowpaths between these buildings. The combination of these building footprints and the modelling method adopted in SKM (2009) does not accurately represent the overland flow paths across the study area and can lead to both over and under-estimation of flood levels. As a result determining flood levels for individual buildings, used for setting planning control limits or estimating flood damages, may be inaccurate.

Depending on the 2D grid and building sizes, common approaches currently employed to represent buildings in the 2D domain include locally increasing the hydraulic roughness of building footprints or modelling building exterior walls around the upstream faces of buildings. Both of these approaches allow for the representation of temporary storage, increased energy dissipation of the water flowing around the buildings whilst providing a consistent flood extent across building footprints.

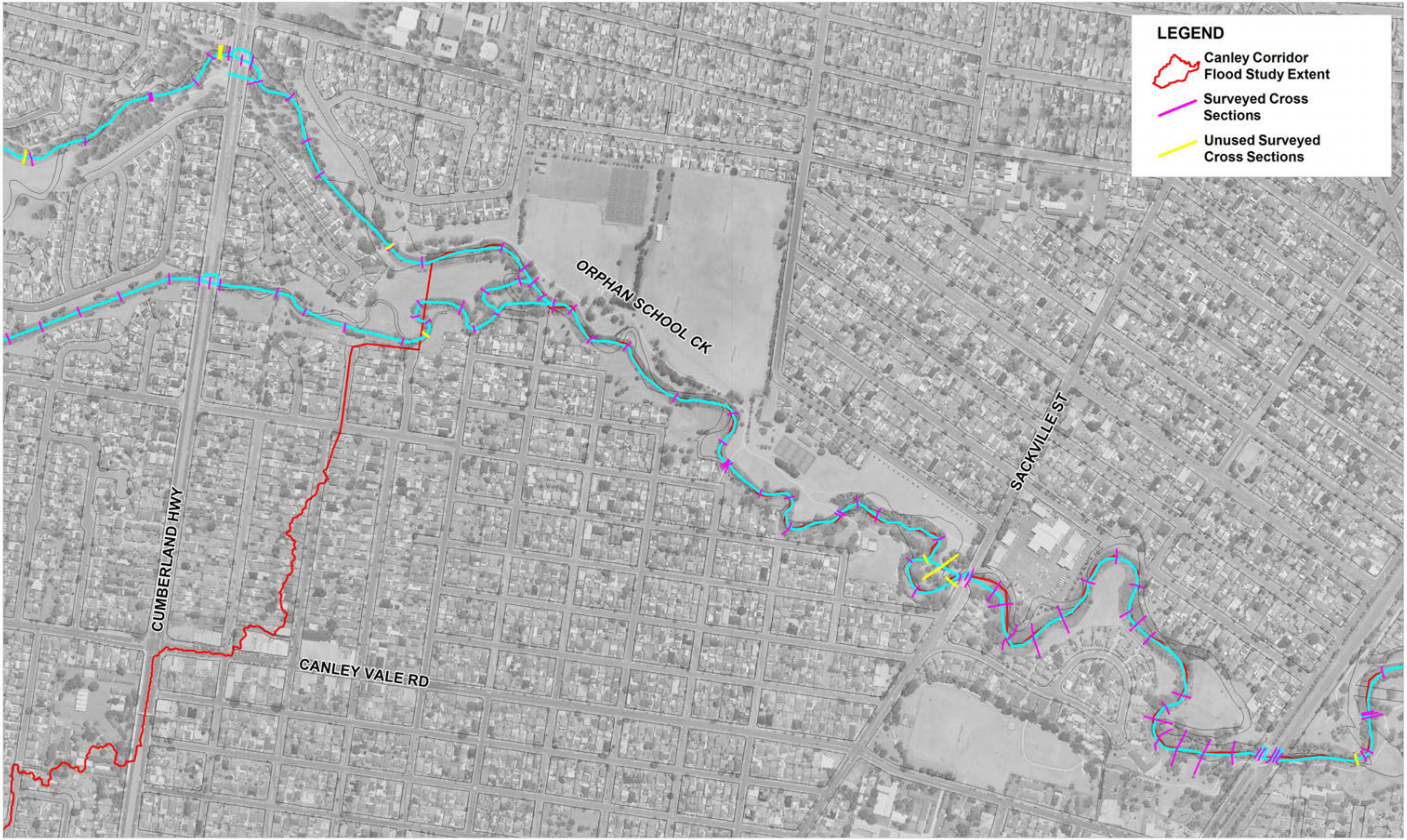
2.4.4 Model Instabilities

The 2009 TUFLOW model topography has been modified in several locations, presumably to improve model instabilities in these areas. These modifications were made by adjusting the elevations of z points or completely removing areas from the 2D domain, as shown in Figure 2-7.

The presence of these instabilities was confirmed when the existing Canley Corridor TUFLOW model was simulated using TUFLOW model build 2007-07-DB (the currently supported 2007 model build, representative of the model build used at the time of the Flood Study) and the latest 2011-09-AF-64 build. Neither builds were able to successfully run the existing Canley Corridor TUFLOW model to completion for all events due to instabilities along Orphan School Creek. This indicated that further modifications to the TUFLOW model were necessary in order to create a model that could be deemed fit for purpose (refer to Section 3.1).

2.5 Flood Mapping

The SKM & FCS (2009) Canley Corridor TUFLOW results and mapping have been provided for review for the 15, 30, 45, 60, 90 and 120 minute, 100 year ARI and PMF storm events. The inadequate digitising of the 1D creeks as discussed in Section 2.4 is evident with visible gaps in the derived flood extents, as shown in Figure 2-6. The extent of the flood mapping also appears to be limited by the extent of the 2D domain, in particular along Railway Parade, as shown in Figure 2-8. It is likely that the extent of the model was previously reduced to provide faster model runtimes.



Title:
Unused Creek Cross Sections

Figure: 2-4

Rev: A

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Title:
Extent of Surveyed Cross Sections

Figure: 2-5

Rev: A

N 0 37.5 75m
Approx. Scale

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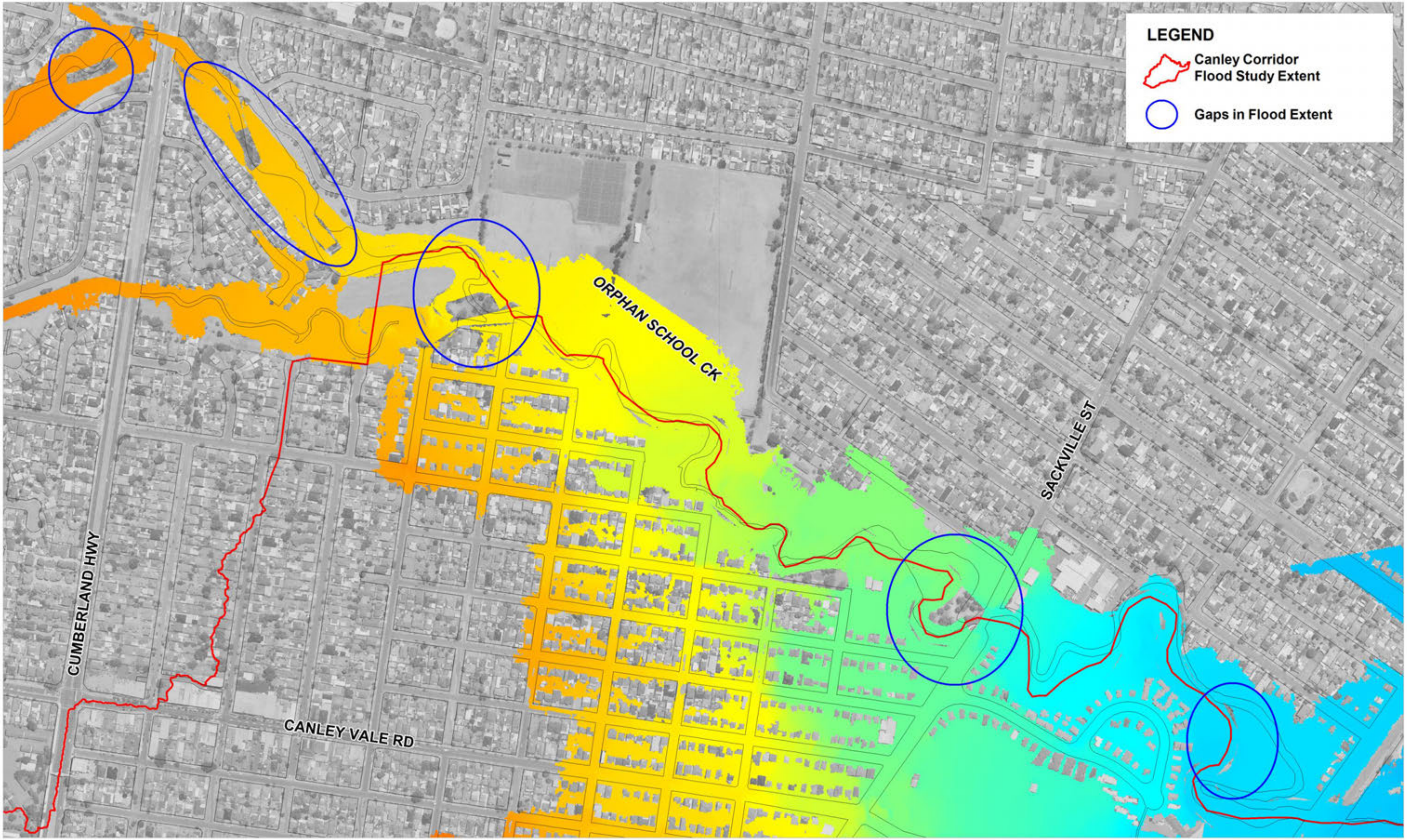

Title:
Flood Extent Gaps

Figure: 2-6

Rev: A

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N

0 125 250m

Approx. Scale

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Title:
Adjusted Topography

Figure: 2-7

Rev: A

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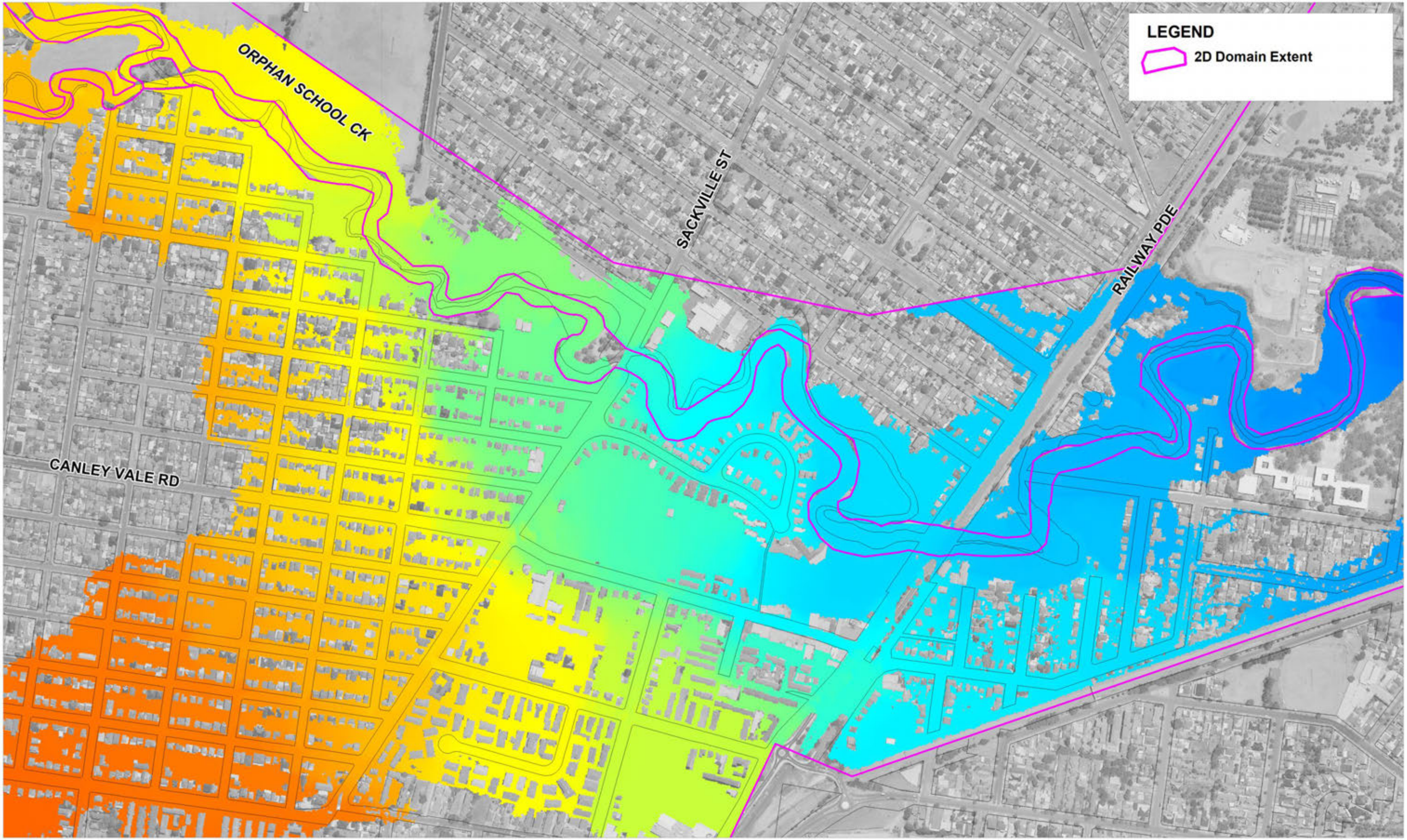

Title:
2D Domain Extent

Figure: 2-8

Rev: A

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3 HYDRAULIC MODEL MODIFICATIONS

Based on the review of the Canley Corridor flood modelling and through further discussions with Fairfield City Council, a number of modifications have been made to the Canley Corridor TUFLOW model. These modifications have resulted in a more robust tool for undertaking the Floodplain Risk Management Study. Furthermore, the modifications have resulted in a more flexible model setup that can readily incorporate new data at a later date, should new data become available to Council. It should also be noted that the pipe drainage network can be extended in the future should the need arise.

The following outlines the modifications made to the Canley Corridor flood model:

- Updates to the 1D representation for Orphan School Creek and Green Valley Creek;
- Changing the building polygon layer from inactive to active with a higher roughness value;
- Revision of the 2D model domain to incorporate the LiDAR DEM in a more flexible arrangement such that any new DEM can be efficiently incorporated at a later date;
- Conversion of the existing DRAINS pipe network to TUFLOW elements; and
- Changes to the hydrological and tailwater inputs from the various sources.

3.1 Creek Representations

The one-dimensional representation of Orphan School Creek and Green Valley Creek in the Canley Corridor TUFLOW model has been replaced with the schematisation taken from the Three Tributaries TUFLOW model (dated June 2012). With this replacement a number of new model instabilities were visible, particularly at the creek meanders. These model instabilities can be attributed to the finer grid resolution of the Canley Corridor TUFLOW model at 2 metres compared with the 10 metre resolution of the Three Tributaries TUFLOW model. To resolve the model instabilities additional 1D cross-sections have been interpolated and incorporated into the 1D representation of the creeks in the Canley Corridor TUFLOW model.

The resolution of the 1D water level lines (WLL) has also been increased to create a more refined model output. The 1D water level lines do not affect the hydraulic computations of the TUFLOW model but facilitate the representation of the 1D model results in the 2D model output. Increasing 1D water level lines resolution, particularly at the creek bends and meanders, ensures clarity with the model output and avoids gaps in the resulting flood mapping as mentioned in Section 2.4.

A comparison of the Orphan School Creek cross section locations and 100 year ARI flood extent for the provided SKM & FCS (2009) TUFLOW model and revised BMT WBM Canley Corridor TUFLOW model is provided as Figure 3-1.

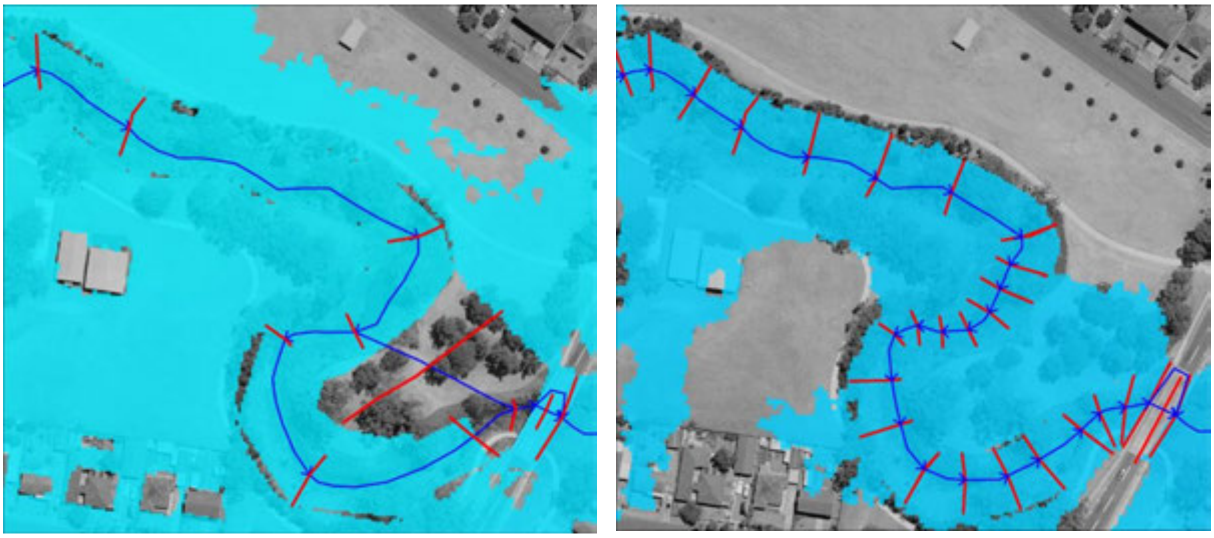


Figure 3-1 Creek Cross-Section Resolution Comparison

3.2 Building Representation

Locally increased hydraulic roughness values have been assigned to the building footprints to represent the effect of the buildings on the passage of water through the floodplain. The previous SKM & FCS (2009) TUFLOW model adopted the approach of removing the building footprints from the 2D domain.

A comparison of the results between the adopted locally increased hydraulic roughness approach and the previous approach where buildings were removed from computation has been made using for the 100 year ARI, 2 hour design storm event. This comparison for one particular property is depicted in Figure 3-2 and Figure 3-3.

These results show that the method adopted for this study (locally increased hydraulic roughness) is adequately representing the flow separation around and between the various buildings.

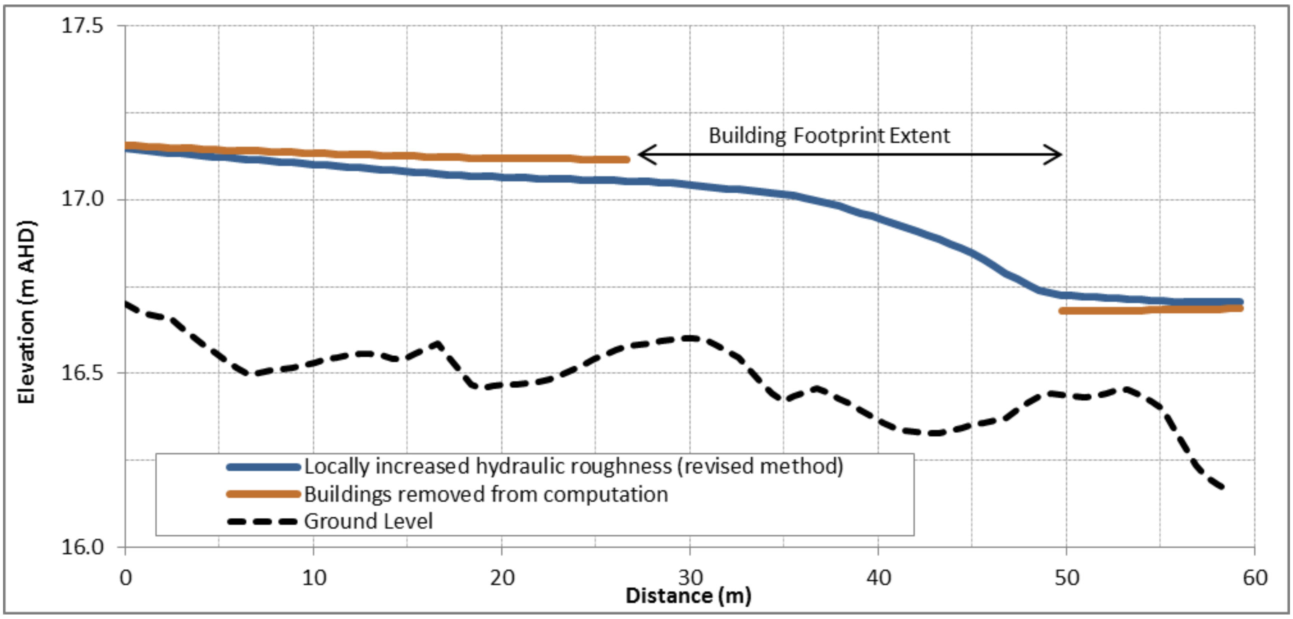
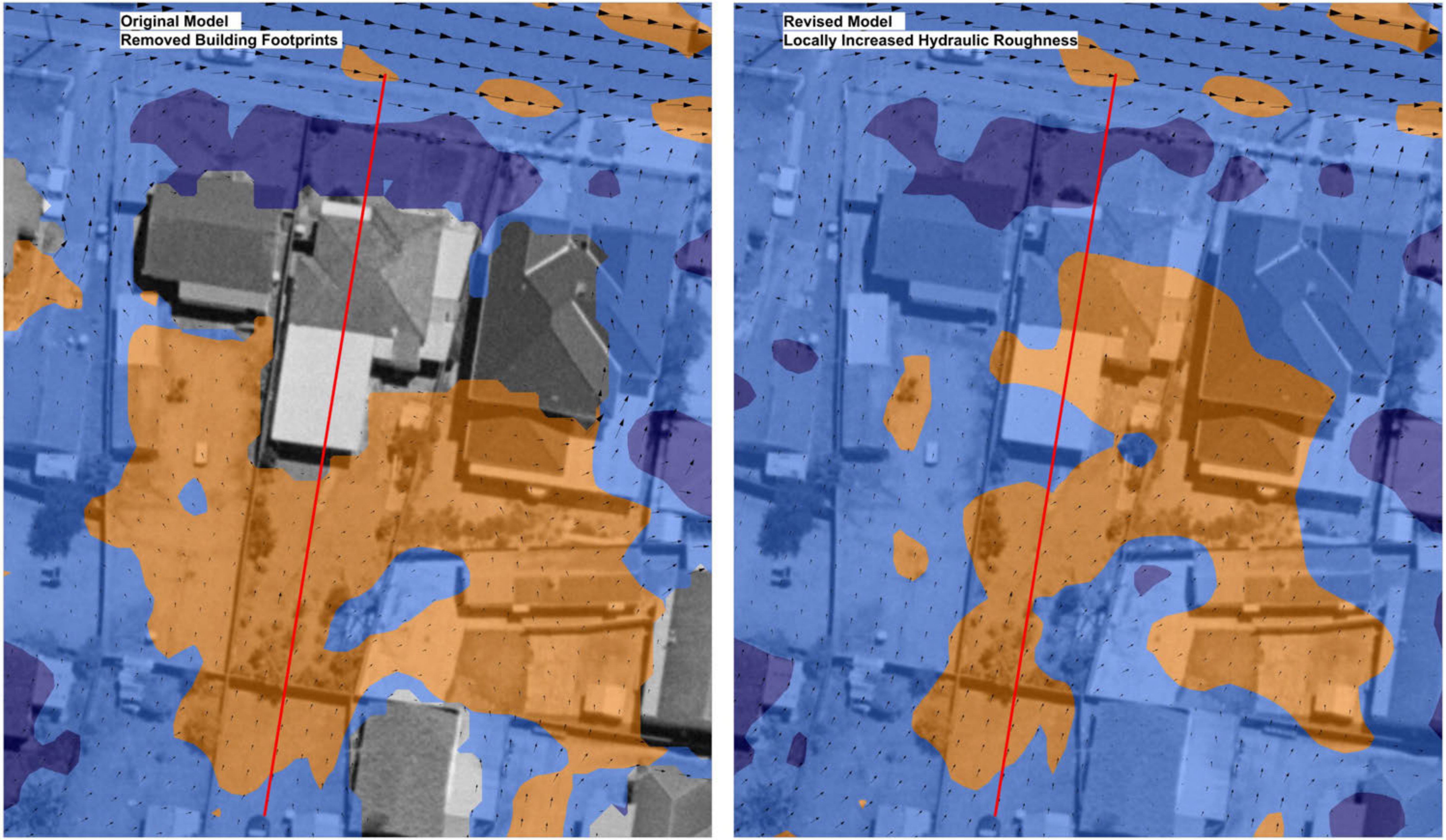


Figure 3-2 Building Cross-Section Comparison



LEGEND

Peak Flood Depths (m)

- 0.00 to 0.30
- 0.30 to 0.50
- 0.50 to 1.00

- Sampled Section
- Velocity Vectors

Title:

Results Comparison - 2 Hour, 100 Year ARI Event
Method of Building Representation

Figure: 3-3

Rev: A

N

0 5 10m
Approx. Scale

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3.3 Topography

The Canley Corridor TUFLOW model has been revised to use newer model setup procedures and directly extract topographic elevations from the DEM derived from LiDAR. The revised structure of the TUFLOW geometry control file is such that any new DEM dataset can be readily incorporated into the model in the future requiring minimal changes to the control file. This change also allows for a different cell size to be specified (should the need arise in the future) by changing one value in the TUFLOW geometry control file.

3.4 Drainage Network Representation

The stormwater drainage network of the Canley Corridor study area has been converted from the DRAINS model to TUFLOW. The drainage network is represented in TUFLOW as 1D elements dynamically linked to the 2D floodplain. Water can flow from the 2D floodplain into the underground pipe network and vice versa (surcharging) via pit inlets. The pit inlet details as specified in the DRAINS model have been set up in the TUFLOW model for consistency between modelling platforms.

The dynamic interaction between the drainage network and floodplain results in a more realistic hydraulic modelling tool for assessing a range of flood mitigation options.

3.5 Hydrograph and Boundary Condition Timing

To ensure a consistent approach with the Three Tributaries modelling, all inflow hydrographs and boundary conditions have had, following discussions with Fairfield Council, a phase shift applied so that all events commence at t=13.0 hours.

3.6 Hydrograph Inflows

3.6.1 Canley Corridor Study Area

The Canley Corridor DRAINS model is used to calculate the sub-catchment runoff hydrographs. No modification to the existing DRAINS model was required. The discharge hydrographs generated from the sub-catchment areas have been applied to the TUFLOW 2D domain at the same pit locations where they are applied in the DRAINS model. It is no longer necessary to schematise the DRAINS model with defined overflows to determine the flow to be applied to the 2D domain as this mechanism is implicitly represented in the updated TUFLOW model.

3.6.2 Orphan School Creek and Green Valley Creek

The inflow hydrographs for Orphan School Creek and Green Valley Creek have been sourced from the latest Three Tributaries TUFLOW model (dated June 2012). The time-series of discharge in the creeks have been extracted from the result files from the Three Tributaries modelling.

3.6.3 Sub-Catchment Inflows to Orphan School Creek

TUFLOW inflow hydrographs for Orphan School Creek local sub-catchments sourced from the Three Tributaries RAFTS model have been revised. RAFTS sub-catchments overlapping with the DRAINS sub-catchments have been removed. The applied inflow locations in TUFLOW have been based on the Three Tributaries TUFLOW model setup. Some of the inflow locations have been relocated to the upstream side of structures to reflect the correct inflow location of the sub-catchment (compared with the inflow location from the Three Tributaries TUFLOW model).

3.7 Impact of Modifications

The revised Canley Corridor TUFLOW model results have been compared with the provided results of the SKM & FCS (2009) TUFLOW model. The differences between the peak water level results for the 100 year ARI and PMF design events are shown in Figure 3-4 and Figure 3-5, respectively.

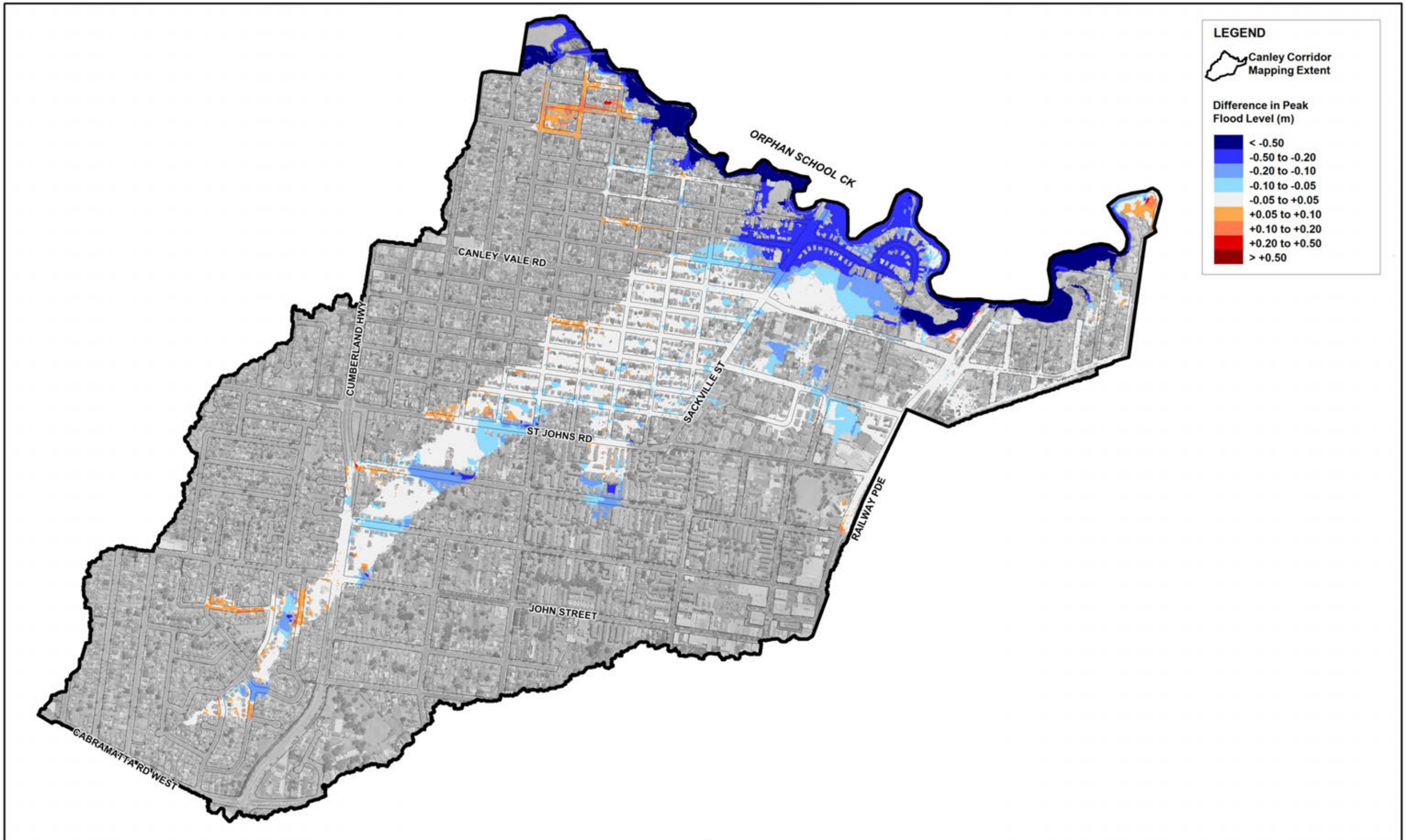
The revised Canley Corridor TUFLOW model results for the study area are generally comparable with those of the provided model for the 100 year ARI design event and generally slightly lower for the PMF design event. Notable differences between the results are as follows:

- An increase in peak water level of up to 0.20m in a localised area near the confluence of Orphan School Creek and Green Valley Creek for the 100 year ARI and PMF events which can be attributed to the dynamic interaction between the drainage network and Orphan School Creek
- An increase in peak water level of up to 0.20m within the flooded extent west of Sackville Street between Canley Vale Road and St Johns Road for the PMF event.
- Decreases in peak water levels of up to 1.2m along Orphan School Creek and Green Valley Creek. This can be attributed to the reduction in discharge in both creeks arising from the Three Tributaries TUFLOW modelling. A major development in the Three Tributaries modelling is the inclusion of various detention basins, resulting in an attenuation of flow at the upstream extent of the Canley Corridor TUFLOW model.
- A comparison between the hydrographs being applied at the upstream of Orphan School Creek and Green Valley Creek for the 90 minute, 100 year ARI design event is provided in Figure 3-6 and Figure 3-7. The revised model applies lower peak flows to the upstream of both of the creeks which has resulted in these lower peak water levels along Orphan School Creek which forms the downstream extent of the Canley Corridor study area.
- For both design events compared, the revised Canley Corridor TUFLOW model produces water levels up to 1.2m higher along Orphan School Creek at the downstream boundary. This has resulted from correction of the timing of the downstream boundary tailwater level outlined in Section 3.5. The existing TUFLOW model applied a constant water level of 1.3 m for the 100 year ARI design events for storm durations greater than 1 hour. The revised TUFLOW model applies a dynamic water level boundary reaching 4.73m for the same design events. The correction made to the timing of the hydrographs has resulted in the Prospect Creek water levels being correctly represented with higher water levels being applied.

The variations across the study area can be attributed to the changes made to the TUFLOW model, specifically:

- the inclusion of the building footprints (see Section 2.4.3);
- the inclusion of the pit and pipe network in TUFLOW (see Section 3.4); and
- modifications made to derivation of local sub-catchment inflows (see Section 3.6.1).

The changes incorporated into the model as a result of the review have resulted in a robust and fit for purpose tool for the purpose of undertaking a Floodplain Risk Management Study. The TUFLOW model can be readily adapted and modified to incorporate new data in the future (e.g. change of land use, new development).



Title:

Maximum Water Level Result Comparison
100 Year ARI Event

Figure: 3-4

Rev: A

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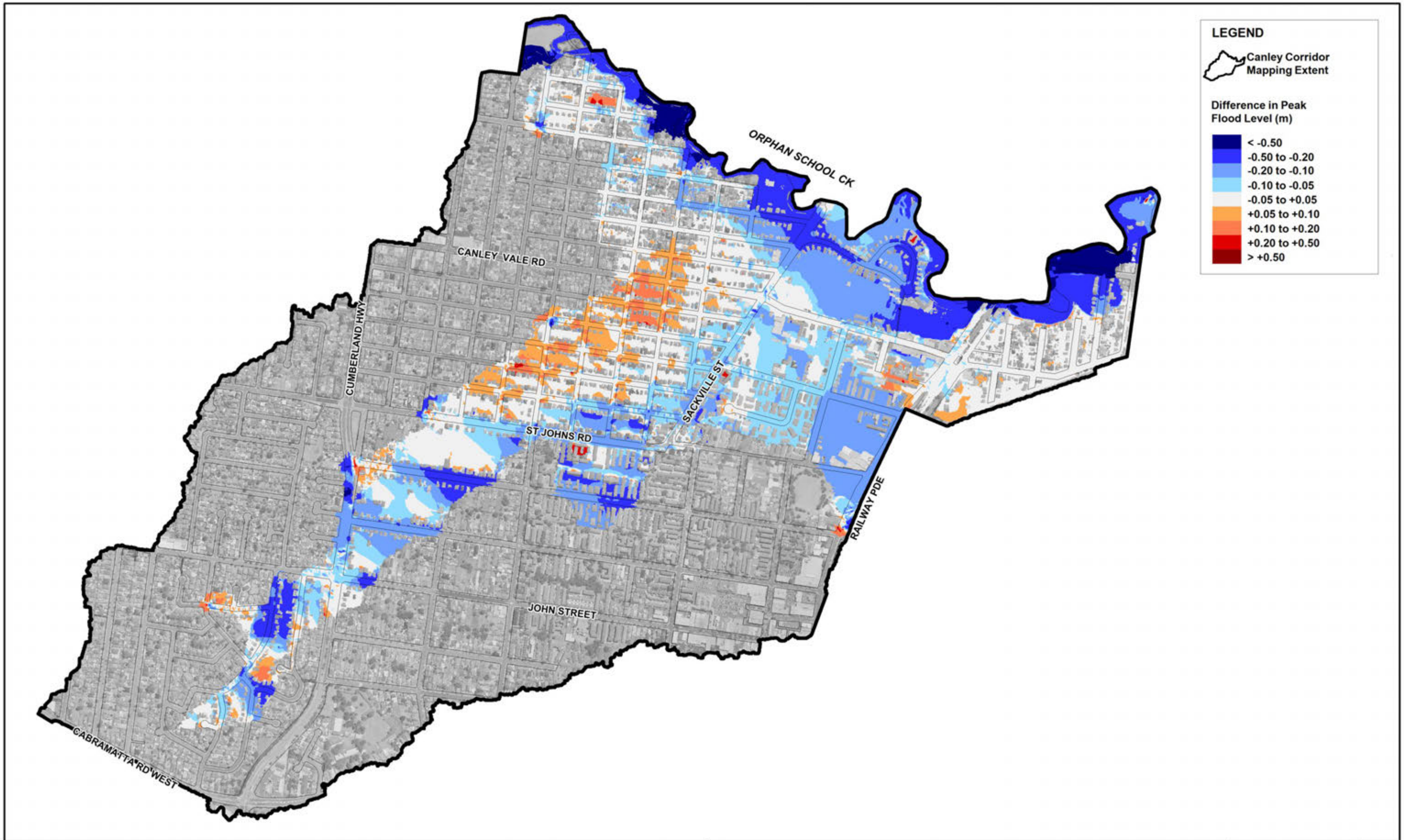

Title:

Maximum Water Level Result Comparison
PMF Event

Figure: 3-5

Rev: A

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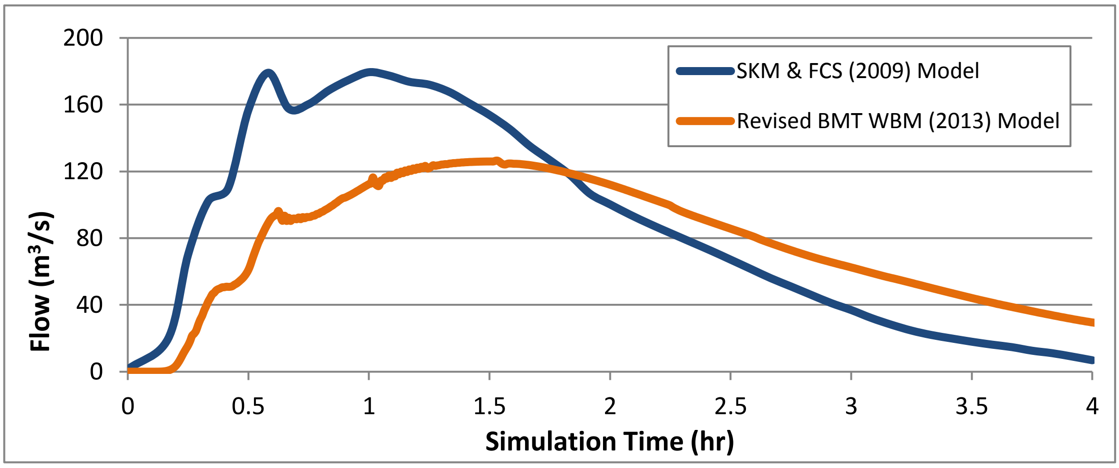

Figure 3-6 Orphan School Creek at Kings Road – TUFLOW Inflow Hydrograph
100 Year ARI, 90 minute event

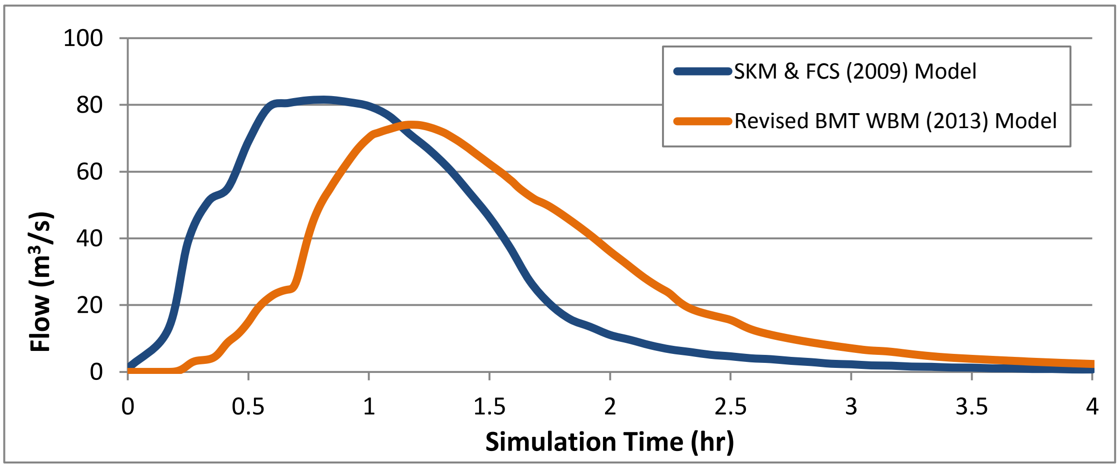

Figure 3-7 Green Valley Creek at Avoca Road – TUFLOW Inflow Hydrograph
100 Year ARI, 90 minute event

Notes:

SKM & FCS (2009) Model inflows were derived from the previous Three Tributaries XP-RAFTS model

The Revised BMT WBM (2013) Model inflows have been derived from the revised Three Tributaries TUFLOW model

4 DESIGN EVENT MODELLING

The updated Canley Corridor TUFLOW model has been used to simulate the 5, 20 and 100 year ARI and PMF design events for numerous standard durations. The TUFLOW model sources inflow hydrographs from a number of sources including the Canley Corridor DRAINS model, Three Tributaries TUFLOW model and Three Tributaries RAFTS model, along with sourcing the downstream boundary tailwater level representative of Prospect Creek from the Three Tributaries TUFLOW model. The combination of ARI's and durations for the local catchment (i.e. Canley Corridor), the various inflow hydrograph sources and the downstream boundary are summarised below in Table 4-1.

Table 4-1 ARI and Duration Combinations

(all durations are given in minutes)

ARI	Duration	Canley Corridor Local Catchment (DRAINS)	Orphan School Ck Main Inflows (3 Tribs TUFLOW)	Orphan School Ck Residual catchments (3 Tribs RAFTS)	Prospect Creek Tailwater Level
5	5	5	25	25	nil
	15	15	25	25	nil
	20	20	25	25	nil
	25	25	25	25	nil
	30	30	30	30	nil
	45	45	30	30	nil
	60	60	60	60	nil
	90	90	90	90	nil
	120	120	120	120	nil
20	5	5	25	25	25
	15	15	25	25	25
	20	20	25	25	25
	25	25	25	25	25
	30	30	30	30	25
	45	45	30	30	25
	60	60	60	60	25
	90	90	90	90	120
	120	120	120	120	120
100	5	5	25	25	25
	15	15	25	25	25
	20	20	25	25	25
	25	25	25	25	25
	30	30	30	30	25
	45	45	30	30	25
	60	60	60	60	25
	90	90	90	90	120
	120	120	120	120	120
PMF	15	15	Q100, 25min	Q100, 25min	Q100, 25min
	30	30	Q100, 30min	Q100, 30min	Q100, 25min
	45	45	Q100, 30min	Q100, 30min	Q100, 25min
	60	60	Q100, 60min	Q100, 60min	Q100, 25min
	90	90	Q100, 90min	Q100, 90min	Q100, 120min
	120	120	Q100, 120min	Q100, 120min	Q100, 120min

These combinations have been based on recent advice from Fairfield Council and the specific combinations used in the original SKM flood study for Canley Corridor. The adopted combinations ensure that consistency is maintained between the Canley Corridor study area and other overland flow catchments within Fairfield City Council which assumes:

- a concurrent flood in Prospect Creek which is of the same ARI as the event in the local catchment, with the exception of the local catchment PMF;
- a concurrent flood in Orphan School Creek (i.e. Three Tributaries catchment) which is of the same ARI as the event in the local catchment, with the exception of the local catchment PMF.

Furthermore, these combinations ensure consistency with modelling undertaken for SKM & FCS, 2009.

Outputs from the revised Canley Corridor modelling provide flood levels and extents for the overland flow flooding mechanism and does not replace flood levels derived from mainstream flooding.

5 FLOOD MAPPING

5.1 Mapping Methodology

The updated TUFLOW model calculates flood conditions on 2 metre intervals and outputs results on a 1 metre grid over the study area. These results include flood levels, flood depths, and flow velocities at regular time intervals throughout the flood simulation, as well as peak values. These grids can be interrogated at any point within the study area using a GIS database, such as MapInfo.

An envelope approach has been used for mapping purposes where the peak of peaks results from all simulated model durations are calculated for each design ARI event. This accounts for the variation in critical storm duration across the catchment.

5.2 Design Flood Maps

The design flood maps for local catchment flooding events are presented in Appendices A to D:

- Peak flood levels for the 5, 20, 100, year ARI and PMF (Figures A-1 to A-4);
- Peak flood depths for the 5, 20, 100, year ARI and PMF (Figures B-1 to B-4);
- Peak flow velocities for the 5, 20, 100, year ARI and PMF (Figures C-1 to C-4); and
- Flood hazard categories for the 5, 20, 100, year ARI and PMF (Figures D-1 to D-4).

The flood mapping of all design storm events have been provided to Council digitally for incorporation into their GIS database.

Flood hazard categorisation has been based on peak depth and velocity criteria as outlined in the *Floodplain Development Manual* (NSW Government, 2005) with *Figure L1* and *Figure L2* of the FDM reproduced in Figure 5-1.

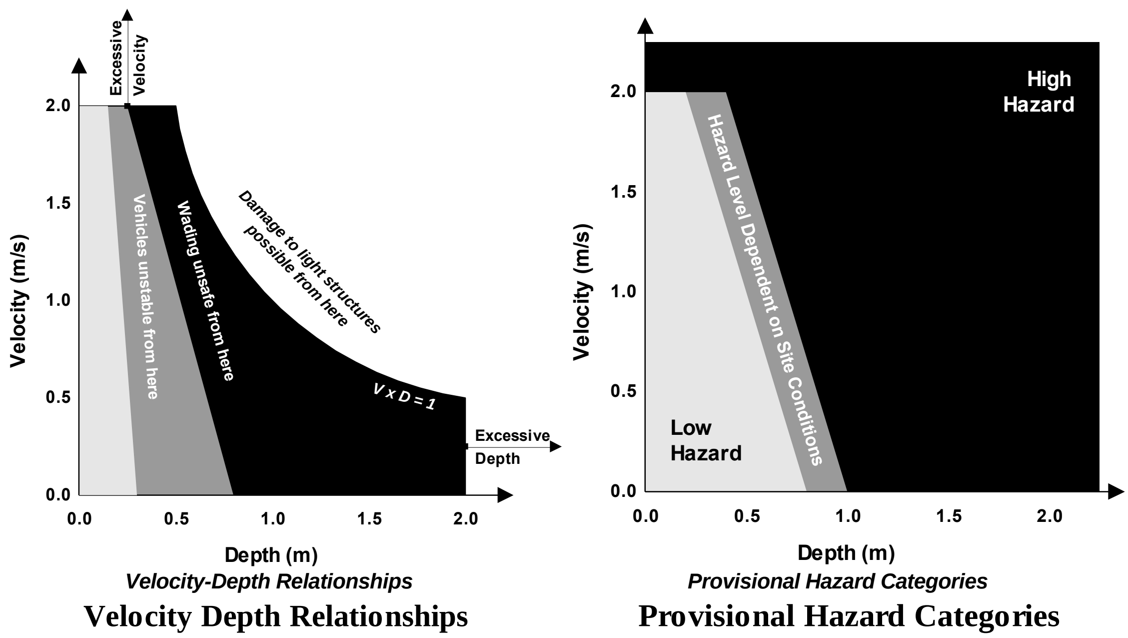

Figure 5-1 Provisional Hydraulic Hazard Categories (NSW Government, 2005)

5.3 Provisional Flood Risk Precinct Map

The floodplain has been divided into three provisional flood risk precincts: high, medium and low. The three (provisional) flood risk precincts have been based on definitions outlined in the Fairfield City Wide Development Control Plan (2013) summarised in Table 5-1. Fairfield City Council also define a *Zone of Significant Flow* which is described in Table 5-1.

Appendix E presents the **Provisional Flood Risk Precinct Map** for the Canley Corridor catchment. It has been derived by compilation of the design flood conditions for catchment runoff events only, excluding Orphan School Creek flooding. It is noted that potential evacuation constraints have not been taken into account as this will be considered as part of the floodplain risk management study. The previously identified Zone of Significant Flow has not been included in the provisional flood risk precinct map at this stage and will also be assessed in more detail as part of the FRMS. Therefore, the flood risk precincts on Figure E-1 should be considered provisional.

Table 5-1 Provisional Flood Risk Categorisation for Fairfield City Council

Flood Risk Category	Description
High Flood Risk	Land below the 100 year flood that is either subject to high hydraulic hazard or where there are significant evacuation difficulties
Medium Flood Risk	Land below the 100 year flood level that is not subject to high hydraulic hazard and where there are no significant evacuation difficulties
Low Flood Risk	All other land within the floodplain (i.e. within the PMF extent) but not identified as either in a high flood risk precinct or medium flood risk precinct
Zone of Significant Flow	The area of the floodplain where a significant discharge of water occurs during floods. Should the area within this boundary be fully or partially blocked, a significant distribution of flood flows or increase in flood levels would occur.

6 CLIMATE CHANGE ASSESSMENT

There is increasing evidence that the earth's atmospheric and ocean temperatures have increased over the last century and that accumulation of greenhouse gases in the earth's environment may accelerate this process. Future climate change can potentially affect flood behaviour through:

- Increased sea levels; and
- Increased severity of storms and other weather systems.

The NSW Government has previously advocated sea level rise planning benchmarks to be considered in all coastal and flood hazard assessments (NSW Government, October 2009 and NSW Government, August 2010). The NSW sea level rise planning benchmarks are an increase above 1990 mean sea levels of 40cm by 2050 and 90cm by 2100. The NSW Government has since ceased to advocate these sea level rise planning benchmarks but they remain the best available estimates for accounting for sea level rise due to climate change and have therefore been adopted for this study.

The impact of climate change on rainfall is less certain. Evidence to date suggests that whilst mean annual rainfall over Australia is likely to reduce, the intensity of extreme daily rainfall could increase. The CSIRO predicts the effects of climate change to result in increases in rainfall of up to 12% by 2070 (CSIRO, February 2007).

Climate change sensitivity assessments in NSW are often conducted by considering the impact of an increase in rainfall intensity on flooding. As the Canley Corridor TUFLOW model utilises inflow hydrographs from a variety of sources it was not possible to directly model an increase in rainfall intensity. As an alternative the inflow hydrographs from the various sources (Canley Corridor DRAINS model, Three Tributaries TUFLOW model and Three Tributaries RAFTS model) were increased. Note a percentage increase applied to inflow hydrographs is not equivalent to an equal percentage increase in rainfall intensity. In reality the impact of an increase in rainfall intensity on rainfall runoff is dependent upon catchment conditions.

A climate change sensitivity assessment for the Canley Corridor catchment was undertaken to estimate the potential impact of a 10%, 20% and 30% increase in rainfall runoff (as applied to the inflow hydrographs) on stormwater flooding. The assessment was undertaken for the 100 year ARI design event simulating the range of standard durations modelled from 5 minutes to 120 minutes. The downstream water level boundary condition representative of Prospect Creek was not modified from the design event. Prospect Creek peaks much later than the Canley Corridor and Orphan School Creek (3 Tributaries) catchments and represents mainstream flooding which is not the focus considered in this study.

The peak water level results for each of the climate change scenarios were compared to 100 year ARI design event as illustrated in Figures F-1 to F-3.

Typical flood level increases of 0.05m, 0.10m and 0.15m for the 10%, 20% and 30% scenarios are evident across the majority of the Canley Corridor catchment. The largest increases in peak water levels are evident along Orphan School Creek. These increases range from approximately 0.20m, 0.35m and 0.55m for the 10%, 20% and 30% scenarios upstream of the Rail line.

Similar increases in flood levels are apparent at the intersection of Sackville Street and Freeman Avenue with increases ranging from 0.15m, 0.35m and 0.35m for the 10%, 20% and 30% scenarios.

The results of the climate change analysis highlight the sensitivity of the peak flood level conditions in the Canley Corridor study area to potential impacts of climate change. Future planning and floodplain risk management in the catchment will need to take due consideration of the increasing flood risk under possible future climate conditions.

7 CONCLUSION

The objective of this review was to ensure the modelling tool was suitable for undertaking assessments as part of the Canley Corridor Floodplain Risk Management Study and Plan.

The review of the existing hydraulic modelling tool identified a number of specific items that required modification in order to create a tool that was considered fit-for-purpose. The subsequent modifications made to the modelling tool have resulted in a robust tool suitable for use in the Floodplain Risk Management Study and for future Council uses. Furthermore, this modelling tool can be readily adapted to incorporate new data if such data becomes available in the future.

It is recommended that the modifications to the hydraulic model implemented as part of this review be considered for Council's other stormwater catchments to ensure consistency across the LGA.

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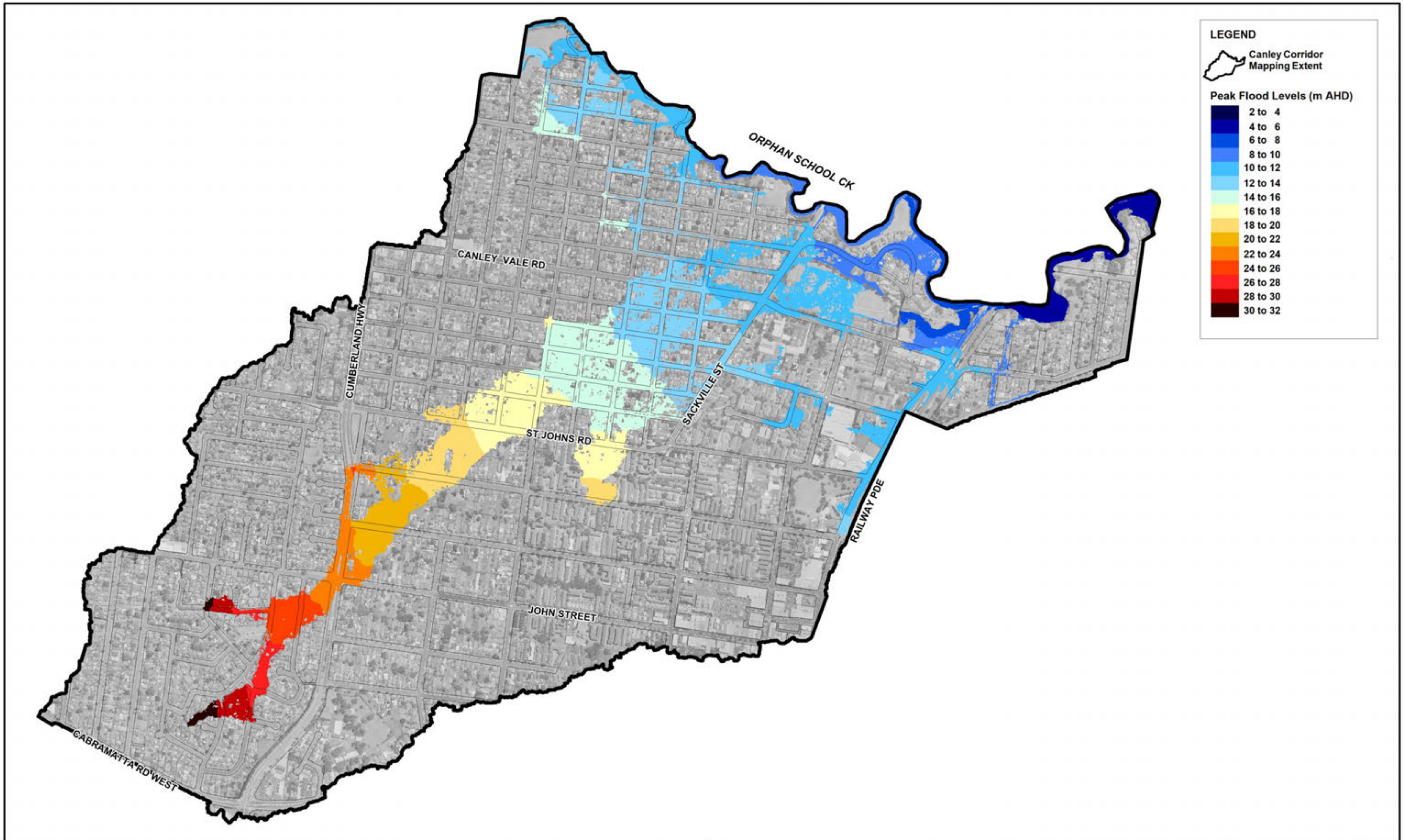
APPENDIX A: PEAK FLOOD LEVEL MAPS



Title:

Modelled Peak Flood Levels - 5 Year ARI Event

Figure: **A-1**

Rev: **A**

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N

0 250 500m

Approx. Scale

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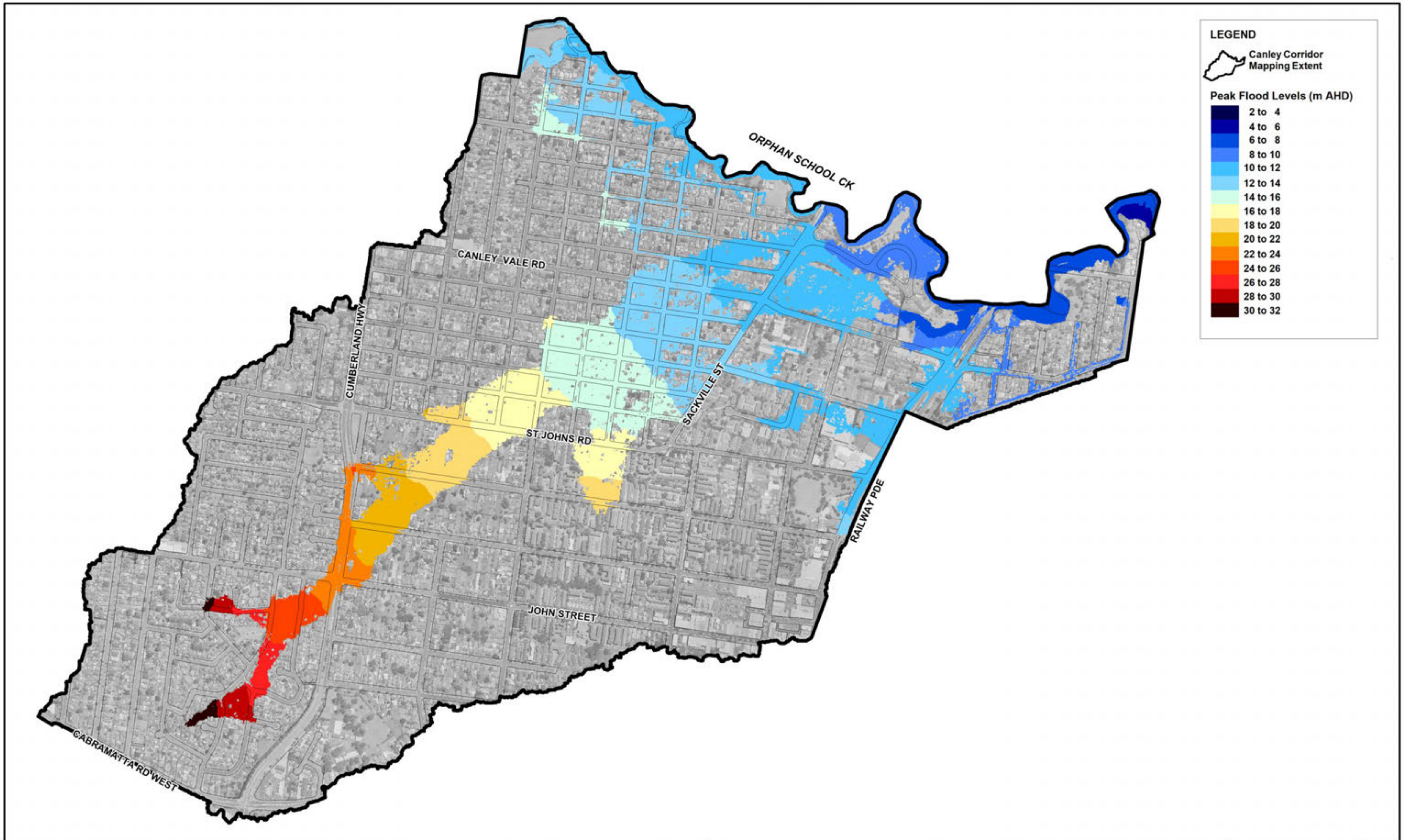

Title:
Modelled Peak Flood Levels - 20 Year ARI Event

Figure: A-2

Rev: A

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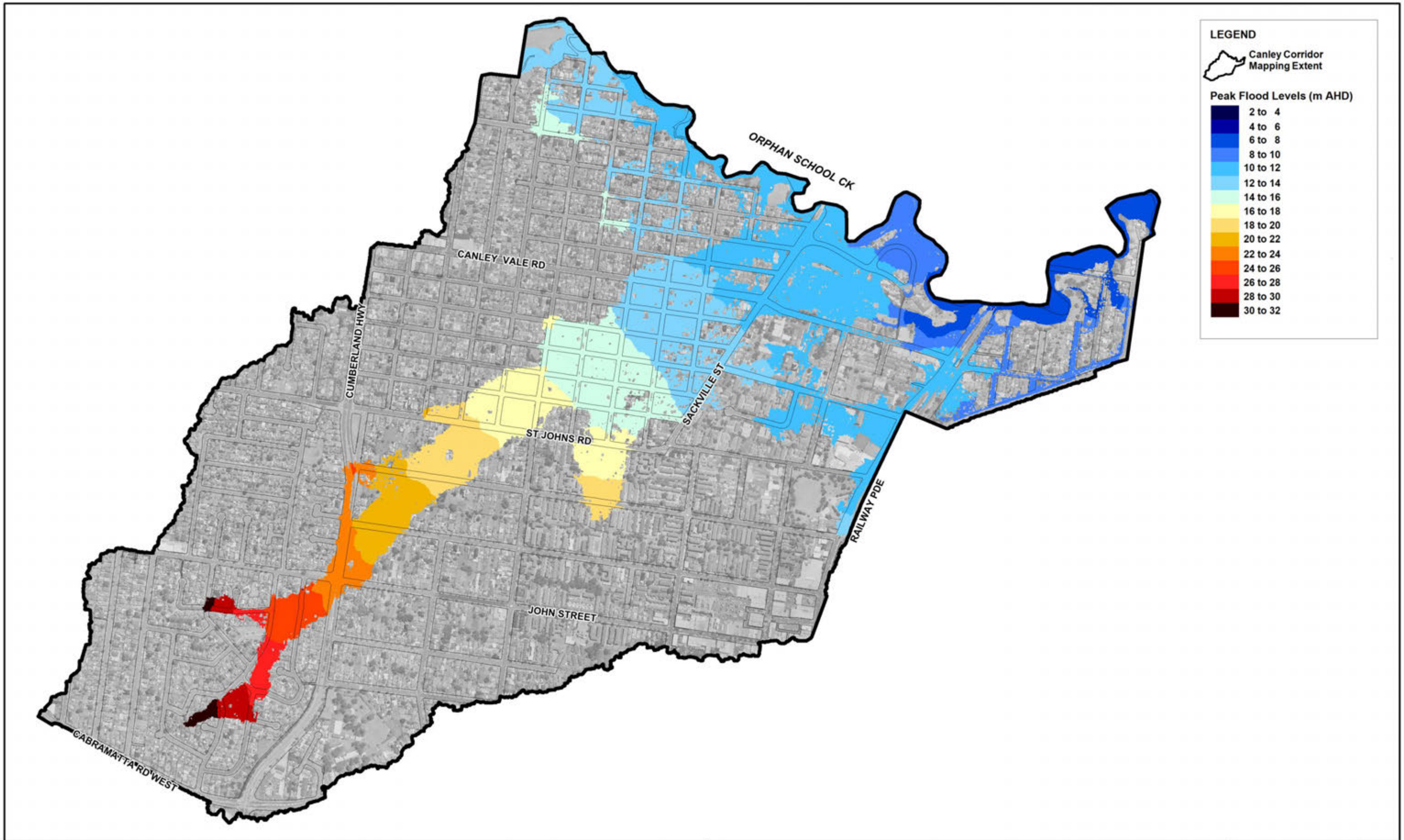

Title:
Modelled Peak Flood Levels - 100 Year ARI Event

Figure: A-3

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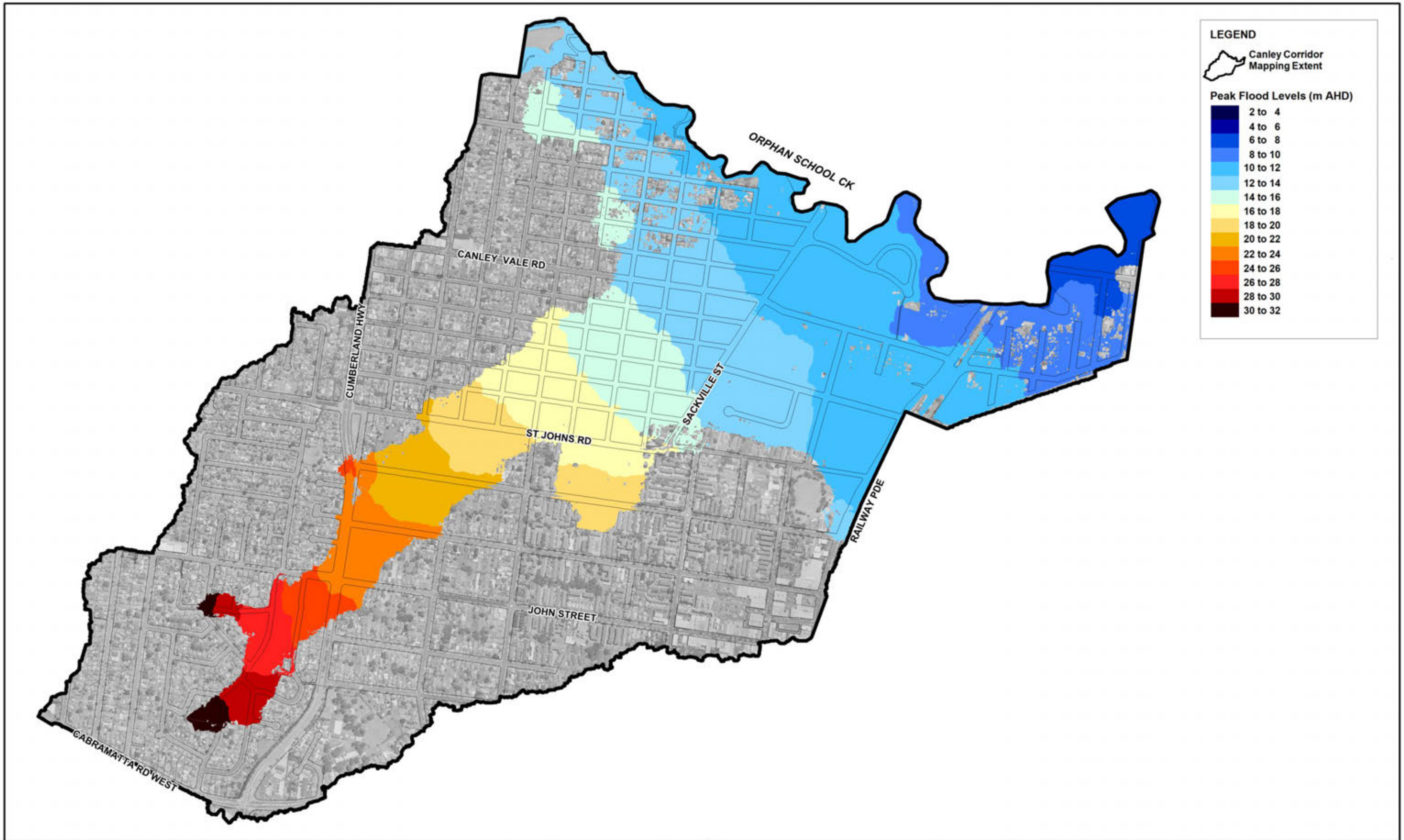

Title:
Modelled Peak Flood Levels - PMF Event

Figure: A-4

Rev: A

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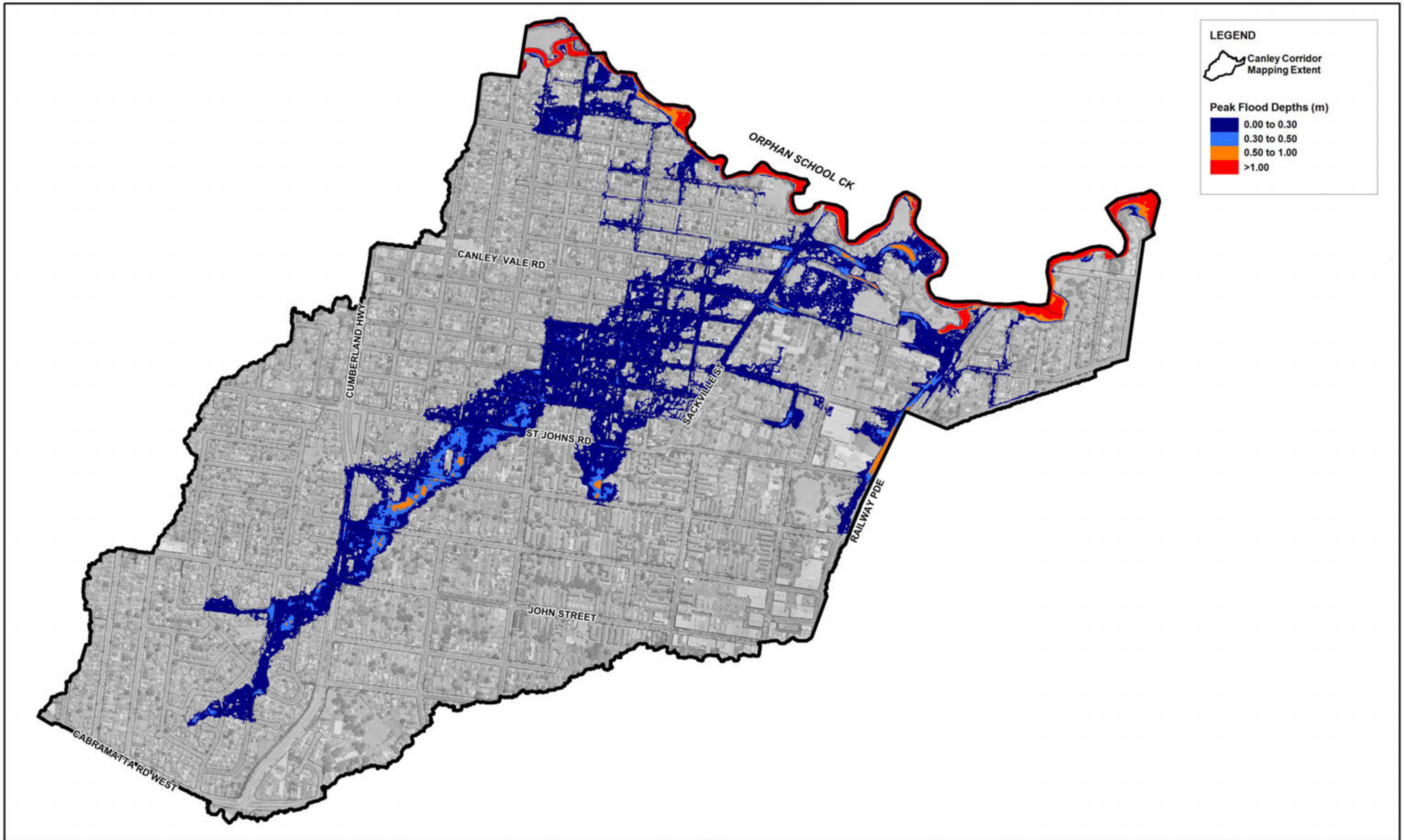
APPENDIX B: PEAK FLOOD DEPTH MAPS



Title:
Modelled Peak Flood Depths - 5 Year ARI Event

Figure: **B-1**

Rev: **A**

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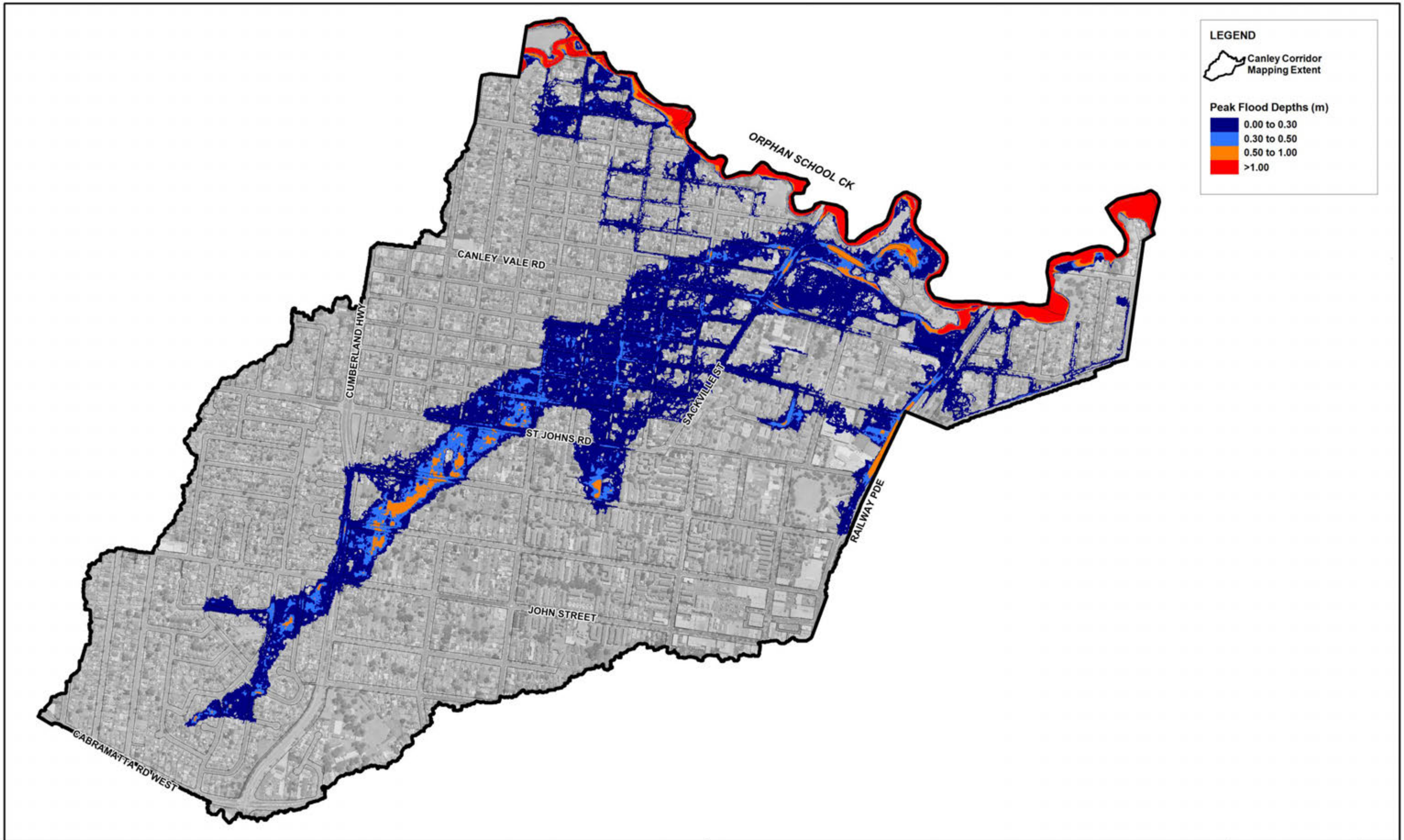

Title:
Modelled Peak Flood Depths - 20 Year ARI Event

Figure: B-2

Rev: A

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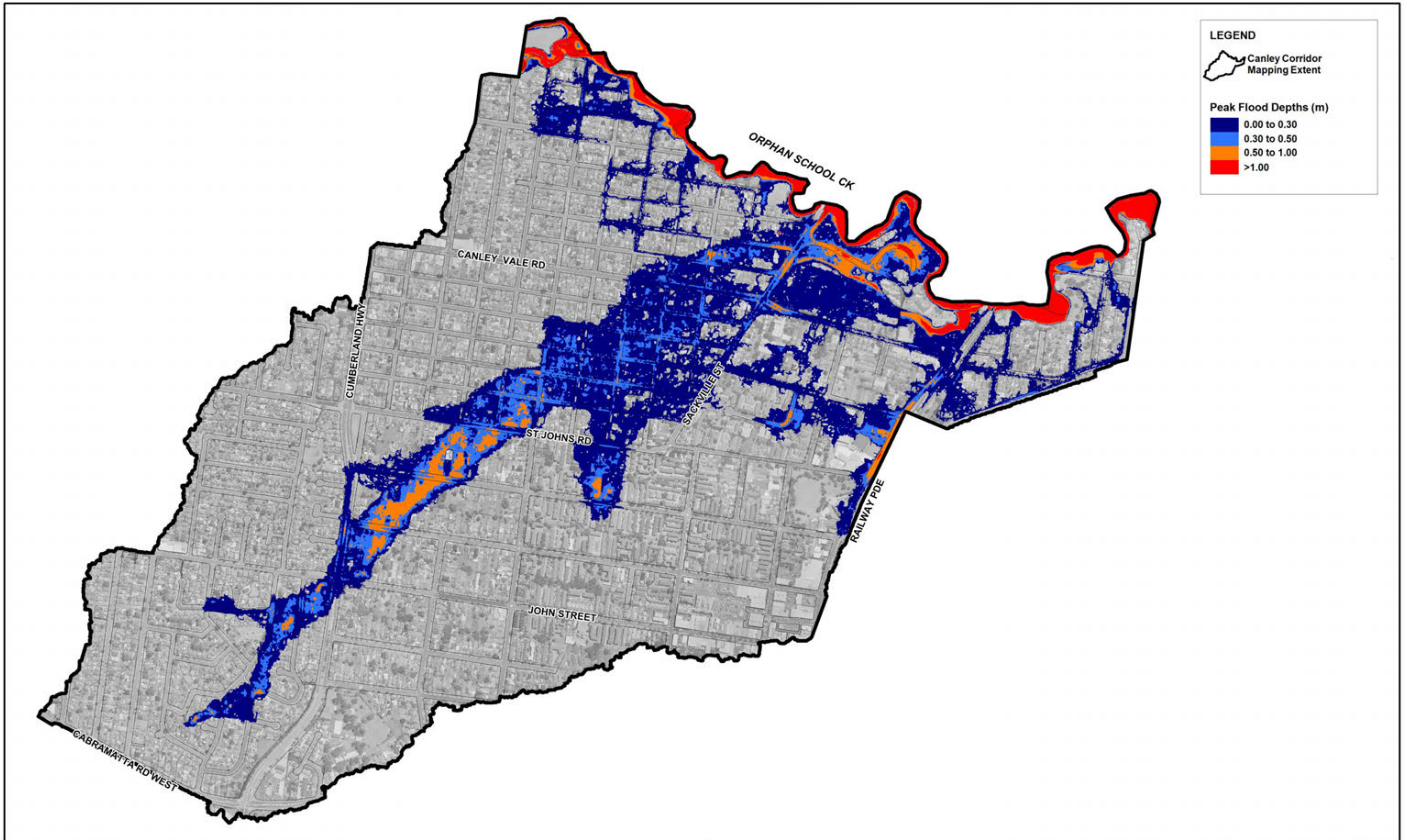

Title:
Modelled Peak Flood Depths - 100 Year ARI Event

Figure: **B-3**

Rev: **A**

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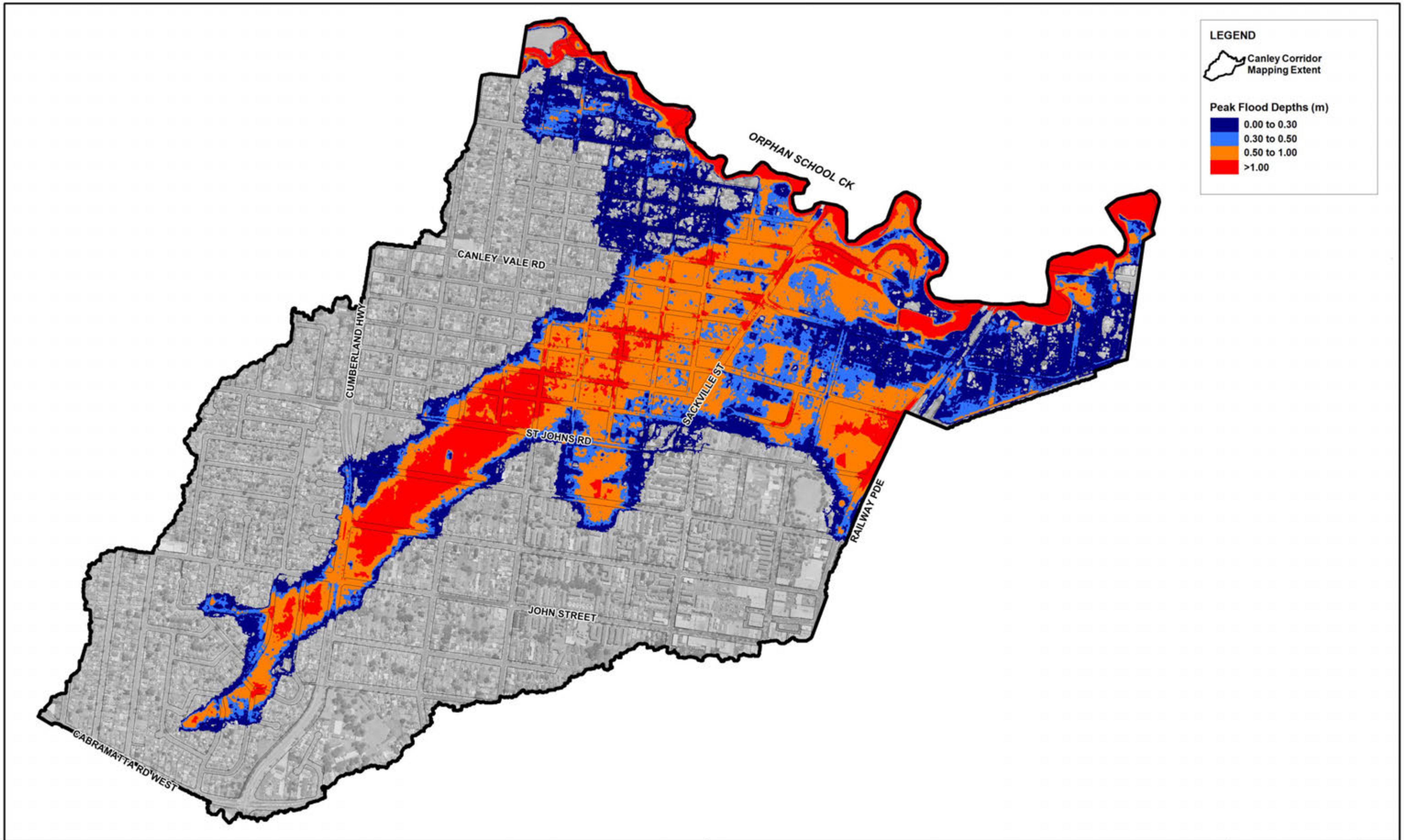

Title:
Modelled Peak Flood Depths - PMF Event

Figure: B-4

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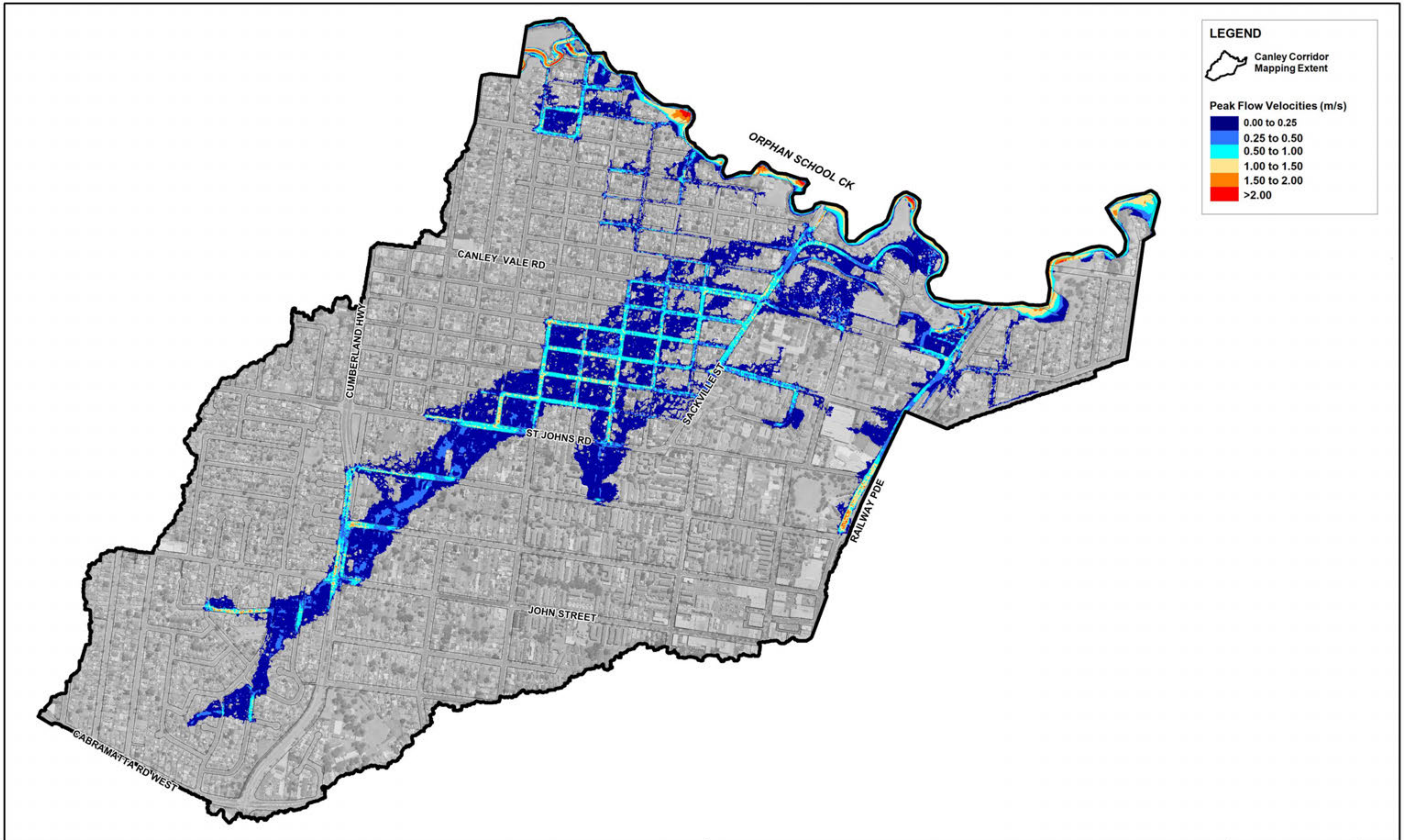
APPENDIX C: PEAK FLOW VELOCITY MAPS



Title:
Modelled Peak Flood Velocities - 5 Year ARI Event

Figure: C-1

Rev: A

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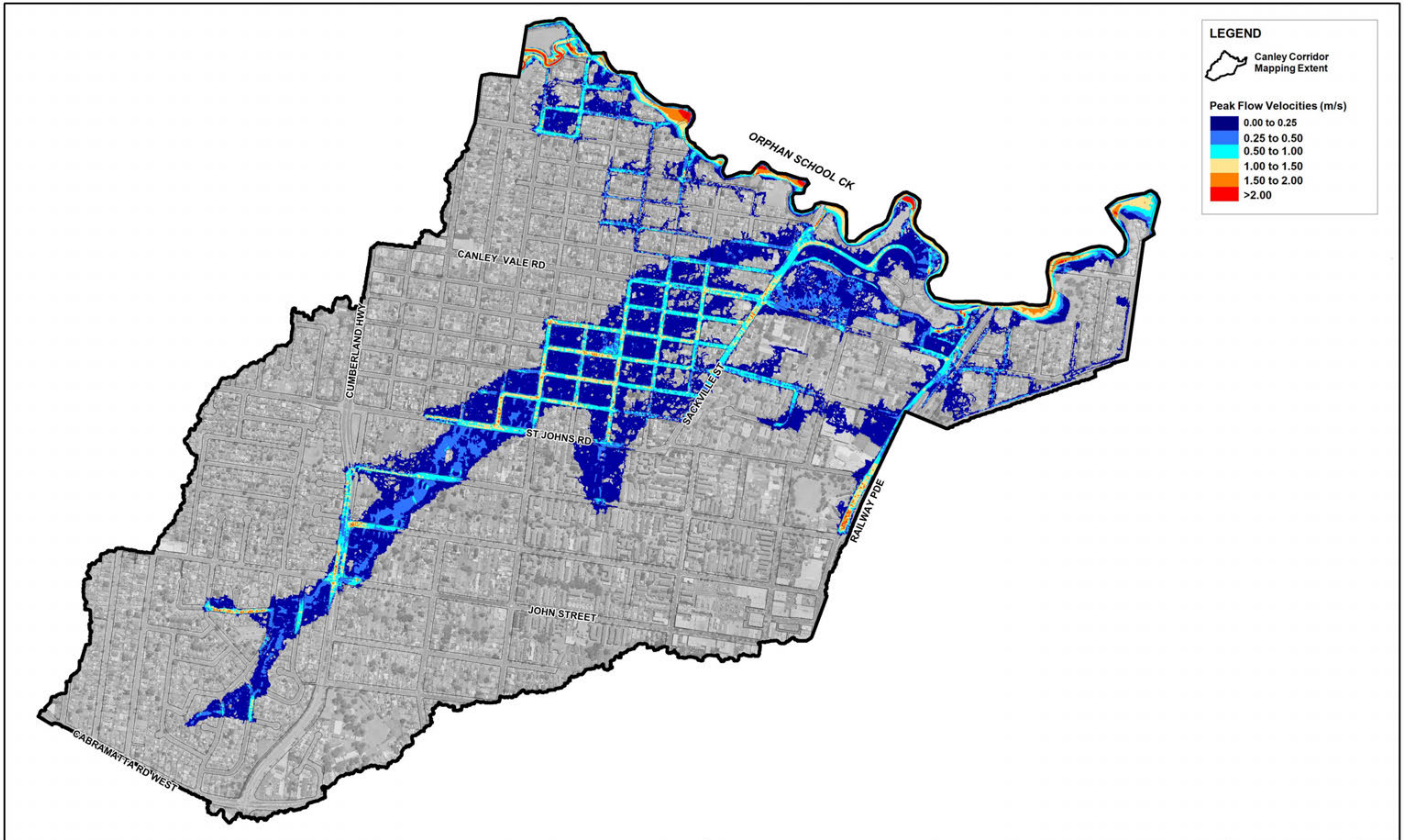

Title:

Modelled Peak Flood Velocities - 20 Year ARI Event

Figure: C-2

Rev: A

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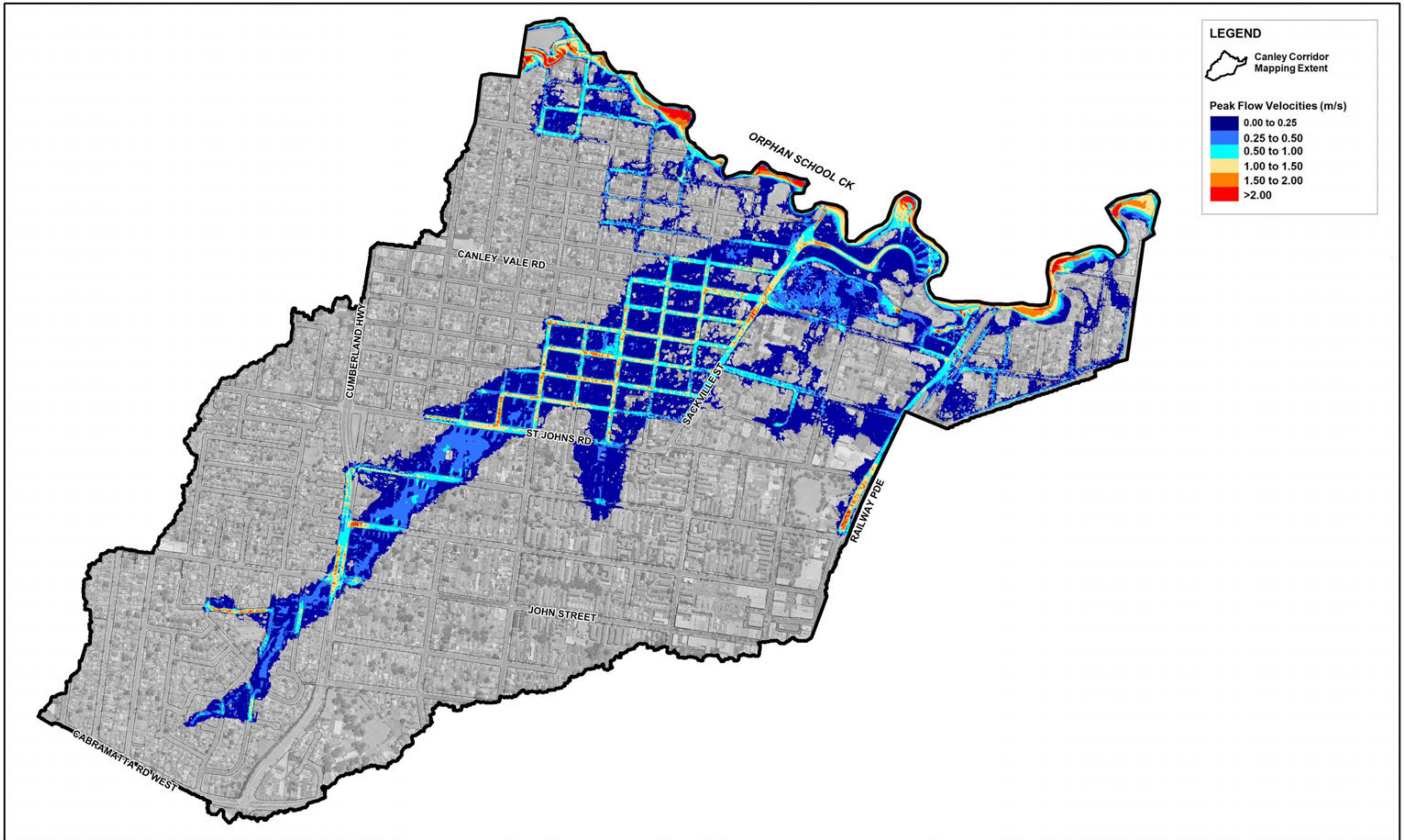

Title:
Modelled Peak Flood Velocities - 100 Year ARI Event

Figure: C-3

Rev: A

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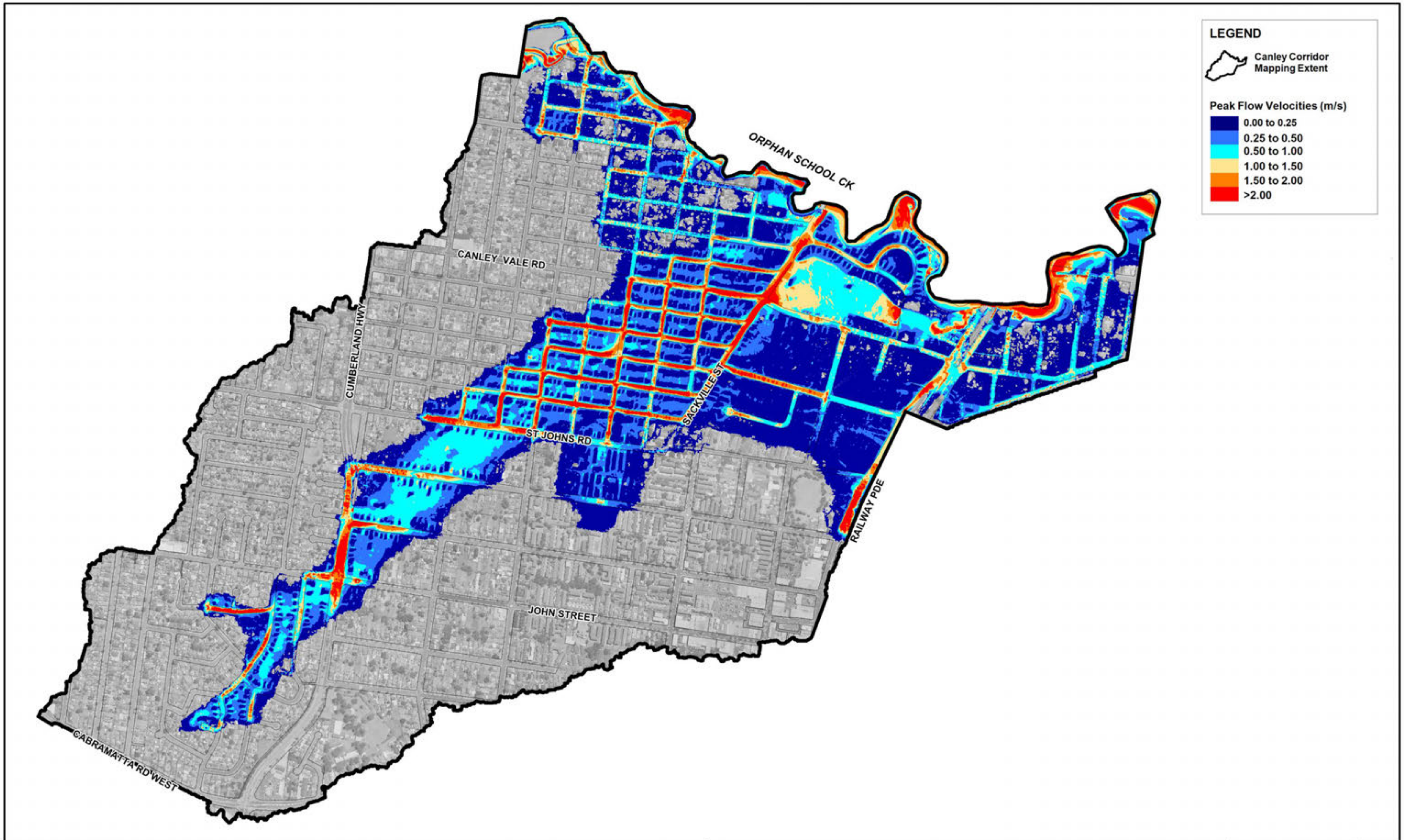

Title:
Modelled Peak Flood Velocities - PMF Event

Figure: **C-4**

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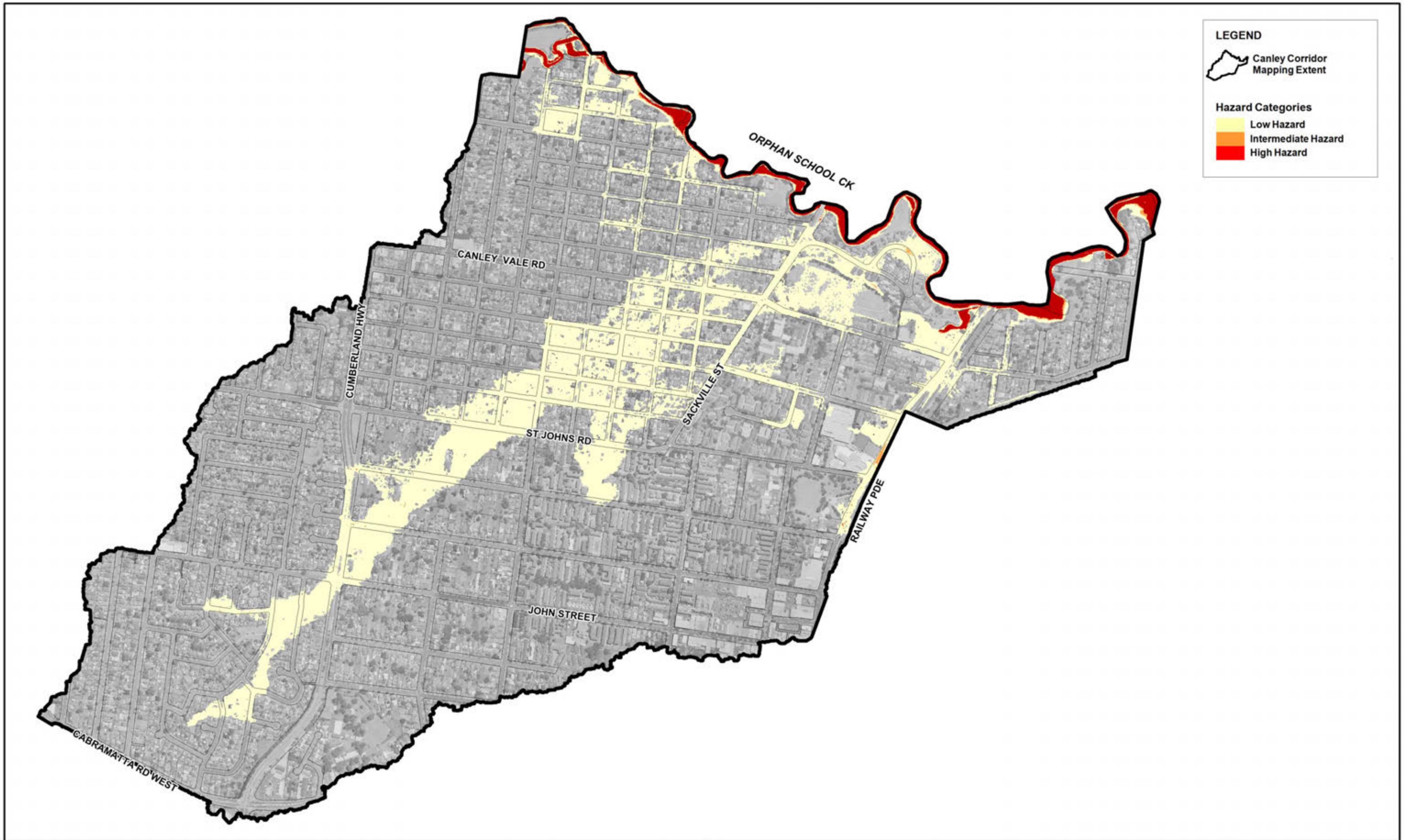
APPENDIX D: FLOOD HAZARD CATEGORY MAPS



Title:
Flood Hazard Categories - 5 Year ARI Event

Figure: D-1

Rev: A

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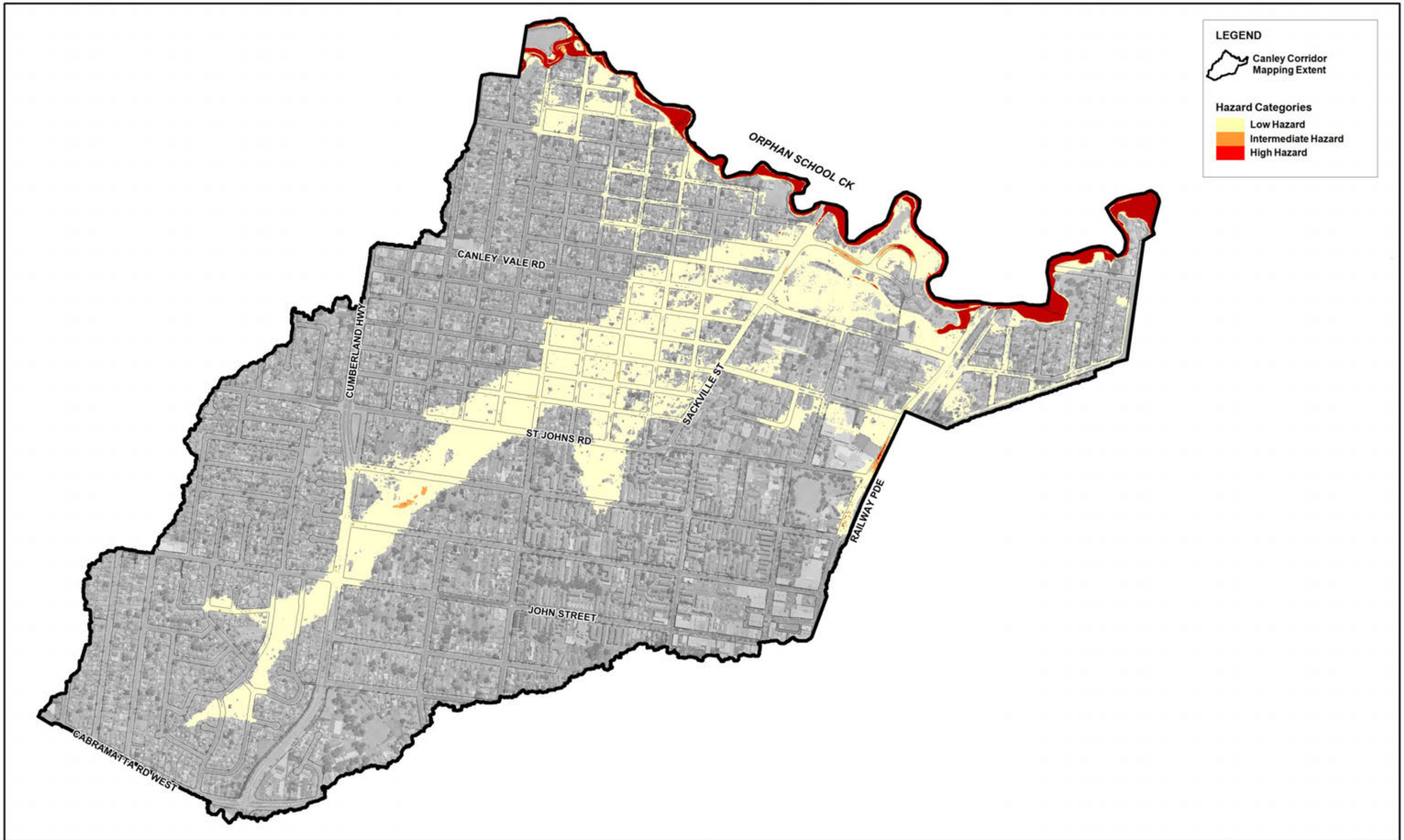

Title:

Flood Hazard Categories - 20 Year ARI Event

Figure: D-2

Rev: A

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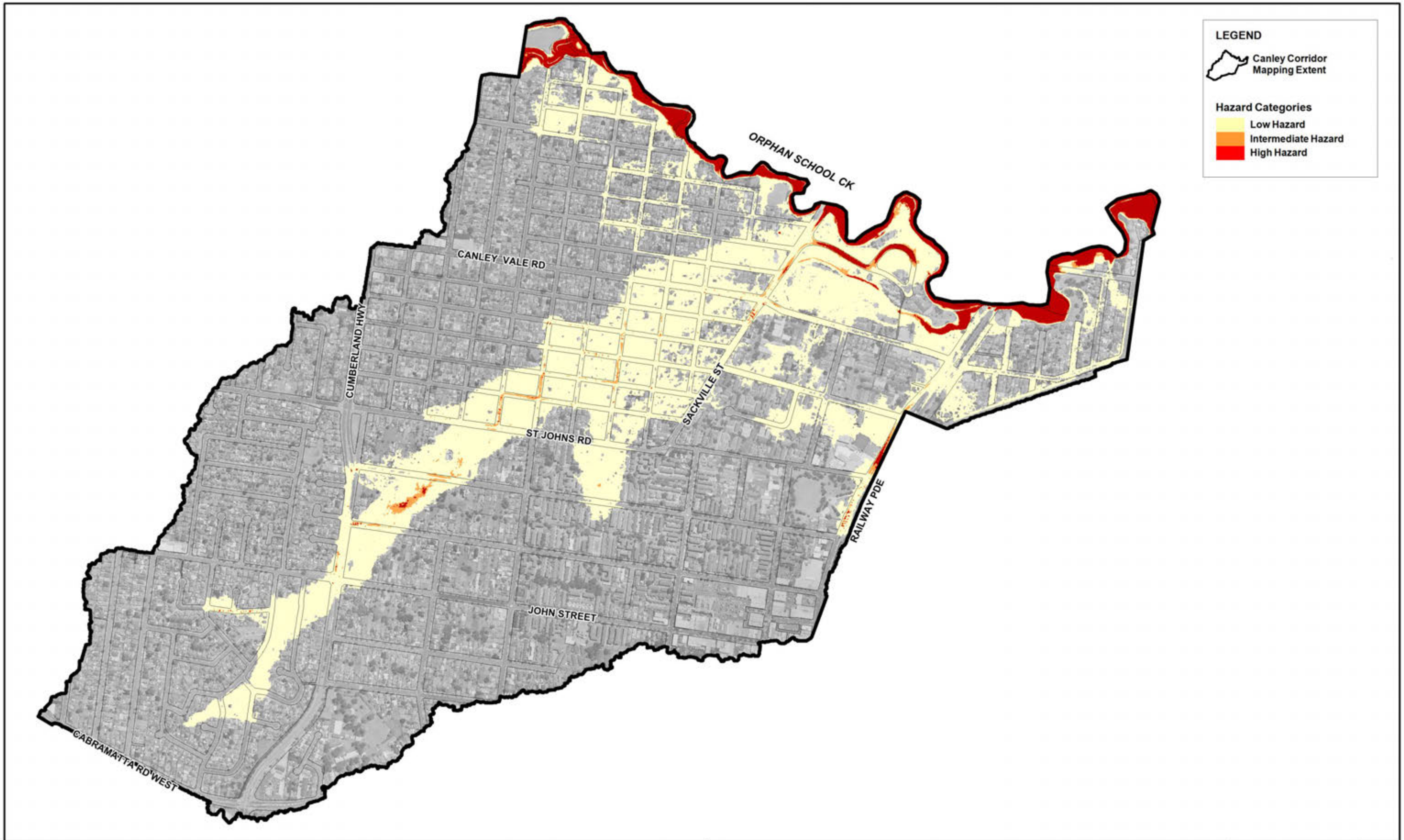

Title:
Flood Hazard Categories - 100 Year ARI Event

Figure: D-3

Rev: A

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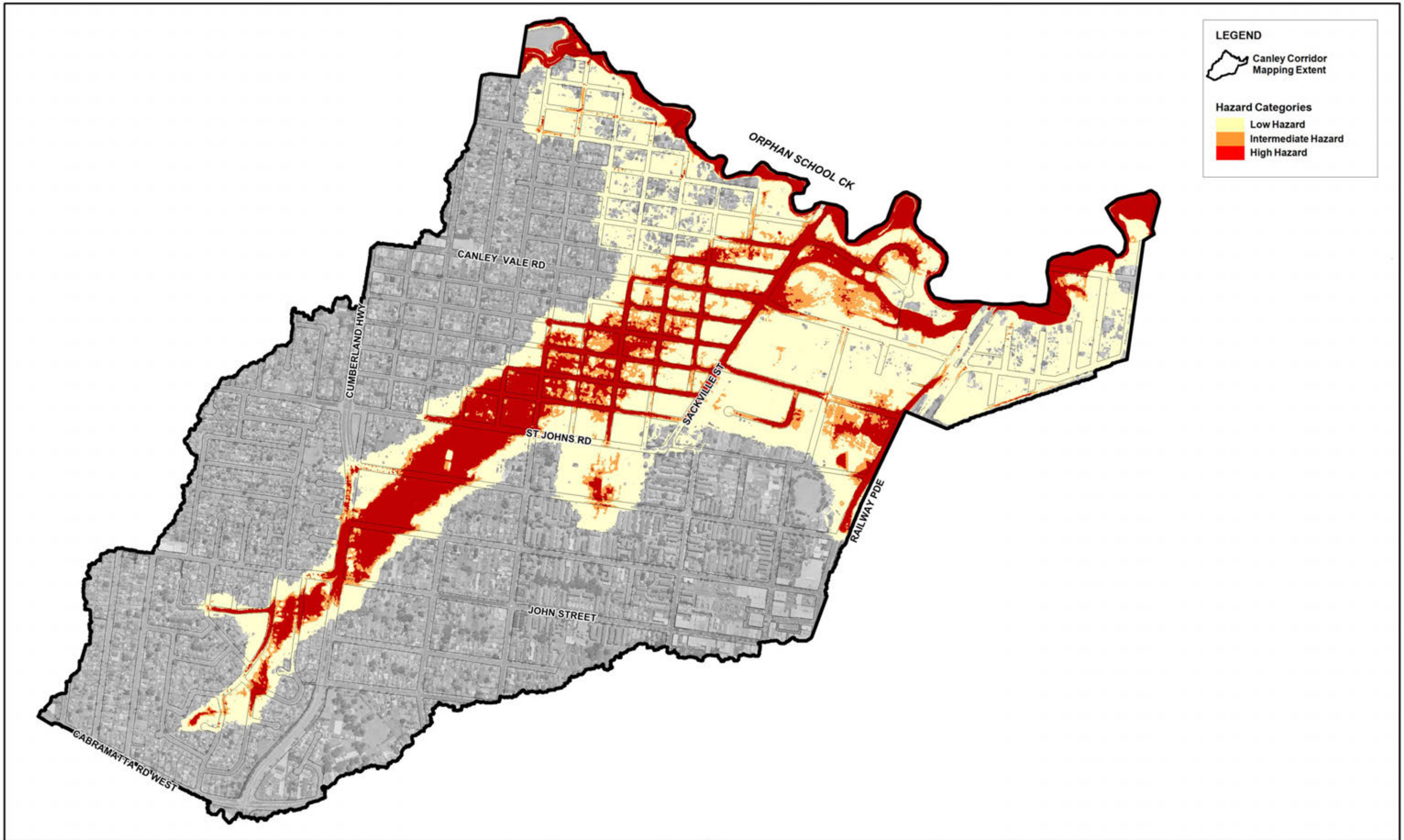

Title:
Flood Hazard Categories - PMF Event

Figure: D-4

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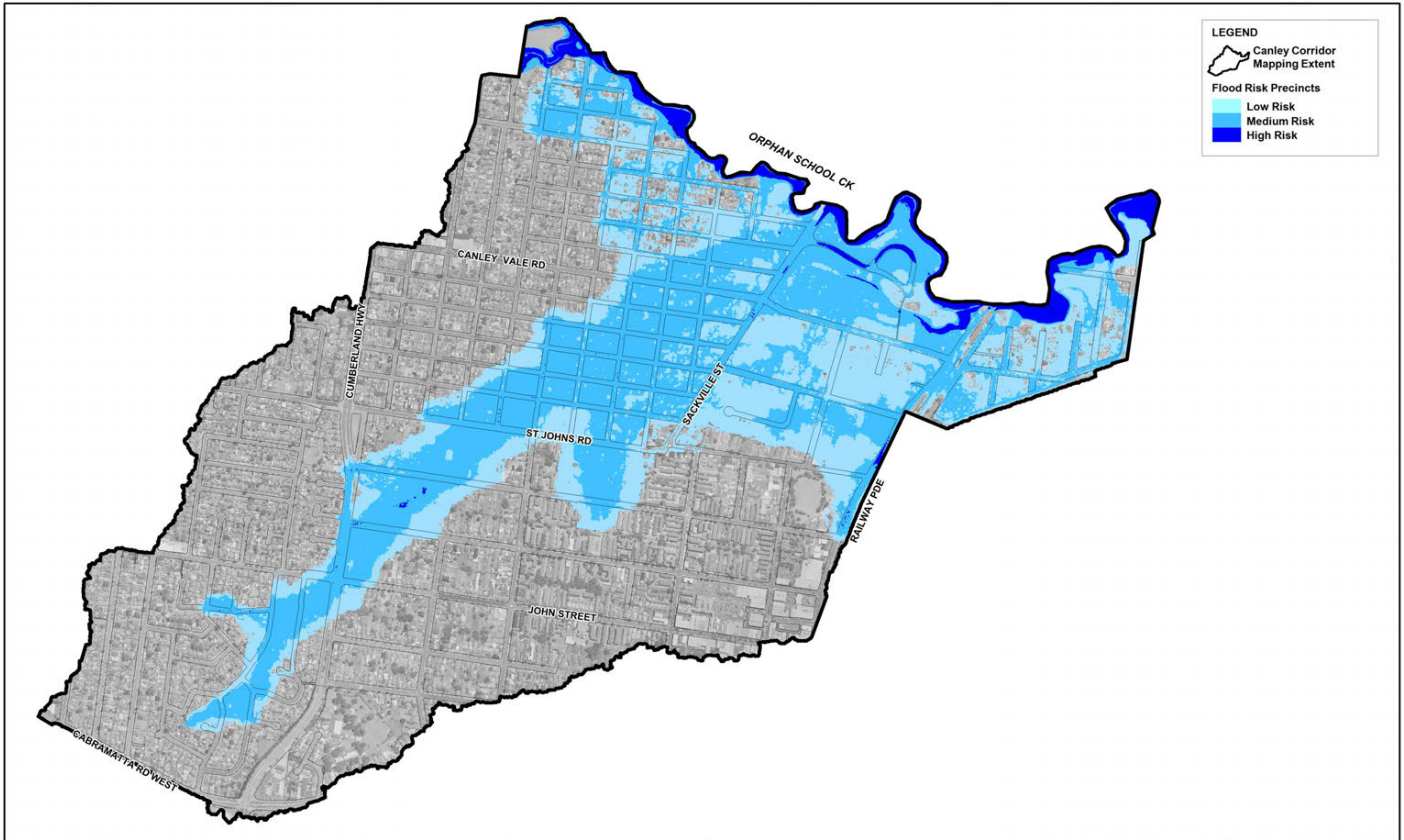
APPENDIX E: PROVISIONAL FLOOD RISK PRECINCT MAP



Title:
Provisional Flood Risk Precinct Map

Figure: E-1

Rev: A

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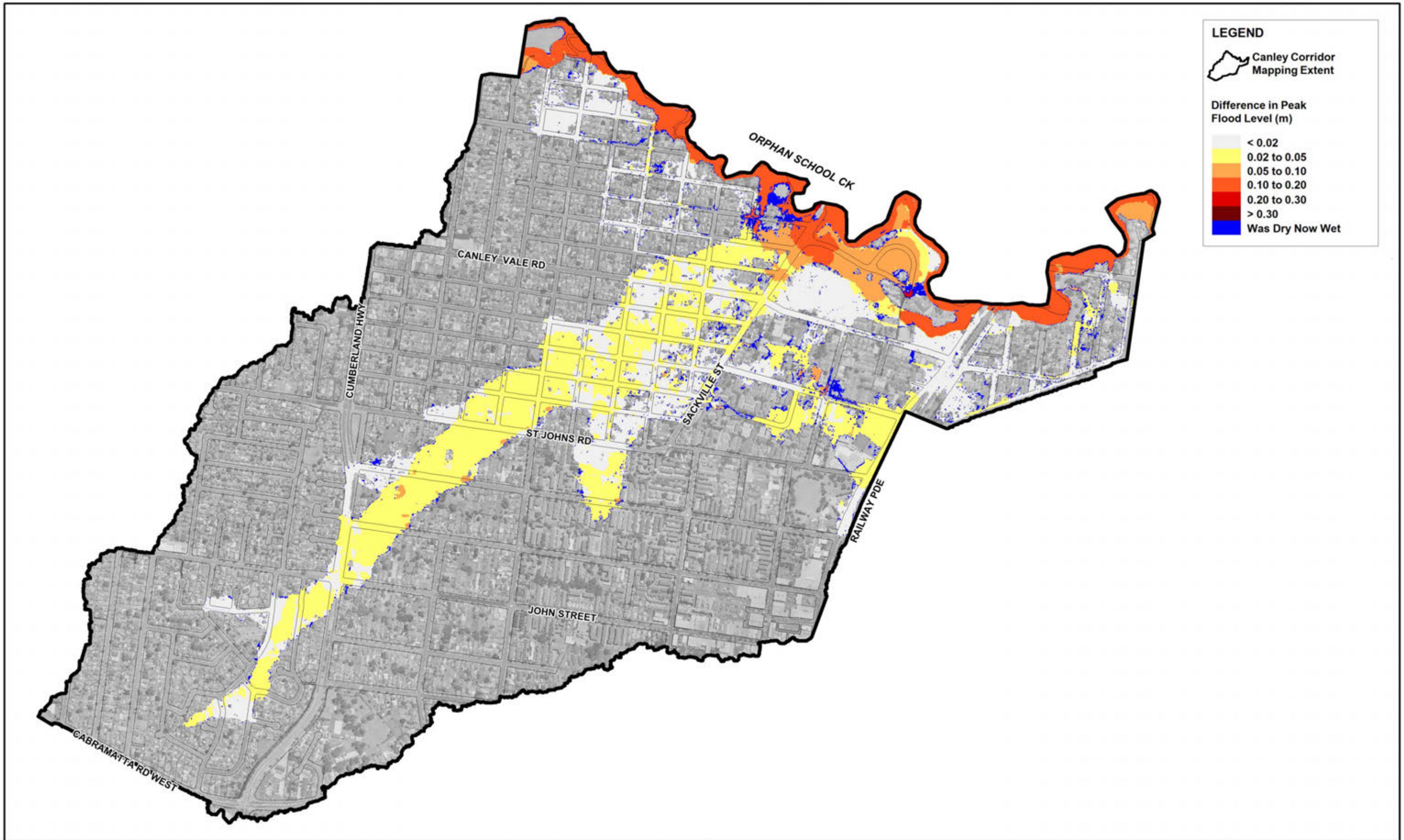
APPENDIX F: CLIMATE CHANGE IMPACT MAPS



Title:

Climate Change Impact Map - 10% Increase in Rainfall Runoff

Figure: F-1

Rev: A

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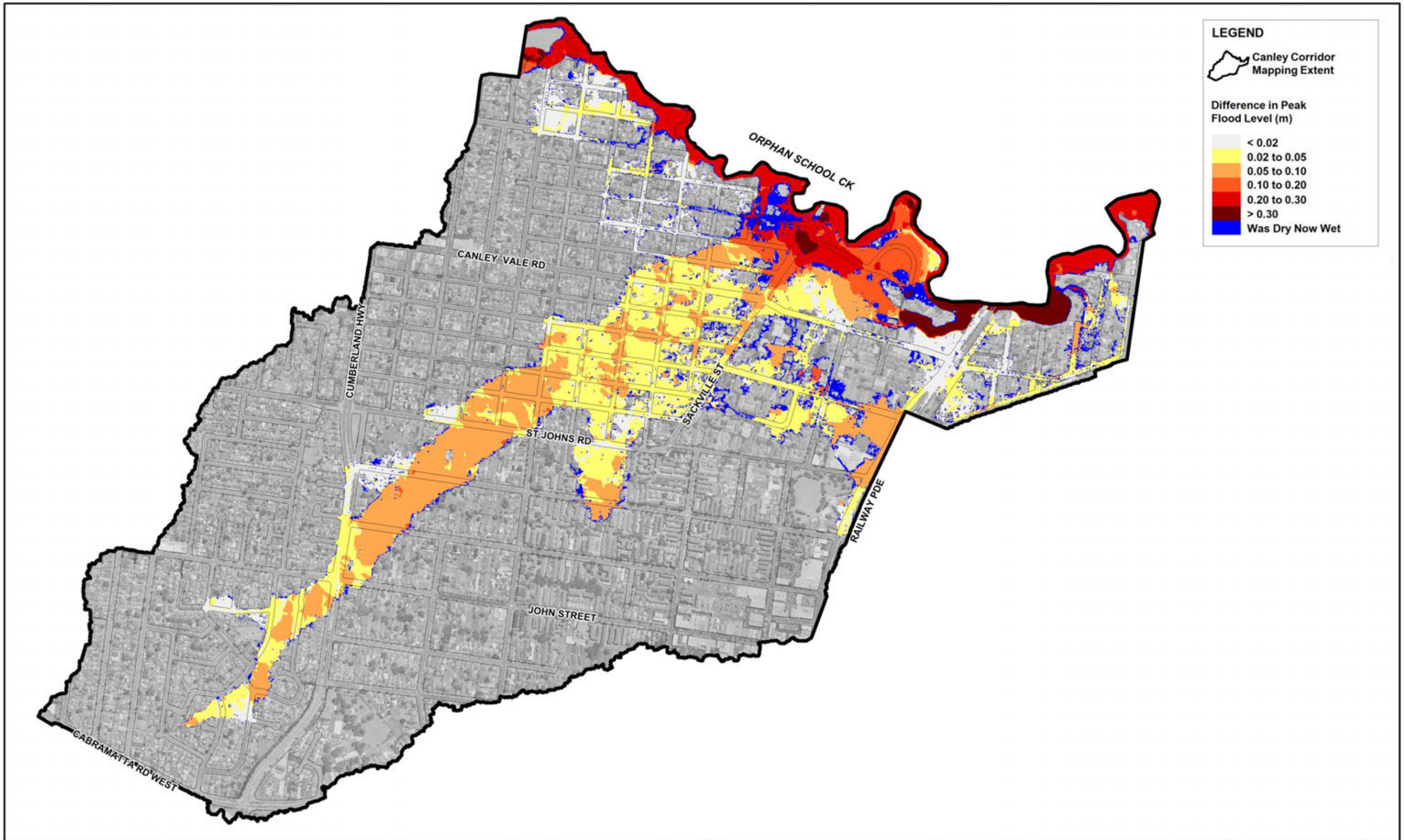

Title:
Climate Change Impact Map - 20% Increase in Rainfall Runoff

Figure: **F-2**

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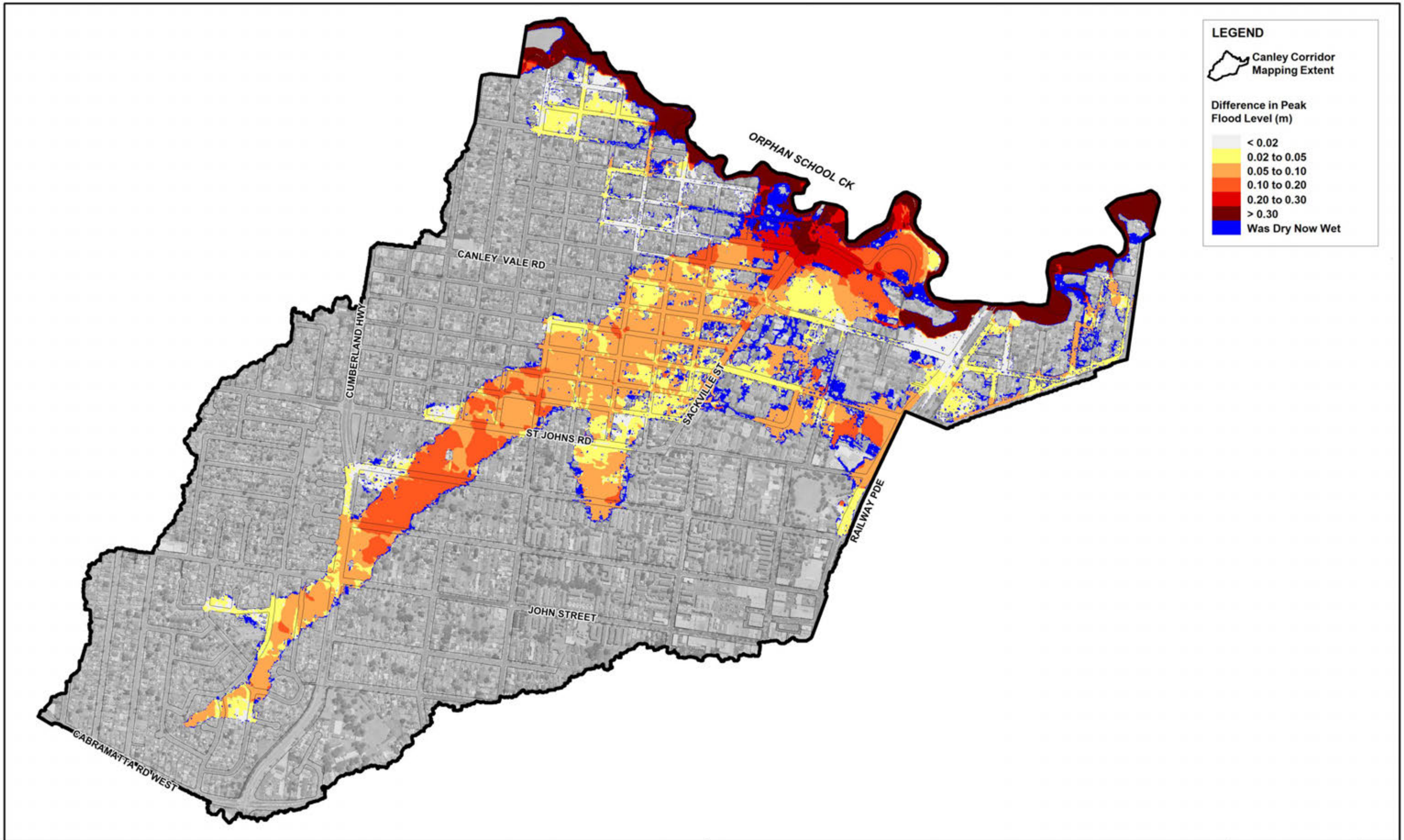

Title:
Climate Change Impact Map - 30% Increase in Rainfall Runoff

Figure: F-3

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Web www.bmtwbm.com.au

APPENDIX C - S.149 WORDING FOR FLOOD NOTATIONS

S149 Wording for Flood Notations

Flood Policy 50015 *Development on the subject land (or part) for the purposes of dwelling houses, dual occupancies, multi-unit housing or residential flat buildings (not including development for the purposes of group homes or seniors housing) is subject to the Fairfield City-Wide Development Control Plan 2006 (which includes provisions for flood management) and applies to all of the Fairfield Local Government Area. Development controls will apply to residential development of the above types if the land (or part of the land) is within the floodplain.* *Development for any other purpose on the subject land (or part) is also subject to the Fairfield City-Wide Development Control Plan 2006 (which includes provisions for flood management) and applies to all of the Fairfield Local Government Area. Development controls will apply to development for any other purpose if the land (or part of the land) is within the floodplain.* ***NOTE:*** *These controls apply to development only if that form of development is permissible on the subject land. Please refer to the land use zone indicated in this certificate and then determine, based on the objectives of that zone and the list of prohibited uses, whether the proposed use is permissible.*	Included in all certificates.
High Flood Risk Precinct Mainstream 50016 *This parcel is within the floodplain and identified as being within a* ***High*** *Flood Risk Precinct as a result of mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term* ***High*** *Flood Risk Precinct is defined as the area of land below the 100-year flood event that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.*	Additional note where catchment mapped and risk determined.
Medium Flood Risk Precinct Mainstream 50017 *This parcel is within the floodplain and identified as being within a* ***Medium*** *Flood Risk Precinct as a result of mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term* ***Medium*** *Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.*	
Low Flood Risk Precinct Mainstream 50018 *This parcel is within the floodplain and identified as being within a* ***Low*** *Flood Risk Precinct as a result of mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term* ***Low*** *Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly High and Medium Risk Mainstream 50019 *This parcel is within the floodplain and identified as being partly within a* ***High*** *Flood Risk Precinct and partly within a* ***Medium*** *Flood Risk Precinct as a result of mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term* ***High*** *Flood Risk Precinct is defined as the area of land below the 100-year flood event that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.* *The term* ***Medium*** *Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.*	
Partly Medium and Low Risk Mainstream 50026	

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S149 Wording for Flood Notations	
This parcel is within the floodplain and identified as being partly within a ***Medium*** *Flood Risk Precinct and partly within a* ***Low*** *Flood Risk Precinct as a result of mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term* ***Medium*** *Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.* *The term* ***Low*** *Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly Low and No Risk Mainstream 50027 *This parcel is within the floodplain and identified as being partly within a* ***Low*** *flood risk precinct and partly* ***not affected*** *by mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term* ***Low*** *Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly High, Medium, and Low Risk Mainstream 50028 *This parcel is within the floodplain and identified as being partly within a* ***High*** *flood risk precinct, partly within a* ***Medium*** *Flood Risk Precinct and partly within a* ***Low*** *Flood Risk Precinct as a result of mainstream flooding* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term* ***High*** *Flood Risk Precinct is defined as the area of land below the 100-year flood event that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.* *The term* ***Medium*** *Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.* *The term* ***Low*** *Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly Medium, Low and No Risk Mainstream 50029 *This parcel is within the floodplain and identified as being partly within a* ***Medium*** *Flood Risk Precinct, partly within a* ***Low*** *Flood Risk Precinct as a result of mainstream flooding and partly* ***not affected*** *by mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.* *The term* ***Medium*** *Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.* *The term* ***Low*** *Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly High, Medium, Low and No Risk Mainstream 50030 *This parcel is within the floodplain and identified as being partly within a* ***High*** *Flood Risk Precinct, partly within a* ***Medium*** *Flood Risk Precinct, partly within a* ***Low*** *Flood Risk Precinct as a result of mainstream flooding and partly* ***not affected*** *by mainstream flooding.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural*	

S149 Wording for Flood Notations

or artificial banks of a stream, river, estuary, lake or dam. *The term **High** Flood Risk Precinct is defined as the area of land below the 100-year flood event that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.* *The term **Medium** Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.* *The term **Low** Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Overland Flow 48001 *Part or all of this land is within the floodplain and may be affected by local overland flooding. This parcel is not in an area in which Council's current programme of overland flood risk mapping has been completed. .* *The term local overland flooding means inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.*	Further additional / alternative note if identified as having overland flood issues
Standard Flood Mapping only 50001 *Based on information currently available to Council, part or all of the land is within the floodplain and affected by the 100-year mainstream floodplain. This parcel is not in an area in which Council's current programme of mainstream flood risk mapping has been completed.* *The term mainstream flooding means inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.*	Standard flood maps available only. (100-year floodplain)
No Identified Flood Risk 50004 *Based on the information currently available to Council, this land is not affected by mainstream or overland flooding and is not identified as being within any floodplain. However, this is subject to future flood studies and reviews.*	Not mapped as flood affected
High Flood Risk Precinct Overland Flooding # *This parcel is within the floodplain and identified as being within a **High** Flood Risk Precinct as a result of overland flooding.* *The term overland flooding means inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.* *The term **High** Flood Risk Precinct is defined as the area of land below the 100-year flood event that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.*	
Medium Flood Risk Precinct Overland Flooding # *This parcel is within the floodplain and identified as being within a **Medium** Flood Risk Precinct as a result of mainstream flooding.* *The term overland flooding means inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.* *The term **Medium** Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.*	
Low Flood Risk Precinct Overland Flooding # *This parcel is within the floodplain and identified as being within a **Low** Flood Risk Precinct as a result of mainstream flooding.* *The term overland flooding means inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.*	

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S149 Wording for Flood Notations	
*The term **Low** Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly High and Medium Risk Overland Flooding # *This parcel is within the floodplain and identified as being partly within a **High** Flood Risk Precinct and partly within a **Medium** Flood Risk Precinct as a result of mainstream flooding.* *The term overland flooding means inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.* *The term **High** Flood Risk Precinct is defined as the area of land below the 100-year flood event that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.* *The term **Medium** Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.*	
Partly Medium and Low Risk Overland Flooding # *This parcel is within the floodplain and identified as being partly within a **Medium** Flood Risk Precinct and partly within a **Low** Flood Risk Precinct as a result of mainstream flooding.* *The term overland flooding means inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.* *The term **Medium** Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.* *The term **Low** Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly Low and No Risk Overland Flooding # *This parcel is within the floodplain and identified as being partly within a **Low** flood risk precinct and partly **not affected** by mainstream flooding.* *The term overland flooding means inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.* *The term **Low** Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly High, Medium, and Low Risk Overland Flooding # *This parcel is within the floodplain and identified as being partly within a **High** flood risk precinct, partly within a **Medium** Flood Risk Precinct and partly within a **Low** Flood Risk Precinct as a result of mainstream flooding* *The term overland flooding means inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.* *The term **High** Flood Risk Precinct is defined as the area of land below the 100-year flood event that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.* *The term **Medium** Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.* *The term **Low** Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly Medium, Low and No Risk Overland Flooding # *This parcel is within the floodplain and identified as being partly within a **Medium** Flood Risk Precinct, partly within a **Low** Flood Risk Precinct as a result of mainstream flooding and partly **not affected** by mainstream*	

S149 Wording for Flood Notations	
flooding. *The term overland flooding means inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.* *The term **Medium** Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.* *The term **Low** Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Partly High, Medium, Low and No Risk Overland Flooding # *This parcel is within the floodplain and identified as being partly within a **High** Flood Risk Precinct, partly within a **Medium** Flood Risk Precinct, partly within a **Low** Flood Risk Precinct as a result of mainstream flooding and partly **not affected** by mainstream flooding.* *The term overland flooding means inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.* *The term **High** Flood Risk Precinct is defined as the area of land below the 100-year flood event that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.* *The term **Medium** Flood Risk Precinct is defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.* *The term **Low** Flood Risk Precinct is defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.*	
Zone of Significant Flow *This parcel is identified as being within a Zone of Significant Flow.*	

Glossary over page

Flood Information Sheet

Fairfield City Council
Administration Centre
86 Avoca Road
WAKELEY NSW 2176
PO Box 21
FAIRFIELD NSW 1860
Telephone: (02) 9725 0222
Facsimile: (02) 9609 3257

Applicant's Details:Property Particulars:

Applicant's Name	[redacted] **C\- Fairfield City Council**
Postal Address	**PO Box 21** **FAIRFIELD NSW 1860**
Phone	
Fax	

House No.	[redacted]
Street & Suburb	[redacted]
Lot Description	***iii)*** [redacted]

Council has adopted a policy on flooding which may restrict the development of land. The Fairfield City-Wide Development Control Plan 2006 (which includes provisions for flood management) applies to all of the Fairfield Local Government area.

Part or all of this land may be affected by mainstream flooding.

Part or all of this land may be affected by local overland flooding.

MAINSTREAM FLOODING

Description

This parcel is identified as being partly within a **High** flood risk precinct, partly within a **Medium** Flood Risk Precinct and partly within a **Low** Flood Risk Precinct as a result of mainstream flooding.

Mainstream Flood Details

Size of Flood	Flood Level (m AHD)
Probable Maximum Flood (PMF)	12.6-13.1
100 Year ARI	10.7-11.1
50 Year ARI	10.6-10.9
20 Year ARI	10.3-10.7

Flood levels in the vicinity of the above property have been extracted from the Sinclair Knight Merz & Fairfield Consulting Services (2008) *Flood Study for Orphan School Creek, Green Valley Creek and Clear Paddock Creek.*

Note: Existing flood information is currently under review. New flood levels may be available in March 2012. Please contact Council after March 2012 for any updated information.

LOCAL OVERLAND FLOODING

Description

This parcel is identified as being partly within a **High** Flood Risk Precinct and partly within a **Medium** Flood Risk Precinct as a result of local overland flooding.

Local Overland Flood Details

Size of Flood	Flood Level (m AHD)
Probable Maximum Flood (PMF)	11.3-11.5
100 Year ARI	11.1-11.4
20 Year ARI	10.5-10.8

Local overland flood levels in the vicinity of the above property have been extracted from the Sinclair Knight Merz & Fairfield Consulting Services (2009) *Canley Corridor Overland Flood Study.*

Alan Young
City Manager

Prepared by: ______________________
date

Glossary over page

GLOSSARY

m AHD	metres Australian Height Datum (AHD).
Australian Height Datum (AHD)	A common national plane of level approximately equivalent to the height above sea level. All flood levels, floor levels and ground levels are normally provided in metres AHD.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as the selected event. For example, floods with a discharge as great as the 20 year ARI event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
flood	A relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam. It also includes local overland flooding associated with major drainage before entering a watercourse, or coastal inundation resulting from raised sea levels, or waves overtopping the coastline.
flood risk precinct	An area of land with similar flood risks and where similar development controls may be applied by a Council to manage the flood risk. The flood risk is determined based on the existing development in the precinct or assuming the precinct is developed with normal residential uses. Usually the floodplain is categorised into three flood risk precincts 'low', 'medium' and 'high', although other classifications can sometimes be used.
	High Flood Risk: This has been defined as the area of land below the 100-year flood event that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.
	Medium Flood Risk: This has been defined as land below the 100-year flood level that is not within a High Flood Risk Precinct. This is land that is not subject to a high hydraulic hazard or where there are no significant evacuation difficulties.
	Low Flood Risk: This has been defined as all land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified within either a High Flood Risk or a Medium Flood Risk Precinct. The Low Flood Risk Precinct is that area above the 100-year flood event.
local overland flooding	The inundation of normally dry land by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
mainstream flooding	The inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
probable maximum flood (PMF)	The largest flood that could conceivably occur at a particular location.
zone of significant flow	That area of the floodplain where a significant discharge of water occurs during floods. Should the area within this boundary be fully or partially blocked, a significant distribution of flood flows or increase in flood levels would occur.

APPENDIX D – FENCING ASSESSMENT

External Memorandum

From: Melanie Gostelow / Simon Kovacevic

To: Neil Benning

Date: 3 December 2013

CC:

Subject: Canley Corridor FRMS&P – Option 4 – Impact Assessment of Fences

As part of the Canley Corridor Floodplain Risk Management Study a number of structural flood mitigation options will be assessed using the TUFLOW model developed for the previous Flood Study and updated as part of this current study. As part of the options assessment the impact of fences on flood levels has been investigated, as outlined herein.

Assessment Objective and Overview

As described in Engineers Australia (2012):

> *"Fences can cause significant blockages to floodwaters and they have the added complication of tending to collapse during a flood. The risk of collapse depends on a range of factors such as the flow velocity, the amount and type of debris build-up and the type and condition of the fence. This means that there may be a significant constriction to flow until it is dramatically reduced at one point in time. These complex conditions are difficult to model. They may also be partially open (eg. a picket or chain wire fence), and may also become blocked with debris. If the floodwaters are sufficiently high they will be overtopped and may act like a weir until the fence is damaged or destroyed.*
>
> *Because of the relatively low and weak condition of fences, they have the most significant impacts on shallow slow moving flow and flat terrain. In these cases, fences may be a key controlling factor in flood behaviour."*

Representing fences within a catchment scale model requires considerable data for each individual fence to ensure the fence can be accounted for correctly. Such data are not available and fences have therefore not been explicitly represented in the Canley Corridor TUFLOW model.

To investigate the potential impact of fences on flood levels, fences have been incorporated into the TUFLOW model over a selected area, as shown in Figure 1. This figure also shows the adopted flood risk precinct mapping. Fences surrounding a total of 21 residential properties, located between McBurney Road, Gladstone Street, Hughes Street and Joseph Street have been modelled for this assessment. . This location has been selected for this assessment as it contains the high risk flood precinct and lies within the 5 year ARI flood extent. Fences have been modelled along all sides of the properties, with the exclusion of the street frontage, based on Council's cadastral information. The overland flow path through this area flows from Hughes Street in the south, north east across McBurney Road.

Within the TUFLOW model, the fences have been represented as continuous blockages in the model by raising the cell sides by 1.0m. Once the depth of water exceeds 0.75m on either side of a fence, the fence is assumed to collapse and the 1.0m height increase in the model is removed, thus allowing for the ponded water to continue flowing along the overland flow path. The model has been schematised with 4.0m lengths of fences to represent a more realistic mode of failure, rather than allowing the instantaneous collapse of the entire fence.

TUFLOW Modelling and Results

The 2 hour storm duration for the 5, 20, 100 year ARI and PMF design events have been modelled and compared with the existing situation design event modelling. The 2 hour duration storm event has been selected as it is generally the critical duration for this area of the catchment. A comparison of the peak water level results is provided as Figure 2, 3, 4 and 5. These figures show the impact of this option on peak flood water levels as well as indicating any newly wet and dry areas resulting from the option.

Including the fences in the TUFLOW modelling has resulted in significant variations in peak flood levels in the immediate and downstream areas. Properties where fences have been modelled generally saw an increase in peak flood levels of over 0.5m in some locations for the 5, 20, 100 year ARI and PMF design events. The properties immediately upstream of the fenced properties, south of Hughes Street, also saw an increase in peak flood levels typically up to 0.1m for the 5, 20, 100 year ARI and PMF design events.

Conversely, the area immediately downstream of the fenced properties, north of McBurney Road, typically saw a decrease in peak flood levels for the 5 and 20 year ARI design events. The decrease in flood levels of typically 0.1m extended north from McBurney Road across several street blocks.

For the less frequent 100 year ARI and PMF design events only the properties immediate downstream (i.e. north of McBurney Road) are impacted with typical variations in flood levels of -0.1m to +0.2m.

Comparisons of the peak velocity results are provided as Figures 6, 7, 8 and 9. As expected by temporarily blocking flow the fences have typically decreased the flow velocity immediately upstream of the fences, whilst increasing velocities in the immediate downstream area. The flow velocities generally differ by +/- 0.5m/s for the design events modelled. The fences have resulted in significant velocity increases (>0.5m/s) along McBurney Road and Hughes Street. Further downstream from the modelled fences the roadway velocities have generally decreased.

A comparison of the hazard results has also been provided as Figures 10, 11, 12 and 13. The hazard categories are a combination of both the peak water depth and flow velocity. Properties where fences have been modelled generally saw an increase in hazard, particular for the upstream properties along Hughes Street, for the 5, 20, 100 year ARI design events. For the 100 year ARI event some limited decreases in hazard were also evident downstream of fences for properties along McBurney Road and some roadways. More minor impacts of including the fences were evident for the PMF design event. Including the fences slightly increased the high and intermediate hazard extents in the immediate upstream areas to the south and west, whilst decreasing these hazard extents to the east.

Conclusions

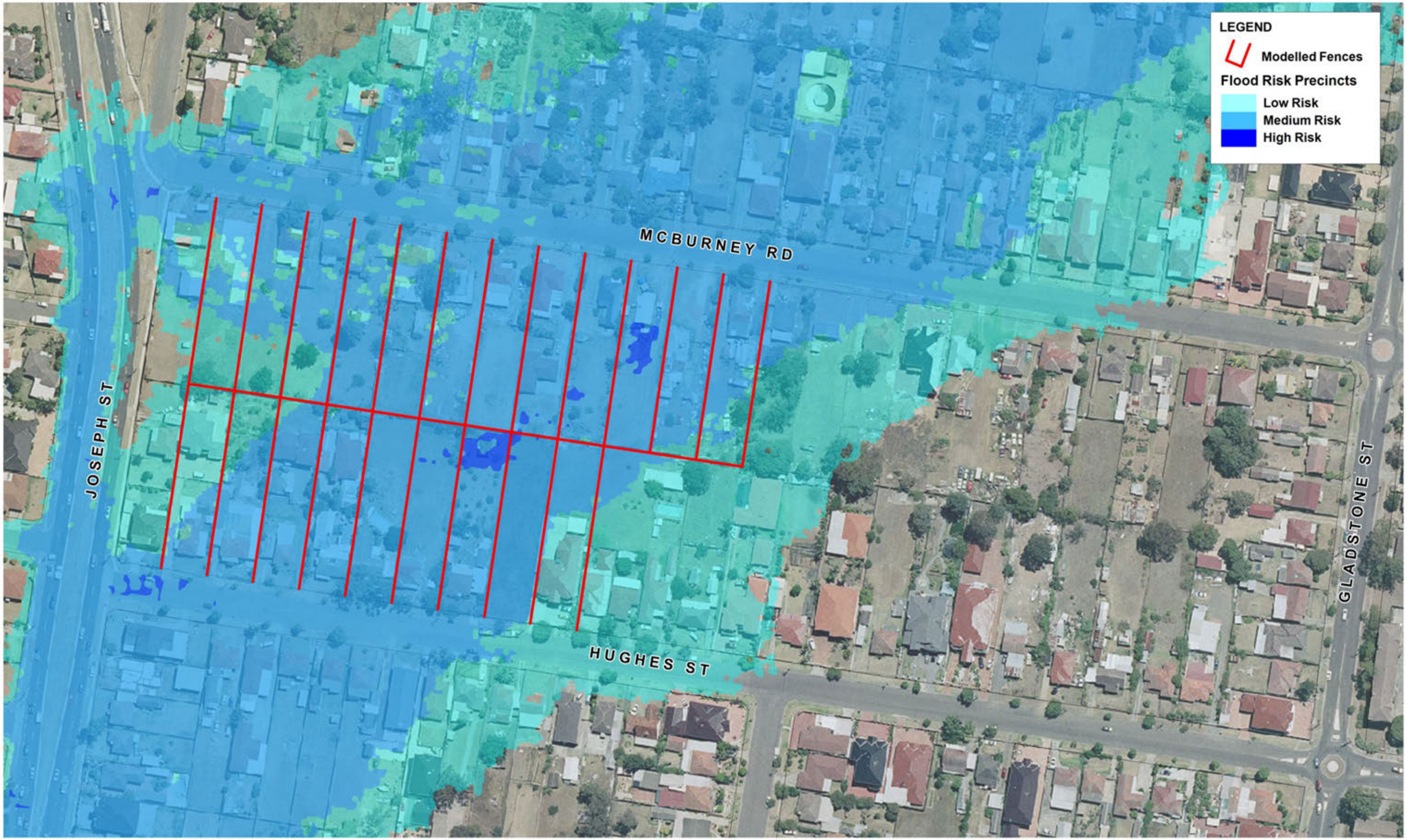
The inclusion of fences in the TUFLOW modelling has significantly impacted the peak flood levels, velocities and flood hazard in the immediate area, in particular:

- Flood levels are increased on the upstream side of the fences (i.e. prior to failure of the fence segments); and
- Velocities and flood hazard are increased as a result of the fence failure.

The results highlight the need for fences to be considered as part of Council development control plans, in particular for area such as that investigated here which convey significant flow volumes.

References

Engineers Australia, November 2012, *Australian Rainfall and Runoff; Revision Project 15: Two Dimensional Modelling in Urban and Rural Floodplains (Stage 1 and 2 Draft Report).*



Title:
Flood Mitgation Option 4 - Layout and Flood Risk Precincts

Figure: 1

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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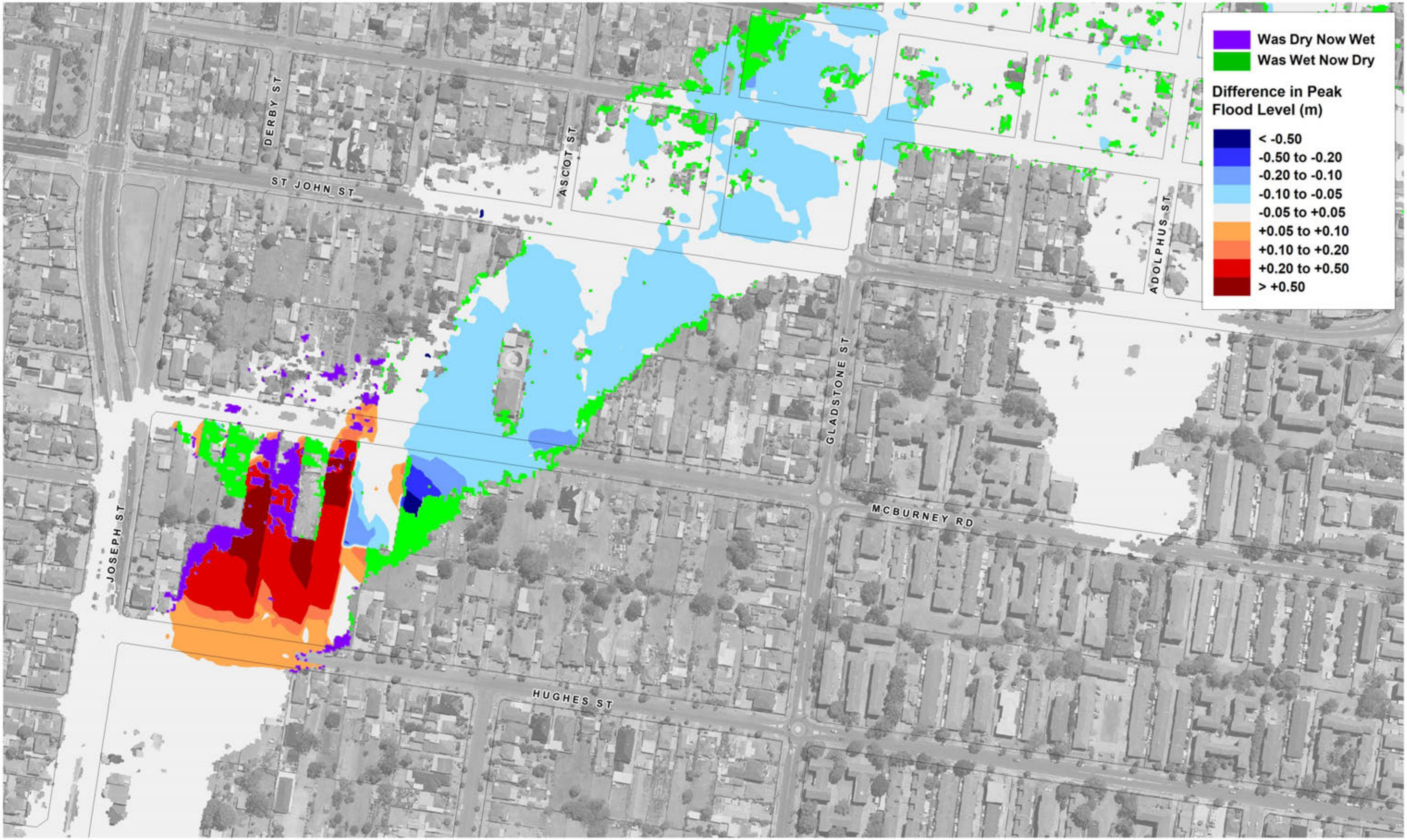

Title:
Flood Mitgation Option 4 - Q005 Water Level Impact

Figure: 2

Rev: A

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Approx. Scale

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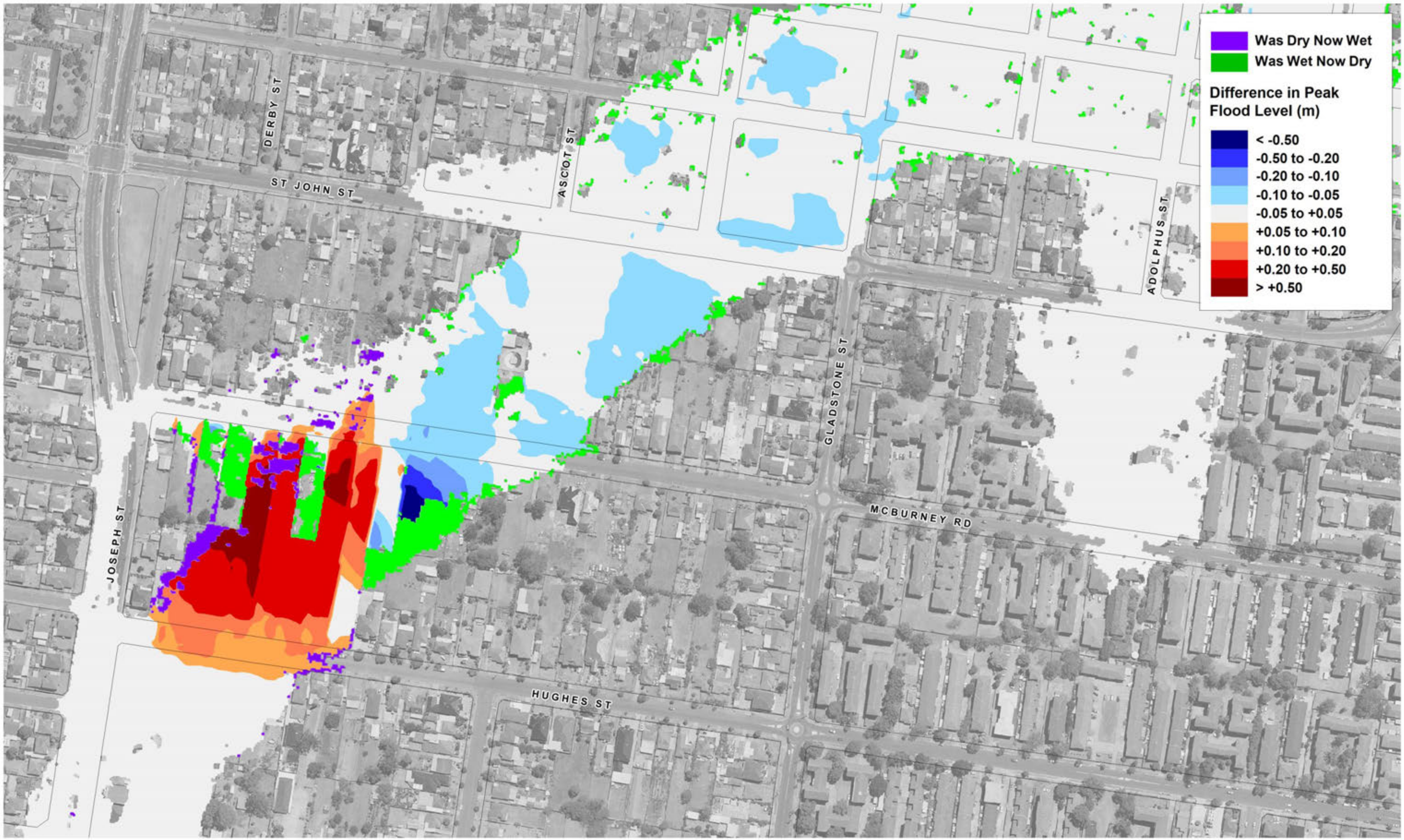

Title:
Flood Mitgation Option 4 - Q020 Water Level Impact

Figure: 3

Rev: A

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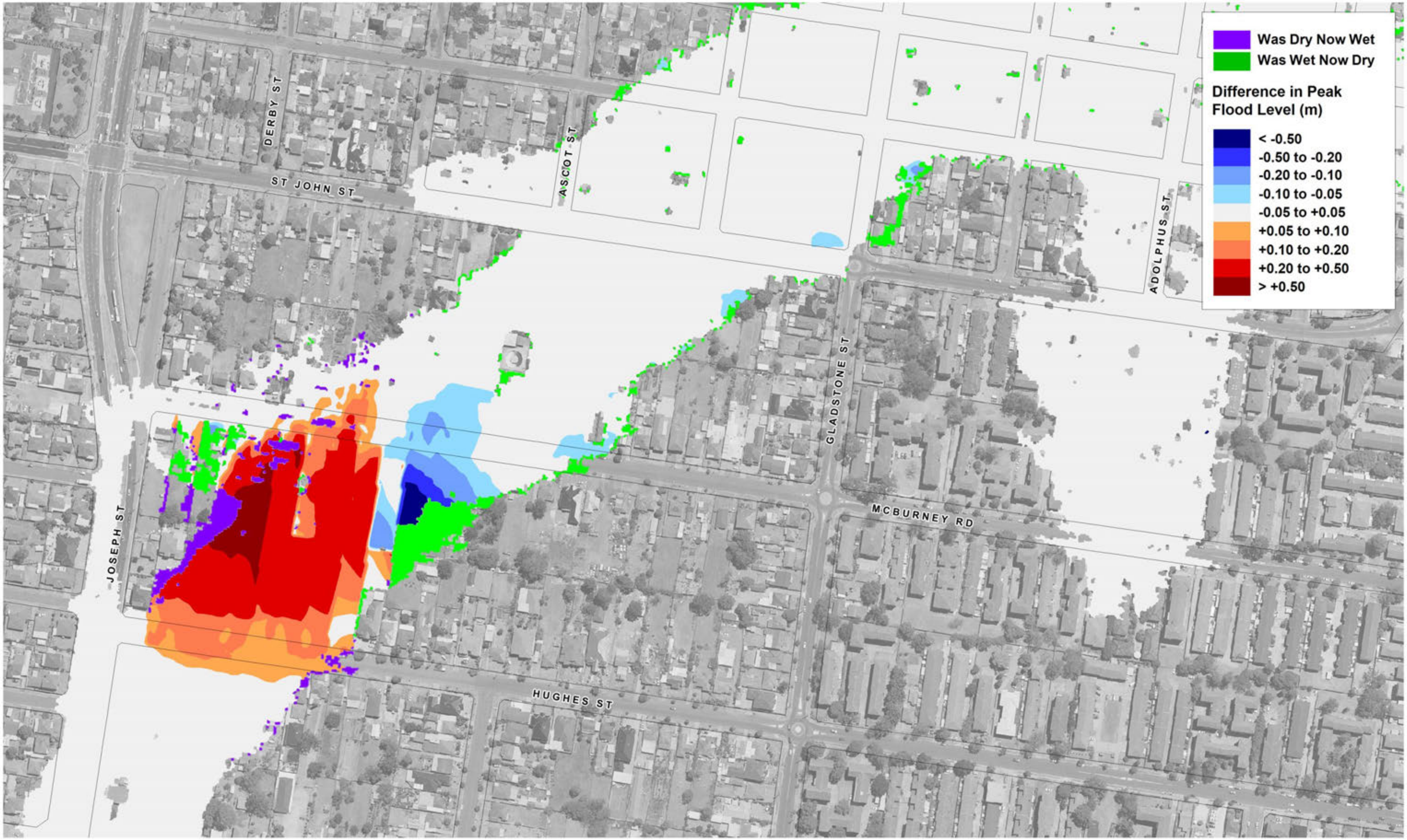

Title:
Flood Mitgation Option 4 - Q100 Water Level Impact

Figure: 4

Rev: A

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Approx. Scale

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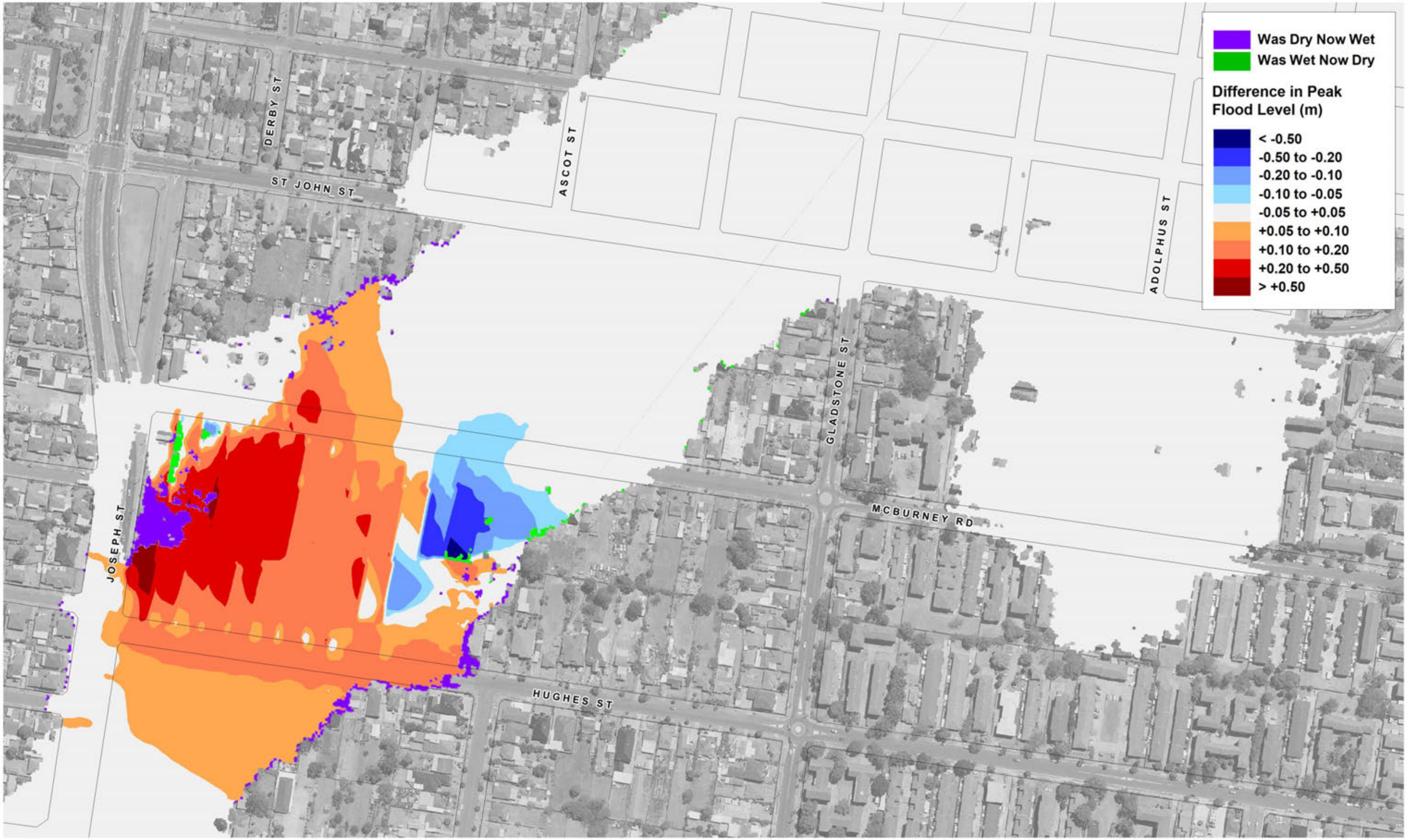

Title:
Flood Mitigation Option 4 - QPMF Water Level Impact

Figure: 5

Rev: A

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Approx. Scale

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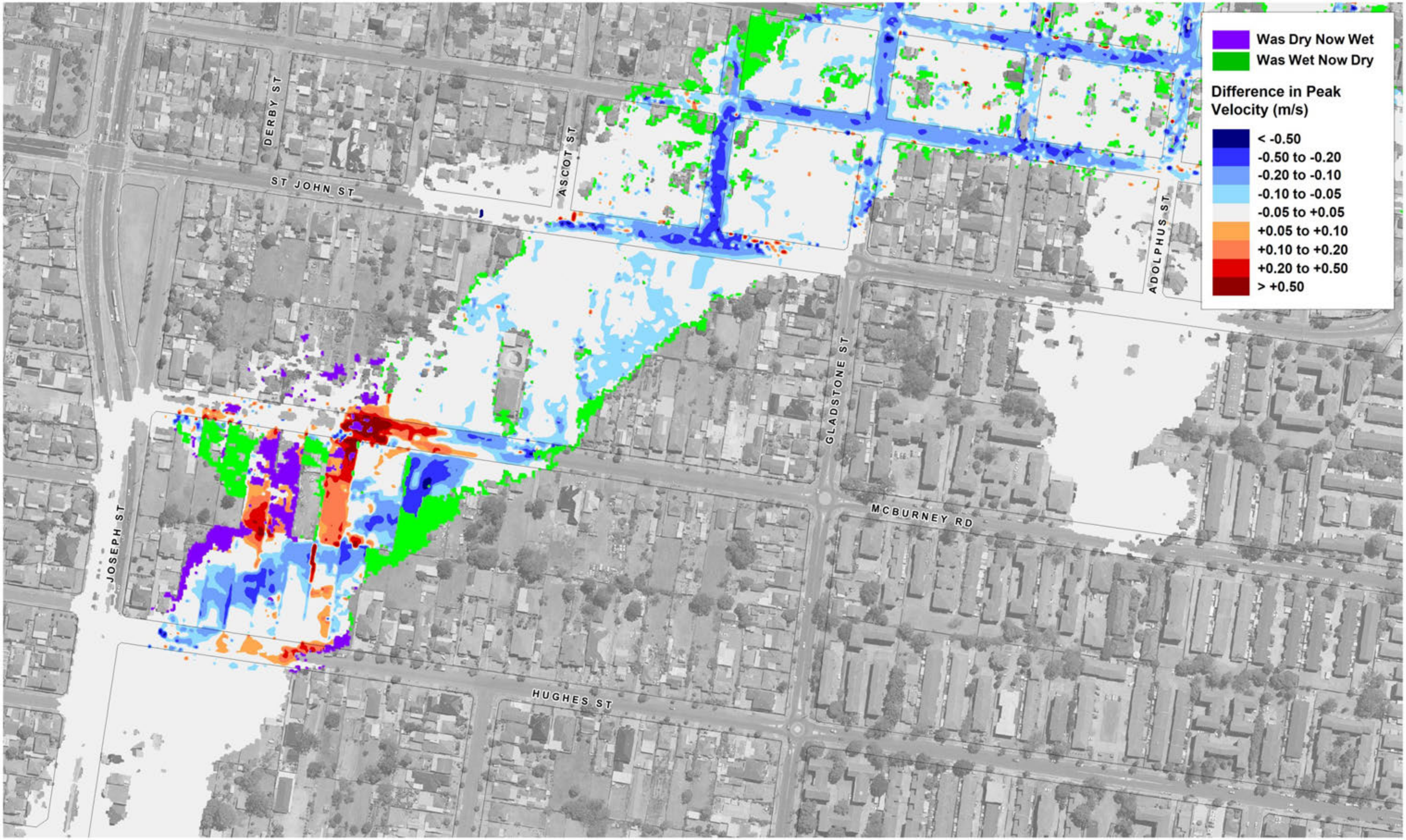

Title:
Flood Mitigation Option 4 - Q005 Velocity Impact

Figure: 6

Rev: A

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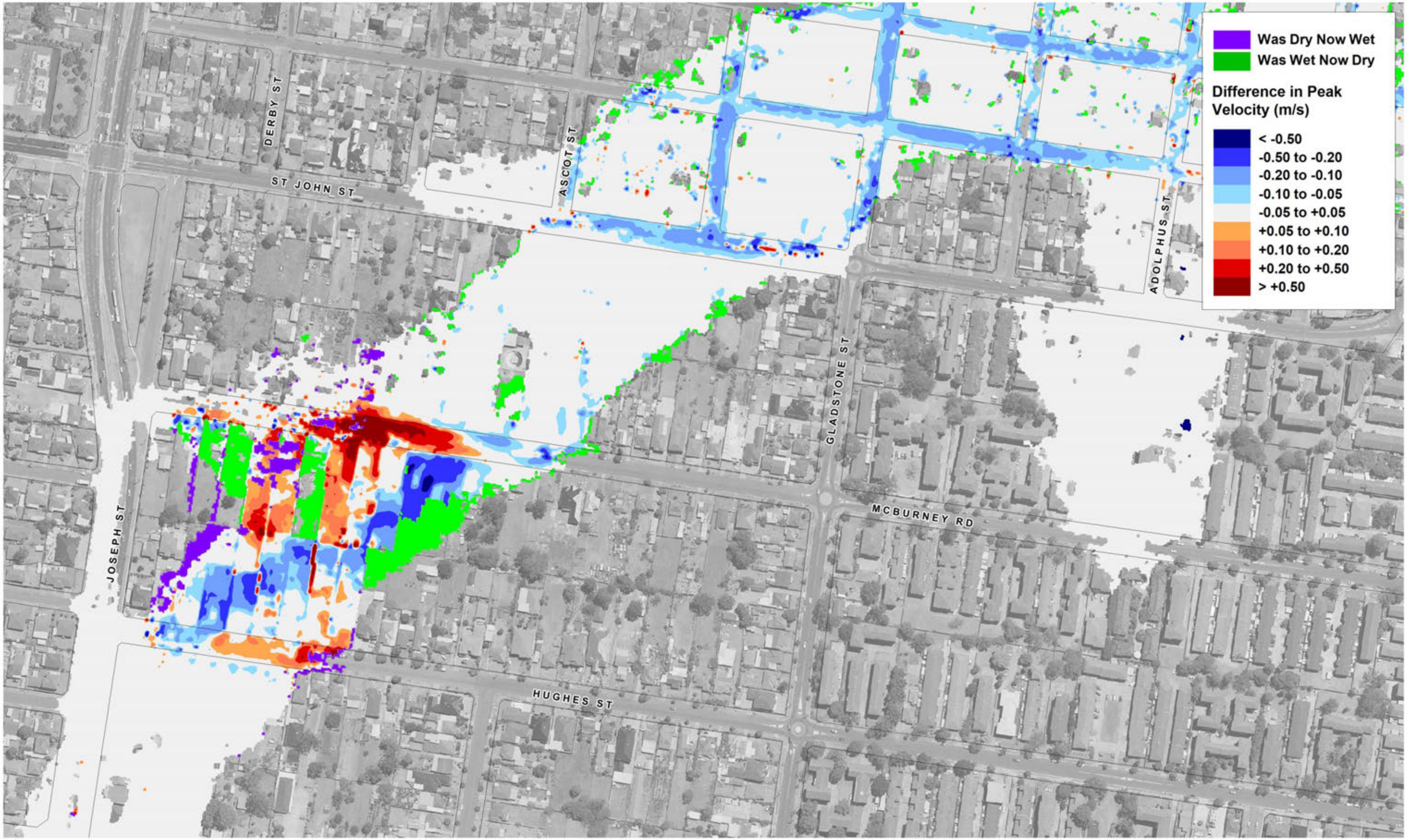

Title:
Flood Mitgation Option 4 - Q020 Velocity Impact

Figure: 7

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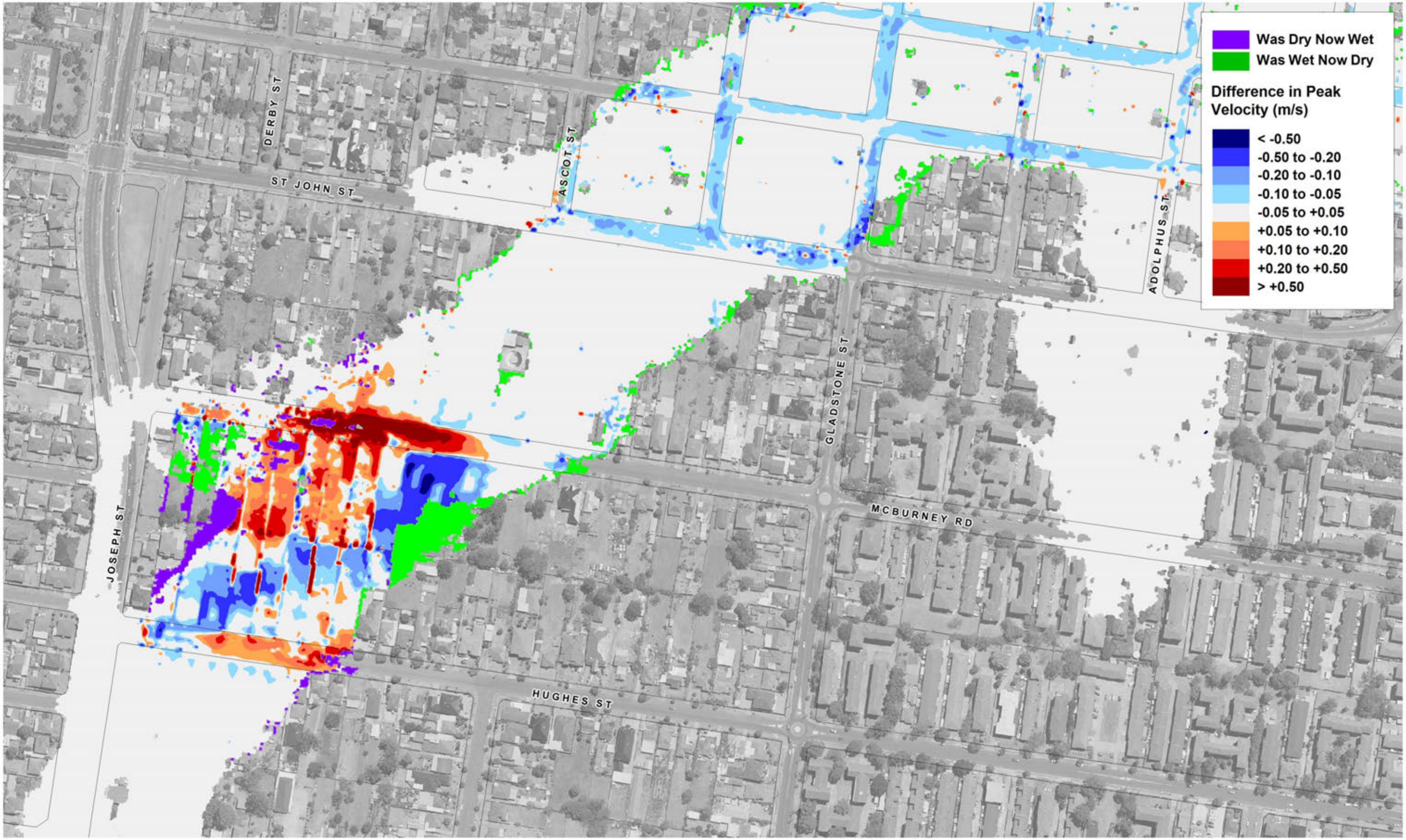

Title:
Flood Mitgation Option 4 - Q100 Velocity Impact

Figure: 8

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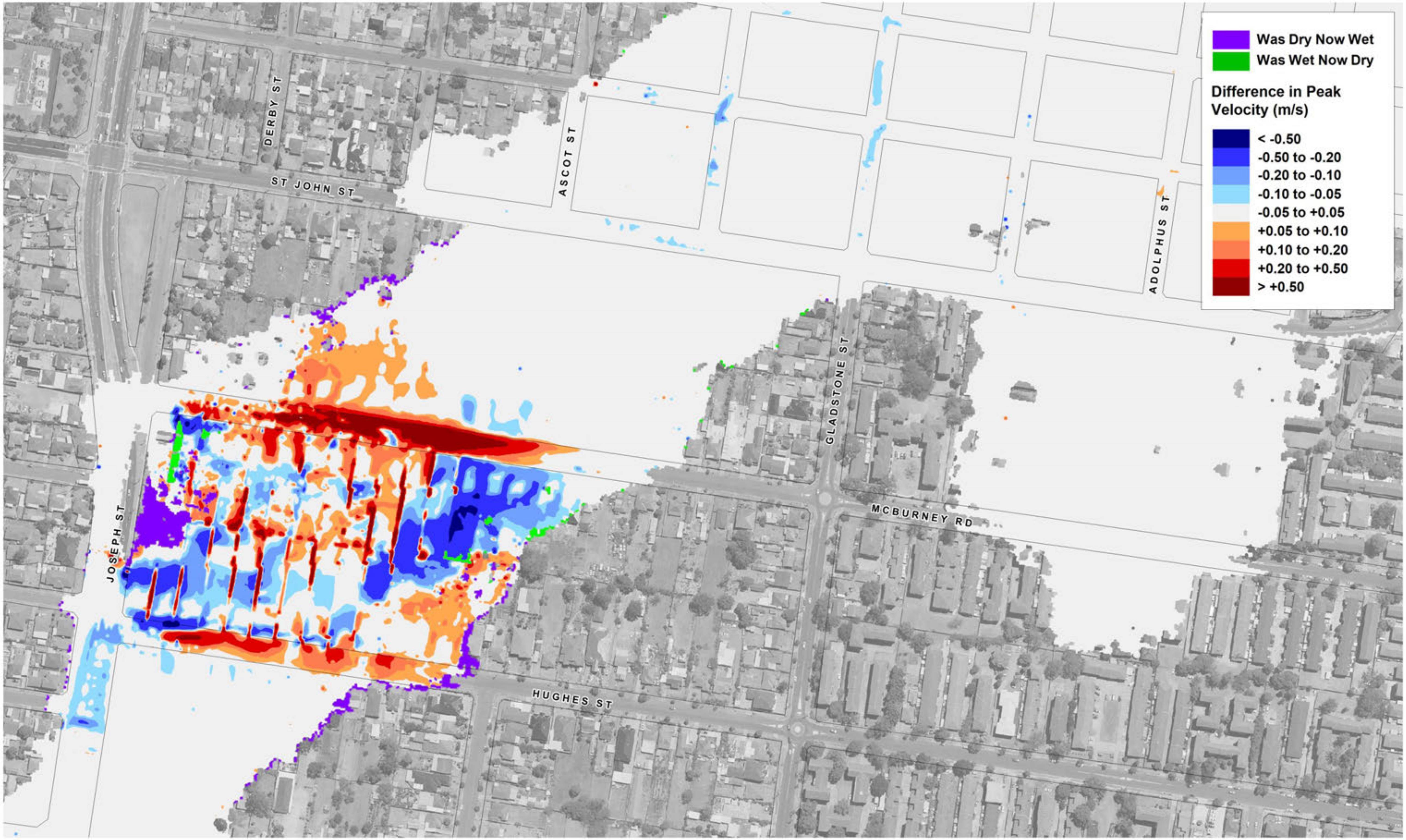

Title:
Flood Mitigation Option 4 - QPMF Velocity Impact

Figure: 9

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Title:

Flood Mitgation Option 4 - Q005 Hazard Impact

Figure: 10

Rev: A

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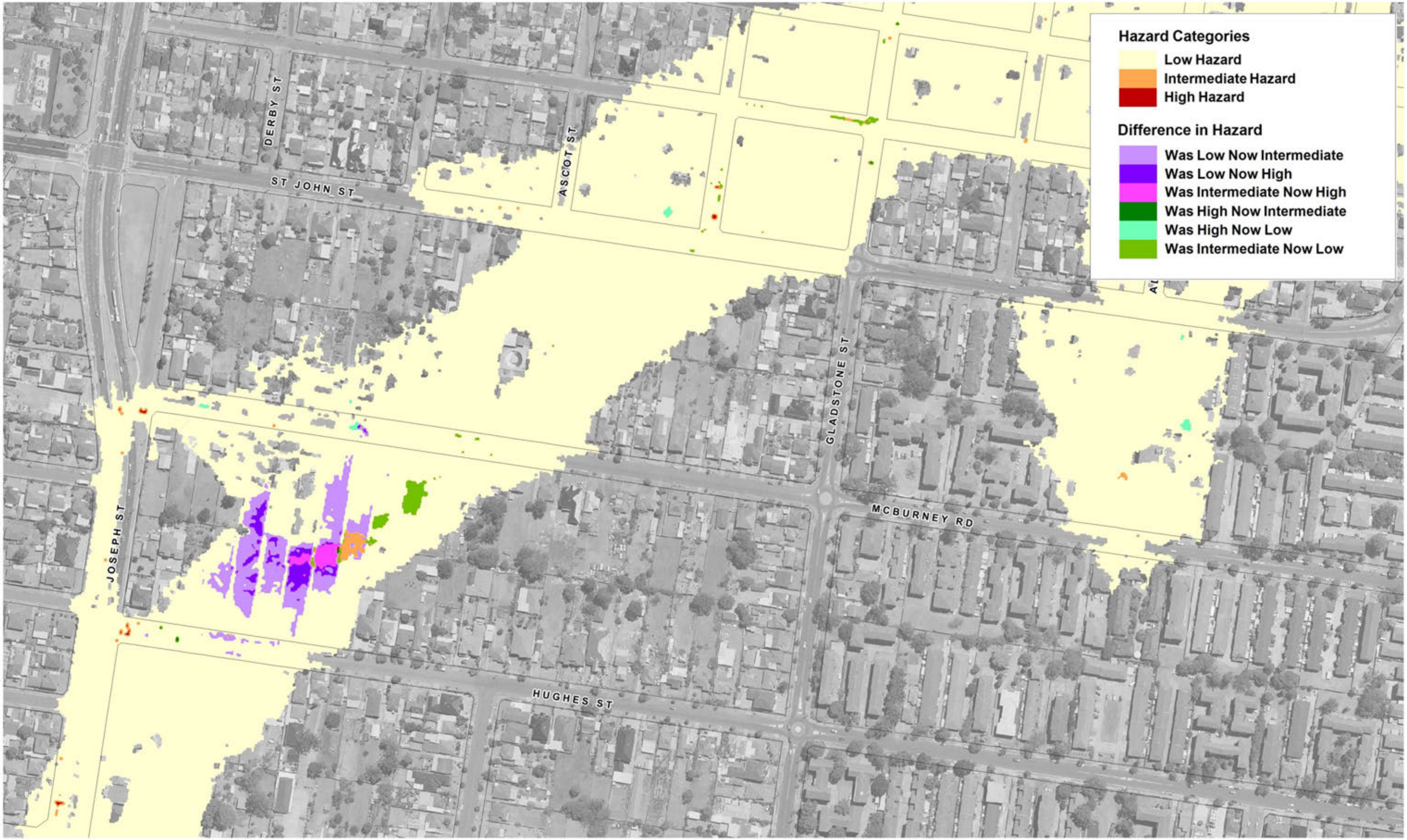

Title:
Flood Mitgation Option 4 - Q020 Hazard Impact

Figure: 11

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Title:
Flood Mitgation Option 4 - Q100 Hazard Impact

Figure: 12

Rev: A

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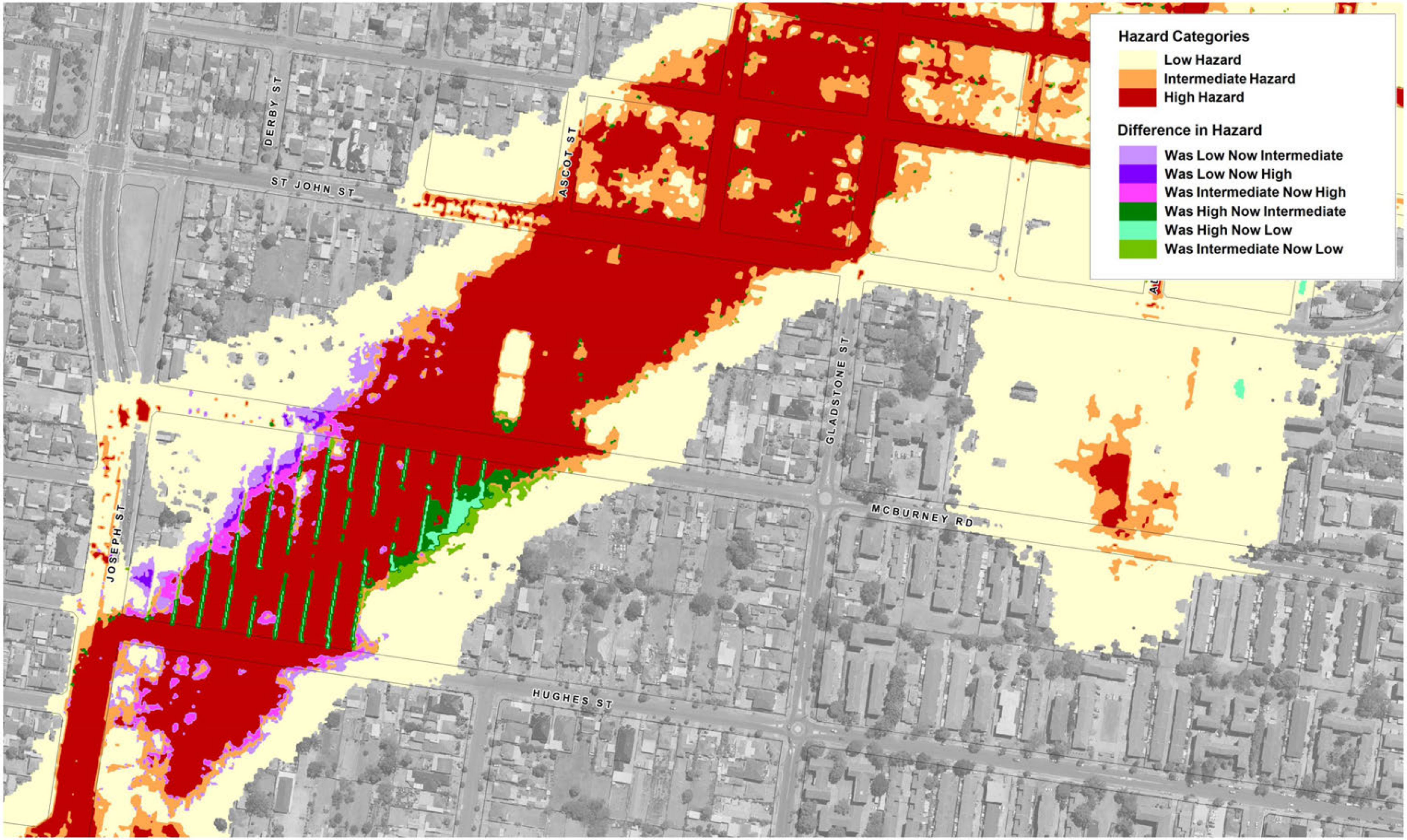

Title:
Flood Mitgation Option 4 - QPMF Hazard Impact

Figure: 13

Rev: A

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APPENDIX E–BASIN ASSESSMENT

BMT WBM

External Memorandum

From: Melanie Gostelow To: Neil Benning

Date: 4 September 2013 CC:

Subject: Canley Corridor FRMS&P – Option 2 – Cabra-Vale Park Flood Detention Basin

As part of the Canley Corridor Floodplain Risk Management Study a number of structural flood mitigation options will be assessed using the developed TUFLOW model. The following outlines the assessment of Option 2 which is described as a flood detention basin at Cabra-Vale Park, Cabramatta.

Option Objective and Overview

Flood detention basins can be used to manage flooding through the temporary storage of flood waters during a flood event, effectively reducing downstream flow rates. As with most urbanised catchments suitable sites for flood detention basins are limited in the Canley Corridor catchment area.

Cabra-Vale Park has been identified as a potential site for a flood detention basin. The public recreational park is roughly 3 hectares of grassed open space with sparse additional vegetation. The site occupies the majority of the urban block bounded by McBurney Road, Park Road, Bartley Street and Railway Parade. The gentle slope of the site is consistent with the surrounding area falling in a north easterly direction from the McBurney Road, Park Road intersection to the Bartley Street, Railway Parade intersection. A significant portion of overland flow from the local sub-catchment area drains north along Railway Parade, east of the site.

This mitigation option aims to reduce flood levels downstream of the site along Railway Parade through the construction of a flood detention basin. A flood detention basin at the park would collect and temporarily store overland flow from the surrounding area to be drained via a pipeline connecting to the existing drainage network.

Flood Detention Basin Layout

An overview of the Option 2 layout is illustrated in Figure 1. Figure 1 illustrates the approximate extent of the flood detention basin, the pipe connection to the existing drainage network and the existing topography of the site.

For the purpose of this assessment the flood detention basin has been assumed to be 2m deep with 1:4 batters and a 600mm diameter outlet pipe connecting to the existing drainage network along Railway Parade.

TUFLOW Modelling and Results

The impact of Option 2 on flood levels has been investigated using the Canley Corridor TUFLOW model. The topography of the site has been modified to represent the flood detention basin using z-shapes.

The Canley Corridor TUFLOW model uses a traditional hydrology model to estimate rainfall runoff hydrographs from sub-catchment areas. These rainfall runoff hydrographs are then applied at point locations in the TUFLOW model. The flood extents of the catchment are impacted by the number and location of these rainfall runoff hydrographs. No rainfall runoff hydrographs are located upstream of the flood detention basin, however a significant portion of overland flow drains north along Railway Parade, east of the site. As a result the flood detention basin can only receive overland flows when the Railway Parade flood extent widens and extends sufficiently west into the park. The flood detention basin can also receive flows from the pipe connection to the existing drainage network if sufficient flows result in surcharging of the drainage network.

The 2 hour storm duration for the 5, 20, 100 year ARI and PMF design events have been modelled for Option 2. The 2 hour duration storm event has been selected as it is generally the critical duration for this area of the catchment. The peak water level results for Option 2 have been compared with the existing situation design event modelling.

The 5, 20 and 100 year ARI design events were not significantly impacted by Option 2 with peak water level variations of less than 0.05m in the immediate area. During these design events no overland flow was captured or stored within the flood detention basin. The flood extent for these design events was limited to the immediate area surrounding Railway Parade and did not extend west to the flood detention basin.

The flood detention basin did receive flows during the PMF design event. During the PMF event the flood extent from Railway Parade extended sufficiently west for overland flows to discharge into the north east corner of the flood detention basin along Bartley Street. The flood detention basin also received surcharging flow from the pipe connection to the existing drainage network. Figure 2 shows the impact of this option on the PMF peak flood water levels as well as indicating any newly wet and dry areas resulting from the option. Whilst the flood detention basin did collect and temporarily store flows it did not receive sufficient water volumes to significantly reduce the flood extent or peak flood levels with variations of less than 0.05m in the surrounding area.

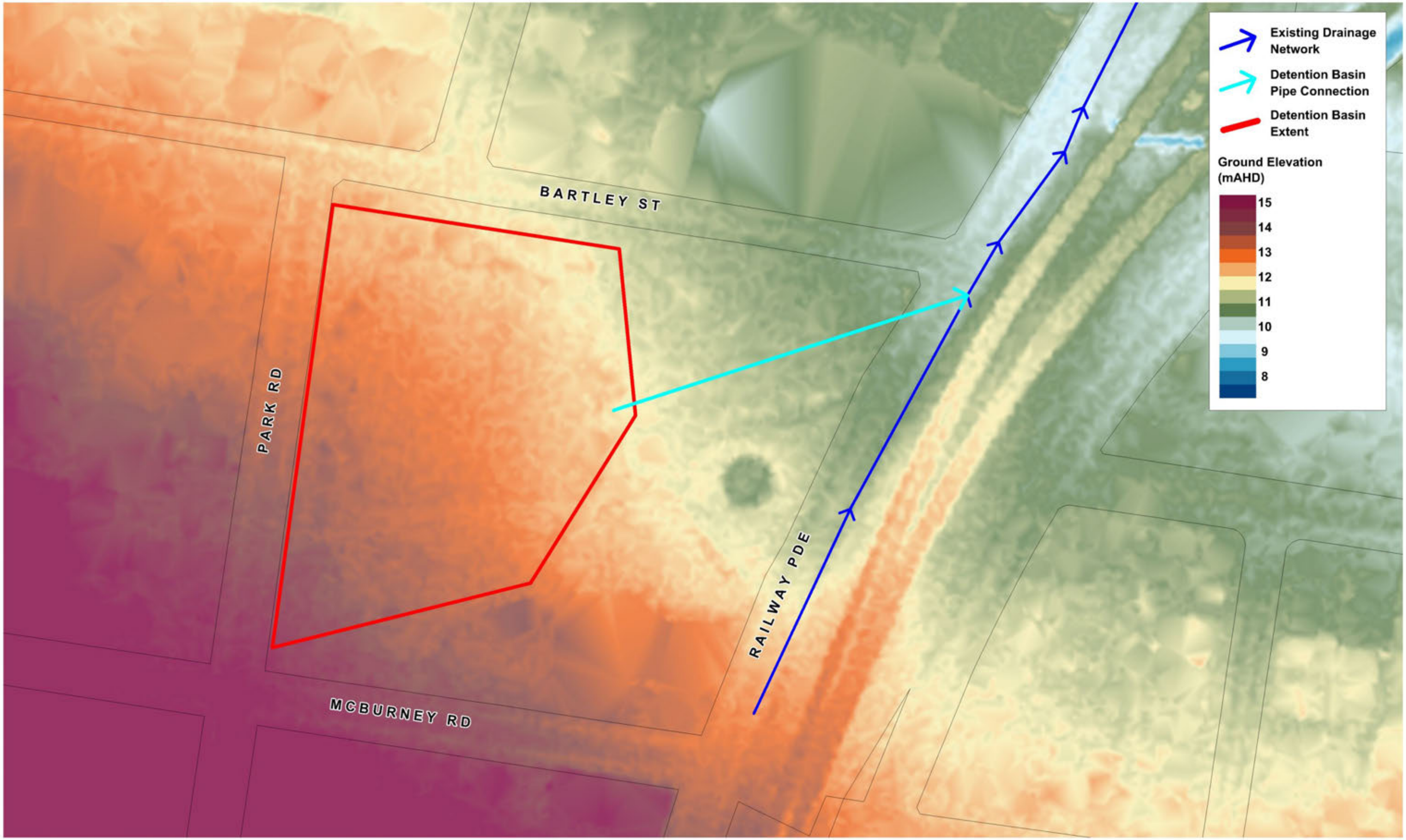
Conclusions

Testing of this flood mitigation option indicates no significant benefit from the construction of a flood detention basin at Cabra-Vale Park.

Modification may be made to the option design to increase the water volume captured by the flood detention basin. Such modifications may include capturing and diverting flow to the flood detention basin:

- from upstream overland flow paths; and
- the existing drainage network along Railway Parade.

These modifications to the option design may provide some flood mitigation benefit. If this option is to be further considered and investigated in more detail additional detailing of the TUFLOW model is recommended to further delineate the hydrology sub-catchments in the immediate and upstream area of the site.



Title:
Flood Mitigation Option 2 - Layout and Topography

Figure: 1

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Title:
Flood Mitgation Option 2 - QPMF Impact

Figure: 2

Rev: A

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APPENDIX F– UNDERGROUND STORAGE ASSESSMENT

BMT WBM

External Memorandum

From:	Melanie Gostelow	To:	Neil Benning
Date:	14 October 2013	CC:	
Subject:	Canley Corridor FRMS&P – Option 3 – Additional Underground Flood Storage		

As part of the Canley Corridor Floodplain Risk Management Study a number of structural flood mitigation options will be assessed using the developed TUFLOW model. The following outlines the assessment of Option 3 which is described as additional underground flood storage.

Option Objective and Overview

Underground flood storages can be used to manage flooding through the temporary storage of flood waters during a flood event, effectively reducing downstream flow rates. This mitigation option aims to reduce flood levels by increasing the capacity of the underground drainage network through the construction of additional underground storages.

Underground storages can be independent structures or connected to the drainage network configured in series or parallel (offline). For this option assessment the underground storages are assumed to be connected in series into the existing drainage network at existing pit locations. Connecting to the existing underground drainage network provides the additional underground storage with collected flows and a flow discharge route.

For the assessment of this option four locations in the Canley Corridor catchment have been selected as potential sites for additional underground storage. The locations have been selected as they are within the main overland flow path, located along minor roadways and offer a connection to the existing underground drainage network.

Additional Underground Storage Layout

An overview of the Option 3 layout is illustrated in Figure 1. Figure 1 illustrates the location of the four additional underground storages along with the existing underground drainage network.

For the purpose of this assessment each additional underground storage has a volume of approximately 700m^3.

TUFLOW Modelling and Results

The impact of Option 3 on flood levels has been investigated using the Canley Corridor TUFLOW model. The 1D representation of the underground drainage network has been modified to represent the additional flood storages. The additional flood storages have been incorporated by increasing the storage surface area at the selected drainage pits.

The 2 hour storm duration for the 5, 20, 100 year ARI and PMF design events have been modelled for Option 3. The 2 hour duration storm event has been selected as it is generally the critical duration for this area of the catchment.

The peak water level results for Option 3 have been compared with the existing situation design event modelling. The 5, 20, 100 year ARI and PMF design events were not significantly impacted by Option 3 with peak water level variations of less than 0.01m in the immediate area.

Conclusions

Testing of this flood mitigation option indicates no significant benefit from the construction of the additional underground storages. Given the volume of rainfall runoff produced from the modelled ARIs, the 700m^3 capacity of the additional underground storages is not sufficient to significantly impact peak flood levels. We therefore do not recommend that further consideration of this option.

Title:

Flood Mitgation Option 3
Layout and Existing Drainage Network

Figure: 1

Rev: A

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APPENDIX G– PIPE CAPACITY ASSESSMENT

BMT WBM

Internal Memorandum

From: Simon Kovacevic | To: Neil Benning

Date: 25 June 2013 | CC:

Subject: Canley Corridor FRMS&P - Pipe Capacity Assessment

The following outlines the pipe capacity assessment undertaken using the updated Canley Corridor TUFLOW model.

Pipe Capacity Assessment Methodology

The pipe capacity assessment can be used to locate pipes that are either under or over capacity compared with adjacent pipes. This can be used for 'first-pass' identification of potential opportunities and constraints in the network with respect to identification of potential flood mitigation options specifically related to the stormwater drainage network. The pipe capacity assessment tool is a strategic tool and does not negate the need for more detailed modelling in potential problem areas.

Limitations of the underlying hydraulic modelling should be considered when interpreting the model results, including:

- Extent of the stormwater drainage network incorporated into the TUFLOW model;
- The cell size of the TUFLOW model (2m for this model) which may not account for all drainage features at a sub-grid scale (e.g. roadside gutters); and
- Lumped hydrology approach.

The design event modelling results of the updated Canley Corridor TUFLOW model have been used to estimate the ARI capacity of each pipe. For this assessment, a pipe is considered to be at-capacity when flowing full. This definition does not consider whether surcharging of flow from pits to the surface occurs.

TUFLOW tracks the maximum percentage full (based on cross sectional area) for each pipe throughout the simulation. For each modelled pipe across the study area, the adopted percentage full for each ARI has been calculated by taking the maximum percentage full from the range of design storm event durations modelled for each ARI (i.e. envelope approach).

The pipe capacity ARI range has been assigned based on the percentage full for each ARI. The upper limit of the pipe capacity ARI range represents the ARI when the pipe is at-capacity with full pipe flow.

Results of the Pipe Capacity Assessment

The pipe capacity assessment has been undertaken for the Canley Corridor drainage network for unblocked inlets, as illustrated in Figure 1.

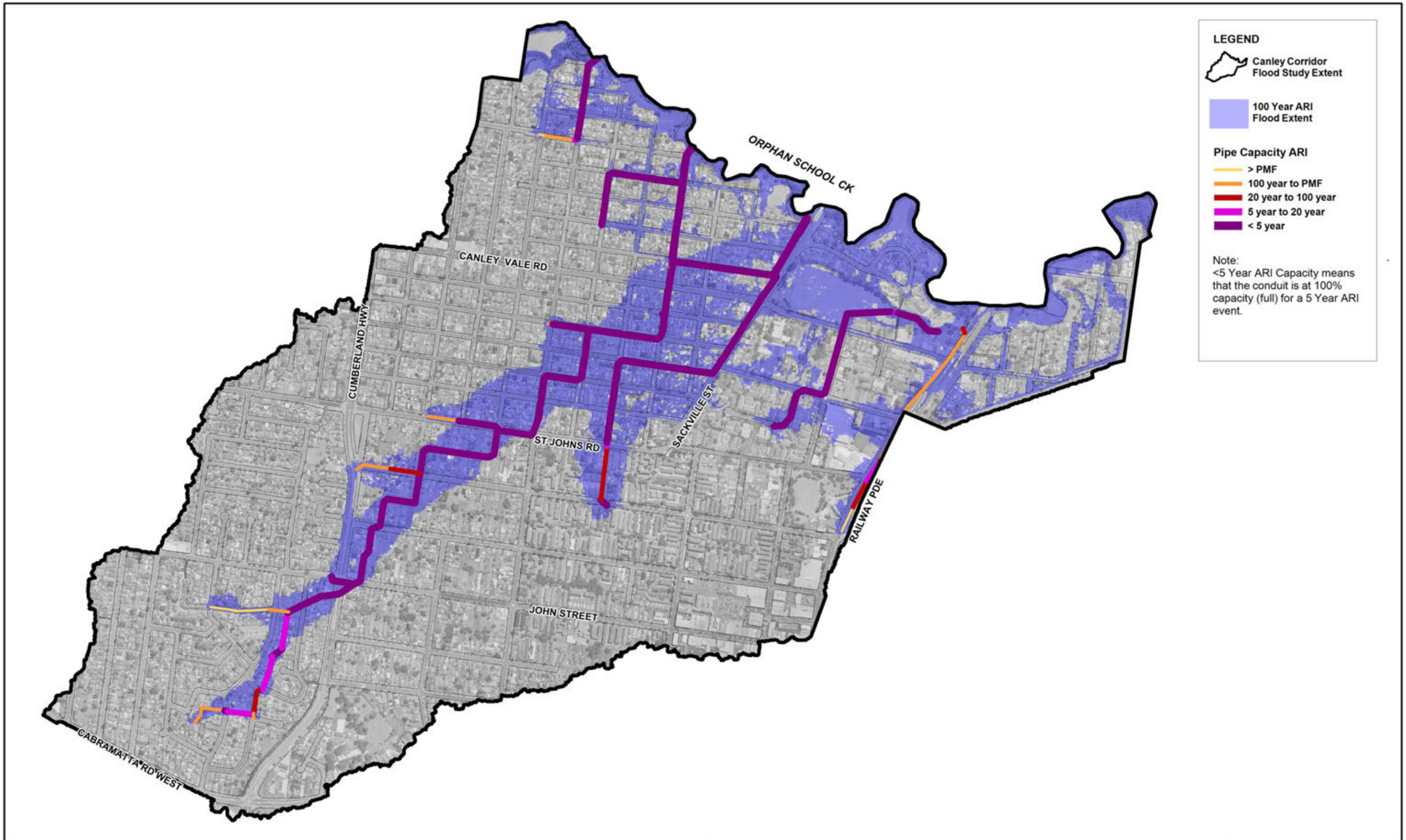
The results from the assessment can be summarised as follows:

- The assessment indicates that the majority of the network is at-capacity (full) during the 5 year ARI event.
- The capacity of the drainage is greater in some locations at the extremities of the network.
- There are no obvious bottlenecks in the drainage network.

Whilst the results indicate some pipe capacity at the upstream extremities of the pipe network, it is likely that this result is due to the adopted modelling approach for the Canley Corridor Flood Study and subsequent revisions for the Floodplain Risk Management Study, whereby only pipes greater than 900mm diameter have been included in the stormwater network, with sub-catchment inflows lumped at drainage pits. In reality, runoff will enter the drainage network further upstream. It is therefore likely that the pipes at the upstream extremities of the modelled stormwater drainage network will be at-capacity (full) during a 5 Year ARI event.

These results indicate that there are not likely to be any viable flood mitigation options within the Canley Corridor study area related to:

- increasing pit inlet sizes to direct more runoff into the stormwater drainage network; and
- local pipe size increases to reduce bottlenecks in the stormwater drainage network.



Title:
Pipe Capacity - Unblocked Inlets

Figure: 1

Rev: A

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Approx. Scale

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APPENDIX H– FLOW DIVERSION ASSESSMENT

BMT WBM

Internal Memorandum

From: Simon Kovacevic   To: Neil Benning

Date: 10 July 2013   CC:

Subject: Canley Corridor FRMS&P – Option 1 – Street Flow Diversion

As part of the Canley Corridor Floodplain Risk Management Study a number of structural flood mitigation options will be assessed using the developed TUFLOW model. The following outlines the assessment of Option 1 which is described as a street flow diversion.

Option Objective and Overview

Across the Canley Corridor catchment a significant portion of the overland flow is conveyed along roadways. This mitigation option aims to reduce flood levels by reducing overland flows through properties by diverting this flow along new or enhanced flow paths that follow the street network. Street flows are to be diverted using speed humps to convey flows to connecting side streets which can then drain to Orphan School Creek.

The feasibility of this option requires proximity to both Orphan School Creek and the main flow path as well as an achievable fall in topography along the additional flow paths. The area bounded by Orphan School Creek, Adolphus Street, Canley Vale Road and Sackville Street was considered appropriate for trialling this option. The option would therefore aim to reduce floods levels in the immediate downstream areas.

Additional Flow Path Layout

An overview of the Option 1 layout is illustrated in Figure 1. Figure 1 illustrates the locations where speed humps have been added and the location of the additional flow paths. These locations have been selected in consideration of main flow paths and the topography of the area.

The main overland flow path from the upper catchment drains in a north-easterly direction from Canley Vale Road to Sackville Street. Overland flows are predominantly conveyed by Canley Vale Road, Buckingham, Burdett, Palmerston, Earl and Sackville Streets as well as through numerous residential properties.

Consequently, Adolphus, Burdett and Palmerston Street have been investigated for use as additional/enhanced flow paths to convey the diverted east-bound overland flow northwards to Orphan School Creek.

Given that numerous speeds humps along Canley Vale Road may be considered undesirable for traffic flow, the Adolphus Street additional flow path commences at Buckingham Street.

Within the area of interest, Earl Street acts as a ridge line in the topography. Consequently the Burdett Street and Palmerston Street flow paths do not continuously extend from Canley Vale Road to Orphan School Creek, instead diverting flows from Canley Vale Road to Buckingham Street aiming to reduce flows along Canley Vale Road.

TUFLOW Modelling and Results

The impact of Option 1 on flood levels has been investigated using the Canley Corridor TUFLOW model. The speed humps have been represented in the model as 0.15m height increases of 2m width extending across the full width of the road reserve. To encourage the passage of the overland flow northwards along the street network, the ground elevations in the model have been modified to ensure that these roadway flow paths are free-draining in a northerly direction. The elevations along the flow paths have been based on the existing topography at the connecting roads. This modification is considered representative of re-grading these road sections.

The 2 hour storm duration for the 5, 20, 100 year ARI and PMF design events have been modelled and compared with the existing situation design event modelling. The 2 hour duration storm event has been selected as it is generally the critical duration for this area of the catchment. A comparison of the peak water level results is provided as Figure 2, 3, 4 and 5. These figures show the impact of this option on peak flood water levels as well as indicating any newly wet and dry areas resulting from the option.

- Flow diversions to Buckingham Street

A portion of street flow from Canley Vale Road is diverted via Burdett Street and Palmerston Street to Buckingham Street. For the 5, 20 and 100 year ARI events the flow diversion reduces downstream flood levels (-0.05m to -0.1m) along Canley Vale Road and several bordering properties. However this modification also increases the flood extent and flood levels (+0.05m to +0.1m) over a larger number of residential properties, particularly surrounding the Palmerston St/Buckingham St intersection. For the PMF event the modification does not produce a significant impact on flood levels. Flow diversions from Canley Vale Road to Buckingham Street, via Burdett Street and Palmerston Street, are therefore not recommended for further consideration.

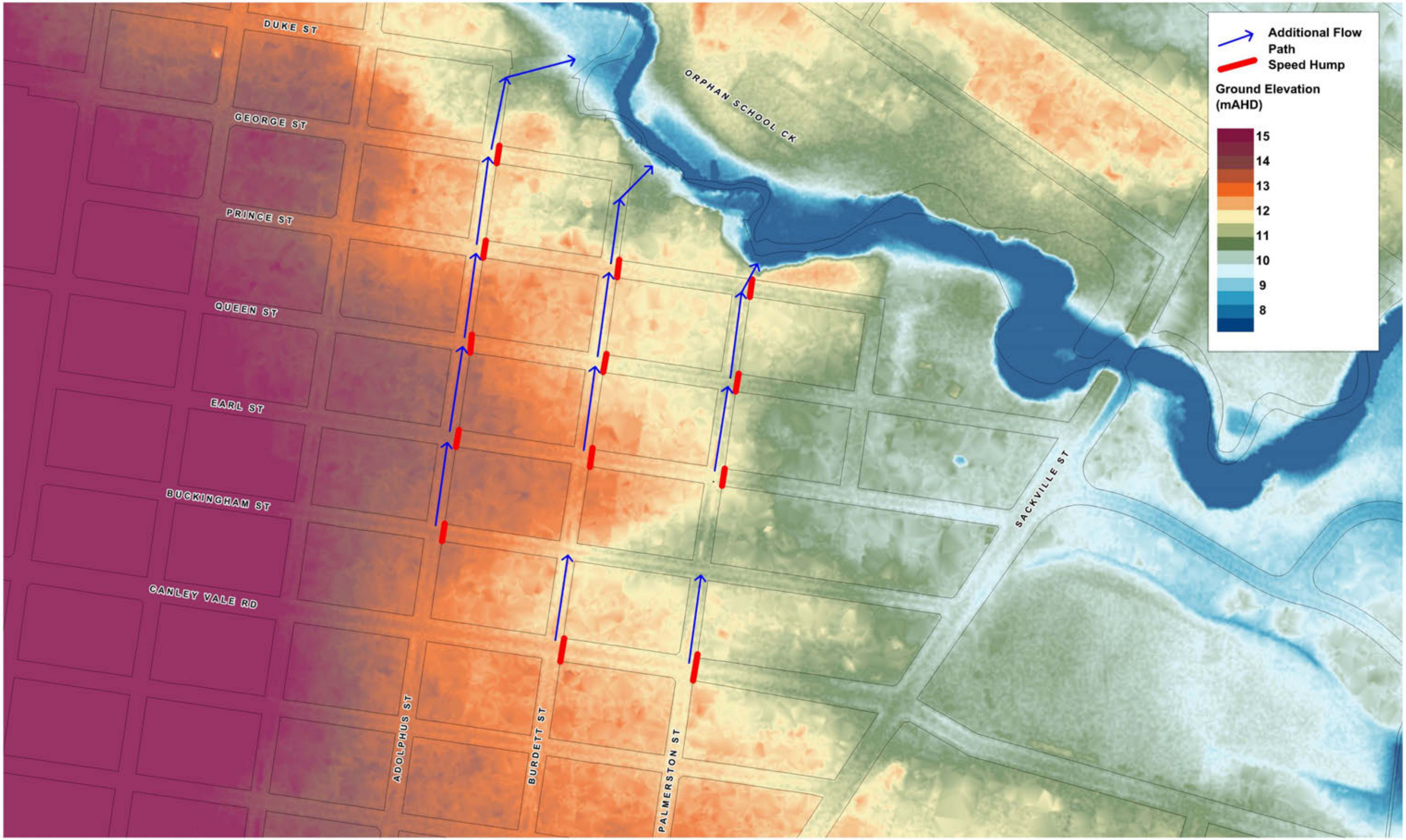
- Flow diversions to Orphan School Creek

A portion of street flow from a number of connecting streets is diverted north to Orphan School Creek via the Adolphus Street and Burdett Street flow paths. For the 5, 20 and 100 year ARI events the flow diversions reduce the downstream flood extent along Earl, Queen and Prince Streets and several bordering residential properties. The modification results in minor increases in the flood extent in this area and also the flood levels at the Buckingham St/ Adolphus Street and Burdett St/ Queen Street intersections. For the PMF event the modification reduces the flood extent along sections of Prince Street and Earl Street and several neighbouring properties. Street flow diversions along Adolphus Street and Burdett Street are recommended for further consideration in the flood risk management study.

Conclusions

Testing of this particular mitigation option has shown that there is some merit in pursuing this as an option for the Floodplain Risk Management Study, specifically in the area north of Buckingham Street. More detailed consideration of this option may require assessment of the spacing of the road humps along the road with respect to road design criteria (e.g. are the modelled humps too close together?), combined with more detailed assessment of any property-related flood level impacts associated with the new flow paths.

The testing has shown that there is minor benefit along Canley Vale Road combined with an adverse impact between Buckingham Street and Earl Street as a result of the flow path improvements between Canley Vale Road and Buckingham Street. We therefore recommend that that no further assessment be undertaken in this area.



Title:

Flood Mitigation Option 1 - Layout and Topography

Figure: 1

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Approx. Scale

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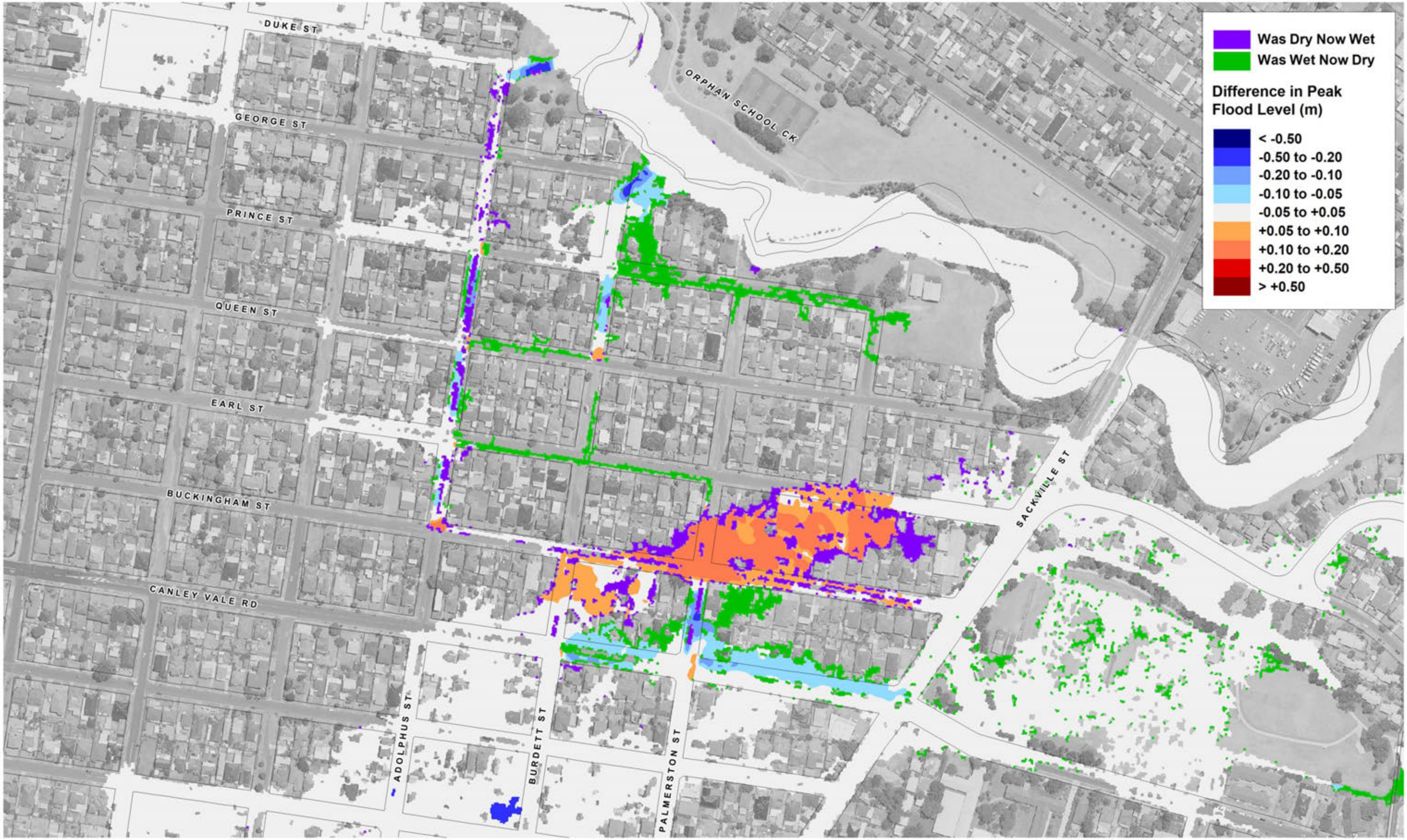

Title:
Flood Mitgation Option 1 - Q005 Impact

Figure: 2

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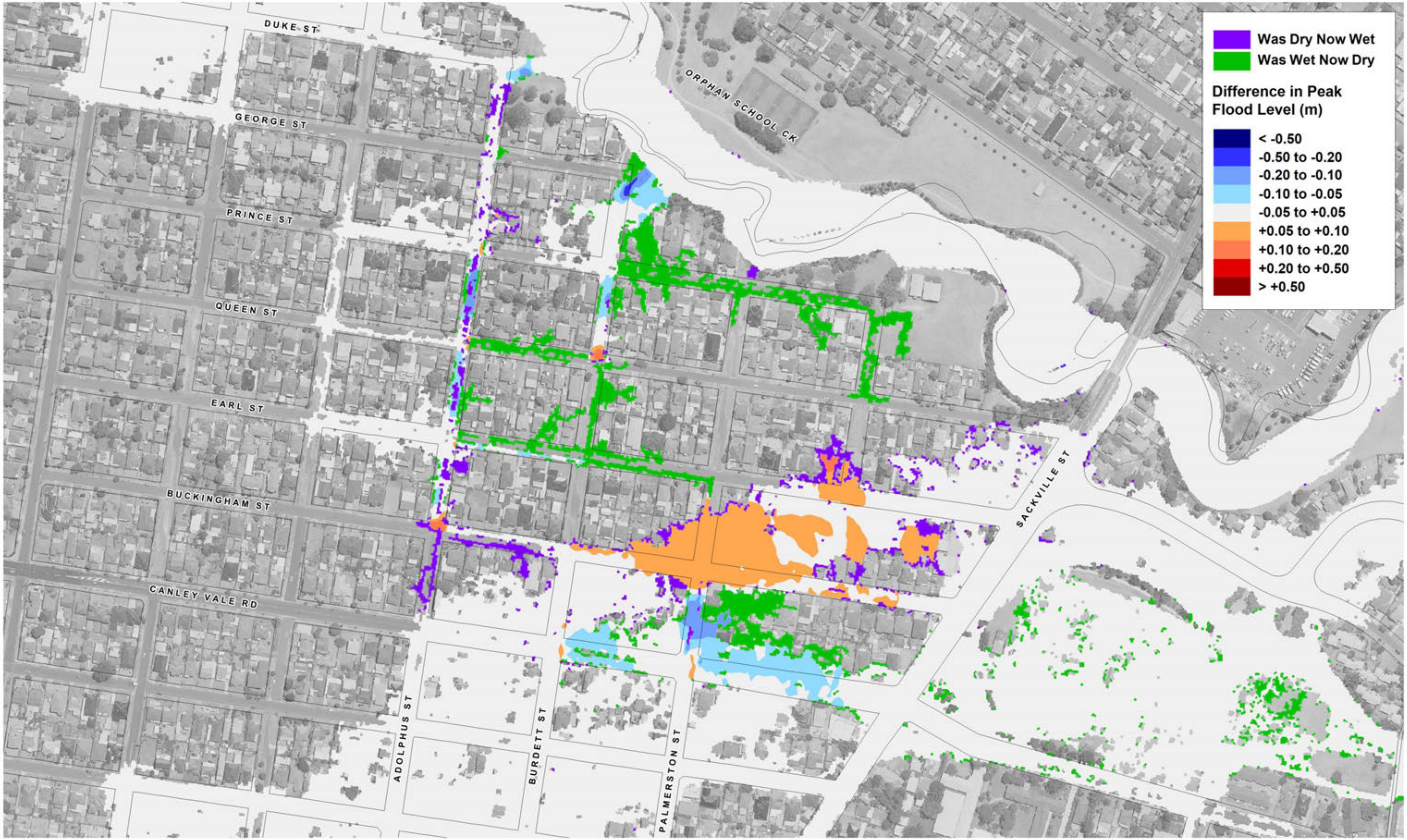

Title:
Flood Mitgation Option 1 - Q020 Impact

Figure: 3

Rev: A

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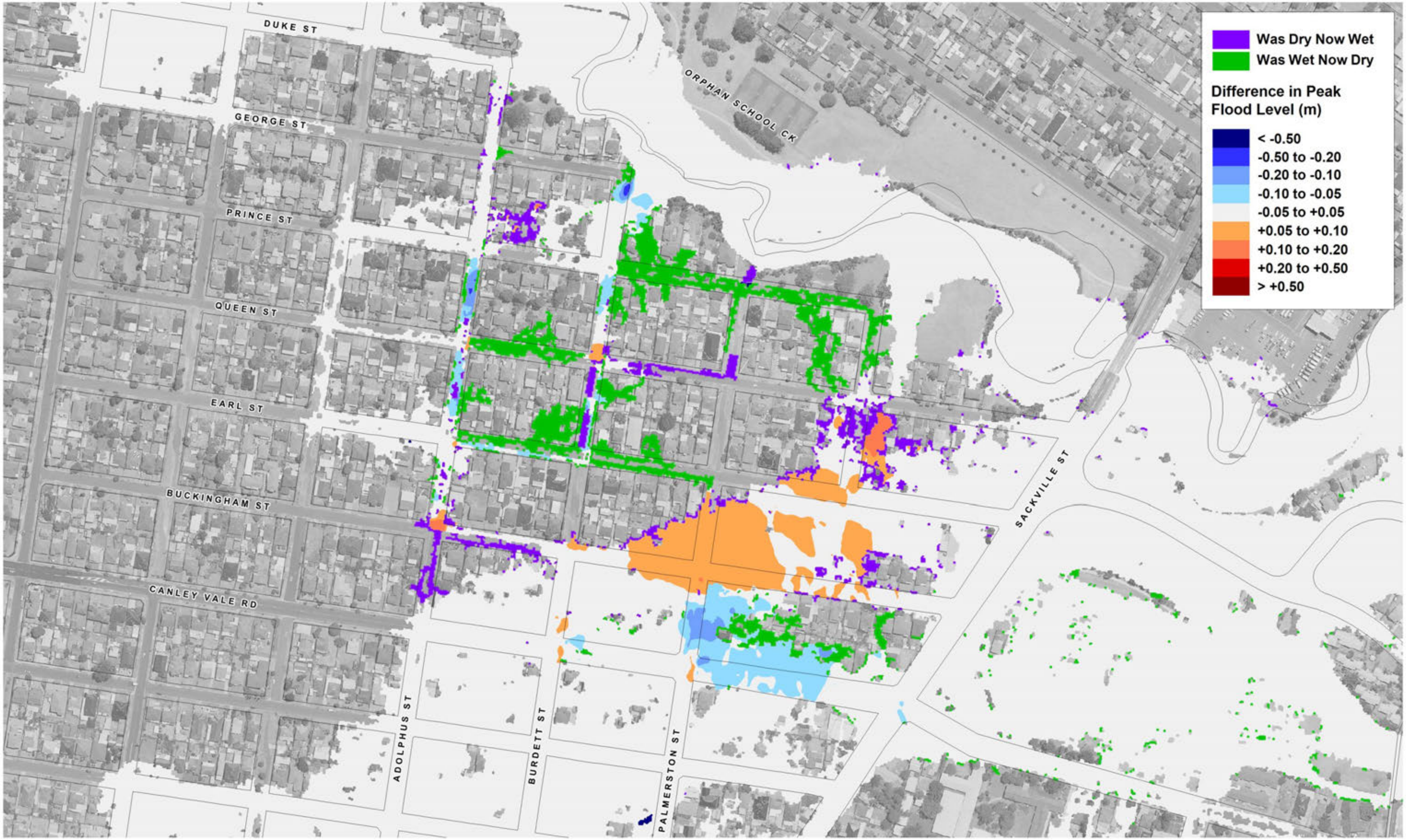

Title:
Flood Mitgation Option 1 - Q100 Impact

Figure: 4

Rev: A

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Title:
Flood Mitgation Option 1 - QPMF Impact

Figure: 5

Rev: A

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APPENDIX I– FLOOD CHECK PROPERTY REPORT

Flood Check Property report

Property

Reference: Lot 266 Plan RP132646

15 DALE STREET
BURPENGARY QLD 4505

Flood Summary

River and Creek *River and creek flooding occurs when water levels rise and escape the main channel following long durations of heavy rain. Some large underground urban drainage systems have been included in this category.*	**AFFECTED**	**High likelihood** Approximately 100% of this property is within the calculated extent of a flood that has a 5% annual chance of occurring. Refer to page 1 of the Technical Summary for further details, including information about larger and less likely floods.
Overland Flow *Overland Flow describes the gullies and depressions where runoff is expected to flow following intense rain.*	Not Affected	This property is outside Council's known overland flow path mapping extents. However small unmapped overland flow paths exist that may affect any property after intense rains.
Tidal Inundation *Tidal inundation occurs on coastal land where sea levels fluctuate based on the position of the sun and the moon.*	Not Affected	This property is above the estimated level of a Highest Astronomical Tide (HAT) which typically occurs twice a year.
Storm Tide *Storm Tide inundation occurs on coastal land where extreme weather conditions raise the sea levels to above the normal tide levels.*	Not Affected	This property is outside the known storm tide floodplain.
Building and Development *When planning new building and development works there may be additional requirements to consider.*	**AVAILABLE**	**Additional flood information is available for this property**, relevant for planning new building and development works. Refer to page 5 of the Technical Summary for further details.

Technical Summary *(page 1 of 5)*

Reference: Lot 266 Plan RP132646

Property Ground Levels

Minimum Ground Elevation:	7.2 m AHD (Australian Height Datum)
Maximum Ground Elevation:	10.8 m AHD
Average Ground Elevation:	10.0 m AHD
Elevation Data Source:	*Aerial Laser Survey - DERM/MBRC (August 2009, Ausgeoid98)*

River and Creek

This property is located in the Burpengary Creek catchment. The details provided below have been extracted from a flood investigation prepared for this catchment: *Hydrologic and Hydraulic Modelling Burpengary Creek (BUR)* by BMT WBM, dated 20/11/2012. The investigation report is available for free download from Council's website: www.moretonbay.qld.gov.au/floodcheck

The river and creek flood investigation for this catchment indicates that **parts of this property have a high likelihood of being affected** by river and creek flooding under existing conditions.

Where relevant, further detail regarding existing river and creek flood behaviour at this property is provided in the following table and on the flood map on page 2. This map only shows the 1% annual chance flood and floodplain extent where applicable. Flood maps for the 5% and 0.1% annual chance floods are available from Council's website: www.moretonbay.qld.gov.au/floodcheck by accessing the suburb flood maps or *Flood Explorer*.

Flood Likelihood	Annual Chance	Minimum Flood Height (m AHD)	Maximum Flood Height (m AHD)	Mean Flood Depth (metres)	Maximum Flood Depth (metres)	Percentage of Property Affected	Data Reliability
High	5%	11.0	11.1	1.1	3.8	100%	A
Medium	1%	11.6	11.6	1.6	4.3	100%	A
Low	0.1%	12.6	12.6	2.6	5.3	100%	A
Negligible	< 0.01%	Council does not provide levels for floods with *Negligible* likelihood. The estimated floodplain extent is shown with pink coloured shading on the flood map provided on page 2 where applicable.					

River and Creek Flood Map

This map shows the existing 1% annual chance flood and the maximum floodplain extent where applicable. Where flood map extents vary from flood summary values, use the summary values in the table on the previous page. To view similar mapping for other flood likelihoods refer to Council's website: www.moretonbay.qld.gov.au/floodcheck

GIS Version Reference: 11 2014

Subject Property

1% Annual Chance - Flood Depth

0 - 0.25m | 0.5 - 1m

0.25 - 0.5m | Greater than 1m

Property Boundaries (DCDB)

Building Footprints

Limited Data Reliability

Data Under Review

Floodplain Extent

Overland Flow Flooding

0 8.5 17 25.5 34

Metres

N W E S

Note: this page must be reproduced in colour to be fully legible.

Technical Summary (page 3 of 5)

Reference: Lot 266 Plan RP132646

Overland Flow

For areas located outside the extent of the river and creek flood investigation Council has undertaken a mapping analysis to identify locations that may be affected by an overland flow path. The report that describes preparation of this overland flow path mapping is titled: *Moreton Bay Regional Council Overland Flow Path Mapping.* The report is dated November 2012 and is available for free download from Council's website: www.moretonbay.qld.gov.au/floodcheck

This property is outside Council's known overland flow path mapping extents. However small unmapped overland flow paths exist that may affect any property after intense rains. Seek further advice from a suitably qualified and experienced engineer if you are concerned about overland flow flooding at this property.

Where relevant, further detail regarding possible overland flow paths at this property is provided on the flood map on page 2. Council does not provide any advice regarding flood height or depth for overland flow paths.

Tidal Inundation

Some properties located near our coast are relatively low-lying compared to sea level and therefore may be affected by regular or seasonal tidal inundation.

The available ground level data for this property indicates that **this property is above the estimated level of a Highest Astronomical Tide (HAT)** which typically occurs twice a year.

The advice provided regarding tidal inundation is sensitive to the accuracy of the ground level information used for this report. This is particularly the case for properties with level terrain and vertical walls on their tidal boundary, for example alongside a canal. If you are concerned about this and wish to confirm the susceptibility of this property to tidal inundation please consult a qualified and experienced engineer for further advice.

Council does not provide any advice regarding flood height or depth for tidal inundation.

Technical Summary *(page 4 of 5)*

Reference: Lot 266 Plan RP132646

Storm Tide

This property is located in the Burpengary Creek catchment.

The storm tide investigation for this area indicates that **this property is not affected by storm tide** flooding under existing conditions.

Where relevant, further detail regarding existing storm tide behaviour at this property is provided in the following table and on the flood map.

Flood Likelihood	Annual Chance	Minimum Flood Height (m AHD)	Maximum Flood Height (m AHD)	Mean Flood Depth (metres)	Maximum Flood Depth (metres)	Percentage of Property Affected	Data Reliability
High	5%	-	-	-	-	-	-
Medium	1%	-	-	-	-	-	-
Low	0.1%	-	-	-	-	-	-
Negligible	< 0.01%	Council does not provide levels for floods with *Negligible* likelihood. The estimated floodplain extent is shown with pink coloured shading on the flood map provided where applicable.					

Technical Summary (page 5 of 5)

Reference: Lot 266 Plan RP132646

Building and Development

The flood information provided below **should be considered when planning new building and development works at this property**.

Flood Type	Annual Chance	Minimum Flood Height (m AHD)	Maximum Flood Height (m AHD)	Data Reliability
River and Creek	1%	11.8	11.9	A
Storm Tide	1%	-	-	-

Please carefully read the following:

- The flood heights provided in the table above account for additional factors, such as climate change, relevant to building and development and may be higher than the levels provided in previous sections of this report.
- In general the highest of the flood heights listed in the table above should be used for calculating minimum building and development levels. However, if you are preparing an application for new building and/or development works you must check all the relevant requirements within the planning scheme. The flood heights provided do not include any freeboard.
- For large properties the difference between minimum and maximum flood heights may be significant. In these situations seek further advice when calculating minimum building and development levels.

For further information refer to the Fact Sheet '*Understanding Your Flood Check Property Report'* attached. Additional fact sheets containing important flood information are also available from Council's website.

Flood Check Fact Sheet 4

How to Interpret a Flood Check Property Report

This document should be read in conjunction with the guidance and information provided in Flood Check Fact Sheet 1 ***Things to Know about Flood Maps.***

The Flood Check Property Report informs interested parties of potential flood levels anticipated for the property from a range of flood events. An explanation of the likelihood of these flood events is described in Flood Check Fact Sheet 5 ***Understanding the Likelihood of Floods.***

When to request a Flood Check Property Report

It is recommended that a *Flood Check Property Report* be obtained before building or purchasing a property. Council encourages parties interested in a property to download a free report from our website to determine the property's anticipated flooding potential.

Before downloading a property report, interested parties should review either: the *Suburb Flood Maps*; or the online *Flood Explorer Interactive Mapping Tool* to gain an understanding of the potential flooding conditions for the general area of interest.

What a Flood Check Property Report may tell you

The Flood Summary

Flood Summary

River and Creek *River and creek flooding occurs when water levels rise and escape the main channel following long durations of heavy rain. Some large underground urban drainage systems have been included in this category.*	**AFFECTED**	**High likelihood** Approximately 10% of this property is within the calculated extent of a flood that has a 5% annual chance of occurring. Refer to page 1 of the Technical Summary for further details, including information about larger and less likely floods.
Overland Flow *Overland Flow describes the gullies and depressions where runoff is expected to flow following intense rain.*	Not Affected	This property is outside Council's known overland flow path mapping extents. However small unmapped overland flow paths exist that may affect any property after intense rains.
Tidal Inundation *Tidal inundation occurs on coastal land where sea levels fluctuate based on the position of the sun and the moon.*	**AFFECTED**	**Low likelihood** Parts of this property are outside the expected range of normal seasonal tides but may be affected by storm tide.
Storm Tide *Storm Tide inundation occurs on coastal land where extreme weather conditions raise the sea levels to above the normal tide levels.*	**AFFECTED**	**High likelihood** Parts of this property are within the calculated extent of a flood event that has a 5% annual chance of occurring. Refer to page 3 of the Technical Summary for further details, including information about larger and less likely floods.
Building and Development *When planning new building and development works there may be additional requirements to consider.*	**AVAILABLE**	Additional flood information, relevant for planning new building and development works, is available for this property. Refer to page 4 of the Technical Summary for further details.

A *Flood Check Property Report* begins with a summary of the potential flooding conditions anticipated for the property for each type of flooding. The summary provides an initial assessment of whether the property is potentially affected or not by flooding. If the property is determined to be affected then an indication of the potential likelihood of this occurring in any given year is described.

If a *Flood Check Property Report* does indicate that the property is affected by a type of flooding then further information for this type of flooding will be presented in the accompanying Technical Summary.

The Technical Summary

The Flood Check Technical Summary follows the Flood Summary when a property is determined to be affected by one or more types of flooding.

The Technical Summary begins by describing the property ground levels. Minimum, maximum and average ground levels are provided in metres AHD. AHD stands for Australian Height Datum; this is the standard elevation reference for mapping purposes adopted by the National Mapping Council of Australia. As a general guide, 0.0m AHD is approximately equal to mean sea level. Flood levels are also be provided in metres AHD.

The Technical Summary will then present the details of the anticipated flooding conditions for each type of flooding that was determined to affect the property. The Technical Summary states the information source for the detailed flood levels provided in the accompanying table of data.

Flood Check Fact Sheet 4

Flood Data Tables

A flood data table is included in the Technical Summary and provides minimum and maximum anticipated flood levels for low, medium and high flood likelihoods where they affect the property. The flood likelihoods are quantified by their equivalent annual chance of occurring in any given year. The flood data table also provides the anticipated maximum flood depth and percentage of property surface area inundated for each of these flood likelihoods.

Flood Likelihood	Annual Chance	Minimum Flood Height (m AHD)	Maximum Flood Height (m AHD)	Mean Flood Depth (metres)	Maximum Flood Depth (metres)	Percentage of Property Affected	Data Reliability
High	5%	2.8	2.8	0.6	1.1	66%	A
Medium	1%	3.2	3.2	0.8	1.4	77%	A
Low	0.1%	3.5	3.5	1.1	1.7	82%	A
Negligible	< 0.01 %	Council does not provide levels for floods with *Negligible* likelihood. The estimated floodplain extent is shown as a pink coloured shading on the flood map provided on page 5 of this Technical Summary.					

Note: the depth of water shown is the depth above the estimated ground surface. This does not necessarily indicate the depth of flooding inside a home. Normally floor levels of homes are elevated above the surrounding ground surface.

Finally, the flood data table provides a data reliability rating as an indicator of the current level of confidence in the values provided for each event. Flood data tables are not provided for overland flow paths or tidal inundation.

Data Reliability Ratings

The flooding information presented via the Council flood maps or a *Flood Check Property Report* is the best available information that Council has at the time. The information has been compiled from numerous sources and studies. The quality of the information available may not be uniform for all catchments or studies, hence the findings of some studies may be considered to have been derived from more reliable information than others. No flood study or related flood information should ever be considered to be perfect.

To communicate the potential difference between sources of flood information, and to infer the degree of confidence held in the data provided, the *Flood Check Property Report* includes a data reliability rating for each item of available data. Users are encouraged to consider the reliability of the data when making related decisions.

A description of each data reliability rating is provided in the table below.

Data Reliability Rating	Council's Definition
A	The flood data used in this report is based on recent flood studies and topographical information. It is therefore considered the most reliable flood data held in the Council flood database.
B	The flood data used in this report is based on the most current, but not recent, flood studies and topographical information held in the Council flood database. Changes to the predicted level and extent of inundation are possible in the near future.
C	Council has commenced review of this flood information and will update this data once the review is completed.
D	Council has commenced review of this flood information and will update this data once the review is completed. The data is out of date and of low quality but an extent has been provided to give an indication of the areas that may be inundated.

Over time Council will continue to upgrade lower rating data sources through information collection and remodelling.

How to interpret flooding information provided on a Flood Check Property Report

When interpreting the information provided in the *Flood Check Property Report* you should consider the overall risk from all types of flooding and their likelihoods.

When purchasing a property

When purchasing a property you should use the information provided in the *Flood Check Property Report* to provide you with a detailed understanding of the potential flooding conditions for the property. If you have not done so already, you should also view either the *Suburb Flood Maps* and/or the *Flood Explorer Interactive Mapping Tool* to gain an appreciation of the potential flooding conditions in the area.

Once you have understood the potential flooding conditions for the property you should consider the potential consequences that may arise from similar sized flood events actually occurring. (eg What areas of the property will be flooded? Will flooding result in any damage to these areas?)

Once you have considered the potential consequences, consider the likelihood of a similar sized flood event occurring, as indicated by the flood likelihood description provided. Please also refer to Fact Sheet 5 **Understanding the Likelihood of Floods.**

The overall risk of loss or damage from each flood event is a combination of the consequence and likelihood. For example, if an area is affected by shallow flooding during a low likelihood flood event then: 1) the potential consequences are likely to be small; 2) the chances of it happening are low; and therefore 3) the flood risks for this area will be very small.

Consider what actions you would need to take to manage the consequences of potential floods on this property. The actions should reflect the overall degree of risk to you, your family, your business and employees, and the home and assets.

Your willingness and ability to undertake the necessary actions to manage the risk should be considered when assessing the suitability of the property to your needs and lifestyle.

Before making any decisions please review the limitations of *Flood Check Property Report* presented on page 4 of this Fact Sheet. If you have any concerns or are uncertain about how to interpret the information, please consult with a qualified professional engineer.

For making a Flood Emergency Plan

The information contained in the *Flood Check Property Report* can help you to understand the likelihood and potential consequences of flooding at your place of residence or work place. If you live in a flood prone area it is important to prepare a Flood Emergency Plan to plan for your safety during floods.

For more information on making an emergency plan, preparing an emergency kit, getting your home ready, tuning into warnings, or preparing for a cyclone, severe storm, tsunami or flood, see the guide available at www.disaster.qld.gov.au/getready

For building and development

Most building standards and development conditions require minimum floor levels to be above the 1% annual chance flood event. This event is described as having a *medium* likelihood of occurring in any given year. Check the Building and Development section (page 4 of the Technical Summary) in the *Flood Check Property Report* to establish the minimum required building and development levels. A current *Flood Check Property Report* should be attached to all building and development applications to demonstrate its compliance. It is also recommended that you understand all the necessary requirements, including those flood related, within the planning scheme relevant to the property.

Flood Check Fact Sheet 4

Limitations of the Flood Check Property Report

Where the report indicates the affect of flooding on the property is 'unknown' or that there is 'no data' available, Council has no suitable information upon which to base any flood advice. However this does not necessarily mean that a property is immune from flooding.

The flood mapping information produced by Council is generated on a regional scale and currently utilises the ground level elevations generated from an Aerial Laser Survey performed in 2009 to predict the extent of flooding for the region. Individual property ground level details could vary from the aerial laser survey results where there is an elevated house pad underneath a building. This level of detail is beyond the resolution of the flood mapping provided by Council.

The survey data used to determine the extent and depth of potential inundation is captured and updated periodically, so the report may incorrectly show inundation of land that has recently been modified, such as a new subdivision. Over time future updates will aim to rectify these differences.

Should the extent of flooding at a property need to be more accurately predicted, then individual property level information (eg building floor levels) could be utilised in conjunction with Council's flood information. Council does not undertake this level of investigation or survey on behalf of property owners.

The mapped extent of flooding may not be accurate where the depth of inundation is very shallow.

The report currently does not show the anticipated velocity of the flood water. Fast flowing water can be very destructive and dangerous even at shallow depths. Avoid entering any flood waters. Remember, If it's flooded – Forget it!

The report only provides information about the inundation caused by peak water levels. It does not give any guidance on the duration of the inundation.

From time to time Council may become aware of flood data that has a potential reliability problem. When this occurs a note is added to the Flood Check Property Reports for these affected properties. The areas of reduced data reliability are also shown with shading on the Flood Check Property Report maps. Flood model refinements will be included in a future model update and may change the flood information provided.

Need More Information?

If you would like to see more detail on potential flooding conditions you may wish to try Council's *Flood Explorer Interactive Mapping Tool*. Please refer to Flood Check Fact Sheet 3 ***How to Interpret the Flood Explorer Interactive Mapping Tool.***

Consult a Registered Professional Engineer of Queensland (RPEQ) for a more detailed flood study or understanding of the potential flooding conditions of a property. The Board of Professional Engineers of Queensland website has a list of registered professional engineers.

Feedback

Enquiries and feedback can be submitted to Council by e-mail **flood@moretonbay.qld.gov.au** or addressed in writing to:

Floodplain Management Team
Moreton Bay Regional Council
PO Box 159
Caboolture QLD 4510

Moreton Bay Regional Council

Flood Check Fact Sheet 5

Understanding the Likelihood of Floods

By using historical rainfall, flood level records and hydrological calculations, we are able to determine the likelihood of different sized floods and the floodplain areas which they may inundate should they occur.

What is the likelihood of the flooding shown on the Flood Maps?

The size of a flood is generally described in terms of how frequently similar sized floods are expected to occur on average. Small floods are likely to occur frequently, while large floods are possible but far less common.

Council flood maps and *Flood Check Property Reports* provide information for a range of flood sizes. The size of a flood is described using a reference to the percentage annual chance of a flood of a certain size occurring in any given year.

For example, a very small flood event that is expected to occur every year would be described as having a 100% annual chance of occurring in any given year. A larger flood event, that is expected to occur less frequently, would have a lower percentage annual chance of occurring in any given year.

The most common flood event that you will hear or read about is a large flood event known as the 'once in 100 year' or 'Q100' flood event. Unfortunately, this type of reference is often misinterpreted to mean that there may be 100 years between events of this size. This is not the case. Large flood events although rare, can occur at any time. Understanding the annual chance of a flood event of this size occurring in any given year is a more appropriate way to interpret the likelihood of a flood. The annual chance of a 'once in 100 year' flood occurring is actually 1%. That is to say, there is a 1% chance of a flood event of this size occurring in any given year.

Although unlikely, from time to time we can observe floods that are even larger than the 1% flood event. During the European history of our region there have been at least two floods estimated to be in this category, including the 'Great Flood of 1893' within the Stanley River catchment and more recently the January 2011 floods within the North Pine River, Caboolture River and Burpengary Creek catchments.

Remember: Although very large floods are unlikely it is important that you are aware they can occur so you can plan for your safety.

The 1% flood event is the minimum standard used by Moreton Bay Regional Council in determining a suitable minimum level for the habitable floors within a dwelling. The minimum level is applied when assessing development applications to ensure that habitable rooms in homes are built to a certain standard above more regularly observed flood events. Many other Councils throughout Australia have also adopted the 1% flood event for the same purpose.

Flood Check Fact Sheet 5

Council has adopted some standard wording and definitions to help describe the likelihood of a certain size flood. These are described in the following table.

Floods are quite rare and uncommon. The terms 'high', 'medium' and 'low' likelihood are intended to give an appreciation of the relative size and likelihood, over a long period of time, of the three flood events displayed on Council's maps occurring.

Flood Size	% Annual Chance	Likelihood (over a long period)	Council's Definition
Small	5%	High	A small flood event that may be observed from time to time. Over a very long period of time an event of similar size may occur on average once every 20 years. Although unusual, an event of this size can occur more frequently. It is likely an event of this size will occur more than once during a single lifetime. The river and creek flood event that occurred in the middle reaches of Burpengary Creek during May 2009 was similar in size to this event
Large	1%	Medium	A large uncommon flood event that is rarely observed but nevertheless still possible. Over a very long period of time an event of similar size may occur on average once every 100 years. It is therefore likely an event of this size will occur at least once during a single lifetime. It is less likely, but still possible, for a flood of this size to occur more than once in a single lifetime. A river and creek flood event of similar size occurred in the upper and middle reaches of the Caboolture River during January 2011
Very Large	0.1%	Low	A very large and very unlikely flood event. Over a very long period of time an event of similar size may occur on average once every 1,000 years. Few people will ever witness an event of this size. When an event of this size is observed it is considered to be very exceptional. A river and creek flood event of similar size occurred in the middle reaches of the North Pine River during January 2011. Whilst very unlikely, it is possible for these events to occur

Council's river and creek and storm tide flood information also includes the estimated floodplain extent. This is the theoretical maximum extent of the floodplain and is shown as a pink coloured shading on the maps. River and creek flooding outside this estimated floodplain extent is considered not possible. While it is practically impossible for a flood event of this size to occur, we cannot rule it out. If a location intersects this extent it is considered to be in the floodplain. It is considered extremely unlikely that anyone will witness an event of this size.

Need more information?

If you want more detailed information about actual flood levels at a property of interest, you can obtain a *Flood Check Property Report*.

The report may prove valuable when preparing your own flood emergency plan, purchasing a property, building a home or when applying for flood insurance.

Enquiries and feedback can be submitted to Council by e-mail **flood@moretonbay.qld.gov.au** or addressed in writing to:

Floodplain Management Team
Moreton Bay Regional Council
PO Box 159, Caboolture QLD 4510

Moreton Bay Regional Council

APPENDIX J – COMMUNITY ENGAGEMENT MATERIALS

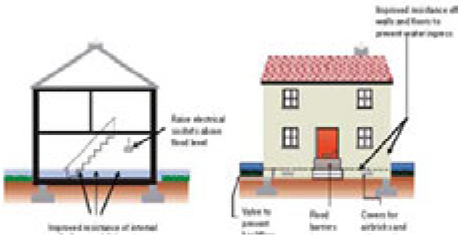
2013 Consultation

Section 3 - Property Modification Measures

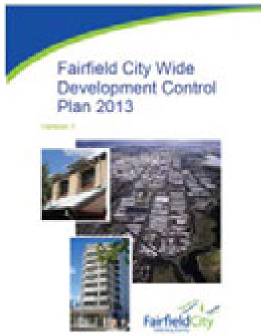
Changing or moving existing properties or buildings from flood affected areas; or changing development rules for future development in flood affected areas.

Before **After**

Voluntary house raising - raising the floor level of your house to above a certain flood level. Council currently provides financial assistance to help owners in other floodplains pay for this.



Flood proofing of buildings - designing and building houses with appropriate water resistant materials and rooms arranged so that structural & contents damage is minimised should the building get flooded.



Development controls - Council can implement special conditions or restrictions which must be followed when developing in the floodplain.

This information has been prepared as part of Fairfield City Council's Floodplain Risk Management Study and Plan for Canley Corridor.

The options presented in this brochure are being considered to manage flood risk in your neighbourhood.

Please visit us at Council's Administration Centre at Avoca Road, Wakeley to look at the community display and talk to us. We encourage you to ask questions and let us know what you think about these options.

For more information please contact:

Phone: Cecilia Tabera 9725 0264 or Email: ctabera@fairfieldcity.nsw.gov.au

Canley Corridor

MANAGING FLOOD RISK

Flood Management Options

MOLINO STEWART

NSW GOVERNMENT

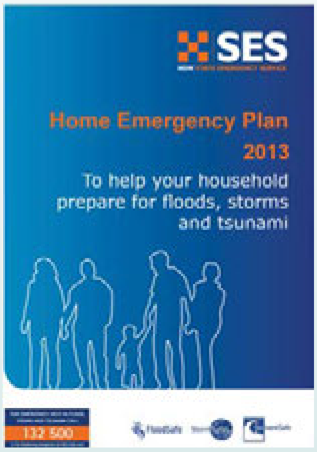
FairfieldCity Celebrating diversity

Section 1 - Response Modification Measures

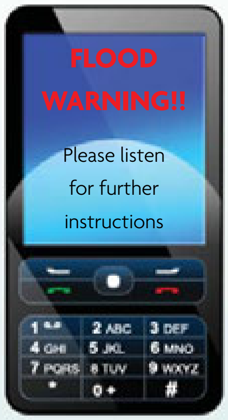
Changing the way people think and react to a flood situation

Inform and educate

Together with the NSW State Emergency Service (SES), Council can provide information on helping you prepare for a flood, what to do if a flood occurs and how to recover from one.



Prepare



Warn

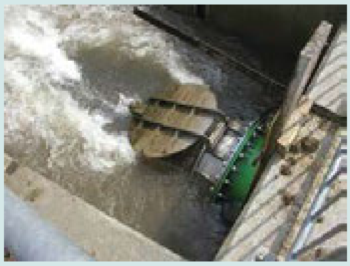
Section 2 - Flood Modification Measures

Structural actions taken to change flood behaviour by reducing flood levels, velocities or the amount and direction of flow

Pit and pipe upgrades - the highly urbanised Canley Corridor catchment, makes this option very expensive and potentially disruptive. Pits and pipes can be upgraded to convey more floodwater underground. However, it is not particularly effective for large floods.

Flow diversions - these could be built as a series of raised thresholds or speed humps to change the direction of floodwaters away from private properties and down the streets.

Modified fencing - fences on private properties can have gaps to allow floodwater to flow through. This stops the fence acting as a dam and reduces the risk of the fence failing. Different types of "flood" fences can be used.



On site detention (OSD) - a way of collecting the rain that falls on a property, storing it temporarily and then releasing it slowly so that it doesn't worsen downstream flooding. OSD can be provided underground in tanks, on ground as ponding areas and above ground as rainwater tanks. OSD also ensures that new developments such as villas, townhouses, factories, roads etc. do not cause more flooding in either local drainage systems or along the creek.

Floodgates - used to keep floodwaters in Orphan School Creek from backing up a stormwater drainage pipe.

CANLEY CORRIDOR COMMUNITY FLOOD SURVEY

Council is looking at how to reduce the impact of flooding in your community. Your responses are valuable and will help the preparation of the Canley Corridor Floodplain Risk Management Study and Plan.

Once completed, please return this survey in the reusable envelope supplied by 6 December.

About you

Address of property:-

1. Is this a residential or business address (please circle)?
   Residential Business

2. Do you own, rent or lease this property (please circle)? Own Rent Lease

About flooding and you

3. Have you ever experienced a flood at this property? YES NO

4. Do you have any records of flooding (photos, videos) or flood markings on your property? YES NO

5. Have you ever seen/heard any information for your local area about flooding? YES NO

6. If a flood did occur, would you know what to do to protect yourself and your property? YES NO

7. Have you prepared a written plan (i.e. flood plan) for your household to follow during a flood? YES NO

8. Do you know who to contact if there is a flood (please tick)?
   ☐ Fairfield City Council ☐ Emergency 000 ☐ NSW State Emergency Service (SES) ☐ Not sure

9. If a flood did occur would you prefer to stay in your house or evacuate (please tick)?
   ☐ Stay in house ☐ Evacuate ☐ Not sure

About flooding and Council

10. What assistance would you like Council to provide to help you be prepared for flooding (please tick)?
   ☐ Workshop ☐ Online information ☐ Flood Preparedness Pack
   ☐ Other__________ ☐ Not sure

11. Who in the community should be responsible for reducing flood risks? (more than one answer allowed)

☐ Fairfield City Council ☐ NSW State Emergency Service (SES) ☐ Landowner/Resident

☐ NSW Government ☐ Someone else (please tell us who) ________________________

12. Do you think Council spends enough on flooding controls and flood awareness in your area? YES NO

Options to reduce flooding

13. Below is a list of flood mitigation options which could help reduce flooding in your community. The enclosed brochure provides further information about some of these options.

Please circle your preference on a scale from 1 to 10 (1 = less preferred, 10=most preferred).

- **Flood education** to show you how to prepare for and deal with floods, now and in the future 1 2 3 4 5 6 7 8 9 10
- Preparation of a **Local Flood Plan** which will be used by the local SES 1 2 3 4 5 6 7 8 9 10
- **Development controls/constraints**, especially **floor-level controls, fencing controls** and **building material controls** for new developments 1 2 3 4 5 6 7 8 9 10
- **On-site detention** i.e. controlling runoff from new developments 1 2 3 4 5 6 7 8 9 10
- **Flow diversions** in streets to redirect water flow along roads 1 2 3 4 5 6 7 8 9 10
- **Floodgates** at the creek to stop flood water backing up in the drain when the creek floods 1 2 3 4 5 6 7 8 9 10
- **Voluntary house raising** where Council can provide financial assistance to raise your house above a certain flood level 1 2 3 4 5 6 7 8 9 10
- **Flood proofing** of your home with water resistant materials 1 2 3 4 5 6 7 8 9 10
- **Non-voluntary fencing controls** , restricting the type of fence you can use 1 2 3 4 5 6 7 8 9 10
- **Voluntary fence modification**, having open-style fences on your property 1 2 3 4 5 6 7 8 9 10
- **Large scale redevelopment**, planning developments with flooding and other water sensitive design elements 1 2 3 4 5 6 7 8 9 10

14. If Council offered financial assistance to change the type of fence on your property to a more flood-friendly fence, would you consider the voluntary fence modification option more favourably? YES NO

15. Would you be willing to change your fence to an open-style fence if Council could NOT provide you with any financial assistance? YES NO

For a chance to ***win an $80 voucher to Holy Basil Restaurant****, all you have to do is talk to Council's catchment management team regarding this survey.*

Please visit Councils Administration Centre (86 Avoca Rd, Wakeley) from ***22 November to 13 December 2013*** *to see the information display, or contact Cecilia Tabera on 9725 0264.*

Information in this survey will remain confidential, and will only be used to assist Council in its planning for how to best minimise the effects of flooding in the Canley Corridor catchment.

In reply please quote: A764280 **Contact**: Cecilia Tabera on 9725 0264

22 November 2013

«Ratepayers»
«Mailing_Address1»
«Mailing_Address2»
«Mailing_Address3»

Dear Community Member,

PLEASE GIVE US YOUR FEEDBACK ON FLOODING FOR A CHANCE TO WIN AN $80 RESTAURANT VOUCHER

We are writing because your property in the **Canley Corridor** catchment area (see attached map) is at risk from overland flooding. Overland flooding or flash flooding occurs after heavy rain when stormwater surcharges from stormwater pits and flows overland to a creek.

Major flooding across Australia in recent years reminds us all of the importance of being informed about and prepared for flooding. This is also important in Fairfield City which is regularly subjected to flooding.

Fairfield City Council has a responsibility to manage the risk of flooding. To do this, Council prepares floodplain risk management studies and plans. These will identify, assess and recommend ways to reduce flood risk.

Council is preparing a floodplain risk management study and plan for the Canley Corridor catchment. More information is attached in the list of frequently asked questions.

We are now seeking your thoughts on ways we could best manage the risk of flooding on your property and in the catchment. Attached is a survey which we would kindly ask you to complete and return **before Friday, 6 December 2013**. Also attached is a brochure with examples of possible management options.

We encourage you to visit our display on flooding at Council's Administration Centre at 86 Avoca Road, Wakeley and talk to us about your thoughts about flooding and the survey. You can also telephone Ms Cecilia Tabera, Council's Catchment Management Engineer, on 9725 0264.

As a thank you for talking to us, your name will be put in a draw to win an $80 gift voucher to Holy Basil Thai restaurant in Canley Heights. You will need to talk to us **before Friday, 13 December 2013**, after which the prize-winner will be drawn.

Yours sincerely,

E. Sellers

Erin Sellers
ACTING MANAGER CATCHMENT MANAGEMENT

CANLEY CORRIDOR COMMUNITY FLOOD SURVEY SCRIPT

Information given during this discussion will remain confidential, and will only be used to assist Council in its planning for how to best minimise the effects of flooding in the Canley Corridor catchment.

About resident

1. Why are you here today?

☐ Interested and want to find out more ☐ Concerned/frightened by letter received ☐ Just curious

☐ Don't understand why letter sent ☐ Want to win prize

2. Have you already completed and sent us the survey sent to you with the letter? YES NO

3. Can you tell us the address of where you live or the property you own in Canley Corridor?

Address of property:-

4. Is this a residential or business address (please circle)?
Residential Business

5. Do you own, rent or lease this property (please circle)? Own Rent Lease

6. Is your property more than one storey? YES NO

7. Can we contact you for more information or to invite you to any future workshops? YES NO

Contact details if YES:

Phone/Mobile: ____________________

Email: ____________________

Resident's experience with flooding & flood awareness

8. Have you ever seen or heard any information for your local area about flooding? YES NO

Where? ____________________

____

9. Have you ever experienced a flood at this property? YES NO

If YES, do you remember when? ____________________

Did the water reach your:

1) yard, YES NO

2) garage YES NO

3) inside the house (above floor)? YES NO

Can you describe what else happened? ____________________

10. Do you have any records of flooding (photos, videos) or flood markings on your property? YES NO

If YES, are you able to give us copies of these? YES NO

If you have a flood mark, can a Council surveyor come to your property to survey it? YES NO

11. If flooded before, have you done anything to reduce flooding on your property in the future? YES NO

If YES, what have you done? ____________________

12. If a flood did occur, would you know what to do to protect yourself and your property? YES NO

If YES, what would you do and where did you get the information to know what to do? ____________________

13. Have you had any contact from any agencies, apart from Council, about flooding in your area? YES NO

If YES, who contacted you?

☐ NSW State Emergency Service (SES) ☐ Sydney Water ☐ Other ____________________

14. Do you know who to contact <u>during</u> a flood (please tick)?

☐ Fairfield City Council ☐ Emergency 000 ☐ NSW State Emergency Service (SES) 132500 ☐ Not sure

15. Do you know who to contact <u>after</u> a flood for recovery assistance? (please tick)

☐ Fairfield City Council ☐ Family & Community Services ☐ Not sure
☐ Other________________________________

16. If a flood did occur and you knew that the depth of water on the street would be around 0.5m depth (up to your knees), would you feel safer staying in your house or evacuating? (please tick)

☐ Stay in house ☐ Self-evacuate ☐ Protect & mitigate ☐ Not sure

What if the water depth was up to your hips (around 1m)?

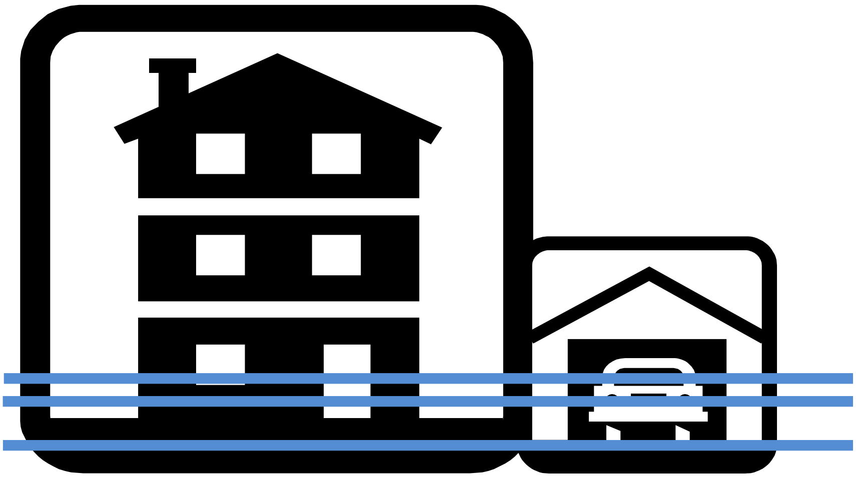
☐ Stay in house ☐ Self-evacuate ☐ Protect & mitigate ☐ Not sure

17. If you selected "stay in house", why would you prefer to do this?__________

____
____
____
____
____
____
____
____

18. In the picture below, how much flooding do you think you would be able to cope with?

Please circle 1, 2 or 3.



1. Up to ankle-deep above floor
2. Garage or garden/yard
3. Ankle-deep water on footpath & road only

19. Who in the community should be responsible for reducing flood risks? (more than one answer allowed)

☐ Fairfield City Council ☐ NSW State Emergency Service (SES) ☐ Landowner/Resident

☐ NSW Government ☐ Someone else (please tell us who) ____________________

20. Do you think Council or SES spends enough on floodplain management e.g. structural works, flood awareness activities, etc in your area?
YES NO

Flood Management Options

There are a number of measures that could be adopted to address the flood problem in your area.

- **Flood education and awareness** to show you how to prepare for, deal with and recover from floods.

21. How would you prefer for Council to assist you to help you be prepared for flooding?
(number boxes in preferred order)

☐ Workshop

☐ Online information

☐ Flood Preparedness Pack

☐ Other ______________________________

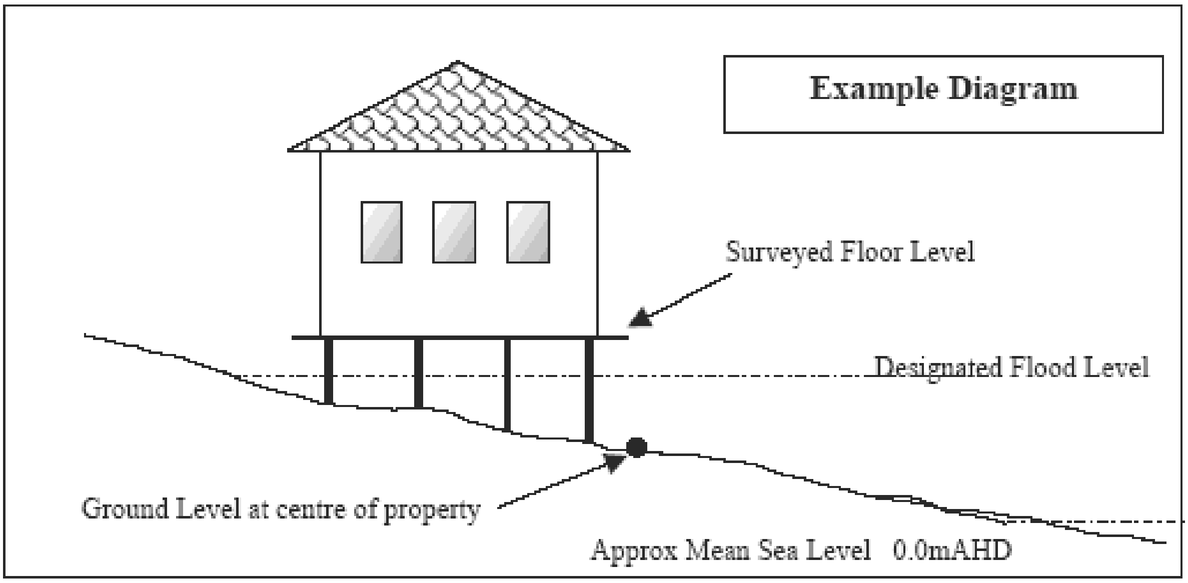
☐ Not sure

- **Development controls/constraints** for new developments. This option includes a number of restrictions to control future development of new houses and commercial properties in the Canley Corridor catchments to make the area safer when a flood occurs.

  *The higher the flood risk, the more restrictions will apply. As part of this Floodplain Risk Management Study and Plan, Council will be updating the Development Control Plan (DCP) with new development controls for the Canley Corridor floodplain and adopting the final **flood risk precinct** maps for Canley Corridor. Once this occurs, the development and planning controls for each flood risk precinct type will be defined for several years.*

Examples of development controls include:

i) Floor-level controls – a building will have to be built above the 100-year design flood level plus a certain freeboard. Currently, Council sets the freeboard to 0.5m for most residential developments in flood-prone areas.



22. Do you think the existing freeboard of 0.5m for residential properties is reasonable for the

Canley Corridor catchment area? YES NO

If NO, why not?____

ii) **Non-voluntary fencing controls** – there are currently restrictions the type of fence new developments can have. They must be open-style fences to allow the flow of flood waters.

23. Do you think non-voluntary fencing controls are a good idea? YES NO

24. Do you currently have open-style fences on your property? YES NO

25. Do you think Council should police/monitor existing flood-friendly fences and issue fines to owners who do not comply? YES NO

iii) **Building materials controls** to ensure houses are built with flood-compatible materials.

26. Do you have any comments about this type of development control? YES NO

Please provide details if YES. ____

- **On-site detention (OSD)** is designed to hold rainwater and slowly release it to control run-off from new developments. OSD can be provided underground in tanks, on ground in ponding areas and above ground in rainwater tanks (if designed and installed properly).

27. Do you have any objections or concerns about this option? YES NO

Please provide details if YES. ____

- **Flow diversions** in streets or on properties to redirect water flow.

28. What do you think of placing speed-humps on some side streets in the Canley Corridor to divert flows away from properties? __________________

29. If you have a vegetable garden on your property, would you consider a different layout to redirect water away from your property and onto the road as shown in the display poster? YES NO

- **Floodgates** at the creek to stop flood water backing up in the drain when the creek is flooded.

30. Do you have any objections or concerns about this option? YES NO

Please provide details if YES. ______________________________
____
____

- **Stormwater drainage upgrades** - where Council increases the size of existing stormwater pipes or adds more pipes and pits to allow more stormwater to enter the drainage system underground rather than flowing overland.

Because of the highly urbanised nature of the Canley Corridor catchment, pit and pipe upgrades is very expensive and not practical. It costs around $3,000/m to upgrade the larger pipes on the road.

An assessment has been done to test this option in the Canley Corridor catchment and unfortunately pipe upgrades will not make a difference in this instance, as most of the pipes are already full in smaller storm events (5-year ARI). We would need giant pipes to capture the amount of water that falls on this catchment – this is not practical!

Sometimes pits overflow and cause nuisance flooding because they are blocked with rubbish or leaves. Council already has a system in place to maintain the stormwater pits which cause the most problems.

31. Do you have any comments or concerns about stormwater drainage upgrades not being a viable option in the Canley Corridor catchments? __________
____
____
____
____

- **Large-scale redevelopment** of a large, flood affected area (such as one or two blocks) which incorporates flooding and water sensitive design elements.

This option is a long-term planning solution which will involve the purchasing several homes. It will require the financial support of Council and the interest of developers. A similar scheme has been built at the Newleaf Estate in Bonnyrigg.

32. Do you have any objections or concerns about this option? YES NO

Please provide details if YES. ______________________________
____
____
____
____

- **Voluntary fence modification –** changing the type of fence on your property to a more flood-compatible fence to allow flood waters to flow through. This stops the fence acting as a dam and reduces the risk of the fence collapsing.

33. If Council offered financial assistance to change the type of fence on your property to a more flood-compatible fence, would you consider a <u>voluntary fence modification</u> option? YES NO

34. If you answered YES above, what financial assistance would you need to voluntarily modify your fence? *See pictures below to help you decide.*

☐ 25% ☐ 50% ☐ 75% ☐ 100%

Approximate fence prices (inc. labour): Galvanised tubular fence $200/m, raised Colourbond fence $110/m

Typical block size north of St Johns Road
Length = 33m x 2 sides = 66m
Width = 14m
Total fence length = 80m

<u>Total cost = $8,800 - $16,000</u> (approx)

Typical block size south of St Johns Road
Length = 80m x 2 sides = 160m
Width = 20m
Total fence length = 180m

<u>Total cost = $19,800 - $36,000</u> (approx)

35. Considering typical costs shown above, would you be willing to change your fence to an open-style fence if Council could NOT provide you with any financial assistance? YES
NO

- **Voluntary house raising** or **flood proofing** where Council can provide financial assistance to raise your house above a certain flood level or to help treat the inside your home with flood-compatible materials.

36. Would you participate in this scheme if Council helped with some of the cost of house raising (e.g. up to $80,000)? YES
NO

37. If you only had to raise your house a very small amount (say less than 0.5m) to be above the flood level, and the financial assistance is reduced to say $20,000, would you still raise your house or would you prefer to limit flood damages in your home by using water resistant or flood compatible materials?

Examples of treating the house includes replacing carpets with tiles, polish flood boards, raise power points, replace Gyprock walls with Villaboard, raising hot water & gas tanks and air-conditioning units *off the ground, replace hollow-core doors with hardwood doors (both internal & external), installing electricity safety cut-off switch.*

☐ Raise house (potentially more expensive) ☐ Use flood compatible materials (flood proofing)

After having discussed the above options, please circle your preference on a scale from 1 to 10 (1 = less preferred, 10=most preferred). *Complete only if flood survey not done.*

- **Flood education** 1 2 3 4 5 6 7 8 9 10
- **Development controls/constraints.** 1 2 3 4 5 6 7 8 9 10
- **On-site detention** 1 2 3 4 5 6 7 8 9 10
- **Flow diversions** 1 2 3 4 5 6 7 8 9 10
- **Floodgates** at the creek 1 2 3 4 5 6 7 8 9 10
- **Stormwater drainage upgrades** 1 2 3 4 5 6 7 8 9 10
- **Large-scale redevelopment** 1 2 3 4 5 6 7 8 9 10
- **Voluntary fence modification** 1 2 3 4 5 6 7 8 9 10
- **Voluntary house raising** 1 2 3 4 5 6 7 8 9 10
- **Flood proofing** your home 1 2 3 4 5 6 7 8 9 10

Flood Mitigation Funding

Council has a limited budget for flood mitigation project and it can take several years before recommended flood mitigation measures to be adopted or constructed. Council often requests funding from the NSW and Federal Governments to assist with the costs of flood management projects.

37. Who do you think should pay to reduce flooding in the Canley Corridor catchment?

(can tick more than one)

☐ Fairfield City Council ☐ NSW Government ☐ Federal Government ☐ Developers ☐ Property owners

Final Comments

____

____

____

____

____

Thank you for your time. Your details will be put in the draw to win an $80 voucher to Holy Basil Restaurant. We will contact you next month if you have won.

Please fill in your details below.

Entry to win $80 gift voucher to Holy Basil Restaurant

NAME: ________________________________

DAYTIME TELEPHONE OR MOBILE: ________________________________

EMAIL ADDRESS: ________________________________

Entry to win $80 gift voucher to Holy Basil Restaurant

NAME: ________________________________

DAYTIME TELEPHONE OR MOBILE: ________________________________

EMAIL ADDRESS: ________________________________

Entry to win $80 gift voucher to Holy Basil Restaurant

NAME: ________________________________

DAYTIME TELEPHONE OR MOBILE: ________________________________

EMAIL ADDRESS: ________________________________

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DAYTIME TELEPHONE OR MOBILE: ________________________________

EMAIL ADDRESS: ________________________________

Entry to win $80 gift voucher to Holy Basil Restaurant

NAME: ________________________________

DAYTIME TELEPHONE OR MOBILE: ________________________________

EMAIL ADDRESS: ________________________________

Entry to win $80 gift voucher to Holy Basil Restaurant

CANLEY CORRIDOR FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

FREQUENTLY ASKED QUESTIONS

1. What is overland flooding?

Overland flooding follows heavy rain when excess stormwater surcharges from stormwater gully pits and flows overland on its way to a creek. It is also known as flash flooding because it occurs quickly and often with little or no warning. This is different to mainstream flooding which is when water overtops the banks of a creek or river.

2. Why is Council studying overland flooding?

Flooding represents a risk to life and property and can cause extensive damage as recent floods across Australia have shown. Under NSW Government policy, local councils have primary responsibility to address flood problems. Fairfield City Council runs an ongoing program of undertaking flood studies to determine how floods behave and to identify properties at risk. This information is used to help identify and recommend measures to better manage and, where possible, to reduce flood risk.

3. Why is it that I have lived here a long time and never seen it flood?

Flooding is unpredictable and can happen at any time. It can be many years between floods but multiple floods can also happen in one year. The longer you live in a floodplain the more chance you have of experiencing a flood. For example, if you live in a floodplain for 70 years, you have roughly a 1 in 2 chance of experiencing a 100 year flood in this time. Many people will remember the major floods on lower Prospect Creek in 1986 and 1988, which were approximately 20 year floods.

4. Why can't flooding be prevented?

Flooding is a natural phenomenon that has and will always occur. Problems with flooding arise when development occurs in the floodplain that does not take full account of flooding. Although it may not be possible to eliminate flooding from all areas, the risk to life and property posed by flooding can be managed through a combination of different measures.

5. How do I obtain information about flooding at my property?

Information on flood levels and flood risk at a property can be obtained from Council by purchasing a Section 149 (5) planning certificate. An application form is available on Council's website at www.fairfieldcity.nsw.gov.au. Council does not provide specific information about flooding over the phone or internet.

6. What is a Floodplain Risk Management Study and Plan?

A floodplain risk management study and plan (FRMS&P) is a document that identifies, assesses and recommends options to better manage and, where possible, reduce flood risk. Council is currently preparing a FRMS&P for the Canley Corridor catchment. It follows on from the Canley Corridor Overland Flood Study that was completed in 2009. Options to modify flood behaviour, modify properties or to change people's response to flooding have been identified as part of the FRMS&P.

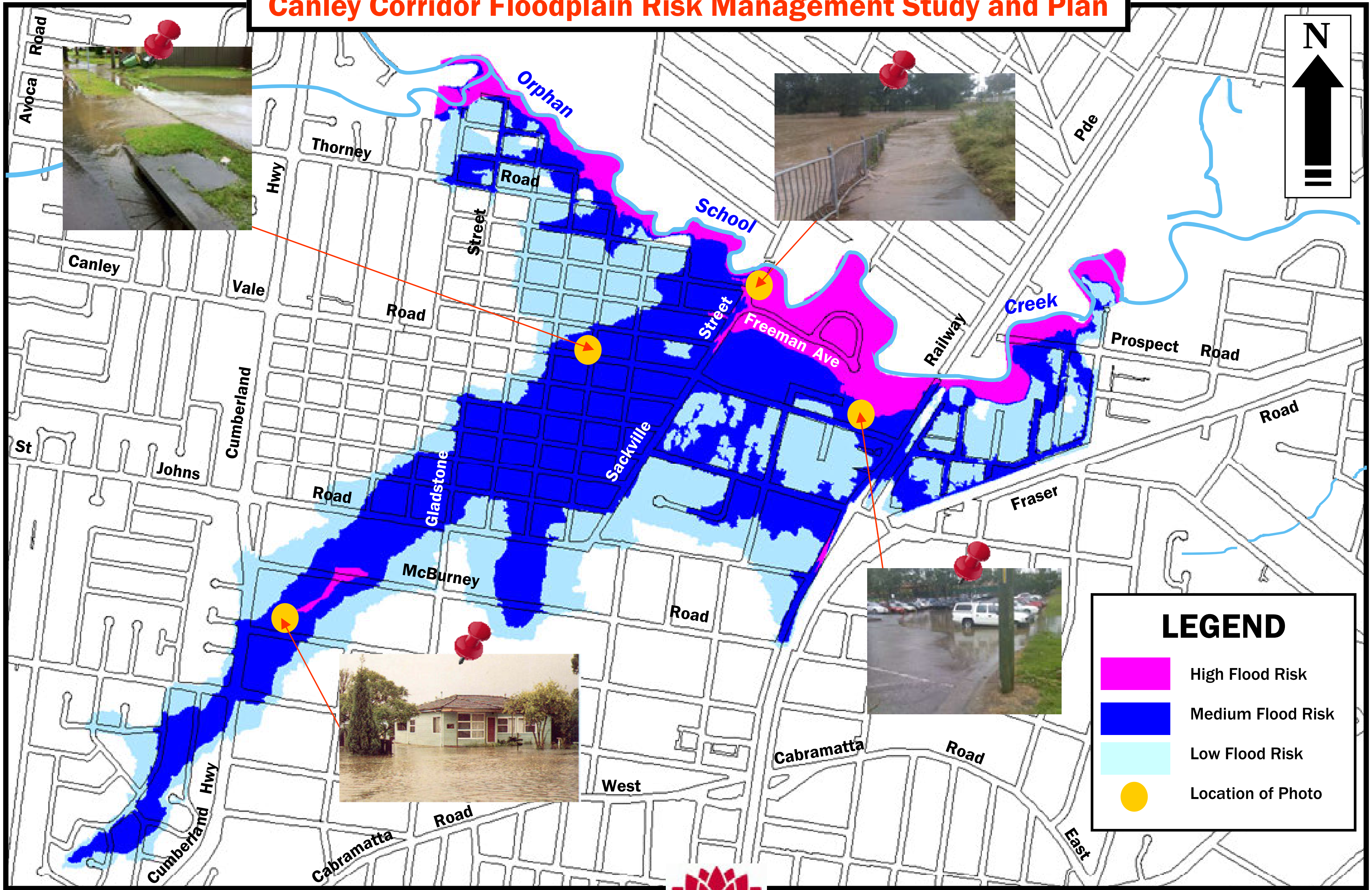
7. Why is Council talking to the community about flooding options?

The local community is critical to the success of any approach to managing flood risk. Council would therefore like to know what you think about flooding in the Canley Corridor catchment and the best options to manage the flood risk.

8. What happens next?

Council will consider the comments and questions raised during the consultation. This information will be used to further assess the flood risk management options. A draft FRMS&P report will be prepared containing a recommended list of options for the Canley Corridor catchment. The draft FRMS&P report will be publicly exhibited before being finalised and recommended for formal adoption by Council. Council will then seek funding for the recommended actions in the adopted FRMS&P report. Actions will be implemented as funding becomes available.

Canley Corridor Floodplain Risk Management Study and Plan



MOLINO STEWART
ENVIRONMENT & NATURAL HAZARDS

NSW GOVERNMENT

FairfieldCity
Celebrating diversity

2015 Consultation

Contact: Nona Ruddell on 9725 0847

11 February 2015

Ratepayer
Mailing Address 1
Mailing Address 2
Mailing Address 3

Dear Sir / Madam

DRAFT CANLEY CORRIDOR FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN - PUBLIC EXHIBITION

I am writing to you because your property at Property Address, Property Suburb NSW Property Postcode, in the Canley Corridor catchment area is at risk from overland flooding. Overland flooding follows heavy rain when stormwater overflows from stormwater pits and pipes, and floods normally dry land.

Major flooding across parts of Australia in recent years has reminded us all of the importance of being informed about and prepared for the risk of flooding. Fairfield City is particularly prone to flooding and has experienced major floods in the past.

Fairfield City Council has a responsibility to manage the risk of flooding. Council does this by first undertaking a flood study to determine the behaviour and extent of flooding. The next step is to undertake a Floodplain Risk Management Study and Plan (FRMS&P) which looks at options and recommends actions to reduce the effects of flooding.

Council has recently completed a draft FRMS&P for the Canley Corridor catchment that encompasses parts of Canley Heights and Canley Vale. A map of recommended actions is enclosed and further information about the FRMS&P is given in the enclosed list of frequently asked questions.

Council would now like to invite you to have your say on the draft FRMS&P. Opportunities for you to comment on the study or to ask questions are described overleaf. **Comments are due by Friday 6 March 2015.**

All comments will be considered by Council before the FRMS&P is recommended for formal adoption.

For more information about the FRMS&P please contact Nona Ruddell, Team Leader – Catchment, on 9725 0847 or catchment@fairfieldcity.nsw.gov.au.

Yours faithfully

Y:\Jobs\2012\0517 Canley Corridor (Fairfield) FPRMS&P\Reports\Draft\Appendices\Appendix J\2015 Consultation\Canley Corridor Public Exhibition Letter to Residents.docx

Mr Erin Sellers
ACTING MANAGER CATCHMENT PLANNING

HAVE YOUR SAY

The draft FRMS&P is being publicly exhibited for three weeks from **Monday 16 February 2015 to Friday 6 March 2015**.

Visit our display

The draft FRMS&P report is available for viewing at:

1. Fairfield City Council Administration Centre
   86 Avoca Road, Wakeley
2. Wetherill Park Library
   Stockland Town Centre, Polding Street, Prairiewood
3. Whitlam Library
   65 Railway Parade, Cabramatta
4. Bonnyrigg Library
   Bonnyrigg Plaza, Bonnyrigg
5. Smithfield Library
   Cnr Oxford & Clancy St, Smithfield

Go online

The draft FRMS&P report is available on Council's website at www.fairfieldcity.nsw.gov.au.

You can view the report and provide comments by clicking on the green "Have Your Say" button and then clicking on the link to "Public Exhibitions".

Write to us

Written submissions can be addressed to:

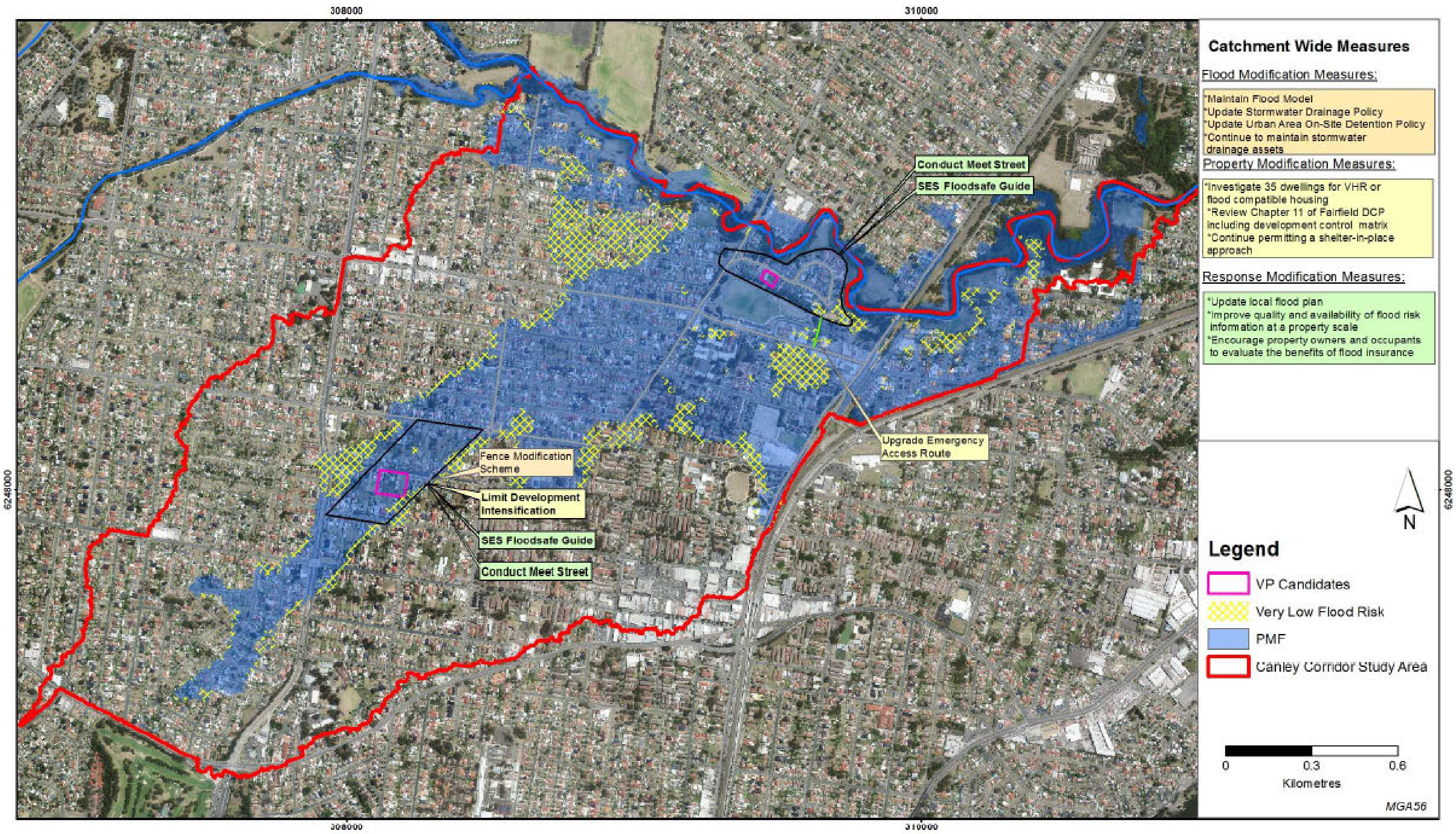
The City Manager
Attention: Ms Leonie Gray
Fairfield City Council
PO Box 21
Fairfield NSW 1860

You can e-mail your comments to us at catchment@fairfieldcity.nsw.gov.au

Talk to Us

We encourage you to come in to Council's Administration Centre at Avoca Road, Wakeley or to call us with your comments and questions. Please ask for:

Ms Leonie Gray
Team Leader - Catchment
Ph (02) 9275 0738



Canley Corridor Floodplain Risk Management Study: Draft FRMP				
MOLINO STEWART ENVIRONMENT & NATURAL HAZARDS	Molino Stewart endeavours to ensure that the information provided in this map is correct at the time of publication. Molino Stewart does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.	Date: 04/02/2015	Checked By: S.M.	Job No: 0517
		Filepath: Y:\Jobs\2012\0517 Canley Corridor (Fairfield) FPRMS&P\GIS\Workspace\Draft FRMP.mxd		

Figure 35: Summary of Floodplain Management Plan

CANLEY CORRIDOR FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

FREQUENTLY ASKED QUESTIONS

1. What is overland flooding?

Overland flooding follows heavy rain when excess stormwater surcharges from stormwater gully pits and flows overland on its way to a creek. It is also known as flash flooding because it occurs quickly and often with little or no warning.

2. Why is Council studying flooding?

Flooding represents a risk to life and property and can cause extensive damage as recent floods across Australia have shown. Under NSW Government policy, local councils have primary responsibility to address flood problems. Fairfield City Council runs an ongoing program of undertaking flood studies to determine how floods behave and to identify properties at risk. This information is used to help identify and recommend measures to better manage and, where possible, to reduce flood risk.

3. Why is it that I have lived here a long time and I've never seen it flood?

Flooding is unpredictable and can happen at any time. It can be many years between floods but multiple floods can also happen in one year. The longer you live in a floodplain the more chance you have of experiencing a flood. Many people will remember the major floods on lower Prospect Creek in 1986 and 1988, which were approximately 20 year floods.

4. Why can't flooding be prevented?

Flooding is a natural phenomenon that has and will always occur. Problems with flooding arise when development occurs in the floodplain that does not take full account of flooding. Although it may not be possible to eliminate flooding from all areas, the risk to life and property posed by flooding can be managed through a combination of different measures.

5. How do I obtain information about flooding at my property?

Information on flood levels and flood risk at a property can be obtained from Council by purchasing a Section 149 (5) planning certificate. An application form is available on Council's website at www.fairfieldcity.nsw.gov.au. Council does not provide specific information about flooding over the phone or internet.

6. What is a Floodplain Risk Management Study and Plan?

A floodplain risk management study and plan (FRMS&P) is a document that identifies, assesses and recommends options to better manage and, where possible, reduce flood risk. Council has prepared a FRMS&P for the Canley Corridor catchment. A suite of actions to modify flood behaviour, modify properties or to change people's response to flooding has been formulated as part of the FRMS&P.

7. Why is Council talking to the community about actions to reduce flooding?

The local community is critical to the success of any approach to managing flood risk. Council would therefore like to know what you think about flooding and flood risk management options in the Canley Corridor catchment.

8. What happens next?

Comments and questions raised during the public exhibition will be considered before finalising the report and recommending formal adoption by Council. Council will then seek funding for the recommended actions in the adopted FRMS&P report. Actions will be implemented as funding becomes available.