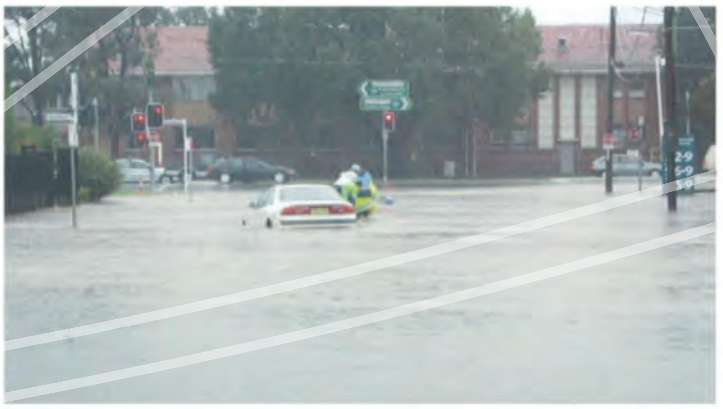
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Floodplain Risk Management Study and Plan for Sub-Catchments of the Mid Georges River

Draft Report

April 2016

BANKSTOWN
City of Progress

Floodplain Risk Management Study and Plan for Sub-Catchments of the Mid Georges River

Prepared for:	Bankstown City Council
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Synopsis: This report documents the Mid Georges River Floodplain Risk Management Study and Plan which investigates and presents a flood risk management strategy for overland flow in the catchments investigated. The study identifies the existing flooding characteristics and canvasses various measures to mitigate the effects of flooding. The end product is the Floodplain Risk Management Plan, which incorporates recommended measures to manage the overland flooding risks.

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Executive Summary

Reasons for the Study and Plan

Stormwater flood studies have been carried out for the seven sub catchments within the Mid Georges River study area. The primary objective of each of the stormwater flood studies has been to define the overland flood behaviour within the respective catchment through the establishment of appropriate numerical models. These models provide detailed information on the extent and depth of inundation for a range of design floods. The most recent stormwater flood studies for each of the seven sub-catchments were completed between 2009 and 2015

In July 2012, BMT WBM was commissioned by Bankstown City Council to assist its Floodplain Management Committee in preparing a floodplain management study and plan for the seven sub catchments within the Mid Georges River study area. Assistance was provided during the course of the study by Grech Planners on planning and development control issues.

The floodplain management study further identifies the flood problem and investigates options to reduce these flooding problems. A plan of recommended actions works and initiatives for managing the overland flooding is also presented for Council to implement.

Responsibilities

The prime responsibility for planning and management of flood prone lands in NSW rests with local government. The NSW Government provides assistance on state wide policy issues and technical support. Financial assistance is also provided to undertake flood and floodplain risk management studies and for the implementation of works identified in any subsequent floodplain risk management plan.

Bankstown Council's Floodplain Management Committee oversaw the Study. This committee includes Councillors and staff from Bankstown City Council, staff from neighbouring Councils including Fairfield City Council, Hurstville City Council and Liverpool City Council, staff from the Office of Environment and Heritage, Sydney Water Corporation and the State Emergency Service. A number of community representatives are also members of the committee.

The Study Area

The Mid Georges River study area is comprised of seven sub catchments, namely, Milperra, Kelso Swamp, East Hills, Lucas Road, Picnic Point, Morris Gully and Little Salt Pan Creek. The sub-catchments are based on natural topographical divides and are bounded by the Georges River along the east and south of the study area. Encompassing a total area of approximately 30km^2, the study area represents a significant proportion of the 77km^2 Bankstown Local Government Area (LGA).

The study area incorporates the entire suburbs of Bankstown Airport, Milperra, Panania, East Hills, Picnic Point, Revesby Heights and parts of Georges Hall, Bass Hill, Yagoona, Condell Park, Revesby, Padstow and Padstow Heights.

A map of the study area is shown on Figure 1-1.

Consultation

Community consultation has aimed to inform the community about the development of the floodplain risk management study and its likely outcome as a precursor to subsequent floodplain risk management activities. Consultation activities have included:

- Regular meetings with the Floodplain Management Committee;
- Establishment of project website (http://midgeorgesfrmsp.bmtwbm.com.au);
- Distribution of a community questionnaire and newsletter to 7600 properties in October 2013;
- Distribution of information leaflet and survey to 25 key stakeholders in August 2013;
- Eight community information sessions that were held during the course of the study; and
- The intended public exhibition of the draft FRMS&P.

Modelling of Flood Behaviour

The stormwater flood studies involved the development of numerical computer models to simulate overland flood behaviour through the sub-catchments of the study area. Bankstown City Council has adopted a consistent flood modelling approach across all sub-catchments in the Bankstown LGA. This approach uses combined two-dimensional (2D) and one dimensional (1D) hydraulic models developed using TUFLOW modelling software. These models are capable of modelling urban overland flow paths and the pipe drainage network, channels and creeks.

Overland flows are typical in urban environments where it is not feasible to design stormwater drainage to capture very large and infrequent flood events. Often the overland flow paths are aligned with roads, however, in some instances, houses and other property may be located on or to adjacent major overland flow routes. Flooding associated with overland flow exhibits different behaviour than mainstream flooding associated with the Georges River.

Flood Risk Management and Development Control

Floodplain management is focused on managing the risk of flooding across the floodplain. In doing so, it should be recognised that different parts of the floodplain are subject to different degrees of flood risk. The following flood risk precincts have been adopted for the study area:

- High Flood Risk. Land below the 100 year ARI flood level that is either located within floodway area, subject to a high hydraulic hazard (as defined in Figure L2 of the Floodplain Development Manual (DIPNR, 2005) or where there are significant evacuation difficulties.
- Medium Flood Risk. Land below the 100 year ARI flood level that is not subject to high hydraulic hazard and where there are no significant evacuation difficulties.
- Low Flood Risk. All land within the floodplain (i.e. within the PMF extent) but not identified as either in a high or medium flood risk precinct.
- Overland Flow Risk. Areas of shallow overland flow, typically less than 0.25m in depth in a 100 year ARI flood event and distant from a recognised watercourse or major drainage system.

The Flood Problem

A flood damages database has been prepared for the study area to quantify the flood problem and to assist in evaluating the merit of a range of flood mitigation measures.

The database includes details on 3,233 properties throughout the study area that could potentially be affected by flooding (in a 100 year flood). Flood damages for the seven sub-catchments of the Mid Georges River study area are presented in Table ES1.

Table ES1 Predicted flood damages for existing flood conditions

Sub-catchment	Damage in Flood Event ($M)					Average Annual Damage ($M)	Net Present Value of Damage ($M)
	5 Year	20 Year	50 Year	100 Year	PMF		
Milperra	55.4	71.1	95.0	105.0	402.5	20.2	5.2
Kelso Swamp	7.9	10.1	11.3	13.3	41.6	2.7	0.7
East Hills	0.7	0.7	0.8	0.9	2.6	0.2	0.1
Lucas Road	3.9	5.9	9.1	10.4	16.5	1.5	0.4
Picnic Point	2.2	3.0	3.2	3.6	5.1	0.7	0.2
Morris Gully	3.7	5.4	6.0	6.7	11.3	1.3	0.3
Little Salt Pan Creek	9.2	14.8	16.5	19.0	42.9	3.5	0.9
Mid Georges TOTAL	**82.9**	**111.0**	**142.1**	**158.8**	**522.4**	**30.2**	**7.8**

Flood Mitigation Options Investigated

Areas with flooding problems have been identified throughout the study area on the basis of:

- The extent of inundation experienced throughout the study area, particularly those areas that experience a high flood risk as shown in Figure 4-3;
- The location of buildings potentially affected by above floor flooding, based on the flood damages database as shown in Figure 5-3;
- Feedback from the community through the community consultation exercises (as shown in Figure 3-2) and subsequent community information sessions; and
- Information from Council and the Committee members.

Specific flood mitigation options for the study area are discussed in Chapter 7.

It will not be feasible to find solutions to all of the flooding problems within the study area, given the magnitude of the problem and the number of properties and buildings potentially affected by flooding. Where localised solutions are not feasible, other study area-wide measures will provide some benefit, such as planning and development controls, public awareness initiatives and

emergency management operations. Further discussion on these types of measures is in Chapter 7.

Recommended Floodplain Management Plan

The draft Floodplain Risk Management Plan for the sub-catchment of the Mid Georges River is summarised in Table ES2.

It is important to note that not all flooding problems in the study area have been alleviated. A complete solution to the flooding problem is not cost effective from a floodplain management perspective. However, problems can be reduced gradually over time as sensible redevelopment occurs in accordance with Council's planning controls.

Table ES2 Recommended Floodplain Management Plan

Summary of Proposed Actions, Works and Initiatives	*Responsibility*	*Estimated Cost*	*Potential Funding Source*	*Priority*
Ensure that flooding is duly considered by current planning policy and future reviews				
Prepare a Planning Proposal to amend LEP 2015 for Carinya Road area - *Adopt an E4 Environmental Living zone for the Carinya Road area subject to development permitted with consent being extended to include environmental protection works, flood mitigation work, recreation area and roads. Note, the foreshore area including reserve, road and boatshed should remain separately zoned RE1 Public Recreation* - *Applying a minimum lot size of 1,000m² consistently across all existing housing lots.*	BCC	Staff Time	BCC	High
Replace Schedule 5 of the DCP in line with the Salt Pan Creek Catchment: - *Adoption of overland flow flood risk precincts (FRP)* - *Separation of overland flow areas from the Medium FRP* - *The freeboard for development, where applied in the Overland Flow FRP has been reduced from 500mm to 300mm*	BCC	Staff Time	BCC	High
Amend DCP for Carinya Road Area - *Amend the DCP to delete the provisions referring specifically to the Carinya Road area including in Clause 4.3.1, 4.3.2 and 4.3.3 of Part E and Schedules 4A, 4B and 4C. The general provisions relating to the Georges River would thereafter apply.*	BCC	Staff Time	BCC	High

Summary of Proposed Actions, Works and Initiatives	*Responsibility*	*Estimated Cost*	*Potential Funding Source*	*Priority*
Review Bankstown City Council Section 94A Development Contributions Plan 2009 - *Consider whether any structural mitigation works identified by this FRMS (or others) should be funded (or partly funded) with S94A funds.*	BCC	Staff Time	BCC	High
Ensure that the overland flow paths are maintained as part of any master plan prepared for the Panania and East Hills Centres	BCC	Staff Time	BCC	High
Ensure existing overland flow path from Eldridge Road through commercial units off Edgar Street is maintained or enhanced as redevelopment occurs.	BCC	Staff Time	BCC	High
Waterways and Water Quality Improvement Plan				
Implement Waterways and Water Quality Improvement Plan for sub catchments of the Mid Georges River - Georges River CZMP actions specific to study area - Planning and policy On-ground works	BCC BCC BCC	Refer to Georges River CZMP Staff Time $4,750,000	BCC BCC BCC	High High Medium
Flood Proofing				
Investigate flood proofing through prioritisation of eligible properties and establishment of a funding model	BCC	Staff Time	BCC/OEH	Low
Voluntary Fence Modification				
Assess feasibility of establishing a voluntary fence modification scheme	BCC	Staff Time	BCC/OEH	Medium
Flood Forecasting and Warning				
Expand flood warning system on Milperra Drain at Ashford Avenue to Milperra Industrial Area	BCC	$50,000	BCC/OEH	High
Develop a Riverine flood warning system for Carinya Road utilising existing gauge at Kelso	BCC	$50,000	BCC/OEH	Medium
Investigate opportunities to develop a flood forecasting and warning system for overland flooding	BCC	$10,000	BCC/OEH	Low
Improve Public Awareness				
Consolidation of the recent flood risk mapping, flood data and flood damages database into Council's GIS system.	BCC	Staff Time	BCC	High
Review flood affectation notations and provide flood certificates to residents	BCC, OEH	Staff Time	BCC, OEH	High
Expand on the flood information page on Council website	BCC, SES, OEH	Staff Time	BCC, OEH	High
Undertake ongoing community education programs	BCC, SES, OEH	$30,000	BCC, OEH	High
Provide targeted awareness to residents living in high flood hazard areas	BCC, SES	$10,000	BCC, OEH	High

Summary of Proposed Actions, Works and Initiatives	*Responsibility*	*Estimated Cost*	*Potential Funding Source*	*Priority*
Notify NSW Department of Education and Communities of schools located in flood prone areas	BCC	Staff Time	BCC	High
Install and maintain flood depth markers on roads affected by higher flood depths	BCC	$20,000	BCC, OEH	High
Emergency Response and Management				
Update and implement as required the Bankstown City Flood Emergency Sub Plan to include overland flood risks	SES	$20,000	BCC, OEH	High
Provide advice to residents on preparing Personal Flood Plans	SES/BCC	$10,000	BCC, OEH	High
Stormwater Drainage Network				
Review, update and implement stormwater drainage maintenance program	BCC	Staff Time	BCC	High
Implement a program for monitoring performance of OSD's	BCC	Staff Time	BCC	High
Localised Flood Mitigation Options				
Increase the size of existing detention at Surrey Reserve, Georges Hall - *Undertake feasibility and design* - *Implement as part of any future upgrades to the park at Surrey Reserve*	BCC	$25,000	BCC, OEH	Medium
Improve overland flow path between Endeavour Road and Rabaul Road - *Liaise with residents regarding issues* - *Provide advice to residents on enhancing overland flow path via a voluntary fence modification scheme*	BCC	Staff Time	BCC, OEH	High
Undertake channel improvement works at 116-120 Milperra Road, Milperra - *Consult with RMS regarding proposed solution* - *Pursue opportunities to improve channel conveyance as part of any future road upgrades to Milperra Road.*	BCC - consultation RMS – design / Construction	$925,000	BCC, OEH, RMS	Low
Increase the size of existing detention basins at Bankstown Airport - *Consult with BAL regarding proposed solution* - *Undertake further analysis on the feasibility of detention basins in Bankstown Airport in consultation with BAL*	BCC - consultation BAL – feasibility / design / construction	$1,900,000	BAL	Low

Summary of Proposed Actions, Works and Initiatives	*Responsibility*	*Estimated Cost*	*Potential Funding Source*	*Priority*
Construct a detention basin within Deverall Park, Bankstown Airport - *Consult with BAL regarding proposed solution* - *Undertake a detailed feasibility into developing a flood detention basin in Deverall Park in consultation with BAL*	BCC - liaison BAL – feasibility / design / construction	$2,600,000	BCC/OEH	Medium
Undertake channel improvement works through Bankstown Golf Club, Milperra - *Develop detailed designs* - *Implement works*	BCC	$1,400,000	BCC/OEH	High
Improve conveyance through the M5 noise wall at Tracey Street Reserve, Revesby - *Consult with RMS regarding proposed solution* - *Implement works*	BCC – consultation RMS – design / construction	$20,000	RMS	High
Increase the size of the culverts on Lucas Road Drain at Henry Lawson Drive, East Hills - *Consult with RMS regarding proposed solution* - *Pursue opportunities to replace culverts on Henry Lawson Drive as part of future road upgrades*	BCC – consultation RMS – design / construction	$600,000	RMS	Low
Construct a flood wall at Thomas Street, Picnic Point - *Liaise with residents* - *Implement works*	BCC	$110,000	BCC/OEH	High

Timing and Funding

The total cost for implementing the Floodplain Management Plan is estimated at $13.45 million and represents relatively large financial implications for Council and other responsible authorities. This is largely as a result some large capital works being recommended.

The timing of the implementation of recommended measures will depend on overall budgetary commitments of Council and the availability of funds from other sources. Many of the Plan components can be implemented progressively with few barriers, particularly those elements requiring Council staff time only which may be undertaken within normal Council operations and budget. It is envisaged that the remainder of the Plan, particularly the structural options investigations, would be implemented progressively over say, a 15 year time frame.

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1 Introduction

1.1 Study Background

The Mid Georges River Floodplain Risk Management Study and Plan (FRMS&P) has been undertaken to understand and manage flood risks associated with local overland flooding due to stormwater runoff in the catchments of the Mid Georges River study area. This FRMS&P includes recommended actions works and initiatives for managing the overland flooding and sets out a program for implementation.

The Mid Georges River study area comprises seven sub-catchments of the Bankstown Local Government Area (LGA) which drain to the Georges River. Individual stormwater catchment flood studies have been completed for each of the seven sub-catchments by BMT WBM and Bewsher Consulting on behalf of Bankstown City Council (Council).

The primary objective of the stormwater flood studies has been to determine the local overland flood behaviour within the Mid Georges River study area. Urban stormwater within the study area is collected and conveyed by a network of surface pits and underground pipelines, which generally discharge to the creeks or Georges River. Periods of prolonged and/or intense rainfall can overload the pipe and creek system causing surface overflows (overland flows) and potentially overland flooding.

The focus of this FRMS&P is addressing the overland flooding risk. The Georges River Floodplain Management Study and Plan (Bewsher Consulting, 2004) specifically deals with the mainstream flooding areas affected by the Georges River, and for the most part does not address in any detail overland flooding.

The stormwater flood studies produced information on flood flows, velocities, levels and extents for a range of flood event magnitudes under existing catchment conditions. The outputs of the stormwater flood studies have established the basis for the identification and assessment of an appropriate mix of management measures and strategies. The management measures and strategies have been devised to effectively manage the local overland flooding issues in accordance with the *Floodplain Development Manual* (2005).

This report documents the analysis of management measures and strategies in the Floodplain Risk Management Study. A Floodplain Risk Management Plan sets out the recommended options in establishing a formal floodplain risk management plan for the Mid Georges River study area for Council to progressively implement over the term of the Plan.

1.2 The Study Area

The Mid Georges River study area is comprised of seven sub-catchments within the Bankstown LGA, located in Sydney's south-west. The study area incorporates the entire suburbs of Bankstown Airport, Milperra, Panania, East Hills, Picnic Point, Revesby Heights and parts of Georges Hall, Bass Hill, Yagoona, Condell Park, Revesby, Padstow and Padstow Heights as shown in Figure 1-1.

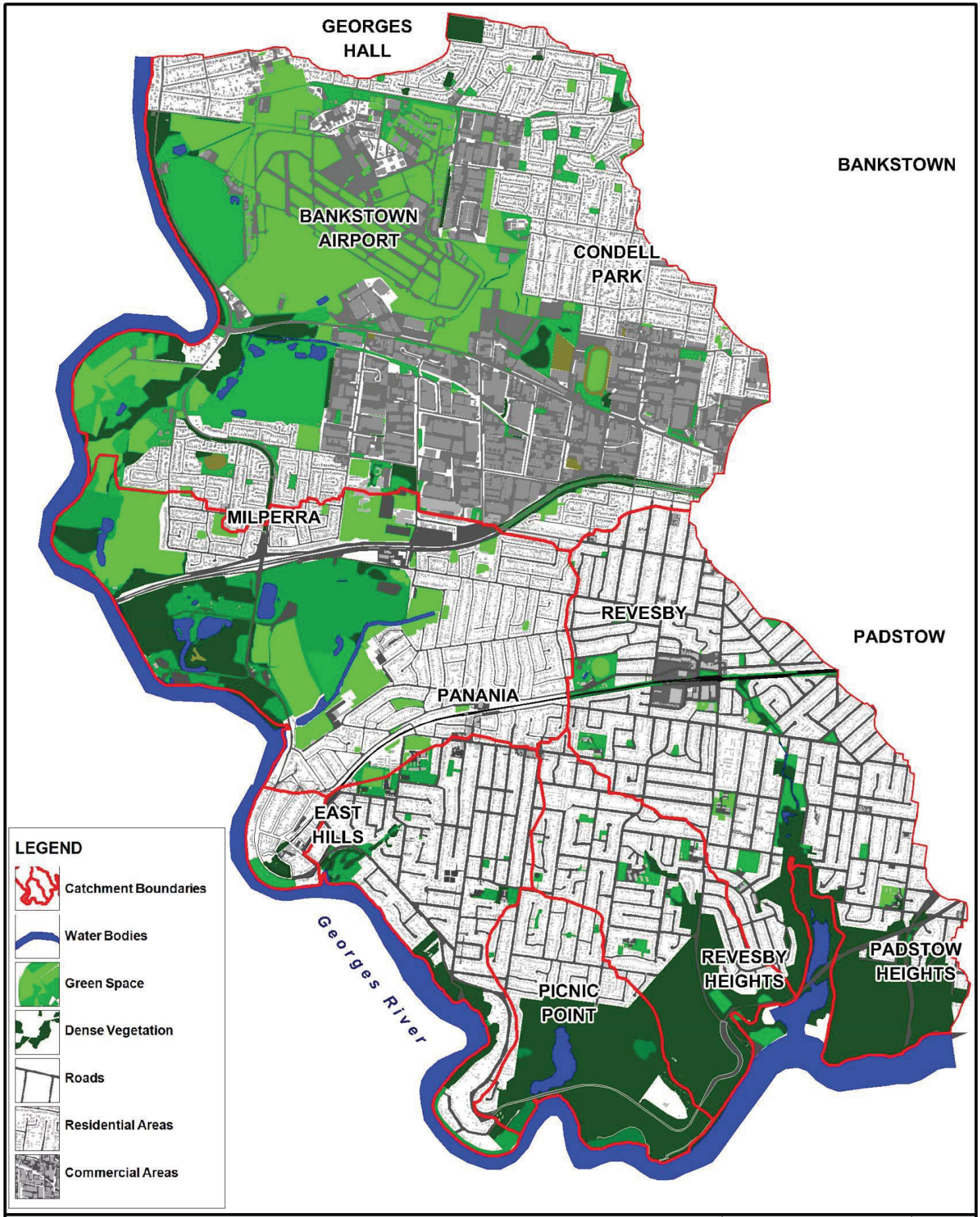
Bankstown City Council is responsible for local planning and land management within the Bankstown LGA including the management of the floodplain with respect to both mainstream and overland flooding.

1.3 The Floodplain Risk Management Process

The NSW State Government's Flood Prone Land Policy is directed towards providing solutions to existing flooding problems in developed areas. The Policy aims to ensure that new development is compatible with the flood hazard and does not exacerbate existing flooding or create additional flooding problems in other areas. Policy and practice are defined in the Government's *Floodplain Development Manual* (2005).

Under the Policy, the management of flood liable land remains the responsibility of Local Government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in carrying out their floodplain risk management responsibilities.

The Policy provides for technical and financial support by the NSW State Government through the five sequential stages outlined in Figure 1-2.



Title:

Study Area

Figure: 1-1

Rev: 0

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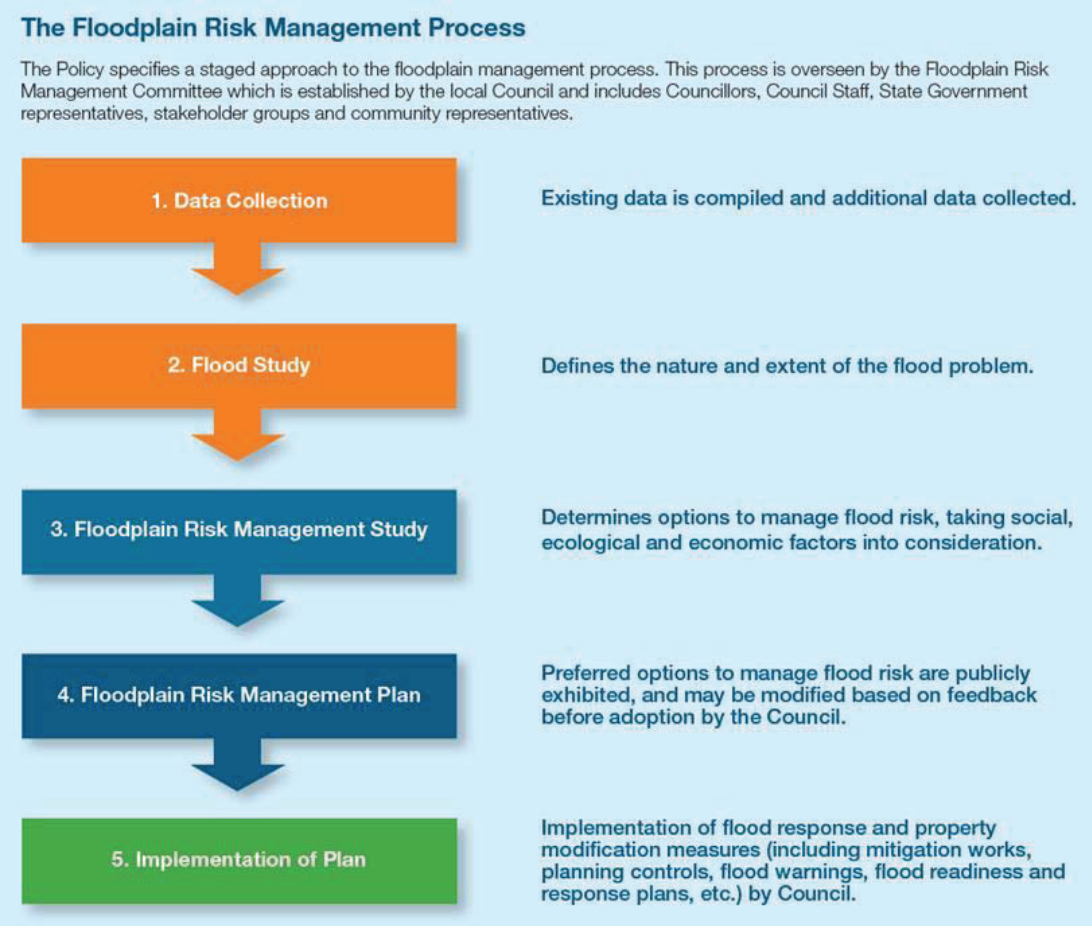


Figure 1-2 Stages of the Floodplain Management Process

The stormwater flood studies for each of the seven sub-catchments of the Mid Georges River study area, address Stage 1 and 2 of the Floodplain Risk Management Process. This FRMS&P constitutes the third and fourth stages of the Floodplain Management Process. It has been prepared for Bankstown City Council and the Floodplain Management Committee to provide the basis for future management of flood liable land within the study area.

The study has been commissioned by Bankstown City Council with funding assistance and technical support from the NSW Office of Environment and Heritage (OEH).

The Bankstown Floodplain Management Committee has overseen the study and assisted and advised Council in the development of the Mid Georges River FRMS&P. The Committee is responsible for recommending the outcomes of the study for formal consideration by Council. Members of the Floodplain Management Committee include Councillors and staff from Bankstown City Council, staff from neighbouring Fairfield City Council, Liverpool City Council, Hurstville City Council, NSW Office of Environment and Heritage (OEH), Sydney Water Corporation and the State Emergency Service (SES). A number of community representatives are also present on the Committee.

1.4 About This Report

This report documents the Study's objectives, results and recommendations. The report is structured as follows:

Chapter 1 introduces the study.

Chapter 2 provides background information including a catchment description, history of flooding and previous investigations.

Chapter 3 outlines the community consultation program undertaken.

Chapter 4 describes the flooding behaviour in the catchment including climate change analysis.

Chapter 5 provides a summary of property inundation and the flood damages assessment.

Chapter 6 summarises the existing flood management measures.

Chapter 7 provides details on the assessment of the property, response and flood modification measures.

Chapter 8 presents the recommended Draft Floodplain Risk Management Plan for managing flood risk.

Chapter 9 is a summary of the recommended Waterways and Water Quality Improvement Plan for improving water quality and water balance in the study area.

2 Background Information

2.1 Catchment Description

The Mid Georges River study area incorporates the seven sub-catchments of Milperra, Kelso Swamp, East Hills, Lucas Road, Picnic Point, Morris Gully and Little Salt Pan Creek. Each sub-catchment has been given a unique label by Council (i.e. the Milperra catchment is labelled C20) as illustrated in Figure 2-1. The sub-catchments are based on natural topographical divides and are bounded by the Georges River along the east and south of the study area. Encompassing a total area of approximately 30km^2, the study area represents a significant proportion of the Bankstown LGA totalling 77km^2.

The topography of the study area ranges from over 69m AHD in the north east (Condell Park) to 0m AHD along the banks of the Georges River. Land use within the study area primarily consists of urban residential development with large open spaces and undeveloped land present along the Georges River. Significant open spaces and undeveloped areas of the catchment include Bankstown Airport, the Georges River National Park, several golf courses and numerous reserves.

The seven sub-catchments of the study area drain individually to the Georges River, generally in a west or south direction. From the study area, the Georges River flows in a south-westerly direction, discharging into Botany Bay.

Urban stormwater is collected and conveyed by a network of surface pits and underground pipelines, which generally discharge to an open channel, creek, or other waterway before draining to the Georges River. Periods of high and/or intense rainfall can at times overload the pipe and channel system causing surface overflows (overland flows) and potentially flooding. Often overland flow paths are aligned with roads, however, in some instances, houses and other properties may be located on or adjacent to major overland flow paths. Some of these overland flow paths are protected by drainage easements. Flooding can be exacerbated through blockages to the drainage system and the presence of fences, trees, shrubs and properties along the overland flow paths.

Mainstream flooding associated with the Georges River was considered in the Georges River FRMS&P. This report primarily considers overland flooding. However it is important to note that properties in close proximity to Georges River may experience flooding from both mainstream and overland flooding, either separately or simultaneously.

A brief description of the catchment characteristics for each of the seven sub-catchments which comprise the Mid Georges River study area is provided in Section 2.1.1 to Section 2.1.7.



Title:

Catchment Areas

Figure: 2-1

Rev: 0

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2.1.1 Milperra (C20)

The Milperra catchment consists of Bankstown Airport and of parts Georges Hall, Bass Hill, Yagoona, Condell Park, Milperra and Revesby suburbs. The catchment area is approximately 12.7 km^2. The northern and eastern extents of the catchment are predominantly urban residential land use with much of the western part of the catchment consisting of open spaces and undeveloped areas associated with Bankstown Airport, several golf courses and reserves. Significant industrial areas are present along with urban residential areas in the south of the catchment.

Elevations range from around 69m AHD near Jocarm Avenue, Condell Park in the north-east to less than 0m AHD at the Georges River. The catchment drains west towards the Georges River via the piped drainage network, constructed channels, natural channels and overland flow routes.

Milperra Drain forms a major open channel reach within the catchment and consists of both, constructed channels and natural channels. Milperra Drain discharges into the Georges River towards the south of the catchment.

2.1.2 Kelso Swamp (C26)

The Kelso Swamp catchment consists of parts of the suburbs of Milperra, Panania and East Hills with a catchment area of approximately 5.4 km^2. The catchment is predominantly urban residential land use in the east and recreational land uses and reserves in the west. Kelso Tip is located within the catchment and the M5 Motorway runs through the north of the catchment.

Elevations range from around 35m AHD near Woodburn Avenue, Panania in the south-east to less than 0m AHD at the Georges River. The Kelso Swamp area and the region around the Riverlands Golf Club include very low lying areas. The lower area of the catchment is characterised by an extensive swamp, which is separated from the Georges River by the Kelso Levee. The levee was constructed to provide protection to homes in the Kelso Park and Panania areas from mainstream flooding on Georges River.

The catchment drains west towards the Georges River via the piped drainage network, unlined open channels and overland flow routes. The main creek within the catchment is Kelso Creek, which discharges into the Georges River via an outlet structure through the Kelso Levee.

2.1.3 East Hills (C30)

The East Hills catchment is located wholly within the suburb of East Hills with a catchment area of approximately 0.4 km^2. The catchment is predominantly urban residential land use with East Hills Park in the south-west. The catchment also includes East Hills Train Station and some surrounding commercial properties.

Elevations range from around 15m AHD near Forrest Rd, East Hills in the north-east to less than 0m AHD at the Georges River. The catchment drains west and south towards the Georges River via the piped drainage network and overland flow routes.

2.1.4 Lucas Road (C28)

The Lucas Road catchment consists of parts of East Hills, Panania and Picnic Point suburbs with a catchment area of approximately 2.2 km^2. The catchment is predominately urban residential land use with reserves along the Georges River.

Elevations range from around 40m AHD near Picnic Point Road, Panania in the east to less than 0m AHD at the Georges River. The northern part of the catchment drains to Lucas Road Drain which discharges to the Georges River at Monash Reserve. The southern part of the catchment drains directly to the Georges River via the piped drainage network and overland flow routes, with very steep gradients along the banks of the Georges River (slopes up to 30%).

2.1.5 Picnic Point (C29)

The Picnic Point catchment is located wholly within the suburb of Picnic Point with a catchment area of approximately 1.7 km^2. The northern part of the catchment is predominantly urban residential land use. The southern part of the catchment includes parts of the Georges River National Park, in particular the Yeramba Lagoon. The Sydney South Electricity Substation is located within the south-east of the catchment.

Elevations range from around 56m AHD at the Sydney South Electricity Substation in the south-east to less than 0m AHD at the Georges River. The catchment drains south towards the Georges River via the piped drainage network, overland flow routes and Yeramba Lagoon.

2.1.6 Morris Gully (C27)

The Morris Gully catchment includes parts of the suburbs of Revesby Heights, Revesby, Panania and Picnic Point with a catchment area of approximately 2.1 km^2. The northern part of the catchment is predominantly urban residential land use. The southern part of the catchment includes parts of the Georges River National Park and open reserves. A portion of the Sydney South Electricity Substation is also located within the south-west of the catchment.

Elevations range from around 55m AHD at the Sydney South Electricity Substation in the south-west to less than 0m AHD at the Georges River. The catchment drains south towards the Georges River via the piped drainage network, unlined open channels, i.e. Morris Gully, and overland flow routes.

2.1.7 Little Salt Pan Creek (C25)

The Little Salt Pan Creek catchment includes parts of the suburbs of Revesby, Revesby Heights, Padstow and Padstow Heights with a catchment area of approximately 5.6 km^2. The catchment is predominantly urban residential land use. Commercial buildings provide denser urbanisation at the intersection between the railway line and The River Road. The south of the catchment remains undeveloped and dense vegetation covers the creek floodplain.

Elevations range from around 50m AHD near Roma Avenue, Padstow Heights in the south-east to less than 0m AHD at the Georges River. The catchment drains south towards the Georges River via the piped drainage network, overland flow routes and through Little Salt Pan Creek before discharging into the Georges River.

2.2 History of Flooding

Historical records indicate that flooding in the study area results from two main sources, namely:

- Overland flooding due to stormwater runoff from the catchment; and
- Mainstream flooding from the Georges River.

Council maintains a Stormwater System Report (SSR) Register that indicates the likely extent of stormwater flooding within a catchment based on known overland flow paths and other anecdotal evidence of flooding. The register indicates properties that require the preparation of a stormwater system report when a development application is lodged. The register has been derived by Council over a number of years through:

- The identification of potential overland flow paths through the extensive catchment wide flood modelling;
- Experience of past flood problems from long term staff;
- Registration of complaints regarding flooding by the community; and
- Updating the SSR maps as stormwater reports are undertaken.

Community questionnaires were issued as part of the earlier stormwater flood studies and as part of this FRMS&P (refer to Chapter 3). The purpose of the questionnaire was to seek information on past floods, flooding issues of concern, and ideas on reducing existing flood problems. Despite the sizeable study area, details of historical flooding, particularly in the form of recorded flood marks and photographs were limited.

Significant flood events on the Georges River include February 1956, August 1986, and April 1988. These floods typically occur as a result of long duration storm events of between 36 hours and 48 hours. Some historical flood height data for the August 1986 and April 1988 events is documented in two post-flood event reports prepared by the Manly Hydraulics Laboratory (MHL, 1987, 1989). Both floods were estimated to have an Average Return Interval (ARI) close to 20 years.

2.3 Previous Studies

2.3.1 Stormwater Flood Studies

2.3.1.1 Seven sub-catchments within the Mid Georges River study area

Stormwater flood studies have been carried out for the seven sub-catchments within the Mid Georges River study area. The primary objective of each of the stormwater flood studies has been to define the overland flood behaviour within the respective catchment through the establishment of appropriate numerical models. The most recent stormwater flood studies for each sub-catchment were completed between 2009 and 2015 as listed in Table 2-1.

The stormwater flood studies involved the development of numerical computer models to simulate overland flood behaviour through the sub-catchments of the study area. Bankstown City Council has adopted a consistent flood modelling approach across all sub-catchments in the Bankstown LGA. This approach uses combined two-dimensional (2D) and one dimensional (1D) hydraulic

models developed using TUFLOW modelling software. These models are capable of modelling urban overland flow paths and the pipe drainage network, channels and creeks. The *Georges River Floodplain Risk Management Study* (Bewsher Consulting, 2004) assessed the flood behaviour on the Georges River and the results from this study have been utilised in the stormwater flood studies to inform the choice of downstream boundary water level.

The stormwater flood studies produced information on flood flows, velocities, levels and extents for a range of design flood events under existing catchment and floodplain conditions. Table 2-1 lists the stormwater flood studies which have formed the technical basis for this FRMS&P and provides a website link to each flood study report.

Table 2-1 Details of the most recent stormwater flood studies completed in the study area

Flood Study Title	Completion Date	Internet Source
Milperra Catchment Flood Study Update	October 2015	Stormwater Catchment Flood Studies - Milperra
Kelso Stormwater Catchment Flood Study	December 2009	Stormwater Catchment Flood Studies - Kelso Swamp
East Hills Stormwater Catchment Flood Study	December 2009	Stormwater Catchment Flood Studies - East Hills
Lucas Road Catchment Flood Study	July 2010	Stormwater Catchment Flood Studies - Lucas Road
Picnic Point Catchment Flood Study	March 2011	Stormwater Catchment Flood Studies - Picnic Point
Morris Gully Catchment Flood Study	March 2011	Stormwater Catchment Flood Studies - Morris Gully
Little Salt Pan Creek Stormwater Catchment Flood Study	October 2009	Stormwater Catchment Flood Studies - Little Salt Pan Creek

2.3.1.2 Assessment of the flood impacts of developments at Bankstown Airport

Bankstown City Council has previously raised concerns that the flood studies undertaken to assess development within Bankstown Airport Limited (BAL) land have been undertaken in isolation from the drainage system upstream and downstream of the airport site. To address these concerns, the model developed for the Milperra Catchment Flood Study Update (BMT WBM, 2015) has been used to assess the impact of development within BAL lands on local overland flooding associated with stormwater runoff.

The current scenario model has been used to assess the impacts of developments on BAL land against a baseline model representing 2003 landform and drainage conditions. An assessment of future impacts has also been undertaken based on a model representing possible future development on BAL land. Details of the model development and model results are reported in the Milperra Catchment Flood Study Model Review at Bankstown Airport (BMT WBM, 2015).

The results indicate that past changes on BAL land have caused adverse offsite flood impacts, i.e. flood impacts off BAL land, at one location, namely, Milperra Road and Nancy Ellis Leebold Drive, Milperra. For the future scenario, the model results indicate that potential future land use changes on BAL land could result in adverse flood impacts. The results indicate that these adverse impacts are generally confined to BAL land.

2.3.2 Georges River Studies

2.3.2.1 Georges River Flood Study: Final Report (PWD, 1991)

The Georges River flood study investigated flood levels and frequency between Liverpool Weir, the Hume Highway and Picnic Point. The study involved various stages including:

- Compilation of survey contour plans of the area;
- Review of historical flood data;
- Hydrology of the catchment including Georges River and tributaries;
- Construction, calibration and testing of a large physical model;
- Determination of 100, 50 and 20 year ARI design flood levels; and
- The impact of an extreme flood on the catchment.

The final report documents the comprehensive study undertaken to examine flooding from the Georges River between Liverpool Weir and Picnic Point.

2.3.2.2 Georges River Floodplain Risk Management Study and Plan (Bewsher Consulting, 2004)

The Georges River FRMS&P was undertaken to understand and manage flood risks associated with mainstream flooding from the Georges River in the Liverpool, Fairfield, Bankstown and Sutherland LGA's. The FRMS&P includes recommended works and measures for managing the mainstream flood risk and sets out a program for implementation.

The study incorporated the development of a detailed MIKE-11 numerical model of the Georges River from Cambridge Avenue Glenfield to Botany Bay to update previous modelling undertaken as part of the Georges River Flood Study (PWD, 1991). The MIKE-11 model was used to map all areas that are at risk of flooding, with the floodplain divided into three flood risk precincts: high, medium and low. These flood risk precincts allow a risk-based approach for floodplain management that provides for a graded approach for land use and development.

2.3.2.3 Georges River Estuary Coastal Zone Management Plan (BMT WBM, 2013)

The Georges River Estuary Coastal Zone Management Plan (CZMP) was developed by BMT WBM (2013) on behalf of the Georges River Combined Councils Committee, and gazetted by the NSW Government in July 2015. The CZMP provides a strategic framework and action plan for the future management of the Georges River Estuary, which is the receiving waterway for the Mid Georges River study area.

The CZMP aims to conserve and improve the existing natural environment of the estuary and improve water quality. The CZMP outlines nine broad aims, the most important of which relate to water quality, aquatic and riparian habitat, landuse planning and development, bank erosion and sedimentation and climate change and sea level rise. A total of 27 management objectives were developed to meet these aims, 10 of which were identified as high priority. The majority of these priority objectives relate to water quality.

GRCCC member councils, including Bankstown City Council, are currently scheduling the progressive implementation of the actions outlined in the CZMP action plan with financial and technical support from the NSW Government's Estuary Management Program.

The CZMP has been considered as part of this project during the preparation of the Waterways and Water Quality Improvement Plan.

2.3.3 Environmental Issues

2.3.3.1 Biodiversity

The biodiversity of the Bankstown LGA is well described in Bankstown City Council's 2015 Biodiversity Strategic Plan 2015-2015. The plan notes that the LGA, although fully urbanised, still contains a variety of ecosystems that are of environmental and social value.

The Bankstown LGA is located in a transition zone between the wetter coastal areas to the east and the drier Cumberland Plain to the west. This zone has a variety or watercourses, soils and landscapes that support aquatic, riparian and terrestrial ecosystems.

Vegetation mapping from different sources and compiled in the plan reveals the Bankstown LGA has a variety of ecological communities, many of which are classified as endangered under the *Threatened Species Conservation Act 1995*. Some of the more important communities include the Shale / Sandstone Transition Forest, the River Flat Eucalypt Forest, Cumberland Plain Woodland and the Cooks River / Castlereagh Ironbark Forest.

Within the study area, the largest areas of vegetation are located in the Georges River National park at the base of the Picnic Point and Morris Gully catchments, at Kelso Swamp and in the western parts of the Milperra catchment close to the Georges River. These areas provides habitat for native flora and fauna, some of which are of national significance or classified as threatened within NSW. Some bird species are migratory and protected under international treaties.

These ecological communities are constant pressure from threats such as clearing, pollution and weed infestation. To address these threats, the Biodiversity Strategic Plan outlines a set of nine goals accompanied by six strategies each with multiple actions.

Flood mitigation works proposed under this FRMS&P will need to acknowledge the goals and strategies of the Biodiversity Strategic Plan. There may also be opportunity when undertaking flood mitigation works to incorporate measures to enhance biodiversity and help achieve the goals of the plan.

2.3.3.2 Waterway Health

The Bankstown LGA is fortunate to have numerous freshwater and estuarine creeks and wetlands, many of which are highly valued by the local community. However like most urban waterways in Sydney, the waterways in the Bankstown suffer from multiple issues including:

- poor water quality;
- bed and bank erosion;
- weed infestation;
- channelisation;
- loss of riparian corridor and development to bank top;
- sediment contamination; and
- poor amenity.

These issues are discussed more fully in the Waterways and Water Quality Improvement Plan.

2.3.4 Heritage Issues

Heritage issues are an important consideration during the development of a floodplain risk management study and plan. Heritage items within the catchment must be considered to ensure that they are not adversely impacted by flood mitigation works.

The State Heritage Inventory is a database of over 25,000 heritage items on statutory lists in NSW. Heritage items are categorised as being of local, regional or State significance.

Bankstown LGA has six State significant heritage items that are listed under the NSW Heritage Act. These include:

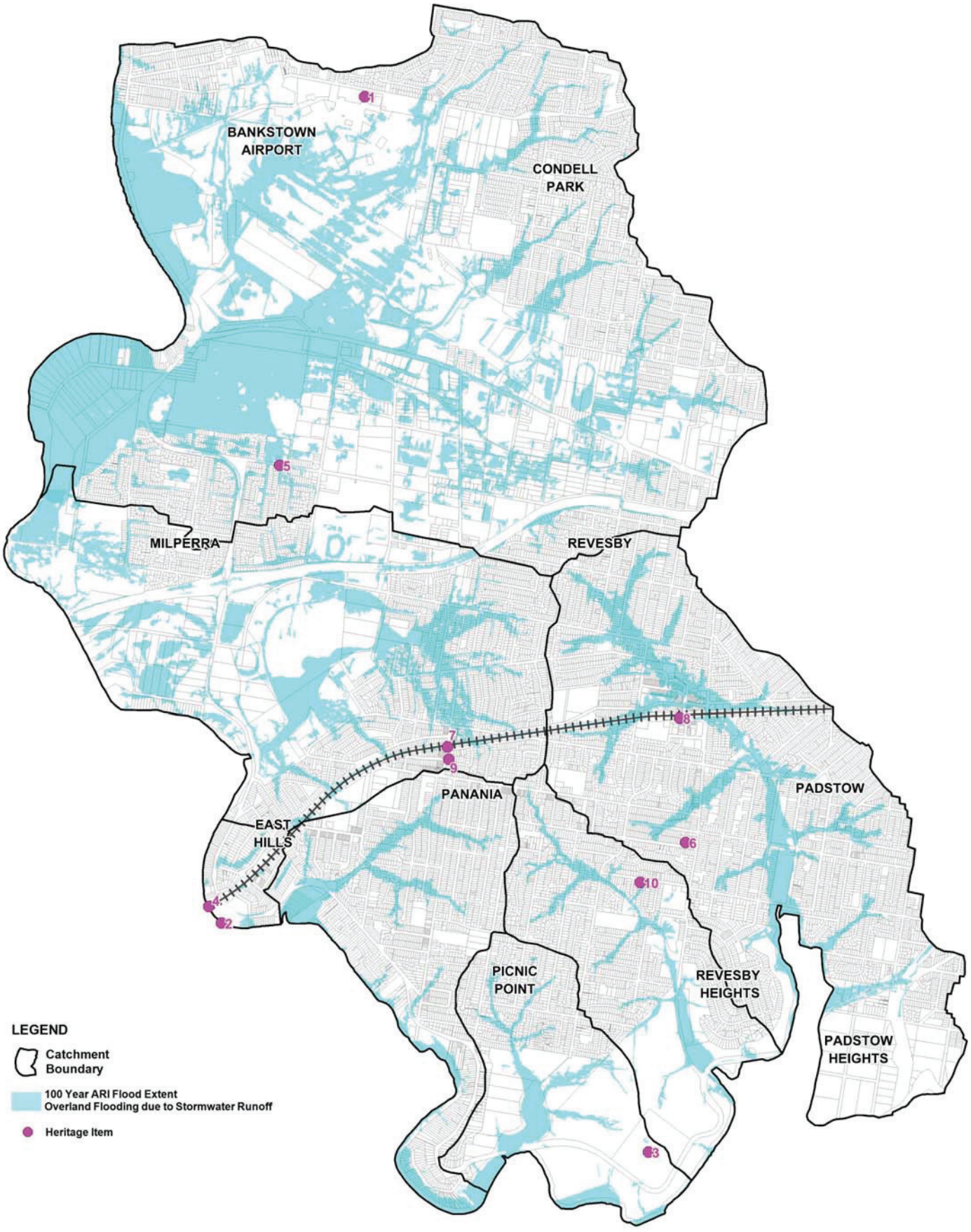
- Air Defence Headquarter Ruin Sydney (former);
- Bankstown Reservoir (Elevated);
- The Homestead;
- Potts Hill Reservoirs 1 and 2 and Site;
- Pressure Tunnel and Shafts; and
- Pressure Tunnel Shaft No. 1 and associated infrastructure.

None of these state significant heritage items are located within the study area. However, the Mid Georges River study area has 10 local heritage items listed by Local Government and State Agencies. These 10 local heritage items are listed in Table 2-2 and shown in Figure 2-2.

Table 2-2 Heritage items in the study area

ID (Refer to Figure 2-2)	Address	Description	Significance
1	Marion Street, Georges Hall	Bankstown Aerodrome – regional strategic importance and defence centre in 1940s.	Local
2	Georges River/East Hills Park, East Hills	Cairds Wharf – nineteenth century timber wharf, with concrete abutments as later additions in the 1920s. Only the abutments remain.	Local
3	925 Henry Lawson Drive, Revesby	Cattle Duffers Flat – reminder of early isolation of the area and its farming economy.	Local
4	Henry Lawson Drive, East Hills	East Hills (Georges River) Underbridge – original infrastructure of East Hills railway line.	Local
5*	Bullecourt Avenue, Fleurbaix Avenue and Ashford Avenue, etc.	Milperra Soldier Settlement (Roads) – evidence of major national settlement scheme.	Local
6	4 Tompson Road, Revesby	The Pah – good example of the Victorian filigree style.	Local
7*	Anderson Avenue, Panania	Panania Railway Station Group – major public work completed as an unemployment relief project during the Great Depression	Local
8	Blamey Street, Revesby	Revesby Railway Station Group – major public work completed as an unemployment relief project during the Great Depression	Local
9	77 Anderson Avenue, Panania	Schwarzel Monument – stone monument to commemorate Nurse Sarah Ann Schwarzel	Local
10	31 Ferndale Road, Revesby	Ferndale Cottage – understood to be amongst the earlier extant houses in Revesby	Local

Comparison of the heritage item locations with flood model extents indicate that heritage items 5 and 7 are affected by the 100 year ARI flood event. This will be considered during the Flood Risk Management Study (FRMS) and FRM Plan (Chapters 7 and 8) and may influence the recommendations made.



Title:

Location of Heritage Items in The Study Area

Figure: **2-2**

Rev: **1**

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3 Community Consultation

3.1 The Community Consultation Process

Community consultation has been an important component in the floodplain management study. The consultation has aimed to inform the community about the development of the floodplain risk management study and its likely outcome as a precursor to the development of the floodplain risk management plan. It has provided an opportunity to collect information on flood experiences, concerns about flooding issues and problem areas, and to collect feedback and ideas on potential floodplain management measures. In addition, the consultation process raises awareness about the flooding risk within the community and improves the community's receptiveness to flooding.

The key elements of the consultation process have been as follows:

- Consultation with the Floodplain Management Committee;
- Establishment of project website;
- Distribution of community questionnaire and newsletter;
- Distribution of stakeholder information and survey;
- Community information sessions on the development of potential management options; and
- Public exhibition of the Draft FRMS&P (to be undertaken).

These elements are discussed in the following sections.

3.2 The Floodplain Management Committee

This study and the previous flood studies for the Mid Georges River sub-catchments have been overseen by the Floodplain Management Committee (Committee). The Committee has assisted and advised Council in the development of the Mid Georges River Floodplain Risk Management Study. The Committee is responsible for recommending the outcomes of the study for formal consideration by Council. Members of the Floodplain Management Committee include representatives from the following:

- Bankstown City Council - Councillors;
- Staff from Bankstown City Council;
- Staff from neighbouring Councils;
- Representatives from the NSW Office of Environment and Heritage (OEH);
- Representatives from the State Emergency Service (SES);
- Representatives from Sydney Water; and
- Community representatives.

3.3 Project Website

A customised, project specific website (http://midgeorgesfrmsp.bmtwbm.com.au) has been established with the aim of providing connectivity between the project and the community. The website provides details about the study, including:

- An overview of the Floodplain Management Process;
- The area included in the study;
- The key study outputs;
- Details regarding community consultation;
- A web enabled version of the community questionnaire; and
- Contact details for both BMT WBM and Council staff.

The website has been kept updated throughout the study as new information became available. The home page for the website is shown in Figure 3-1.

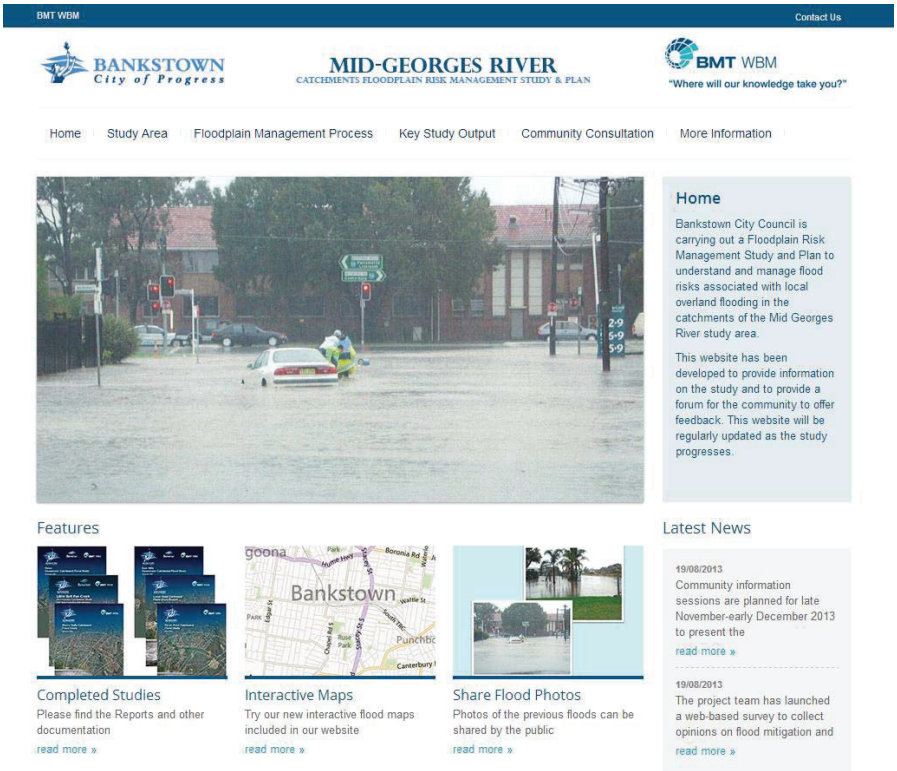


Figure 3-1 Homepage of the Mid Georges River FRMS&P project website

3.4 Community Questionnaire and Newsletter

3.4.1 Overview

Community questionnaires and newsletters were issued as part of the earlier stormwater flood studies to seek information on past floods, flooding issues of concern, and ideas on reducing existing flood problems.

As part of this FRMS&P, residents within the high and medium flood risk precinct (refer to Section 4.2.3 for further information on flood risk precincts) were invited to participate in the study by providing information on past floods in the catchment, flooding issues of concern and ideas on reducing existing flood problems. A copy of the letter, information sheet and community questionnaire issued to residents is included in Appendix A.

A summary of the consultation and key issues raised during the earlier flood studies and as part of this FRMS&P is provided in Sections 3.4.2 and 3.4.3 respectively. A full list of issues raised by the community is contained in Appendix A.

3.4.2 During Earlier Studies

During earlier stormwater flood study investigations, six of the seven Mid Georges River sub-catchments included in this study underwent community consultation. Between July 2006 and October 2010, letters and questionnaires were sent to residents in the Milperra, Kelso Swamp, East Hills, Picnic Point, Lucas Road, and Morris Gully sub-catchments that were identified as likely to be affected by local overland catchment flooding in a 100 year ARI event. The letter provided information about the study, and invited residents to participate by responding to the questionnaire. The questionnaire sought information on past floods in the sub-catchments, flooding issues of concern, and ideas on reducing existing flood problems.

As the Little Salt Pan Creek Study was completed prior to the six catchments mentioned above, and considering the poor response rate from the Milperra sub-catchment (less than 1%), Council decided to conduct community consultation for this catchment as part of the FRMS&P.

Consultation on the Milperra Catchment Flood Study Update (BMT WBM, 2015) has also been undertaken as part of this FRMS&P (refer to Section 3.4.3).

Across the six sub-catchments, a total of 3,777 questionnaires were distributed. Of these, 287 were completed and returned (7.6% response rate). This is a typical average response rate for consultation on flood studies. A summary of the responses received through these questionnaires is provided in Table 3-1.

Table 3-1 Questionnaire responses from flood studies completed between 2006 and 2010

Description	*Sub-catchments*					
	Milperra	*Kelso Swamp*	*East Hills*	*Picnic Point*	*Lucas Road*	*Morris Gully*
Distribution						
Number distributed	1,500	1,280	121	129	462	285
Number returned	14	122	16	25	66	44
Response rate	<1%	10%	13%	19%	14%	15%
Flood Experience						
Experienced a flood	-	42	8	6	29	6
Property has flooded	5	27	6	5	23	5
House has flooded	-	4	1	1	1	1

A summary of the key issues raised by residents in these questionnaires is listed below:

- Adequacy of the stormwater network in terms of flow capacity and maintenance;
- Extent of maintenance of the open creek channels to manage sediment and build-up of rubbish;
- Degree of maintenance of flood defences, e.g. Kelso Levee; and
- Control of development, particularly new developments being undertaken before the completion of the flood studies.

A summary of ideas from residents for reducing flood problems is provided below:

- Improve and upgrade the stormwater infrastructures and drainage system;
- Increase maintenance of the stormwater network and channels, e.g. ensure drains and waterways are kept clear;
- Improve maintenance of existing flood defences;
- Reduce runoff through stormwater retention and increased infiltration; and
- Provide community awareness campaigns to inform residents on the level of flood risk to their properties and measures to reduce the flood risk.

3.4.3 During The Current Study

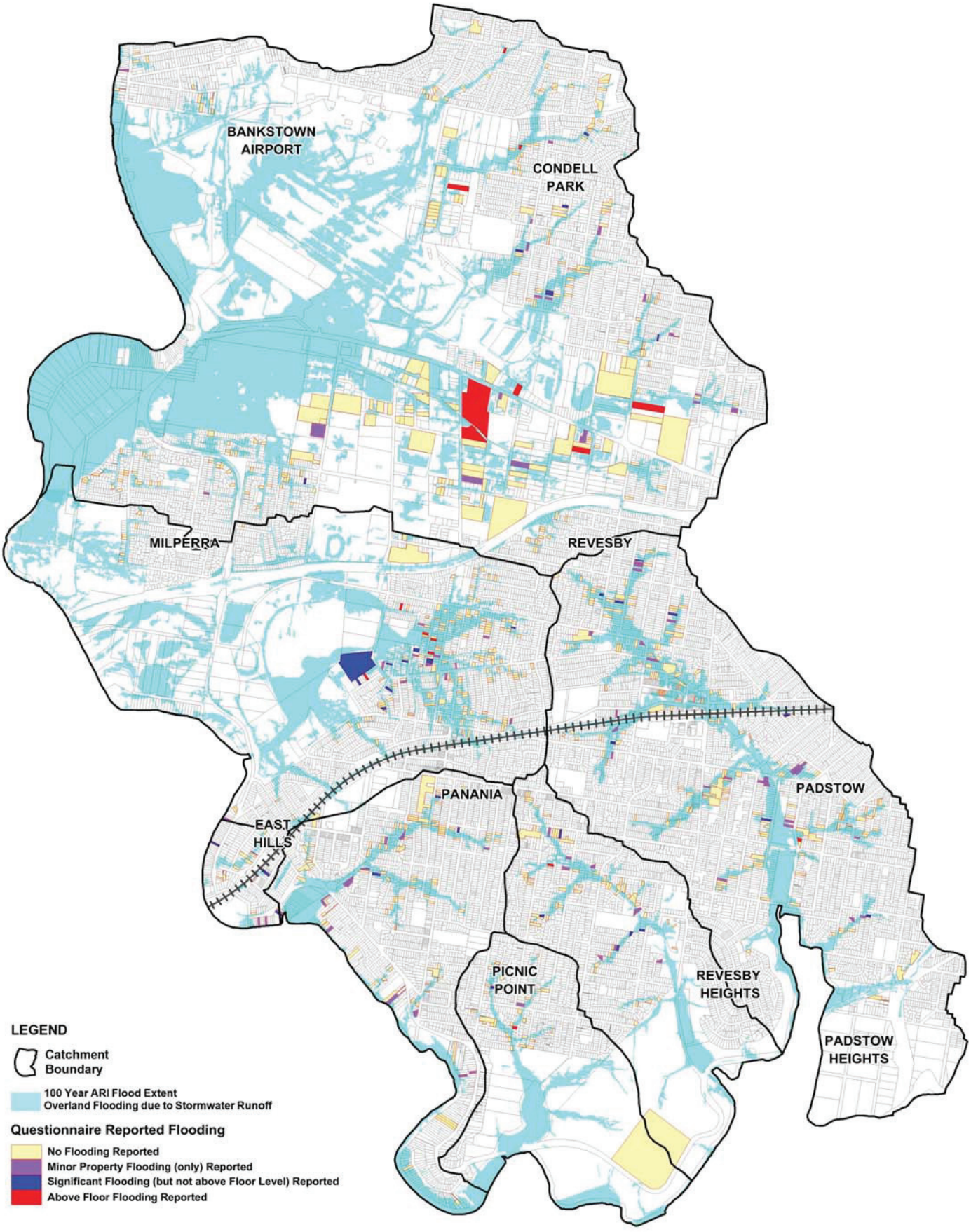
In October 2013, landowners, residents and businesses within the Mid Georges River study area that were identified as being within the high and medium flood risk precincts were sent a letter, study information sheet and questionnaire. The letter invited residents to participate in the study via the questionnaire by providing information on past floods in the catchment, flooding issues of concern, and ideas on reducing existing flood problems.

Council directly mailed the correspondence to approximately 7,600 properties. The community questionnaire was also made available for completion on the project website.

A total of 855 questionnaires were completed and returned, representing a response rate of 11%. This represents an average response rate for a floodplain risk management study and plan. By comparison, the Salt Pan Creek Catchments FRMS&P had a 15% response rate from a total of 3,084 questionnaires. A summary of the information received concerning the flood experience of the community is provided in Table 3-2 with the locations of respondents illustrated in Figure 3-2. The breakdown of the questionnaire responses regarding property types and flooding experience are also presented in Figure 3-3 and Figure 3-4.

Table 3-2 Mid Georges River FRMS&P questionnaire distribution and flood experience

Description	*Mid Georges River Catchment*
Distribution	
Number Distributed	7,600
Number Returned	855
Response Rate	11%
Flood Experience	
Experienced a Flood	137
Property has Flooded	127
House has Flooded	16



Title:

2013 Questionnaire Responses Map

Figure: 3-2

Rev: 1

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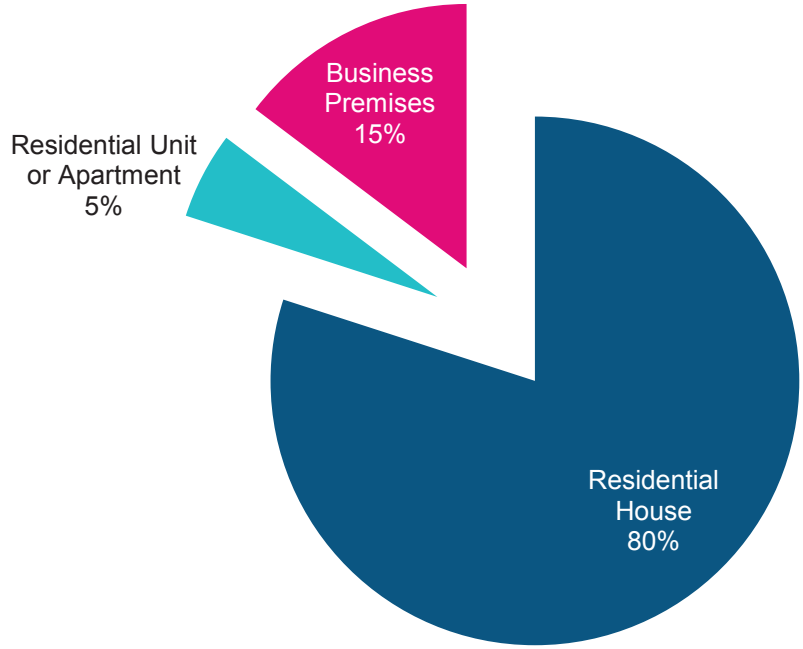


Figure 3-3 2013 Questionnaire responses – property type

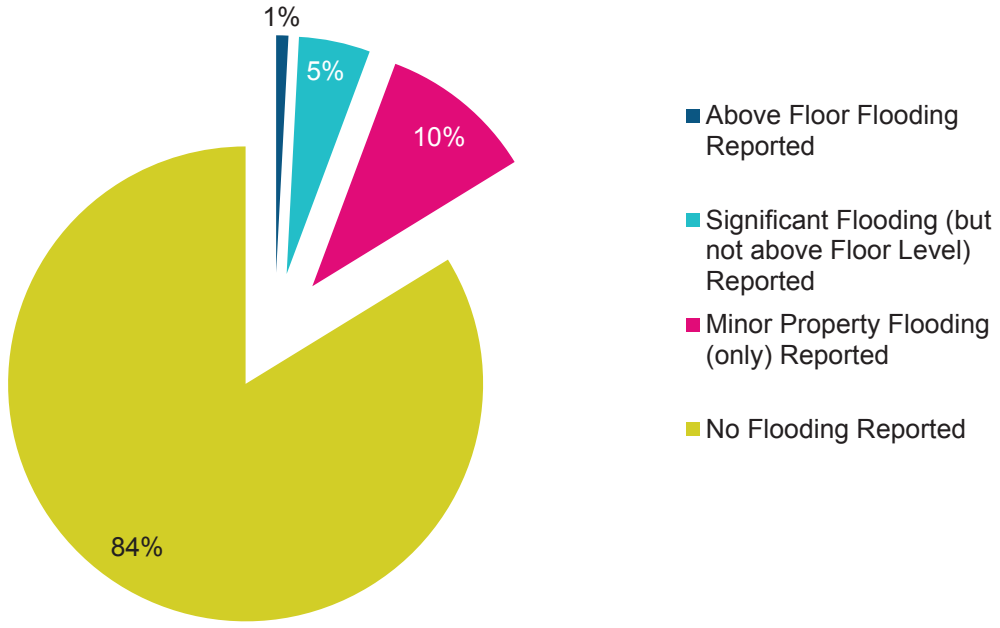


Figure 3-4 2013 Questionnaire responses – experienced flooding

A summary of the key issued raised by residents in these questionnaires is provided below.

- Adequacy of the development controls with particular reference to ongoing development in flood prone areas (i.e. Riverlands Golf Course, Bankstown Airport and M5 Motorway);
- Impact of the study outputs on property resale value and insurance premiums;
- How residents can prepare for and minimise the impact of flooding on their property;
- Extent of maintenance of the stormwater network; and
- Impact of Georges River flooding.

The most commonly raised community ideas for reducing flood problems focused on:

- Improve and upgrade stormwater infrastructure and drainage;
- Increase maintenance of the stormwater network and channels, e.g. ensure drains and waterways are kept clear;
- Apply appropriate development controls in flood prone areas;
- Provide community awareness campaigns to inform residents on the level of flood risk to their properties and measures to reduce the flood risk;
- Implement structural measures to manage the flood risk, e.g. retention ponds, levees, pollution traps, creek widening, flow diversions and flood walls; and
- Dredge silted reaches of the Georges River.

3.5 Liaison with Stakeholders

A number of stakeholders have assets, infrastructure and interests within the Mid Georges River study area. In August 2013, a personalised letter and accompanying information leaflet, mapping booklet and questionnaire was sent to a total of 25 stakeholders. The correspondence outlined the study objectives, provided 100 year ARI flood extent mapping for the Mid Georges River study area and requested a formal response regarding:

- Availability of data relevant to flooding;
- Views on key flooding issues and how these issued could be addressed;
- Comments regarding the future flood management in the Mid Georges River catchments; and
- Any other known relevant issues and concerns that should be considered in the Floodplain Risk Management Study and Plan.

The stakeholders issued with the information were comprised of relevant government departments, community groups and associations, private enterprises and public utilities. All organisations that were liaised with are listed in Table 3-3.

Table 3-3 List of stakeholders

Organisation
A.G.L. Gas Company
Bankstown Airport Limited
Bankstown Bushland Society
Bankstown Golf Club
Bankstown Historical Society
Bankstown Trotting Recreational Club
Bureau of Meteorology
Endeavour Energy
Energy Australia
Georges Hall Progress Association
Integral Energy Australia
Interlink Roads Pty Ltd
Milperra and District Progress Association
NSW Business Chamber - Sydney South West Region
NSW Department of Education & Communities
NSW Department of Primary Industries (Fisheries)
NSW Police Force - Revesby Police Station
NSW Roads and Maritime Services
Rail Infrastructure Corporation
Revesby Workers' Club
Riverwood Golf Club
State Emergency Service (Sydney Southern Region)
State Rail Authority
Sydney Water Corporation Ltd
TransGrid (head office)

Of the 25 stakeholders contacted, six responses were received. The key findings from the survey responses included:

- Georges Hall Progress Association (now inactive) confirmed the existence of historically flood prone land in the southern area of Bankstown Airport. They also raised concern about the flood impact of ongoing filling within the airport site.
- Interlink Roads Pty Ltd provided data on the drainage, water quality plans and final design report for the M5 West widening works which are currently being undertaken near Salt Pan

Creek. They indicated the original design of the motorway was based on the 100 year ARI flood event.

- The NSW Department of Primary Industries (Fisheries) indicated that waterways in the Kelso Swamp, Picnic Point and Little Salt Pan Creek sub-catchments have been mapped as key fish habitat (KFH) and that any flood mitigation measures must not block the passage of fish. They also referred to the Georges River Coastal Zone Estuary Management Plan and the proposal to open the weir entrance at Yeramba Lagoon, Picnic Point.
- Sydney Water provided information with regards to their assets within the study area.
- NSW Police indicated that the study and subsequent mapping will be extremely valuable to them and other agencies in the event of severe flooding and flood evacuations.
- The NSW Department of Education and Communities indicated that the preference for all new education establishments are sites located outside the 100 year ARI flood event and the Probable Maximum Flood extent. They also requested that if this investigation reveals any existing school are located within a flood prone area that the Department be notified so a Flood Management Plan can be prepared for the schools in question.

3.6 Community Information Sessions

3.6.1 Overview

Community information sessions were held in November/December 2013 and in May 2014. The sessions presented an overview of the Mid Georges River Floodplain Risk Management Study and Plan process and provided opportunities for the community to provide feedback on the issues of concern in their locality.

A summary of the information sessions and key issues raised during the November/December 2013 consultation and May 2014 consultation is provided in Sections 3.6.2 and 3.6.3 respectively. A full list of issues raised by the community during these community information sessions is contained in Appendix A.

3.6.2 Community Information Sessions in November/December 2013

Six community information sessions were conducted in late November/ early December 2013, as detailed below:

- Wednesday 27 November, 4 December and 11 December from 2:30pm to 4:30pm at the Panania Senior Citizen's Centre, 77 Anderson Avenue, Panania; and
- Thursday 28 November, 5 December and 12 December from 6:00pm to 8:00pm at the Milperra Community Hall, 128 Ashford Avenue, Milperra.

The community was notified of the community information sessions in the letter mailed to residents in October 2013 (see Section 3.4.3). Copies of the correspondence mailed to property owners are provided in Appendix A.

The community information sessions were attended by Council and BMT WBM representatives and registered community members. The sessions presented an overview of the Mid Georges River

Floodplain Risk Management Study and Plan process with a presentation made by BMT WBM. Community members were encouraged to discuss their concerns and suggestions with the representatives present. An information sheet on the Mid Georges River Floodplain Risk Management Study and Plan, feedback forms and frequently asked questions were also provided to the attendees.

A total of 51 residents attended over the six information sessions. A summary of the key issues raised in the community information sessions are provided below.

- Understanding the differences between overland stormwater flooding and mainstream flooding from the Georges River;
- Impact of the flood studies on property re-sale values and insurance premiums;
- Community awareness and preparedness for a 100 year ARI flood event even if it hasn't been experienced in our lifetime;
- How rainfall patterns, climate change and future development have been considered;
- Whether flood risk management measures would address localised problem areas;
- The impact of ongoing development on flooding (e.g. developments at Bankstown Airport); and
- The impact on flooding of the potential rezoning of Riverland's Golf Course, Milperra for future residential development.

Residents also provided details of specific flooding issues which they would like to see addressed. A full list of these issues in contained in Appendix A.

3.6.3 Carinya Road Community Information Sessions

Council indicated that the Carinya Road residents were quite interested during the consultation process of the *Georges River Floodplain Risk Management Study and Plan* (Bewsher Consulting, 2004). As part of the Mid Georges River FRMS&P, the development control plans (DCP) for flood risk management specific to Carinya Road were to be reviewed. As part of this review, Council elected to undertake consultation specifically catering for Carinya Road residents and owners as part of this FRMS&P. The main aim of the consultation has been to gather feedback from the community on the existing DCP for flood risk management.

Two community information sessions were conducted on the 12th of May 2014 at the Revesby Community Centre, Macarthur Avenue, Revesby, from 2:30pm to 4:30pm and 6:00pm to 8:00pm specifically catering for Carinya Road residents and owners.

Council notified Carinya Road residents of the consultation sessions by mail with a total of 30 residents attending on the day.

The community consultation sessions were conducted by Council, BMT WBM and GLN Planning representatives. The sessions presented a brief overview of the Mid Georges River Floodplain Risk Management Study and Plan process and DCP specific to Carinya Road with a presentation made by BMT WBM and their planning sub-consultant GLN Planning.

Community members were encouraged to discuss their concerns and suggestions with the representatives present. An information sheet of frequently asked questions and feedback forms were also provided to the attendees. A summary of the key issues raised in the community information sessions are provided below:

- Difficulty understanding the existing DCP and how it related to their property;
- Necessity of the controls in the DCP relating to access walkways to Carinya Road;
- Necessity of the controls in the DCP relating to garage locations;
- Available flood warning time from mainstream flooding from the Georges River;
- Impacts of ongoing developments in the Georges River catchment on the flood levels at Carinya Road;
- Local community awareness of the risks of flooding at Carinya Road;
- The impact of the tide levels on flooding issues at Carinya Road; and
- Maintenance of existing defences and the drainage infrastructure.

4 Flood Behaviour

4.1 Overland and Mainstream Flooding

The Mid Georges River study area is potentially affected by two sources of flooding, namely:

- Overland flooding due to stormwater runoff from the local catchment (i.e. local catchment event); and
- Mainstream flooding from the Georges River.

Flood behaviour for the sub-catchments of the Mid Georges River have been investigated in the stormwater flood studies completed from 2009 to 2015 as outlined in Section 2.3. Flood behaviour on the Georges River has been studied since the mid 1960's. The most recent study undertaken is the *Georges River Floodplain Management Study and Plan* (Bewsher Consulting, 2004) as detailed in Section 2.3.2.

With this Floodplain Risk Management Study, an opportunity has been created to consolidate the management of all types of flooding across the Mid Georges River study area. In some areas of the floodplain, properties may be exposed to both mainstream and overland flooding risks, which need to be acknowledged and managed in different ways with consideration to the mechanism of flooding, frequency and severity.

Given the differences in scale of the Mid Georges River study area and larger Georges River catchment, it is unlikely that coincident major flooding would occur simultaneously. Significant Georges River flooding has typically resulted from prolonged rainfall with storm durations of between 36 hours and 48 hours identified as being critical. The sub-catchments of the Mid Georges River typically have a critical storm duration of 2 hours or less. Nevertheless, there remains the possibility for coincident major flooding in both catchment areas.

The *Georges River Floodplain Management Study and Plan* (Bewsher Consulting, 2004) specifically deals with the mainstream flooding areas affected by the Georges River, and in the most part does not address in any detail overland flooding. Accordingly, the focus of this FRMS&P is addressing the overland flooding risk.

4.2 Flood Risk Mapping

For each of the Mid Georges River sub-catchment flood studies the flood results were presented in a series of maps showing peak flood levels, depth, velocity and velocity-depth product for key design events as well as provisional flood risk precincts. Additional mapping has been undertaken in this FRMS&P to further refine the hydraulic category and flood risk precincts.

4.2.1 Hydraulic Categorisation

Hydraulic categorisation is one of the tools used to identify flood behaviour and risk in a FRMS&P. Outcomes of the categorisation are primarily used to inform future land use planning. The categorisation is not used to assess individual developments, but rather to give a catchment-scale overview of which areas may be appropriate for various types of land use.

There are no prescriptive methods for determining what parts of the floodplain constitute floodways, flood storages and flood fringes. Descriptions of these terms within the *Floodplain Development Manual* (DIPNR, 2005) are essentially qualitative in nature. Of particular difficulty is the fact that a definition of flood behaviour and associated impacts is likely to vary from one floodplain to another depending on the circumstances and nature of flooding within the catchment.

The hydraulic categories as defined in the *Floodplain Development Manual* are:

- Floodway - Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.
- Flood Storage - Areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it will result in elevated water levels and/or elevated discharges. Flood Storage areas, if completely blocked would cause peak flood levels to increase by 0.1m and/or would cause the peak discharge to increase by more than 10%.
- Flood Fringe - Remaining area of flood prone land, after Floodway and Flood Storage areas have been defined. Blockage or filling of this area will not have any significant effect on the flood pattern or flood levels.

A number of approaches were considered when attempting to define flood hydraulic categories across the study catchments. Approaches to define hydraulic categories that were considered for this assessment included partitioning the floodplain based on:

- Peak flood velocity;
- Peak flood depth;
- Peak velocity-depth product (sometimes referred to as unit discharge);
- Cumulative volume conveyed during the flood event; and
- Combinations of the above.

The definition of hydraulic categories that was considered to best fit overland flooding in the Mid Georges River study area was based on a combination of velocity-depth product and depth parameters. Hydraulic category mapping for the overland flooding due to stormwater runoff from the local catchment derived 100 year ARI design event is shown in Figure 4-2 based on the adopted hydraulic categorisation as defined in Table 4-1.

Table 4-1 Hydraulic categories

Hydraulic Category	Definition	Description
Floodway	Velocity * Depth > 0.5	Areas and flow paths where a significant proportion of floodwaters are conveyed (including all creek sections).
Flood Storage	Velocity * Depth < 0.5 and Depth > 0.5 metres	Areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks.
Flood Fringe	Velocity * Depth < 0.5 and Depth < 0.5 metres	Areas that are low-velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behaviour.

Some manual editing of the floodway was required to ensure continuity of the floodway was maintained for all creek sections. This involved connecting isolated pockets of floodway based on aerial photographs of the creek alignment. .

Figure 4-2 also shows the drainage connections between lengths of open channel floodway that are made by culverts or large diameter stormwater pipes. These are labelled on the figure as key drainage connections.

4.2.2 Flood Hazard

Hazard categorisation is carried out to establish how hazardous (i.e. dangerous) various parts of the floodplain are. Primarily the hazard is a function of the depth and velocity of floodwater, however, the hazard categorisation considers a wider range of flood risks, particularly those relating to personal safety and evacuation. These hazard factors are derived from both hydraulic factors (such as depths and velocities) and human / behavioural issues (such as flood readiness).

Depth and velocity hazards have been identified according to the provisional hydraulic hazard categories provided in the *Floodplain Development Manual* (DIPNR, 2005). This has been further sub-categorised to show the predominant 'type' of hydraulic hazard (i.e. high velocity, depth, or combination) as shown in Figure 4-1.

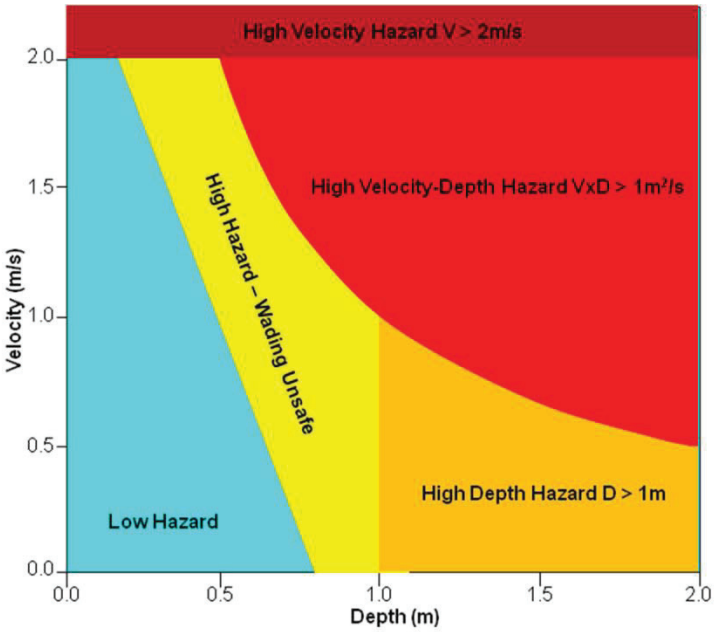
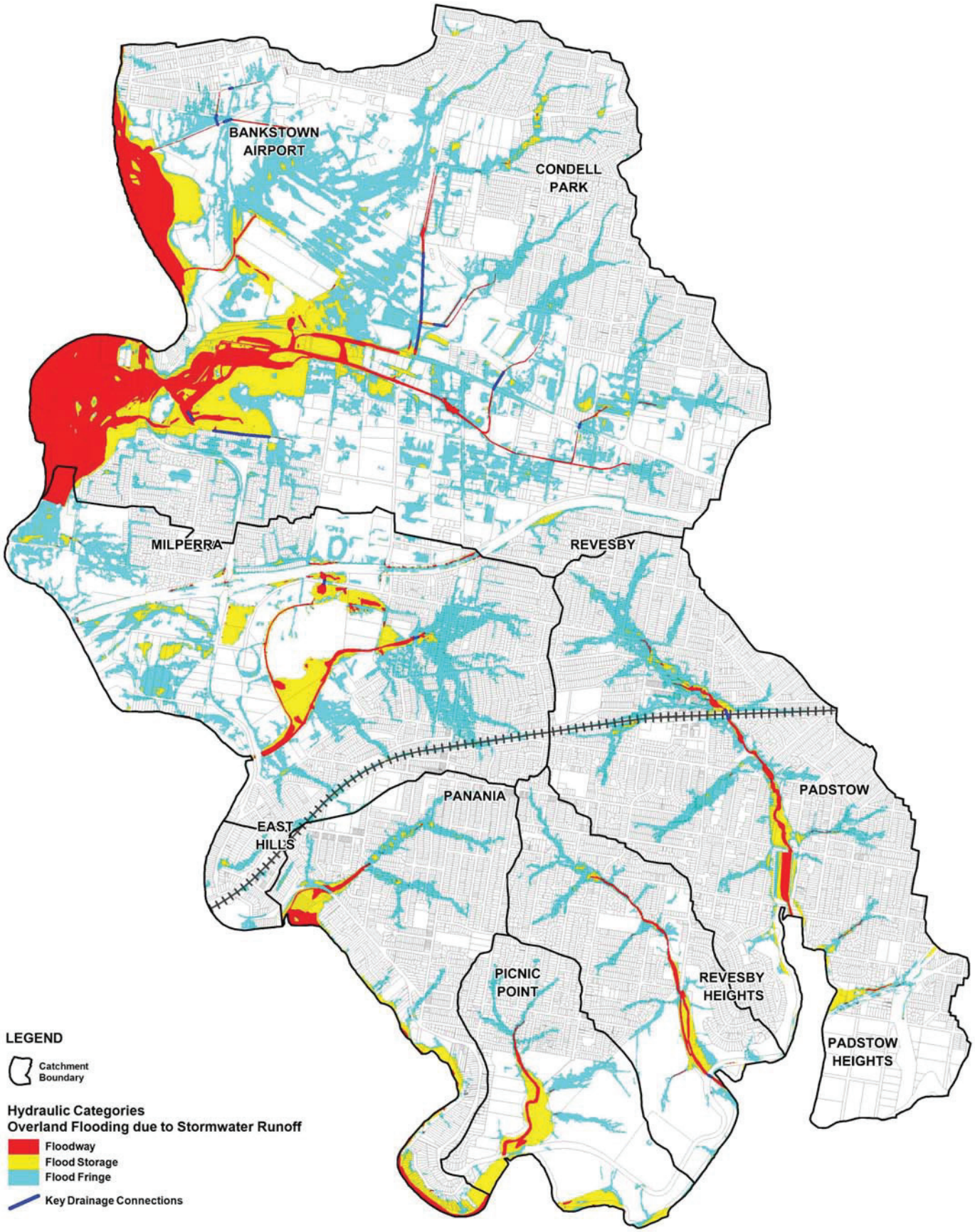


Figure 4-1 Hydraulic hazard as a function of depth and velocity (BMT WBM)



Title:

Hydraulic Categories Map - Overland Flooding due to Stormwater Runoff
100 year ARI Event

Figure: 4-2

Rev: 1

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Flood hazard in association within each hydraulic categorisations have been considered in establishing the adopted flood risk precincts for the overland flow areas as discussed in Section 4.2.3.

4.2.3 Flood Risk Categorisation

Floodplain management is focused on managing the risk of flooding across the floodplain. In doing so, it should be recognised that different parts of the floodplain are subject to different degrees of flood risk.

It is important not to confuse 'flood risk' with 'flood hazard' or 'provisional flood hazard'. The terms 'hazard' and 'provisional hazard' are defined in the *Floodplain Development Manual* (DIPNR, 2005) and relate to the magnitude of a specific flood. For example, a site may experience high hazard conditions in a 100 year ARI flood event and low hazard conditions in a 5 year ARI flood event. On the other hand, flood risks (as used to define land use planning precincts) do not relate to a single flood, but rather to all floods.

Key factors that influence flood risk are:

- hydraulic hazard;
- size of the flood;
- rate of rise - effective warning time;
- community awareness;
- duration of inundation;
- obstructions to flow; and
- access and evacuation.

Flood risk precincts consider the probabilities and consequences of flooding over the full spectrum of flood frequencies that might occur at a site. Probability refers to the chance of a flood occurring, and consequence is the property damage and personal danger resulting from the site's flood characteristics. In assessing the flood risk precincts, the existing land uses and any private warning/evacuation plans at the site are ignored, and typical residential land uses and the normal public warning/evacuation plans are assumed.

The categorisation of the floodplain into risk precincts allows for the identification of relative risk within the study area and to guide planning controls appropriate for the different flood risk categories. The following flood risk precincts have been adopted for the study area, consistent with risk categories adopted for the *Georges River Floodplain Management Study* (Bewsher Consulting, 2004) and *Salt Pan Creek Floodplain Risk Management Study and Plan* (Bewsher Consulting, 2013):

- High Flood Risk – land below the 100 year ARI flood level that is either located within floodway area, subject to a high hydraulic hazard (as defined in Figure L2 of the *Floodplain Development Manual* (DIPNR, 2005) or where there are significant evacuation difficulties.

- Medium Flood Risk – Land below the 100 year ARI flood level that is not subject to high hydraulic hazard and where there are no significant evacuation difficulties.
- Low Flood Risk – All land within the floodplain (i.e. within the PMF extent) but not identified as either in a high or medium flood risk precinct.

The **high flood risk** area is where high flood damages, potential risk to life, or evacuation problems are anticipated. Most development should be restricted in this area.

The **medium flood risk** area is where there is still significant risk of flood damage, but where these damages can be minimised by the application of appropriate development controls.

The **low flood risk area** is that area above the 100 year ARI flood, where the risk of damage is low based on the likelihood of flooding alone. Most land uses would be permitted within this area.

These three flood risk precincts have been further modified to accommodate an additional overland flow risk precinct. The additional risk precinct has arisen from community concern regarding shallow overland flow being mapped as "flooded" particularly in areas that are some distance from recognised watercourses or major drainage systems. The overland flow risk precinct is defined as per the *Salt Pan Creek Floodplain Risk Management Study and Plan* (Bewsher Consulting, 2013).

- Overland Flow Risk – areas of shallow overland flow, typically less than 0.25m in depth in a 100 year ARI flood event and distant from a recognised watercourse or major drainage system.

For further discussion of the overland flow precinct and how it relates to the flood risk precincts refer to Figure 8.2 of the *Salt Pan Creek Catchments Floodplain Risk Management Study and Plan* (Bewsher Consulting, 2013).

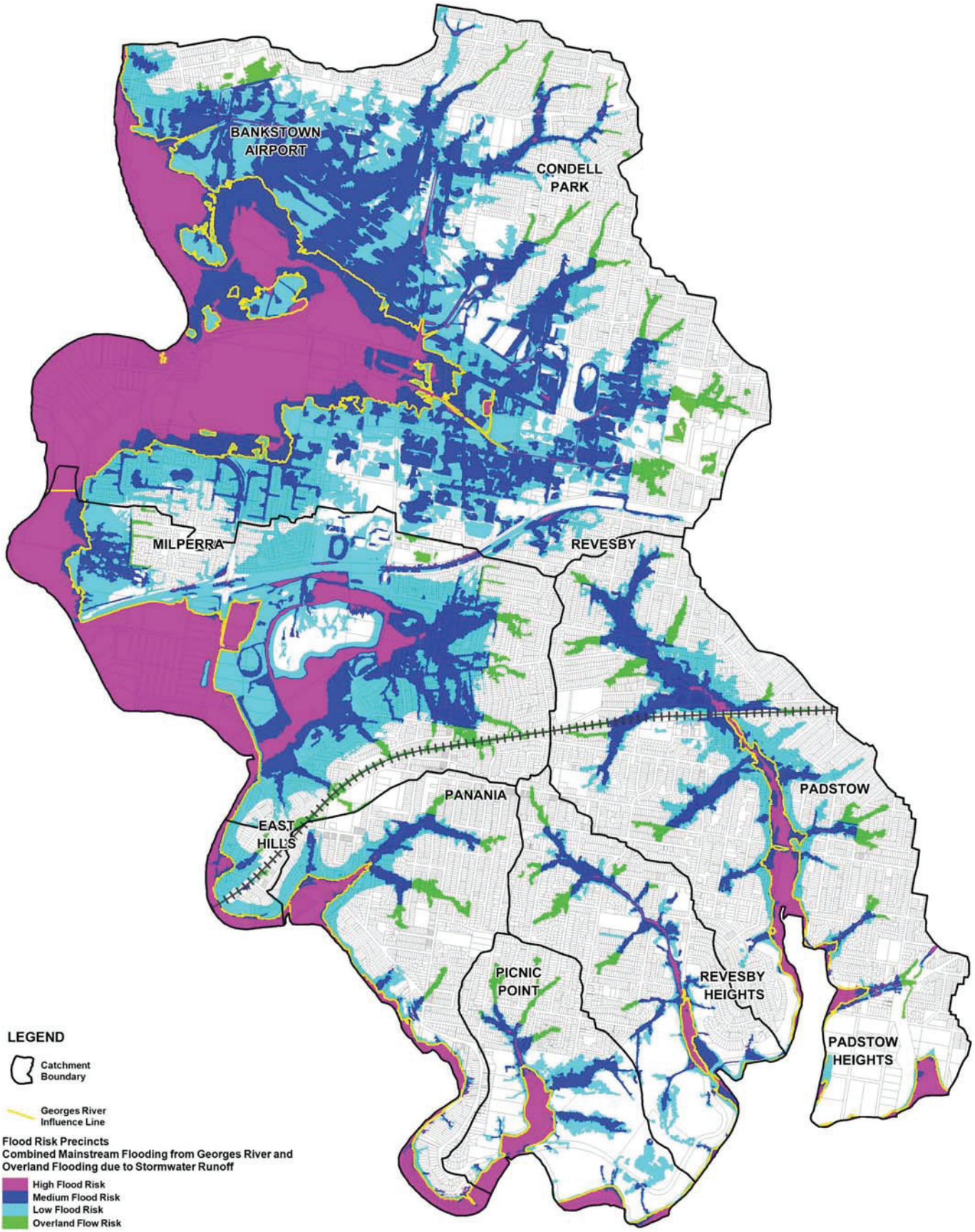
The flood risk precincts for the entire Mid Georges River study area are shown in Figure 4-3 and for each individual sub-catchment in Appendix B. The precincts have been derived by compiling the design flood results of all identified sources of flooding, including mainstream flooding from the Georges River as documented in the *Georges River Floodplain Management Study and Plan* (Bewsher Consulting, 2004), as well as the overland flooding due to stormwater runoff from the local catchment derived flood events. The mainstream flood extent from the Georges River for a 100 year ARI flood event is shown as the Georges River influence line in Figure 4-3 for reference. The interaction of overland and mainstream flooding and interpretation of flood risk precincts where both mechanisms are possible is further discussed in Chapter 6.

4.3 Flood Planning Levels

Flood planning levels and extents were developed for the 100 year ARI event (refer to Figure 4-4). The flood planning levels and extents have been derived based on the following methodology:

- 0.5m has been added to the 100 year ARI peak water level surface;
- The water level surface has been extended to reflect additional areas within the 100 year ARI event peak flood level plus 0.5m.
- The increase in extents has been projected to the natural ground surface level using techniques in WaterRIDE software.

- The flood planning level surface exceeded the PMF peak flood level in some locations and therefore extended beyond the PMF flood extent. Areas of the flood planning level surface outside the PMF extent have been removed.



Title:

Flood Risk Precincts Map - Combined Mainstream Flooding from Georges River and Overland Flooding due to Stormwater Runoff

Figure: **4-3**

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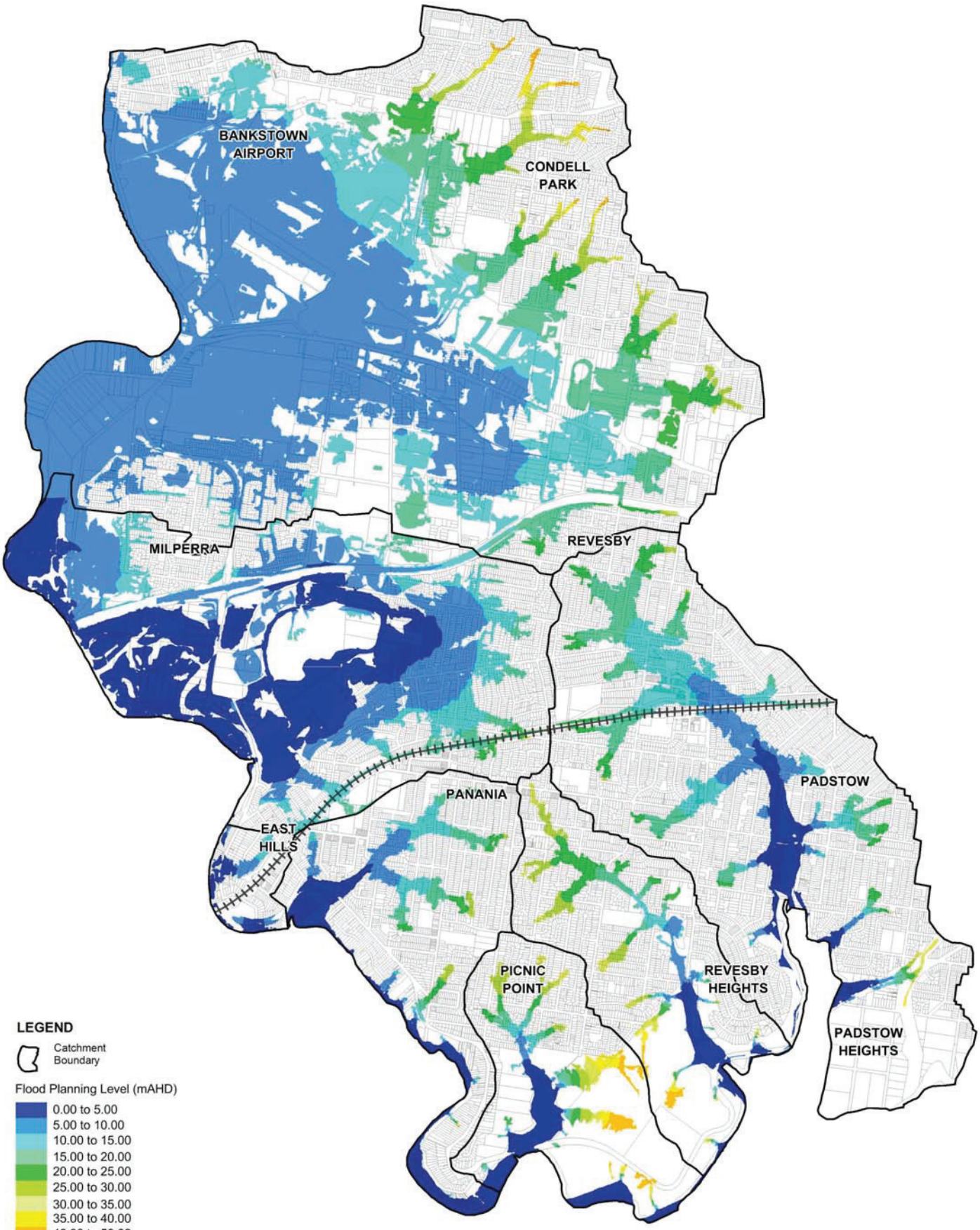
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Title:

Flood Planning Level Map Overland Flooding due to Stormwater Runoff
100 Year ARI Event + 0.5m

Figure: **4-4**

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4.4 Climate Change

4.4.1 Overview

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.

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 10% by 2070 (CSIRO, 2007).

Future climate change has been predicted to result in an increase in sea level, which will have an impact on tides and flood behaviour in the Georges River. In 2009 the NSW State Government announced the NSW Sea Level Rise Policy Statement (DECC, 2009) that adopted sea level rise planning benchmarks to ensure consistent consideration of sea level rise. These planning benchmarks provided increases (above 1990 mean sea level) of 40 cm by 2050 and 90 cm by 2100.

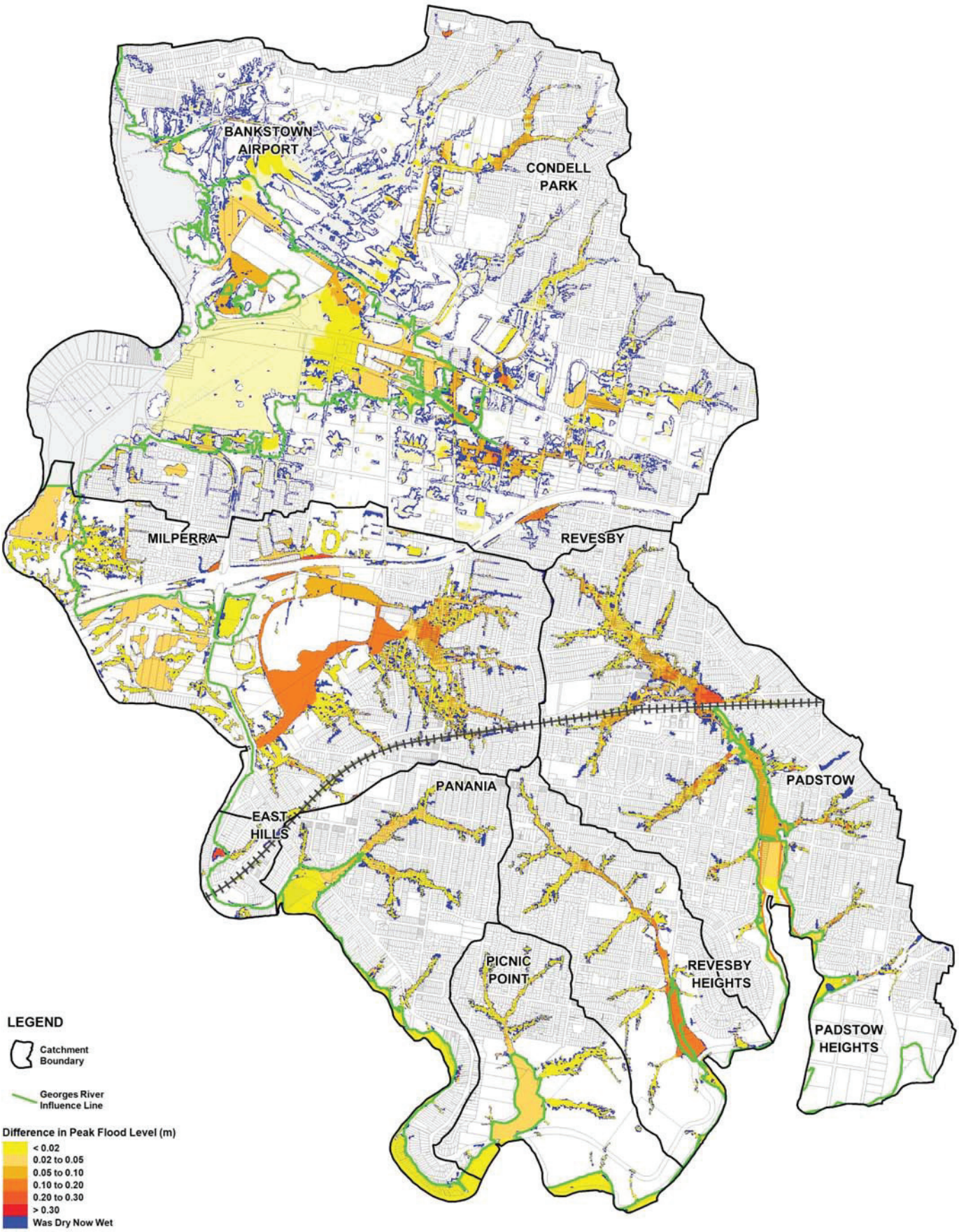
The impact of climate change on flood behaviour within the Mid Georges River study area will be largely influenced by changes to mainstream flood behaviour in the Georges River. An assessment of the effects of climate change on mainstream flood behaviour in the Georges River has been undertaken separately and reported in the *Sea Level Rise Impact Assessment for the Georges River* (FloodMit, 2012).

A review and assessment of the impact of climate change on overland flooding within the Mid Georges River study area has been undertaken as part of this FRMS&P. This review and assessment considered the impacts of climate change on rainfall intensity and sea level rise.

4.4.2 Rainfall Intensity

The impact of climate change on rainfall intensities has been considered as part of the flood studies completed for the Mid Georges River sub-catchments. A summary of the assessment and model results is provided in this section of the report with further details in Appendix C. A sensitivity assessment on the potential impact of a 10% increase in rainfall intensity has been undertaken for each sub-catchment. The assessments considered the impact of increased rainfall intensities on overland flooding due to stormwater runoff.

The impact of the 10% increase in rainfall intensity has been assessed by comparing flood model peak overland water level results with the current critical 100 year ARI peak water levels. In general, the 10% increase in rainfall intensity results in increases in flood levels of approximately 0.05m to 0.10m across much of the Mid Georges River study area, with localised flood level increases of up to 0.30m. A climate change impact map for the 10% increase in rainfall intensity is provided as Figure 4-5 for the entire Mid Georges River study area with maps of each individual sub-catchment are provided in Appendix C.



Title:

Climate Change Impacts - Overland Flooding due to Stormwater Runoff
10% Increase in Rainfall Intensity 100 Year ARI Event

Figure: 4-5

Rev: 1

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The mapped results include details of areas classified as “Was Dry Now Wet”. This shows areas where the extent of flooding has increased as a result of the increase in rainfall intensities. The map indicates increases in flood extents across the study area, particularly in Milperra sub-catchment.

4.4.3 Sea Level Rise

An assessment of the impact of sea level rise on overland flooding has been undertaken as part of this FRMS&P. A summary of the assessment and model results is provided in this section of the report with further details in Appendix C.

Sea level rise impacts presented in the Sea Level Rise Impact Assessment for the Georges River (FloodMit, 2012) adopted sea level rise planning benchmarks of +0.4m and +0.9m by the years 2050 and 2100. The outputs from this study have been used to define the downstream water level conditions for assessing the impact of sea level rise on overland flooding within the Mid Georges River study area.

The impact of +0.4m and +0.9m rise in sea levels has been assessed by comparing flood model peak overland water level results with the current critical 100 year ARI peak water levels. A climate change impact map for a +0.4m and +0.9m rise in sea levels is provided in Figure 4-6 and Figure 4-7 respectively for the entire Mid Georges River study area. Maps of each individual sub-catchment are provided in Appendix C.

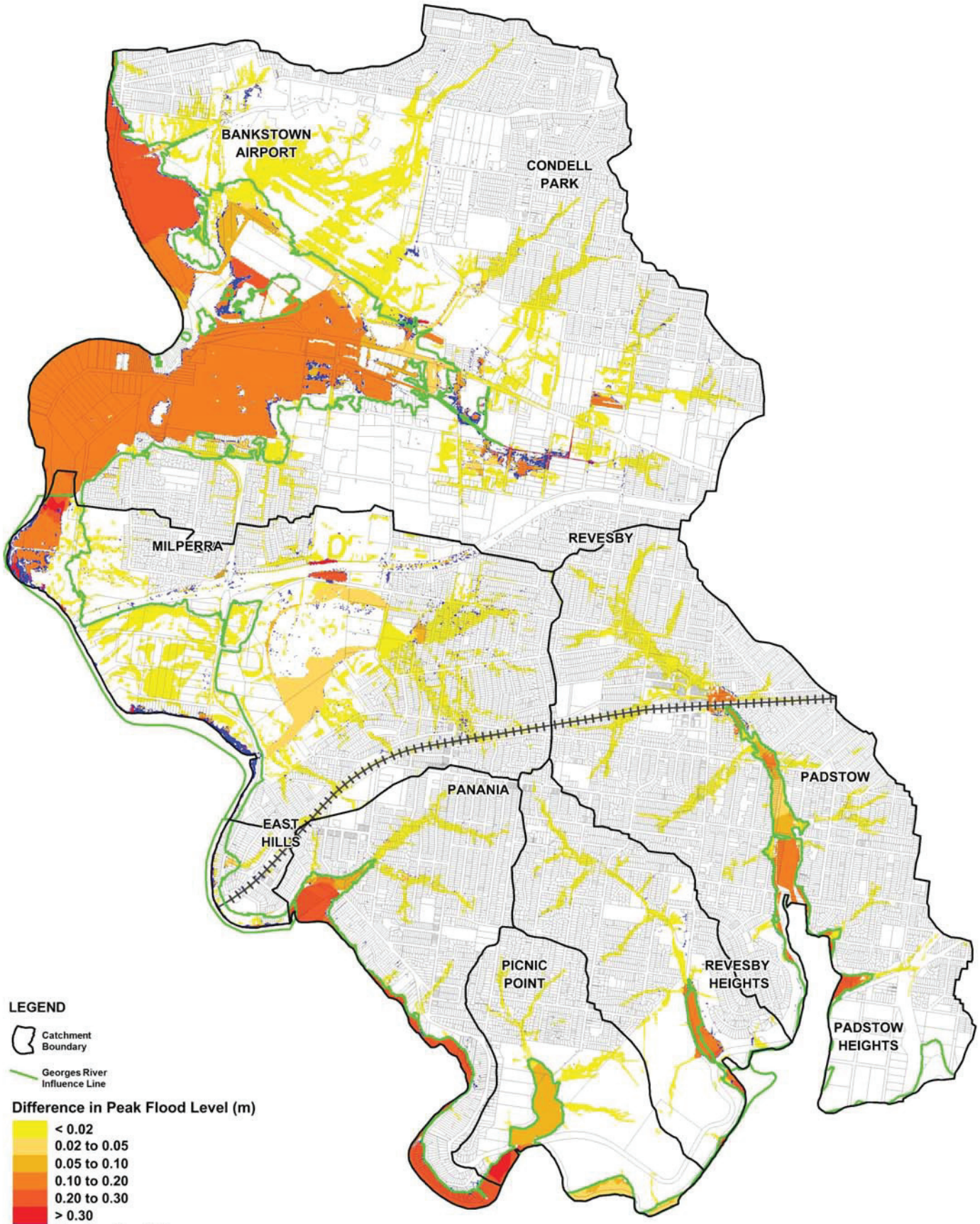
The mapped results include details of areas classified as “Was Dry Now Wet”. This shows areas where the extent of flooding has increased as a result of the increase in sea levels. The maps indicate increases in flood extents along the downstream reaches of the sub-catchments, i.e. along Georges River, with the largest increases in flood extents in the Milperra sub-catchment.

The results indicate that there are varying increases in the flood planning area for both sea level rise scenarios. This increase in the flood planning area affects the lower reaches of the sub-catchments which are influenced by water levels in the Georges River. In general, a 0.4m increase in sea levels results in increases in flood levels of approximately 0.05m to 0.30m across the lower reaches of the sub-catchments. A 0.9m increase in sea levels results in larger increases in levels, with increases ranging from +0.2m to +0.9m.

4.5 Road Inundation

A significant proportion of overland flow in highly urbanised areas is conveyed by the road system. This is consistent with minor/major drainage system philosophy whereby the major drainage system is designed to convey stormwater runoff from less frequent storms (larger, more severe events) when the capacity of the minor storm drainage system is exceeded. This type of flow is typically shallow depth and high velocity. The flood mapping presented shows many of the major flow paths are aligned along roadways.

Flooding of some major arterial roads would be expected in significant flood events, possibly resulting in some temporary road closures.



Title:

Climate Change Impacts on Overland Flooding due to Stormwater Runoff
0.4m Increase in Sea Levels

Figure: **4-6**

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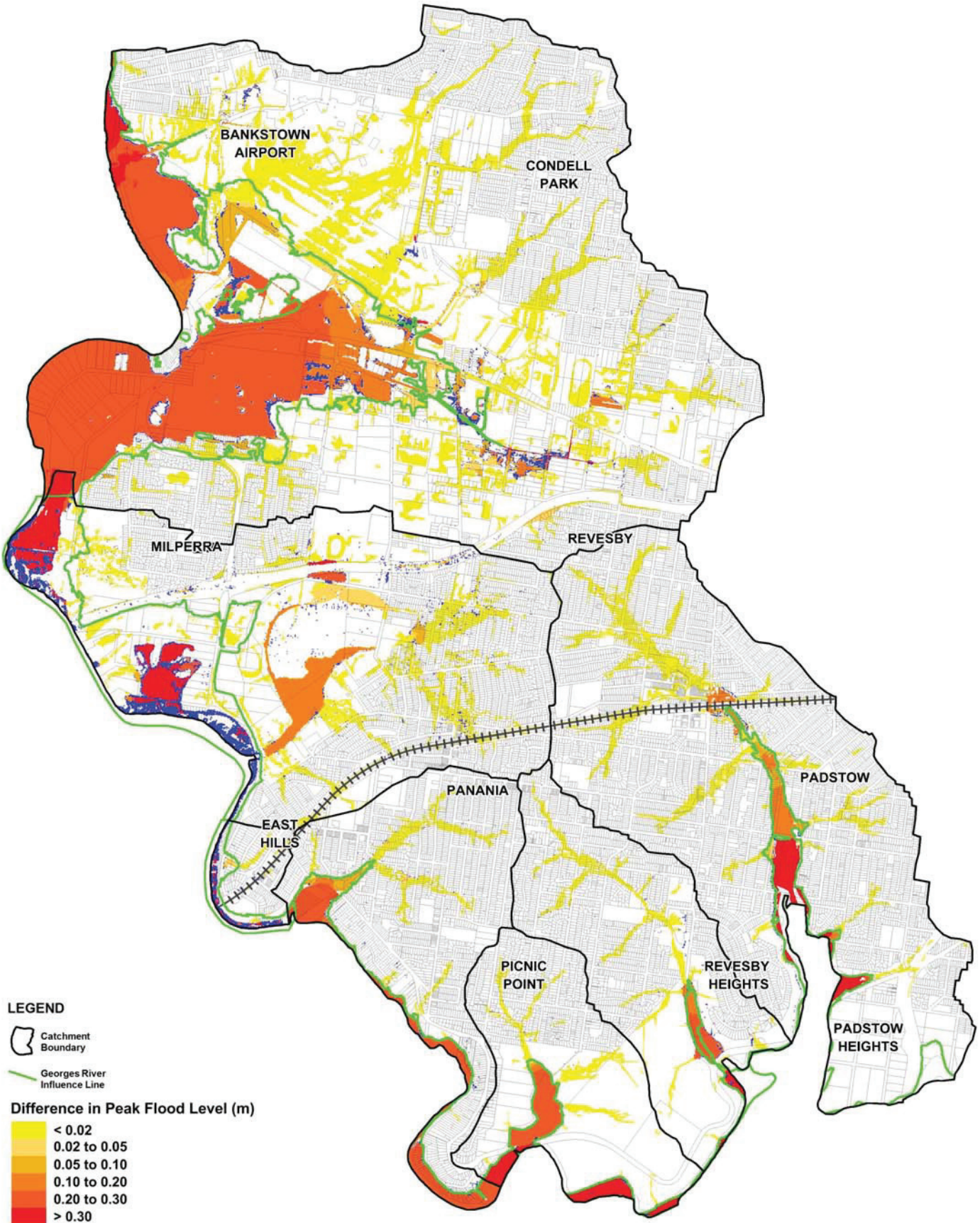
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Title:

Climate Change Impacts on Overland Flooding due to Stormwater Runoff
0.9m Increase in Sea Levels 100 Year ARI Event

Figure: **4-7**

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Given the general responsive nature of the catchments to overland flooding, with relatively small contributing sub-catchment areas, durations of flooding as a result of local overland flows due to stormwater runoff may only be relatively short and potentially in the region of one to three hours.

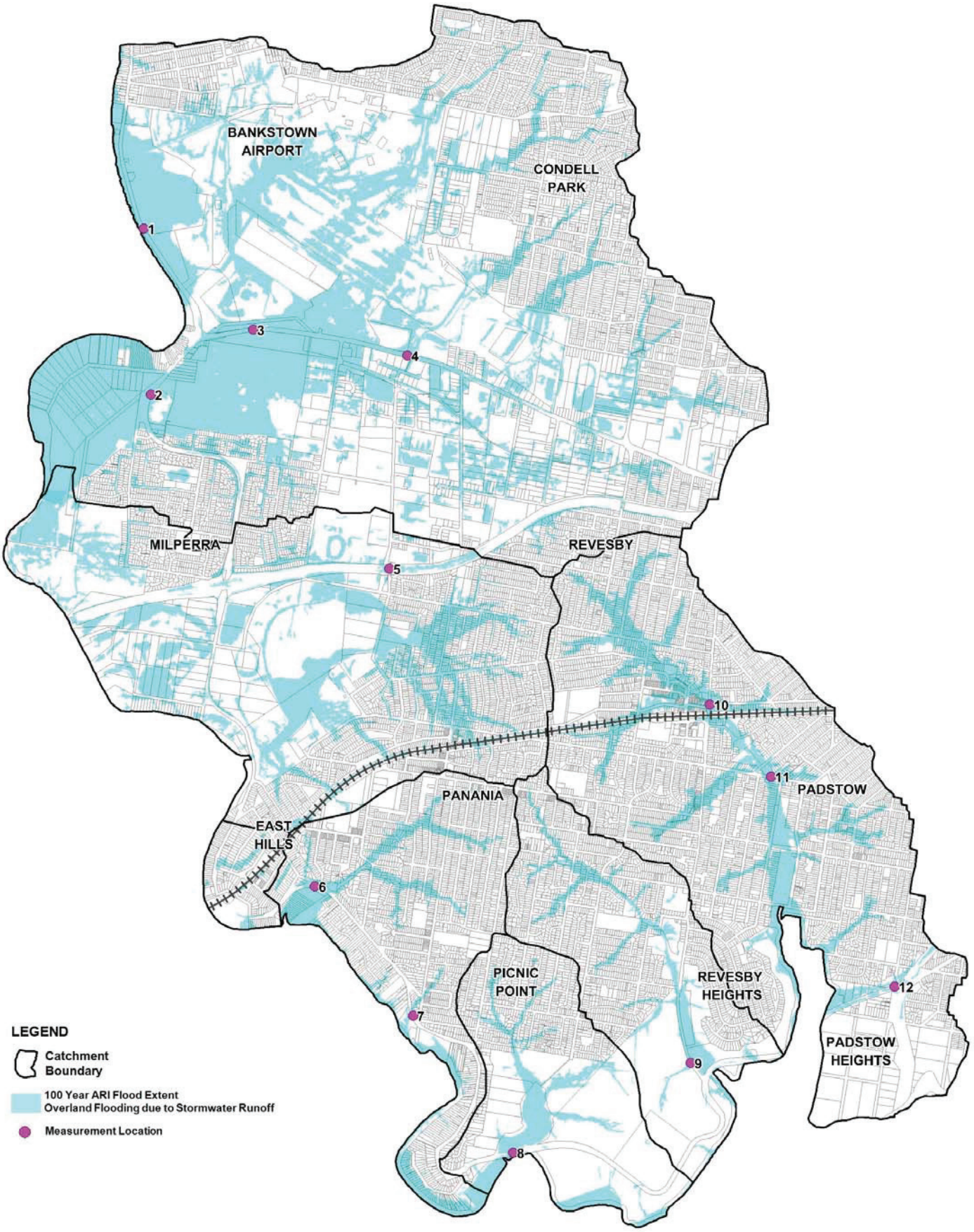
A summary of the peak flood depths over major arterial roads traversed by overland flows in the study area is provided in Table 4-2. The locations are shown on Figure 4-8 below.

Table 4-2 Peak flood depths over major arterial roads

ID (refer to Figure 4-8)	Location	Peak flood depths (m)				
		5 year ARI	20 year ARI	50 year ARI	100 year ARI	PMF
1	Henry Lawson Drive (Georges River Golf Course)	NFI*	NFI	2.3	2.3	3.3
2	Henry Lawson Drive (Bankstown Golf Club)	NFI	NFI	0.9	0.9	2.3
3	Milperra Road (Bankstown Golf Club)	NFI	NFI	0.7	0.7	1.9
4	Milperra Road (McDonalds)	0.1	0.3	0.4	0.5	1.6
5	M5 Horsley Road Overpass	0.3	0.3	0.3	0.3	0.5
6	Henry Lawson Drive (Monash Reserve)	NFI	0.1	0.2	0.2	1.1
7	Henry Lawson Drive (Lambeth Reserve)	0.4	0.4	0.4	0.4	0.5
8	Henry Lawson Drive (Yeramba Lagoon)	NFI	NFI	0.3	0.3	1.0
9	The River Road (Henry Lawson Drive)	NFI	0.1	0.4	0.5	2.1
10	The River Road (Sphinx Avenue)	NFI	0.1	0.3	0.5	2.1
11	Uranus Road at Little Salt Pan Creek crossing	0.5	0.6	0.7	0.7	1.8
12	Henry Lawson Drive (Alfords Point Road Interchange)	NFI	0.2	0.3	0.3	0.6

*NFI – No flooding indicated

It is important to note that flood depths at the majority of the above locations are a result of mainstream flooding from the Georges River. The duration of road inundation due to mainstream flooding will also be significantly longer than for overland flooding because of the significant difference in the durations of the critical storm.



Title:

Measurement Locations for Flood Depths over Major Arterial Roads

Figure: **4-8**

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4.6 Flooding "Hot-Spots"

Areas with localised flooding problems have been identified throughout the study area on the basis of:

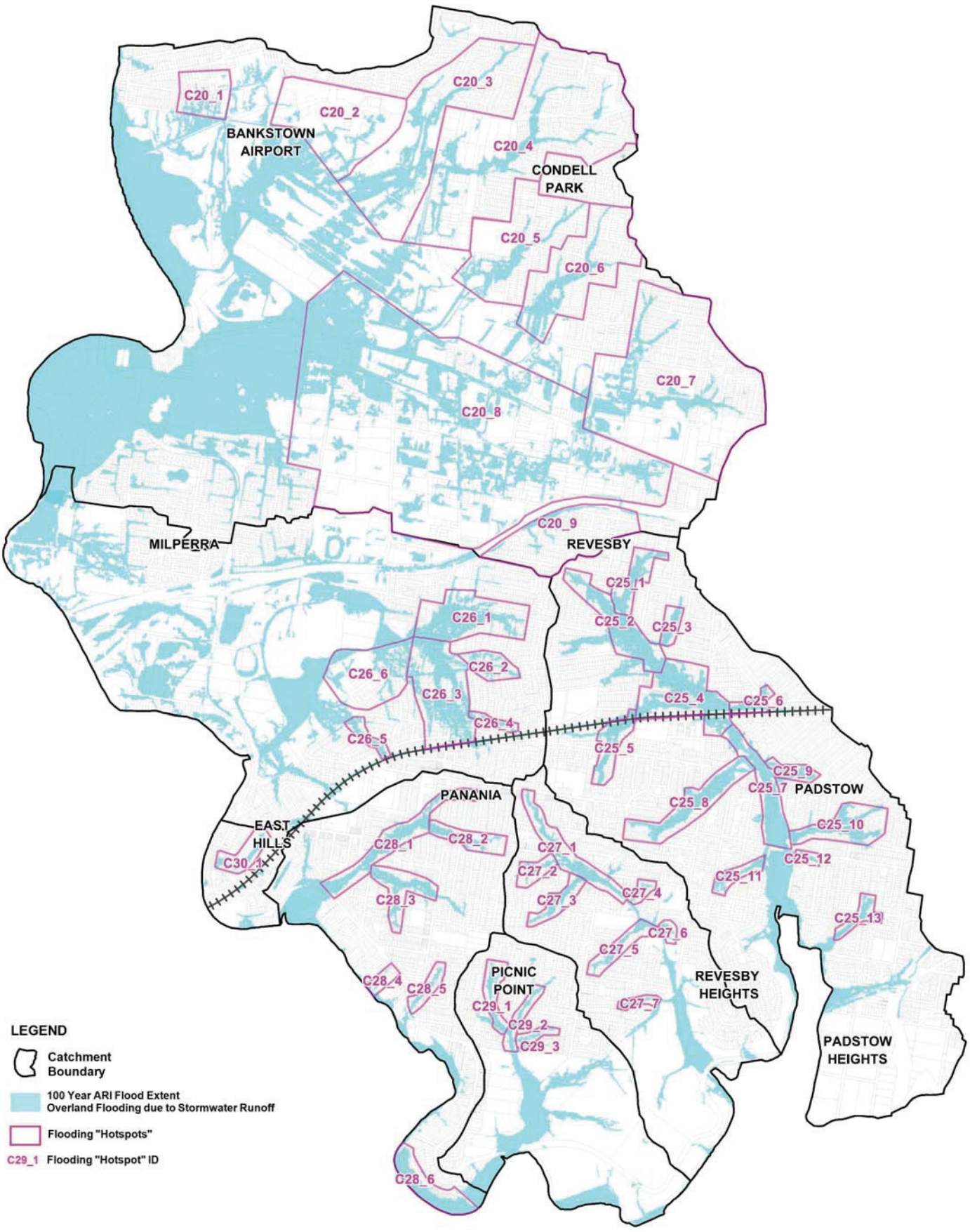
- The extent of inundation experienced throughout the study area, particularly those areas that experience a high flood risk as shown in Figure 4-3;
- The location of buildings potentially affected by above floor flooding, based on the flood damages database as shown in Figure 5-3;
- Feedback from the community through the community consultation exercises as shown in Figure 3-2);
- Information from Council and the Committee members; and
- Future flood risk associated with climate change (refer to Section 4.4).

The "hot-spot" areas generally represent clusters of affected properties along overland flow paths distributed through the study area. Table 4-3 below lists the full list of flooding "hot-spots" within the study area. Locations of flooding "hot-spots" are shown on Figure 4-9.

Table 4-3 List of identified flooding "hot spots" in the study area

Catchment	"Hot-spot" locations	Hot spot ID (refer to)
Milperra (C20)	Endeavour Road to Bankstown Airport	C20_1
	Marion Street to Bankstown Airport.	C20_2
	Georgina Street to Bankstown Airport.	C20_3
	Waruda Street to Bankstown Airport.	C20_4
	Jensen Street to Wackett Street.	C20_5
	Simmat Avenue to Yanderra Street.	C20_6
	Virtue Street to Milperra Road	C20_7
	Milperra Industrial Area.	C20_8
	Alliance Avenue.	C20_9
Little Salt Pan Creek (C25)	Sherwood Street to Ely Street.	C25_1
	Beaconsfield Street to Swan Street.	C25_2
	Albert Street to Bansgrove Road.	C25_3
	River Road., Marco Avenue, Sphinx Avenue, Montgomery Rd.	C25_4
	Tyalgum Avenue to Polo Street.	C25_5
	Wilbertforce Road. to Sphinx Avenue	C25_6
	Little Salt Pan Creek.	C25_7

Catchment	"Hot-spot" locations	Hot spot ID (refer to)
	Eastern Avenue to Uranus Road.	C25_8
	Howard Road to McGirr Street.	C25_9
	Uralla Avenue to Virginius Street.	C25_10
	Vega Street to Centaur Avenue.	C25_11
	Lang Street to Virginius Street.	C25_12
	Watt Avenue to Richardson Avenue.	C25_13
Morris Gully (C27)	Tower Street to Kinross Place.	C27_1
	Douglas Street to Bruce Avenue.	C27_2
	Ramsay Road to Parkhurst Avenue.	C27_3
	Ferndale Road to Kinross Place.	C27_4
	Prince Street to Thomas Street.	C27_5
	Bardi Circuit.	C27_6
	Thomas Street to Bluegum Crescent.	C27_7
Picnic Point (C29)	Kathleen Street to Karen Avenue.	C29_1
	Victor Avenue to Karen Avenue.	C29_2
	Valmay Avenue to Karen Avenue.	C29_3
Lucas Road (C28)	Hurndell Ln. to Henry Lawson Drive.	C28_1
	Picnic Point Road to Eddie Avenue.	C28_2
	Lambeth Street to Lucas Road.	C28_3
	Henry Lawson Drive to Burbank Avenue.	C28_4
	Donald Street to Henry Lawson Drive.	C28_5
	Carinya Road.	C28_6
East Hills (C30)	Forrest Road to Henry Lawson Drive.	C30_1
Kelso Swamp (C26)	Rosebank Street to Killara Avenue.	C26_1
	Wylong Street to Benfield Parade.	C26_2
	Anderson Avenue to Killara Avenue.	C26_3
	Marco Avenue to Brighton Avenue.	C26_4
	Braesmere Road to Marco Avenue.	C26_5
	Knight Avenue to Horsley Road.	C26_6



Title:

Flooding "Hot Spots" in the Study Area

Figure: **4-9**

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The nature of flooding and underlying reasons for potential property flooding at the majority of the "hot-spot" areas is very similar. Below is a summary of the flooding issues that are generally common to the identified "hot-spot" areas:

- Roadways typically form major flow paths once the stormwater drainage system capacity is exceeded. A number of the "hot-spots" are located in developed areas where roads are not aligned along natural drainage paths and overland flow paths occur through properties;
- Further to the above point, where overland flow paths occur through private properties, there generally are no existing drainage easements and no or limited space availability for new easements;
- The majority of private properties have boundary fences as property lot dividers. These fences can impede and redirect overland flows and exacerbate the flooding problem; and
- The creeks are undersized to cope with the rapid stormwater runoff. Out of bank flooding from creeks contributes to the flooding issues in the "hotspots".

4.7 Future Catchment Development

There is the potential for future in-fill development with the Mid Georges River study area. In-fill development generally involves the subdivision of existing residential lots which results in higher density urban residential developments. In-fill development has the potential to impact the flood behaviour in the Mid Georges River study area in a number of ways including:

- Providing additional impediments to existing mainstream and overland flow paths (i.e. fence lines, buildings altering existing flow paths, etc.);
- Increasing the percentage of impervious surfaces resulting in increased surface water runoff; and
- Raising of ground levels can reduce the effective storage volume of the catchment.

The cumulative impact of these developments would be increased runoff, modified overland flow paths and potential increases to the risk of flooding to properties.

Appropriate controls for new and infill developments are effectively incorporated in the Bankstown Development Control Plan 2015 (DCP 2015). The purpose of a DCP from a floodplain risk management perspective is to provide a practical application of Council's Flood Policy and is to be taken into consideration by Bankstown City Council when exercising its environmental assessment and planning functions in relation to new development within the Bankstown LGA. Further discussion on the Bankstown DCP 2015 and the developments controls is in Section 6.3.2.3.

5 Property Inundation and Flood Damages Assessment

5.1 Overview

A flood damage assessment has been undertaken to identify flood affected properties, to quantify the extent of damages in economic terms for existing flood conditions and to enable the assessment of the relative merit of potential flood mitigation options by means of benefit-cost analysis. The flood damage assessment has been undertaken for flood risk associated with overland flooding due to stormwater runoff. As part of the flood damage assessment a property database has been developed to assess the economic damages to individual buildings subject to overland flood inundation.

The general process for undertaking a flood damages assessment incorporates:

- development of a property database;
- defining appropriate water level-economic damage relationships for various property types/uses;
- determining depth of inundation above floor level for a range of design event magnitudes for each property; and
- estimating potential flood damage for each property for a range of design events.

5.2 Property Database

5.2.1 Building Selection

The buildings included within the property database initially have been selected as those within or partly within the extent of the 100 year ARI design flood extent. The building footprints have been digitised based on the 2011 aerial photography. Buildings with an area of less than 60m^2 have not been included in the database as these were typically garages or sheds, and the economic damages to these types of building have not been included in the assessment. In addition, economic damages have not been assessed at properties having a small portion of their building footprint within the 100 year ARI flood extent (typically less than 20% of the footprint area) as it is probable that the floor level would be well above the estimated flood level. There are a total of 3,233 buildings included in the database with the numbers for each sub-catchment provided in Table 5-1.

5.2.2 Floor Level

Surveyed floor level estimates for selected buildings were provided by Bankstown City Council as geo-referenced point data. These floor level estimates have been assigned to individual buildings based on their proximity to building footprints. Floor level estimates within building footprints have been given priority and those within 5m of buildings have also been considered. Where several surveyed floor level estimates are available at one building, the minimum surveyed floor level estimate has been assigned. Of the floor level estimates provided by Council, 1,887 were assigned to building footprints.

Table 5-1 Number of buildings in flood damages property database

Sub-catchment	Building Type		
	Residential	Commercial	Total
Milperra	673	495	1168
Kelso Swamp	525	50	575
East Hills	77	4	81
Lucas Road	331	2	333
Picnic Point	105	0	105
Morris Gully	211	5	216
Little Salt Pan Creek	685	70	755
Mid Georges River TOTAL	**2607**	**626**	**3233**

Floor levels were not available for a remaining 1,346 buildings across a range of catchments. In the absence of surveyed floor level data, the floor levels of these remaining buildings have been estimated by adding a nominal 0.3m to a Digital Elevation Model (DEM) of the ground surface. The nominal "height above ground level" of 0.3m is considered appropriate as an average value based on the general building construction types in the study area. DEMs have been obtained from the hydraulic models developed as part of the stormwater flood studies (refer to Section 2.3.1). The DEMs have primarily been derived from aerial laser survey (ALS). The representative ground level of each building has been estimated as the average DEM ground level of the building footprint.

5.2.3 Land Use and Building Type

For the purposes of the flood damage assessment, buildings have been categorised as either residential or commercial. For simplicity, commercial and industrial properties and damages are referred to in this study as commercial, but in all cases refer to both. Commercial buildings have primarily been identified based on Council's land use zoning. A damage class was assigned to each commercial property based on a review of Google Maps Street View to identify individual commercial building uses. Based on aerial photographs, Google Maps Street View and site visit notes, the majority of residential buildings are assumed to be slab/low set single story. The 2011 aerial photography has been used to identify unit buildings and estimate the number of units per floor. Google Maps Street View has been used to verify unit numbers where available.

5.2.4 Flood Level

Design flood levels have been obtained from the various stormwater flood studies (refer to Section 2.3.1) for the 5 year ARI, 20 year ARI, 50 year ARI, 100 year ARI and PMF design flood events. For each design event, a flood level has been assigned to each building based on the maximum flood level across the building footprint.

5.3 Property Inundation

The following section details the number of properties potentially affected by above floor level flooding associated with overland flows due to stormwater runoff. A summary of the number affected buildings for a range of design flood events is provided as Table 5-2. The number of affected buildings for the 100 year ARI for each sub-catchment is provided as Table 5-3 and illustrated in Figure 5-1.

Table 5-2 Number of buildings affected by above floor level flooding for various local catchment ARI's for the Mid Georges River Study Area

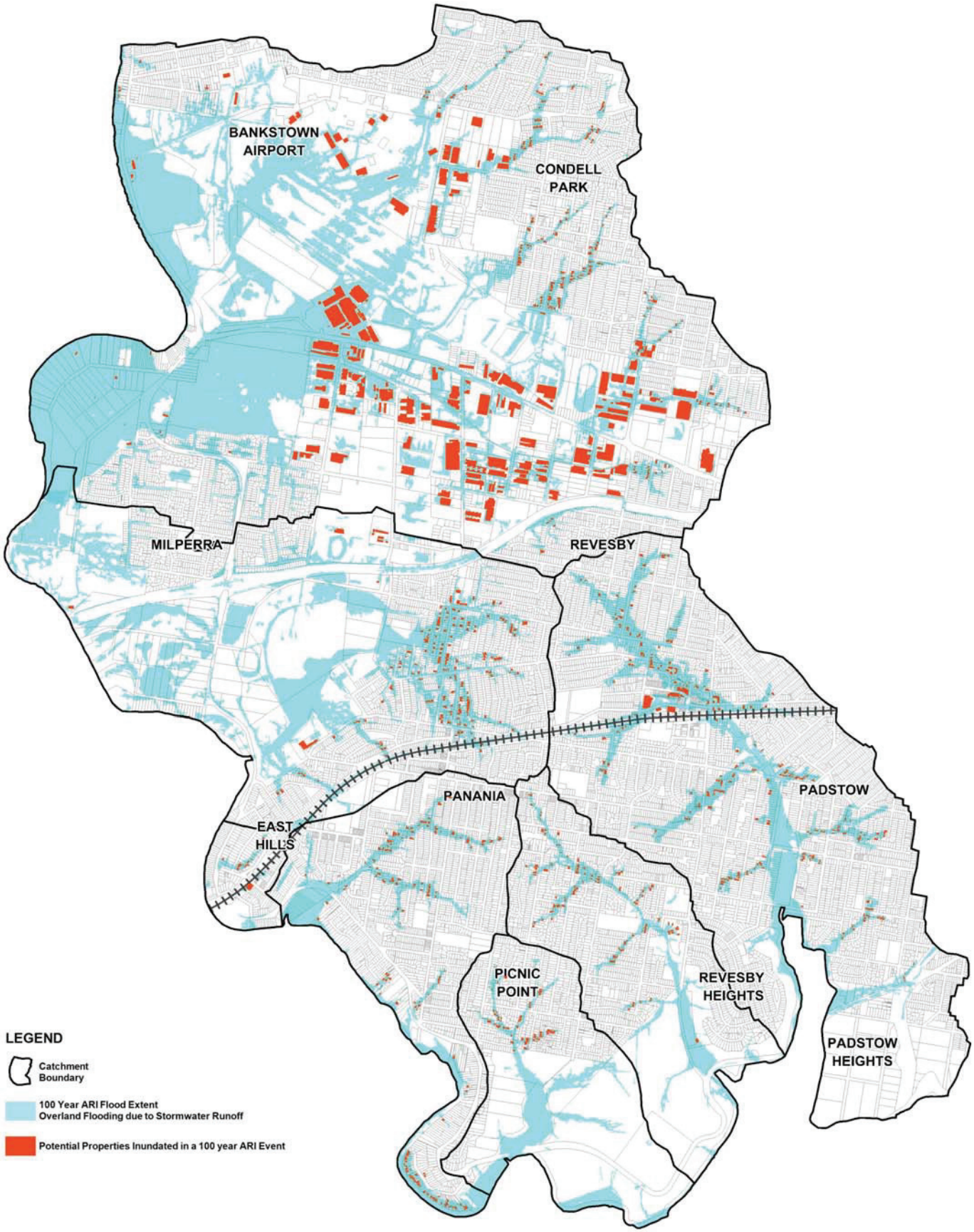
Design Flood Event	Building Type		
	Residential	Commercial	Total
5 year ARI	449	194	643
20 year ARI	654	235	889
50 year ARI	794	273	1067
100 year ARI	908	295	1203
PMF	1797	530	2327

Table 5-3 Breakdown of the number of buildings affected by above floor level flooding during a 100 year ARI local catchment design storm event by sub-catchment

Sub-catchment	Building Type		
	Residential	Commercial	Total
Milperra	211	244	455
Kelso Swamp	169	17	186
East Hills	10	1	11
Lucas Road	148	1	149
Picnic Point	51	0	51
Morris Gully	100	1	101
Little Salt Pan Creek	219	31	250
Mid Georges River TOTAL	908	295	1203

Table 5-3 and Figure 5-1 collectively illustrate the significant number of large commercial properties potentially impacted by overland flooding in the Milperra sub catchment.

The affected properties are predominantly concentrated at a number of "hot-spot" areas (refer to Section 6.2.1). The most significant overland flooding problems predominantly arise on the main overland flow paths and open channel reaches with flow accumulation from a fairly sizeable contributing catchment. On lesser overland flow paths with significantly less contributing catchment area, flooding is typically confined to the roadways or at relatively low depths, thereby limiting property affectation.



Title:

Potential Inundation Above Floor Level Overland Flooding Due to Stormwater Runoff - 100 Year ARI Event

Figure: **5-1**

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5.4 Flood Damages Estimation

5.4.1 Overview

A flood damages assessment has been undertaken to identify and, where possible, estimate the economic cost of damages associated with the risks of flooding. The main objective of the flood damages assessment is to establish the 'baseline' economic costs of flooding (i.e. based on current conditions) which can then be used to help quantify the benefits of potential flood mitigation measures.

5.4.2 Types of Flood Damages

Flood damages can be classified as tangible or intangible, depending on whether costs can be assigned monetary values. Intangible damages arise from adverse social and environmental effects caused by flooding, including factors such as loss of life and limb, stress and anxiety. Tangible damages are monetary losses directly attributable to flooding.

The flood damages assessment estimates tangible damages to provide information on the economic impact of flooding and potential management measures. Intangible impacts by their nature cannot generally be quantified in the flood damages assessment; however they are considered throughout this FRMS&P, alongside the economic impacts, in terms of identifying key risks and weighing up the costs and benefits of various flood risk management options.

Tangible damages comprise both direct and indirect flood damages. Direct damages result from the actions of floodwaters, inundation and flow, on property and structures. Indirect damages arise from the disruptions to physical and economic activities caused by flooding. Examples include losses due to the disruption of business, expenses of alternative accommodation, disruption of public services, emergency relief aid and clean-up costs.

Direct damages are typically estimated separately for urban, rural and infrastructure damages. Figure 5-2 below summarises the "types" of flood damages considered in this study.

This study focussed on quantifying estimates of urban damages together with preliminary estimates of infrastructure damages. Urban damages are typically further separated into damage to residential and commercial properties, and internal and external components.

5.4.3 Methodology

There are a range of industry-standard approaches for estimating the cost of the different types of flood damages described previously. Typically, stage-damage curves (SDC) are used to estimate internal flood damage to a property. The SDC describes the relationship between the depth of inundation (stage) and the monetary damage. The SDC are generally derived from loss adjustor surveys which vary for different types of property and contents. External, structural, infrastructure and indirect damages are generally estimated using other approaches.

The damage estimates derived in this study are for the **tangible damages only**. Whilst intangible losses may be significant, these effects have not been quantified due to difficulties in assigning a meaningful dollar value.

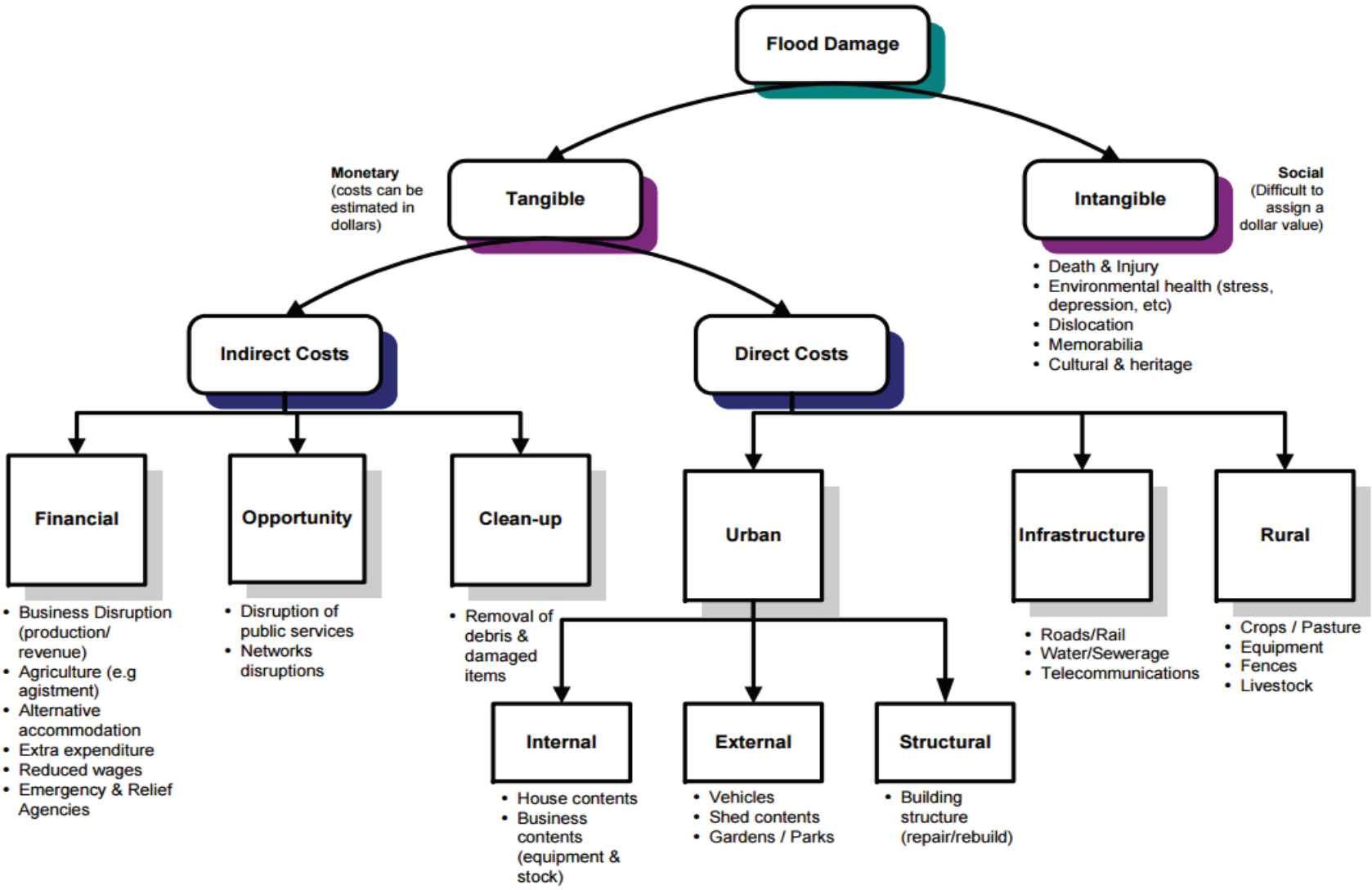


Figure 5-2 Flood damage classification

The following is an overview of the methodology adopted for the flood damages assessments.

- **Residential damages** are based on the *Floodplain Risk Management Guideline: Residential Flood Damages* (DECC, 2007b). This utilises stage-damage curves for three typical dwelling types; low set, high set and double storey. The curves include external and indirect damages. The curves do not however include multi-unit dwellings or vehicles.

  A summary of the parameters of the stage-damages curves specific to the study area are provided in Table 5-4.

Table 5-4 Input parameters for DECC (2007) residential stage-damage curves

Input Parameters	Adopted	Explanation
Regional cost variation factor	1.0 (from Rawlinson's 2012)	Used for adjusting material cost to be specific to Bankstown.
Average house size	180m^2	Used to determine the building size adjustment from the baseline 240 m^2. The adopted parameter of 180 m^2 has been based on an assessment of floor areas for typical residential buildings within the study area.
Level of flood awareness	Low	Used to calculate the preparedness of the resident and opportunity to relocate possessions above flood waters (DIPNR, 2004)
Effective warning time	1 hour	Average warning time before the onset of flooding based on the flood study model results
Damage reduction factor	0.96	Ratio of actual to potential losses. Used to convert potential damage estimate to actual damage estimates. In assessing potential damages, it is assumed that no actions are taken by the flood affected population during a flood event to reduce damage such as lifting items to flood free locations. The length of effective warning time and the level of flood awareness are two parameters which affect the damage reduction factor.

- **Commercial damages** are based on *Guidance on the Assessment of Tangible Flood Damages* (NRM, 2002). This utilises a set of stage-damage curves for different types of businesses based on size and contents value. Indirect damage to commercial property can be substantial due to loss of production/revenue, etc., which has been estimated as 55% of direct damages. External damage has been excluded with the majority of damage typically expected to be allowed for when assigning appropriate contents value. A damage reduction factor has not been applied to the commercial damages.
- **Infrastructure damages** are difficult to quantify without an extensive valuation and assessment of each of the individual infrastructure at risk. Instead, infrastructure damages have been approximated as 15% of the direct commercial and total residential damages.

- **Vehicle damages** have been excluded from the damages assessment as it difficult to make assumptions regarding whether vehicles are parked at ground level or are elevated on the property, and whether flood affected residents will decide to (or have the time to decide) to drive the vehicle away from floodwaters. Moreover, inclusion of vehicles is not expected to significantly influence the assessment and selection of structural flood mitigation options. Notwithstanding, vehicles could be considered and flood damage estimates further refined to assist in deciding to proceed with a flood mitigation option, particularly where the benefit-cost of the option is marginal.

Table 5-5 below summarises the approach to the flood damages assessment undertaken for this FRMS&P.

Table 5-5 Summary of flood damages assessment approach

TANGIBLE	DIRECT ►	Urban►	Internal►	Commercial►	NRM Stage-Damage Curves
				Residential►	DECC Stage-Damage Curves
			External►	Commercial►	Not included
				Residential►	DECC Stage-Damage Curves
			Structural►	Not included in this assessment	
		Infrastructure►	15% of total residential and direct commercial damages		
		Rural ►	Not included in this assessment		
	INDIRECT►	Commercial►	55% of direct commercial damages		
		Residential►	DECC Stage-Damage Curves		

5.4.4 Summary of Flood Damages

As described in Section 5.2.4, the depth of flooding at each building has been determined for the 5 year ARI, 20 year ARI, 50 year ARI, 100 year ARI and PMF design storm events. The associated flood damage cost to each building has subsequently been estimated from the stage-damage relationships. Total damages for the sub-catchments and the Mid Georges River study area have been determined by summing the damages at each individual property. Table 5-6 provides a summary of the Average Annual Damage (AAD) and Present Value (PV) of damages for each of the Mid Georges River sub-catchments and the Mid Georges River study area.

Table 5-6 Predicted flood damages for existing conditions

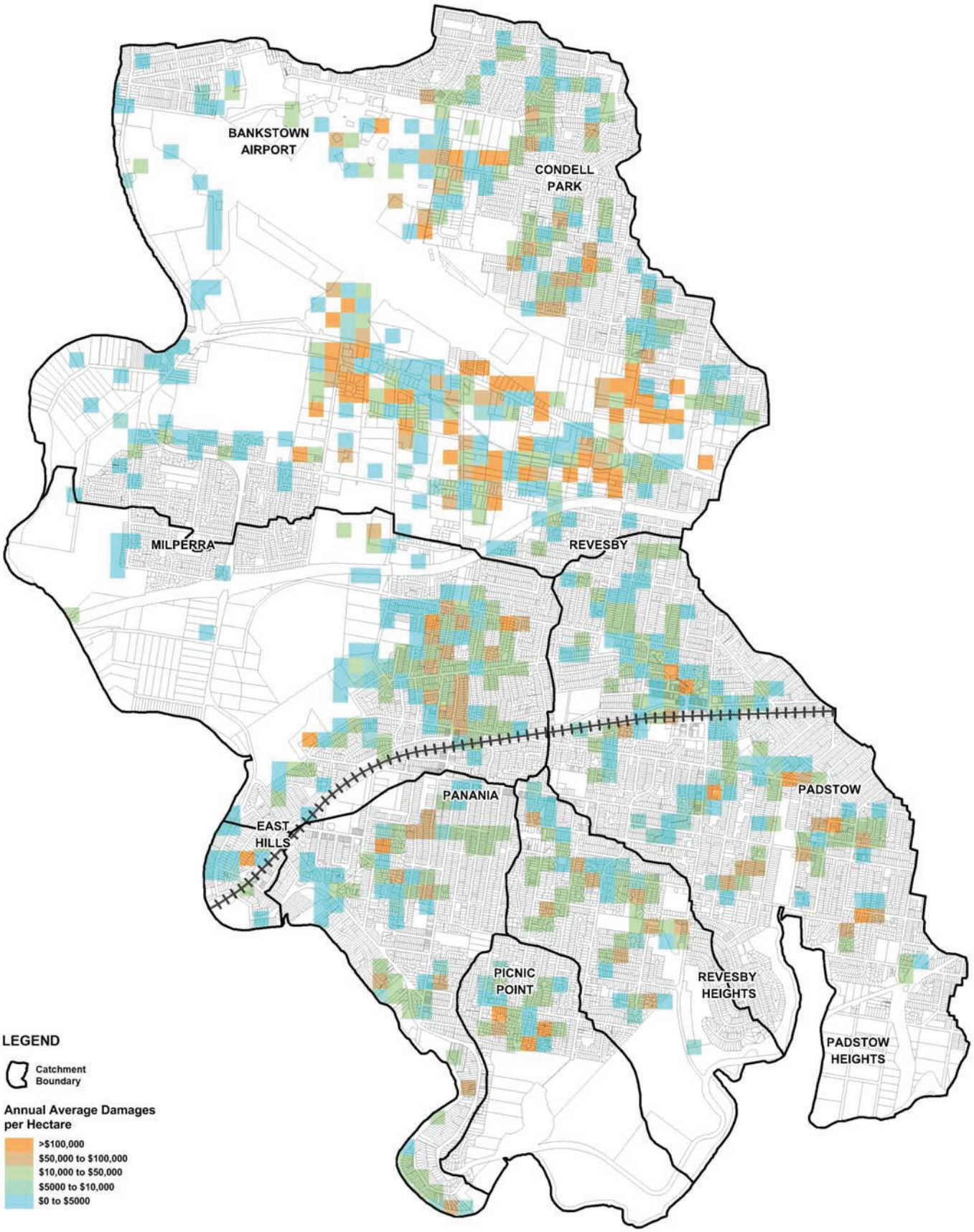
Sub-catchment	Damage in Flood Event ($M)					Average Annual Damage ($M)	Present Value of Damage ($M)
	5 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI	PMF		
Milperra	55.4	71.1	95.0	105.0	402.5	20.2	5.2
Kelso Swamp	7.9	10.1	11.3	13.3	41.6	2.7	0.7
East Hills	0.7	0.7	0.8	0.9	2.6	0.2	0.1
Lucas Road	3.9	5.9	9.1	10.4	16.5	1.5	0.4
Picnic Point	2.2	3.0	3.2	3.6	5.1	0.7	0.2
Morris Gully	3.7	5.4	6.0	6.7	11.3	1.3	0.3
Little Salt Pan Creek	9.2	14.8	16.5	19.0	42.9	3.5	0.9
Mid Georges TOTAL	**82.9**	**111.0**	**142.1**	**158.8**	**522.4**	**30.2**	**7.8**

The AAD is the average damage in dollars per year that would occur in a designated area from flooding over a very long period of time. In many years there may be no flood damage, in some years there will be minor damage (caused by small, relatively frequent floods) and, in a few years, there will be major flood damage (caused by large, rare flood events). Estimation of the AAD provides a basis for comparing the effectiveness of different floodplain risk management measures (i.e. the reduction in the AAD). The calculation of the AAD for this study assumes no damage costs at the 2 year ARI event.

The present value of flood damages has been calculated assuming a 7% discount rate discounted over a period of 20 years, in accordance with NSW Treasury guidelines. The present value of damages allows a comparison with the present value of the capital and operating costs of structural flood mitigation measures as well as the present value of the corresponding reduction in flood damage associated with that option. This allows a benefit cost ratio to be estimated.

The total estimated flood damage to occur in a 100 year ARI local catchment flood event is $159M, increasing to an estimated $522M worth of damage for the PMF event. The AAD per hectare across the study area is illustrated in Figure 5-3. The relative contribution of the residential, commercial and industrial damages to the AAD is illustrated in Figure 5-4.

Over 66% of the calculated damages from the 100 year ARI event can be attributed to the Milperra sub-catchment resulting from the significant number of impacted commercial properties as outlined in Table 5-2. For the PMF event, this increases to 77%.



Title:

Annual Average Damages Overland Flooding due to Stormwater Runoff

Figure:	Rev:
5-3	0

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.

N

0 0.75 1.5km

Approx. Scale

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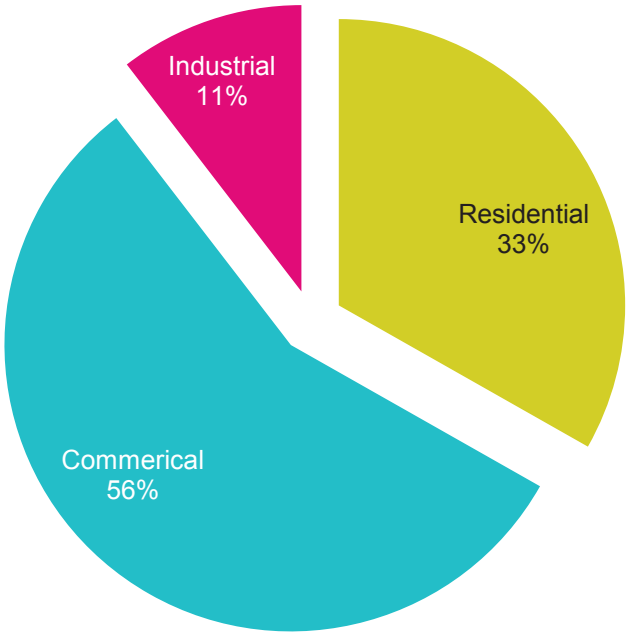


Figure 5-4 Components of average annual flood damage

6 Current Flood Management

6.1 Overview

Overland flooding due to stormwater runoff is already managed to some degree through a range of flood risk management options and initiatives that have been developed and supported by Council and other agencies, including the NSW State Emergency Services (SES). Current flood management approaches within the study area are described in this chapter.

Current flood management approaches have been divided into elements that aim to:

- reduce specific flood risks (through physical works);
- improve resilience in living with flood risks;
- facilitate emergency management; and
- manage overland flooding through catchment management initiates.

A number of flood risk management options and initiatives have also been established to manage the mainstream flood risk from Georges River within the study area, e.g. Kelso Levee. Further information on these options is contained in the Georges River Floodplain Risk Management Study and Plan (Bewsher Consulting, 2004).

6.2 Reducing Flood Risks

Council undertake regular maintenance of the drainage network to ensure system performance during a flood event. A number of structural flood mitigation works have also been undertaken in the Mid Georges River study area to reduce/manage the impacts of flooding. A summary of the maintenance regime and flood mitigation works is provided in the following sections.

6.2.1 Milperra Drain Channel Improvements

A flood investigation for the Milperra Industrial Area was completed in 1990 (Willing & Partners, 1990). The report noted that there was little scope to improve flood behaviour in a mainstream Georges River flood, but improvements to Milperra Drain could alleviate inundation from local catchment flood events.

Improvements to Milperra Drain commenced in 1990. This involved channel widening, channel lining, and culvert amplification. Completed channel improvement works extend from Queen Street, Milperra to west of Ashford Avenue, Milperra.

6.2.2 Channel improvement Works at Edgar Street, Condell Park

Channel improvement works have been completed on a tributary of Milperra Drain in the vicinity of Edgar Street, Condell Park. The channel improvement works included channel widening and channel lining and were completed prior to 2000.

6.2.3 Detention Basins at Bankstown Airport

As part of development works undertaken at Bankstown Airport, a stormwater detention basin was constructed adjacent to McDonalds at Nancy Ellis Leebold Drive, Bankstown Airport. The detention basin was constructed to manage the local catchment runoff within the airport. Construction of the basins was completed in 2000.

6.2.4 Kelso Levee Floodgates

A feasibility study for the Kelso levee was completed in 1984 (PWD, 1984), with construction commencing in 1986. The primary function of the levee is to provide protection to homes in the Kelso Park and Panania areas from mainstream flood events on Georges River.

Local drainage within the area protected by the levee is an important component of the levee scheme. Local catchment runoff is drained to the river through four 1.2m diameter pipes under the levee bank. These pipes have manually operated floodgates that are usually left open to allow tidal exchange with Kelso Creek. The SES closes the floodgates when flood warnings are issued by the Bureau of Meteorology (BoM). This results in internal ponding behind the levee when the floodgates are closed. The level of the internal ponding is dependent on the duration of floodgate closure and the volume of local catchment runoff.

6.2.5 Culvert Augmentation Works on the Bankstown Railway Line at Revesby

Culvert augmentation works have been completed on the Bankstown railway line to the rear of property 119 Sphinx Road, Revesby. The culvert augmentation works involved pipe jacking an additional two culverts of 1500 mm diameter under the railway line. The culverts were installed to help alleviate overland flooding north of the railway line with flow conveyed under the railway line to Little Salt Pan Creek at Montgomery Reserve. The works were completed in 2007.

6.2.6 Channel Improvements Works at Montgomery Reserve, Revesby

Channel improvements have been undertaken through Montgomery Reserve, Revesby to reduce flood risks from Little Salt Pan Creek. The channel improvement works involved removal of vegetation and minor channel augmentation. The works were completed in 2010.

6.2.7 Channel Improvement Works at Uranus Road, Padstow

Channel improvement works have been undertaken along Little Salt Pan Creek south of Uranus Road, Padstow. The works involved channel widening, channel lining, and bridge amplification to reduce flood risk to properties along both banks of Little Salt Pan Creek south of Uranus Road. The works were completed in 2014.

6.2.8 On-Site Stormwater Detention

On-site stormwater detention (OSD) is a structural measure for new development that aims to ensure that any increase in stormwater runoff associated with an increase in impervious surface does not adversely impact on downstream properties. OSD typically comprises on-ground or below-ground storages with a restricted outlet that are designed to detain and slowly release

excess runoff during storm events, so that post-development hydrology mimics pre-development hydrology.

Bankstown City Council has developed an OSD policy that requires on-site storage to be provided on all developments that increase the amount of impervious area. The policy is documented in Council's 2009 Development Engineering Standards and requires that peak stormwater discharges from the site in the 5 to 100 year ARI events, do not exceed predevelopment stormwater discharges.

6.2.9 Stormwater Drainage Network Maintenance Regime

Leaves and litter can be a significant problem in urban catchments because:

- blockage of stormwater pits can prevent surface flows from entering the underground pipe system;
- the capacity of stormwater pipes and channels can be reduced through the accumulation of leaves, rubbish and other debris; and
- culverts and channels can become blocked by larger obstacles such as shopping trolleys or cars.

Council currently operate a maintenance regime which involves pit, pipe and open drain cleaning.

6.3 Living with Flood Risks

6.3.1 Legal and Planning Controls

The prime responsibility for planning and management of flood prone land in New South Wales rests with local government. Management of existing and future flood risks must be investigated and advanced within a legislative, legal, policy and planning framework.

In New South Wales the primary legislation governing Councils is the Local Government Act 1993. A key qualifier of Council's role in floodplain risk management is specifically identified in s733 of the Local Government Act which specifies that Council's do not incur any liability in respect of any advice furnished in good faith by the council relating to the likelihood of any land being flooded or the nature or extent of any such flooding, or anything done or omitted to be done in good faith by the Council in so far as it relates to the likelihood of land being flooded or the nature or extent of any such flooding.

Section 733 of the Local Government Act 1993 protects councils from liability if they have followed the requirements of the Floodplain Development Manual. The NSW Flood Prone Land Policy and a Floodplain Development Manual (NSW Government, 2005) form the basis of floodplain management in New South Wales and are discussed further below.

6.3.2 Council Planning Controls

6.3.2.1 Local Planning Framework and Considerations

Land use planning and development controls are a key mechanism by which Council can manage future flood risk by legally controlling and directing future development and redevelopment of

private and public lands. Because of the incremental nature of development, the benefits of flood planning controls may not be realised for many years. Local Environment Plans (LEPs) and Development Control Plans (DCPs) can be amended at any stage in the future hence the opportunity always remains to improve flood planning controls as our understanding of flood risks become more refined.

One of the future challenges of Council will be managing the potential flood risks associated with climate change and sea level rise. Without intervention, certain localities within the LGA will experience gradual changes in flooding frequency, duration and depth as time passes. The LEP and DCP are potentially key mechanisms by which to pre-emptively adapt to this future.

The principal planning mechanism for managing floodplain within Bankstown City Council is provided through the Bankstown LEP 2015 and Bankstown DCP 2015. These are supported by Council's Development Engineering Standards 2009, which provides guidelines for all building and subdivision works for development on privately owned land and Council owned lands to ensure a satisfactory level of engineering infrastructure is provided.

A Planning Consideration Report has been prepared (Appendix D) which provides details on these Council planning controls along with the various layers of non-statutory strategic planning policies and statutory planning instruments that provide a framework for planning within the study area. A summary of these Council planning mechanisms is provided in the following sections.

6.3.2.2 Bankstown LEP 2015

LEPs are prepared in accordance with Part 3 Division 4 of the Environmental Planning and Assessment Act 1979. The intent of the LEP is to define the legal framework for land use and development by 'zoning' all land. The LEP incorporates standard planning provisions, clauses, definitions and zones into the one document. It identifies standard zones and zone objectives and specifies permitted and prohibited uses in zones, and identifies compulsory and optional provisions. An LEP is essentially a legal document of words and maps which sets out the legal standards or requirements for development to control the use of private and public land.

The latest version of the Bankstown LEP 2015 came into effect on 7 August 2015 and is Council's principal planning control for development in the City of Bankstown.

The LEP provisions incorporate general considerations in regard to development of flood liable land. Clause 6.3 of the Bankstown LEP 2015 relates to flood planning. The objectives of this clause are as follows:

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

The clause applies to land at or below the flood planning level. Details of the flood planning level are discussed in Section 4.3.

6.3.2.3 Bankstown DCP 2015

A DCP is established under the provisions of Part 3 Division 6 of the EP&A Act 1979. It provides more detailed provisions with respect to development in particular areas, and is to be considered by Council in determining development applications.

Council prepared the latest Bankstown DCP in 2015. The purpose of the DCP from a floodplain risk management perspective is to provide a practical application of Council's Flood Policy and is to be taken into consideration by Council when exercising its environmental assessment and planning functions in relation to new development within the Bankstown LGA.

The DCP should address the directions in flood risk management that are embodied in the NSW Government's *Flood Prone Land Policy* and which are emphasised in the 2005 edition of the government's *Floodplain Development Manual*.

The Bankstown DCP 2015 covers flood prone land in Part B12 of the policy, *Flood Risk Management*. The objectives of Part B12 of the DCP are to:

- reduce the risk to human life and damage to property caused by flooding through controlling development on land affected by potential floods;
- apply a "merit–based approach" to all development decisions which takes account of social, economic and environmental as well as flooding considerations in accordance with the principles contained in the NSW *Floodplain Development Manual* (FDM);
- control development and other activity within each of the individual floodplains within the LGA having regard to the characteristics and level of information available for each of the floodplains; and
- assess applications for development on land that could be flood affected in accordance with the principles included in the FDM, issued by the State Government.

6.3.3 Education and Awareness Programmes

The Bankstown City Council website serves as an avenue for landholders and residents to access details on flood affectation, flood planning controls and completed flood study and management plan documentation within the Bankstown LGA. The flood maps available in the flood study reports provide residents and business owners with a useful tool to identify the degree of flood risk to their property for a range of design flood events for both mainstream flooding from Georges River and overland flooding due to stormwater runoff.

As part of the consultation, exercises completed as part of the overland flood studies and this FRMS&P (refer to Section 2.3), Council have raised awareness of the flooding issues in the study area and the available resources to identify flood risk.

The NSW SES provides general information about emergency management including educating the community about floodplain management and emergency response in Bankstown. The SES website site contains practical advice in regards to "what to do in times of flood". A specific flood emergency information brochure for the Georges River (refer to Figure 6-1**Error! Reference source not found.**), which includes the Mid Georges River study area, is also available on the

SES website. The brochure provides advice on flood risk, preparedness, communication and evacuation.



Figure 6-1 Sample of the SES Flood Safe Brochure for Georges River

6.4 Emergency Management

6.4.1 Bankstown City Flood Emergency Sub Plan

The SES has formal responsibility for emergency management operations in response to flooding. Other organisations normally provide assistance, including the Bureau of Meteorology (BoM), council, police, fire brigade, ambulance and community groups. Emergency management operations are usually outlined in a Local Flood Plan.

The Bankstown City Flood Emergency Sub Plan is a sub plan of the Bankstown Local Emergency Management Plan and was endorsed in November 2015. The plan covers responsibilities,

preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the Bankstown LGA. The plan can be accessed through the SES FloodSafe website.

The plan identifies mainstream flooding from the Georges River as the primary threat with local catchment flooding affecting the Milperra Road area around Ashford Avenue and Kelso Creek catchment in areas defended by Kelso Levee.

6.4.2 Flood Forecasting and Warnings

The BoM prepares and disseminates flood forecasts and warnings and information to the public in close cooperation with state, territory and local government agencies and other stakeholders. Users of flood warning services include emergency management agencies and members of the public, particularly those in flood-prone areas. More detailed local interpretation of BoM flood warning products and information is provided directly to the public by flood response agencies such as the SES.

BoM warning products include early alerts to the possibility of flooding through a flood watch product, with site-specific forecasts of river height and the expected impact in terms of minor, moderate or major flooding in specific river basins, including the Georges River. The flood warning system on Georges River provides direct benefits to residents living within areas influenced by flood conditions within the Georges River.

The BoM is currently in the process of phasing out its existing flood forecasting system (the HyModel) in favour of a new Next Generation Hydrological Forecasting System (HyFS). HyFS will provide the capability to support current forecasting techniques, while also having the capacity to evolve to utilise new advances in hydrological science.

There is no formal flood warning service for overland flooding within the Bankstown LGA. However there are a number of general warning services provided by the SES and the BoM. The warning services provided by BoM that cover both overland and mainstream flood risk include:

- Flood Watches – typically provide 24-48 hour notice. These are issued by the NSW Flood Warning Centre providing initial warnings of potential riverine flooding based upon current catchment conditions and future rainfall predictions.
- Flood Warning - advise that flooding is occurring or expected to occur in a geographical area based on defined criteria. A quantitative or qualitative flood warning of Minor, Moderate or Major flooding is provided in areas where the Bureau has specialised warning systems. Generalised flood warnings are issued when there is not enough data to make specific predictions or in the developing stages of a flood. They typically rely on forecast rainfall and knowledge of historical flood response (Flood Warning Service, 2015).
- Severe Thunderstorm Warning Services – typically provide 0.5 to 2 hours notice. These short range forecasts are based upon radar, data from field stations, reports from storm spotters and synoptic forecasts.

- Severe Weather Warnings – for synoptic scale events that cause a range of hazards, including flooding. Examples of synoptic scale events are the deep low pressure systems off the NSW coast as shown in Figure 6-2.

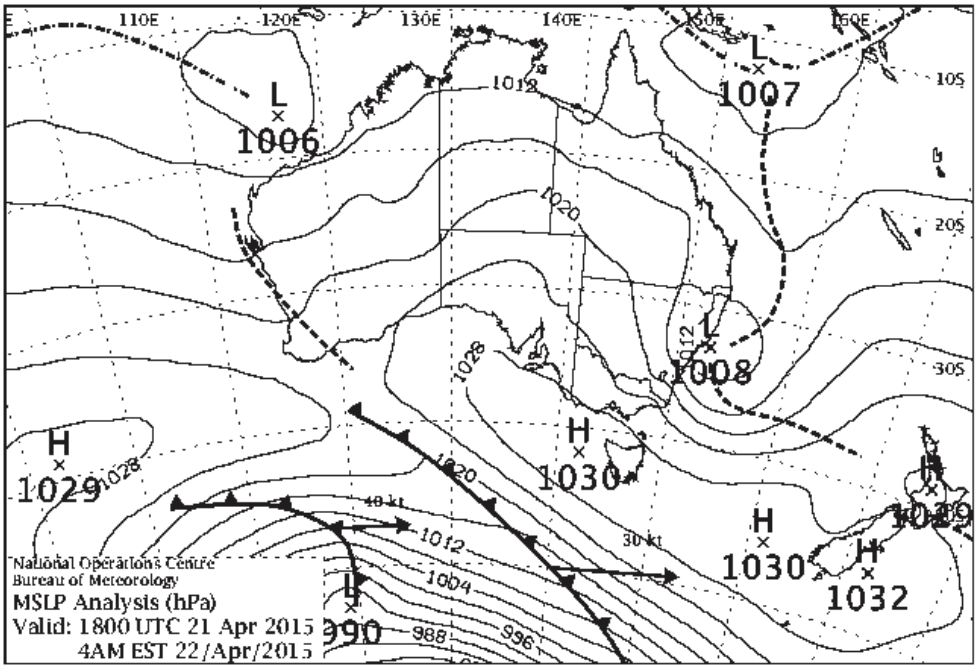


Figure 6-2 Mean Sea Level Pressure (MSLP) Analyses for Australia on 21 April 2015 (Source: BoM)

Real time water level and rainfall information is also available for a number of gauges in the study area from the Manly Hydraulics Laboratory and the BoM websites. The water level gauges are located on the Georges River at Kelso and Milperra and provide real time data for riverine flood events. There are a number of rainfall gauges in the study area with real time data available for the Kelso Creek gauge.

A flood warning system has also been developed by Bankstown City Council to warn of flooding from Milperra Drain at Ashford Avenue. The system provides flood warning to road users via a roadside message board on Ashford Avenue. The flood warnings are detail the degree of flood risk based on water level data from a gauge located at the Ashford Avenue/ Milperra Drain crossing.

6.5 Stormwater Management Initiatives

Stormwater management initiatives primarily seek to manage the water quality components associated with urban runoff through water sensitive urban design (WSUD). However, WSUD also provide secondary benefits in terms of reducing flood risk, largely through managing runoff at source providing benefits in terms of floodplain risk management. Figure 6-3 shows an example of the benefits of adopting WSUD in improving urban water balance.

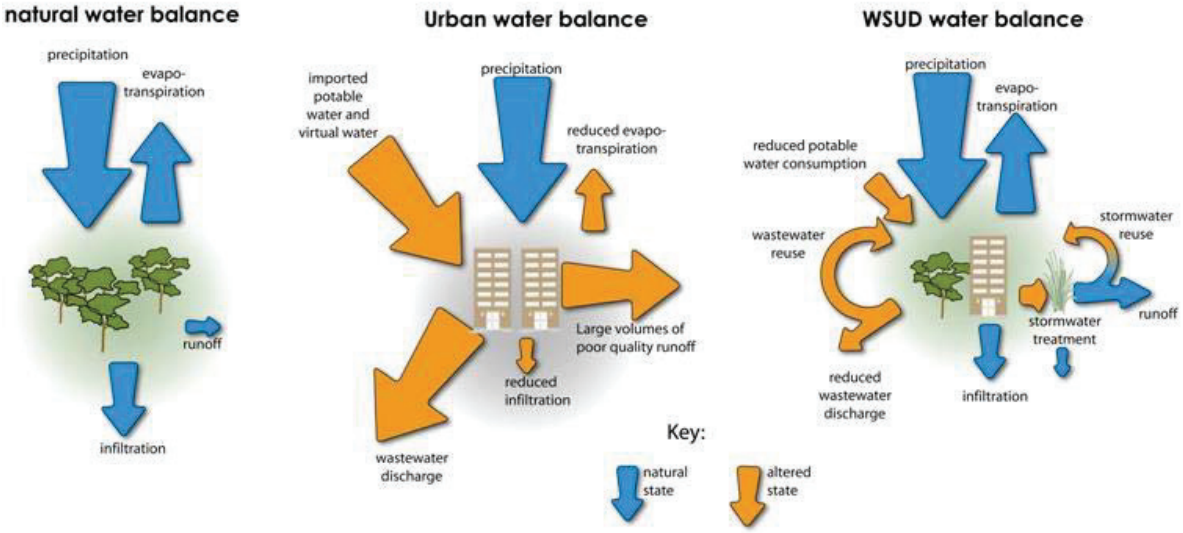


Figure 6-3 Urban Water Cycle (https://waterbydesign.com.au/whatiswsud/)

Bankstown City Council has implemented a number of stormwater management initiatives within the Mid Georges River study area. These include:

- requirements in the Bankstown DCP 2015 and Development Engineering Standards (2006) for control of site runoff from new developments and OSD; and
- gross pollutant traps (GPT's).

In addition, the Georges River Estuary Coastal Zone Management Plan (CZMP) was prepared for the Georges River Combined Council's Committee (GRCCC) in 2012. The key purpose of the CZMP was to "provide strategic direction and guidance on future actions within the estuary and its catchment, which will help to achieve long term balanced environmental sustainability" (BMT WBM, 2012).

The Mid Georges River study area forms part of the region considered in the Georges River Estuary CZMP. As such, the CZMP forms a key strategic document for the management of the Mid Georges River study area.

This CZMP has been integrated into a Waterways and Water Quality Improvement Plan for the Mid Georges River study area (herein referred to as the "Mid Georges River WWQIP"). The Mid Georges River WWQIP was developed as part of this FRMS&P to characterise water movement and stormwater pollutants through the Mid Georges River study area to gain a better understanding of the key pressures, identify opportunities for improvement and recommend an action plan for Council to implement.

The Mid Georges River WWQIP has been prepared and provided to Council as a separate report (included in Appendix E). The plan is summarised in Section 9.

7 Potential Options for Improving Flood Management

7.1 Overview of Available Measures

One of the key outputs from this FRMS&P is a set of options for managing flood risk in the study area, which are then developed into a floodplain risk management plan (refer Chapter 8). This chapter identifies options for improving flood management within the Mid Georges River study area with respect to existing and future flood risks. Measures considered for improved flood management can be grouped into three categories:

- flood modification measures;
- property modification measures; and
- response modification measures.

7.2 Option Assessment Process

The option assessment process was undertaken in two key steps:

- identification of potential flood risk management measures; and
- development and assessment of flood risk management options.

The identification of potential flood risk management measures provided a first pass assessment of measures by determining if they would be applicable/suitable to managing the overland flood mechanisms assessed as part of this study. For those measures that were considered applicable/suitable, a more detailed assessment was undertaken.

This more detailed assessment utilised flood mapping from the flood studies together with information generated as part of this report to identify flood problem areas within the study area. The shortlist of measures have been reviewed and formulated into flood risk management options.

These options have been assessed on two geographic scales:

- Localised: Focussed on flood modification measures to modify the flood behaviour and reduce the flood risk to a small number of properties; and
- Study area wide: Focussed on property and response modification measures that can be applied across the study area.

Flood modification measures (refer to Section 7.3.1) were generally considered to modify the flood behaviour and reduce the flood risk to a small number of properties within the flooding “hot-spots”. Localised flood risk management options have been formulated from these measures and are further discussed in Section 7.4.

It will not be feasible to find flood modification measures which eliminate or reduce all of the flooding problems within the study area, given the magnitude of the problem and the number of properties and buildings potentially affected by overland flooding due to stormwater runoff. Where localised solutions are not feasible, other study area-wide measures will provide some benefit, such as land use planning. An overview of these types of measures is provided in Section 0 and

Section 0. Study area wide flood risk management options have been formulated from these measures and are further discussed in Section 7.5.

7.3 Identification of Potential Options

7.3.1 Flood Modification Measures

These measures are designed to modify or manipulate the behaviour of the flood, either by changing its passage (redirection of flow paths) or its characteristics of flow depth and velocity. Table 7-1 lists the flood modification measures that were considered and the applicability of these measures for managing the overland flood risk in the study area. A brief description of the measure is provided along with additional commentary where measures are not considered viable.

Table 7-1 List of flood modification measures considered

Measure	Applicable	Comments
Exclusion of flood waters		
Flood walls and embankments	✓	Flood defence which involves the construction of permanent structures to exclude areas of floodplain from inundation.
Temporary demountable flood barriers	✖	Flood defences which are temporarily erected during a flood event to exclude areas of floodplain from inundation. Requires ample flood warning time for installation and can be labour intensive. No opportunities have been identified to install these devices due to the limited flood warning time for overland flooding.
Floodgates	✖	Flood defence which prevents backwater inundation of floodplains or low-lying areas. Due to the nature of the overland flood mechanisms, no opportunities have been identified to install these devices.
Sand bags	✖	Flood defence which is temporarily placed during a flood event to exclude areas of floodplain from inundation. Requires a ready supply of bags and sand to construct a temporary flood defence. This measure is very labour intensive and requires ample warning time for installation. No opportunities have been identified to use sand bags due to the limited flood warning time for overland flooding.
Containment of floodwaters		
Detention / storage basin	✓	Structure which is designed to assist with flood control and storm water management by temporarily holding flood waters in a controlled area which helps to reduce peak stormwater runoff rates and reduce flood risk downstream.
Diversion of flood waters		
Increased channel conveyance	✓	Drainage system improvements through augmentation or reconfiguration of existing culverts and widening and deepening of existing channel reaches. Measure increases channel conveyance and reduces flood risk.

Measure	Applicable	Comments
Improvements to existing pits and pipe stormwater network	✓	Drainage system improvements through augmentation or reconfiguration of existing stormwater pits and pipes and the installation of new pits and pipes. Measure increases pit inlet capacity and pipe conveyance and reduces flood risk.
Development and enhancement of overland flow paths	✓	Engineered overland flow paths designed to convey a significant portion of the overland flow in a controlled manner.
Pumping station	✖	A facility which includes pumps and other equipment for pumping excess flood water from one place to another. Due to the nature of the overland flood mechanisms, no opportunities have been identified to install pumping stations.

7.3.2 Property Modification Measures

Property modification measures seek to reduce flood risk through modification measures applied to existing developments and careful planning of future developments as outlined in Table 7-2.

Table 7-2 Property modification measures considered

Measure	Applicable	Comments
Existing Development		
Voluntary purchase	✓	Permanent relocation of residents to alternative properties away from the high flood hazard areas. Can be a very costly option, and will reduce both risks to life and property.
House raising	✖	Involves raising a house off its foundations above the flood level. Insignificant number of properties identified to form an overall floodplain risk management strategy for an area rather than a stand-alone measure. Issue with risk to life remains.
Flood proofing of buildings (walls, floors, etc.)	✓	Reduces damages to properties through modifications to buildings. Includes the use of flood resilient building materials and raising fixtures, i.e. electrics, above flood levels.
Temporarily relocate contents	✖	Relocating contents away from flooding can be effective at limiting some flood damage. Dependent on having enough time to perform the relocation process. Limited opportunities due to the inadequate flood warning time for overland flooding.

Measure	Applicable	Comments
Sand bags and drop-in boards	✖	Flood defence which is temporarily placed during a flood event to exclude individual properties from inundation. Requires a ready supply of bags and sand to construct a temporary flood defence. Is very manual-labour intensive and requires ample warning time for installation. No opportunities have been identified to use sand bags due to the limited flood warning time for overland flooding.
Future Development		
Zonings to restrict development in critical areas	✓	Certain types of development are considered more suited to development outside the floodplain, for example, developments that contain the elderly or infirm, or developments that are critical to the provision of emergency services.
Building controls requiring flood-smart design and structural integrity	✓	Controls could require mechanisms for minimising flood-related damages, especially in relation to building materials, electrics etc.

7.3.3 Response Modification Measures

Response modification measures are designed to reduce the potential risks to life and property by modifying the overall response of individuals before, during and after a flood event. Table 7-5 lists the response modification measures that were considered and the applicability of these measures for managing the overland flood risk in the study area.

Table 7-3 Flood response modification measures

Measure	Applicable	Comments
Before a Flood		
General education to inform the community of the flood risk	✓	Provide key messages regarding what to do and what not to do if caught in a flood. As new residents move into communities and as complacency sets in on longer term residents, education is required on a periodic basis.
Targeted education (property or neighbourhood specific) to inform individuals of specific risk	✓	Provide key messages regarding how to manage risks to life and risks to property at an individual property basis, including evacuation routes and measures that can be implemented to be better prepared.

Measure	Applicable	Comments
Local flood plans and pre-planned evacuation arrangements	✓	Evacuation centres and emergency responses need to be set-up at very short notice, so pre-planning is required. Evacuation centres need to be flood free, and there needs to be a sufficient number to potentially cater for large numbers of affected people.
Disclose information and share knowledge	✓	Information readily available via S149 certificates, publicly available flood studies and flood plans. Property-scale flood information should be available via the internet.
During a Flood		
Flood forecasting and warning system	✓	A flood forecasting and warning system can buy extra time for appropriate flood response, if accurate information can be disseminated to the community on time. A flood warning system is usually an acceptable flood risk management tool to the community, but can lead to a false sense of security.
Flood warnings via social media, mobile apps and automated voice & text messaging services	✓	Possible methods and tools for disseminating flood warning information. Can be a very effective tool for disseminating information quickly to targeted audiences.
Flood warnings via multi-media bulletins for notification of	✓	Urgency of disseminating flood warnings is critical to providing the community with as much preparation time as possible. This should extend to all radio and TV channels.
Flood markers indicating problem areas	✓	Flood markers indicate flood depths and levels. Can be designed to provide information on both historical and design flood events.
After a Flood		
Inter-agency co-operation and arrangements and recovery plans	✓	Post-flood recovery co-ordination between agencies is required to outline roles and responsibilities, especially as the community starts seeking out support and assistance.
Financial and charity assistance	✓	Assistance is provided through various state and federal schemes subject to conditions and by charity organisations (i.e. food and clothes).
Charity assistance	✓	Assistance provided by charity organisations (food, clothes, shelter, basic needs).

7.4 Localised Flood Mitigation Options

7.4.1 Initial Assessment of Mitigation Options

Due to the urban nature of the study area, there are limited opportunities for measures requiring a large amount of space, such as detention basins. Therefore, the majority of the measures considered were localised options comprising augmentation or reconfiguration of the existing stormwater drainage system.

A large number of options were not considered viable, primarily on the following technical and economic grounds:

- relatively small number of properties at risk within a "hot-spot" area such that benefits through potential flood damages savings would not prove economically feasible;
- high cost of construction in upgrading stormwater drainage network; and
- residual flood risks for events in excess of upgrade design capacity and potential for stormwater drainage pit and pipe blockages may keep flood damages high which impacts on the economic feasibility of this measure.

Ultimately, 99 flood modification options were identified to address flooding at the flooding "hot-spots" identified in Section 4.6. Table E-1 in Appendix E outlines the options that were identified and assessed. The initial assessment considered whether the technical, economic, social and environmental benefits warranted further investigation and modelling.

A total of 26 flood modification options for the "hotspot" areas were subsequently flagged for further investigation and assessment of performance.

7.4.2 Performance Assessment of Mitigation Options

The performance of each of the 26 options was assessed against the following criteria:

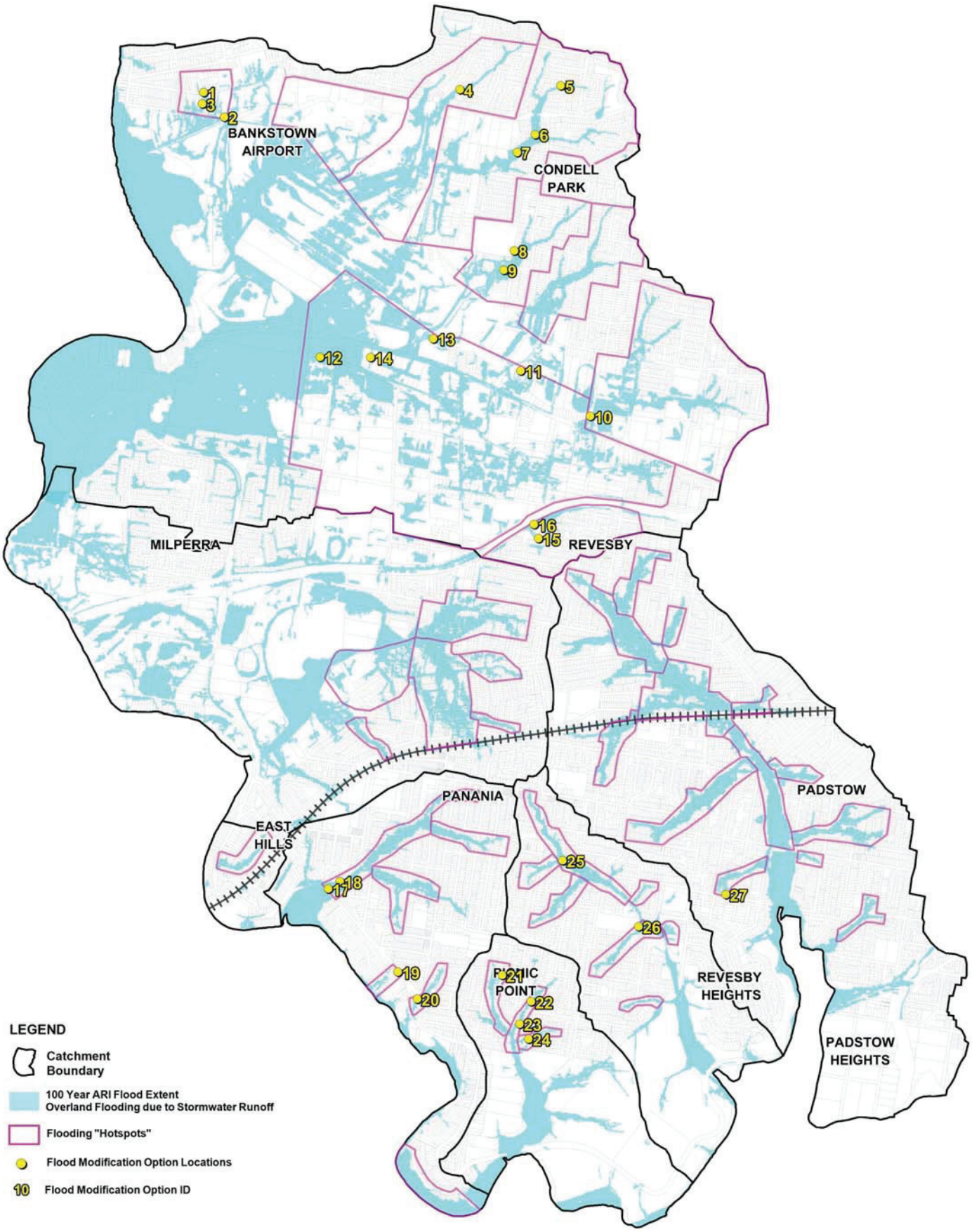
- Technical: Addresses issues relating to the build-ability, performance and operation of an option. This was informed by site visits undertaken with Council and through flood modelling of preliminary outline option designs.
- Economic: Addresses the economic viability of an option. The flood models have been used to assess the potential change in flooding behaviour based on preliminary outline option designs. The changes in flood behaviour with the options in place have been used to assess the reduction in flood damages, i.e. economic benefits, using the methodology outlined in Chapter 5. The costs to construct each option have been estimated based on Rawlinson's Cost Guide (2012). The costs to construct an option have been compared to the economic benefits to determine a benefit cost ratio for each option.
- Social: Considers the implications of an option on the community and the social acceptability of an option. This includes the social benefits of reducing the flood risk to the community and the social, recreational and safety implications of an option.
- Environmental: Considers the impacts of an option on the environment and heritage. Changes to the flooding regime as a result of an option can have impacts, both positive and negative, on the environment and heritage features in the study area.

Table 7-4 summarises the flood modification options assessed and identifies options considered as viable following this assessment. Where options are not considered viable for any of the core assessment criteria, the option is generally considered unviable. There have been some exceptions to this, i.e. on Lucas Road Drain, as discussed further in the following sections. The location of each option is shown in Figure 7-1 below.

Table 7-4 Performance Assessment and Viability of Selected Flood Modification Options

Option ID (refer to Figure 7-1)	Hotspot ID (Refer to Figure 4-9)	Option description and location	Assessment Criteria				Viable
			Technical	Economic	Social	Environmental	
1	C20_1	Increase stormwater pit and pipe capacity on Endeavour Road, Georges Hall	N	N	-	-	N
2	C20_1	Increase culvert capacity at Rabaul Road near Tower Road and construct open channel downstream of Rabaul Road on BAL land	N	-	-	-	N
3	C20_1	Enhance overland flow path through properties between Endeavour Road and Rabaul Road	Y	Y	Y	Y-	Y
4	C20_3	Increase existing detention at Surrey Reserve, Georges Hall	Y	Y	Y	Y	Y
5	C20_4	Construct a detention basin at Reliance Reserve, Yagoona	Y	N	-	-	N
6	C20_4	Construct a flow retarding embankment in the park adjacent to Grace Avenue, Condell Park	N	-	-	-	N
7	C20_4	Create a floodway along Higgins Street, Condell Park	N	-	-	-	N
8	C20_4	Develop overland floodway at Third Avenue, Condell Park	N	-	-	-	N
9	C20_5	On-site detention at Kinch Reserve	N	-	-	-	N
10	C20_7	Channel improvement works at 116-120 Milperra Road, Milperra, downstream of Bankstown Trotting Recreational Club	Y	Y	Y	Y	Y
11	C20_8	Construct a detention basin within Deverall Park, Bankstown Airport	Y	Y	Y	Y	Y
12	C20_8	Channel improvement works through Bankstown Golf Club, Milperra	Y	Y	Y	Y	Y
13	C20_8	Increase the size of existing detention basins at Bankstown Airport	Y	Y	Y	Y	Y
14	C20_8	Develop an overland floodway at Sheridan Close, Milperra	Y	N	-	-	N

Option ID (refer to Figure 7-1)	Hotspot ID (Refer to Figure 4-9)	Option description and location	Assessment Criteria				Viable
			Technical	Economic	Social	Environmental	
15	C20_9	Develop an overland flood way at Tracey Street Reserve, Revesby	Y	N	-	-	N
16	C20_9	Improve conveyance through the M5 noise wall at Tracey Street Reserve, Revesby	Y	Y	Y	Y	Y
17	C28_1	Increase the size of the culverts on Lucas Road Drain at Henry Lawson Drive, East Hills	Y	N	Y	Y	Y
18	C28_1	Construct flood walls and embankments alongside Lucas Road Drain, East Hills	Y	N	-	-	N
19	C28_4	Develop an overland floodway to re-route flows from Henry Lawson Drive to Georges River, Picnic Point	N	-	-	-	N
20	C28_5	Develop an overland floodway to re-route flows along Lambeth Street southwards to Georges River, Picnic Point	N	-	-	-	N
21	C29_1	Enhance overland floodway between 13 and 15 Kathleen Parade, Picnic Point	N	-	-	-	N
22	C29_2	Enhance overland floodway along Austin Boulevard, Picnic Point	N	-	-	-	N
23	C29_2	Enhance overland floodway along Karen Avenue, Picnic Point	N	-	-	-	N
24	C29_3	Develop overland floodway along Drysdale Avenue, Picnic Point	N	-	-	-	N
25	C27_2	Develop a detention basin at Bruce Reserve, Panania	Y	N	-	-	N
26	C27_5	Construct a flood wall at Thomas Street, Picnic Point	Y	Y	Y	Y	Y



Title:

Flood Modification Option Locations

Figure: **7-1**

Rev: **0**

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.

N

0 0.5 1km

Approx. Scale

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Filepath :S:\WATER\PROJECTS\S1304 - Water - Mid-Georges River FRMS\Drafting\WOR\FRMS_Report\Fig_7_1_Flooding_Hotspots_Options.wor

Each of the options assessed as being viable is presented in further detail in the following sections. The nature of the flooding problem is presented for each location with a brief description of the option and a discussion on its performance.

7.4.3 Increase Existing Detention at Surrey Reserve, Georges Hall

7.4.3.1 Problem

Flooding occurs through a number of properties near the junction of Marion Street and Surrey Avenue, Georges Hall. Overland flooding from the upstream catchment spills along Lincoln Road, through Surrey Reserve and along the overland flow path through the lowest properties on Surrey Avenue. Aerial photos from 1943 indicate that properties along Surrey Avenue have been built along the original channel alignment. With no dedicated overland flow path, properties are affected as the overland flow continues along the natural gully line across Marion Street and into Bankstown Airport.

Overland flood depths for the 100 year ARI event are generally less than 0.5m. The property database indicates that 3 properties along Marion Street are inundated above floor level for the 100 year ARI event.

7.4.3.2 Option Description

The topography of the park at Surrey Reserve lends itself to a detention basin without the need for significant civil engineering works. This option would involve increasing the existing detention storage in the park by raising the footpath along the southern boundary of the park. The footpath would be raised by approximately 1m at its lowest point. The raised elevation of the footpath would be consistent in height with the footpath running alongside the reserve at Surrey Avenue.

This option would be combined with improvements to the covered pit located within the reserve. The pit would be converted from a covered pit to an inlet pit to allow it to perform as an outlet flow control structure for the basin.

Figure 7-2 provides a preliminary outline of the extent of the engineering works required.

7.4.3.3 Performance

Based on the flood model and damage assessment results, this option would reduce flood risk to 3 residential properties along Surrey Avenue south of Surrey Reserve resulting in a $21,000 reduction in AAD.

Activation of the overland flow path can only be removed if sufficient storage and drainage capacity is provided. The detention capacity within Surrey Reserve is limited and the flow through the flow control structure is constrained by the pit inlet and pipe capacities. There remains the residual risk of flooding as a result of larger events exceeding the design capacity of the detention and through potential blockages of the pits and pipes.

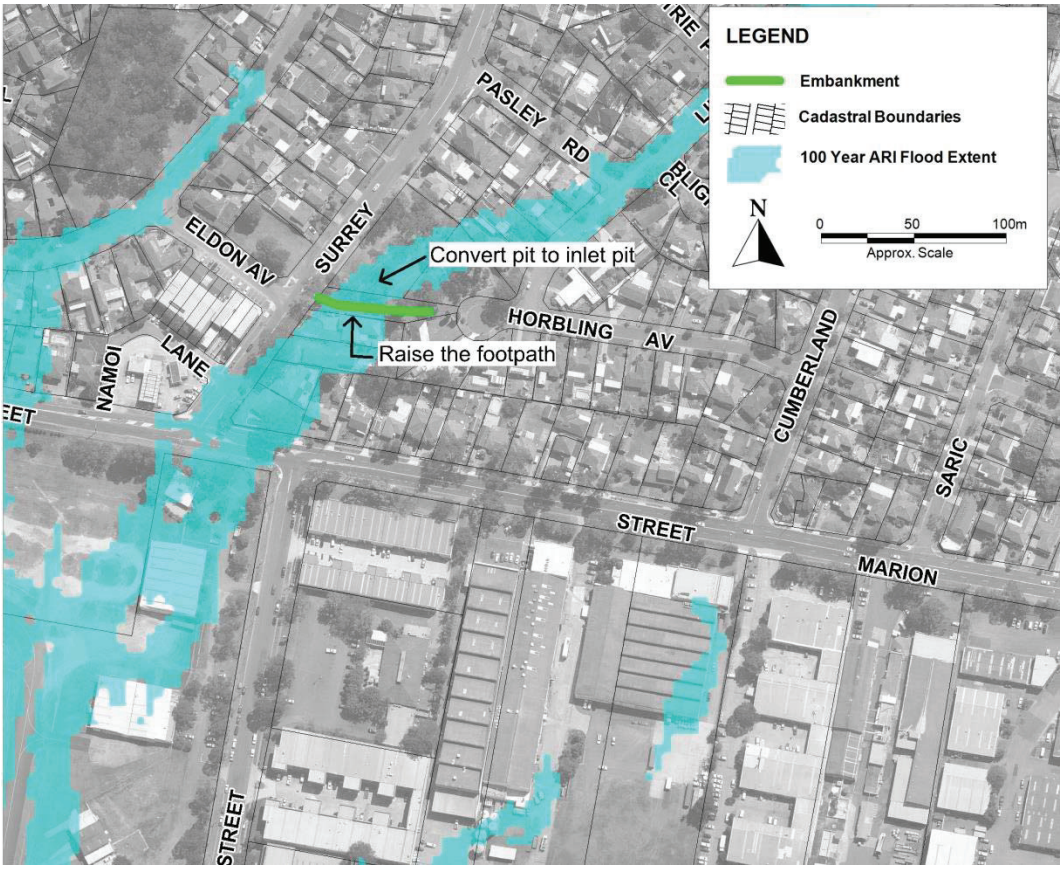


Figure 7-2 Proposed flood mitigation works at Surrey Reserve, Georges Hall

7.4.3.4 Recommendation

Council should pursue opportunities to increase storage capacity and amend pit inlet as part of any future upgrades to the park at Surrey Reserve.

7.4.4 Channel Improvement Works at 116-120 Milperra Road, Milperra

7.4.4.1 Problem

Flooding occurs through a number of commercial properties in Condell Business Park, Condell. The majority of flood risk is as a result of overland flooding due to stormwater runoff and out of bank flooding from a tributary of Milperra Drain. Flooding also affects Milperra Road impacting transport during times of flood. Works have already been completed to help reduce flood risk in this area by improving conveyance on the Milperra Drain tributary (refer to Section 6.2.1). Conveyance along this tributary downstream of these works is constrained by heavy in-stream vegetation, a bridge crossing and culverts under Milperra Road.

Overland flood depths for the 100 year ARI event are generally less than 0.5m. The property database indicates that a number of commercial properties in the vicinity of Edgar Street and Milperra Road are inundated above floor level for the 100 year ARI event.

7.4.4.2 Option Description

This option involves channel improvement works on the tributary of Milperra Drain extending from Condell Business Park to south of Milperra Road. These works include removing in-channel vegetation, widening the channel and replacing existing structures with new larger capacity structures. The option also includes the construction of a low flood embankment along the eastern bank of the channel extending from the business park to Milperra Road.

The works should also use natural channel design principles where possible to improve the geomorphic and ecological integrity of the channel and minimise the risk of bed and bank erosion, or weed infestation.

Figure 7-3 provides a preliminary outline of the extent of the works required.

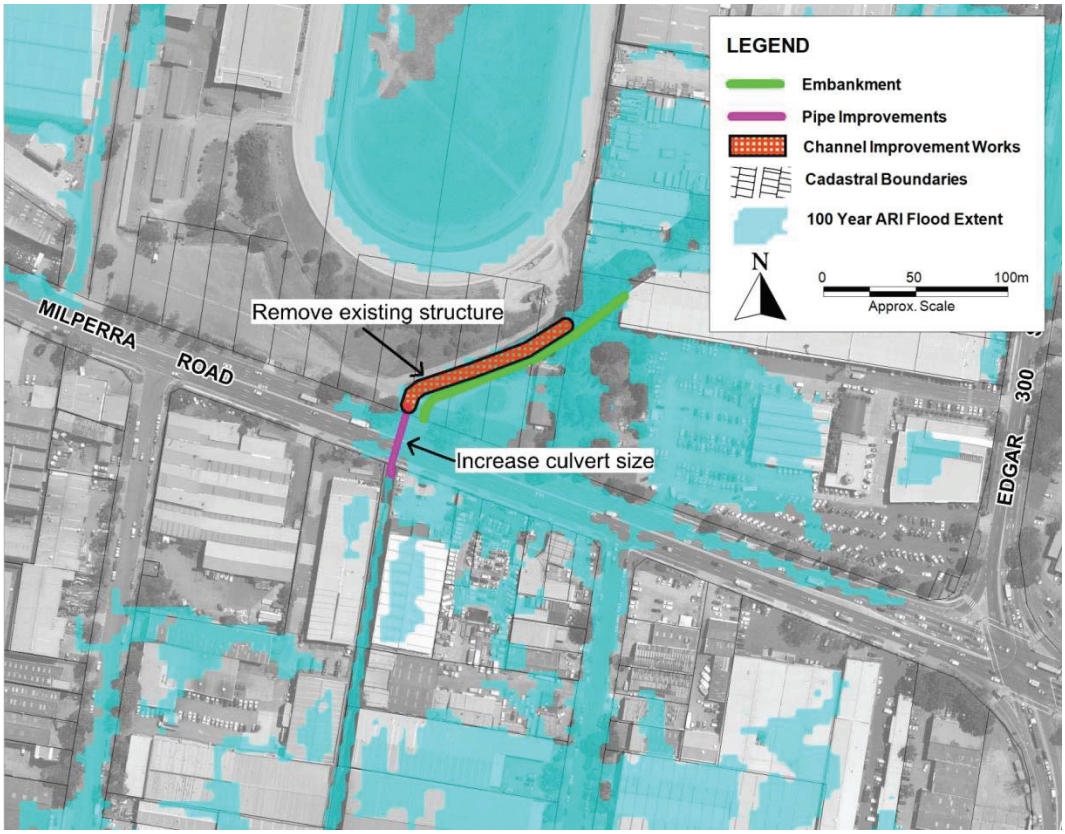


Figure 7-3 Proposed channel improvement works at Condell Business Park, Condell

7.4.4.3 Performance

Based on the flood model and damage assessment results, this option reduces the flood risk to 18 commercial properties resulting in a $160,000 reduction in AAD damages. This estimated reduction in damages is however sensitive to the capital cost of the works, which may be higher than estimated depending on the need for and extent of service relocation, property acquisition, spoil disposal, bank protection and landscaping.

This option reduces the flood risk to Milperra Road, with levels dropping by approximately 0.1m for the 100 year ARI event resulting in flood depths of approximately 0.2m on Milperra Road for the

100 year ARI event. This option does not eliminate flood risk to Milperra Road from this tributary reach, with flooding occurring for the 5 year ARI event.

A major limitation of such upgrades is the residual risk of flooding. The channel improvement works will have a finite capacity, and there is the potential for culvert blockages. Therefore there is a residual risk of flooding as a result of larger events exceeding the design capacity of the channel and through potential blockages of culverts at Milperra Road.

7.4.4.4 Recommendation

It is recommended that opportunities be pursued to improve channel conveyance as part of any future road upgrades to Milperra Road. The option will be relatively ineffective without improvements to the size of the culverts under Milperra Road. It is recommended that Council consult with RMS regarding upgrades to the culverts under Milperra Road as part of any planned works to upgrade this road. More detailed investigations of upgrade works will need to consider the existing capacity of the downstream channel to ensure future works do not significantly increase downstream flood risk.

7.4.5 Increase the Size of Existing Detention Basins at Bankstown Airport

7.4.5.1 Problem

The Milperra Industrial Area, Milperra has been identified as an area of significant flood risk. The area is at risk from both overland flooding due to stormwater runoff and out of bank flooding from Milperra Drain. Flooding also affects Milperra Road impacting transport during times of flood.

BMT WBM recently completed an assessment of the impact of developments within BAL lands on overland flooding due to stormwater runoff (Refer to Section 0). The results of the flood impact assessment indicated off-site flood impacts on Milperra Road at the intersection of Nancy Ellis Leebold Drive. The offsite flood impacts have resulted in an increase in flood levels between the baseline scenario (year 2003) and current scenario (year 2014) of between +0.1m to +0.2m at Milperra Road for the 100 year ARI event.

The identification of flood mitigation options focussed on replacing the lost floodplain storage from developments at Bankstown Airport with flood storage elsewhere in the airport. The aim of this option has been to reduce flood levels at Milperra Road to 2003 pre-development levels, a time preceding most of developments in the floodplain at Bankstown Airport.

7.4.5.2 Option Description

This option would involve increasing the size of the two existing detention basins located north of McDonald's, Milperra Road and south of the roundabout on Nancy Ellis Leebold Drive.

The existing detention basin north of McDonald's would be increased in area by approximately 15,000m^2. The capacity of the existing basin would also be increased with the construction of a low embankment and a headwall near the outlet of the existing basin.

The storage volume of the existing basin south of the roundabout on Nancy Ellis Leebold Drive would be increased by deepening the existing basin.

Figure 7-4 provides a preliminary outline of the extent of the engineering works required.

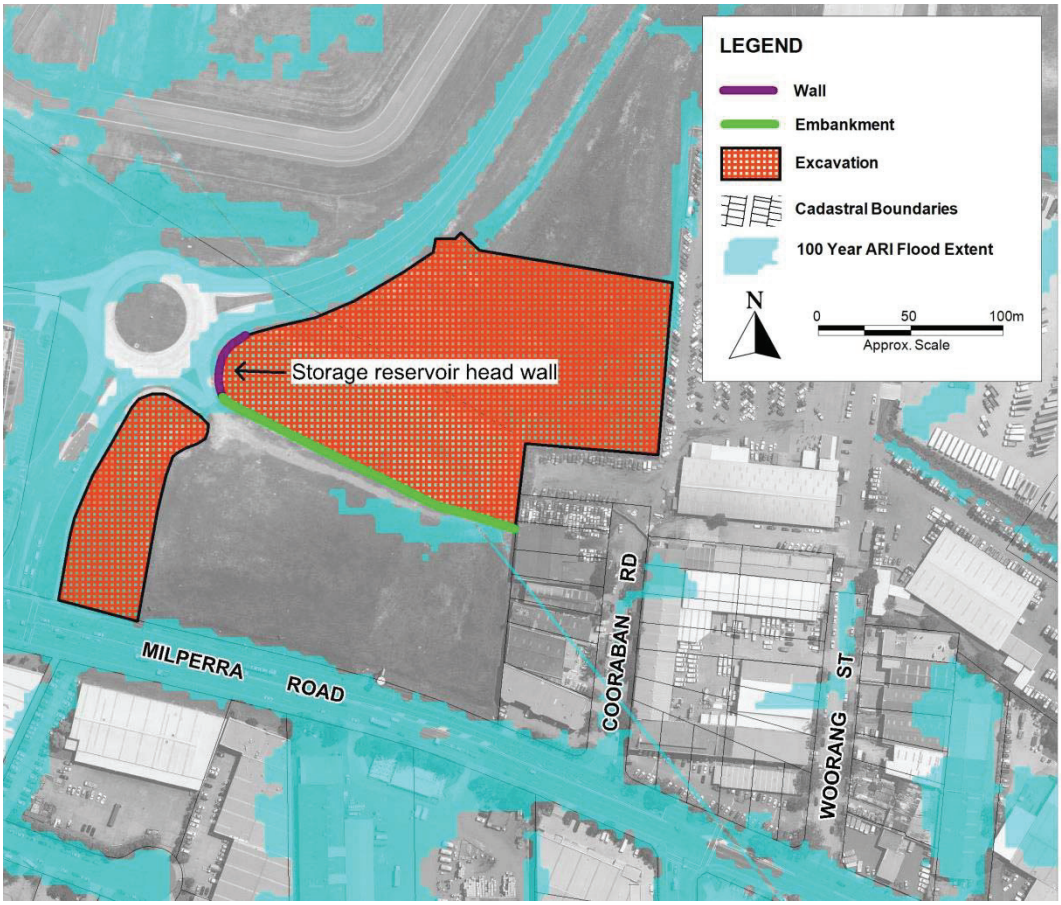


Figure 7-4 Proposed flood detention basins at Bankstown Airport

7.4.5.3 Performance

The flood model results indicate that this option reduces the flood risk at Milperra Road and Nancy Ellis Leebold Drive however there is no reduction in flood damages to properties.

The option reduces flood levels on Milperra Road to predevelopment levels (i.e. developments on BAL land in 2003) for the 20 year ARI event. The flood levels are also reduced for the 100 year ARI event, however, the levels are 0.06m higher than the predevelopment levels.

This option does not eliminate the flood risk at Milperra Road and there remains the residual risk of elevated flood levels at Milperra Road for events exceeding the design capacity of the detention basins.

7.4.5.4 Recommendation

Council should pursue opportunities to develop flood detention basins in Bankstown Airport in consultation with BAL.

7.4.6 Construct a Detention Basin within Deverall Park, Bankstown Airport

7.4.6.1 Problem

The Milperra Industrial Area, Milperra has been identified as an area of significant flood risk. The area is at risk from both local overland flooding due to stormwater runoff and out of bank flows from Milperra Drain. Flooding also affects Milperra Road affecting transport during times of flood.

Flood depths within the Milperra Industrial Area typically range from 0.25m to 0.75m in a 100 year ARI event. The property database indicates that a large number of commercial properties in the Milperra Industrial Area are inundated above floor level for the 100 year ARI event.

7.4.6.2 Option Description

This option would involve the development of a detention basin at Deverall Park, Bankstown Airport, through the construction of a dam embankment, outlet control structure and a spillway structure.

The topography within Deverall Park lends itself to the construction of detention basin without the need for significant excavation works. Based on concept design information provided by Bankstown City Council, this option would involve the construction of a dam embankment built along the western, southern and eastern boundary of the park and a spillway and outlet control structure along the alignment of the existing channel north of 287 Milperra Road, Milperra. The embankment would have an elevation of approximately 12m AHD which results in a maximum dam embankment height of approximately 4m.

The design and construction of the embankment will need to take account of the endangered ecological community (EEC) within Deverall Park. Impacts and possible mitigation measures on the EEC should be considered by Council as part of their environmental impact assessment of the proposed works.

Figure 7-5 provides a preliminary outline of the extent of the engineering works required.

7.4.6.3 Performance

Based on the flood model and damage assessment results, this option would reduce flood risk to 27 commercial properties within the Milperra Industrial Area resulting in in a $169,500 reduction in AAD.

This option also reduces the flood risk to Milperra Road, with 100 year ARI flood depths reduced to 0.15 m on the road surface in the vicinity of 287 Milperra Road, Milperra.

A residual risk of flooding remains as a result of larger events exceeding the design capacity of the detention basins.

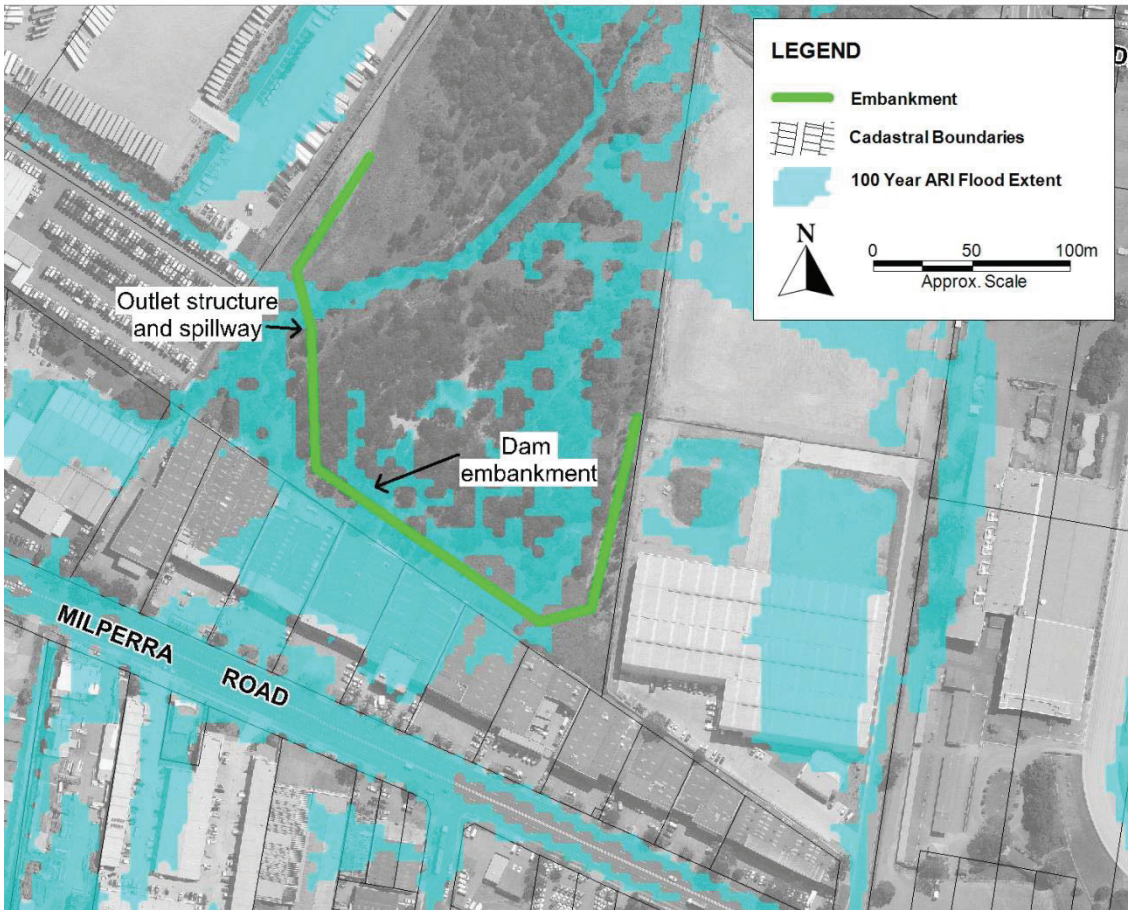


Figure 7-5 Proposed flood detention basin at Deverall Park, Bankstown Airport

7.4.6.4 Recommendation

Council should pursue opportunities to develop flood detention basins in Bankstown Airport in consultation with BAL.

7.4.7 Channel Improvement Works through Bankstown Golf Club, Milperra.

7.4.7.1 Problem

The Milperra Industrial Area has been identified as an area of significant flood risk. The area is at risk from both local overland flooding due to stormwater runoff and out of bank flows from Milperra Drain. Flooding also impacts Milperra Road affecting transport during times of flood.

Flood depths within the Milperra Industrial Area range from 0.25m to 0.75m in a 100 year ARI event. The property database indicates that a large number of commercial properties in the Milperra Industrial Area are inundated above floor level for the 100 year ARI event.

7.4.7.2 Option Description

Flood mitigation works have previously been implemented on Milperra Drain (refer to Section 6.2.1). The most recent works involved widening an approximate 350m length of channel downstream of Ashford Avenue, Milperra (Stage 11 Part 1 channel works).

The proposed option includes the widening of Milperra Drain from downstream of Ashford Avenue, Milperra, through Georges River Golf Club to Henry Lawson Drive, Milperra. The drain would be widened by approximately 20m in line with the Stage 11 Part 1 channel works. The works would also involve replacing cross channel structures though Milperra Golf Club with larger capacity structures and the removal of dense in-bank channel vegetation though Milperra Golf course upstream of Henry Lawson Drive, Milperra.

Consideration should be given to employing natural channel design principles as part of the design of these works to meet creek stability, biodiversity and water quality objectives. This will need to take account of existing environmental assets, issues and landuse at the Georges River Golf Club.

Figure 7-6 provides a preliminary outline of the extent of the engineering works required.

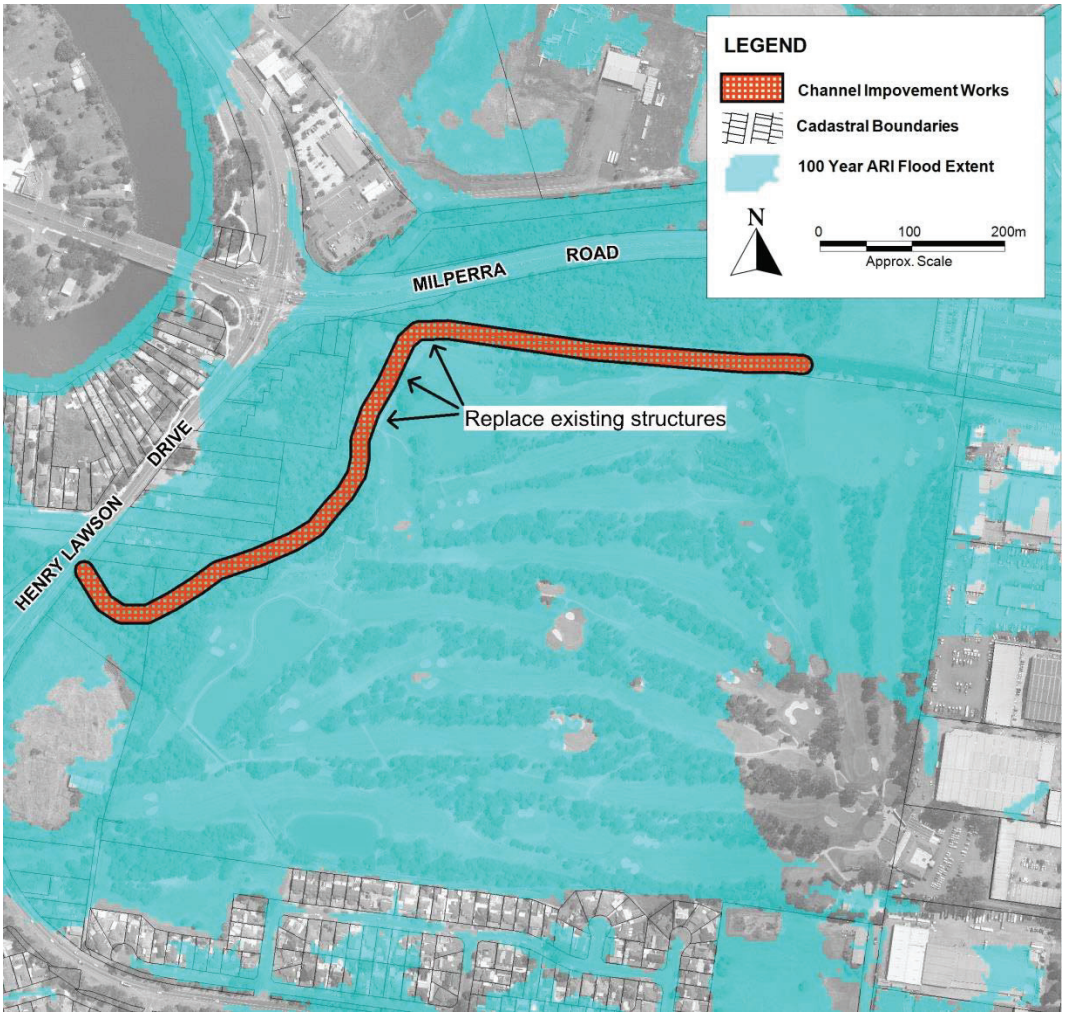


Figure 7-6 Proposed channel improvement works along Milperra Drain, Milperra

7.4.7.3 Performance

Based on the flood model and damage assessment results, this option would reduce flood risk to 34 properties within the Milperra Industrial Area resulting in in a $212,500 reduction in AAD. The estimated reduction in AAD is however sensitive to the estimated capital cost of the works, which will be affected by factors such as the linear extent of the work, need for service relocation, soil

contamination, spoil disposal, and the degree to which natural channel design principles are incorporated.

This option reduces the flood risk to Milperra Road, with levels dropping by approximately 0.1m for the 100 year ARI event resulting in water levels of approximately 0.6m on the road surface in the vicinity of Bankstown Golf Club. This option does not eliminate flood risk to Milperra Road with flooding occurring for the 5 year ARI event.

A limitation of such upgrades is the residual flood risk as a result of larger events exceeding the design capacity of the channel and through potential blockages of structure along the reach. The channel improvement works will have a finite capacity and there is the potential for culvert blockages. The capacity of Milperra Drain is also heavily influenced by the downstream tail water levels in Georges River. Elevated levels in Georges River reduce the conveyance capacity of Milperra Drain.

7.4.7.4 Recommendation

At the time of preparation of this study, Council sought tenders for the detailed design of flood mitigation works. It is recommended that Council pursue this design through to construction.

7.4.8 Improve Conveyance through the M5 Noise Wall at Tracey Street Reserve, Revesby

7.4.8.1 Problem

The property database indicates that three properties along Alliance Avenue, Revesby, are inundated above floor level for the 100 year ARI event. Flooding of these properties results from the accumulation of overland flows within Tracey Street Reserve, Revesby. The flooding problem is exacerbated by the M5 noise wall, which impounds water within Tracey Street Reserve. Flood depths of up to 1m exist for the 100 year ARI event.

7.4.8.2 Option Description

This option involves the provision of improved flow conveyance through the M5 noise wall at the north-eastern corner of Tracey Reserve. Adjustments to ground elevations and the installation of stormwater drainage measures would improve drainage of flood water impounded by the noise wall. The drainage measures would connect to the existing M5 road drainage network.

Figure 7-7 provides a preliminary outline of the extent of the engineering works required.

7.4.8.3 Performance

Based on the flood model and damage assessment results, this option would reduce flood risk to 3 properties on Alliance Avenue, Revesby, resulting in in a $7,500 reduction in AAD.

A major limitation of such upgrades is the residual flood risk. Any stormwater drainage system will have a finite capacity, and there is the potential for blockages resulting in a residual flood risk.

7.4.8.4 Recommendation

Council should consult with RMS regarding the M5 noise wall and drainage improvements. Although, RMS would ultimately be responsible for construction and maintenance of the improvement works within the RMS-owned road corridor, Council will need to discuss how financial contributions can be appropriately shared between both organisations.

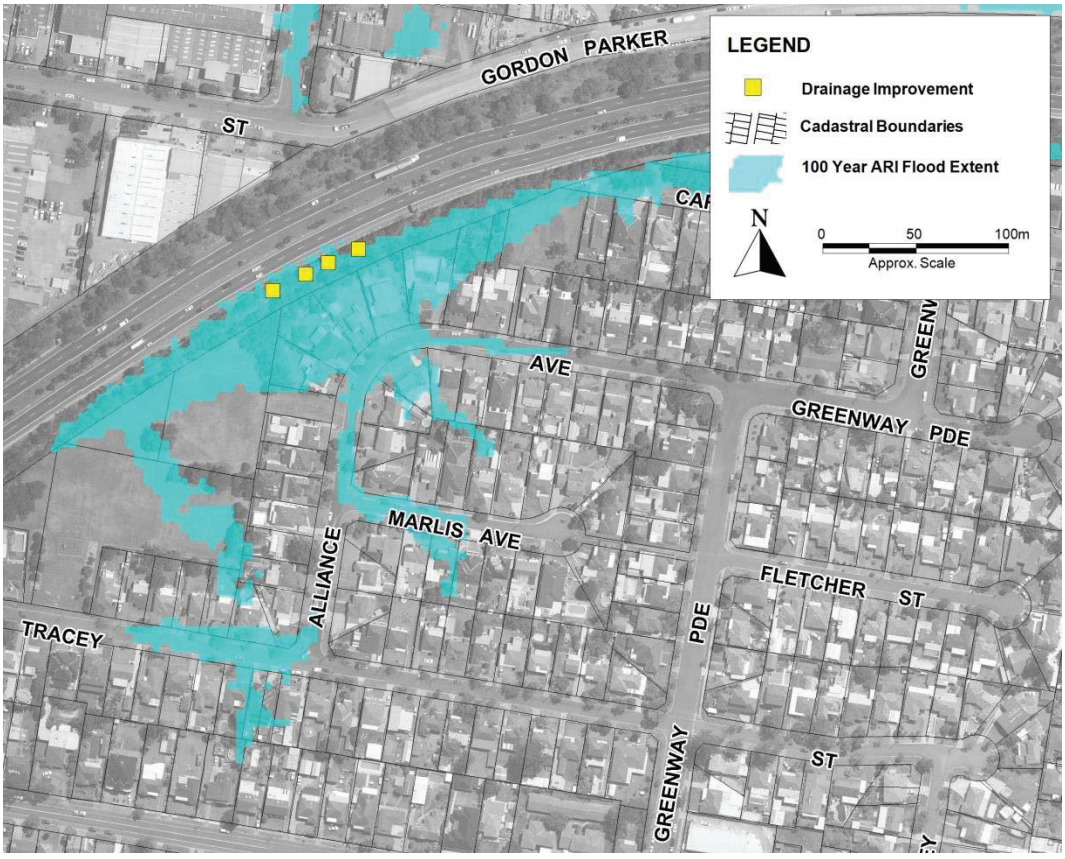


Figure 7-7 Proposed conveyance improvement works through the M5 Noise Wall at Tracey Street Reserve, Revesby

7.4.9 Increase the Size of the Culverts on Lucas Road Drain at Henry Lawson Drive, East Hills

7.4.9.1 Problem

Out-of-bank flooding from Lucas Road Drain results in flood risk to a number of properties immediately upstream of Henry Lawson Drive. Flooding also overtops Henry Lawson Drive, affecting transport along this route during times of flood.

Flood depths at properties are generally less than 0.5m for the 100 year ARI event. The property database indicates that 7 residential properties along Lucas Road Drain are inundated above floor level for the 100 year ARI event.

7.4.9.2 Option Description

This option would involve the construction of new larger capacity culverts under Henry Lawson Drive to improve conveyance along Lucas Road Drain.

Figure 7-8 provides a preliminary outline the extent of the engineering works required.

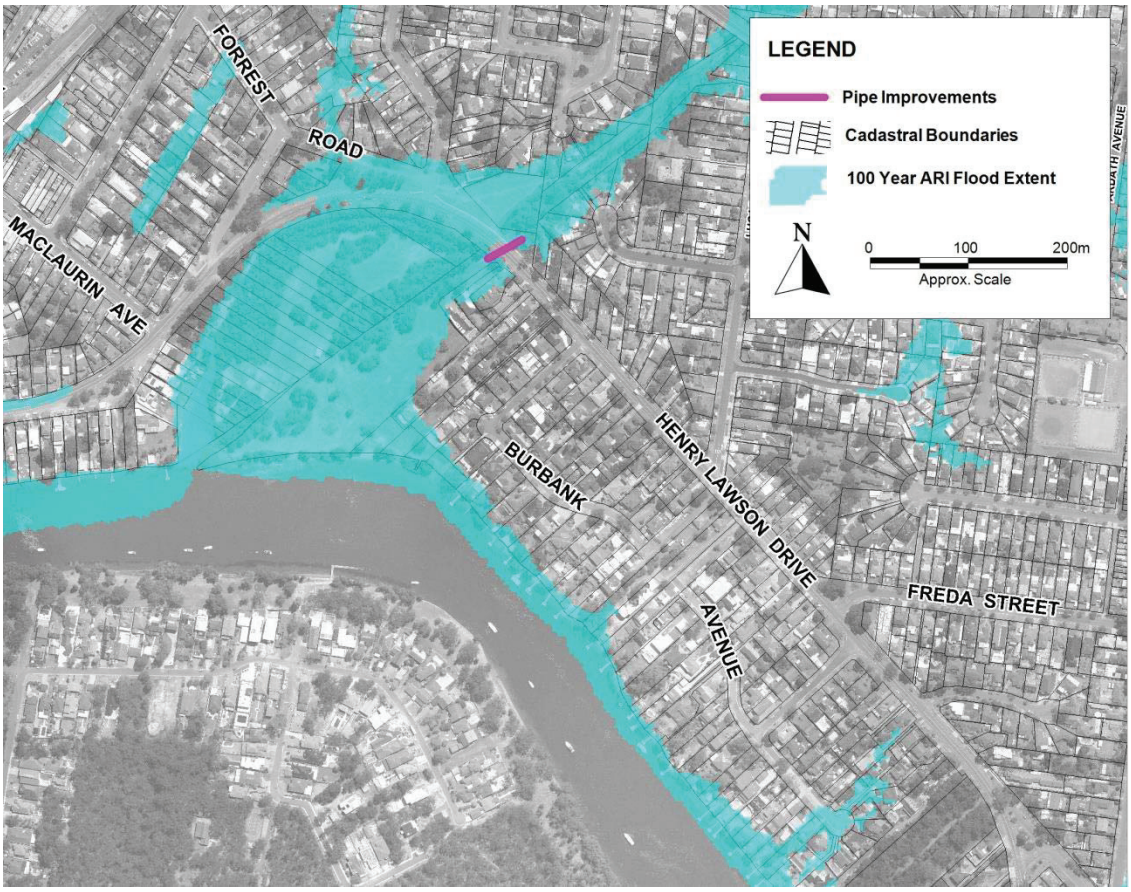


Figure 7-8 Proposed flood mitigation works on Lucas Road Drain at Henry Lawson Drive

7.4.9.3 Performance

Based on the flood model and damage assessment results, this option would reduce flood risk to 4 properties resulting in in a $30,500 reduction in AAD.

This option also reduces the flood risk to Henry Lawson Drive, with levels dropping by approximately 0.1 m for the 100 year ARI event resulting in water levels approximately 0.1 m deep on Henry Lawson Drive at Monash Reserve.

A limitation of such upgrades is the residual risk of flooding. There remains the residual risk of flooding as a result of potential blockages of culverts at Henry Lawson Drive.

It should also be noted that this location is subject to mainstream flooding from Georges River which has larger implications for flood evacuation. This is addressed in more detail in the 2004 Georges River FRMS&P.

7.4.9.4 Recommendation

Council should consult with RMS regarding upgrades to the culverts on Henry Lawson Drive as part of any planned works to upgrade this road. Financial responsibilities for upgrade works will need to be negotiated between Council and the RMS.

7.4.10 Construct a Flood Wall at Thomas Street, Picnic Point

7.4.10.1 Problem

Flooding occurs through a number of properties on Thomas Street, Picnic Point. Overland flooding from the upstream catchment spills along an overland flow path through properties before discharging into Morris Gully. With no dedicated overland flow path, properties are affected as the overland flow continues along the natural gully line with the majority of the flood damages at the point of discharge into Morris Gully at Thomas Street.

At this location, overland flow depths for the 100 year ARI event are generally less than 0.2 m. The property database indicates that 5 properties along Thomas Street are inundated above floor level for the 100 year ARI event.

7.4.10.2 Option Description

This option would involve the construction of a 100 m long flood diversion wall along the eastern boundary of the Picnic Point High School site and extending between No. 77 Thomas Street and No.85 Thomas Street. A 1 m high flood wall would provide protection to properties up to the PMF event. Figure 7-9 provides a preliminary outline of the extent of the engineering works required.

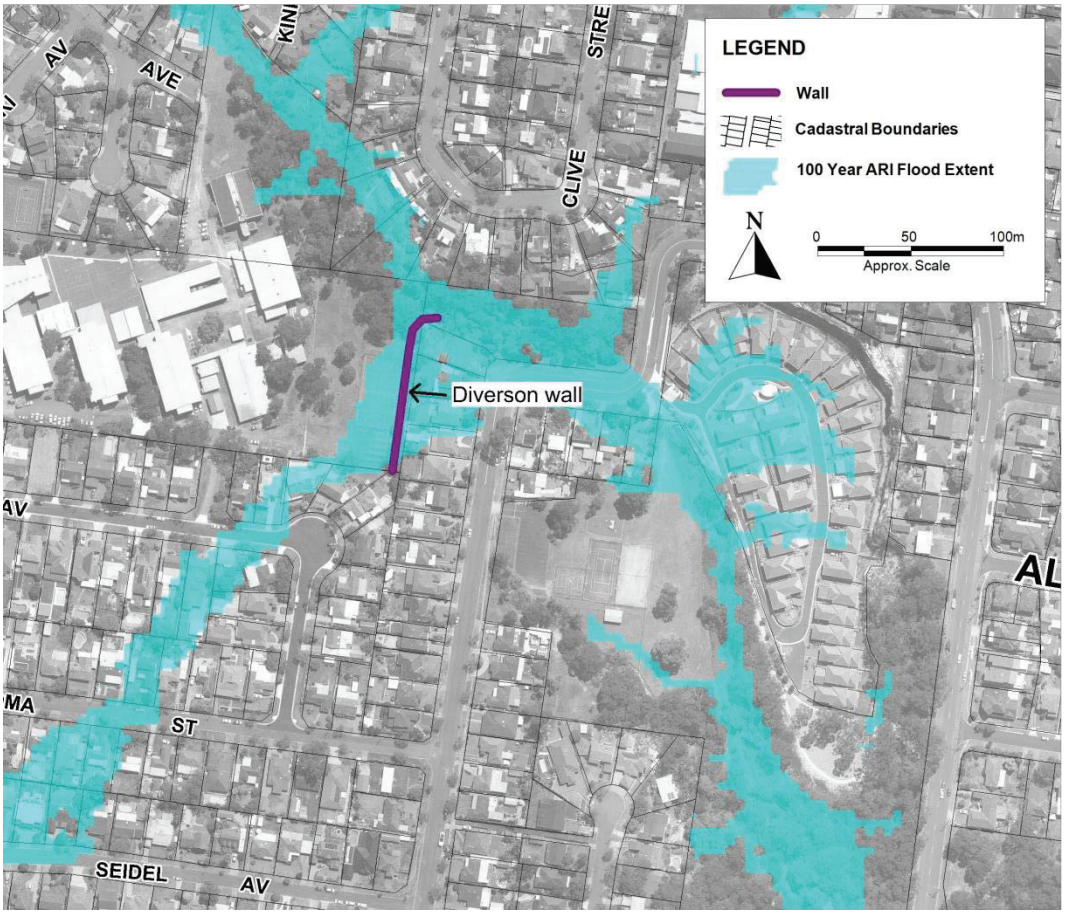


Figure 7-9 Proposed mitigation works at Thomas Street, Picnic Point

7.4.10.3 Performance

Based on the flood model and damage assessment results, this option would reduce flood risk to 5 properties resulting in in a $77,250 reduction in AAD.

7.4.10.4 Recommendation

It is recommended that Council pursues this option in consultation with local residents and the Department of Education.

7.5 Study Area Wide Floodplain Management Options

7.5.1 Planning Considerations

BMT WBM engaged GLN Planning to provide town planning input into the preparation of the Mid Georges River FRMS&P. A separate Planning Considerations Report (GLN Planning, 2015) has been prepared and provided separately to Council (included in Appendix D).

The purpose of this Planning Considerations Report is to:

- Outline and review the state and local planning policy context (including existing environmental planning polices and instruments and long term planning strategies for the area);

- Identify the planning issues associated with implementing a FRMS&P for the study area;
- Discuss options to address these planning issues; and
- Make recommendations for incorporation into the FRMP.

The planning recommendation focus on providing recommendations to inform:

- The Waterways Chapter of South West Local Area Plan (South West LAP);
- Bankstown Local Environmental Plan (LEP); and
- Part E3 of the Bankstown Development Control Plan (DCP) 2005 – Flood Risk Management DCP, particularly Schedules 3, 4A, 4B, 4C and 5.

Council's planning approach to flood risk management of riverine flooding was substantially developed through the preparation of the Georges River FRMP. This FRMP established the framework for Council's existing Development Control Plan (DCP) FRM provisions.

The Salt Pan Creek FRMP (Bewsher Consulting, 2013) built upon the framework established by the Georges River FRMP to formulate a FRM framework for overland flow flooding.

The Mid Georges River FRMS&P builds upon the framework established by the Georges River and Salt Pan Creek FRMPs and will not revisit the philosophical basis to the formation of these frameworks. The primary focus of the Planning Considerations Report was on overland flow flooding issues within the various sub-catchments and a review riverine flooding issues associated with the Carinya Road Area.

An outline of the suggested areas of focus for the planning component of the FRMS&P is provided in the following sections.

7.5.2 Strategic Planning Input

7.5.2.1 South West Local Area Plan

The South West Local Area Plan (LAP) provides a plan for the urban renewal and sustainable growth of Bankstown City's south-western suburbs. The plan has a particular focus on the Panania Small Village Centre and East Hills Neighbourhood Centre where much of the renewal and growth is expected to occur.

The above two centres are partly affected by overland flow flooding that should be capable of being managed in association with the redevelopment of properties. Redevelopment can also provide the opportunity to reduce existing flood risk to such properties. Appropriate controls for such development are effectively incorporated in the DCP controls recommended within the Salt Pan Creek FRMP. These recommended controls would also be sufficient to address infill development scattered across the Southwest local area precinct.

Should Council move towards a more prescriptive precinct approach to planning controls for these centres, then such a precinct should ensure that the overland flow paths are maintained.

7.5.2.2 Development Contributions

Bankstown City Council Section 94A Development Contributions Plan 2009 should be reviewed to consider whether any structural mitigation works identified by this FRMS&P (or others) should be funded (or partly funded) with S94A funds.

7.5.2.3 Climate Change

Flood maps have been prepared that depict flood extents which factor in climate change considerations (refer to Section 4.4 and Appendix C).

However, the current uncertainty associated with the impacts of climate change on overland flood risk as well the absence of any recent NSW Government direction, suggests the introduction of specific flood planning controls to address climate change are not warranted at this stage. While specific planning controls are not recommended, clear explanation needs to be provided with these maps as part of public consultation as to why these were prepared and their limited role at this stage of informing Council and the public of possible effects of climate change.

7.5.3 Review of Planning Controls

7.5.3.1 State Environmental Planning Policy (Exempt and Complying Development Codes 2008) Provisions

The State Environmental Planning Policy (SEPP) is divided into a number of “Codes” that deal with exempt development and different types of complying development. The relevant clauses of the Codes SEPP apply to “flood control lots”: The manner in which the exemption criteria and development controls apply to a flood liable land are summarised within Figure 7-10.

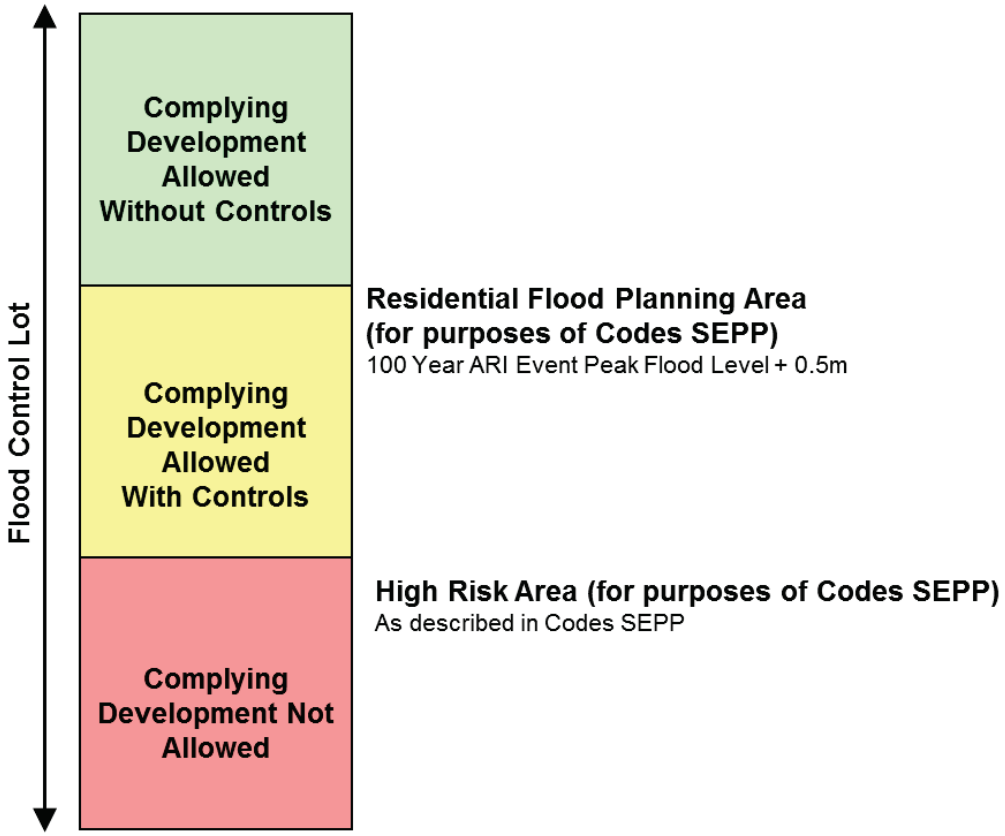
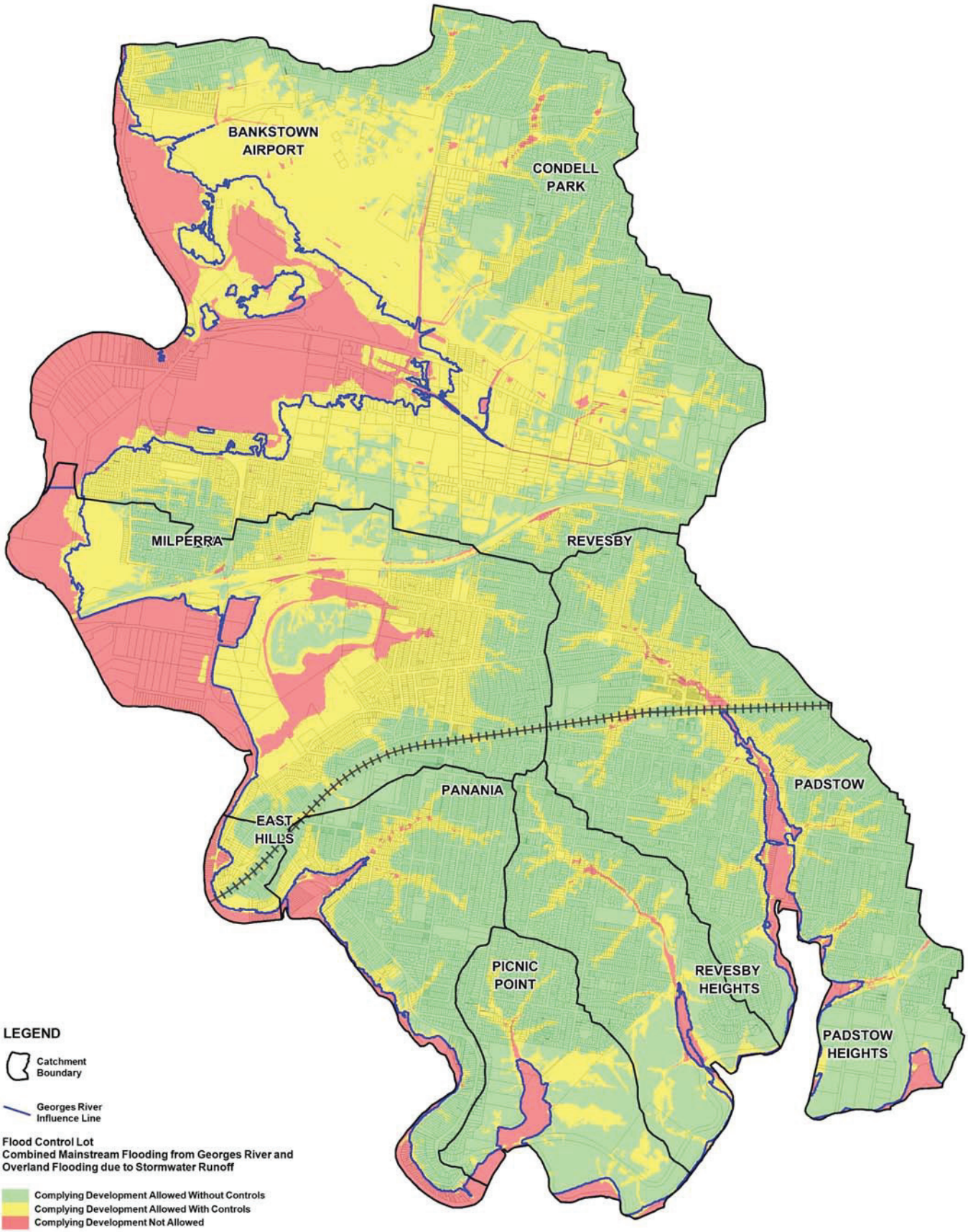


Figure 7-10 Application of the Codes SEPP to Flood Liable Land

The principal relevance of the FRMS&P to Codes SEPP is the identification of land for which Council could be confident is not subject to high flood risk (i.e. not part of a flood control lot which is a flood storage area, a floodway area, a flow path, a high hazard area or a high risk area). Where it can be confirmed that land is not subject to such high flood risk categorisations, development could be dealt with under the provisions of the Codes SEPP.

In order to a take a proactive role in informing private certifiers where the Codes SEPP should and should not apply, a Codes SEPP map has been prepared as part of this FRMS&P (Figure 7-11). This map identifies areas where Complying Development Certificates (CDC's) should be able to be issued. Where a CDC is issued is this area, the certifier will need to consult with Council in regard to minimum floor levels and ensure the development conditions in the Codes SEPP are complied with.



Title:

Codes SEPP for Flood Liable Land - Combined Mainstream Flooding from Georges River and Overland Flooding due to Stormwater Runoff

Figure:	Rev:
7-11	0

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.

N

0 0.75 1.5km

Approx. Scale

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7.5.3.2 LEP Provisions for Carinya Road Area

The review of LEP provisions needs to be considered in conjunction with the DCP provisions that relate to the Carinya Road area. There are fundamentally two directions that the planning controls could take:

1. Maintain the existing LEP 2015 zoning and subdivision standards and pursue minor refinements to the DCP provisions to effectively update the controls but maintain a similar level of stringency.

2. Amend the LEP zoning and subdivision standards to differentiate the Carinya Road area from other similarly zoned residential areas based on the flood risk and associated environmental qualities of the area and rely on the more generalised DCP controls that apply to the overall Georges River floodplain (i.e. Schedule 3). The more generalised DCP controls for the Georges River Floodplain would need to be amended to require the failsafe evacuation walkways.

It is recommended that the LEP 2015 adopt a zone for the Carinya Road area that prohibits those uses identified as undesirable in the current planning matrix (Schedule 4A) and contains objects that reflect the specific flooding and environmental constraints of the area. In this regard it is recommended to adopt the base Zone E4 Environmental Living zone from the Standard Instrument. The Zone E4 Environmental Living is a zone for land with special environmental or scenic values where residential development can be accommodated.

7.5.4 DCP Provisions

7.5.4.1 Schedule 5 Matrix Controls

As the Mid Georges River Catchment and Salt Pan Creek Catchment have similar characteristics, it is proposed that the replacement of Schedule 5 of the DCP that was recommended for Salt Pan Creek Catchment also apply to the Mid Georges River Catchment.

The principal elements of the updated Schedule 5 and changes from existing provisions are summarised as follows:

- An additional Flood Risk Precinct (FRP) is added to address areas affected by “Overland Flow”. This FRP will be excised from the Medium FRP and will apply to land inundated to depths of between 50mm and 250mm in a 100 year flood. Areas with inundation below 50mm would be adequately addressed by standard BCA considerations and the application of controls in the Low FRP.
- The separation of overland flow areas from the Medium FRP, allows for the introduction of the standard controls into this precinct without imposing excessive requirements on development that were affected by very shallow inundation in the 100 year ARI event that did not warrant controls designed to apply to main stream flooding.
- The freeboard for development, where applied in the Overland Flow FRP has been reduced from 500mm to 300mm.
- The controls in the catchments applying to land in the Overland Flow FRP are generally tailored to be reflective of the minor flood hazard.

7.5.4.2 Carinya Road Area

Consistent with the recommendations in Section 7.5.3.2, the change to the zoning controls to restrict further development potential would remove the need for the more stringent controls applying to the Carinya Road area under the DCP. Consequently, the DCP could be amended to delete the provisions of the DCP referring specifically to the Carinya Road area including in Clause 4.3.1, 4.3.2 and 4.3.3 of Part E and Schedules 4A, 4B and 4C.

The consequence of the above change to the DCP would be that dwelling houses within the Carinya Road area would be considered "potentially unsuitable land uses" but as the development would be permissible under the LEP 2015, each development application would be required to dealt with on a performance basis. However, it is recommended that Note 3 of Schedule 3 should be updated from its current wording to be consistent with Note 3 within the planning matrix recommended as part of the Salt Pan Creek FRMP, being:

Note 3. Unsuitable Land Uses: Uses identified as unsuitable will generally not be considered as a result of their overall incompatibility with flood risk and difficulty in addressing these risks without consequential unacceptable amenity or environmental impacts. Such uses may however be considered where they show compliance with the objectives and performance criteria of the DCP. In such cases, these uses will also need to comply with controls as specified by Council.

The consideration of individual development applications will include addressing issues such as evacuation, and it could be that this will result in elevated walkways, should that be the most acceptable means of addressing this consideration for any particular application. The New South Wales State SES has indicated their position on the elevated walkways has not changed since 2005. In response to resident submissions on flood related planning controls for Carinya Road (2005), the NSW SES supported Council in its' policy for improved flood egress conditions on new dwellings through the provision of elevated walkways.

7.5.5 Voluntary Purchase

The primary objective of voluntary purchase (VP) is to reduce risks to personal safety by purchasing properties located in areas subject to excessive hazard. A VP scheme is generally applicable only to areas where flood mitigation is impractical and the existing flood risk is unacceptable. Such measures can only be undertaken on a voluntary basis with the property owner. Post-purchase the property should be rezoned for flood compatible use.

The OEH guidelines for VP schemes notes that the identification of properties for VP should consider the true hazard assessment which looks at a range of factors that influence flood hazard including the size of flood, effective flood warning time, duration of flooding and evacuation problems.

One property has been identified as being at significant risk of flooding based on the true hazard assessment, namely KU Revesby Preschool on Sphinx Avenue, Revesby. The property is located on an overland flow path and is subject to the following flood hazards:

- Hydraulic categories map indicates that the property is located within a floodway;

- The flood risk precinct map indicates that the property is located within a within a High Flood Risk Precinct;
- Hydraulic model results indicate flood depths greater than 1m for the 100 year ARI event;
- The property usage poses an increased risk to life due to potential evacuation problems given the number and mobility of occupants (i.e. preschool children).

KU Revesby Preschool is a Council owned property and therefore cannot be listed for VP. It is recommended that Council cease leasing the premises for use as a preschool.

As an interim step, Council, under it duty of care, has advised the preschool of the flood hazards to allow for the preparation of a flood plan. It is recommended that Council consider rezoning the land for flood compatible use.

7.5.6 Flood Proofing

Flood proofing refers to the design and construction of buildings with appropriate water resistant materials such that flood damage is minimised should the building be inundated. Flood proofing is more effectively achieved during construction with appropriate selection of materials and design. Council's DCP already includes requirements for flood proofing of buildings for new development. However, there are a number of non-structural options that can be retrofitted to existing property to help reduce flood damage including changes to joinery and fittings, floor coverings and electrical services.

Given the generally shallow depth of overland flooding and potentially low economic feasibility of major stormwater drainage system upgrades, flood proofing is seen as an effective measure for much of the existing property constructed across natural overland flow paths. Flood proofing can often be done during building renovations, and at a relatively marginal additional cost.

It is recommended that Council consider the merits of establishing a voluntary flood proofing scheme for eligible properties. This scheme could be administered in a similar fashion to Council's voluntary house raising scheme. Information in the damage database could be used to identify eligible properties.

7.5.7 Voluntary Fence Modification

Fences in the floodplain can have a significant impact on overland flow behaviour. For instance fences can act to obstruct the free flow of floodwaters causing a local increase in flood levels upstream of the fence and potentially the creation of new overland flow paths. Excessive hydrodynamic loadings on a fence can also cause the fence to fail suddenly causing a surge in water downstream.

In both circumstances local flood levels can exceed those predicted by hydraulic models. However, it is currently not possible to accurately predict the performance of fences during flooding given the differences in fence type, structural condition and possible modes of failure.

Modifying fences to allow for the free flow of floodwaters is one method of reducing flood risk. This could be achieved by allowing a space beneath the bottom of the fence and the ground, creating vertical gaps, using offset palings or even using collapsible fencing. Section 5 of Part B12 of

Council's 2015 DCP already requires that any new fencing be designed and constructed such that it can withstand the forces of floodwaters as well as not increase flood risk on surrounding land. Fencing within high flood risk precincts also requires a development application.

To supplement these development controls, it is recommended Council consider establishing a voluntary fence modification scheme. The scheme would entail offering a subsidy to owners of selected properties to voluntarily modify their fences. Properties could potentially be selected in high hazard areas where a substantial proportion of flow passes through the private property, where the risk of over-floor flooding may be sensitive to the presence of fences and where other flood risk management options are not viable.

There are a range of issues that Council will need to be considered in determining the feasibility of a voluntary fence modification scheme. These include:

- identifying applicable properties and establishing appropriate eligibility criteria;
- determining the need for development consent, and consistency with the Dividing Fences Act 1991 and 2008 Code SEPP;
- determining an appropriate level of financial incentive that would generate interest and uptake by property owners, and how costs for development approval, construction and maintenance are to apportioned between Council and the property owner;
- assessing the potential for the scheme to attract ongoing financial support from the NSW Government's Floodplain Management Program;
- establishing the appropriate relationship (contractual or otherwise) between Council, the property owner and fencing contractor;
- determining the need for a positive covenant or similar under the Conveyancing Act 1919 to ensure the modified fence remains as built;
- determining the need for ongoing audits of properties with modified fencing;
- assessing the need for pilot project to confirm the viability of the scheme; and
- determining the staff resources required for establishing, administering, marketing and auditing the scheme.

7.5.8 Flood Forecasting and Warning

Flood forecasting involves the use of real time rainfall and river level data and forecast rainfall in flood models to forecast flow rates and water levels. Flood warning is an important component of flood forecasting and involves the dissemination of observed flood data and forecast flood data to relevant stakeholders and the public.

Section 6.4.2 provides details on the flood forecasting and warning services that currently exist within the study area. There is no formal flood warning service for overland flooding within the study area. The local overland flood catchments in the study area are typically small urban catchments where the response to flooding is rapid (often within an hour of heavy rainfall). This provides little opportunity to provide a warning of flooding based on rainfall that has already

occurred; to disseminate that warning to the public; and for the public to take appropriate action to reduce their exposure to the flood threat.

The amount of warning available for an approaching flood can have a significant impact on the risk to life. Less warning time clearly represents a greater risk to the community as there is less opportunity to respond appropriately and implement risk-reduction measures. Minimal warning time also means that emergency services are unlikely to be able to provide any assistance or direction for affected communities.

To assess flood warning opportunity for overland flooding in the study area, consideration has been given to the levels of warning times as defined in Table 7-5.

Table 7-5 Flood warning time categories

Category	Flood warning time	Description
No effective flood warning	<1 hour	No time for pro-active and systematic organisation of flood mitigation, evacuation, emergency response etc. Individuals would be self-directed in regards to emergency response.
Minimal flood warning	1-6 hours	Limited assistance and direction likely from emergency services. Measures requiring minimal time for implementation may be appropriate for flood management.
Moderate flood warning	6-12 hours	Potential assistance and direction from emergency services, depending on time of day. Measures requiring moderate time, or less, for implementation may be appropriate for flood management.
Good flood warning	12+ hours	Significant assistance and direction from emergency services may be available, including assistance with evacuation. Most measures requiring some form of on-demand implementation would be appropriate for flood management.

A flood warning system currently exists on Milperra Drain at Ashford Avenue as discussed in Section 6.4.2. There are opportunities to utilise the existing flood warning system to disseminate warnings to properties within the Milperra Industrial Area. A 'Minimal Flood Warning' (between 1-6 hours) is available for out of bank flooding from Milperra Drain at the Ashford Avenue gauge. Flood warnings would be issued based on appropriate trigger levels and rate of rise of flooding. The flood warnings would be issued to businesses within an appropriate zone of influence from the gauge. There are a number of flood warning dissemination technologies that could be applied which would need to be investigated as part of any detailed design. These technologies could include automated telephone dial out, SMS alerts and additional Flood Warning Signs.

Opportunities exist to enhance the flood warning on Georges River for residents within the Carinya Road area. The existing gauge telemetry at Kelso Levee could be utilised to provide accurate flood warnings to Carinya Road. The system would utilise the recorded flood level data at Kelso Levee to provide riverine flood warnings at Carinya Road based on correlating the recorded flood levels at

the Kelso Levee gauge with river levels at Carinya Road. As above, there are a number of flood warning dissemination technologies that could be applied, e.g. flood warning signs.

For the remaining locations, opportunities to provide an effective flood forecasting and warning service for overland flooding are reduced due to the available flood warning times. Advances in observed data collection methodologies, forecast rainfall products and recent developments in 2D flood models offers opportunities to use 2D flood models for operational flood forecasting and flood warning for overland flooding.

In order to get the most benefit from flood warnings, people in flood prone areas will need to know what, if any, effect the flood will have on their property and some knowledge of how best to deal with a flood situation. Sources of such information could include:

- Flood Bulletins/Warnings issued by the BoM and/or SES which often contain details of areas affected by flooding, road closures and other advice on what the community should do if they are likely to be flooded;
- Long term residents who may have experienced a similar flood in the past and remember how it affected them;
- Flood mapping available from Council showing areas likely or potentially inundated during significant overland flooding events; or
- Information leaflets specific to overland flood risk.

The majority of this information is currently available through existing resources, i.e. the BoM, Council and SES websites. Public awareness is also an important component in disseminating this data and is discussed in more detail in the following section.

7.5.9 Public Awareness

Raising and maintaining flood awareness provides residents with an appreciation of the flood problem and what measures can be taken to reduce potential flood damage and to minimise personal risk during future floods.

The basic objectives of a public awareness program are to:

- Make people aware they are living / working in a flood zone;
- Receiving, understanding and reacting to flood warnings; and
- Appropriate actions, e.g. protecting property, vehicular and pedestrian access during flood time.

Community awareness is an on-going process and there is also the inherent danger of complacency between flood events. There are numerous mechanisms to inform the community, with the following recommended to be incorporated in the Mid Georges River FRMP.

- Flood mapping availability (Council website). Consolidation of the flood mapping, flood data and flood damages database prepared during this FRMS into Council's computer based GIS system. This will provide Council with valuable flood information that can be easily retrieved, and which will form the basis of information that can be supplied to the public when requests are made, or on a periodic basis.

- Section 149 certificates or Flood certificates. Consideration could be given to providing information on the flood risk and the flood levels that apply to a particular property on a special flood certificate. These certificates could be:
  - Appended to the Section 149(5) certificates.
  - Provided whenever flood information is requested for a property.
  - Provided on a regular basis to all residents in the study area.
- Flood information page on Councils websites. This webpage can include for example, links to BoM rainfall and flood warning pages and a how to guide in understanding and reacting to flood warnings. This may be extended to other media including community newsletters/publications with Council providing regular input regarding flood awareness/preparedness.
- Installation of flood depth markers on roads affected by higher depth overland flows.
- Targeted consultations for people living/working in high risk areas. This would involve one on one meeting between Council/SES and residents. The consultation would provide site specific information on the flood risks and advice on actions during a flood event.

7.5.10 Emergency Response and Management

Emergency management operations are outlined in the Bankstown City Flood Emergency Sub Plan as discussed in Section 6.4.1. Information contained in the plan is largely derived via local knowledge, historical records and completed flood studies. The SES follows the Bankstown City Flood Emergency Sub Plan ,using information from flood intelligence and BoM's predictions, to respond in flood events.

For rapid onset of flooding such as may be experienced in an overland flood event within the study area, it would not be realistic to expect the SES to be able to undertake much in the way of emergency response for several reasons:

- The SES is principally a volunteer organisation and the time required to mobilise personnel could exceed the warning time available;
- A major flood event in the sub-catchments of the Mid Georges River may coincide with major flooding in other catchments within the Bankstown region further stretching already limited emergency response resources;
- Some of the principal roads within the region are cut in major floods making access difficult for mobilising or responding; and
- There is generally insufficient time to undertake tasks such as sandbagging or evacuation to reduce impacts on property or people.

For some overland flooding situations, the SES's role may be limited to assisting with recovery after the event. In the rapid onset of a flood, individuals and groups of people must essentially take appropriate actions to protect themselves. Occupants of premises within the flood prone areas should be encouraged to have private flood emergency response plans.

It is important that the Bankstown City Flood Emergency Sub Plan incorporates all relevant technical data and specific community vulnerabilities (including addresses of areas at highest risk) that have been determined through this FRMS and the overland flood studies. Provision of this data is particularly important with regard to those areas that are potentially subject to above floor flooding or where key transport routes are subject to closure.

A summary of the emergency response issues to be incorporated in the FRMP include:

- Update Bankstown City Flood Emergency Sub Plan in consultation with the SES. The updated plan will utilise information generated as part of the overland flood studies and this FRMS&P:
  - Design flood mapping
  - Property database and inundation statistics
  - Alert and warning levels at monitoring locations
  - Evacuation arrangements
  - Recovery plans
- Personal Flood Action Plans. In recognition of the potential for limited external support and requirement for self-help, these plans detail steps to prepare for a flood event, respond when a flood event occurs and recover after the flood event.

7.5.11 Stormwater Maintenance

Details of the existing drainage maintenance tasks undertaken by Council are provided in Section 6.2.9. One of the key findings from the community questionnaire was concern by residents the extent of maintenance of the stormwater drainage network. In addition, one of the most commonly raised community ideas for reducing flood problems focused on increasing maintenance of the stormwater network and channels, e.g. ensure drains and waterways are kept clear (refer to Chapter 3 and Appendix B for further information).

A review of Council's maintenance programs to inspect the stormwater drainage system and to clear leaves, debris or larger obstacles on a regular basis is recommended. The simple activity of using a mechanical sweeper to keep roadside kerbs clear of leaves on a frequent basis will reduce potential blockage problems and provide a visual reminder to residents of Council’s commitment to keep the stormwater system clear.

A significant measure that Council imposes to control runoff from new developments is the requirement for OSD as discussed in Section 6.2.8. It is recommended that Council implement a program that involves establishing a register of OSDs, checking to see if the OSD was constructed as per the design, education of owners about functionality and maintenance requirements, and performance monitoring of OSD’s within both public and private properties.

8 Draft Floodplain Risk Management Plan

8.1 Overview

The majority of overland flooding problems within the study area are as a result of past planning practices for development, and these problems have been compounded by lack of information on past flooding. In these instances, much of the older development has been undertaken without due consideration of natural drainage lines and appropriate provision for overland flow paths. Accordingly, many properties have been constructed across natural gully lines/overland flow paths, and in the instance where stormwater drainage system capacity is exceeded, excess flows are conveyed through property which in many areas results in property inundation.

The floodplain risk management study has considered a range of measures and options to minimise the adverse impact of flooding on existing property and future development. In addition to over-arching policy and study area wide floodplain risk management options, a number of flood modification options have also been considered for managing localised overland flooding issues in "hot-spot" areas.

This draft Plan forms the basis for further discussion with Council, the Floodplain Management Committee and the community, to consider further the recommended options in establishing a formal floodplain risk management plan for the Mid Georges River study area.

8.2 The Draft Plan

The draft Mid Georges River Floodplain Risk Management Plan has been developed to direct and co-ordinate the future management of areas affected by overland flooding in the Mid Georges River study area. The draft FRMP sets out a strategy of actions and initiatives that are to be pursued by agencies and the community in order to adequately address the risks posed by flooding. Development of the draft FRMP has been guided by the NSW Government's Floodplain Development Manual (DIPNR, 2005).

Completion of the study and ultimately adoption of the recommended FRMP represents a major step in ongoing floodplain risk management in the study area with a number of positive outcomes including:

- That a number of options have been identified and recommended that would alleviate some of the impacts of overland flooding on the community;
- Once adopted, the FRMP can provide access to funding for council and property owners to implement a number of recommended actions;
- The recommended actions will inform Council's capital works program; and
- The FRMP recommends further investigations that will require active community involvement and engagement.

8.3 Recommended Floodplain Management Options

The recommended floodplain risk management options are summarised in Table 8-1 together with details on what action need to be undertaken, responsibilities and a priority schedule. Figure 8-1 provides a layout of the proposed flood risk mitigation options.

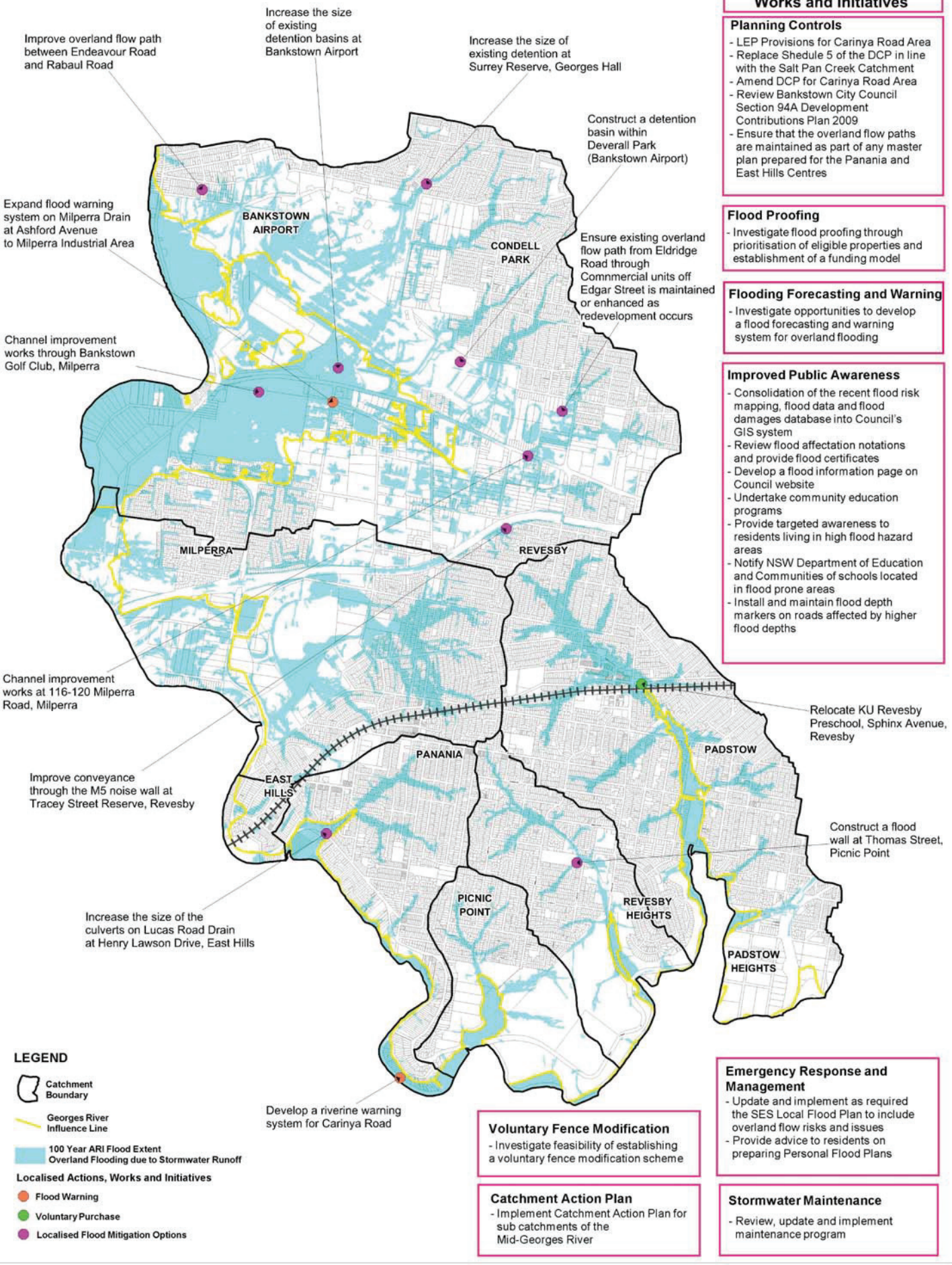
Table 8-1 Summary of recommended flood risk management options

Summary of Proposed Actions, Works and Initiatives	*Responsibility*	*Estimated Cost*	*Potential Funding Source*	*Priority*
Ensure that flooding is duly considered by current planning policy and future reviews				
Prepare a Planning Proposal to amend LEP 2015 for Carinya Road area - *Adopt an E4 Environmental Living zone for the Carinya Road area subject to development permitted with consent being extended to include environmental protection works, flood mitigation work, recreation area and roads. Note, the foreshore area including reserve, road and boatshed should remain separately zoned RE1 Public Recreation* - *Applying a minimum lot size of 1,000m² consistently across all existing housing lots.*	BCC	Staff Time	BCC	High
Replace Schedule 5 of the DCP in line with the Salt Pan Creek Catchment: - *Adoption of overland flow flood risk precincts (FRP)* - *Separation of overland flow areas from the Medium FRP* - *The freeboard for development, where applied in the Overland Flow FRP has been reduced from 500mm to 300mm*	BCC	Staff Time	BCC	High
Amend DCP for Carinya Road Area - *Amend the DCP to delete the provisions referring specifically to the Carinya Road area including in Clause 4.3.1, 4.3.2 and 4.3.3 of Part E and Schedules 4A, 4B and 4C. The general provisions relating to the Georges River would thereafter apply.*	BCC	Staff Time	BCC	High
Review Bankstown City Council Section 94A Development Contributions Plan 2009 - *Consider whether any structural mitigation works identified by this FRMS (or others) should be funded (or partly funded) with S94A funds.*	BCC	Staff Time	BCC	High
Ensure that the overland flow paths are maintained as part of any master plan prepared for the Panania and East Hills Centres	BCC	Staff Time	BCC	High
Ensure existing overland flow path from Eldridge Road through commercial units off Edgar Street is maintained or enhanced as redevelopment occurs.	BCC	Staff Time	BCC	High

Summary of Proposed Actions, Works and Initiatives	*Responsibility*	*Estimated Cost*	*Potential Funding Source*	*Priority*
Waterways and Water Quality Improvement Plan				
Implement Waterways and Water Quality Improvement Plan for sub catchments of the Mid Georges River - Georges River CZMP actions specific to study area - Planning and policy - On-ground works	BCC BCC BCC	 Refer to Georges River CZMP Staff Time $4,750,000	 BCC BCC BCC	 High High Medium
Flood Proofing				
Investigate flood proofing through prioritisation of eligible properties and establishment of a funding model	BCC	Staff Time	BCC/OEH	Low
Voluntary Fence Modification				
Assess feasibility of establishing a voluntary fence modification scheme	BCC	Staff Time	BCC/OEH	Medium
Flood Forecasting and Warning				
Expand flood warning system on Milperra Drain at Ashford Avenue to Milperra Industrial Area	BCC	$50,000	BCC/OEH	High
Develop a Riverine flood warning system for Carinya Road utilising existing gauge at Kelso	BCC	$50,000	BCC/OEH	Medium
Investigate opportunities to develop a flood forecasting and warning system for overland flooding	BCC	$10,000	BCC/OEH	Low
Improve Public Awareness				
Consolidation of the recent flood risk mapping, flood data and flood damages database into Council's GIS system.	BCC	Staff Time	BCC	High
Review flood affectation notations and provide flood certificates to residents	BCC, OEH	Staff Time	BCC, OEH	High
Expand on the flood information page on Council website	BCC, SES, OEH	Staff Time	BCC, OEH	High
Undertake ongoing community education programs	BCC, SES, OEH	$30,000	BCC, OEH	High
Provide targeted awareness to residents living in high flood hazard areas	BCC, SES	$10,000	BCC, OEH	High
Notify NSW Department of Education and Communities of schools located in flood prone areas	BCC	Staff Time	BCC	High
Install and maintain flood depth markers on roads affected by higher flood depths	BCC	$20,000	BCC, OEH	High
Emergency Response and Management				
Update and implement as required the Bankstown City Flood Emergency Sub Plan to include overland flood risks	SES	$20,000	BCC, OEH	High

Summary of Proposed Actions, Works and Initiatives	*Responsibility*	*Estimated Cost*	*Potential Funding Source*	*Priority*
Provide advice to residents on preparing Personal Flood Plans	SES/BCC	$10,000	BCC, OEH	High
Stormwater Drainage Network				
Review, update and implement stormwater drainage maintenance program	BCC	Staff Time	BCC	High
Implement a program for monitoring performance of OSD's	BCC	Staff Time	BCC	High
Localised Flood Mitigation Options				
Increase the size of existing detention at Surrey Reserve, Georges Hall - *Undertake feasibility and design* - *Implement as part of any future upgrades to the park at Surrey Reserve*	BCC	$25,000	BCC, OEH	Medium
Improve overland flow path between Endeavour Road and Rabaul Road - *Liaise with residents regarding issues* - *Provide advice to residents on enhancing overland flow path via a voluntary fence modification scheme*	BCC	Staff Time	BCC, OEH	High
Undertake channel improvement works at 116-120 Milperra Road, Milperra - *Consult with RMS regarding proposed solution* - *Pursue opportunities to improve channel conveyance as part of any future road upgrades to Milperra Road.*	BCC - consultation RMS – design / Construction	$925,000	BCC, OEH, RMS	Low
Increase the size of existing detention basins at Bankstown Airport - *Consult with BAL regarding proposed solution* - *Undertake further analysis on the feasibility of detention basins in Bankstown Airport in consultation with BAL*	BCC - consultation BAL – feasibility / design / construction	$1,900,000	BAL	Low
Construct a detention basin within Deverall Park, Bankstown Airport - *Consult with BAL regarding proposed solution* - *Undertake a detailed feasibility into developing a flood detention basin in Deverall Park in consultation with BAL*	BCC - liaison BAL – feasibility / design / construction	$2,600,000	BCC/OEH	Medium
Undertake channel improvement works through Bankstown Golf Club, Milperra - *Develop detailed designs* - *Implement works*	BCC	$1,400,000	BCC/OEH	High

Summary of Proposed Actions, Works and Initiatives	*Responsibility*	*Estimated Cost*	*Potential Funding Source*	*Priority*
Improve conveyance through the M5 noise wall at Tracey Street Reserve, Revesby - *Consult with RMS regarding proposed solution* - *Implement works*	BCC – consultation RMS – design / construction	$20,000	RMS	High
Increase the size of the culverts on Lucas Road Drain at Henry Lawson Drive, East Hills - *Consult with RMS regarding proposed solution* - *Pursue opportunities to replace culverts on Henry Lawson Drive as part of future road upgrades*	BCC – consultation RMS – design / construction	$600,000	RMS	Low
Construct a flood wall at Thomas Street, Picnic Point - *Liaise with residents* - *Implement works*	BCC	$110,000	BCC/OEH	High



Catchment Wide Actions, Works and Initiatives

Planning Controls
- LEP Provisions for Carinya Road Area
- Replace Shedule 5 of the DCP in line with the Salt Pan Creek Catchment
- Amend DCP for Carinya Road Area
- Review Bankstown City Council Section 94A Development Contributions Plan 2009
- Ensure that the overland flow paths are maintained as part of any master plan prepared for the Panania and East Hills Centres

Flood Proofing
- Investigate flood proofing through prioritisation of eligible properties and establishment of a funding model

Flooding Forecasting and Warning
- Investigate opportunities to develop a flood forecasting and warning system for overland flooding

Improved Public Awareness
- Consolidation of the recent flood risk mapping, flood data and flood damages database into Council's GIS system
- Review flood affectation notations and provide flood certificates
- Develop a flood information page on Council website
- Undertake community education programs
- Provide targeted awareness to residents living in high flood hazard areas
- Notify NSW Department of Education and Communities of schools located in flood prone areas
- Install and maintain flood depth markers on roads affected by higher flood depths

Emergency Response and Management
- Update and implement as required the SES Local Flood Plan to include overland flow risks and issues
- Provide advice to residents on preparing Personal Flood Plans

Voluntary Fence Modification
- Investigate feasibility of establishing a voluntary fence modification scheme

Catchment Action Plan
- Implement Catchment Action Plan for sub catchments of the Mid-Georges River

Stormwater Maintenance
- Review, update and implement maintenance program

Title:
Recommended Floodplain Management Plan

Figure: 8-1

Rev: 0

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.

N

0 0.75 1.5km

Approx. Scale

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8.3.1 Planning Controls

Land use planning and development controls are key mechanisms by which Council can manage flood affected areas with the Mid Georges River study area. These controls could maximise the compatibility of new developments with flood risk and allow for existing flooding issues to be gradually reduced over time as re-development takes place.

A summary the suggested recommendations relating to planning controls are as follows:

- Any master plan prepared for the Panania and East Hills Centres should ensure that the overland flow paths are maintained;
- Bankstown City Council Section 94A Development Contributions Plan 2009 should be reviewed to consider whether any structural mitigation works identified by this FRMP (or others) should be funded (or partly funded) with S94A funds.
- Climate change flood risk associated with overland flow flooding does not warrant the introduction of specific planning controls at this stage. The decision to apply planning controls to address climate change flood risks should be based on broader policy considerations undertaken an LGA wide basis.
- The FRMP should endorse the recommendations of previous FRMPs (Georges River FRMP and Salt Pan Creek FRMP) regarding the format and content of the Bankstown LEP 2015. The LEP 2015 generally reflects these recommendations and is supported other than as stated below:
- Prepare a Planning Proposal to amend LEP 2015 to:
    - Adopt an E4 Environmental Living zone for the Carinya Road area subject to development permitted with consent being extended to include environmental protection works, flood mitigation work, recreation area and roads. Note, the foreshore area including reserve, road and boatshed would be separately zoned RE1 Public Recreation.
    - Applying a minimum lot size of 1,000m² consistently across all existing housing lots.
- Adopt the DCP changes for overland flow flooding that have been recommended as part of the Salt Pan Creek FRMP.
- Delete the provisions of the DCP referring specifically to the Carinya Road area including in Clause 4.3.1, 4.3.2 and 4.3.3 of Part E and Schedules 4A, 4B and 4C. The general provisions relating to the Georges River would thereafter apply to this area.

8.3.2 Waterways and Water Quality Improvement Plan

The Mid Georges River WWQIP identifies opportunities for improving stormwater movement and managing stormwater pollutants through a series of recommended actions (refer to Chapter 9 for further information). The FRMP recommends that actions, works and initiatives identified in the WWQIP are implemented.

The Mid Georges River WWQIP identified that the Georges River CZMP actions were relevant for incorporation into the WWQIP. Further information on the estimated costs for implementing the

CZMP actions is in the Georges River CZMP (BMT WBM, 2012). A number of additional actions were also identified to assist to achieve the aims and objectives of the CZMP and the Mid Georges River WWQIP. These additional actions have been integrated into the existing aims and best management options adopted from the CZMP and include policy recommendations and on-ground works. The estimated costs of implementing these additional actions are $4.75 million.

8.3.3 Relocation

KU Revesby has been identified as being at significant risk of flooding based on a true hazard assessment. KU Revesby Preschool is a Council owned property and it recommended that Council cease leasing the premises to the preschool with the aim to have the preschool relocate to an alternate location.

It is recommended that Council consider rezoning the land for flood compatible use. A change in land use provides opportunities to improve the conveyance along the over land flow path through the removal of obstructions at the railway culvert inlets.

The total estimated cost of this option is $0.8 million and has been assigned a high priority for implementation given the risk to life posed at this location. The option is considered to have some minor social impacts with the relocation of school children to alternative accommodation. The option provides opportunities for environmental enhancement by returning developed land to park land.

As an interim step to completing the relocation, Council, under it duty of care, has advised the preschool of the flood hazards to allow for the preparation of a flood plan for the school.

8.3.4 Flood Proofing

Given the generally shallow depth of overland flooding and potentially low economic feasibility of major stormwater drainage system upgrades, flood proofing is seen as an effective measure for much of the existing property constructed across natural overland flow paths.

It is recommended that the majority of costs for this option are borne by the home owners as part of building renovation works. It is recommended that Council given consideration to establishing a funding model to provide some financial support to eligible properties in undertaking flood proofing. Information in the damage database could be used to identify eligible properties.

The option is considered to have negligible social and environmental impacts and has been assigned a low priority.

8.3.5 Flood Forecasting and Warning

It is recommended that Council expand the existing flood warning system on Milperra Drain to provide flood warnings to commercial businesses with the Milperra Industrial Area. Flood warnings would be issued based on appropriate trigger levels and rate of rise of flood levels in Milperra Drain. The flood warnings would be issued to businesses within an appropriate zone of influence from the gauge. Appropriate flood warning trigger levels and approaches for dissemination warnings would need to be investigated as part of any detailed design. The estimated cost of this

option is $0.05 million and is considered a high priority given the extent and frequency of flooding and the availability of existing flood warning telemetry.

It is recommended that Council pursue opportunities to improve flood warnings for Georges River flooding at Carinya Road. The existing gauge telemetry at Kelso Levee could be utilised to provide more accurate flood warnings to Carinya Road. Appropriate flood warning trigger levels and approaches for dissemination warnings would need to be investigated as part of any detailed design. The estimated cost of this option is $0.05 million and is considered a medium priority given the adequacy of the existing warning services provided for this area.

As data collection methodologies, forecast rainfall products and 2D flood models advance, there will be opportunities to use 2D flood models for operational flood forecasting and flood warning for overland flooding. It is recommended that Council explore opportunities for developing an overland flood forecasting and warning system as technologies advance.

These options are considered to have positive social impacts through improved awareness of flooding in the community. The option is not considered to have any environmental impacts.

8.3.6 Improved Public Awareness

There are numerous mechanisms to inform the community and the following actions are recommended:

- Consolidation of the flood mapping, flood data and flood damages database prepared during this FRMS into Council's computer based GIS system.
- Provide information on the flood risk and the flood levels that apply to a particular property on a special flood certificate. These certificates could be;
  - Appended to the Section 149(5) certificates.
  - Provided whenever flood information is requested for a property.
  - Provided on a regular basis to all residents in the study area.
- Expand on the existing flood information page on Councils website by providing material on flood awareness and preparedness.
- Undertake ongoing community education programs to remind the community of the flood risks and measures to reduce the flood risk.
- Notify NSW Department of Education and Communities of schools located in flood prone areas. The NSW Department of Education and Communities requested this information so a Flood Plan can be prepared for the schools in question.
- Install and maintain flood depth markers on roads affected by higher depth overland flows. These markers would provide flood hazard information based on the depth of flooding. The markers would be located along Milperra Road, Henry Lawson Drive (Monash Reserve, Lambeth Reserve and Yeramba Lagoon), The River Road at Sphinx Avenue and Uranus Road at the Little Salt Pan Creek crossing.

- Provide targeted consultations for people living/working in high risk areas. This would involve one on one meeting between Council/SES and residents to provide site specific information on the flood risks and advice on actions during a flood event.

The total estimated costs to implement all of the actions, works and initiatives identified for an improved public awareness campaign is $0.06 million. These actions have been assigned a high priority as they provide an effective tool in highlighting the flood risks to the community at a relatively low cost. These options are considered to have positive social impacts through improved awareness of flooding in the community. The option is not considered to have any environmental impacts.

8.3.7 Emergency Response and Management

Information generated as part of this FRMS, including flood mapping and the flood damages database provides a valuable dataset on which to update the Bankstown City Flood Emergency Sub Plan for overland flooding issues within the study area. Whilst this is normally the responsibility of the SES, assistance could be offered through the Floodplain Management Committee to assist in the development and review of the Bankstown City Flood Emergency Sub Plan.

In recognition of the potential for limited external support and requirement for self-help associated in an overland flood event, it is recommended that households prepare Personal Flood Plans. These plans are undertaken to determine steps to prepare for a flood event, respond when a flood event occurs and recover after the flood event.

The total estimated cost to implement emergency response actions, works and initiatives is $0.03 million. These actions have been assigned a high priority as they provide an effective tool in managing the flood risk to the community. These options are considered to have positive social impacts through both improved awareness and management of flooding. The option is not considered to have any environmental impacts.

8.3.8 Stormwater Maintenance

One of the more dominant issues raised by the community as part of the community consultation related to the perceived lack of maintenance by Council to keep the stormwater system clear of leaves and other rubbish. A review of Councils maintenance program for the study area is recommended. It is also recommended undertaking regular street sweeping to help reduce blockage problems.

The option is considered to have a high priority. The option will have a positive social impact by providing the community with a visual reminder of Councils commitment to maintaining the stormwater system. The option is not considered to have any environmental impacts.

8.3.9 Voluntary Fence Modification

Modification of fences to allow for the free flow of floodwaters is considered to be a potentially cost-effective option particularly in areas such as Endeavour Road, Georges Hall, where other structural flood mitigation options are not cost-effective. It is recommended that Council commence investigating the feasibility of establishing a voluntary fence modification scheme, in consultation with OEH.

The initial assessment of the feasibility of the scheme will require staff time. The possible costs of the scheme and it social and environmental impacts can be assessed if and when the scheme is determined to be feasible.

8.3.10 Localised Flood Mitigation Options

8.3.10.1 Increase the Size of Existing Detention at Surrey Reserve, Georges Hall

This option would involve increasing the existing detention storage in the park by raising the footpath along the southern boundary of the park. This option would be combined with improvements to the covered pit located within the park to convert it to an outlet flow control structure.

The cost of the works is estimated to be $0.025 million. No environmental issues were identified and the option would reduce flood risk to 3 properties providing positive social benefits. The option has been assigned a medium priority and it is recommended that Council pursue it as part of any future upgrades to the park at Surrey Reserve.

8.3.10.2 Improve Overland Flow Path between Endeavour Road and Rabaul Road

Flooding occurs through a number of properties on Endeavour Road. Flooding accumulating at a sag point on Endeavour Road activates an overland flow path through properties on Endeavour Road. With no dedicated overland flow path, properties are affected as the overland flow continues along the natural gully line southwards to Rabaul Road and into Bankstown Airport land. Flooding is exacerbated by boundary fences and building located along the overland flow path. Overland flow depths for the 100 year ARI event are generally less than 0.25m.

Given the relatively shallow flow depths, the property database indicates no flood damages to properties at this location for the 100 year ARI event. It is noted that although brick walls and fences could significantly affect local overland flood flow paths through these properties, these have not been explicitly incorporated into the flood model, and were instead considered in the setting of appropriate land use roughness values. Recent flood events indicate that these local features affect the flood depth and property flooding at this location.

The ponding effect in the sag point and activation of the overland flow path can only be removed if sufficient drainage system capacity is provided. Increasing the capacity of the drainage network in this location is however not cost-effective due to the lengths of pipe required, downstream channel constraints and that flood modelling indicates very little reduction in flood levels from the drainage upgrade. There is also the residual risk of flooding as a result of larger events exceeding the design capacity and through potential blockages of the system.

The option of increasing the capacity of the culvert underneath Rabaul Road just to the west of the intersection with Tower Road / Link Road, and establishing an open channel connection to the existing open channel on BAL land, was investigated. Modelling revealed only minor reductions in flood levels which were constrained to the immediate vicinity of Rabaul Road.

Given these constraints, it is recommended that Council explore the option of voluntary fence modification with local property owners in order to improve overland flow path. Given the frequency of flooding, this has been assigned a high priority. The option is not considered to have any

environmental impacts and would provide some social benefits through reduced risks and inconveniences associated with flooding.

8.3.10.3 Channel Improvement Works at 116-120 Milperra Road, Milperra

Flooding within the Milperra Industrial Area affects a large number of commercial properties. An assessment of the feasibility of reducing flood risk from a tributary of Milperra Drain at Condell Business Park was undertaken. This option would involve the removal of vegetation, the widening of a channel and the replacement of existing structures with new larger capacity structures. A low flood embankment would also be constructed along the left bank of the channel.

The estimated costs of these works are relatively high at $0.93 million. The assessment of economic benefits for this option indicates a Benefit Cost Ratio (BCR) of 2.6. The majority of the costs are driven by the need to replace the culverts under Milperra Road. As the option is relatively ineffective without improvements to the size of the culverts under Milperra Road, it is recommended that this option is pursued of as part of future upgrades to Milperra Road. This option has been assigned a medium priority. It is assumed that construction costs for the culvert replacements on Milperra Road would be borne by RMS with the remaining works potentially funded by Council/OEH.

There are potential environmental impacts with this option associated with the engineering works to widen and deepen the existing channel. These environmental impacts would need to be assessed as part of the detailed design. The option would reduce flood risk to commercial properties providing social benefits through reduced risks and inconveniences associated with flooding.

8.3.10.4 Increase the Size of Existing Detention Basins at Bankstown Airport

This option would involve increasing the size of the existing detention basins north of McDonald's, Milperra Road and south of the roundabout on Nancy Ellis Leebold Drive to mitigate the impacts of development at Bankstown Airport on flood levels at Milperra Road.

The estimated costs of this option are relatively high at $1.9 million and would be borne by BAL. The option reduces flood risk to Milperra Road however, it does not eliminate the flooding issues on Milperra Road and does not reduce flood risk at any properties. It is recommended that further analysis is undertaken on the feasibility of this option given the benefits provided. The option is considered a low priority.

No environmental issues were identified with this option. The option would reduce flood risk to Milperra Road providing social benefits through improved transport access during times of flood.

8.3.10.5 Construct a Detention Basin within Deverall Park, Bankstown Airport

This option would involve the development of a detention basin at Deverall Park, Bankstown Airport, through the construction of a dam embankment, outlet control structure and a spillway structure. The detention basin would reduce flood risk to commercial buildings within the Milperra Industrial Area.

The estimated costs of this option are relatively high at $2.6 million and would potentially be funded through OEH and Council. The assessment of economic benefits for this option indicates a BCR of 0.95. This option has been assigned a medium priority.

There are potential environmental issues with this option associated with bushland adjacent to Deverall Park. It is zoned an “Environmental Protection Zone” and is protected from clearing. The option would reduce flood risk to commercial properties providing social benefits through reducing risk and inconveniences associated with flooding.

It is recommended that Council progress with a detailed feasibility into the viability of this option in consultation with BAL.

8.3.10.6 Channel Improvement Works through Bankstown Golf Club, Milperra

Council has recently tendered (December 2015) for the investigation and Design of Milperra Drain Widening Scheme. The option would help reduce the flood risk along Milperra Drain and provide benefits to the commercial areas within the Milperra Industrial Area. It is recommended that Council pursue this option through to construction and it has been assigned a high priority.

The estimated costs of this option are high at $1.4 million and would potentially be funded through OEH and Council. The assessment of economic benefits for this option indicates a BCR of 2.2.

There are potential environmental impacts with this option associated with the extensive engineering works to widen and deepen the channel. These environmental impacts would need to be assessed as part of the detailed design. The option would reduce flood risk to Milperra Industrial Area providing social benefits through reducing inconveniences associated with flooding.

8.3.10.7 Improve Conveyance through the M5 Noise Wall at Tracey Street Reserve, Revesby

This option would involve the provision of improved conveyance through the M5 noise wall at the north-eastern corner of Tracey Reserve to reduce flood risk to properties on Alliance Avenue. The flooding is exacerbated by the M5 noise wall which impounds water within the park.

The estimated costs of this option are low at $0.02 million. The assessment of economic benefits for this option indicates a BCR of 6.7. It is assumed that construction costs for the works would be borne by RMS. The option has been assigned a high priority given the limited works required to achieve a reduction in flood risk

No environmental issues were identified with this option. The option is considered to provide social benefits through reducing risk and inconveniences associated with flooding.

8.3.10.8 Increase the Size of the Culverts on Lucas Road Drain at Henry Lawson Drive, East Hills

Out of bank flooding from Lucas Road Drain results in flood risk to a number of properties immediately upstream of Henry Lawson Drive. Construction of new larger capacity culverts under Henry Lawson Drive improves the conveyance along Lucas Road Drain and reduces the flood risk to properties.

The estimated costs of these works are relatively high at $0.6 million which is driven by the expenses of undertaking works on Henry Lawson Drive. The assessment of economic benefits for this option indicates a BCR of 0.75. It is recommended that this option is pursued of as part of any planned works to upgrades to Henry Lawson Drive and has therefore been assigned a medium priority. It is assumed that construction costs for the works would be borne by RMS.

No environmental issues were identified with this option. The option is considered to provide social benefits through reducing risk and inconveniences associated with flooding.

8.3.10.9 Construct a Flood Wall at Thomas Street, Picnic Point

A flood wall to the rear of properties off Thomas Street will prevent overland flooding to a total of 5 residential properties.

The estimated costs of these works are relatively low at $0.1 million. The assessment of economic benefits for this option indicates a BCR of 10 indicating significant economic benefits.

It is recommended that Council pursue the development of this option in consultation with the local residents as a high priority.

No environmental issues were identified with this option. The option is considered to provide social benefits through reduced inconveniences associated with flooding.

8.3.10.10 Ensure Existing Overland Flow Path from Eldridge Road through Commercial Units off Edgar Street is Maintained or Enhanced

As part of any future developments with the commercial area off Edgar Street, Council need ensure that the existing overland flow path is maintained or enhanced. This is considered a high priority.

8.4 Plan Funding and Implementation

The next steps in progressing the floodplain risk management process from this point includes:

- Public exhibition of the draft Floodplain Risk Management Study and Plan;
- Review of comments/submissions received and amendments as considered appropriate;
- Adoption by Council following recommendation from the Floodplain Management Committee;
- Determination of program of works for responsible authorities based on overall priority, available funds and other constraints;
- Implementation of the Plan proceeds as funds become available in line with established priorities.

The total cost for implementing the Floodplain Management Plan is estimated at $13.45 million and represents relatively large financial implications for Council and other responsible authorities. This is largely as a result some large capital works being recommended.

The timing of the implementation of recommended measures will depend on overall budgetary commitments of Council and the availability of funds from other sources. Many of the Plan components can be implemented progressively over the next 12 months with few barriers, particularly those elements requiring Council staff time only which may be undertaken within

normal Council operations and budget. It is envisaged that the remainder of the Plan, particularly the structural options investigations, would be implemented progressively over a 1 to 5 year time frame.

There are a variety of sources of potential funding that could be considered to implement the FRMP. These include:

1. Council funds;
2. Section 94 contributions;
3. State funding for floodplain risk management measures through the Office of Environment and Heritage;
4. State Emergency Service, either through volunteered time or funding assistance for emergency management measures;

State funds are available to implement measures that contribute to reducing existing flood problems. Funding assistance is likely to be available on a 2:1 (State Council) basis. Although much of the FRMP may be eligible for Government assistance, funding cannot be guaranteed. Government funds are allocated on an annual basis to competing projects throughout the State. Measures that receive Government funding must be of significant benefit to the community. Funding is usually available for the investigation, design and construction of flood mitigation works included in the FRMP.

8.5 Review of Plan

The plan should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change can include new flood events and experiences, legislative change, alterations in the availability of funding, or changes to local planning strategies.

Ongoing monitoring and review of plan progress & success should be undertaken regularly. In broad terms the review should identify:

- the strategies that have been implemented;
- a measure of the relative performance of implemented measures
- review of the appropriateness of the strategy; and,
- if necessary, required modifications in the FRMP to define a more desirable/achievable outcome.

The strategies that are outstanding, reasons for delay in implementation if relevant, revision of the FRM to reflect alternate timeframe for implementation.

9 Waterways and Water Quality Improvement Plan

9.1 Overview

As part of the FRMS&P for the sub-catchments of the Mid Georges River a Waterways and Water Quality Improvement Plan (WWQIP) was developed. The Mid Georges River WWQIP was undertaken to characterise water movement and stormwater pollutants through the Mid Georges River study area to gain a better understanding of the key pressures, identify opportunities for improvement and recommend an action plan for Council to implement.

The Mid Georges River WWQIP is summarised below. A separate report has been prepared and provided separately to Council (included in Appendix EF).

9.2 Description of Study Area

The Mid Georges River study area is a highly urbanised catchment that drains directly to the Georges River and in turn Botany Bay. As such, it has a notable influence on the water quality and health of one of Sydney's most significant waterways.

Existing water quality and waterway health across the catchment is regularly monitored by the Georges River Combined Councils Committee River Health program with results indicating poor waterway conditions. Of particular note is Little Salt Pan Creek, which most recently received an overall river health grade of D+ which falls into the lowest grade condition indicating very poor waterway health.

9.3 Strategic Planning Context

A review of Bankstown planning documents has shown that the Bankstown Community values the environment and views their waterways as having great importance. This is reinforced through the vision outlined in the Bankstown Community Plan 2023 which makes reference to wanting clean waterways and pristine bushland (Bankstown City Council, 2013). One of the five key strategic directions of the Community Plan is "Green" – to be a sustainable city that respects its natural environment. The Community Plan identified the following community aspirations (shown in quote) for a green city.

> "The community wants clean waterways, healthy green corridors and to produce a smaller environmental footprint. The community also wants Bankstown to be leader in environmental protection and management. Protecting waterways and environmental education are areas in which the Community wants further investment"
>
> (BCC, 2013)

To assist in meeting these community aspirations the Georges River Estuary Coastal Zone Management Plan (CZMP) and the Mid Georges River WWQIP will be key strategic documents for Bankstown City Council.

The development of the Mid Georges River WWQIP involved close consideration of the CZMP. As sub-catchments from the Mid Georges River drain directly to the Georges River Estuary, the aims and management options formulated by the CZMP form an integral component for management of the Mid Georges River study area. As such, the CZMP aims and best management options (actions) have been adopted as the basis for the development of the Mid Georges River WWQIP. The aims of the CZMP and the Mid Georges River WWQIP are shown in Table 9-1.

Table 9-1 CZMP and Mid Georges River WWQIP aims and objectives (adapted from BMT WBM, 2012)

Aim Being Addressed	Objective
Water Quality	Reduce the volume & pollutant load of stormwater runoff through the study area
	Improve the performance of sewer overflows
	All greenfield and redevelopments should have a minimal negative impact on flow and water quality, meeting targets for water quality proposed in the Botany Bay WQIP
	Strive to protect undeveloped areas of the broader study area that act as a buffer to water quality
	Minimise the negative impacts of new and existing commercial operations in the study area and estuary on flow and water quality
	Minimise build-up of gross pollutants and illegal dumping of waste into and along the estuary foreshore and waterways
Bank Erosion and Sedimentation	Reduce the extent and severity of bank and foreshore erosion while minimising the impacts on estuary health
	Reduce the causes and impacts of sedimentation in the estuary
Aquatic and Riparian Habitat	Protect and improve the extent and condition of estuarine and riparian vegetation
	Minimise the cause and spread of invasive species in aquatic and terrestrial habitats

9.4 Identification and Assessment of Opportunities

The Mid Georges River WWQIP has identified and assessed a range of opportunities for improving water quality conditions in the study area and recommended a prioritised action plan for Council to implement. In addition, existing fish barriers within the study area were identified and an existing case water balance has been developed.

The recommended actions from the CZMP are included in the WWQIP, however they have been reviewed and assessed to remove actions that are;

- Primarily related to coastal management (rather than catchment management), and
- Not relevant to the Mid Georges River study area.

In addition the relevant CZMP actions, a number of additional actions were identified that assist in achieving the aims and objectives of the CZMP and the Mid Georges River WWQIP. Key opportunities investigated in the development of the Mid Georges River WWQIP include:

- Retrofit of Water Sensitive Urban Design (WSUD) measures; and
- Policy implementation measures to ensure new development pollutant loads meet the Botany Bay Water Quality Improvement Plan (BBWQIP) water quality targets.

Retrofit of WSUD measures throughout the study area will greatly assist in optimising water quality within the Georges River Estuary and its tributaries in addition to helping achieve a key study area objective, that is reduce the volume and pollutant load of stormwater runoff through the study area.

WSUD retrofit options investigated included; bioretention, swales, gross pollutant traps (GPTs) and revegetation. Opportunities were evaluated and prioritised based on a triple bottom line assessment. A priority list of options was developed and is shown in Table 9-2.

Table 9-2 WSUD retrofit prioritised actions

Prioritised Actions	WSUD Type
Deverall Park Bioretention Basin	Bioretention
Revesby Preschool Bioretention Basin	Bioretention
Grace Avenue Bioretention Basin	Bioretention
Surrey Reserve Bioretention Basin	Bioretention
Pollutant Control Device (PCD) 5 - Lucas Road 1 (upstream)	GPT
Pollutant Control Device (PCD) 4 - Amberdale Avenue / Reserve	GPT
Pollutant Control Device (PCD) 19 - Daisy Street	GPT
Pollutant Control Device (PCD) 9 - Virginius Street (Virginius Reserve)	GPT
Montgomery Reserve Creek Filtration	Swale
Park Road Raingarden	Bioretention
Pollutant Control Device (PCD) 8 - Neptune Street	GPT
Pollutant Control Device (PCD) 17 - Newland Reserve	GPT

9.5 Scenario Testing

In addition to WSUD measures, future development across the study area was investigated to test the affect policy changes would have on pollutant loads. A key management action recommended by the Georges River Estuary CZMP and the Botany Bay WQIP is the incorporation of pollutant load reduction targets in Council planning controls (such as Development Control Plans and Local Area Plans) to ensure WSUD is applied where practicable to all future infill and greenfield developments.

To identify the extent of this management action, future development areas in the study area were identified to include; LAP zoning changes (The River Road Area, Revesby Village Centre, Panania Small Village Centre and East Hills Neighbourhood), the Bankstown Airport development and Riverlands Golf Club development.

Where possible, the performance of future proposed management actions in improving water quality was assessed using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC).

The following management actions (MA) were assessed using MUSIC in a future 'mitigated' scenario:

- MA2: Implementation of best practice load reduction targets to future development in the study area (redevelopment and greenfield)
- MA3: WSUD retrofit opportunities identified in this investigation, including all potential locations identified for green infrastructure and proposed new GPTs.

9.6 Predicted Management Outcomes

A summary of the predicted treatment performance of these management actions on total study area pollutant loads is shown in Table 9-3.

Table 9-3 Predicted treatment performance of Management Actions on Study Area Pollutant Loads

Pollutant	Existing Scenario (kg/yr)	Future Unmitigated Scenario (kg/yr)	Future Mitigated Scenario (kg/yr)	Study Area Load Reduction (kg/yr)	Study Area Load Reduction (%)
Total Suspended Solids (TSS)	1,698,932	1,903,072	1,388,800	514,272	27.0%
Total Phosphorus (TP)	3,045	3,374	2,748	626	18.5%
Total Nitrogen (TN)	23,004	25,541	22,230	3,311	13.0%
Gross Pollutants (GP)	283,715	305,753	223,550	82,203	26.9%

As can be seen, these management actions can achieve a significant reduction in the study area pollutant loads, with predicted loads less than the existing scenario pollutant loads. Consequently, this is likely to result in improvements to the existing state of receiving water quality and waterway health. The relative contribution of each management action (i.e. MA2 and MA3) in achieving these results is also presented in Figure 9-1.

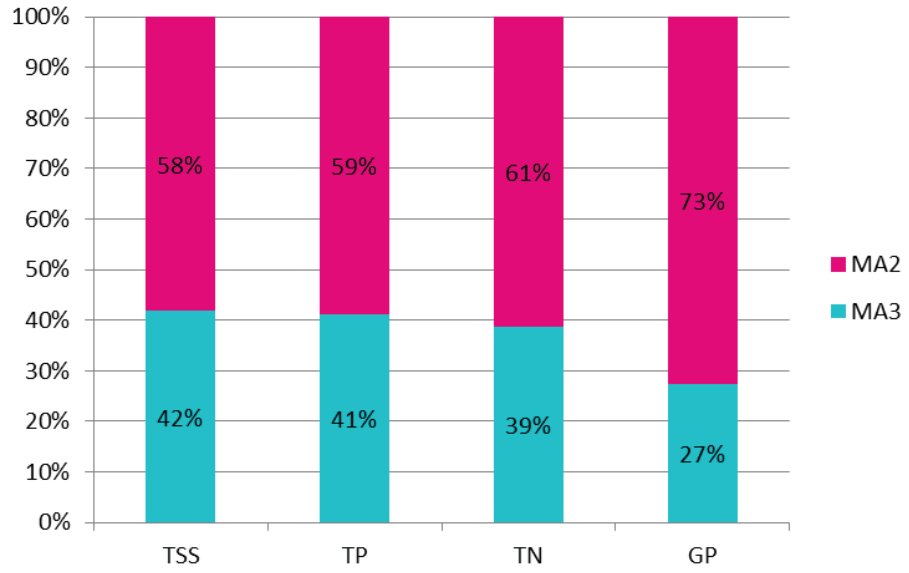


Figure 9-1 Contribution of management actions to predicted future pollutant load reductions

Figure 9-1 shows that a large proportion of the predicted treatment is achieved due to action MA2. This indicates that ensuring best practice load reduction targets are applied to all future development / redevelopment in the study area is of high importance.

It is important to note that while the study identifies the largest potential reduction in the study area pollutants loads from applying water quality controls on future development, the time it takes to see these benefits will depend on the redevelopment rate in the study area. Hence an effective strategy for improving water quality in the study area would be to focus on targeting WSUD retrofit throughout the study area in the interim and as opportunities arise.

All of the actions (CZMP and WWQIP) have been prioritised and integrated into a single action plan. The plan is presented in Appendix F.

10 Acknowledgements

This study has been carried out by BMT WBM Pty Ltd with the assistance of GLN Planning. Financial assistance through the State Floodplain Management Grant program, complemented by Council funding support, has made this document possible. The assistance of the following in providing data and/or guidance to the study is gratefully acknowledged:

- Councillors and Council staff from Bankstown City Council;
- NSW Office of Environment and Heritage;
- State Emergency Service; and
- The Floodplain Risk Management Committee.

Finally, we wish to thank the community who have willingly contributed to discussions and voiced their concerns, opinions and support throughout the whole process.

11 References

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12 Glossary

annual exceedance probability (AEP)	AEP (measured as a percentage) is a term used to describe flood size. It is a means of describing how likely a flood is to occur in a given year. For example, a 1% AEP flood is a flood that has a 1% chance of occurring, or being exceeded, in any one year. It is also referred to as the '1 in 100 year flood'.
average annual damages (AAD)	The damage that would be expected to occur each year from flooding if averaged over a very long period of time.
Average recurrence interval (ARI)	Average Reccuance Interval is a term used to describe flood size. It is a means of describing how likely a flood is to occur in a given year. For example, a 100 year ARI event is a flood that has a 1 in 100 chance of occuring or being exceeded in any given year. It is also referred to as the '1 in 100 year flood'. The ARI terminology has been used primarily in this document.
100 year ARI	There is a 1 in 100 (or 1%) chance that a flood of this size or bigger will occur in any year (sometimes called the 1 in 100 year flood)
1% AEP flood	There is a 1% (1 in 100) chance that a flood of this size or bigger will occur in any year (sometime called the 1 in 100 year flood).
Australian Height Datum (AHD)	National survey datum corresponding approximately to mean sea level. All floor levels, flood levels and ground levels in this study have been provided in m AHD.
attenuation	Weakening in force or intensity
catchment	The catchment at a particular point is the area of land that drains to that point.
continuing risk	The risk remaining after all management works and initiatives have been implemented. This is the risk that people just have to live with, and therefore it must be at an acceptable level
design flood	A hypothetical flood representing a specific likelihood of occurrence (for example the 100 year ARI flood).
development	Existing or proposed works that may or may not impact upon flooding. Typical works are filling of land, and the construction of roads, floodways and buildings.

discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m3/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).
existing risk	Flooding risks that affects existing development
flood	Any significant flow within channel or waterway as well as concentrated overbank flow or temporary storage / ponding of water resulting from rainfall within local catchments, or backwater inundation from elevated downstream waters Local street drainage is not considered a flood in the context of this report.
flood awareness	An awareness of flooding that may encompass an understanding of flood history, types of flooding, flood behaviour and flood risk. Flood awareness tends to decrease in the times between floods.
flood behaviour	The pattern / characteristics / nature of a flood.
flood fringe	Land that may be affected by flooding but is not designated as floodway or flood storage.
flood hazard	The potential for damage to property or risk to persons during a flood. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.The degree of flood hazard varies with circumstances across the full range of floods.
flood level	The height of the flood described either as a depth of water above a particular location (eg. 1m above a floor, yard or road) or as a depth of water related to a standard level such as Australian Height Datum (eg the flood level was 2.6m AHD).
flood liable land	see flood prone land
floodplain	Land susceptible to flooding up to the Probable Maximum Flood (PMF). Also called flood prone land. Note that the term flood liable land now covers the whole of the floodplain, not just that part below the flood planning level.

floodplain risk management study	Studies carried out in accordance with the Floodplain Development Manual (DIPNR, 2005) that assesses options for minimising the danger to life and property during floods. These measures, referred to as 'floodplain risk management measures / options', aim to achieve an equitable balance between environmental, social, economic, financial and engineering considerations. The outcome of a Floodplain Risk Management Study is a Floodplain Risk Management Plan.
floodplain risk management plan	The outcome of a Floodplain Risk Management Study, which provides specific implementation details on actions, works and initiatives to improve floodplain risk management.
flood risk precinct	An area of flood liable land that has been given an assigned level of flood risk, often for the purposes of development control and flood awareness.
flood planning levels (FPL)	The combination of flood levels and freeboards selected for planning purposes, as determined in Floodplain Risk Management Studies and incorporated in Floodplain Risk Management Plans. The concept of flood planning levels supersedes the designated flood or the flood standard used in earlier studies..
flood prone land	Land susceptible to inundation by the Probable Maximum Flood (PMF) event. Under the merit policy, the flood prone definition should not be seen as necessarily precluding development. Floodplain Risk Management Plans should encompass all flood prone land (i.e. the entire floodplain).
flood storage	Floodplain area that is important for the temporary storage of floodwaters during a flood.
flood study	A study that investigates flood behaviour, including identification of flood extents, flood levels and flood velocities for a range of flood sizes.
floodway	Those areas of the floodplain where a significant discharge of water occurs during floods. Floodways 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	A factor of safety usually expressed as a height above the adopted flood level thus determing the flood planning level. Freeboard tends to compensate for factors such as wave action, localised hydraulic effects and uncertainties in the design flood levels.
future risk	Flooding risks that will affect future development, once built

high flood hazard	For a particular size flood, there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.
hydraulics	The term given to the study of water flow in rivers, estuaries and coastal systems.
hydrology	The term given to the study of the rainfall-runoff process in catchments.
local environmentyal plan (LEP)	A enviromental planning instrument stipulated under Part 3 of the Environmental Planning and Assessment Act 1979 that is prepared by councils and approved by NSW Government. The LEP provides the framework for the appropriate use and development of land within a local government area.
low flood hazard	For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.
m AHD	metres Australian Height Datum (AHD).
m/s	metres per second. Unit used to describe the velocity of floodwaters.
m^3/s	Cubic metres per second or 'cumecs'. A unit of measurement for creek or river flows or discharges. It is the rate of flow of water measured in terms of volume per unit time.
merit approach	A flexible approach to flood policy that operates at both a site-specific and strategic level. The approach advocates for proposed developments on the floodplain to be assessed on their merits but still based on certain planning and development principles. The approach also recognises the need to balance social, economic, ecological and cultural factors when formulating options for floodplain management.
net present value	The discounted benefits minus the discounted costs of a project or activity. The project or activity is worth undertaking if the NPV is positive.
overland flow path	The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Floodwaters travelling along overland flow paths, often referred to as 'overland flows', may or may not re-enter the main channel from which they left; they may be diverted to another water course.

peak flood level, flow or velocity	The maximum flood level, flow or velocity that occurs during a flood event.
probable maximum flood (PMF)	The largest flood likely to ever occur, many times larger than the 1% AEP. The PMF represents extreme flooding conditions and defines the extent of flood prone land or flood liable land, that is, the floodplain. The PMF is primarily used in the management of Risk to Life. Whilst it can potentially occur, it has a very low chance of occurring.
probability	A statistical measure of the likely frequency or occurrence of flooding.
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment. Reducing the propobability of flooding reduces the risk while increasing the consequences, increases the risk.
risk to life	Flooding risks that threaten life. This is the worst type of flood risk
risk to property	Flooding risks that threaten to damage property
runoff	The amount of rainfall from a catchment that actually ends up as flowing water in the river or creek.
stage – damage curve	Graphed curves that relate the actual and potential flood damage to a property and its contents based on the depth of flooding above a defined level, typically the floor level. Stage-damage curves are derived for different property types such as urban residential, commercial, rural, etc.
topography	The shape of the surface features of land
velocity	The term used to describe the speed of floodwaters, usually in m/s.
water level	See flood level.

Appendix A Summary of Community Consultation

A.1 Community Questionnaire and Newsletter

A.1.1 During Earlier Studies

During earlier stormwater flood study investigations, six of the seven Mid Georges River sub catchments included in this study underwent community consultation. Between July 2006 and October 2010, letters and questionnaires were sent to residents in the Milperra, Kelso Swamp, East Hills, Picnic Point, Lucas Road, and Morris Gully sub-catchments that were identified as likely to be affected by local overland catchment flooding in a 100 year ARI flood event. The letter provided information about the study, and invited residents to participate by responding to the questionnaire. The questionnaire sought information on past floods in the sub-catchments, flooding issues of concern, and ideas on reducing existing flood problems. The key issues raised by residents in these questionnaires included:

- Overpopulation of area with inadequate drainage and sewerage;
- Underground drainage capacity;
- Time it takes for floodwaters to drain following heavy rain;
- The existing condition of stormwater infrastructure and vegetation including blockages;
- The levels of stormwater network maintenance (including creeks) and effect on network performance;
- The potential for siltation of rivers and creeks and the impact on flood levels;
- The direct impact of flooding on individual residents' properties;
- Flooding of Monash Reserve, East Hills and Lambeth Reserve, Picnic Point;
- Regular flooding at the end of Samoa Avenue in the reserve;
- Repeated rupturing of a pipeline at the corner of Forrest and Park Road, East Hills;
- Requests for additional information on the Kelso levee;
- The current state of retaining walls;
- Undertaking development before flood studies are completed;
- Need for appropriate development controls; and
- Whether recent drain improvements have been incorporated in the flood models.

The most commonly raised community ideas for reducing flood problems focused on:

- Improve and upgrade stormwater infrastructures and drainage;
- Increased stormwater network maintenance, e.g. ensuring drains and waterways are clear;
- Ensuring property drainage is properly connected to the stormwater system;
- Investigate areas when flooding issues occur;
- Planting additional trees and vegetation to reduce overland flows;

- Controls to limit runoff through retention and increased infiltration;
- Encourage residents to harvest rainwater to reduce catchment runoff;
- Distribute flood information from previous events within the property and for property boundaries;
- Extend and upgrade retaining walls, particularly along Morgan's Creek;
- Carry out a mortar repair of old retaining walls;
- Expanding the area protected by the Kelso levee;
- Regular maintenance of the Kelso levee to ensure it provides the desired level of protection; and
- Dredging silted reaches of the Georges River.

A.1.2 During The Current Study

In October 2013, landowners, residents and businesses within the Mid Georges River study area that were identified as being within the medium flood risk precinct were sent a letter, study information sheet and questionnaire. The letter invited residents to participate in the study via the questionnaire by providing information on past floods in the catchment, flooding issues of concern, and ideas on reducing existing flood problems.

The key issued raised by residents in these questionnaires included:

- Ongoing development in flood prone areas (particularly at Riverlands Golf Course, Bankstown Airport and M5 Motorway);
- Overpopulation of areas with inadequate drainage and sewerage;
- The adequacy of development controls in considering flooding impacts;
- Identification and notification of potential affected properties;
- Impact of the study outputs on property resale value and insurance premiums;
- How residents can prepare for, and minimise the impact of flooding on their property;
- Stormwater network blockages (by vegetation and rubbish) and maintenance;
- Impact of creek vegetation on flooding;
- Cost to Council of completing the study;
- Impact of Georges River flooding;
- Impact of Kelso levee and floodgates; and
- Impact of sewer overflows during heavy rainfall events;

The most commonly raised community ideas for reducing flood problems focused on:

- Improve and upgrade stormwater infrastructure and drainage;

- Increased stormwater network maintenance, e.g. ensuring drains and waterways are kept clear;
- Apply appropriate development controls in flood prone areas;
- Provide flood information to properties likely to be affected by flooding;
- Implement structural measures e.g. retention ponds, levees, pollution traps, creek widening, flow diversions and flood walls;
- Dredge silted reaches of the Georges River.
- Implement vegetation management to minimise blockages;
- Increase pervious areas, and
- Educate the community to avoid the disposal of litter to the drainage network.

A.2 Liaison with Stakeholders

A number of stakeholders have assets, infrastructure and interests within the Mid Georges River study area. In August 2013, a personalised letter and accompanying information leaflet, mapping booklet and survey was sent to a total of 25 stakeholders. The stakeholders issued with the information were comprised of relevant government departments, community groups and associations, private enterprises and public utilities. All organisations that were liaised with are detailed in Table A-1.

Table A-1 Stakeholder Consultation Contacts

Organisation	Attention
A.G.L. Gas Company	Manager, Planning
Bankstown Airport Limited	Colin Grove, CEO
Bankstown Bushland Society	Officer in Charge
Bankstown Golf Club	The General Manager
Bankstown Historical Society	Officer in Charge
Bankstown Trotting Recreational Club	Shane Scanlon-Keevers
Bureau of Meteorology	Mr Gordon McKay
Endeavour Energy	Manager, Planning
Energy Australia	Network Planner
Energy Australia	Manager, Planning
Georges Hall Progress Association	Mrs Senia Robey
Integral Energy Australia	Network Planner
Interlink Roads Pty Ltd	J. Lindoy - Asset Planning Manager
Milperra and District Progress Association	The Secretary
NSW Business Chamber - Sydney South West Region	Michelle Caruso - Regional Manager
NSW Dept of Education & Communities	Peter Riordan – Deputy Director-General Corporate Services

Organisation	Attention
NSW Dept of Primary Industries (Fisheries)	Carla Ganassin - Conservation Manager
NSW Police Force - Revesby Police Station	David Small - Chief Inspector
NSW Roads and Maritime Services	Strategic Planning Manager
Rail Infrastructure Corporation	Manager, Planning
Revesby Workers' Club	The Secretary
Riverwood Golf Club	The General Manager
State Emergency Service (Sydney Southern Region)	Divisional Controller
State Rail Authority	Manager, Planning
Sydney Water Corporation Ltd	Mark McGowan – Wastewater Product Team Leader
TransGrid (head office)	Manager, Planning

A.3 Community Information Sessions

A.3.1 Community Information Sessions in November/December 2013

From the community questionnaire issued as part of this study, a total of 163 individuals indicated that they wished to attend a community information session. Additional requests to attend the information sessions were also made directly to Council. Council contacted the interested individuals and registered 78 to attend an information session, of which 51 attended. In addition 3 individual requests to attend an information session were received after all the information sessions were completed. A total of 15 feedback forms were received from the community information sessions. A summary of the issues raised in the community information sessions are provided below:

Understanding Flooding and its Impacts:

- **Overland Flooding:** several residents had difficulty understanding how they could be found to be flood affected given their distance from the Georges River and/or not having any flooding experienced in the past.
- **100 year flood event:** several residents had difficulty understanding the 100 year flood event as a 1% probability and not something that can occur only once in 100 years or an experienced historical event.
- **Property Value and Insurance Premiums:** several residents were concerned about the impact of the flood studies on their property re-sale value and insurance premiums.
- **Property Flooding Impact:** several residents requested information on how their specific property would be impact by the 100 year flood event and the floodplain risk management study and plan.
- **Flood Preparation:** A resident asked how the 100 year flood event can be adequately prepared for if it hasn't been experienced in our lifetime.

Floodplain Risk Management Study and Plan:

- **Flood Modelling Methodology:** A resident inquired about Council's involvement in the flood modelling approach. Several residents also inquired as to how rainfall patterns, climate change and future development are considered. A resident also inquired about the 100 year flood level and if this would change from previous studies.
- **"Hot-Spot" Areas:** A resident inquired as to whether flooding hot spots areas had been identified and if so how they were identified.
- **Flood Management Options:** A resident inquired as to whether a list of priority options was already developed as part of the study and if further community consultation would be undertaken. A resident also inquired as to how Georges River flooding is being addressed. Residents inquired if widening the Kelso swamp channel, downstream reaches of Milperra drain or Little Salt Pan Creek would be options. A resident was concerned about the implications of using sporting fields for flood detention on the sporting clubs which use them. A resident noted their objection to any infilling of water retention areas/swamp lands due to anticipated flooding implications.
- **Rainwater Tanks:** A resident inquired as to whether rainwater tanks could potentially be used to reduce flooding. Another resident suggested a rainwater tank subsidy be provided as an incentive for people with homes in the flood zone.
- **Project Completion & Future Funding:** Several residents inquired as to when the floodplain risk management study would be completed and if funding for the proposed works would be provided by the state government.

Specific Catchment Concerns:

- **Kelso Levee:** A resident was concerned about flooding occurring when the Kelso levee floodgates are closed and noted frequent flooding of the upstream sports grounds.
- **Picnic Point Weir:** A resident was concerned about the impact of the picnic point weir on flooding.
- **Georges River Dredging:** A resident asked if dredging of the Georges River had stopped due to contaminated sediment issues.
- **Drainage Network Blockages and Cleaning:** Residents were concerned about blockages of the drainage network and inquired about Council's cleaning program. Residents suggested preventative maintenance to be carried out on a scheduled basis and following heavy rainfall. Several residents were concerned about the open channel running from Marion St to Rabaul Rd, Bankstown in particular. A resident also suggested placing a mesh grill over drainage inlets to prevent blockages. Residents also suggested Council review the vegetation species planted along drainage lines as some are known to produce significant amounts of leaf litter.
- **Little Salt Pan Creek Reserve:** A resident recommended Council continue armouring the creek banks and widen the creek through Little Salt Pan Reserve, Padstow Heights to provide additional flood storage. The resident was concerned past filling of the reserve reduced its flood storage capacity. The resident also recommended replacing the old telegraph pole car barriers

along Centaur St with bollards, similar to those placed along Virginius St, to prevent the barriers being carried away by floodwaters.

- **Water Quality:** A resident requested water quality issues be considered for the local drainage network.

Development and Planning Issues:

- **Ongoing and Previous Development:** Numerous residents were concerned about the impact of ongoing development on flooding. Residents were concerned about the increase in paved surfaces (in particular duplex developments), noting that size of existing street drainage pipes has not increased. Residents were concerned the development approval process may not be considering impacts on flooding. Residents wanted to know more about the development approval process and also when the process came into place. Several residents also inquired as to why development has/is taking place on flood prone land. Some residents would also like to see Council consider possible future large scale developments in its flood studies.
- **Riverlands Golf Course Redevelopment**: Numerous residents were concerned about the potential rezoning of Riverlands Golf Course, Milperra for future residential development. Residents were concerned that the development would increase flooding elsewhere. A resident also inquired about the development process, concerned that developers may bypass the flooding issues whilst this floodplain risk management study and plan are yet to be finalised.
- **Bankstown Airport:** Several residents were concerned about ongoing development within Bankstown Airport potentially increasing flooding elsewhere. Residents from Rabaul Rd and Endeavour Rd, Georges Hall believe flooding in their area has worsened since the airport ownership changed hands as they believe the current owners don't sufficiently maintain the open channels on their site.
- **Carinya Road:** A resident from Carinya Rd, Picnic Point mentioned that residents in the area were unhappy with the existing development controls relating to the area. The resident wanted to know if ideas for the area had been developed as part of this study.

Additional community feedback on the format of the community information session is provided below:

- **Presentation:** Several residents found the presenters/representatives to be knowledgeable and helpful noting the topics were informative, well covered and explained. A resident suggested the presenters use plain language as well as technical terms in communicating and the resident appreciated the use of "real world" examples in explanations. A resident found the duration of the presentation to be too long and generic.
- **Materials:** Several residents felt the presentation PowerPoint slides were visually too small for the audience size. Several residents appreciated being shown the digital mapping results for their individual property on the presentation screen.

A.3.2 Community Information Sessions in May 2014

Council notified Carinya Road residents of the consultation sessions by mail with a total of 30 residents attending on the day. The community consultation sessions were conducted by Council, BMT WBM and GLN Planning representatives.

Community members were encouraged to discuss their concerns and suggestions with the representatives present. An information sheet of frequently asked questions and feedback forms were also provided to the attendees. Following the consultation sessions, feedback forms with comments were returned by seven residents. A summary of the issues raised in the community information sessions are provided below:

Existing DCP Issues:

- **General Resident Sentiment:** Some residents felt that the existing DCP would remain unchanged by the review whilst others hoped it would provide an opportunity to correct mistakes of the past. In general residents had difficulty understanding the existing DCP and how it relates to their property but acknowledged the flood risk present. In general residents would like to see more streamlined, simplified and generalised controls in the DCP.
- **Matrix Format:** Several residents felt that the matrix of the DCP is difficult to read, interpret and understand for both residents and Council planners and would like to see it revised. In general residents suggested that the controls are more streamlined and easier to interpret. Some residents had experienced difficulty with individual Council planners having varied interpretation of the DCP.
- **DCP Divisions:** Several residents expressed confusion about the east and west boat shed divide of Carinya Road in the DCP and why the DCP commented on individual properties. Several residents felt the DCP unfairly discriminates against Carinya Road residents (mentioning garage locations, subdivision sizes and maximum density controls). Residents also expressed that that the same DCP conditions should be applied to Carinya Road as areas of Bankstown LGA.
- **Future Controls:** Several residents were concerned about the impact of future DCP changes on their properties and requested transparency with the community. Residents queried if the DCP changes would impact existing and/or proposed dwellings and if controls would comment on individual properties. A resident also asked if they should wait until the DCP has been revised before completing their current development plans.
- **Pedestrian Walkways:** Several residents were unhappy about the controls relating to access walkways to Carinya Road Residents felt they were an unnecessary restriction given the frequency of flood events, flood warning time and flood awareness of residents. Some residents considered walkways to be visually unpleasant and were concerned about anticipated cost, privacy, safety and liability issues. Residents also mentioned that the walkways would require locks to control access with the keys unlikely to be found during a rare flood event. Residents requested that alternatives to walkways are investigated and suggested that the wording of the DCP is changed regarding the walkways as a recommendation and not a mandatory requirement.

- **Garage Locations**: A resident was unhappy about the controls relating to garage locations. The resident felt that controls regarding proximity, elevation and accessibility to Carinya Rd were imposing a costly and unnecessary restriction on home owners given the frequency of flooding events.
- **Granny Flats**: Several residents requested that the controls regarding granny flats are further clarified.

Flood Knowledge and Concerns:

- **Flood Warning:** Several residents inquired as to what flood warning time was available to them. Residents anticipate sufficient warning time would be provided to them by the SES prior to a flood event and felt this needed to be adequately reflected in the DCP. Residents also suggested improved flood warning, i.e. a flood warning siren similar to that used in bushfires is employed. Residents were favourable of evacuation plans being developed by Council/SES and communicated to residents.
- **Flood Awareness:** In general residents felt they were aware of the flooding risks to their properties and felt this needed to be adequately reflected in the DCP.
- **On-going Development:** Several residents raised the issue of ongoing development within the Georges River catchment and the potential impacts on flooding. The development of the Milperra Bunning's site, Chipping Norton Lakes and development of the Riverlands Golf Course were raised.
- **Tide Considerations:** Several residents noted the impact of the tide cycle on previous flooding events and suggested it is considered when predicting flood events and providing flood warnings.
- **Sewerage Discharge:** A resident was concerned about discharge of sewerage to the Georges River from an upstream sewerage treatment plant during flood events. The resident noted that they observed an unpleasant odour on several occasions and was concerned about the health impact of these sewerage releases.

Flood Mitigation Works:

- **Drainage Maintenance:** A resident inquired as to whether Council had an ongoing maintenance program for cleaning the drains in the area. The resident had witnessed flooding from drain blockages and surcharging of the drainage network in the area as well as adverse flood impacts due to road raising. Residents also mentioned their efforts to clean the drains which they felt Council may not be aware of.
- **Flood Mitigation Works:** A resident inquired as to what flood mitigation works had been undertaken by Council and what impact these works had on the flood risk. A resident suggested that the existing flood mitigations works are re-surveyed to ensure they remained at design standard levels.
- **Flood Walls:** A resident requested that the ownership of the existing floodwalls in the street is clarified.

Previous Flood Studies and Floodplain Risk Management Plans:

- **Updating Flood Studies:** Several residents questioned whether the previous Georges River studies required updating based on changes to the catchment over time including development and flood mitigation works.
- **Consideration of Dams:** A resident injured as to whether dam operations are considered in the Georges River studies and suggested that feedback from these studies is provided to dam operators.
- **Rainfall Consideration:** A resident was concerned that rainfall hadn't been considered as part of the previous Georges River flood studies.
- **Sea Level Rise:** A resident inquired as to whether climate change had been considered in the Georges River studies.

General Comments:

- **Project Timing:** Several residents inquired as to what the timeline of the project was.
- **Presentation material:** Several residents requested that the project website is modified to allow them to provide feedback online. A resident requested a copy of the presentation slides. A resident also noted that the text size used in the PowerPoint slides was too small for the audience.

A.4 Community Consultation Material

Mid Georges River Floodplain Risk Management Study & Plan

Questionnaire

The information provided from this questionnaire will help us to identify any flooding problems within the catchment, and to consider measures that may reduce these problems. It would help us if you could indicate the location of your property, or other problem areas, on the map on the back.

The questionnaire is voluntary. No names or addresses will be included in any published material.

---

1. Your Address? _____

2. Within the study area, do you own or reside in:
   - ❑ A residential house
   - ❑ A residential unit or apartment
   - ❑ A business premises

3. Have you experienced any form of flooding in this area?
   - ❑ Yes Date of largest flood: _____
     Date of other floods: _____
     Do you have flood records (eg photos) we could borrow? _____
   - ❑ No

4. Has your property previously flooded?
   - ❑ Yes, above floor level. The depth of flooding over the floor was _____m.
   - ❑ Yes, significant flooding within the grounds or garage, but **not** above floor level.
   - ❑ Yes, minor flooding within a small portion of the property only.
   - ❑ No flooding within the property.

5. Are there any flood problems that you are aware of beyond your property?
   _____
   _____
   _____

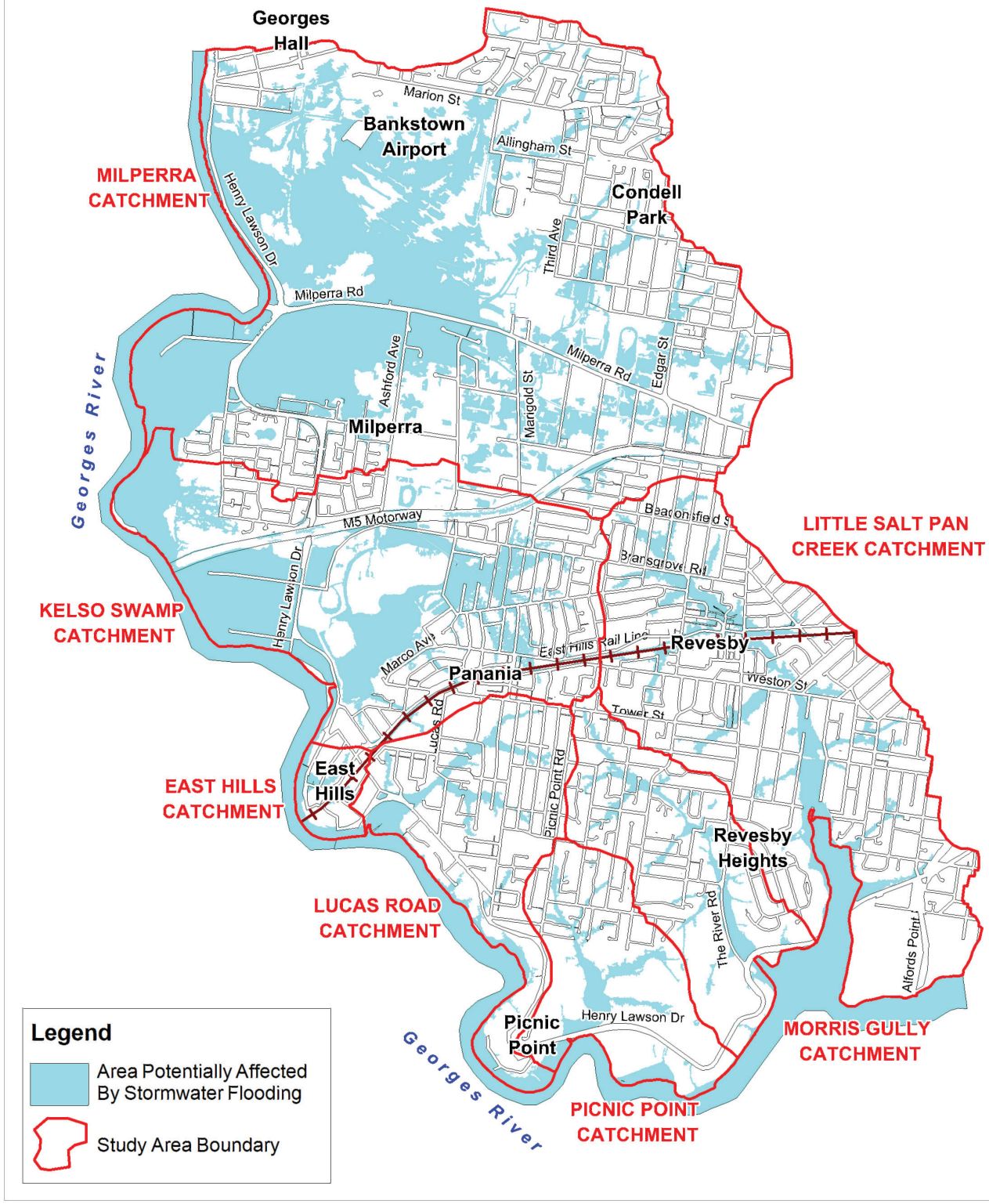
6. Do you have any ideas on reducing flood problems?
   _____
   _____
   _____

7. Are there any flooding issues you would like the study to consider?
   _____
   _____
   _____

8. Your Contact Details (in case we need to ask you anything further)
   Name: _____
   Email: _____ Phone: _____
   - ❑ I am interested in receiving future correspondence regarding this study.
   - ❑ I am interested in attending an information session in late Nov 2013 / early Dec 2013.

Please return your completed questionnaire in the supplied envelope by <u>26 NOVEMBER 2013.</u>
No postage stamp is required.

Thank you for your participation



Title:
Mid-Georges River Catchment

Figure: **1**

Rev: **A**

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Approx. Scale

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15 October 2013

«NAME»
«PROPERTY_ADD1»
«PROPERTY_ADD2»

Dear Sir/Madam,

Mid Georges River Floodplain Risk Management Study & Plan
Your property at «PROPERTY_ADD1» «PROPERTY_ADD2»

Bankstown City Council recently completed flood studies of the seven stormwater catchments, which form the Mid Georges River Floodplain that drain to Georges River. The studies identified areas of the catchment that may be affected by stormwater inundation (see attached map) and our records show that the above property may be affected by one of these studies. These flood study reports are on public exhibition and can be viewed at Council's Customer Service Centre and libraries at Bankstown and Panania from 15 October 2013 till Close of Business 26 November 2013. The reports are also available on Council's website www.bankstown.nsw.gov.au.

Council has now commissioned BMT WBM Consulting to undertake the next stage of the process and develop a Floodplain Risk Management Study and Plan for these catchments. The Floodplain Risk Management Study and Plan will review problem areas identified in the earlier studies and investigate measures to reduce these problems and to better manage the flood risk within the catchment.

All flood studies and floodplain management studies are overseen by Bankstown Council's Floodplain Management Committee. Funding and technical assistance is provided by Bankstown Council and the NSW Office of Environment and Heritage.

If there are any problem areas or issues you would like investigated within the catchment as part of the risk management study, we would be pleased to hear from you. You may have already completed a questionnaire as part of the earlier studies, in which case we'd like to thank you for your contribution. If you haven't, it would be appreciated if you could complete the enclosed questionnaire and return it in the **Reply Paid** envelope by 26 November 2013. The questionnaire can also be viewed and completed online on http://midgeorgesfrmsp.bmtwbm.com.au

A series of information sessions are also proposed to be held in late November 2013 / early December 2013. If you are interested in attending one of these sessions or would like to be informed of the progress of this study, you can indicate this in the enclosed questionnaire or by calling 9707 9920. Only those who register their interest will continue to receive correspondence from Council on this study.

If you have any questions on the study or require further information please contact me on 9707 9920.

Yours faithfully

Vila Gupta
Catchment Management Planner

BANKSTOWN CITY COUNCIL
PO Box 8, Bankstown NSW 1885 PH 02 9707 9400 FAX 02 9707 9495

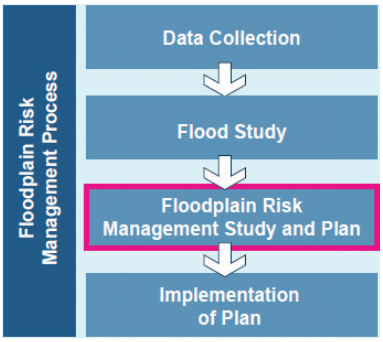
Mid-Georges River Floodplain Risk Management Study and Plan

What is the study about?
Bankstown City Council is carrying out a Floodplain Risk Management Study and Plan (FRMS&P) to understand and manage flood risks in the Mid Georges River study area associated with local overland flooding.

Overland flooding (which is addressed in the Georges River FRMS&P) results from local rainfall events and not the Georges River (Riverine) flooding.

Flood studies have already been undertaken by Council for the seven sub-catchments that make up the Mid Georges River study area. These flood studies investigated in detail the flooding characteristics within the sub-catchments and produced information on flood flows, velocities, levels and extents for a range of flood magnitudes. This information will form the basis for assessing various options to reduce the risks and damage caused by flooding within the study area.

The next stage of the floodplain risk management process, which this study is focused on, is the assessment of a range options to manage these flood risks for existing and future development.



Where is the study?
There are seven sub-catchments that make up the Mid Georges River study area and include Little Salt Pan Creek, Morris Gully, Picnic Point, Kelso Swamp, East Hills, Lucas Road, and Milperra. These sub-catchments, which cover an area approximately 30 km^2 in size, are largely urbanised and comprise parts of the suburbs of Revesby, Revesby Heights, Picnic Point, Panania, Kelso, East Hills, Milperra and Condell Park.

Who is responsible?
The Bankstown Floodplain Management Committee will oversee the study, providing regular input and feedback on key outcomes. The Committee has a broad representation including Councillors, Council staff, State Government representatives, stakeholder groups and community representatives. The study will be undertaken by BMT WBM, an independent company specialising in flooding and floodplain risk management.

Key Study Outputs
Floodplain Risk Management considers the consequences of flooding on the community and aims to develop appropriate floodplain management measures to minimise and mitigate the impact of flooding.

The outcomes of the study provide the basis for the Floodplain Risk Management Plan, containing an appropriate mix of management measures and strategies, to help direct and coordinate the responsibilities of Government and the community in undertaking immediate and future flood management works and initiatives.

Information from the study will be used by the State Emergency Service (SES) during flood emergencies and will be used by Council to assist them to manage development in flood affected areas.

Further Information
For more information about the Mid Georges River FRMS&P, please visit http://midgeorgesfrmsp.bmtwbm.com.au or contact:

Bankstown City Council
Vila Gupta
Phone: 9707 9920
Email: vila.gupta@bankstown.nsw.gov.au

Appendix B Flood Risk Mapping

B.1 Provisional Flood Risk Precincts

The flood risk precincts are based on the provisional flood risk precincts presented in the flood study reports for each sub-catchment as list below:

- Milperra Catchment Draft Flood Study Update – October 2013 – BMT WBM
- Little Salt Pan Creek Stormwater Catchment Study – September 2011 – BMT WBM
- Picnic Point Catchment Flood Study – March 2011 – BMT WBM
- Morris Gully Catchment Flood Study – March 2011 – BMT WBM
- Lucas Road Catchment Flood Study – July 2010 – BMT WBM
- Kelso Stormwater Catchment Flood Study – December 2009 – BMT WBM
- East Hills Stormwater Catchment Flood Study – December 2009 – BMT WBM

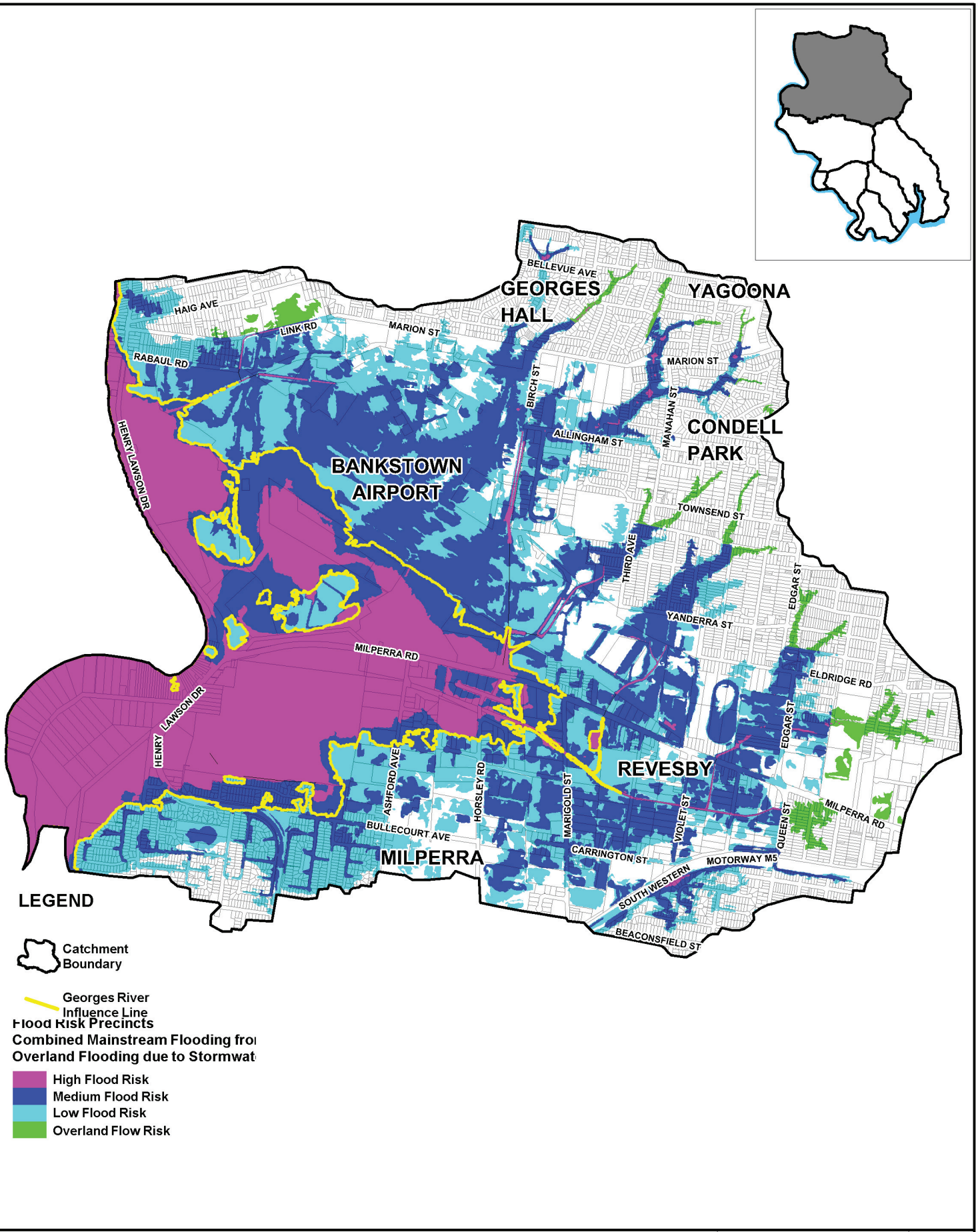
B.2 Flood Risk Precinct Mapping

The flood precinct mapping has been derived by compilation of the design flood conditions of all identified sources of flooding, including the Georges River, as documented in the *Georges River Floodplain Management Study and Plan* (Bewsher Consulting, 2004), as well as the catchment runoff events. The provisional flood risk mapping divides the floodplain into three (low, medium and high) flood risk precincts which are consistent with the risk categories defined in the NSW Government *Floodplain Management Manual* (DLWC, 2001). The provisional flood risk precinct mapping has been further modified to accommodate an additional overland flow precinct. The overland flow precinct has been defined as per the *Salt Pan Creek Catchments Floodplain Risk Management Study* (Bewsher Consulting, 2013).

The flood risk precincts provided in the mapping are defined as follows:

- **High Flood Risk**: Land below the 100 year ARI flood that is either subject to a high hydraulic hazard (i.e. provisional hazard in accordance with the Floodplain Development Manual) or where there are significant evacuation difficulties.
- **Medium Flood Risk**: Land below the 100 year ARI flood level that is not subject to high hydraulic hazard and where there are no significant evacuation difficulties.
- **Overland Flow Risk**: Depth of inundation of between 50mm to 250mm arising from overland flow in a 100 year flood.
- **Low Flood Risk**: Comprises all remaining areas of the floodplain (defined as the limit of inundation in a PMF) which is not identified as a high or medium flood risk or overland flow precinct, and where the risk of damage is low for most land uses.

Figures B-1 to B-7 depicts the flood risk precincts for the seven subject sub-catchments of the Mid Georges River study area.



Title:

Flood Risk Precincts Map - Milperra

Figure: B-1

Rev: 1

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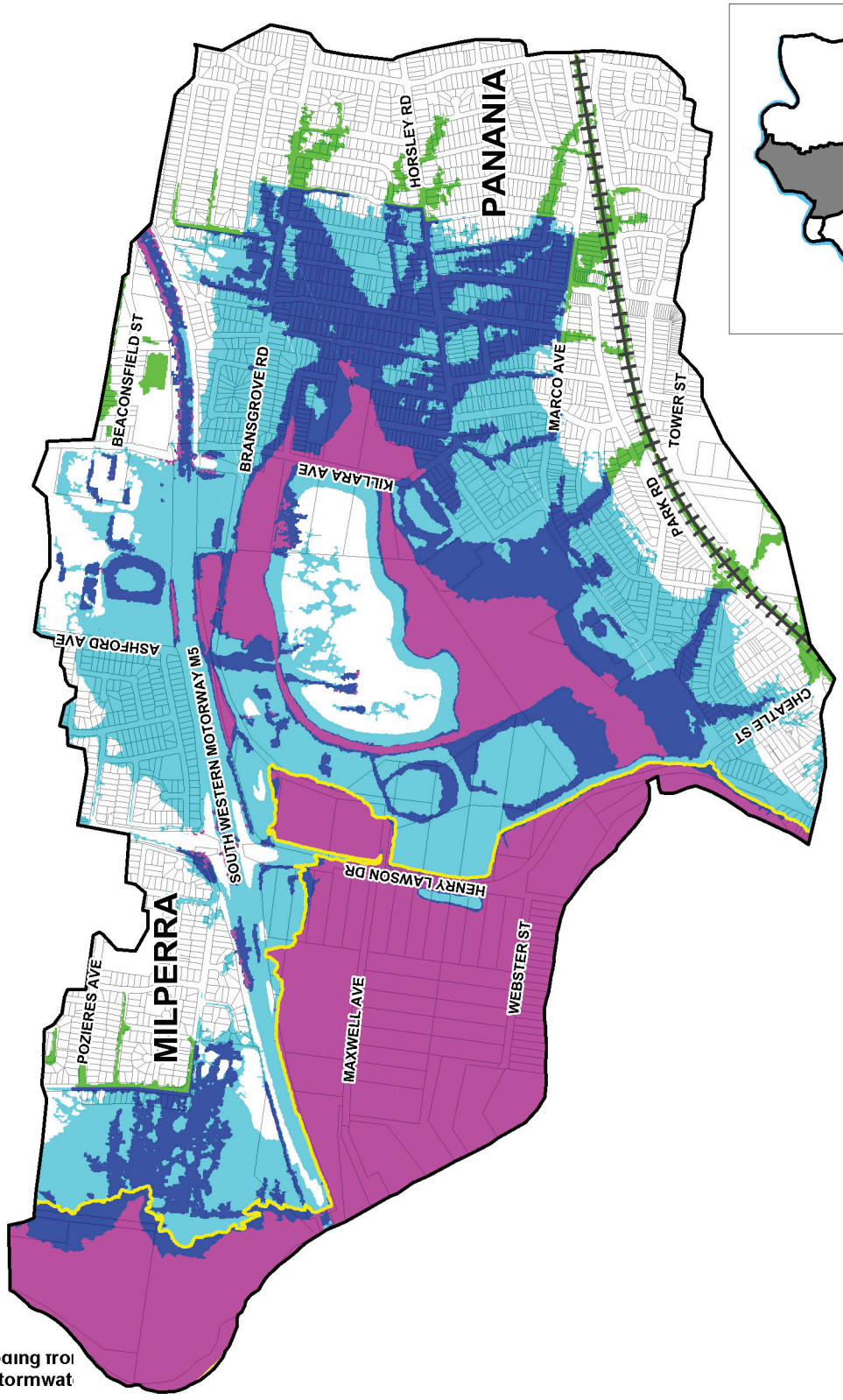
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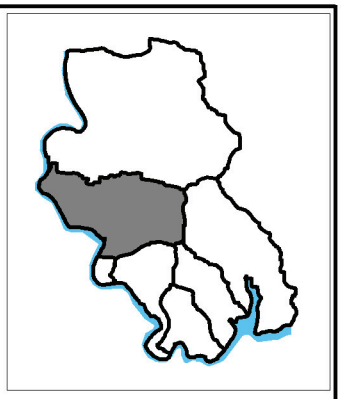
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LEGEND

Catchment Boundary

Georges River Influence Line

Combined Mainstream Flooding fro
Overland Flooding due to Stormwat

- High Flood Risk
- Medium Flood Risk
- Low Flood Risk
- Overland Flow Risk

Title:

Flood Risk Precincts Map - Kelso Swamp

Figure: B-2

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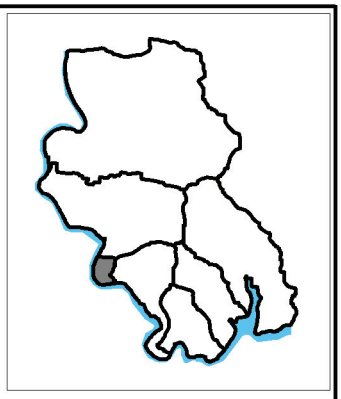
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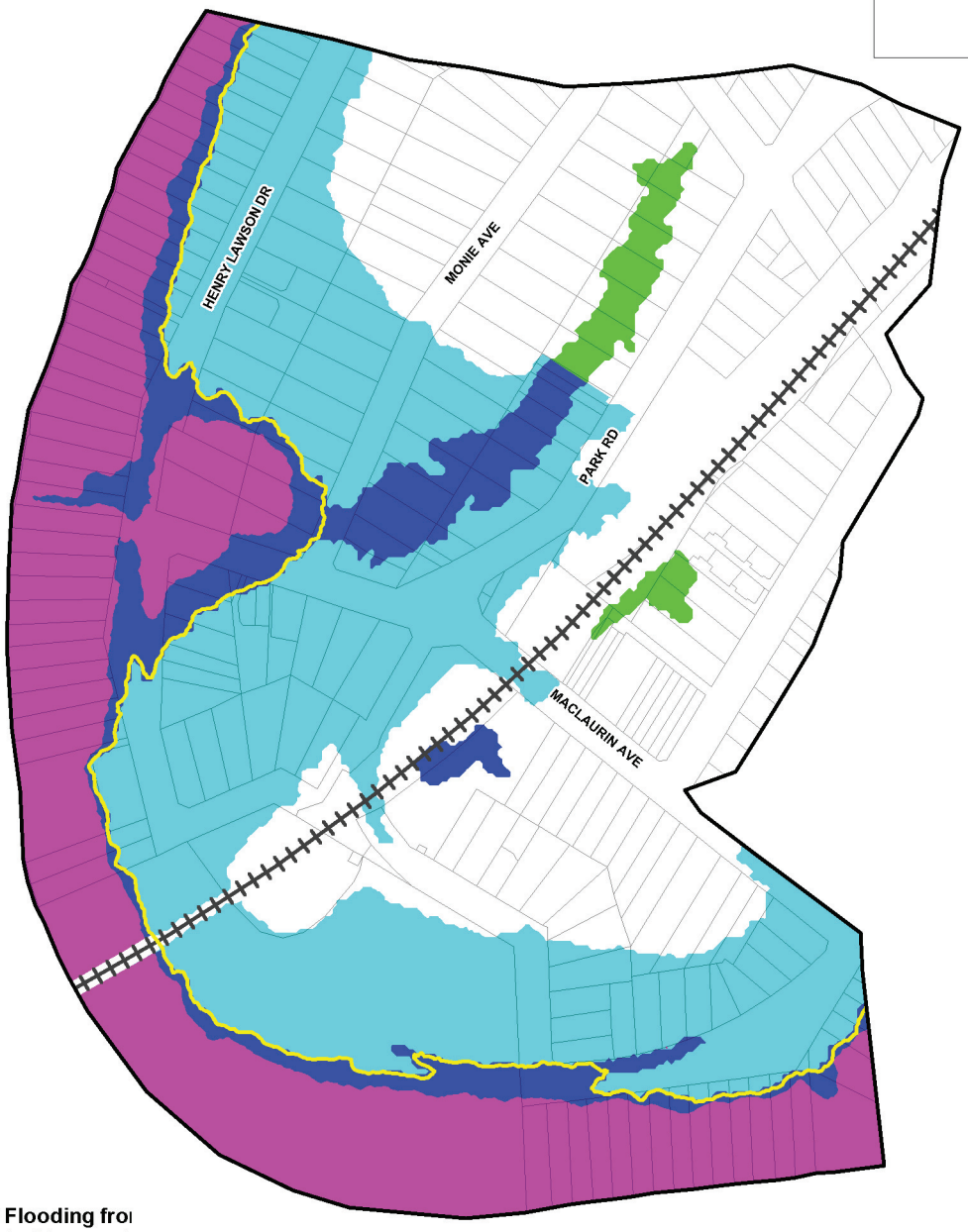
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LEGEND

Catchment Boundary

Georges River Influence Line

Flood Risk Precincts

Combined Mainstream Flooding fro

Overland Flooding due to Stormwat

- High Flood Risk
- Medium Flood Risk
- Low Flood Risk
- Overland Flow Risk

Title:

Flood Risk Precincts Map - East Hills

Figure: **B-3**

Rev: **1**

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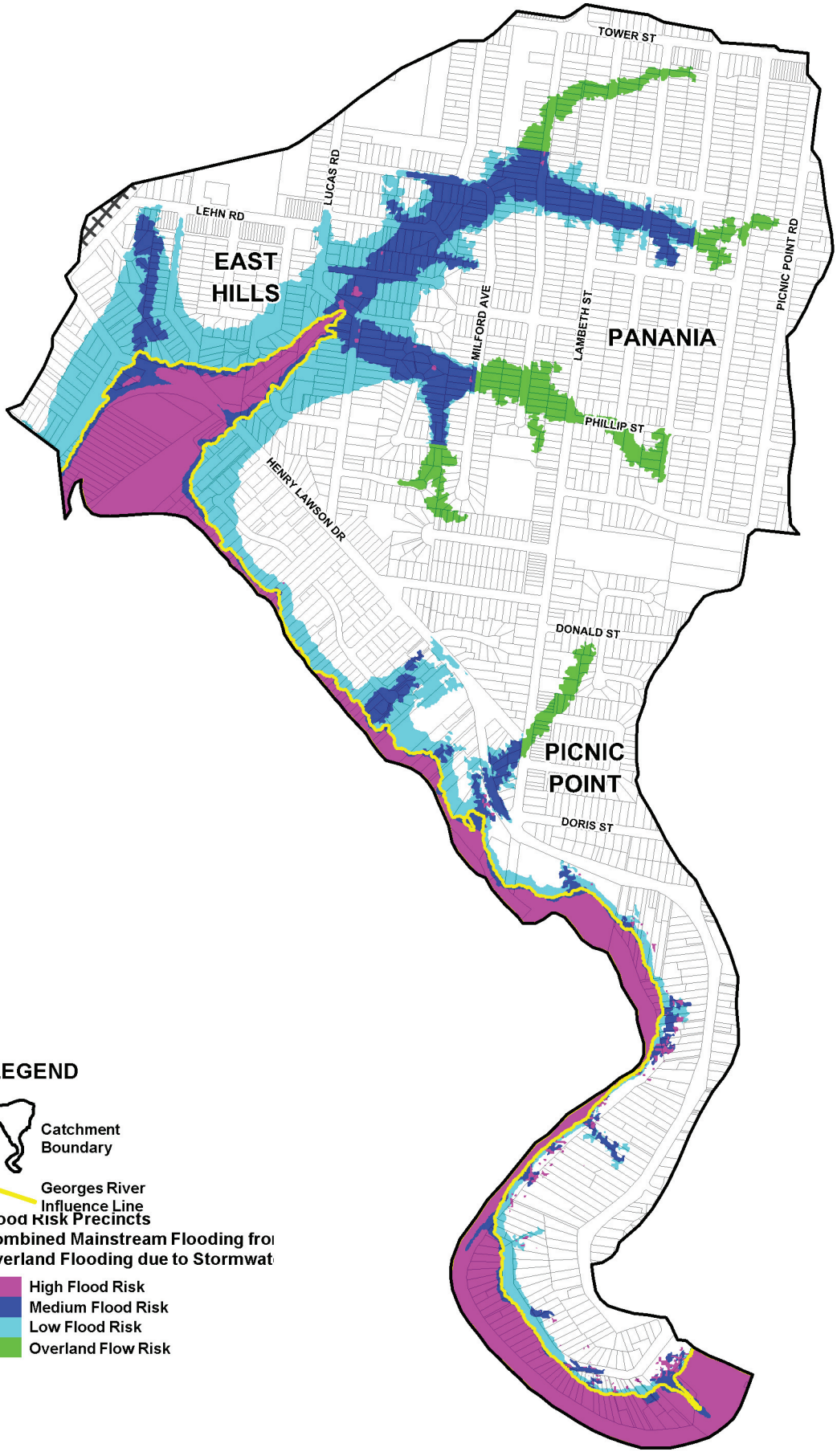
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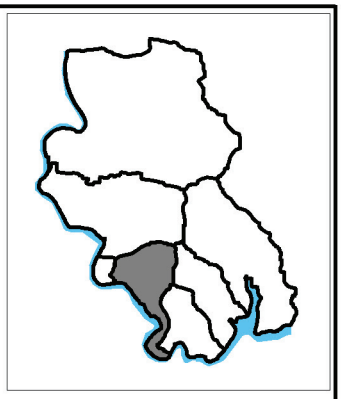
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LEGEND

Catchment Boundary

Georges River Influence Line

Flood Risk Precincts
Combined Mainstream Flooding fro
Overland Flooding due to Stormwat

- High Flood Risk
- Medium Flood Risk
- Low Flood Risk
- Overland Flow Risk

Title:

Flood Risk Precincts Map - Lucas Road

Figure: B-4

Rev: 1

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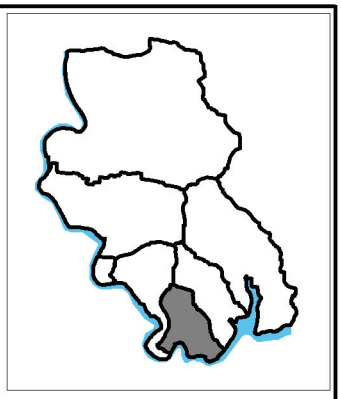
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Title:

Flood Risk Precincts Map - Picnic Point

Figure: **B-5**

Rev: **1**

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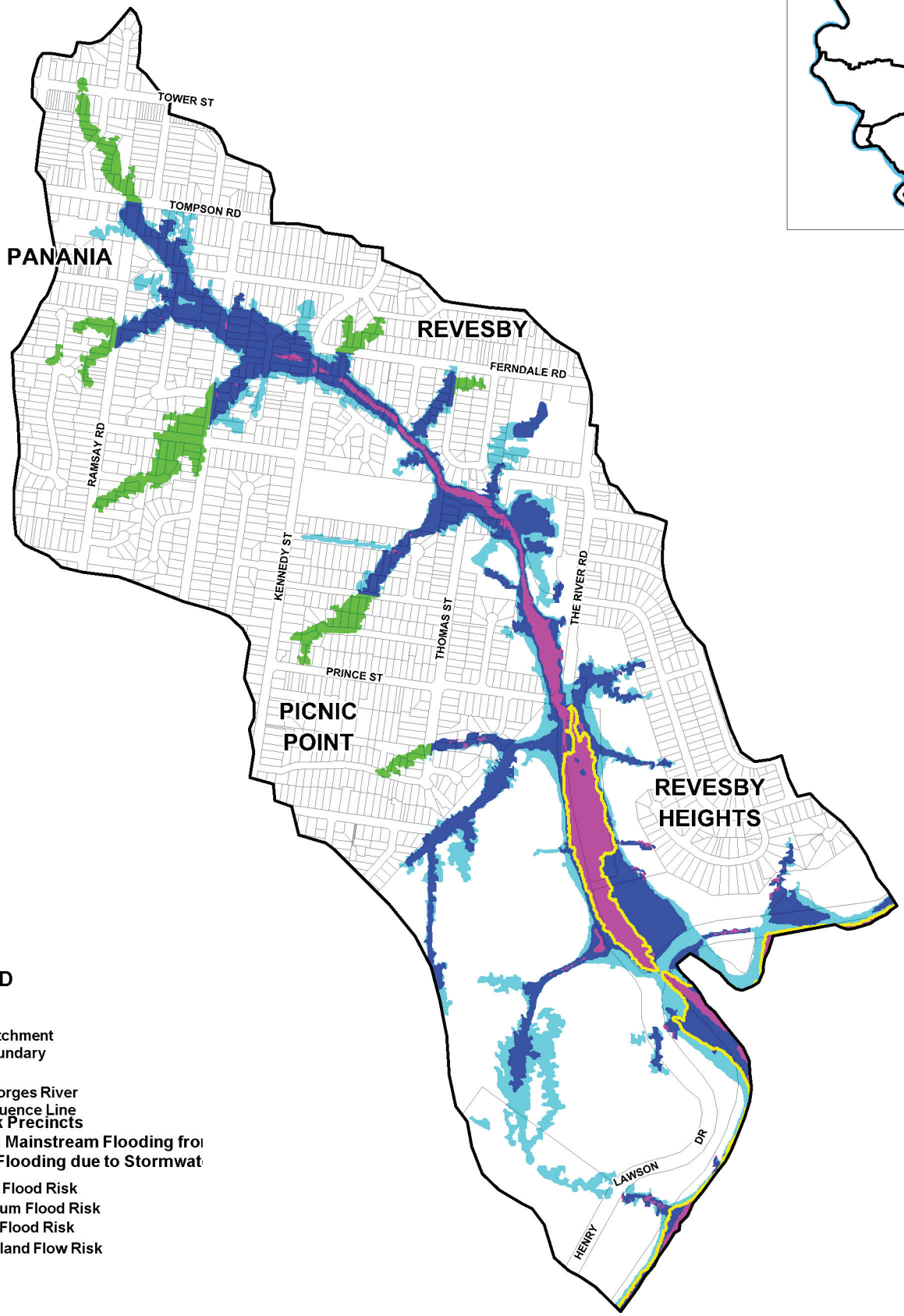
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Title:

Flood Risk Precincts Map - Morris Gully

Figure: B-6

Rev: 1

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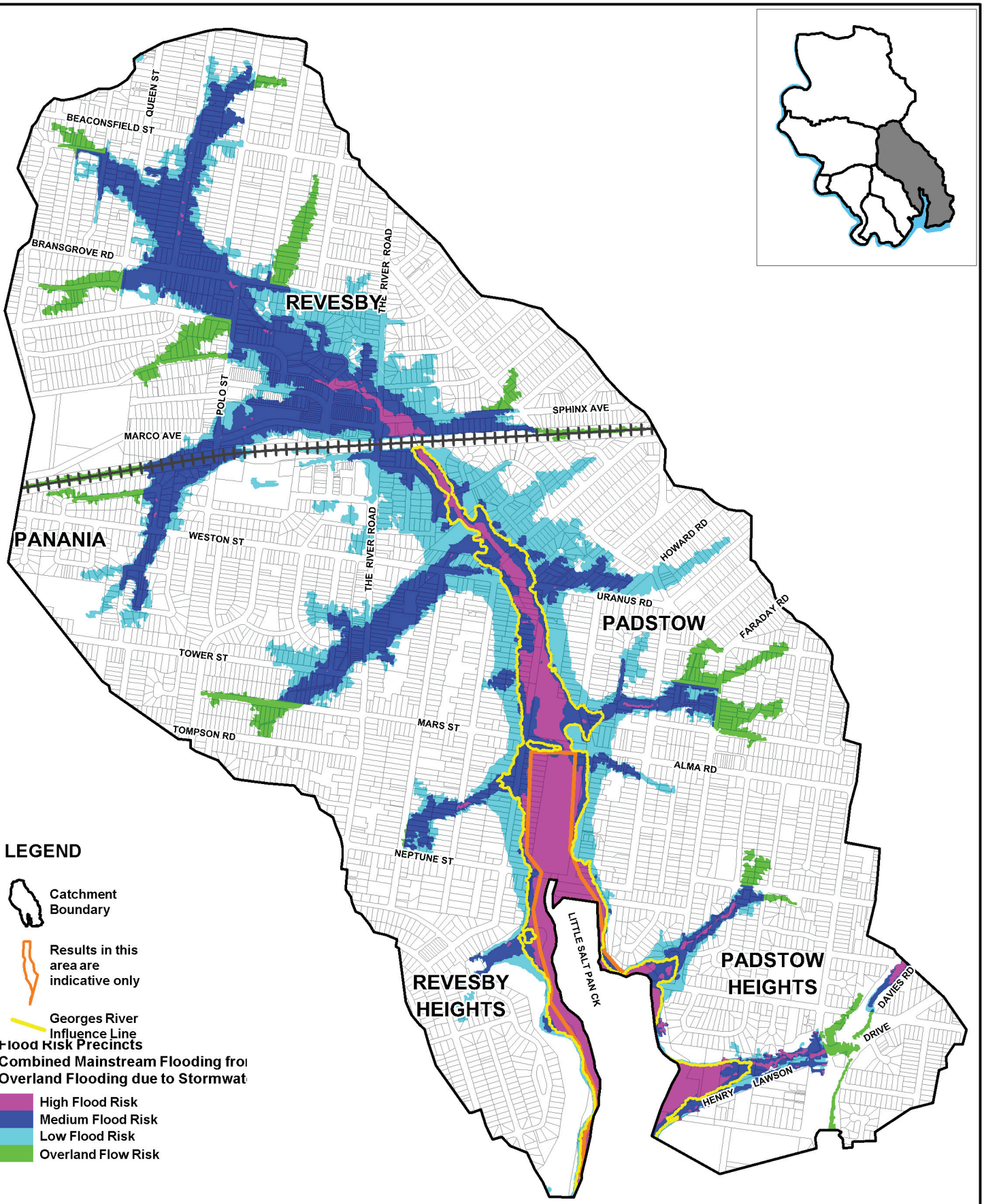
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Title:

Flood Risk Precincts Map - Little Salt Pan Creek

Figure: B-7

Rev: 1

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Appendix C Climate Change Summary

C.1 Introduction

Future climate change has been predicted to result in an increase in sea level and the severity of flood-producing storms and other weather systems. These systems have a direct impact on tides and rainfall responsible for flood behaviour within the Georges River and the sub-catchments draining to the Georges River. The potential for climate change impacts is therefore a key consideration for floodplain management.

The NSW Floodplain Development Manual (DIPNR, 2005) requires consideration of climate change in the preparation of Floodplain Risk Management Studies and Plans, with further guidance provided in:

- Floodplain Risk Management Guideline – Practical Consideration of Climate Change (DECC, 2007a); and
- Flood Risk Management Guide - Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments (DECCW, 2010a).

In 2009, the NSW Government incorporated consideration of potential climate change impacts into relevant planning instruments. The NSW Sea Level Rise Policy Statement (DECCW, 2009) was prepared to support consistent adaptation to projected sea level rise impacts. The policy statement incorporates sea level rise (SLR) planning benchmarks for use in assessing potential impacts of sea level rise in coastal areas, as well as in flood risk and coastal hazard assessments. The benchmarks are a projected rise in sea level, relative to the 1990 mean sea level, of 0.4 metres by 2050 and 0.9 metres by 2100.

The NSW Government announced its Stage One Coastal Management Reforms in September 2012. As part of these reforms, the NSW Government no longer recommends state-wide sea level rise benchmarks for use by local councils, but instead provides councils with the flexibility to consider local conditions when determining future hazards within their LGA.

Bankstown City Council undertook a sea level rise impact assessment for the Georges River which was completed in October 2012 (FloodMit, 2012). This study adopted the sea level rise benchmarks from the 2009 NSW Sea Level Rise Policy in determining the potential impacts along the Georges River.

Regional climate change studies (e.g. CSIRO, 2007) indicate that aside from sea level rise, there may also be an increase in the maximum intensity of extreme rainfall events. This may include increased frequency, duration and height of flooding and consequently increased number of emergency evacuations and associated property and infrastructure damage.

In 2007 the NSW Government released a guideline for practical consideration of climate change in the Floodplain Management Process that advocates consideration of increased design rainfall intensities of up to 10% for the Sydney Metropolitan Catchments by the year 2070 (CSIRO, 2007). Accordingly, this increase in design rainfall intensity will translate into increased flood inundation within the subject sub-catchments. Future planning and floodplain management in the catchment will need to take due consideration of this increased flood risk.

C.2 Impact of Increased Rainfall Intensities

C.2.1 Modelling Overview

Flood studies have been completed for each of the Mid Georges River sub-catchment. The flood behaviour throughout each of the sub-catchments has been defined by using flood models. A sensitivity assessment on the potential impact of a 10% increase in rainfall intensity has been undertaken for each sub-catchment by using the flood models. The percentage increase in rainfall intensity (10%) was selected in consultation with Council to represent approximate CSIRO predictions for the effect of climate change on rainfall by 2070 (CSIRO, 2007).

The sensitivity assessments only consider the impact of increased rainfall intensities on sub-catchment derived stormwater flooding and do not consider the impact of climate change on the flooding behaviour of the Georges River.

The impact of the rainfall intensity increase was assessed on the critical 100 year ARI event specific to each sub-catchment. The critical 100 year ARI event considered both blocked and unblocked scenarios of the drainage network. Further details on the design flood event modelling and mapping can be found in the respective flood study report for each sub-catchment. A climate change impact map for rainfall intensities for each sub-catchment is provided as Figures C-1 to C-7. A summary of the impacts is provided in the following sections.

C.2.2 Milperra (C20)

The climate change sensitivity assessment for the Milperra sub-catchment was completed as part of the Milperra Catchment Flood Study Update (BMT WBM, 2015). A 10% increase in rainfall intensity results in increases in flood levels of approximately 0.05m to 0.10m across much of the catchment. Flood level increases up to 0.20m are also evident at Tracey Reserve south of the M5 motorway where ponding occurs as the overland flow path is blocked by a noise wall and the flow cannot be sufficiently drained to the downstream via the pipe and pit drainage network.

C.2.3 Kelso Swamp (C26)

The climate change sensitivity assessment for the Kelso Swamp sub-catchment was completed as part of the current study using the flood model developed for the Kelso Stormwater Catchment Flood Study (Bewsher Consulting & BMT WBM, 2009). A 10% increase in rainfall intensity results in increases in flood levels of approximately 0.05m to 0.10m across much of the catchment. There are increases of up to 0.20m within areas of the catchment generally surrounding the former Bankstown Tip and extending downstream to the Georges River. Increased flood levels occur in these areas as the conveyance of overland flow is limited by the capacity of the Kelso levee flood gates. Flood level increases up to 0.30m also occur at several small localised depressions bordering the M5 South Western Motorway.

C.2.4 East Hills (C30)

The climate change sensitivity assessment for the East Hills sub-catchment was completed as part of the current study using the flood model developed for the East Hills Stormwater Catchment Flood Study (Bewsher Consulting & BMT WBM, 2009). A 10% increase in rainfall intensity results

in increases in flood levels of generally less than 0.03m across the catchment. A localised depression at the corner of Henry Lawson Drive and Maclaurin Avenue, near Monie Avenue shows increases of up to 0.30m. Ponding occurs in the area as overland flow cannot be sufficiently drained to the downstream via the pipe and pit drainage network.

C.2.5 Lucas Road (C28)

The climate change sensitivity assessment for the Lucas Road sub-catchment was completed as part of the Lucas Road Catchment Flood Study (BMT WBM, 2010). A 10% increase in rainfall intensity results in increases in flood levels of approximately 0.02m to 0.05m across much of the catchment, and up to 0.10m in localised areas.

C.2.6 Picnic Point (C29)

The climate change sensitivity assessment for the Picnic Point sub-catchment was completed as part of the Picnic Point Catchment Flood Study (BMT WBM, 2011). A 10% increase in rainfall intensity results in increases in flood levels of approximately 0.05m to 0.10m across much of the catchment.

C.2.7 Morris Gully (C27)

The climate change sensitivity assessment for the Morris Gully sub-catchment was completed as part of the Morris Gully Flood Study (BMT WBM, 2011). A 10% increase in rainfall intensity results in increases in flood levels of approximately 0.02m to 0.05m across much of the upper catchment (upstream of Ferndale Road and Victor Avenue), and increases in the range of 0.05m to 0.15m in the central and lower parts of the catchment. The greatest increases in flood levels of up to 0.15m occur within the main overland flow path from Thomas Street downstream (south) to Henry Lawson Drive. Increased flood levels occur in these areas as the conveyance of overland flow is limited by the capacity of the hydraulic structures in this reach.

C.2.8 Little Salt Pan Creek (C25)

The climate change sensitivity assessment for the Little Salt Pan Creek sub-catchment was completed as part of the current study using the flood model developed for the Little Salt Pan Creek Stormwater Catchment Study (Bewsher Consulting & BMT WBM, 2009). The 10% increase in rainfall intensity resulted in increases in flood levels of approximately 0.05m to 0.10m across much of the catchment. Increased flood levels of up to 0.30m occur immediately upstream of the railway line at the River Road and Sphinx Avenue. Ponding occurs in this area as the natural overland flow path is blocked by the railway embankment.

C.3 Impact of Future Sea Level Rise

C.3.1 Modelling Overview

An assessment of the effects of climate change on flood behaviour in the Georges River has been undertaken separately and reported in the Sea Level Rise Impact Assessment for the Georges River (FloodMit, 2012). This study adopted sea level rise planning benchmarks of +0.4m and +0.9m by the years 2050 and 2100 as detailed in Section C1. The hydraulic model developed as

part of this sea level rise impact assessment has been utilised to define the water levels in the Georges River as a boundary condition for the climate change model runs.

For the sub-catchments of the Mid Georges River, the 100 year local catchment runoff has been modelled with either a Mean High Water Spring (MHWS) or a 20 year ARI tail water condition in Georges River. Details of the tail water conditions for a +0.4m and +0.9m rise in sea levels have been determined from the hydraulic model used for the Sea Level Rise Impact Assessment for the Georges River (FloodMit, 2012).

The impacts of future sea level rise on overland flooding within the sub-catchments of the Mid Georges River study area is provided in sea level rise impact maps presented for each sub-catchment in Figure C-8 to Figure C-21. A summary of the impacts is provided in the following sections.

C.3.2 Milperra (C20)

The impact of sea level rise on overland flooding in the Milperra catchment affects a large area of the Milperra catchment, primarily along Milperra Drain. Typically, a 0.4m rise in sea levels results in increases in overland flood levels which typically range from +0.1m to +0.2m. These increases in levels extend to the upstream limit of the open channel reach of Milperra Drain. The maximum increase in levels is approximately +0.25m at Georges River Golf Course.

Increases in overland flood levels typically range from +0.2m to +0.3m with a 0.9m rise in sea levels. The geographic extent of these increases is similar to the 0.4m SLR scenario. The peak increase in flood levels is +0.35m which occurs in the north of the catchment at the intersection of Rabaul Road and Henry Lawson Drive.

C.3.3 Kelso Swamp (C26)

The impact of sea level rise on overland flooding in the Kelso Swamp catchment affects areas along Georges River to the north of the catchment and areas affected by ponding behind Kelso Levee. Typically, a 0.4m rise in sea levels results in an average increase in overland flood levels of +0.05m in areas defended by the levee. There is an isolated pocket of flooding adjacent to the M5 South Western Motorway where flood depth increases are +0.25m. This is as a result of the effects of the increased flood levels on conveyance within the drainage system in this location. The maximum increase in levels is approximately +0.35m at Riverland Golf Course.

Increases in overland flood levels average +0.1m for areas defended by the levee with a 0.9m rise in sea levels. The geographic extent of these increases is similar to the 0.4m SLR scenario. The peak increase in flood levels is +0.45m which occurs at Deepwater Park and Riverland Golf Course.

C.3.4 East Hills (C30)

The impact of sea level rise on overland flooding in the East Hills catchment is relatively minor. Typically, a 0.4m rise in sea levels results in an average increase in overland flood levels of +0.05m. The increase in flood levels affect a small portion of the overland flooding within the influence line of the Georges River. The maximum increase in flood levels is approximately +0.05m.

Increases in overland flood levels average +0.05m with a 0.9m rise in sea levels. The geographic extent of these increases is similar to the 0.4m SLR scenario. The peak increase in levels is +0.05m.

C.3.5 Lucas Road (C28)

The impact of sea level rise on overland flooding in the Lucas Road catchment primarily affects areas within the influence line of the Georges River. The maps indicate that the majority of the increases in flood levels are associated with riverine flooding. Typically, a 0.4m rise in sea levels results in an average increase in flood levels of +0.2m. The maximum increase in levels is approximately +0.25m at Carinya Road.

Increases in flood levels average +0.2m with a 0.9m rise in sea levels. The geographic extent of these increases is similar to the 0.4m SLR scenario. The peak increase in flood levels is +0.3m at Carinya Road.

C.3.6 Picnic Point (C29)

The impact of sea level rise on overland flooding in the Picnic Point catchment primarily affects areas within the influence area of the Georges River. The maps indicate that the majority of the increases in flood levels are associated with riverine flooding. Typically, a 0.4m rise in sea levels results in an average increase in flood levels of +0.05m in Yeramba Lagoon. The maximum increase in levels is approximately +0.4m downstream of Yeramba Lagoon.

Increases in flood levels average +0.2m with a 0.9m rise in sea levels in Yeramba Lagoon. The geographic extent of these increases is similar to the 0.4m SLR scenario. The peak increase in flood levels is +0.9m downstream of Yeramba Lagoon.

C.3.7 Morris Gully (C27)

The impact of sea level rise on overland flooding in the Morris Gully catchment primarily affects areas within the influence line of the Georges River. The maps indicate that the majority of the increases in flood levels are associated with riverine flooding. Typically, a 0.4m rise in sea levels results in an average increase in flood levels of +0.15m at Boomerang Reserve. The maximum increase in levels is approximately +0.25m at Georges River.

Increases in flood levels average +0.2m with a 0.9m rise in sea levels in Boomerang Reserve. The geographic extent of these increases is similar to the 0.4m SLR scenario. The peak increase in flood levels is +0.5m at Georges River.

C.3.8 Little Salt Pan Creek (C25)

The impact of sea level rise on overland flooding in the Little Salt Pan Creek catchment affects areas along Salt Pan Creek extending to north of the railway line at Revesby. Typically, a 0.4m rise in sea levels results in increases in overland flood levels which typically range from +0.1m to +0.2m. The maximum increase in levels is approximately +0.25m at Padstow Heights.

Increases in overland flood levels typically range from +0.1m to +0.4m with a 0.9m rise in sea flood levels. The geographic extent of these increases is similar to the 0.4m SLR scenario. The peak increase in levels is 0.5m which occurs at Padstow Heights.

C.4 Conclusions

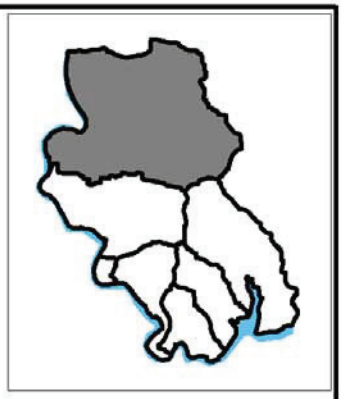
The increases in flood levels from future increased rainfall intensities are relatively modest (typically ≤ 0.10m) across much of the study area. There are a number of localised increases up to 0.30m but these are generally limited to ponding areas of flood waters. These ponding areas occur in depressions where the overland flow path is fully or partially blocked from continuing downstream by the natural terrain, constructed levees, noise walls, railway or roadway embankments. Drainage structures (pits, pipes, culverts and bridges) may be present at these locations but their capacity isn't sufficient to accommodate the conveyance of overland flow without increasing flood levels in the surrounding area.

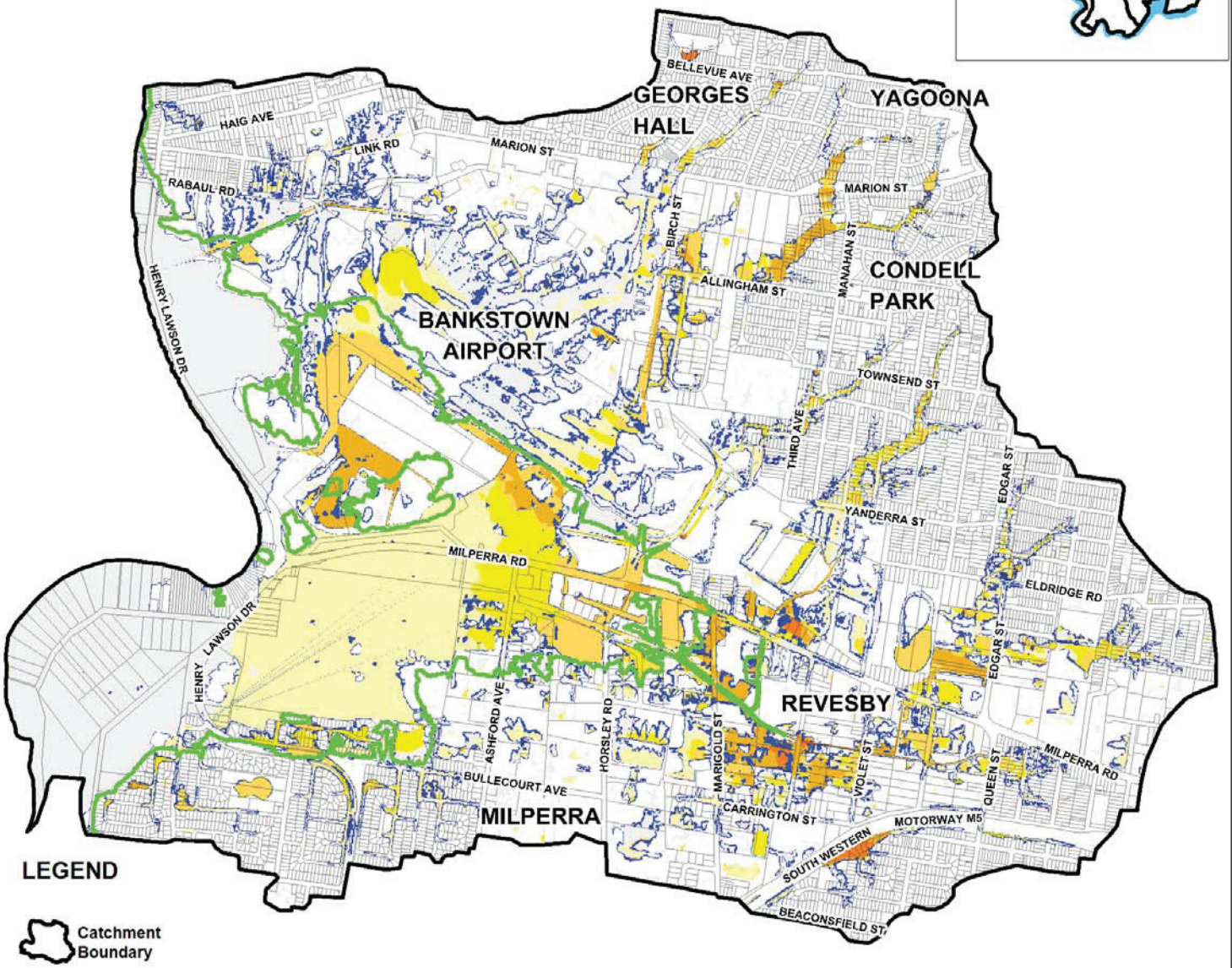
The assessment of the impacts of sea level rise indicates that there are varying increases in the flood planning area for both sea level rise scenarios. This increase in the flood planning area affects the lower reaches of the sub-catchments which are influenced by water levels in the Georges River. In general, a 0.4m increase in sea levels results in increases in flood levels of approximately 0.05m to 0.3m across the lower reaches of the sub-catchments. A 0.9m increase in sea levels results in larger increases in levels, with increases ranging from +0.2m to +0.9m.

There are uncertainties around predicted increases in rainfall intensities associated with climate change. The flood depth increases from a 10% increase in rainfall intensity are relatively modest and within the additional 0.5m freeboard applied to the current 100 year ARI design flood levels incorporated into the planning controls. Additionally,

While there are uncertainties around climate change predictions, sea level rise flood risk associated with overland flooding indicates maximum increases in levels of +0.9m for a 0.9m SLR scenario and warrants consideration of specific sea level rise planning controls. The consideration of climate change flood risks should be undertaken on an LGA basis, and a policy response should be set consistently for the whole of the LGA.

The Flood Risk Management Guide (DECCW, 2010b) indicates that freeboard (normally 0.5m) should not be used to allow for sea level rise impacts, but that the increased flood planning area resulting from the sea level rise planning benchmarks should be applied. This implies that flood planning levels along the Georges River and affected areas within each of the subject sub-catchments should be increased to include allowance for the increased flood levels due to sea level rise.





LEGEND

Catchment Boundary

Georges River Influence Line

Difference in Peak Flood Level (m)

- < 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- > 0.30
- Was Dry Now Wet

Title:

Climate Change Impact Map - Milperra
10% Increase in Rainfall Intensities 100 Year ARI Event

Figure: **C-1**

Rev: **1**

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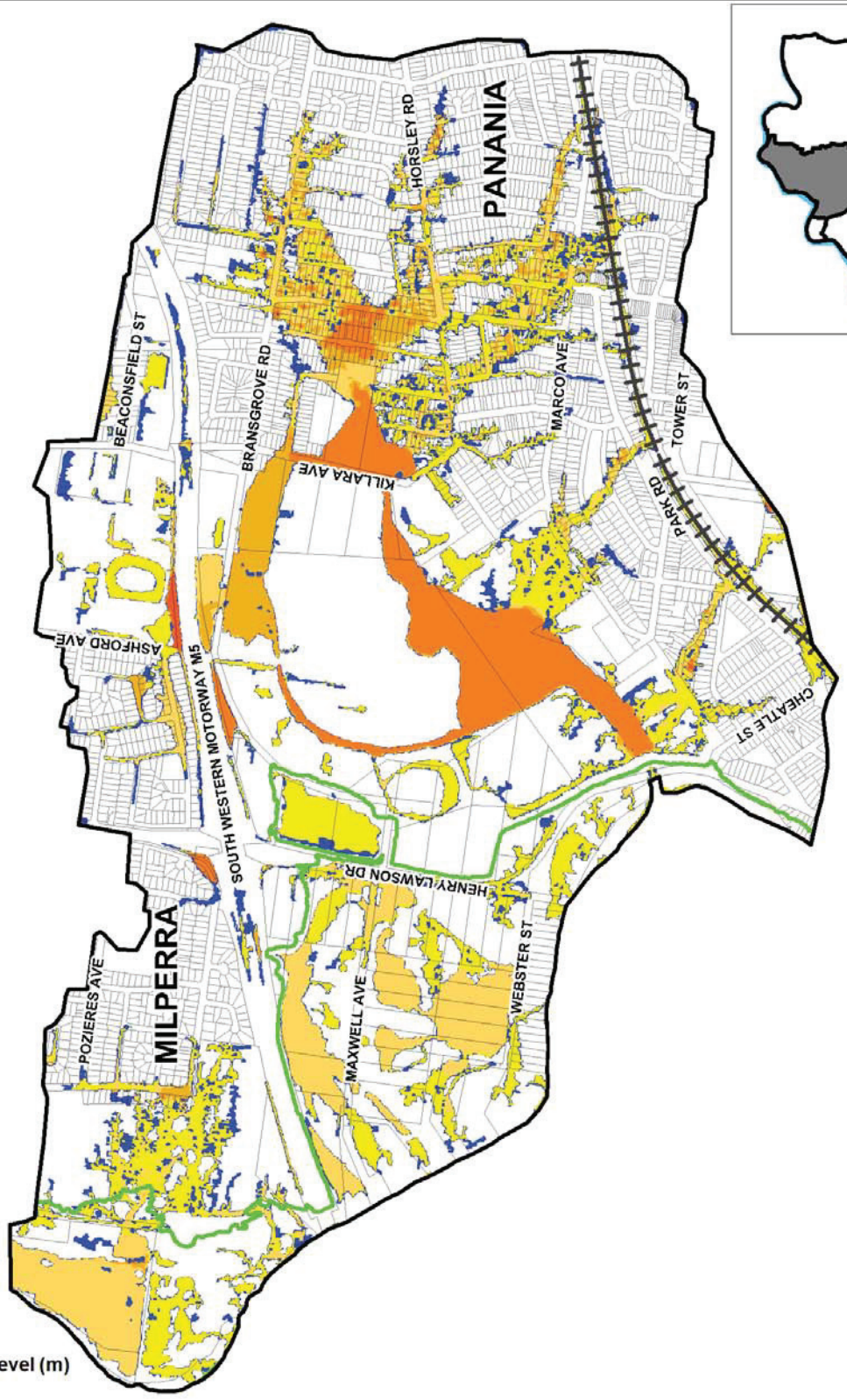
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0 0.5 1km

Approx. Scale

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Title:

Climate Change Impact Map - Kelso Swamp
10% Increase in Rainfall Intensities 100 Year ARI Event

Figure: C-2

Rev: 0

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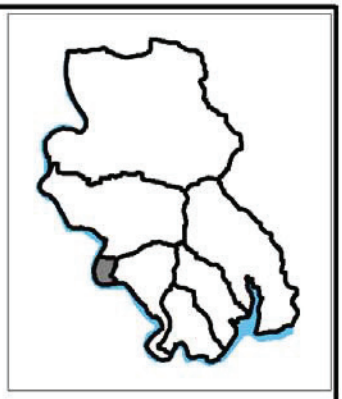
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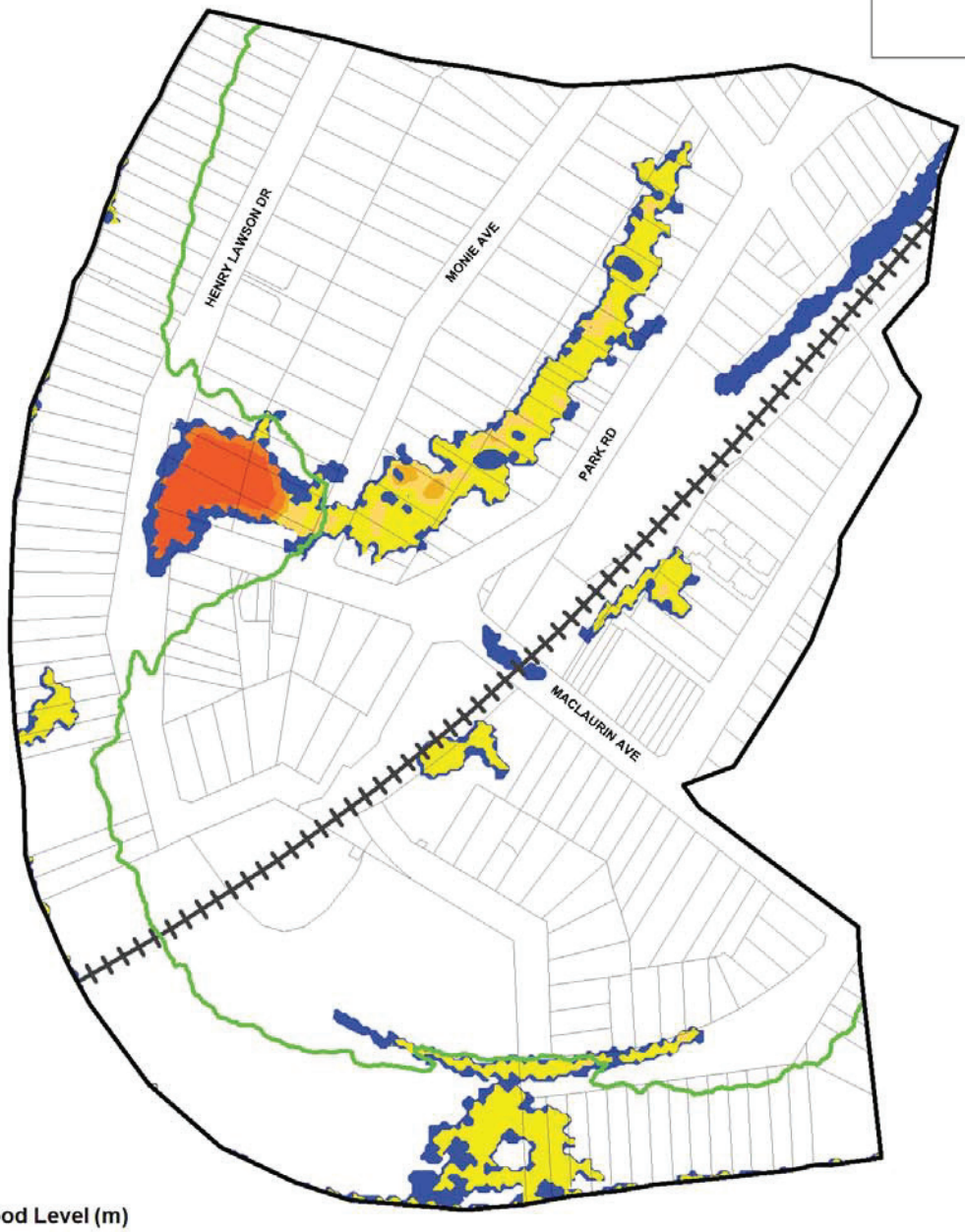
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Approx. Scale

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LEGEND

Catchment Boundary

Georges River Influence Line

Difference in Peak Flood Level (m)

- < 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- > 0.30
- Was Dry Now Wet

Title:

Climate Change Impact Map - East Hills
10% Increase in Rainfall Intensities 100 Year ARI Event

Figure: **C-3**

Rev: **0**

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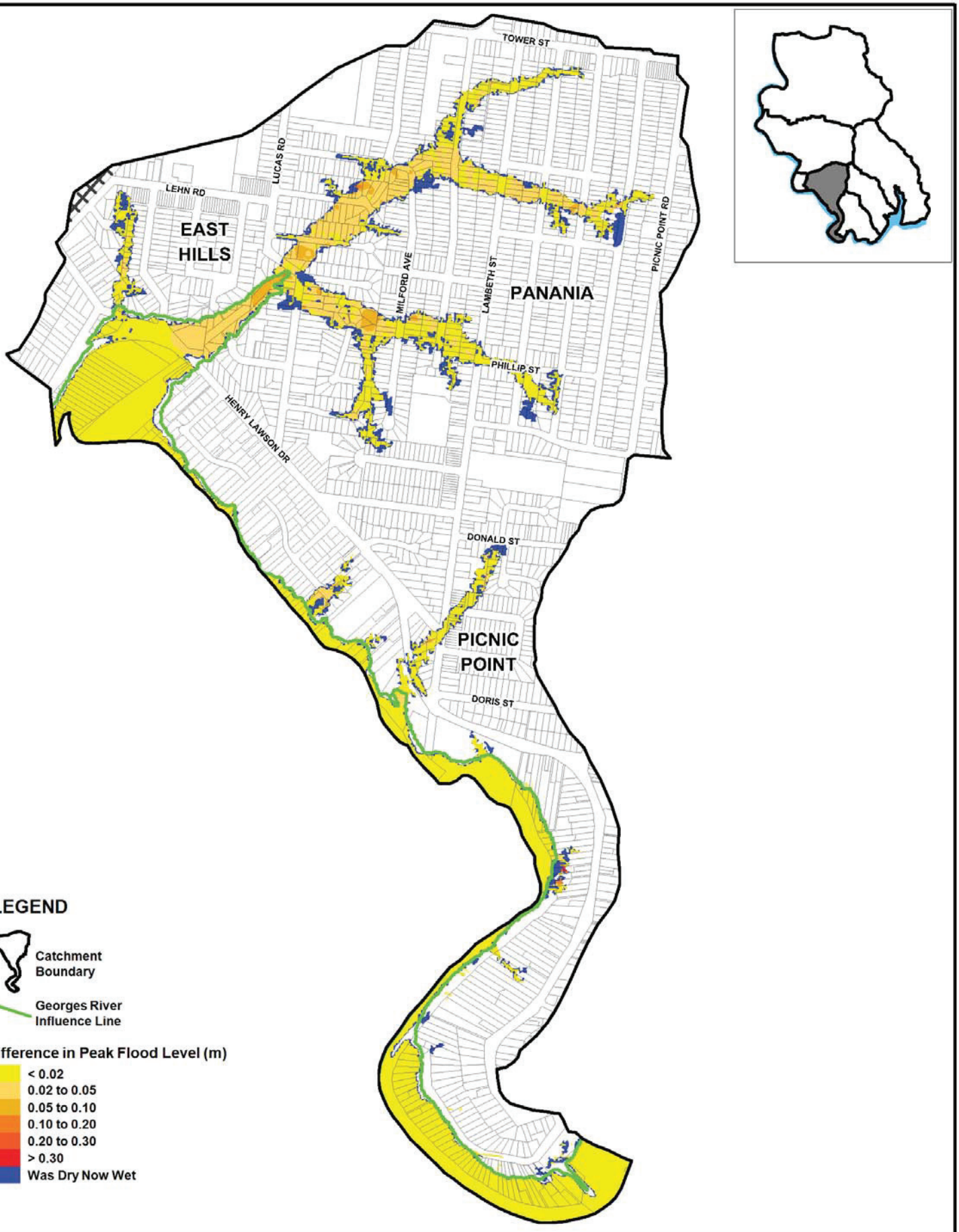
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Approx. Scale

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Title:

Climate Change Impact Map - Lucas Road
10% Increase in Rainfall Intensities 100 Year ARI Event

Figure: **C-4**

Rev: **0**

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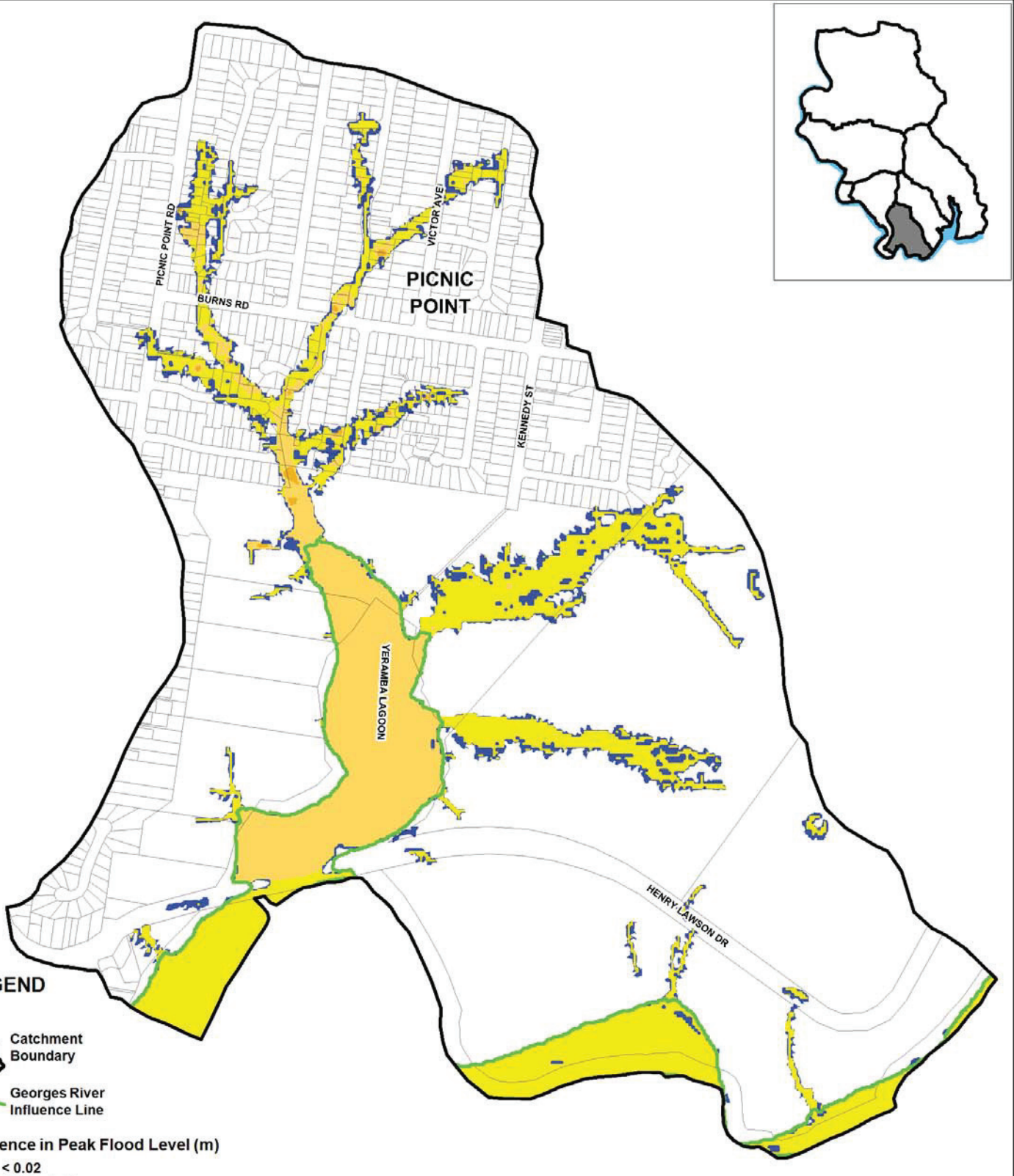
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Approx. Scale

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Title:

Climate Change Impact Map - Picnic Point
10% Increase in Rainfall Intensities 100 Year ARI Event

Figure: C-5

Rev: 0

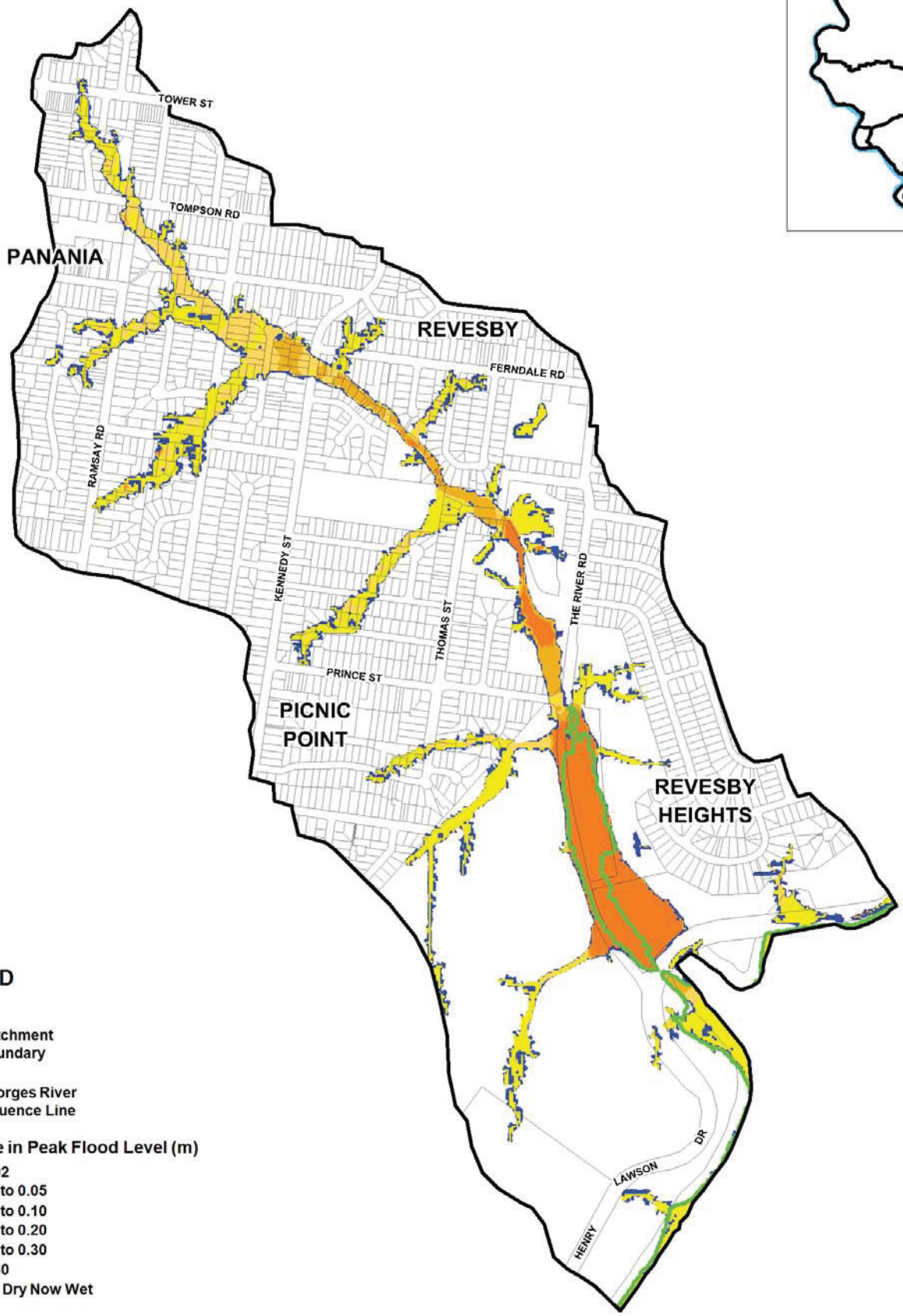
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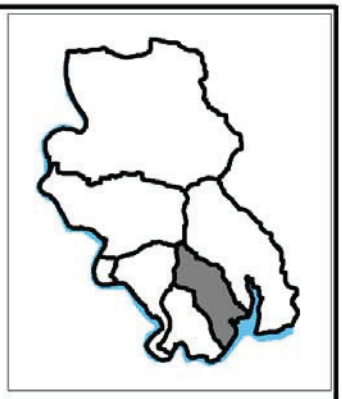
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LEGEND

Catchment Boundary

Georges River Influence Line

Difference in Peak Flood Level (m)

- < 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- > 0.30
- Was Dry Now Wet

Title:

Climate Change Impact Map - Morris Gully
10% Increase in Rainfall Intensities 100 Year ARI Event

Figure: **C-6**

Rev: **0**

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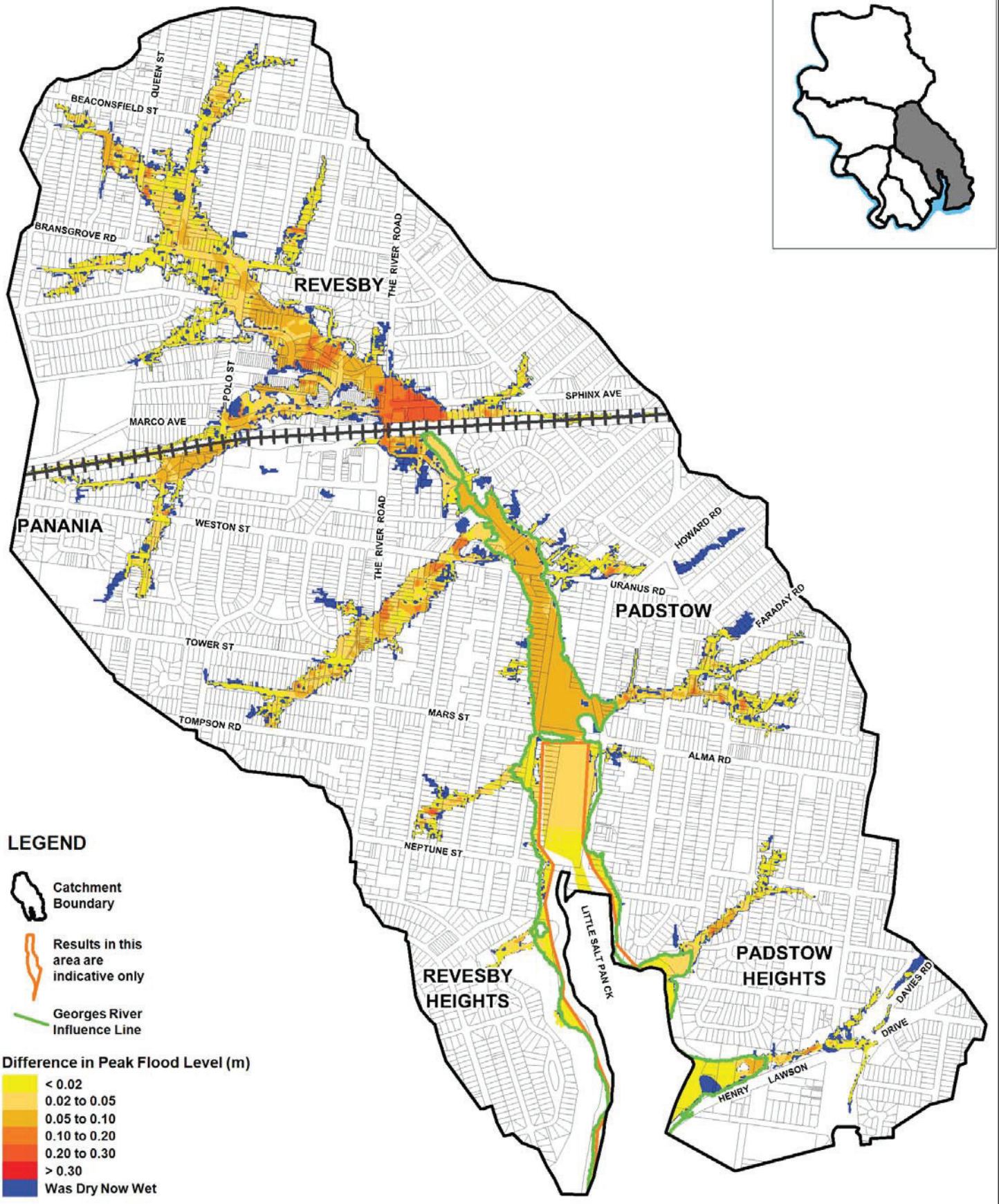
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Approx. Scale

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Title:

Climate Change Impact Map - Little Salt Pan Creek
10% Increase in Rainfall Intensities 100 Year ARI Event

Figure: C-7

Rev: 0

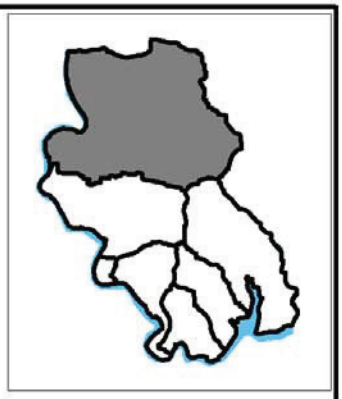
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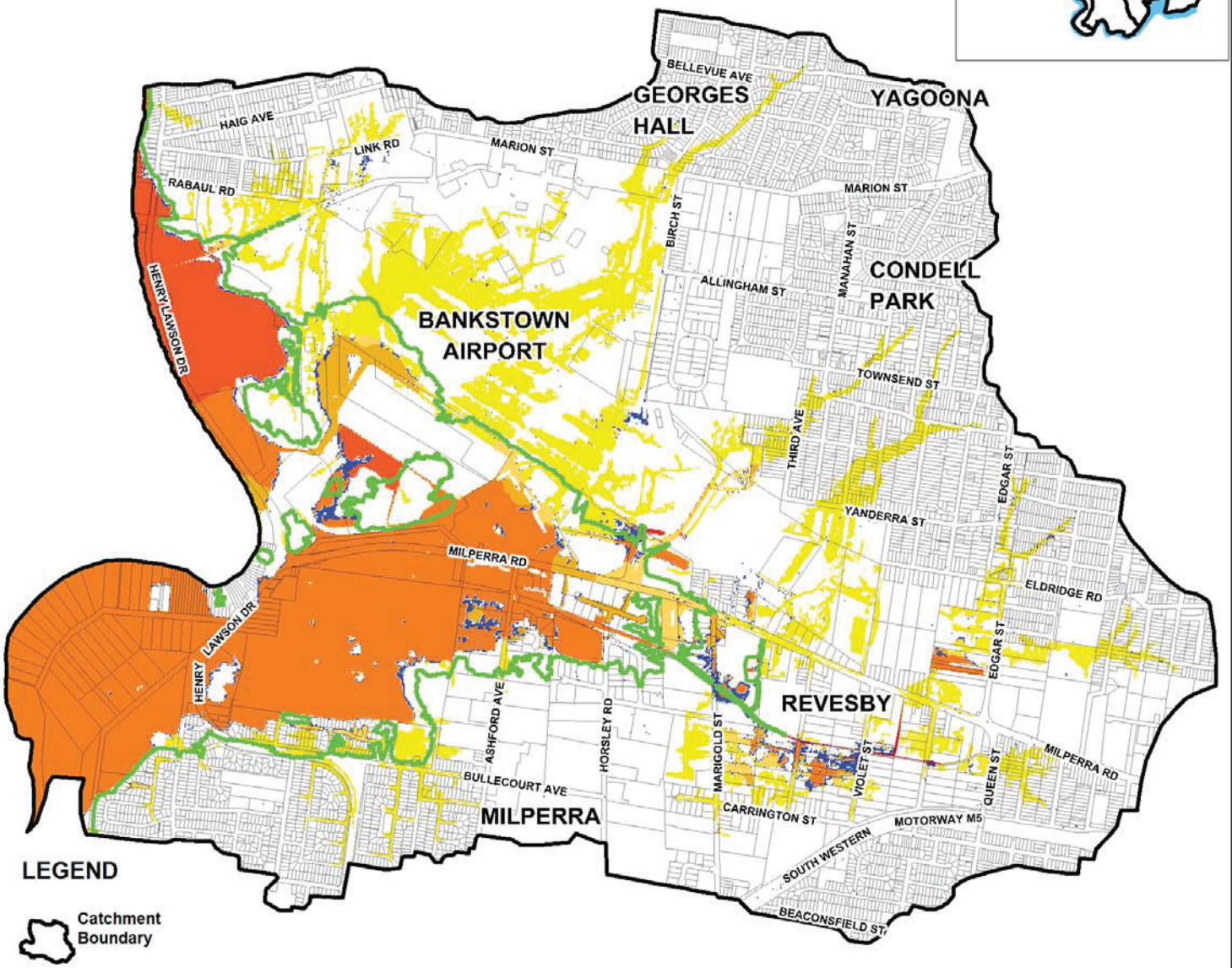
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Approx. Scale

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LEGEND

Catchment Boundary

Georges River Influence Line

Difference in Peak Flood Level (m)

- < 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- > 0.30
- Was Dry Now Wet

Title:

Sea Level Rise Impact Map - Milperra
0.4m Sea Level Rise 100 Year ARI Event

Figure: **C-8**

Rev: **0**

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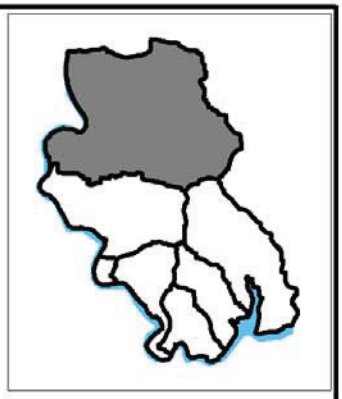
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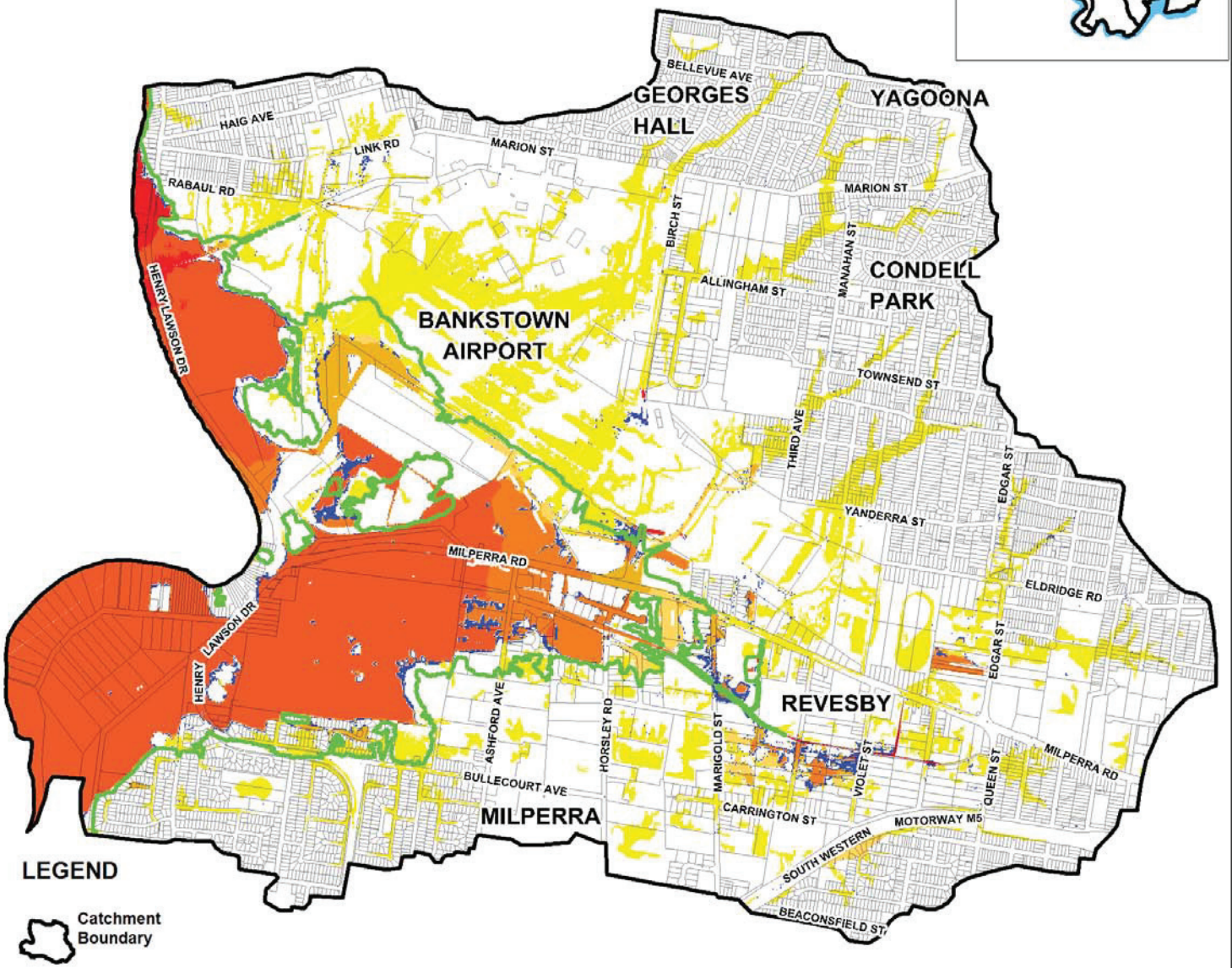
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Approx. Scale

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LEGEND

Catchment Boundary

Georges River Influence Line

Difference in Peak Flood Level (m)

- < 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- > 0.30
- Was Dry Now Wet

Title:

Sea Level Rise Impact Map - Milperra
0.9m Sea Level Rise 100 Year ARI Event

Figure: **C-9**

Rev: **0**

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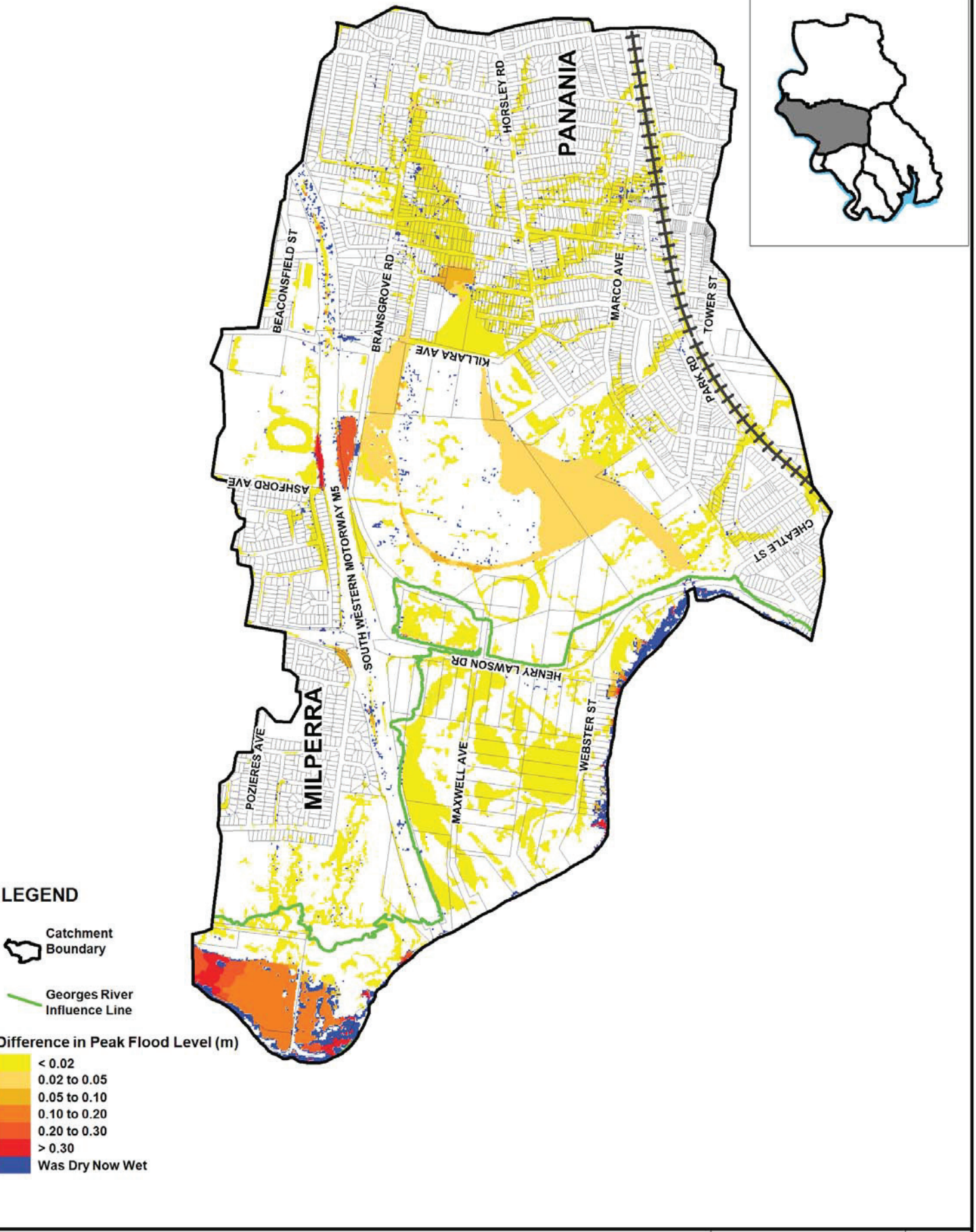
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Approx. Scale

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Title:

Sea Level Rise Impact Map - Kelso Swamp
0.4m Sea Level Rise 100 Year ARI Event

Figure: C-10

Rev: 0

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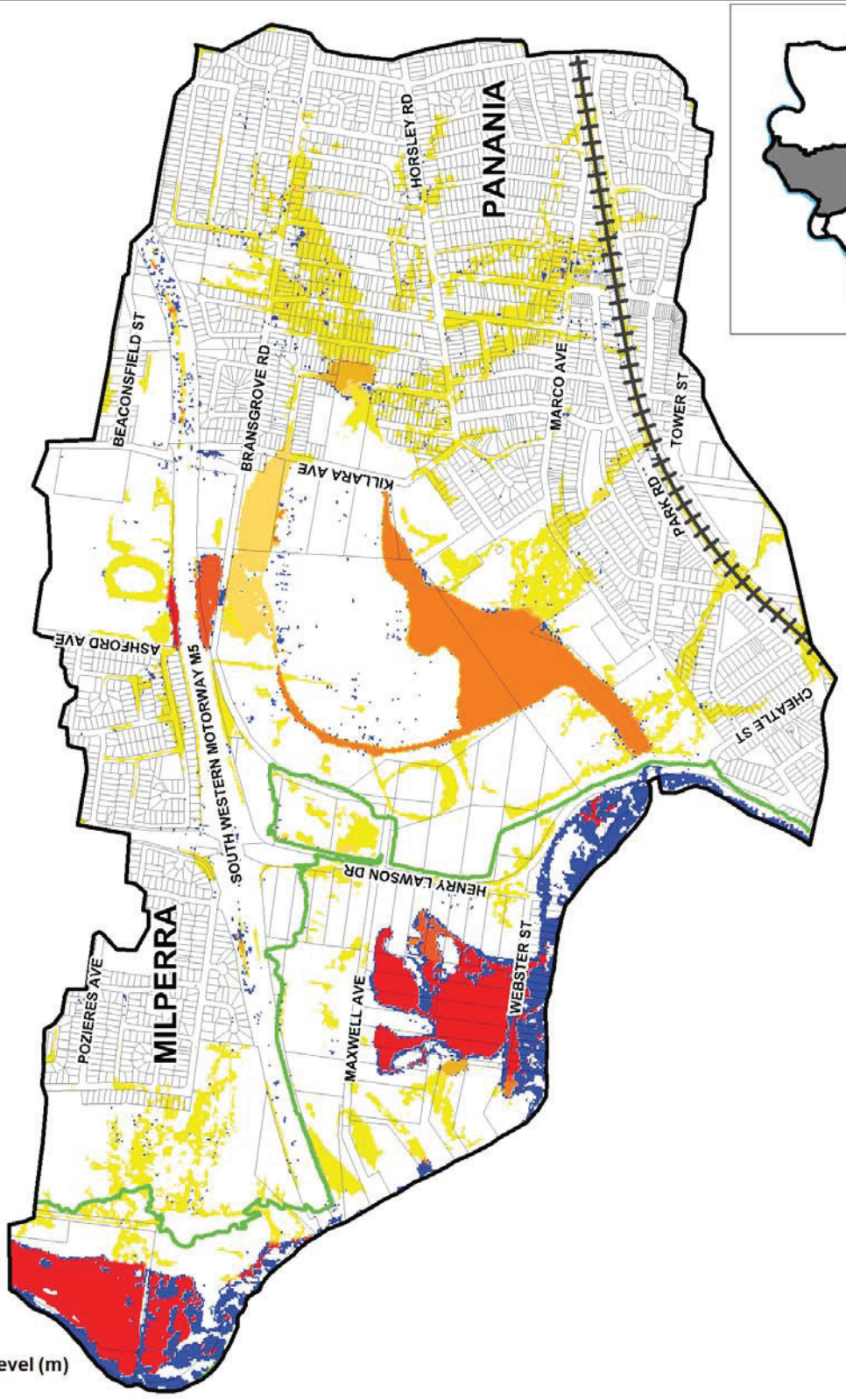
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0 375 750m

Approx. Scale

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Title:

Sea Level Rise Impact Map - Kelso Swamp
0.9m Sea Level Rise 100 Year ARI Event

Figure: C-11

Rev: 0

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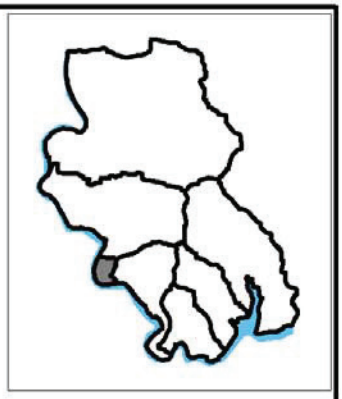
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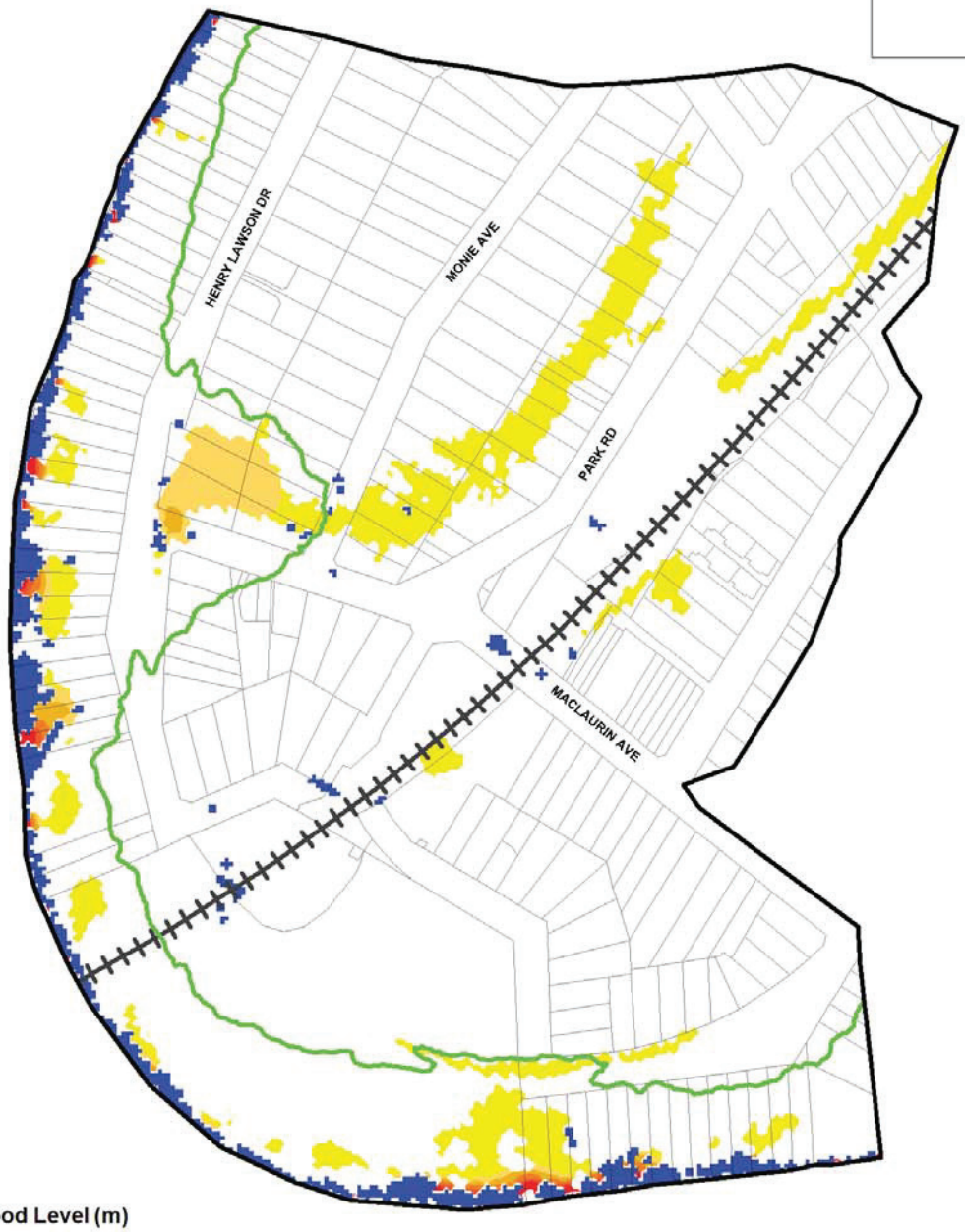
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LEGEND

Catchment Boundary

Georges River Influence Line

Difference in Peak Flood Level (m)

- < 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- > 0.30
- Was Dry Now Wet

Title:

Sea Level Rise Impact Map - East Hills
0.4m Sea Level Rise 100 Year ARI Event

Figure: **C-12**

Rev: **0**

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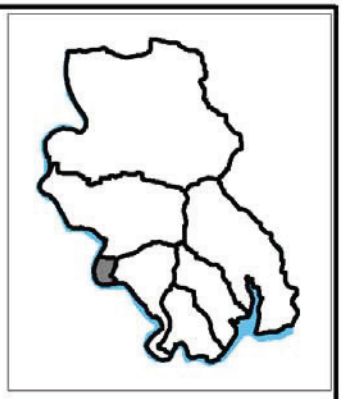
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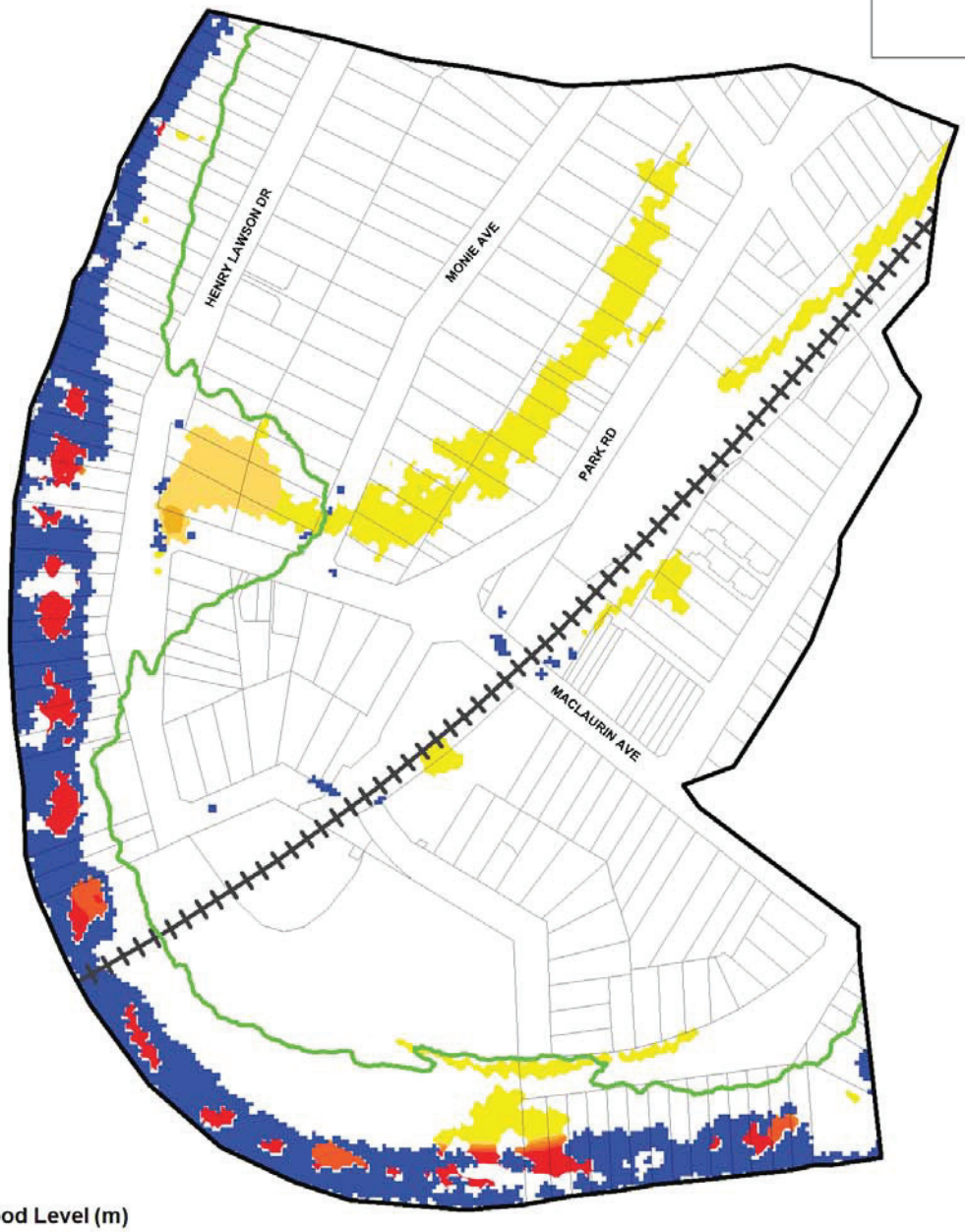
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LEGEND

Catchment Boundary

Georges River Influence Line

Difference in Peak Flood Level (m)

- < 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- > 0.30
- Was Dry Now Wet

Title:

Sea Level Rise Impact Map - East Hills
0.9m Sea Level Rise 100 Year ARI Event

Figure: **C-13**

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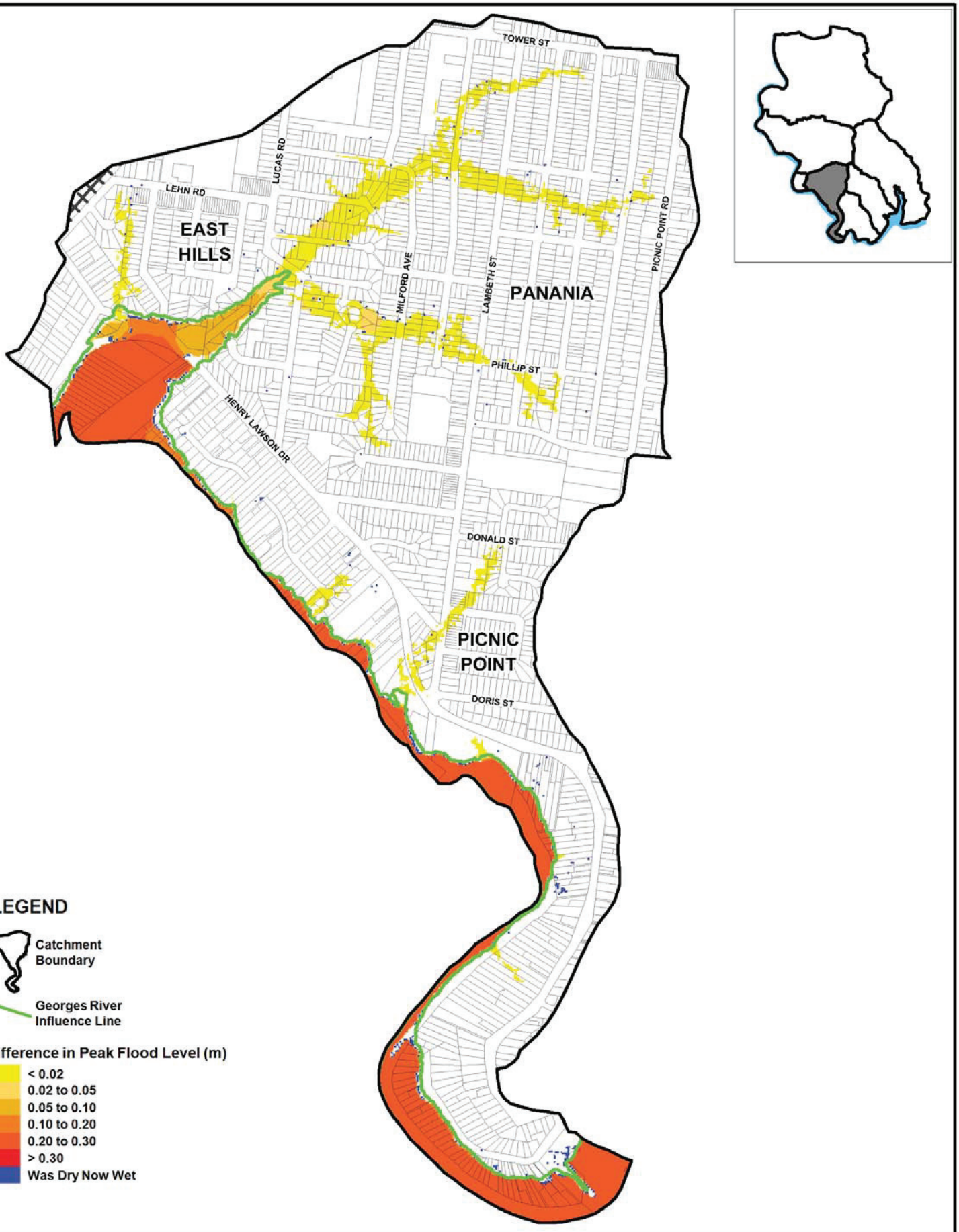
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Title:

Sea Level Rise Impact Map - Lucas Road
0.4m Sea Level Rise 100 Year ARI Event

Figure: C-14

Rev: 0

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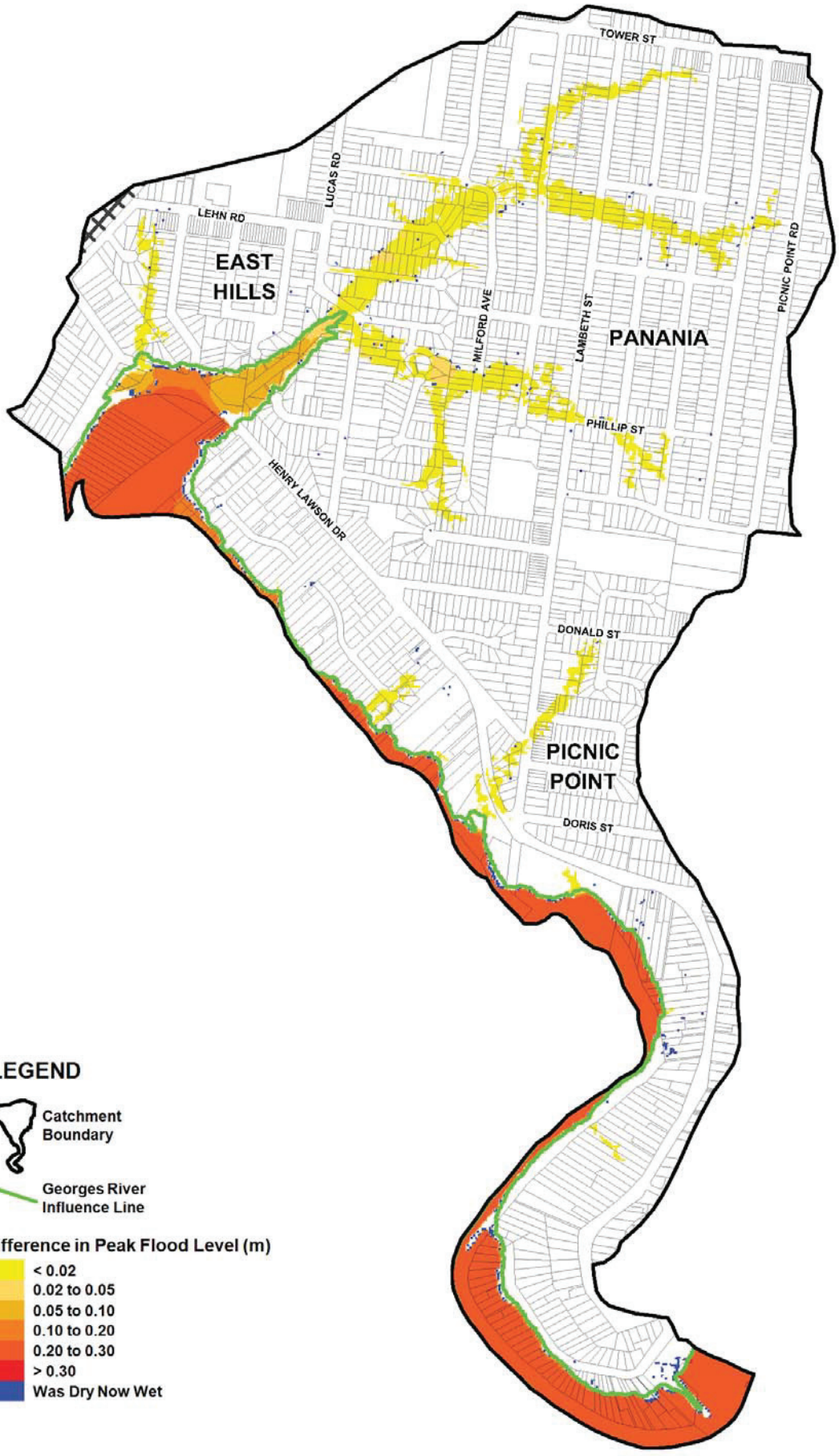
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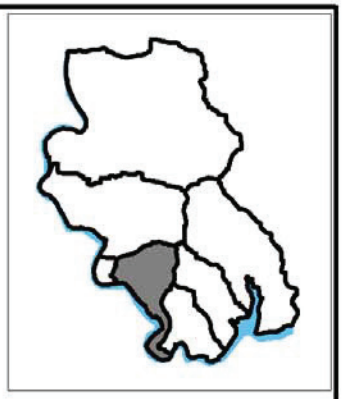
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Approx. Scale

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LEGEND

Catchment Boundary

Georges River Influence Line

Difference in Peak Flood Level (m)

- < 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- > 0.30
- Was Dry Now Wet

Title:

Sea Level Rise Impact Map - Lucas Road
0.9m Sea Level Rise 100 Year ARI Event

Figure: **C-15**

Rev: **0**

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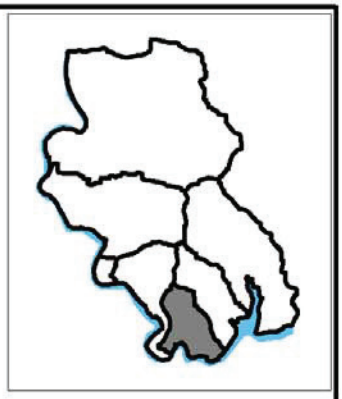
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Approx. Scale

BMT WBM
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Title:

Sea Level Rise Impact Map - Picnic Point
0.4m Sea Level Rise 100 Year ARI Event

Figure: **C-16**

Rev: **0**

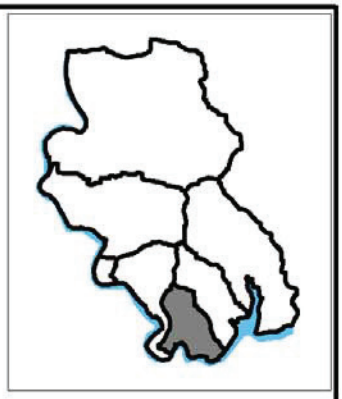
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N 0 250 500m

Approx. Scale

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LEGEND

Catchment Boundary

Georges River Influence Line

Difference in Peak Flood Level (m)

- < 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- > 0.30
- Was Dry Now Wet

Title:

Sea Level Rise Impact Map - Picnic Point
0.9m Sea Level Rise 100 Year ARI Event

Figure: **C-17**

Rev: **0**

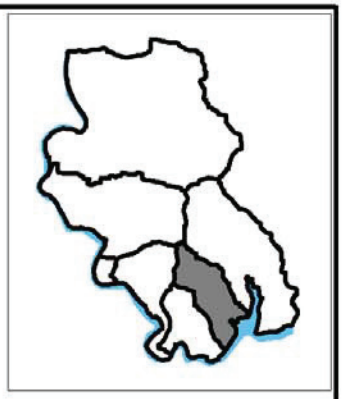
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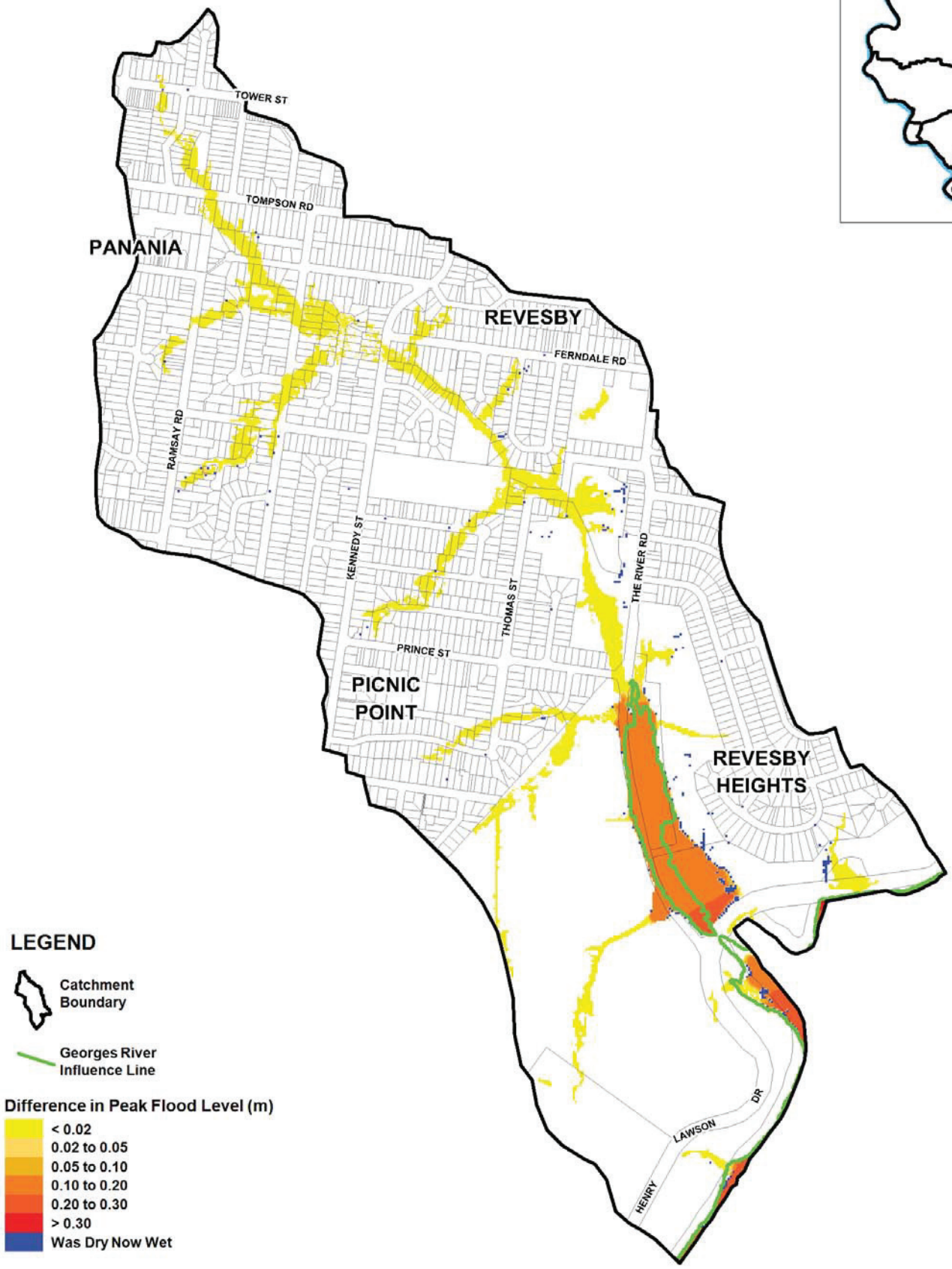
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LEGEND

Catchment Boundary

Georges River Influence Line

Difference in Peak Flood Level (m)

- < 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- > 0.30
- Was Dry Now Wet

Title:

Sea Level Rise Impact Map - Morris Gully
0.4m Sea Level Rise 100 Year ARI Event

Figure: C-18

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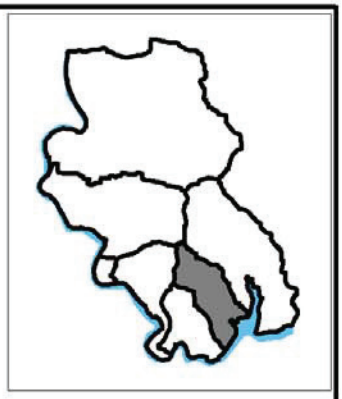
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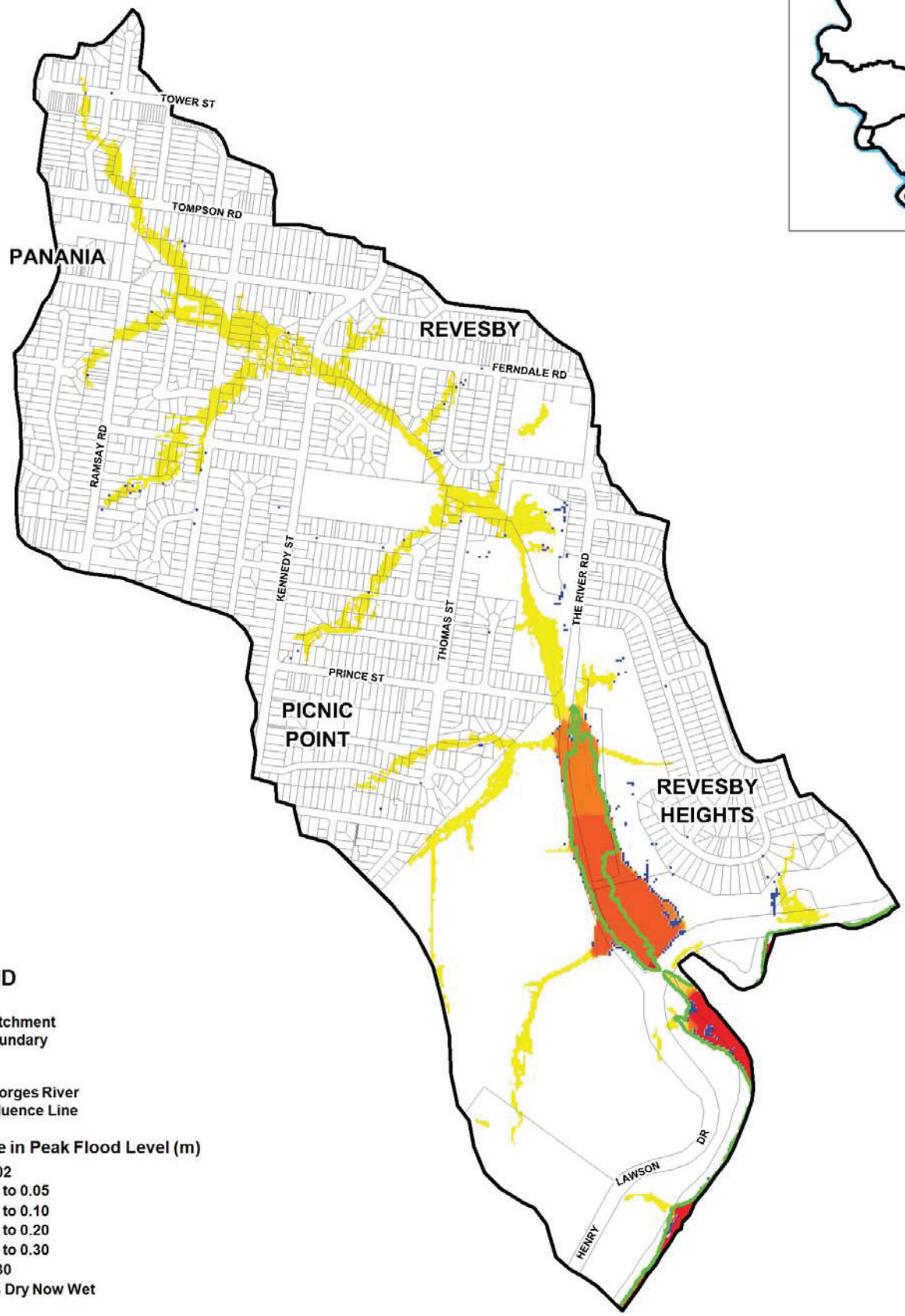
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LEGEND

Catchment Boundary

Georges River Influence Line

Difference in Peak Flood Level (m)

- < 0.02
- 0.02 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- > 0.30
- Was Dry Now Wet

Title:

Sea Level Rise Impact Map - Morris Gully
0.9m Sea Level Rise 100 Year ARI Event

Figure: C-19

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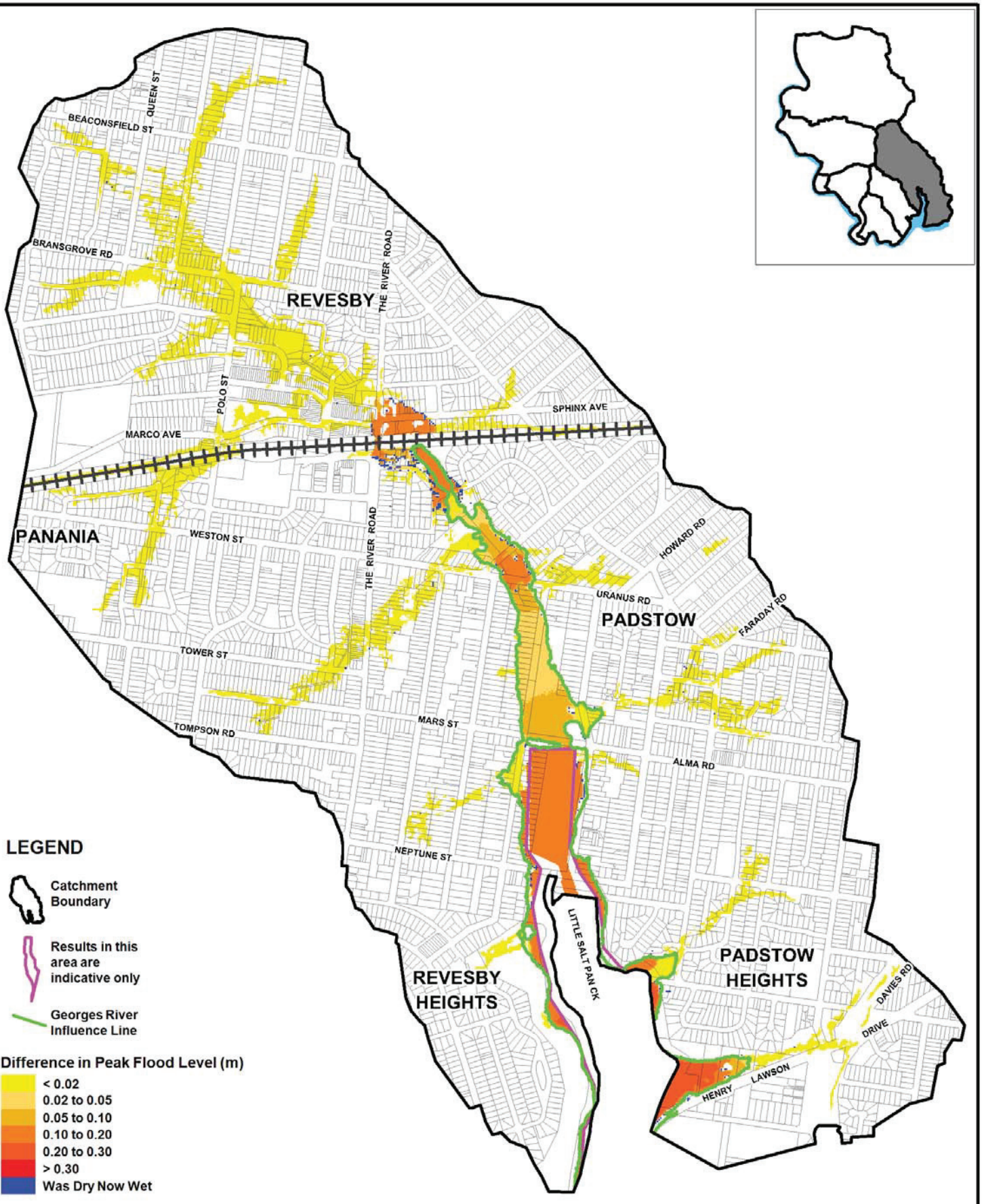
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Title:

Sea Level Rise Impact Map - Little Salt Pan Creek
0.4m Sea Level Rise 100 Year ARI Event

Figure: C-20

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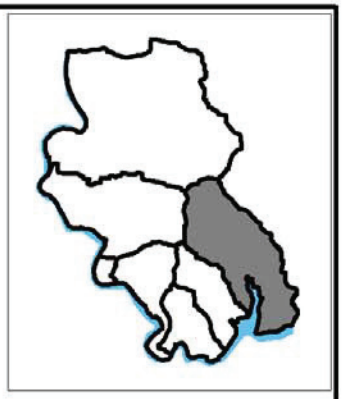
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Title:

Sea Level Rise Impact Map - Little Salt Pan Creek
0.9m Sea Level Rise 100 Year ARI Event

Figure: C-21

Rev: 0

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Appendix D Planning Considerations Report

Mid Georges River Sub-Catchments

Floodplain Risk Management Study & Plan - Planning Considerations

Prepared for BMT WBM
On behalf of Bankstown City Council

May 2016
Project No: 10170

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1.0 Introduction

BMT WBM has engaged GLN Planning, to provide town planning input into the preparation of the Mid Georges River Floodplain Risk Management Study (**FRMS**) and Floodplain Risk Management Plan (**FRMP**) being prepared on behalf of Bankstown City Council (**Council**).

2.0 Purpose of Report

The purpose of this report is to:

- Outline and review the state and local planning policy context (including existing environmental planning polices and instruments and long term planning strategies for the area);
- Identify the planning issues associated with implementing a flood risk management strategy for the study area;
- Discuss options to address these planning issues; and
- Make recommendations for incorporation into the FRMP.

The planning recommendation will focus on providing recommendations to inform a review of:

- The Waterways Chapter of South West Local Area Plan (**South West LAP**).
- Bankstown Local Environmental Plan 2015 (**LEP 2015**).
- Part B12 of the Bankstown Development Control Plan (**DCP**) 20015 – Flood Risk Management (**FRM**) DCP provisions, particularly Schedules 3, 4A, 4B, 4C and 5.

Council's planning approach to flood risk management (FRM) of riverine flooding was substantially developed through the preparation of the Georges River FRMP[1]. This FRMP established the framework for Council's existing Development Control Plan (DCP) FRM provisions.

The Salt Pan Creek FRMP[2] built upon the framework established by the Georges River FRMP to formulate a FRM framework for overland flow flooding.

The Mid Georges River FRMS and FRMP will build upon the framework established by the Georges River and Salt Pan Creek FRMPs and will not revisit the philosophical basis[3] to the formation of these frameworks. The primarily focus of this report will be on

[1] Bewsher Consulting, *Georges River Floodplain Risk Management Study and Plan* (2005) for Fairfield, Bankstown, Liverpool and Sutherland Councils.

[2] Bewsher Consulting, *Salt Pan Creek Floodplain Risk Management Study and Plan* (2012) including Grech Planners Planning Considerations Discussion Paper (2012) for Bankstown City Council.

[3] This framework includes the approach of preparing flood risk maps and applying graduated controls that vary depending on the sensitivity of different land uses to different flood hazards. (See Bewsher & Grech, May 1997 and HNFMSC, June 2006a).

overland flow flooding issues within the various sub-catchments but will also review riverine flooding issues associated with the Carinya Road Area.

A review of flood behaviour and flood planning controls for the Carinya Road area was prepared subsequent to the preparation of the Georges River FRMP to more closely consider the planning issues in this part of the Georges River floodplain[4]. The FRM planning controls that apply to this area remain an issue for Council. The review required by this report is therefore to be more detailed with respect to this area.

The issues associated with the Carinya Road area relate to mainstream flooding and not overland flow flooding and therefore differ to the primary focus of the FRMP. To assist in reviewing these issues we undertook an inspection of the area on 6 March 2014, reviewed Council officer's (C Blackburn) memoranda dated 8 June, 2011 and 1 July 2011, considered relevant submissions made to the Draft new City wide planning controls[5] and reviewed example development applications considered by Council in the area over the last 5 years[6].

3.0 Study Area

The sub-catchments of the Mid Georges River, within the Bankstown Local Government Area (**LGA**) include the following seven sub-catchments:

- Little Salt Pan Creek,
- Morris Gully;
- Picnic Point;
- Kelso Swamp;
- East Hills;
- Lucas Road; and
- Milperra.

The catchment is urbanised and comprises parts of the suburbs of Revesby, Revesby Heights, Picnic Point, Panania, Kelso, East Hills, Milperra and Condell Park. The catchment covers an area of approximately 30 km² in size.

While the study brief discusses the whole of the drainage catchment, the focus of the FRMS and FRMP is the floodplain, being the area defined as that potentially inundated by floods up to and including a probable maximum flood (**PMF**). The extent of the floodplain is depicted on **Figure 1**, by BMT WBM, and shows the flood risk precincts prepared for planning purposes which include a combination of mainstream and overland flow flooding within the PMF.

The focus of the Mid Georges River FRMS and FRMP is overland flow flooding. Consequently this FRMS and FRMP adds to understanding of the flood risk and mitigation options already determined by the Georges River FRMS and FRMP for riverine flooding.

[4] Bewsher Consulting & Don Fox Planning, (1994) *Carinya Road Area Floodplain Management Study and DCP for Bankstown City Council*.

[5] Council briefed us with 9 submissions from the same resident of Carinya Road dealing with different detail provisions of the current and identically proposed floodplain risk management controls applying to the area.

[6] Council briefed us with 3 example development applications for extensions to a balcony, alterations and additions to a dwelling and a new 2 storey dwelling house lodged between 2009 and 2011, all of which were issued with conditional approvals.

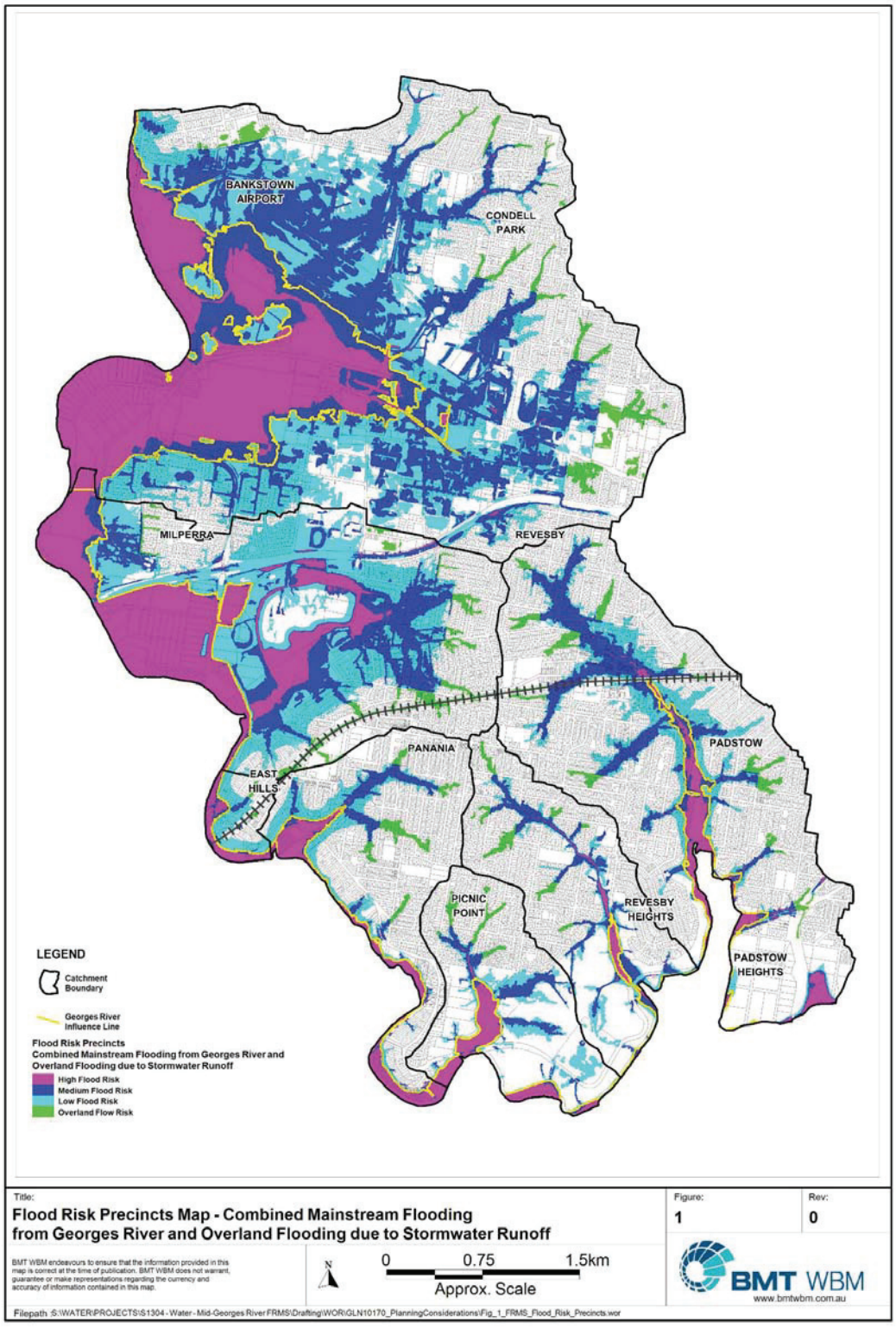


Figure 1 *Study Area*

4.0 General Planning Policy Framework

4.1 Overview

The formulation and implementation of FRMPs is the cornerstone of the NSW Government's Flood Prone Land Policy. As with other local planning processes, the preparation of FRMPs is a Council responsibility. The planning recommendations ultimately incorporated within a FRMP and adopted by Council will subsequently require implementation through the separate planning processes, principally governed by the *Environmental Planning and Assessment Act 1979* (**EP&A Act**).

There are various layers of non-statutory strategic planning policies and statutory planning instruments that provide a framework for planning within the study area. The majority of these documents are directed towards the general planning of the area and few have any provisions relating to FRM issues.

The imposition of planning controls can be an effective means of managing flood risks associated with future development (including redevelopment). Such controls might vary from prohibiting certain land uses in areas of high flood risk to specifying development controls such as minimum floor levels and building materials.

In principle, the degree of restriction that is imposed on development due to flooding should relate to the level of risk that the community is prepared to accept after balancing economic, environmental and social considerations (i.e. the application of the merits based approach required by the Floodplain Development Manual (**FDM**)). In practice, the planning controls that may ultimately be imposed are influenced by a complex array of considerations including state imposed planning policy and directions, existing local planning strategies and policies and ultimately the acceptability of conditions that could be imposed through the development application process.

The following provides an outline of policy that is potentially relevant because it either directs the flood risk management (**FRM**) planning controls that could be adopted or affects the way flood risk is identified in the planning controls.

4.2 The FRMP Relationship with EP&A Legislation

In 1984 the NSW State Flood Policy was introduced disbanding the mandatory application of a singular 100 year flood standard[7] and required local Councils to prepare individual floodplain management plans based on a "merit based approach". The first FDM was published in 1986 to assist Councils in this task.

While the policy has evolved over time it has remained fundamentally the same, with a new Manual being published but not gazetted in 2001 and the current policy and Manual published and gazetted in 2005.

The changes in the Manual and policy over time are not considered to be significant, and have principally retained the following key principles:

a. Local Government is responsible for FRM in NSW with financial and technical support being provided by the State Government. The actions, decisions and information provided by Council and exercised in this duty are indemnified through the provisions of Section 733 of *the Local Government Act, 2003*. Indemnity is

[7] 1986 Manual, New South Wales Government, 1986, page 33

provided where Council acts in good faith, which is deemed to be in accordance with the principles of the FDM unless proven otherwise.

b. A merit approach is to be adopted for the purposes of formulating a FRMP that provides a basis for decision making in the floodplain. This is in recognition that flood prone land is a valuable resource which should not be unnecessarily sterilised by the rigid application of prescriptive criteria, and to avoid the approval of inappropriate proposals. The merit approach is defined as follows:

"The merit approach weighs socio-economic, ecological and cultural impacts of land use options for different flood prone land areas together with flood damage, hazard and behaviour implications, and environmental protection and wellbeing of the State's rivers and floodplains."[8]

c. The level of flood risk acceptable to the community is to be determined through a process overseen by a committee comprised of local elected representatives, community members and State and Local Government officials (including the SES). This process is shown in **Figure 2.**

The ultimate intent is to prepare FRMPs for individual floodplains that are adopted by Councils. FRMPs should have an integrated mix of management measures that address existing, future and continuing risk.

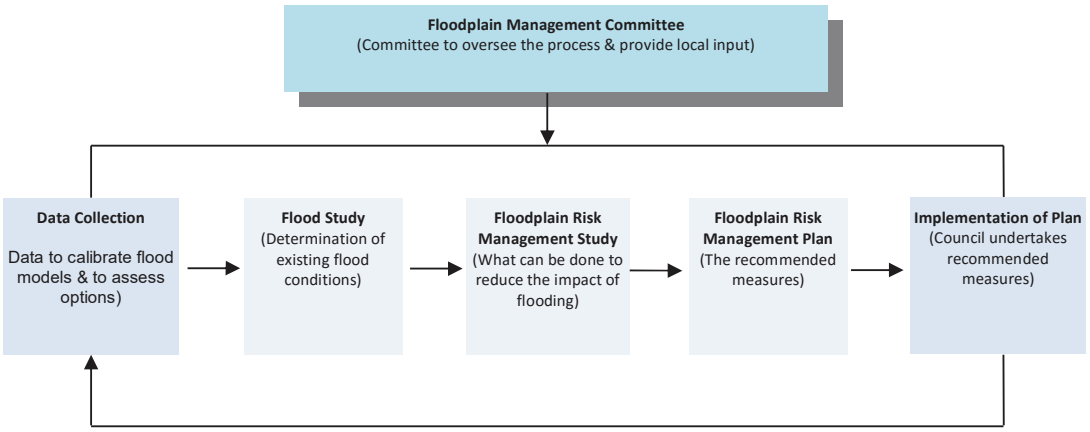


Figure 2 *NSW FRM Process (Adapted from FDM 2005, pg.6)*

As discussed by Pain J [22] in *Neate v Shellharbour City Council [2007] NSWLEC 526*, the FDM and planning controls under the EP&A Act should not be considered as providing alternate approaches.

The Flood Prone Lands Policy and Manual are separate to the principal planning legislation in NSW, being that contained within the EP&A Act and associated Regulations. Ultimately, the planning recommendations of a FRM Plan may be reflected in planning instruments and policies brought into force in accordance with the EP&A Act. While the EP&A Act and Regulation refers to flooding as an issue requiring consideration in some circumstances9 this legislation does not refer to the Flood Prone Lands Policy or the Manuals. The plans prepared under the EP&A Act provide the relevant considerations for the assessment of development applications.

[8] 2005 Manual, NSW Government, 2005, page 23.

[9] For example in the determination of what is designated development for the purposes of the Act and therefore requiring the preparation of an Environmental Impact Statement.

The FRMP can provide appropriate input to the EP&A Act planning processes in 3 ways:

a. Providing direction at a local and state strategic planning level in addressing FRM (e.g. where new urban areas should be located and the distribution of land uses therein);

b. Recommendation of development controls to be incorporated in appropriate planning instruments (e.g. LEPs and DCPs) to mitigate the risk to development where permitted in the floodplain; and

c. Ensuring that the planning controls and associated documents (e.g. S149 Planning Certificates) contribute to ensuring the community is appropriately informed about the flood risk.

To understand how these outcomes may be best achieved, it is important to consider the existing EP&A Act framework and guidelines that relate to FRM.

4.3 EP&A Act Statutory FRM Framework and Guidelines

4.3.1 2007 Flood Planning Guideline

On January 31, 2007 the NSW Planning Minister announced a new guideline for development control on floodplains (the "Flood Planning Guideline"). An overview of the new Guideline and associated changes to the EP&A Act and Regulation was issued by the Department of Planning in a Circular dated January 31, 2007 (Reference PS 07-003). The Flood Planning Guideline issued by the Minister in effect relates to a package of directions and changes to the EP&A Act, Regulation and FDM.

This Flood Planning Guideline provides an amendment to the Manual. The Guideline confirms that unless there are "exceptional circumstances", Councils are to adopt the 100 year flood as the flood planning level (FPL) for residential development, with the exception of some sensitive forms of residential development such as seniors living housing. The Guideline does provide that controls on residential development above the 100 year flood may be imposed subject to an "exceptional circumstances" justification being agreed to by the Department of Natural Resources (now the Office of Environment and Heritage - OEH) and the Department of Planning (now the Department of Planning and Environment - DPE) prior to the exhibition of a Draft LEP or Draft DCP.

The Flood Planning Guideline provides various potentially ambiguous statements in regard to what is the Residential FPL for the purposes of applying the directions in the Guideline. The reference to the FPL is a reference to both the 100 year flood plus freeboard (typically 0.5 metres).

As discussed below, under Council's existing DCP the floodplains of the Mid Georges River sub-catchments form part of the general Georges River Floodplain which provides controls on residential development above the 100 year (plus freeboard) extent. Additionally, the introduction of specific controls for the Salt Pan Creek floodplain may technically trigger the requirement for an "exceptional circumstances" dispensation.

4.3.2 Section 117 Directions

Ministerial directions pursuant to Section 117(2) of the EP&A Act specify matters which local councils must take into consideration in the preparation of LEPs. Direction 4.3, as currently applies, deals specifically with flood [liable] prone land. The Direction applies

to all councils that contain flood prone land when an LEP proposes to "create, remove or alter a zone or provision that affects flood prone land." In such cases, the Direction requires draft LEPs to ensure the following:

- Consistency with the principles of the FDM (including the Planning 2007 Flood Guideline).
- Do not rezone flood prone land zoned special use areas, recreation, rural or environmental protection to a residential, business, industrial or special use area zone;
- Do not permit development in floodways that would result in significant flood impacts on others, permit a significant increase in development on the floodplain, require substantial government spending on flood mitigation, or allow development without consent except for agriculture or flood mitigation works.
- That flood related development controls are not imposed on residential development above the "residential flood planning level" unless adequate justification to the satisfaction of the DPE [and OEH] is provided.
- Flood planning levels must be consistent with the FDM and 2007 Flood Planning Guideline.

Clause (6) of the Direction specifies that a variation to the Direction may be permitted where it is minor or accords with an FRMP.

While Section 117 Directions are not relevant to DCPs, the new Flood Planning Guideline does indicate the approval of the DPE is required prior to the exhibition of a draft DCP that varies from the Guideline.

4.4 Climate Change Considerations

4.4.1 Current State Policy Context

In 2010, the NSW Government adopted sea level rise planning benchmarks (measured as an increase above 1990 mean sea levels) of 40 cm by 2050 and 90 cm by 2100. On 8th September 2012 a new NSW Government announced the first stage of a number of coastal management reforms, including the removal of the recommended sea level rise planning benchmarks. Any reference to the 'NSW sea level rise planning benchmarks' in other guidelines and documents should be taken as meaning 'council's adopted sea level rise projections' where available. Consequently, Councils now have the flexibility to consider alternative benchmarks based on local circumstances.

Councils have been advised to consider information on historical and projected sea level rise that is widely accepted by competent scientific opinion[10], including information from the NSW Chief Scientist and Engineer's report titled 'Assessment of the Science behind the NSW Government's Sea Level Rise Planning Benchmarks' (April 2012).

Subject to the above, the *NSW Coastal Planning Guideline: Adapting to Sea Level Rise* (Department of Planning (DoP), August 2010) continues to apply to all coastal areas of NSW. This Guideline recommends a strategic risk based management process to the consideration of sea level rise when undertaking land use planning and development

[10] This advice was reiterated in a letter from the Hon. Robyn Parker MP (Minister for the Environment and Minister for Heritage) in a letter to the Mayors of individual councils.

assessment. The Guideline relates to both coastal erosion hazards and coastal flooding, and forms an extension to the *Floodplain Development Manual* as well as the *Coastal Management Manual*.

The climate change considerations particularly relevant to the Mid Georges River FRMS and FRMP are limited, as discussed below, due to the focus on overland flow flooding. Coastal inundation is not an issue in this case.

4.4.2 Draft Planning Circular on Coastal Hazards

The DPE exhibited a draft circular during February 2014 that recommends councils distinguish between current and future hazards on Section 149 certificates. The relevant underlying principle being that the information communicated through planning controls should clearly identify calculation of flood risks based on current day parameters (sea level and rainfall intensity) with the calculation of flood risks based on predicted future parameters.

4.4.3 Climate Change Flood Risk within the Study Area

Future climate change has been predicted to result in an increase in sea levels and the severity of flood-producing storms and other weather systems. These systems have a direct impact on tides and rainfall responsible for flood behaviour within the Georges River and the sub-catchments draining to the Georges River.

Bankstown City Council undertook a sea level rise impact assessment for the Georges River which was completed in October 2012 (FloodMit, 2012). The Sea Level Rise Impact Assessment for the Georges River (FloodMit, 2012) adopted the sea level rise benchmarks of +0.4m and +0.9m by the years 2050 and 2100 respectively from the 2009 NSW Sea Level Rise Policy.

The outputs from the Sea Level Rise Impact Assessment for the Georges River (FloodMit, 2012) have been used to define the downstream water level conditions for mapping the impact of sea level rise on overland flooding within the Mid Georges River study area. This impact assessment has been undertaken for the 100 year ARI local catchment event with tail water conditions in Georges River reflecting both +0.4m and +0.9m rise in sea levels.

The results indicate that there are varying increases in the flood planning area for both sea level rise scenarios. This increase in the flood planning area affects the lower reaches of the sub-catchments which are influenced by water levels in the Georges River. In general, a 0.4m increase in sea levels results in increases in flood levels of approximately 0.05m to 0.30m across the lower reaches of the sub-catchments. A 0.9m increase in sea levels results in larger increases in levels, with increases ranging from +0.2m to +0.75m.

Regional climate change studies (e.g. CSIRO, 2007) indicate that aside from sea level rise, there may also be an increase in the maximum intensity of extreme rainfall events. For sensitivity analysis purposes, the impact of a nominal 10% increase in rainfall intensity has been undertaken for each sub-catchment. The assessments only consider the impact of increased rainfall intensities on sub-catchment derived stormwater flooding.

The impact of a 10% increase in rainfall intensity was assessed and mapped as part of the Mid Georges River FRMS. This assessment involved comparing the peak sub-catchment derived stormwater levels with the current critical 100 year ARI design flood

event results for each of the seven sub-catchments of the study area. In general a 10% increase in rainfall intensity results in increases in flood levels of approximately 0.05m to 0.10m across much of the Mid Georges River catchment, with localised flood level increases of up to 0.30m.

The flood depth increases from a 105 increase in rainfall intensity are generally low (0.05m to 0.10m) and within the additional 0.5m freeboard applied to the current 1% AEP design flood levels incorporated into the planning controls. Additionally, there are uncertainties around predicted increases in rainfall intensities associated with climate.

While there are uncertainties around climate change predictions, sea level rise flood risk associated with overland flooding warrants consideration of specific sea level rise planning controls. The controls could be applied across the LGA and should consider a different response depending on the type of development, based on the following principles:

- Established areas. Existing development and redevelopment in established areas should continue with appropriate controls which consider the timeframe of predicted changes, degree of predicted change, scale of development and the impacts of development controls on streetscape and the community.

- Greenfield development/Major Brownfield Redevelopment Areas. Future development should be subject to development controls that ensure the development is designed to manage flood risk associated with sea level rise over its expected lifespan. This could be achieved through design which considers current climate change predictions or through future adaptability of developments that considers uncertainties around the timeframe and degree of predicted changes.

Despite the above analysis, the consideration of climate change flood risks should be undertaken on an LGA basis, and a policy response should be set consistently for the whole of the LGA. The policy response will need to consider issues beyond the scope of this report, including rainfall intensity modelling assumptions and the approach to applying planning controls to reduce the liability associated with future predicted flood risks.

4.5 State and Regional Planning Strategies

Subregional Strategies are a key planning tool for Councils in implementing the Sydney Metropolitan Strategy. The draft West Central Subregional Strategy -- covering the Auburn, Bankstown, Fairfield, Holroyd and Parramatta LGAs was exhibited between 24 December 2007 and 28 March 2008 and remains a draft document. This Strategy is relatively general but identifies the following relating to flood risk management:

> *When managing growth in the west Central Subregion, appropriate measures to address environmental constraints such as high levels of noise, site contamination, acid sulphate soils and flooding will need to be considered. (pg.116)*

> *Floodplain risk management assessment needs to be undertaken strategically through the development of floodplain risk management studies and plans, which consider the flooding implications for existing and proposed development. Further details on how flooding is to be considered in the development of draft LEPs is contained in Section 117 Direction No.4.3–Flood Prone Land and the Floodplain Development Manual. (pg.126)*

As with any planning exercise the identification of land to meet the future needs of a growing and changing population requires the balancing of various environmental, social and economic considerations, of which FRM is one.

4.6 State Environmental Planning Policies (SEPPs)

4.6.1 General

A State Environmental Planning Policy (SEPP) is a planning document prepared in accordance with the EP&A Act by the DPE and eventually approved by the Minister, which deals with matters of significance for environmental planning for the State. No SEPP has been prepared dealing specifically with the issue of flooding, but some regulate development in response to potential flood risks.

4.6.2 Seniors Living SEPP

SEPP (Housing for Seniors or People with a Disability) 2004 (**Seniors Living SEPP**) applies to urban land or land adjoining urban land where dwellings, hospitals and similar uses are permissible. The Seniors Living SEPP would apply to parts of the study area, and would effectively override Council's planning controls to permit residential development for older and disabled persons to a scale permitted by the SEPP. Notwithstanding, Clause 6(2)(a) of the SEPP restricts its application if land is identified as "floodways" or "high flooding hazard" in Council's LEP.

As discussed in Section 4.8, the draft city wide Bankstown LEP does not propose the identification of floodways or areas of high flooding hazard. Further, the standard instrument model LEP FRM clause and typically accepted LEP maps are not structured to accommodate the inclusion of these specific flood hazard types. Accordingly, there are no opportunities to introduce local planning controls to work in conjunction with the Seniors Living SEPP.

4.6.3 Codes SEPP

The specification of exempt and complying development is primarily governed by *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* (the **Codes SEPP**). Bankstown LEP 2001 and DCP 2005 also includes exempt and complying development provisions but these are less extensive and are intended to be ultimately superseded by the Codes SEPP.

The Codes SEPP is divided into a number of "Codes" that deal with exempt development and different types of complying development. Those Codes of specific relevance to the Study are the Exempt Development Codes (Part 2), the General Housing Code (Part 3), the Rural Housing Code (Part 3A) and the Commercial and Industrial (New Buildings and Additions) Code (Part 5A). The relevant clauses of the Codes SEPP apply to "flood control lots" defined as:

> ***flood control lot*** *means a lot to which flood related development controls apply in respect of development for the purposes of industrial buildings, commercial premises, dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (other than development for the purposes of group homes or seniors housing).*
>
> ***Note****. This information is a prescribed matter for the purpose of a certificate under section 149 (2) of the Act.*

The Exempt Development Code in the SEPP provides a number of exclusions to what can be considered exempt development on a flood control lot. The General Housing, Rural Housing and Commercial and Industrial (New Buildings and Additions) Codes provide a number of exclusions as to what can be complying development on a flood control lot (i.e. must not be on any part of a flood control lot which is a flood storage area, a floodway area, a flow path, a high hazard area or a high risk area) and where otherwise permitted on a flood control lot specified flood related development controls must be imposed on a Complying Development Certificate (**CDC**). The manner in which these exemption criteria and development controls apply are summarised within **Figure 3**.

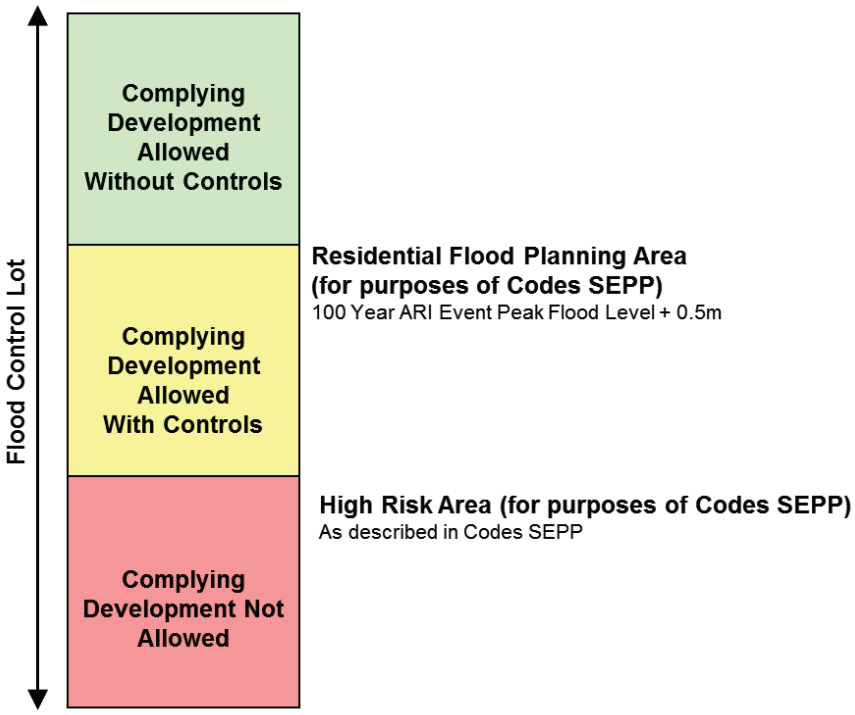


Figure 3 *Application of the Codes SEPP to Flood Liable Land*

The important outcomes of the FRMP, in regard to establishing rules for housing, commercial and industrial development that could be approved as complying development is the defining of high risk areas (where complying development is excluded) and setting of minimum floor levels. The objective should be to ensure that such future development does not lead to increased flood risk to property and persons as a consequence of the application of the CDC process in comparison to outcomes otherwise likely to be achieved through the full development application (**DA**) process.

Based on the flood mapping now completed by BMT WBM for the Mid Georges River catchment, Council could proactively provide advice as to where the Codes SEPP applies within the terms depicted by Figure 3. Therefore, to assist in advising the public and certifiers where the Codes SEPP should and should not apply, a Codes SEPP map has been produced by BMT WBM for the study area as shown in **Figure 4.**

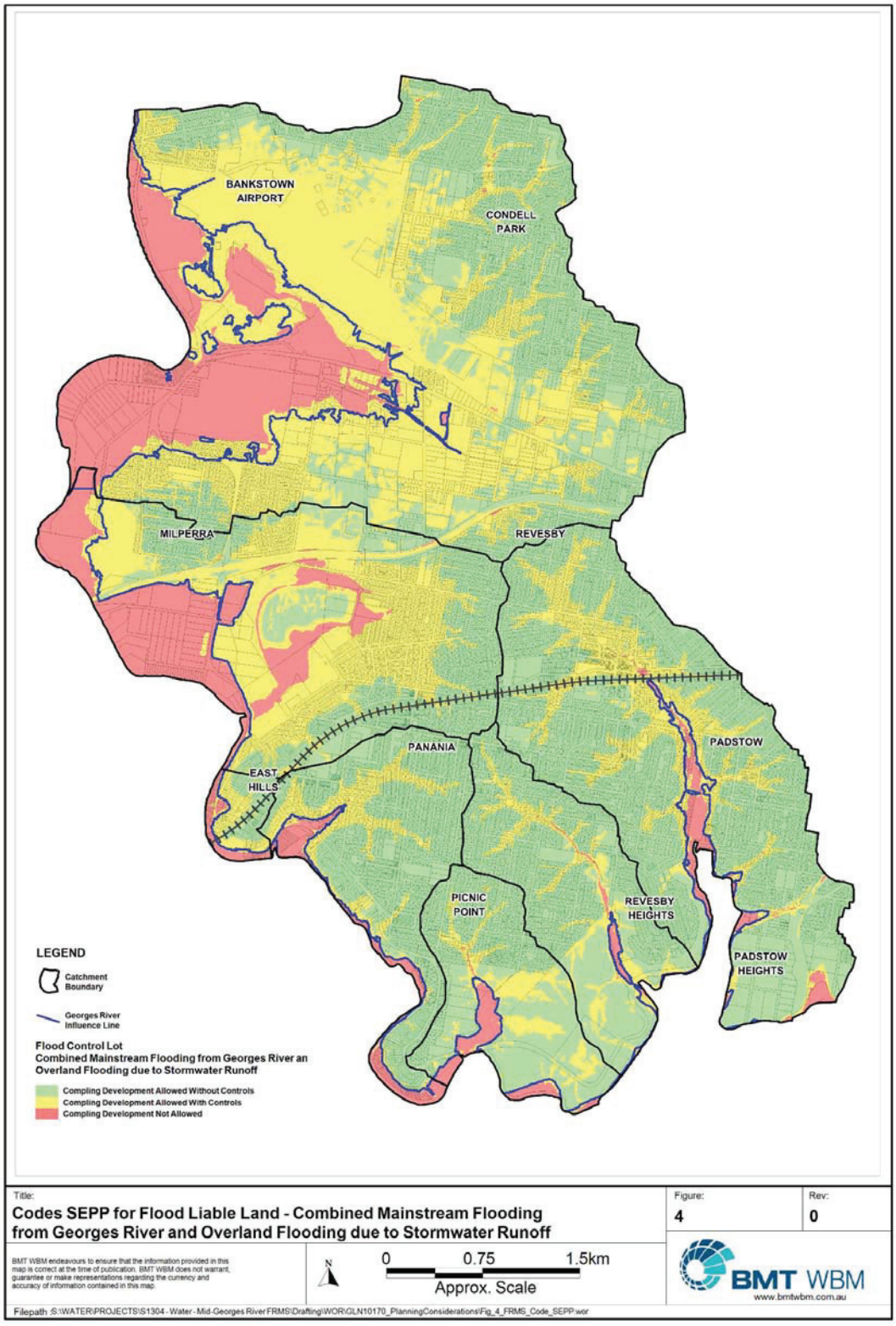


Figure 4 *Codes SEPP Map for Flood Liable Land*

4.7 Regional Environmental Plans (REPs)

Regional Environmental Plans (**REPs**) no longer form part of the statutory planning framework in NSW and existing REPs are now deemed SEPPs. *Greater Metropolitan Regional Environmental Plan No 2—Georges River Catchment* applies to the study area as a deemed SEPP and provides both guidelines for the preparation of LEPs and additional matters for consideration when determining applications for certain types of development. Clause 9 includes the following principles:

> **… (3) Flooding**
>
> *The following are to be recognised:*
>
> *a) the benefits of periodic flooding to wetland and other riverine ecosystems,*
>
> *b) the pollution hazard posed by development on flood liable land in the event of a flood,*
>
> c) *the cumulative environmental effect of development on the behaviour of flood water and the importance of not filling flood prone land…*
>
> ***(10) Urban development areas***
>
> *The environment within the Catchment is to be protected by ensuring that new or expanding urban development areas are developed in accordance with the Urban Development Program and the Metropolitan Strategy and that the requirements of the NSW Floodplain Development Policy and Manual (prepared by and available from the Department of Land and Water Conservation) are also satisfied. It is important to ensure that the level of nutrients entering the waterways and creeks is not increased by the development.*

The REP also provides the following definitions:

> ***Floodplain** means the floodplain level nominated in a local environmental plan or those areas inundated as a result of a 1 in 100 flood event, if no such level has been nominated.*
>
> ***Flood liable land** means land identified in an environmental planning instrument as flood liable land.*
>
> ***Flood prone land** means land susceptible to inundation by the probable maximum flood event.*
>
> ***Floodway** means those areas of a floodplain where a significant discharge of water occurs during floods. Floodways are areas which, even if partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.*
>
> ***Urban Development Program** means the government land release system managed by and available from the Department of Urban Affairs and Planning.*

Clause 11 of the REP provides restrictions on certain development in parts of the floodplain. For example, item 8 provides that housing development on land identified in the Urban Development Program is prohibited on *flood liable land*.

4.8 Bankstown LEP 2015 (LEP 2015)

The EP&A Act was amended to facilitate the reproduction of planning instruments into a standardised format known as a "standard instrument" and commonly referred to as the "LEP template". Section 33A of the EP&A Act deals with the prescribing of a standard instrument for LEPs.

The standard instrument contains no compulsory clauses or map requirements specifically relevant to addressing flood hazards. However, the DPE have adopted a model local clause in regard to flooding. A model local clause is one which has been settled by Parliamentary Counsel as acceptable and the DPE encourage that it is used as is. However, such a clause may be varied with justification to suit local circumstances.

LEP 2015 adopts a modified version of the model local clause (clause 6.3) which provides clear objectives and matters for consideration. The clause applies to "land at or below the flood planning level" (FPL). The clause adopts the common definition for the FPL as being "…the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard." LEP 2015 does not include flood planning area maps as part of the LEP map set.

This clause and approach is not wholly consistent with the recommendations of the Salt Pan Creek FRMS and FRMP. The primary difference is that the FRMP recommends that the LEP clause apply to the whole floodplain as defined by the Floodplain Development Manual. However, Council has been restrained from a applying the clause to the whole of the floodplain by the 2007 Flood Planning Guideline, unless an exceptional circumstances case is put to the relevant government departments and approved. The submission of an exceptional circumstances case primarily relates to riverine flooding issues which is beyond the scope of this report.

Other than the area of application, the provisions of clause 6.3 of LEP 2015 are consistent with the approach recommended in the Georges River FRMP and the Salt Pan Creek FRMP.

Notwithstanding the above, a review of the specific FRM and associated planning issues for the Carinya Road area are provided below in Section 4.8.4 as part of the review of the DCP controls.

In addition to the above, LEP 2015 adopts foreshore building line (**FSBL**) provisions that include a map showing the FSBL and clause 6.5 that restricts development to a limited range and subjects this limited range of development to particular considerations. Development such as dwelling houses would not be permitted within the FSBL. The objective of the FSBL clause relates specifically to the preserving the natural environment and the amenity of the area.

The FSBL is purposely a discontinuous line along the Georges River. It relates to a 30m setback line from the river but excludes land in public ownership. However the mapping may have inadvertently excluded the application of the FSBL provisions to land within 30m of the river where there is public land in between that does not extent the full 30m. This would appear to be the case in the Carinya Road area.

The FSBL provisions could be considered as a means of restricting development in high flood risk precincts in addition to general zoning restrictions and DCP controls. If pursued this would require a review of the FSBL clause to expand its objectives to include FRM outcomes. Additionally the FSBL maps would need to be reviewed to include the greater area encompassed by either a 30m setback or the high flood risk precinct.

BMT WBM have undertaken a separate exercise of mapping the outcome of reviewing the FSBL to include all private owned land and the high flood risk precinct. If applied this would

restrict development oi some land not previously restricted. The additional restrictions are not considered critical to the FRM outcomes addressed by this report as they would already be covered by the DCP provisions. The FSBL provisions would also allow less flexibility in application at the development assessment stage compared to the DCP provisions. Accordingly the use of the FSBL provisions is not recommended as part of this report but should be a matter that Council could monitor and reconsider in later reviews of the LEP and DCP.

Development Control Plan 2015 (DCP 2015)

4.8.1 General

The DCP controls that were recommended as part of the Salt Pan Creek FRMP were required to fit within the structure of the existing FRM DCP provisions of DCP 2005. In particular, the recommended controls were intended to be inserted into Part E3 of the DCP 2005 – Flood Risk Management. DCP 2005 has now been replaced by Bankstown DCP 2015 which re-incorporates materially the same FRM controls within Part B12

The Introduction states that "*Part B12 applies to all flood liable land in the City of Bankstown"*. The DCP provides the following definition (see Part C, pg.13):

"***Flood prone land*** *(being synonymous with flood liable and floodplain) is the area of land which is subject to inundation by the probable maximum flood (PMF)."*

The DCP provides other flood related definitions that are identified as part of the Salt Pan Creek FRMP. Schedules 4A, 4B and 4C of Part B12 of DCP 2015 relate specifically to Carinya Road and were not reviewed as part of the Salt Pan Creek FRMP. Section 4 of Part B12 of DCP 2015 also contains special considerations in regard to land protected by the Kelso Park Levee, the East Hills Floodplain, and the Carinya Road area that were not reviewed as part of the Salt Pan Creek FRMP, and consequently are discussed below.

4.8.2 Area Protected by the Kelso Park Levee (Clause 4.1)

The DCP notes that the levee was constructed for the purposes of providing protection from mainstream flooding from the Georges River but the protected area would be affected by local stormwater flooding. The DCP provides no added special development controls for this area other than to provide advice in association with any consent for building in this area to warn that the levee was constructed to provide limited protection from flooding from the Georges River and could be overtopped in floods greater than a 100 year event.

Issues associated with mainstream flooding are beyond the scope of this report. However the flood modelling undertaken by BMT WBM provides up-to-date detail regarding local stormwater flooding. The planning controls recommended by the Salt Pan Creek FRMP would address local stormwater flooding.

4.8.3 East Hills Floodplain (Clause 4.2)

These provisions of the DCP relate to requirements for "fail safe pedestrian access to land above the 100-year flood level" for various forms of residential development and additions. While this relates to main stream flooding and is beyond the scope of this report, we observe that reliance on access to land just above the 100 year flood level would not meet current best practice for flood risk emergency management. Evacuation or refuge in place should be to a place above the PMF level.

Separate to the matters to be dealt with by this report, Council could take this opportunity of reviewing these DCP provisions to consider whether the general planning controls for Georges River mainstream flooding that deal with evacuation would be more suitable.

4.8.4 Carinya Road, Picnic Point (Clause 4.3 and Schedules 4A, 4B &4C)

The flood liable land within the Carinya Road area is depicted on detail flood extent maps prepared by BMT WBM, but generally relates to over 40 residential lots between Carinya Road and the Georges River and a boatshed/general store, public roads and opens space and utility infrastructure. This area is mapped as high flood risk. The existing planning controls for this area have been the subject of a number of past studies and presently comprise the following:

a. Subdivision and density standards (clause 4.3.1) that are aimed at limiting the potential to create additional separate dwelling rights.

b. Scenic and amenity considerations (clause 4.3.2) that aim to ensure that design outcomes sought to address flooding issues are not permitted where they give rise to unacceptable environmental impacts.

c. The purported prohibition of certain land uses (clause 4.3.3) which are particularly vulnerable to flood hazards.

d. The Carinya Road area is also subject to specific controls (which differ to those applying to the remainder of the Georges River floodplain) as set out in Schedules 4A, 4B and 4C.

Each of these elements of the DCP are reviewed separately under the following section subheadings.

Subdivision and density standards (clause 4.3.1)

Clause 4.3.1 of Part E of the DCP generally provides a maximum residential dwelling density standard of 1 per 650m² east of the boatshed and 1 per 500m² west of the boatshed. The reference to a density standard includes new lots and additional dwellings that might be proposed on a lot (e.g. dual occupancy housing). Schedule 4C of the DCP provides specific subdivision controls for a number of individual lots.

The intent of the controls is to limit the potential to raise expectations for additional dwellings generally beyond developing vacant lots or in discreet locations where access for evacuation purposes could be readily achieved and to outline the manner in which subdivision and further development could acceptably proceed.

LEP 2015 imposes minimum lot sizes ranging from 450m² to 650m² as shown on **Figure 5**.



Figure 5 *Minimum Lot Size Map (LEP 2015)*

The issues raised within Council memoranda include a fundamental concern about allowing any further development within the Carinya Road area having regard to the high flood risk within the area. This was a matter reviewed in detail within previous studies which sought to provide Council with options and recommendations that provided a balance between meeting reasonable development expectations and minimising flood risk consistent with the merits based approach required by the FDM.

There are presently 2 vacant lots east of the where Carinya Road connects with the roadway along the riverfront (the "Carinya Rd Intersection") and 1 vacant lot west of the Carinya Rd Intersection. The minimum lot size standards within LEP 2015 appear to have been purposely formulated to prevent any further subdivision.

Despite the lot size, standard development more intensive than detached housing would be permitted under the provisions of LEP 2015 and other SEPPs, as discussed under the following subheading Prohibition of certain land uses (clause 4.3.3).

Scenic quality and amenity considerations (clause 4.3.2)

The controls impose a building height limit of 9m and general points of consideration to emphasise that structural solutions to address flood risk will not be accepted where this leads to unacceptable scenic or amenity impacts.

LEP 2015 proposes the application of a maximum building height standard of 9m in the Carinya Road area which will make the DCP height standard superfluous. Most development within area will not qualify as complying development under the Codes SEPP due to it being in a high risk flood precinct. Consequently, relevant proposals will continue to require a development application.

The direction in which the NSW planning system is moving places greater emphasis on the base zoning and development standards contained with statutory planning instruments such as the LEP. Accordingly the recommendations for review discussed in Section 5.2 will explore the options of an alternate zoning to clarify the special nature of Carinya Road to strengthen the basis for the merit assessment of development applications and a simplification of the DCP.

Prohibition of certain land uses (clause 4.3.3)

The DCP states that the following uses are prohibited in the Carinya Road area:

- Childcare centres
- Educational establishments
- Hospitals
- Residential Flat Buildings for aged persons not exceeding two storeys
- Places of assembly
- Places of public worship
- Dual occupancy;
- Multi dwelling housing
- Seniors housing.

The DCP provisions do not apply where inconsistent with an LEP or SEPP. The planning controls for the DCP recommended in previous studies specifically phrased controls aimed at discouraging such land uses as being “potentially unsuitable land uses.” This wording has been carried across to the planning matrix contained in Schedule 4A of the DCP. The approach was to identify those land uses that were unlikely to be able to resolve FRM issues without unacceptable environmental impacts.

Notwithstanding the above, the intent of the planning matrix was to provide a strategic planning tool as well as development assessment guidance. The review of council’s LEP and DCP provides an important opportunity to review the base zoning and development standards contained with statutory planning instruments such as the LEP and to simplify the DCP provisions.

The Carinya Road area is now zoned R2 Low Density Residential under LEP 2015. The objectives of this zone are:

- *To provide for the housing needs of the community within a low density residential environment.*
- *To enable other land uses that provide facilities or services to meet the day to day needs of residents.*
- *To allow for certain non–residential development that is compatible with residential uses and does not adversely affect the living environment or amenity of the area.*

- *To allow for the development of low density housing that has regard to local amenity.*

- *To require landscape as a key characteristic in the low density residential environment.*

The uses permitted in this zone are extensive and include child care centres, hospitals, places of public worship, dual occupancies, secondary dwellings, seniors housing and emergency services facilities. While it is unlikely that these uses might be proposed in the future, there is no certainty as to this and these uses are considered to be incompatible with the high flood risk applicable to the area.

In addition to the above, secondary dwellings could be permitted on the existing lots in the Carinya Road area pursuant to SEPP (Affordable Rental Housing) 2009.

Schedules 4A, 4B and 4C – Specific Controls

Schedule 4A provides a (planning) matrix of development controls that apply instead of the controls in Schedule 3 which apply to the balance of the Georges River floodplain in the Bankstown LGA. The schedule 4A controls combine the medium and high flood risk precincts (**FRP**s) and apply one set controls for both precincts.

The high FRP for the general Georges River floodplain identifies a greater range of "potentially unsuitable land uses than in the medium/high FRP for the Carinya Road area. This is because the development controls in the medium/high FRP for the Carinya Road area are more stringent than the development controls in the medium FRP for the general Georges River floodplain to mitigate risks. Consequently, a review of Schedule 4A could determine which of the following two approaches is preferable:

a. Maintain Schedule 4A with only minor refinements (refer to Section 5.2 for further information) to the details of the controls.

b. Remove Schedule 4A and rely on Schedule 3 of the DCP that applies to the balance of the Georges River floodplain.

These alternate approaches are evaluated within the discussion of options in Section 5.2.

Schedule 4B provides detailed controls and examples relating floor levels, driveway locations, construction of failsafe pedestrian access, construction methods and materials, filling and Section 149 Certificates within different parts of the Carinya Road Area. This schedule effectively provides more detail description of the controls contained within the planning matrix in schedule 4A and notes that Schedule 4A prevails where there is an inconsistency. The DA examples provided by Council did not indicate that these more detailed provisions were used and due to the limited extent of development potential remaining within the area and the changes to overriding the LEP and SEPPs, the controls in these schedules appear to be now superfluous.

Schedule 4C provides controls for subdivision and has been discussed above.

4.9 Developer Contributions

Bankstown City Council Section 94A Development Contributions Plan 2009 (**S94A Plan**) applies to the LGA. As provided for by the EP&A Act a S94A Plan is not required to be based on a nexus between the works to be funded by the plan and the

development from which contributions will be sought. The S94A Plan requires a contribution based on a set rate of up to 1% of development costs.

A S94 A plan must outline the works that will be undertaken with the contributions fund. Appendix B of the plan provides the works schedule and includes $2.4 million dollars for flooding, drainage and water management. The descriptions in the works schedule appear to relate mainly to environmental works.

Any structural mitigation works identified by this FRMS (or others) could use S94A funds. However, council will accumulate finite funds through a S94A plan and it will be a Council policy position as to how to allocate those funds.

4.10 Local Area Plans

Council embarked on the preparation of suite of strategies to inform the preparation of LEP 2015. The South West Local Area Plan (**LAP**) represents one of these studies. The brief requires that Mid Georges River Catchment FRMS and FRMP contribute to the Waterways Chapter of South West LAP. The South West LAP includes the suburbs of East Hills and Picnic Point and parts of Milperra, Panania, Revesby and Revesby Heights.

The South West LAP (pgs. 99-106) specifically addresses flooding issues. The LAP reinforces the relevance of the Georges River FRMP in regard to establishing a planning framework for managing Riverine FRM issues and notes that Council has commissioned the Mid Georges River FRMP to manage overland flow FRM issues. The LAP also describes FRM issues in existing centres where future growth is targeted, as discussed further below.

The South West LAP issues paper was exhibited by Council during 2013 and adopted in September 2013. Consistent with Council's Residential Development Strategy, the issues paper identifies the most appropriate locations for new housing to be concentrated in the Panania and East Hills Centres and other areas would be expected to experience low population growth in a dispersed pattern. The additional dwelling targets set for the Panania and East Hills Centres are 440 and 40 respectively, which reflects relatively low growth. The South West local area does not contain industrial employment lands.

The Panania Town Centre (**Figure 6**) comprises Panania Centre South (from Panania Railway Station to Tower Street and Panania Centre North (from Panania Railway Station to Marco Avenue). Both parts of the centre are outside of the influence of Georges River flooding. There is minor overland flow flooding (depth of 0.0 – 0.25m in a 100 year flood) on the northern side of the railway line Panania Centre North, within the streets and parts of lots east of Anderson Avenue.

There are effectively no FRM issues within the Panania Centre South. While a relevant consideration this flooding should be capable of being managed in association with the redevelopment of properties in the centre to achieve the assigned housing targets. Redevelopment can also provide the opportunity to reduce existing flood risk to such properties. Appropriate controls for such development are effectively incorporated in the DCP controls recommended within the Salt Pan Creek FRMP.

Should Council move towards a more prescriptive masterplan approach to planning controls for the centre, then such a masterplan should ensure that the overland flow paths identified by BMT WBM flood maps are maintained.

The East Hills Centre (**Figure 7**) is located partly on the western side but mostly on the eastern side of the railway station.

The East Hills centre is also outside of the influence of Georges River flooding. There is minor overland flow flooding (depth of 0.0 – 0.5m in a 100 year flood) on the northern end of Thomson Lane and within the area generally between the 'standalone centre' and the East Hills Hotel. As for the Panania Centre relevant FRM considerations should be capable of being addressed with redevelopment subject to the DCP controls recommended within the Salt Pan Creek FRMP.



Figure 6 *Panania Town Centre (Source: As cited in South West LAP, pg.39)*



Figure 7 *East Hills Town Centre (Source: As cited in South West LAP, pg.43)*

5.0 Management Options & Recommendations

The following is a broad outline of the suggested areas of focus for the planning component of the FRMS.

5.1 Strategic Planning Input

5.1.1 General

The following provides recommendations regarding broader strategic planning considerations identified in the brief, not otherwise dealt with in the review of planning controls or notification matters.

5.1.2 South West LAP

The LAP identifies the most appropriate locations for new housing to be concentrated in the Panania and East Hills Centres and other areas would be expected to experience low population growth in a dispersed pattern.

The two centres are partly affected by overland flow flooding that should be capable of being managed in association with the redevelopment of properties. Redevelopment can also provide the opportunity to reduce existing flood risk to such properties. Appropriate controls for such development are effectively incorporated in the DCP controls recommended within the Salt Pan Creek FRMP. These recommended controls would also be sufficient to address infill development scattered across the Southwest LAP area.

Should Council move towards a more prescriptive masterplan approach to planning controls for the centre, then such a masterplan should ensure that the overland flow paths identified by BMT WBM flood maps are maintained.

5.1.3 Development Contributions

Bankstown City Council Section 94A Development Contributions Plan 2009 should be reviewed to consider whether any structural mitigation works identified by this FRMS (or others) should be funded (or partly funded) with S94A funds.

5.1.4 Climate Change

As discussed above, while a relevant consideration, climate change flood risk associated with overland flow flooding does not warrant the introduction of specific planning controls at this stage. The decision to apply planning controls to address climate change flood risks should be based on broader policy considerations undertaken an LGA wide basis.

Despite the above, in addition to flood maps that depict current day flood extents, this FRMS has produced flood maps which factor in climate change considerations (predicted sea level rise and added rainfall intensity for sensitivity analysis purposes). While we do not recommend that specific planning controls be prepared to deal with these climate change flood extents, the maps should be made publically available by Council as part of the exhibition of the FRMS and FRMP with a clear explanation as to why they were prepared and their limited role at this stage of informing Council and the public of possible effects of climate change.

5.2 Review of Planning Controls

5.2.1 SEPP (Codes SEPP) Provisions

As discussed above the principal relevance of the FRMS and FRMP to SEPPs is the identification of land for which Council could be confident is not subject to high flood risk (i.e. not part of a flood control lot which is a flood storage area, a floodway area, a flow path, a high hazard area or a high risk area). Where it can be confirmed that land is not subject to such high flood risk categorisations development could be dealt with under the provisions of the Codes SEPP where otherwise applicable.

In order to a take a proactive role in informing private certifiers where the Codes SEPP should and should not apply, a Codes SEPP map has been produced by BMT WBM for the Mid Georges River study area (**Figure 4**). The map indicates areas subject to high flood risk (i.e. part of a flood control lot which is a flood storage area, a floodway area, a flow path, a high hazard area or a high risk area). The nomenclature within the Codes SEPP does not directly correlate with that in the Council FRMPs but generally the High, Medium and Overland Flow flood risk precincts in the FRMPs would equate to the various excluded categories in the Codes SEPP.

The Codes SEPP map identifies areas where CDC's should be able to be issued. Where a CDC is issued on a flood controls lot (outside of a high flood risk or associated area), the certifier will need to consult with Council in regard to minimum floor levels and ensure the development conditions in the Codes SEPP are complied with.

5.2.2 REP (Deemed SEPP) Provisions

The only other applicable (deemed) SEPP is the *Greater Metropolitan Regional Environmental Plan No 2—Georges River Catchment.* No action is recommended in regard to this SEPP.

5.2.3 LEP Provisions

General

Previous FRMPs (Georges River FRMP and Salt Pan Creek FRMP have previously made recommendations for Council's consideration that have not, at this stage. been fully incorporated into LEP 2015. It is recommended that the Mid Georges River Catchments FRMP endorses the general recommendation of these previous FRMPs and continue to work towards the full implementation of those recommendations. The primary outstanding recommendation is to seek to have the LEP flood provisions apply broadly the all flood prone land which will require the preparation of an exceptional circumstances submission to the relevant government department and if accepted an LEP amendment.

In addition to the above, the following discussion evaluates further LEP review options associated specifically with the Carinya Road area based on the further review provided within this report and provides recommendations specific to this area.

Carinya Road Area

As outlined above, the review of LEP provisions needs to be considered in conjunction with the DCP provisions that relate to the Carinya Road area. There are fundamentally two directions that the planning controls could take:

1. Maintain the existing LEP 2015 zoning and subdivision standards and pursue minor refinements to the DCP provisions to effectively update the controls but maintain a similar level of stringency.

2. Amend the LEP zoning and subdivision standards to differentiate the Carinya Road area from other similarly zoned residential areas based on the flood risk and associated environmental qualities of the area and rely on the more generalised DCP controls that apply to the overall Georges River floodplain (i.e. Schedule 3).

Based on the comments provided by Council officers, the documents reviewed, and as the area is now substantially developed with minimal opportunity for further development that is likely to be acceptable, the first option of no changes is not recommended.

There have been comments from both Council officers and the community that question the severity of the DCP controls (such as elevated walkways) and their complexity. These controls were, however, the mitigating measures that allowed for limited further development.

Consequently, the second option is recommended and involves:

- Amending LEP 2015 to adopt a zone for the Carinya Road area that prohibits those uses identified as undesirable in the current planning matrix (Schedule 4A) and contains objects that reflect the specific flooding and environmental constraints of the area. In this regard we recommend the base *Zone E4 Environmental Living* zone from the Standard Instrument, being:

Zone E4 Environmental Living

Direction

The following must be included as either "Permitted without consent" or "Permitted with consent" for this zone:

Environmental protection works
Roads

Home industries may (but need not) be included as permitted with consent.

1. Objectives of zone

- *To provide for low-impact residential development in areas with special ecological, scientific or aesthetic values.*

- *To ensure that residential development does not have an adverse effect on those values.*

2. Permitted without consent

Home occupations

3. Permitted with consent

Dwelling houses

4. Prohibited

Industries; Service stations; Warehouse or distribution centres; any other development not specified in item 2 or 3:

- Including additional appropriate development as "permitted with consent" such as environmental protection works, flood mitigation work, recreation area and road. Note as per the LEP 2015 maps, the foreshore area including reserve, road and boatshed remain separately zoned RE1 Public Recreation.

- Including an additional objective to the Environmental Living Zone to the effect "To ensure that development is compatible with the natural hazards in the area, such as flooding." Keeping the objectives broad would allow for the zone to be used in other areas of the LGA, which, although is presently not proposed, might be contemplated in the future.

- Reviewing the minimum lot size to 1,000m² to provide a consistent standard across the area. There would be appear to be no change as to the subdivision potential outcome on any lot and this is not a critical change but would simplify the planning controls in the LEP that apply to the area. Note the provisions of DLEP 2012 as exhibited do not prohibit the erection of a dwelling house on an existing lot and accordingly development on vacant lots or rebuilding of existing dwelling houses.

Such a change to the LEP 2015 would require a separate Planning Proposal process under the EP&A Act and would require Gateway approval form the Department of Planning and Environment and a public consultation process.

The use of the E4 zone would also have the advantage of circumventing the inappropriate facilitative provisions of SEPPs such as the Seniors Living SEPP and Codes SEPP.

5.2.4 DCP Provisions

General

Previous FRMPs (Georges River FRMP and Salt Pan Creek FRMP) have made recommendations for Council's DCP. The general provisions relating to mainstream flooding are beyond the scope of this report but generally have already been incorporated into Council's existing DCP.

DCP changes required to incorporate consideration of overland flow flooding have been recommended as part of the Salt Pan Creek FRMP. These changes should be endorsed by the Mid Georges River Catchments FRMP.

As mentioned above, the Georges River FRMS originally outlined a philosophical approach to the preparation of the planning controls – now embodied within the Bankstown DCP. The key component of this approach, was the preparation of a planning matrix, which are now the schedules attached to Part B12 of the DCP that specify the prescriptive controls.

The intent of the Salt Pan Creek FRMS and FRMP (and currently the Mid Georges River Catchment FRMS and FRMP) was to build upon the approach taken in the Georges River FRMS, which was adopted by Council. The following is a summary of the process that was applied to that approach which lead to the preparation of the planning matrix that was recommended in the Salt Pan Creek FRMP (and once again will be recommended for the Mid Georges River Catchment FRMP).

Step 1 - Mapping of flood risk precincts – this involves dividing the floodplain (i.e. all land affected up to the PMF) into areas with similar levels of risk. The number of precincts may vary between different floodplains. A three tier category of low, medium and high was adopted in the Georges River FRMP for riverine flooding. It is proposed to add a further category called "Overland Flow" to the matrix developed for catchments affected by stormwater flooding as part of this study. These precincts are described by **Table 1**.

Table 1 *Proposed Flood Risk Precincts (as per the Salt Pan Creek FRMP)*

High	The area of land below the 100 year flood that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties.
Medium	Land below the 100 year flood level but excluding that land identified as being within a high or overland flow precinct.
Low	All other land within the floodplain (i.e. within the extent of the probable maximum flood) not identified as being within a high, medium or overland flow precinct.
Overland Flow	Depth of inundation of between 50mm to 250mm arising from overland flow in a 100 year flood. Note where the depth of inundation is less than 50mm it is not mapped and would generally be dealt with as part of normal BCA construction requirements.

The separation of overland flow areas from the other Flood Risk Precincts (FRPs) allows for the introduction of the standard controls into the Low FRP without imposing excessive requirements on development in overland flow areas that did not warrant controls designed for more mainstream flooding. This maintains a consistency of standard for all development within the 100 year floodplain plus 0.5m freeboard regardless of whether the development is in the Low or Medium FRP.

Step 2 - Prioritising land uses in the floodplain – this involves identifying discrete categories of land uses with similar levels of vulnerability to the flood hazard and identifying what flood risk precincts within which they should be permitted or prohibited. This has already been undertaken for the purposes of the existing DCP, and will be relied upon.

Step 3 – Identifying controls to modify building form and response to flooding - where the planning process determines land uses are appropriate, but still subject to flood risk. Different planning and building controls can be imposed to minimise potential damages and to maximise the ability of the community to respond (i.e. preparedness and capacity to evacuate) during a flood. The types of development controls that would appropriately apply for the purposes of this study correspond with those within the existing DCP planning matrices.

The primary intent of the above is the preparation of a planning matrix that would control development within the floodplain at a level of risk that is expected to be acceptable to the community. This involves having a graded set of planning controls that impose restrictions on development, which reflect the vulnerability of that development to flooding and the degree of the flood hazard at the site. This reflects a basic risk management approach to FRM. A planning matrix can encapsulate all relevant FRM controls for the purposes of preparing and assessing development applications and can also provide strategic planning direction in regard to the distribution of land uses within the floodplain to minimise risk.

Schedule 5 Matrix Controls

As the Mid Georges River Catchment and Salt Pan Creek Catchment have similar characteristics, it is proposed that the replacement of Schedule 5 of the DCP that was recommended for Salt Pan Creek Catchment also apply to the Mid Georges River Catchment.

The principal elements of the updated Schedule 5 and changes from existing provisions are summarised as follows:

- An additional Flood Risk Precinct (FRP) is added to address areas affected by “Overland Flow”. This FRP will be excised from the Medium FRP and will apply to land inundated to depths of between 50mm and 250mm in a 100 year flood. Areas with inundation below 50mm would be adequately addressed by standard BCA considerations and the application of controls in the Low FRP.

- The separation of overland flow areas from the Medium FRP, allows for the introduction of the standard controls into this precinct without imposing excessive requirements on development that were affected by very shallow inundation in the 100 year event that did not warrant controls designed to apply to main stream flooding.

- The freeboard for development, where applied in the Overland Flow FRP has been reduced from 500mm to 300mm.

- The controls in the catchments applying to land in the Overland Flow FRP are generally tailored to be reflective of the minor flood hazard.

Carinya Road Area

Consistent with the recommendations in this section of the report, the change to the zoning controls to restrict further development potential would remove the need for the more stringent controls applying to the Carinya Road area under the DCP. Consequently, subject to the rezoning proceeding the DCP could be amended to delete the provisions of the DCP referring specifically to the Carinya Road area including in Clause 4.3.1, 4.3.2 and 4.3.3 of Part E and Schedules 4A, 4B and 4C. The general provisions relating to the Georges River Floodplain would thereafter apply.

The consequence of the above change to the DCP would be that dwelling houses within the Carinya Road area would be considered "unsuitable land uses" but as the development would be permissible under the LEP 2012, each development application would be required to be dealt with on a performance basis. This is consistent with Note 3 provided within the planning matrix for the Georges River Floodplain. However this Note 3 should be updated (as was similarly recommended in the Salt Pan Creek FRMP) to read as follows:

3. *Unsuitable Land Uses: Uses identified as unsuitable will generally not be considered as a result of their overall incompatibility with flood risk and difficulty in addressing these risks without consequential unacceptable amenity or environmental impacts. Such uses may however be considered where they show compliance with the objectives and performance criteria of the DCP. In such cases, these uses will also need to comply with controls as specified by Council.*

The consideration of individual development applications will include addressing issues such as evacuation, and it could be that this will result in elevated walkways, should that be the most acceptable means of addressing this consideration for any particular application. The New South Wales State Emergency Service (NSW SES) has indicated that the NSW SES position on the elevated walkways has not changed since 2005. In response to resident submissions on flood related planning controls for Carinya Road (2005), the NSW SES supported Council in its' policy for improved flood egress conditions on new dwellings through the provision of elevated walkways.

5.3 Notifications (communication)

Other than the above recommendations regarding the disclosure of climate change flood risk predictions and information on the applicability of the Codes SEPP, there are no further recommendations in relation to the notification of flood risks through planning documents.

The recommendations of previous FRMPs in relation to flood awareness and preparedness should nonetheless be pursued by Council. In particular, we emphasise that the change in approach to the planning controls for the Carinya Road area does not resolve issues associated with existing and continuing flood risks in the area and the promotion of flood awareness and preparedness is essential to minimising risk to life in areas such as this.

6.0 Conclusion

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within the Mid Georges River Catchment. This could maximise the compatibility of new development with the flood risk, and allow for existing problems to be gradually reduced over time through sensible redevelopment.

The above contents and recommendations of this report together with the overarching FRMS and FRMP prepared by BMT WBM provide an overall analysis of flood risk management issues and a basis for implementing the above recommendations in accordance with the principles of the FDM. The planning options are discussed in section 5.0 of this report and in summary the suggested recommendations for inclusion in the FRMP are:

1. Any masterplan prepared for the Panania and East Hills Centres should ensure that the overland flow paths are maintained.

2. Bankstown City Council Section 94A Development Contributions Plan 2009 should be reviewed to consider whether any structural mitigation works identified by this FRMS (or others) should be funded (or partly funded) with S94A funds.

3. Flood maps that depict flood extents which factor in climate change considerations (predicted sea level rise and sensitivity analysis to increased rainfall intensity) should be made publically available as part of the exhibition of the FRMS and FRMP with a clear explanation as to why they were prepared and their limited role at this stage in informing Council and the public of the possible effects of climate change.

4. The FSBL provisions not be be used as a means of restricting development in the high flood risk precinct at this stage but that this be monitored and reconsidered in later reviews of the LEP and DCP. Should Council experience difficulties in managing appropriate development in the high flood risk precinct then the use of the FSBL provisions could provide a more stringent planning control mechanism. If pursued this would require a review of the FSBL clause to expand its objectives to include FRM. Additionally the FSBL maps would need to be reviewed to include to include all private owned land within the high flood risk precinct.

5. The FRMP should endorse the recommendations of previous FRMPs (Georges River FRMP and Salt Pan Creek FRMP) regarding the format and content of the Bankstown Draft LEP 2012. The Draft LEP 2012 generally reflects these recommendations and is supported other than as stated below.

6. Adopt the DCP changes for overland flow flooding that have been recommended as part of the Salt Pan Creek FRMP.

7. The recommendations of previous FRMPs in relation to flood awareness and preparedness should be pursued by Council.

8. Climate change flood risk associated with overland flow flooding does not warrant the introduction of specific planning controls at this stage. The decision to apply planning controls to address climate change flood risks should be based on broader policy considerations undertaken an LGA wide basis.

9. Prepare a Planning Proposal to amend LEP 2015 to:

a. Adopt an E4 Environmental Living zone for the Carinya Road area subject to development permitted with consent being extended to include environmental protection works, flood mitigation work, recreation area and roads. Note, the foreshore area including reserve, road and boatshed should remain separately zoned RE1 Public Recreation.

b. Applying a minimum lot size of 1,000m² consistently across all existing housing lots.

10. Subject to approval of the Planning Proposal (Recommendation 8) amend the DCP to delete the provisions referring specifically to the Carinya Road area including in Clause 4.3.1, 4.3.2 and 4.3.3 of Part E and Schedules 4A, 4B and 4C. The general provisions relating to the Georges River Floodplain would thereafter apply.

11. Note 3 of the planning controls matrix for the Georges River Floodplain in the DCP (Schedule 3) should be updated to reflect the wording for Note 3 recommended by the Salt Pan Creek FRMP for the same note in Schedule 5 of the DCP.

7.0 Glossary

100 year flood	A **flood** that occurs on average once every 100 years. Also known as a 1% flood. See **Annual Exceedance Probability (AEP)** and **Average Recurrence Interval (ARI)**.
Annual Exceedance Probability (AEP)	AEP (measured as a percentage) is a term used to describe **flood** size. It is a means of describing how likely a flood is to occur in a given year. For example, a 1% AEP flood is a **flood** that has a 1% chance of occurring, or being exceeded, in any one year. It is also referred to as the '100 year flood' or 1 in 100 year flood'. The terms **100 year flood**, **50 year flood**, **20 year flood** etc., have been used in this study. See also **Average Recurrence Interval (ARI)**.
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 in this study have been provided in metres AHD.
Average Recurrence Interval (ARI)	ARI (measured in years) is a term used to describe **flood** size. It is the long-term average number of years between floods of a certain magnitude. For example, a 100 year ARI flood is a flood that occurs or is exceeded on average once every 100 years. See also **Annual Exceedance Probability (AEP)**.
BCA	Building Code of Australia is a uniform set of technical provisions for the design and construction of buildings and other structures throughout Australia. The BCA is produced and maintained by the Australian Building Codes Board (ABCB), and given legal effect through the Building Act 1975.
catchment	The land draining through the main stream, as well as tributary streams.
CDC	Complying Development Certificate
DPE	The NSW Department of Planning and Environment (formerly NSW Department of Planning and Infrastructure – DPI and Department of Planning – DoP).
DA	Development Application
Development Control Plan (DCP)	A DCP is a plan prepared in accordance with the *Environmental Planning and Assessment Act, 1979* that provides detailed guidelines for the assessment of development applications.
DDCP	Draft Development Control Plan
DLEP	Draft Local Environmental Plan. Refer to glossary on LEP for further information.
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.
EP&A Act	*Environmental Planning and Assessment Act, 1979*.

flood	A relatively high stream flow that 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 hazard	The potential for damage to property or risk to persons during a **flood**. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.
flood level	The height of the **flood** described either as a depth of water above a particular location (e.g. 1m above a floor, yard or road) or as a depth of water related to a standard level such as **Australian Height Datum**.
flood liable land	Land susceptible to flooding up to the **Probable Maximum Flood (PMF)**. Also called **flood prone land**. Note: that the term flood liable land covers the whole of the **floodplain**, not just that part below the **Flood Planning Level**.
FDM	Floodplain Development Manual
Flood Planning Levels (FPLs)	The combination of flood levels and **freeboards** selected for planning purposes, as determined in **Floodplain Management Studies** and incorporated in **Floodplain Management Plans**. The concept of flood planning levels supersedes the designated flood or the flood standard used in earlier studies.
flood prone land	Land susceptible to flooding up to the **Probable Maximum Flood (PMF**). Also called **flood liable land** in the Floodplain Development Manual.
FRM	Flood Risk Management
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). (See also risk).
Flood Study	A study that investigates flood behaviour, including identification of flood extents, **flood levels** and flood velocities for a range of flood sizes.
floodplain	The area of land that is subject to inundation by floods up to and including the probable maximum flood event, that is, **flood prone land** or **flood liable land**.
Floodplain Risk Management Plan (FRMP)	The outcome of a **Floodplain Risk Management Study**. (Note: that the term 'risk' is often dropped in common usage.
Floodplain Risk Management Study (FRMS)	Studies carried out in accordance with the *Floodplain Development Manual* (NSW Government, 2005) that assesses options for minimising the danger to life and property during **floods**. These measures, referred to as 'floodplain management measures/options', aim to achieve an equitable balance between environmental, social, economic, financial and engineering considerations. The outcome of a Floodplain Risk Management Study is a **Floodplain Risk Management Plan**.

floodway	Those areas of the **floodplain** where a significant discharge of water occurs during **floods**. Floodways 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	A factor of safety expressed as the height above the **Design Flood Level**. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the **floodplain**, such and wave action, localised **hydraulic** behaviour and impacts that are specific event related, such as levee and embankment settlement. Note: that freeboard should not be used to allow for sea level rise impacts but can be used to allow for uncertainties in estimating climate change impacts and other effects in accordance with the Floodplain Development Manual and other Government guidelines
high flood hazard	For a particular size **flood**, there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and **velocity**.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of **peak discharges**, flow volumes and the derivation of hydrographs (graphs that show how the discharge or stage/flood level at any particular location varies with time during a flood).
LAP	Local Area Plan, being a strategic planning document prepared by Council.
Local Environmental Plan (LEP)	A Local Environmental Plan is a plan prepared in accordance with the *Environmental Planning and Assessment Act*, 1979, that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.
LGA	Local Government Area
low flood hazard	For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.
merit approach	The principles of the merit approach are embodied in the *Floodplain Development Manual* (NSW Government, 2005) and weigh up social, economic, ecological and cultural impacts of land use options for different **flood prone** areas together with flood damage, **hazard** and behaviour implications, and environmental protection and wellbeing of the State's rivers and **floodplains**.
NSW Planning & Infrastructure	The NSW planning department at the time of preparing this report. Previous departmental names included the Department of Planning (DoP).

OEH, DPC	Department of Premier and Cabinet - Office of Environment and Heritage (being the government agency currently responsible for flooding in NSW – formerly the Department of Environment, Climate Change and Water, DECCW.
overland flow path	The path that floodwaters can follow if they leave the confines of the main flow channel, or in the upper areas of catchments, these are the paths that runoff takes on its way to pipes or watercourses such as channels, creeks and rivers. Overland flow paths can occur through private or public property including along roads. Waters travelling along overland flow paths, often referred to as 'overland flows', are usually on their way to a watercourse or pipe system, or in some cases, may be diversions from one watercourse or pipe system to another.
Probable Maximum Flood (PMF)	The largest flood likely to ever occur. The PMF defines the extent of **flood prone land** or **flood liable land**, that is, the **floodplain**. The extent, nature and potential consequences of flooding associated with the PMF event are addressed in the current study.
REPs	Regional Environmental Plans
reliable access	Reliable access during a flood means the ability for people to safely evacuate an area subject to imminent flooding to a defined regional evacuation route within effective warning time, having regard to the depth and velocity of flood waters, the suitability of the local evacuation route, and without a need to travel through areas where water depths increase.
risk	Risk is measured in terms of consequences and likelihood. In the context of floodplain management, it is the likelihood and consequences arising from the interaction of floods, communities and the environment. For example, the potential inundation of an aged person's facility presents a greater flood risk than the potential inundation of a sports ground amenities block (if both buildings were to experience the same type and probability of flooding). Reducing the probability of flooding reduces the risk, increasing the consequences increases risk. (See also **Flood Risk Precinct**).
SEPPs	State Environmental Planning Policies
SLR	Sea Level Rise

Appendix E Initial Assessment of Flood Modification Options

Table E-1 Identification and Initial Assessment of Flood Mitigation Options

Item	Catchment	HotSpot ID	Description	Technical	Economic	Social	Environmental	Model Option?	Review existing model	Comments
1	C20	2	Overland floodway	Y	Y	Y	Y	Y		Could involve bunding/wall along southern side of reserve and directing flow along Surrey Avenue. 1943 photography shows that properties have been built on the original channel alignment. Approx. $100k AAD in 3 properties would benefit at this location.
2	C20	2	Provisions for flow-through fencing between Sturt Ave & Marion St	Y	Y	Y	Y	N		Properties are currently flooding in Q5. 1943 photography shows that properties have been built on the original channel alignment. Modified fencing should however be considered as part of catchment wide option.
3	C20	3	Basin in Reliance Reserve	Y	Y	Y	Y	Y		Should attenuate flows to reduce flooding further south
4	C20	3	Basin at Higgins St & Manhattan St	Y	Y	Y	Y	Y		Should reduce flooding further SW from this location
5	C20	3	VP - 12 Grace Avenue	Y	Y	Y	Y	N		Offset by sale of land within the park on the NW bend of Higgins St
6	C20	3	VP - 14 Grace Avenue	Y	Y	Y	Y	N		Offset by sale of land within the park on the NW bend of Higgins St
7	C20	3	Create floodway along Higgins St	Y	Y	Y	N	N		Direct flow into open space from the SW corner of Higgins St through to Allingham St. Re-routing flows to this open space will however affect the flooding regime in this location, which could impact on native plants in the park. This may be unacceptable to Council.
8	C20	3	Basin at 23 Allingham St	Y	N			N		Would only serve to protect industrial land downstream. Potential environmental issues.

9	C20	3	Basin in reserve at Caloola St & Alison Ave	N				N		
10	C20	3	Increase inlet capacity	N				N	Y	Further assessment of existing model shows pipe capacity is not a problem here.
11	C20	3	Create floodway along Allingham St into reserve	Y	N			N		Would only serve to protect industrial land downstream. Potential environmental issues.
12	C20	4	Basin within grounds of Condell Park High School	Y	N			N		
13	C20	4	Increase inlet capacity	N				N	Y	Further assessment of existing model shows pipe capacity not a problem here (Pipe1602)
14	C20	4	Flood walls and embankment combined with swales/pipes	Y	Y	Y	Y	Y		Would involve installing pipes / swales for approx. 130m along Railway Pde, then through the school land to Kinch Reserve. Could incorporate 'hump' on Fourth Ave to direct flow in conjunction with bunding along Railway Pde. Option was ruled out at options meeting so potentially do not need to model.
15	C20	5	Basin in park on Mitchell St	N				N		
16	C20	5	Road re-profiling along Fifth Ave & Sixth Ave	N				N		
17	C20	6	Basin within the existing Trotting Track	N				N		Consider as a future opportunity only
18	C20	6	Channel improvements north of Milperra Rd	Y	Y	Y	Y	Y		Could involve channel widening works, removal of structures and increase in culvert/structure capacity under Milperra Rd. Flag for future opportunity with RMS. Plans already in place by Council.
19	C20	6	New walls/embankments along left bank at open channel reach (U/S Milperra Rd)	Y	N			N		Not protecting anything significant
20	C20	6	Opportunity to develop an overland floodway through the commercial business units in Condell Park to the west of Edgar St. to open channel	Y	Y	Y	Y	Y		

21	C20	6	Overland floodway along Edgar St (south of Eldridge Rd toward milperra Rd) to open channel	N				N		
22	C20	7	Basin within airport land at Deverall Park	Y	Y	Y	Y	Y		Plans already prepared for a basin at this location. Plans provided by Council
23	C20	7	Increase inlet capacity in the Ely St/Queen St area	N				N	Y	Further assessment of existing model shows pipe capacity not a problem here
24	C20	7	Increase inlet capacity in the Carrington/Violet area	N				N	Y	Further assessment of existing model shows pipe capacity not a problem here
25	C20	7	Channel improvements south of Milperra Rd	Y	Y	Y	Y	Y		Could involve channel widening works and removal of structures.
26	C20	7	Create floodway along Daisy/Violet/Fitzpatrick	N				N		
27	C20	8	Basin in the grounds of Bankstown Airport	N				N		Involves developing shallow swales through ground re-profiling works along the strips of land between the airport runways
28	C20	8	Review operation of Ashford Avenue flood warning system	Y	Y	Y	Y	N		Possibility for extensions to existing forecasting system. Areas in C20_8 and elsewhere that would benefit need to be identified. Included in the catchment scale options.
29	C20	8	Channel improvements through Bankstown Golf course	Y	Y	Y	Y	Y		Could involve channel widening works and removal of structures.
30	C20	8	Flood walls and embankments at Ashford Avenue	N				N		
31	C20	8	Flood walls and embankments through the open channel reach at Bankstown Golf course.	N				N		
32	C20	8	Overland floodway at Sheridan Close	Y	Y	Y	Y	Y		Ground re-profiling and kerbing/training walls through the rear of the business units.
33	C20	8	Channel/floodway connecting Milperra Drain to Georges River near the intersection of Milperra Road and Henry Lawson Drive	Y	N			N		This measure was previously explored by Council and was considered uneconomical.
34	C20	9	Detention basins within Tracey St. Reserve and Greenway Reserve	N				N		

35	C20	9	Flood embankments within Tracey St. Reserve and Greenway Reserve	N				N		
36	C20	9	Ground re-profiling within Tracey Reserve between 11 and 15 Alliance Avenue.	Y	Y	Y	Y	Y		
37	C20	9	Provision of conveyance through this noise wall allowing flows to drain to the M5 drainage network.	Y	Y	Y	Y	Y		May not be viable based on RMS feedback i.e. implications of increased flood risk to motorway.
38	C26	All	Flood warning - link to Gauge	Y	Y	Y	Y	N		Possibility of using existing gauge to provide flood warning. Areas in C26 that would benefit need to be identified. Included in the catchment scale options.
39	C26	1	VP - 23 Dowding Street	Y	Y	Y	Y	N		Lies on original watercourse (1943 photography)
40	C26	1	Detention basin was considered within the playing fields of Panania North Public School on Bansgrove Rd.	N				N		The school is located at the head of the catchment and there are limited opportunities to attenuate flows to reduce the flood risk.
41	C26	1	A detention basin was considered at Gowlland Reserve to reduce the flood risk in this location	N				N		The topography of this park would require significant engineering works to develop sufficient storage
42	C26	1	A pumping station has been considered upstream of Kelso Levee	N				N		Most of the flood risk in this area is from overland flooding and not from Kelso Swamp
43	C26	3	A detention basin was considered within the small park adjacent to Panania Station	N				N		The park is located at the head of the catchment and there are limited opportunities to attenuate flows to reduce the flood risk downstream.
44	C26	3	A pumping station has been considered upstream of Kelso Levee	N				N		Most of the flood risk in this area is from overland flooding and not from Kelso Swamp
45	C26	3	Develop/enhance the overland flood route along Horsley Rd	N				N		Road re-profiling along this roadway would require significant civil works to lower the road levels sufficiently to convey storm water flows
46	C26	5	Detention basin was considered within the playing fields of East	N				N		The school is located at the head of the catchment and there are limited opportunities to attenuate flows to reduce the flood

			Hills Boys Technology High School							risk.
47	C26	5	Detention basin was considered within the park at the junction of Truscott St. and Fenton St.	Y	N			N		Option not economically viable.
48	C26	6	A pumping station has been considered upstream of Kelso Levee	N				N		Most of the flood risk in this area is from overland flooding and not from Kelso Swamp
49	C26	6	Develop/enhance the overland flood route along Horsley Rd., and Killara Av.	N				N		Road re-profiling along this roadway would require significant civil works to lower the road levels sufficiently to convey storm water flows
50	C30	1	VP 627 Henry lawson Drive	Y	Y	Y	Y	N		
51	C28	1	A detention basin was considered in the playing fields of St. Christopher's School (Tower Street)	N				N		Developing an off-line basin, in an urban environment is not considered viable at this location .
52	C28	1	Detention basin was considered in the playing fields of East Hills Boys High School	Y	Y	N		N		There is an increased safety risk with the detention ponds located within the grounds of schools.
53	C28	1	Increase flows to a 1.8m diameter pipe running to the rear of properties on Singleton Avenue to Duke Street	N				N	Y	Further assessment shows issue with pipe connection at this location. Model updated to include correct pipe connections. Revised model results rules this option out. Alternative options are still viable at this location.
54	C28	1	Increase the capacity of the culverts at Henry Lawson Drive	Y	Y	Y	Y	Y		Potentially limited benefit based on blockage scenarios applied and enveloping with and without blockages. Option may only be viable if flood walls and embankments are not constructed as it would provide limited benefit. Potential future option that would need to be discussed with RMS.
55	C28	1	Flood walls and embankments alongside the open channel reach of Lucas Road Drain	Y	Y	Y	Y	Y		
56	C28	3	Detention basin was considered within the playing fields of Panania Public School	N				N		The school is located at the head of the catchment and there are limited opportunities to attenuate flows to reduce the flood risk.

57	C28	3	Detention basin was also considered within the small park at the junction of Clifford St. and Philip St.	N				N		There is limited storage potential at this location due to the topography of the land and the area of the park.
58	C28	3	Increase inlet capacity in the pipes from Ardath Avenue to Lucas Road	Y	N			N	Y	Pipe 28C0450 details consistent with Council Asset Data - 375 mm Dia confirmed, constriction present. Note pipe location is at the rear of adjoining residential properties with no road access (and below a swimming pool). Street view confirm presence of 3 D/S pits at Ardath Ave. Pipe line from Ardath Ave to Lucas Rd consistently falls with only increases in dia. Option not economically viable, but this pipe size should be confirmed - unlikely that a 375 exists at this location given the U/S and D/S pipe sizes.
59	C28	4	Overland floodway to re-route flows from Henry Lawson Drive to Georges River through the open parcel of land owned by Sydney Water	Y	Y	Y	Y	Y		Consult with Sydney Water
60	C28	5	A detention basin was considered within the playing fields of Panania Public School	N				N		The school is located at the head of the catchment and there are limited opportunities to attenuate flows to reduce the flood risk.
61	C28	5	Overland floodway to re-route flows along Lambeth St. from Kelvin Pde. and at the junction of Elliot St. southwards to Georges River.	Y	Y	Y	Y	Y		Possibility of combining with future upgrade of Henry Lawson Drive to get flows across the road at this location.
62	C29	1	A detention basin was considered within the small open reserve on Eileen Street	N				N		The reserve is located at the head of the catchment and there are limited opportunities to attenuate flows to reduce the flood risk downstream.
63	C29	1	A detention basin was considered within open ground between Kathleen Pde. and Ramsay Rd.	N				N		The park is located at the head of the catchment and there are limited opportunities to attenuate flows to reduce the flood risk downstream.
64	C29	1	An overland flow route has been considered to convey flow from	N				N		Given the topography in this location, road re-profiling along these roadways would require significant civil works to lower

			the sag point on Picnic Point Road to Samoa Av.							the road levels sufficiently to convey storm water flows
65	C29	1	Enhancement of an overland floodway between 13 and 15 Kathleen Parade	Y	Y	Y	Y	Y		Review damages for the directly affected property to understand if option is economically feasible.
66	C29	2	A detention basin was considered within the small open reserve on Apex Av.	N				N		The reserve is located at the head of the catchment and there are limited opportunities to attenuate flows to reduce the flood risk downstream.
67	C29	2	Along Austin Boulevard, there is an opportunity to divert flows along Austin Boulevard onto Burns Road through kerbing/training walls/embankments	Y	Y	Y	Y	Y		
68	C29	2	Further south along Karen Avenue, there is an opportunity to divert flows along Karen Avenue to the reserve to the south through road re-raising (i.e. ramp) and embankments, raised kerbs, to divert flows along Karen Avenue	Y	Y	Y	Y	Y		
69	C29	3	There is an opportunity to develop an overland floodway along Drysdale Av. to the reserve south of this street.	Y	Y	Y	Y	Y		
70	C29	3	An overland flow route has also been considered to convey flow along Eucalyptus Crescent southwards to the reserve.	N				N		Given the topography in this location, road re-profiling along these roadways would require significant civil works to lower the road levels sufficiently to convey storm water flows
71	C27	1	VP - 14 & 16 Kennedy Av. And 27 Garnsey Av.	Y	Y	Y	Y	N		
72	C27	1	Detention basin at Bruce Reserve	Y	Y	Y	Y	Y		
73	C27	4	There is an opportunity to develop an overland floodway to re-route flows along Clive St.	N				N		Road re-profiling along these roadways would require significant civil works to lower the road levels sufficiently to convey storm water flows

74	C27	5	Flood embankment along western boundary of properties on Thomas St. (i.e. north of Stretham Av.)	Y	Y	Y	Y	Y		
75	C27	5	There is a pipe running to the rear of properties at Stretham Av. to the open channel reach which is under capacity	N				N	Y	The model has been set up incorrectly. Pipe 27C0296 is not snapped to anything at its downstream end. Therefore, Pipe 27C02940 is not flowing to its full capacity as it should be. Model to be corrected before determining necessity of options at this location.
76	C27	7	Increase inlet capacity in the pipes along Burns Rd	N				N	Y	Pipes are legitimately under capacity. Increase pit sizes to get pipes flowing full earlier.
77	C27	7	A detention basin was considered within the playing fields of Picnic Point Public School	N				N		The school is located at the head of the catchment and there are limited opportunities to attenuate flows to reduce the flood risk downstream.
78	C25	4	VP - 38 and 38a Winders Lane and 43 and 41 Simmons Street	Y	Y	Y	Y	N		
79	C25	4	VP 123 Sphinx Avenue	Y	Y	Y	Y	N		
80	C25	4	A detention basin was considered at Johnstone Reserve	Y	N			N		Option not economically viable.
81	C25	4	A detention basin was considered at Amour Park	N				N		The park is located at the head of the catchment and there are limited opportunities to attenuate flows to reduce the flood risk downstream.
82	C25	4	A pumping station has been considered upstream of the railway on Sphinx Road	N				N		
83	C25	4	Installation of new pits and a pipe running along the River Road and discharging to the open channel reach east of Montgomery St	Y	N			N		Option not economically viable.
84	C25	4	Developing overland floodways through the Woolworths car park, Marco Avenue & Abel Reserve, River Road and Montgomery	N				N		

			Street and through to the open channel reach to the south of the railway.							
85	C25	4	A detention basin was considered within the playing fields of Tower St Public School	N				N		The school is located at the head of the catchment and there are limited opportunities to attenuate flows to reduce the flood risk.
86	C25	4	A small detention basin in the park at the junction of Howard Road and Uranus Road	Y	Y	N		N		Council has indicated that a detention basin at this location would be socially unacceptable.
87	C25	4	Improving the conveyance at the inlet to the culverts under the railway through changes to local obstructions	N				N		Limited benefits in this area as the culverts are flowing at capacity for the lower AEP events
88	C25	4	Widening railway culverts with new bridge structure or larger culverts to restore natural floodplain behaviour	Y	Y	Y	Y	Y		Long-term opportunity only. Option not for Council to implement.
89	C25	9	Increasing the capacity of pipe inlets on pipe running from Howard Road to the rear of properties along Uranus Road	Y	Y	Y	Y	N	Y	Further assessment shows pipe capacity not a problem here
90	C25	9	Neptune Park was considered as a potential location for developing a detention basin	N				N		The park is located at the head of the catchment, there are limited opportunities to attenuate flows to reduce the flood risk
91	C25	11	Increasing the capacity of pipe inlets on pipe running along Neptune Street.	N				N	Y	Pipes have capacity to reduce flow heading northwards, therefore assess increase to pit inlet to get more water into the pipes. Constrained downstream, so not considered viable.
92	C25	11	There is an opportunity to develop an overland floodway to re-route flows crossing Neptune Street	Y	Y	Y	Y	Y		
93	C25	13	Increasing the capacity of pipe inlets on pipe running from Chamberlain Rd to Courtney Ave and Richardson Ave area	N				N	Y	Pipes have capacity to reduce flow heading northwards, therefore assess increase to pit inlet to get more water into the pipes. Constrained downstream, so not considered viable.

94	C25	13	VP of 33 and 35 Richardson Ave & develop local basin on these properties	Y	Y	Y	Y	Y		Offset by sale of land within the park further north on Richardson Ave. Option unlikely to be: a) technically viable based on the available land area and ground elevations at this location to develop storage, or b) economically viable or sensible given cost of option. VP two properties plus constructions costs of basin to provide benefits to three properties.
95	C25	13	VP within Fiona Close & Vera Place	Y	Y	Y	Y	N		No properties within this location fall within the criteria for VP i.e. property building located within High Hazard Area for the 1% AEP event.
96	C20		Increasing the size of existing detention basins to the north of MacDonald's, Milperra Road and to the south of the roundabout on Nancy Ellis Leebold Drive (refer to Figure 1)	Y	Y	Y	Y	Y		Additional option identified as part of additional modelling work at Bankstown Airport.
97	C20		On-site detention at Kinch Reserve	Y	Y	Y	Y	Y		Additional option identified as part of additional modelling work at Bankstown Airport.
98	C20		Increase pipe diameter and add two more pipes along Endeavour Rd	Y	Y	Y	Y	Y		Additional option identified following numerous complaints from local residents in area between Endeavour Road and Rabaul Road
99	C20		Increase culvert size under Rabaul Road and add open channel	Y	Y	Y	Y	Y		Additional option identified following numerous complaints from local residents in area between Endeavour Road and Rabaul Road

Appendix F Waterways and Water Quality Improvement Plan for the Sub-Catchments of the Mid Georges River

BMT WBM

"Where will our knowledge take you?"









Catchment Action Plan
for the Sub-Catchments of the Mid-Georges River

July 2015

BANKSTOWN
City of Progress

Catchment Action Plan for the Sub-Catchments of the Mid-Georges River

Prepared for:	Bankstown City Council
Prepared by:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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Synopsis: **This document characterises the water balance and stormwater pollutant loads across the sub-catchments of the Mid-Georges River study areas. It outlines catchment conditions and future pressures and identifies opportunities for improvement through the preparation of a Catchment Action Plan (CAP).**

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Executive Summary



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Executive Summary

The Mid-Georges River study area is a highly urbanised and is comprised of seven sub-catchments; Milperra, Kelso Swamp, Little Salt Pan Creek, Morris Gully, Lucas Road, Picnic Point and East Hills. The catchment drains directly to the Georges River and in turn Botany Bay and as such, has a notable influence on the water quality and health of one of Sydney's most significant waterways.

Existing water quality and waterway health across the catchment is regularly monitored by the Georges River Combined Councils Committee River Health program with results indicating poor conditions. Of particular note is Little Salt Pan Creek, which most recently received an overall River Health grade of D+ which falls into the lowest grade condition indicating very poor waterway health.

A review of Bankstown planning documents has shown that the Bankstown Community values the environment and views their waterways as having great importance. This is reinforced through the vision outlined in the Bankstown Community Plan 2023 which makes reference to wanting clean waterways and pristine bushland (Bankstown City Council, 2013). One of the five key strategic directions of the Community Plan is "Green" – to be a sustainable city that respects its natural environment. The Community Plan identified the following community aspirations (shown in quote) for a green city.

> "The community wants clean waterways, healthy green corridors and to produce a smaller environmental footprint. The community also wants Bankstown to be leader in environmental protection and management. Protecting waterways and environmental education are areas in which the Community wants further investment"
>
> (BCC, 2013)

To assist in meeting these community aspirations the Georges River Estuary Coastal Zone Management Plan (CZMP) and the Catchment Action Plan (CAP) for the Sub-Catchments of the Mid-Georges River (herein referred to as the "Mid-Georges River CAP") will be key strategic documents for Bankstown City Council.

The development of the Mid-Georges River CAP involved close consideration of the CZMP. As sub-catchments from the Mid-Georges River drain directly to the Georges River Estuary, the aims and management options formulated by the CZMP form an integral component for management of the Mid-Georges River study area. As such, the CZMP aims and best management options (actions) have been adopted as the basis for the development of the Mid-Georges River CAP. The aims of the CZMP and the Mid-Georges River CAP are shown in Table 1.

Table 1 CZMP and Mid-Georges River CAP Aims and Objectives (adapted from BMT WBM, 2012)

Aim Being Addressed	Objective
Water Quality	Reduce the volume & pollutant load of stormwater runoff through the study area
Water Quality	Improve the performance of sewer overflows

Aim Being Addressed	Objective
Water Quality	All greenfield and redevelopments should have a minimal negative impact on flow and water quality, meeting targets for water quality proposed in the Botany Bay WQIP
Water Quality	Strive to protect undeveloped areas of the broader study area that act as a buffer to water quality
Water Quality	Minimise the negative impacts of new and existing commercial operations in the study area and estuary on flow and water quality
Bank Erosion and Sedimentation	Reduce the extent and severity of bank and foreshore erosion while minimising the impacts on estuary health
Water Quality	Minimise build-up of gross pollutants and illegal dumping of waste into and along the estuary foreshore and waterways
Bank Erosion and Sedimentation	Reduce the causes and impacts of sedimentation in the estuary
Aquatic and Riparian Habitat	Protect and improve the extent and condition of estuarine and riparian vegetation
Aquatic and Riparian Habitat	Minimise the cause and spread of invasive species in aquatic and terrestrial habitats

The Mid-Georges River CAP characterises water movement and stormwater pollutant generation across the Mid-Georges River study area to identify existing conditions and assist in predicting future pressures and conditions. The Mid-Georges River CAP has identified and assessed a range of opportunities for improving conditions in the study area and recommended a prioritised action plan for Council to implement. In addition, existing fish barriers within the study area were identified and an existing case water balance has been developed.

The recommended actions from the CZMP are included in the CAP, however they have been reviewed and assessed to remove actions that are;

- Primarily related to coastal management (rather than catchment management), and
- Not relevant to the Mid-Georges River study area.

In addition the relevant CZMP actions, a number of additional actions were identified that assist in achieving the aims and objectives of the CZMP and the Mid-Georges River CAP. All of the actions have been prioritised and integrated into a single CAP, presented within this report.

Key opportunities investigated in the development of the Mid-Georges River CAP include:

- Retrofit of Water Sensitive Urban Design (WSUD) measures; and
- Policy implementation measures to ensure new development pollutant loads meet the Botany Bay Water Quality Improvement Plan (BBWQIP) water quality targets.

Retrofit of WSUD measures throughout the study area will greatly assist in optimising water quality within the Georges River Estuary and its tributaries in addition to helping achieve the number one ranking study area objective (Table 1), which is to reduce the volume and pollutant load of stormwater runoff through the study area.

WSUD retrofit options investigated included; bioretention, swales, gross pollutant traps (GPTs) and revegetation. Opportunities were evaluated and prioritised based on a triple bottom line assessment. A priority list of options was developed and is shown in Table 2.

Table 2 WSUD Retrofit Prioritised Actions

Prioritised Actions	WSUD Type
Deverall Park Bioretention Basin	Bioretention
Revesby Preschool Bioretention Basin	Bioretention
Grace Avenue Bioretention Basin	Bioretention
Surrey Reserve Bioretention Basin	Bioretention
Pollutant Control Device (PCD) 5 - Lucas Road 1 (upstream)	GPT
Pollutant Control Device (PCD) 4 - Amberdale Avenue (Amberdale Reserve)	GPT
Pollutant Control Device (PCD) 19 - Daisy Street	GPT
Pollutant Control Device (PCD) 9 - Virginius Street (Virginius Reserve)	GPT
Montgomery Reserve Creek Filtration	Swale
Park Road Raingarden	Bioretention
Pollutant Control Device (PCD) 8 - Neptune Street	GPT
Pollutant Control Device (PCD) 17 - Newland Reserve	GPT

In addition to WSUD measures, future development across the study area was investigated to test the affect policy changes would have on pollutant loads. A key management action recommended by the Georges River Estuary CZMP and the Botany Bay WQIP is the incorporation of pollutant load reduction targets in Council planning controls (such as Development Control Plans (DCPs) and Local Area Plans (LEPs)) to ensure WSUD is applied where practicable to all future infill and greenfield developments.

To identify the extent of this management action, future development areas in the study area were identified to include; LAP zoning changes (The River Road Area, Revesby Village Centre, Panania Small Village Centre and East Hills Neighbourhood), the Bankstown Airport development and Riverlands Golf Course development.

Where possible, the performance of future proposed management actions in improving water quality was assessed using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC).

The following management actions (MA) were assessed using MUSIC in a future 'mitigated' scenario:

- MA2: Implementation of best practice load reduction targets to future development in the study area (redevelopment and greenfield)
- MA3: WSUD retrofit opportunities identified in this investigation, including all potential locations identified for green infrastructure and proposed new GPTs.

A summary of the predicted treatment performance of these management actions on total study area pollutant loads is shown in Table 3.

Table 3 Predicted Treatment Performance of Management Actions on Study Area Pollutant Loads

Pollutant	Existing Scenario (kg/yr)	Future Unmitigated Scenario (kg/yr)	Future Mitigated Scenario (kg/yr)	Study Area Load Reduction (kg/yr)	Study Area Load Reduction (%)
Total Suspended Solids (TSS)	1,698,932	1,903,072	1,388,800	514,272	27.0%
Total Phosphorus (TP)	3,045	3,374	2,748	626	18.5%
Total Nitrogen (TN)	23,004	25,541	22,230	3,311	13.0%
Gross Pollutants (GP)	283,715	305,753	223,550	82,203	26.9%

As can be seen, these management actions can achieve a significant reduction in the study area pollutant loads, with predicted loads less than the existing scenario pollutant loads. Consequently, this is likely to result in improvements to the existing state of receiving water quality and waterway health. The relative contribution of each management action (i.e. MA2 and MA3) in achieving these results is also presented in Figure 1.

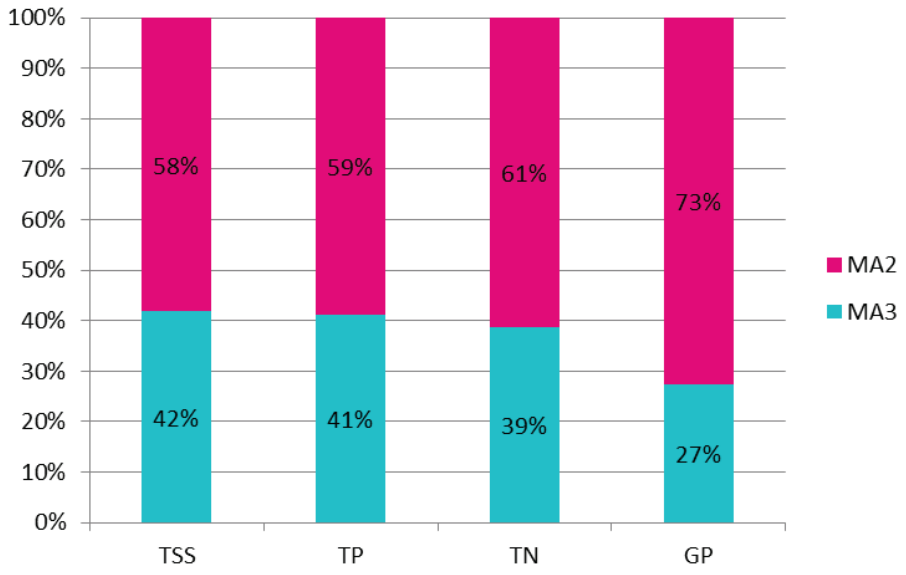


Figure 1 Contribution of Management Actions to Predicted Future Pollutant Load Reductions

Figure 1 shows that a large proportion of the predicted treatment is achieved due to action MA2. This indicates that ensuring best practice load reduction targets are applied to all future development / redevelopment in the study area is of high importance.

It is important to note that while the study identifies the largest potential reduction in the study area pollutants loads from applying water quality controls on future development, the time it takes to see these benefits will depend on the redevelopment rate in the study area. Hence an effective strategy for improving water quality in the study area would be to focus on targeting WSUD retrofit throughout the study area in the interim and as opportunities arise.

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1. Introduction



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1 Introduction

The Mid-Georges River study area is a highly urbanised and located within the Local Government Area (LGA) of Bankstown City Council (BCC). The study area drains directly to the Georges River and as such has a considerable influence on the waterway health of one of Sydney's most notable rivers.

This report has been commissioned by Bankstown City Council and intends to characterise water movement and stormwater pollutants through the Mid-Georges River study area to gain a better understanding of the key pressures, identify opportunities for improvement and recommend a Catchment Action Plan (CAP).

The investigation has involved the application of e-water MUSIC modelling software (Version 6.1.0) and spreadsheet-based water balance calculations. This report describes the models developed and gives cost effective, prioritised management actions for reducing stormwater flows and pollutants within the Mid-Georges River study area.

Whilst undertaking this project the methodology outlined in Figure 1-1 was followed.

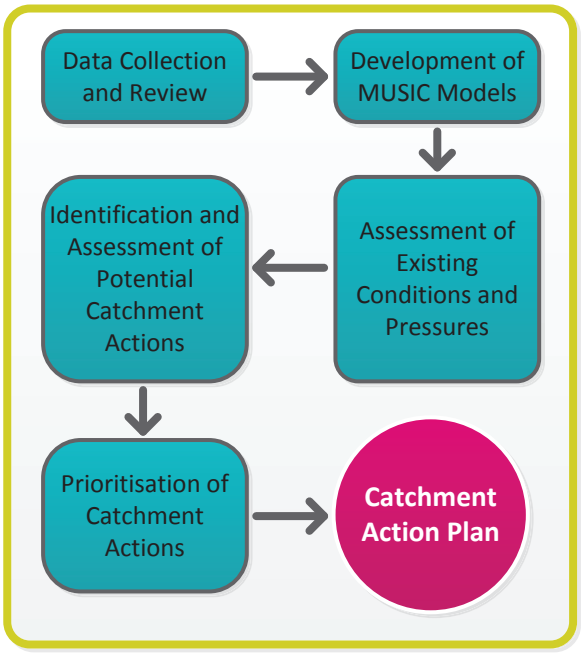


Figure 1-1 BMT WBM Methodology for the Mid-Georges River CAP

2. Study Background



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2 Study Background

A number of Council policies and plans were reviewed and incorporated in the development of the Mid-Georges River CAP. A brief summary of the key strategic documents is outlined below.

2.1 Bankstown Community Plan 2023

Bankstown City Council identifies the Bankstown Community Plan 2023 as Council's single most important strategic document. The Bankstown Community Plan 2023 is a ten year plan which provides the basis for Council's integrated planning suite of documents, ascertains the key community priorities and aspirations for the future as well as identifying key directions for achieving these outcomes (Bankstown City Council, 2013).

This plan is of high importance as it highlights what the community wants and provides the basis for Councils delivery program, resourcing strategy and yearly operational plan. The Bankstown Community Plan 2023 essentially sets the focus for Council actions for the next 8 years.

The plan has "5 City Directions" one of which is a community vision for "Green". The green direction within the plan outlines the desire of the Bankstown community to have a sustainable city that respects its natural environment. The Bankstown City Plan 2023 community priorities and aspirations have been adopted as the vision and objectives for the Mid-Georges River study area, as discussed in Section 3.

2.2 Local Area Plans – South West and South East Plans

Bankstown City Council has developed Local Area Plans (LAP) for the whole Bankstown LGA. The key features of the LAPs are that they set out the vision for distinctive localities and town centres, specify the best way to accommodate residential and employment growth and outline the delivery of supporting infrastructure, facilities and open space. The LAPs are important documents for future planning of the Bankstown LGA, as such it was vital that this CAP utilised the information they contain in assessing future catchment conditions and pressures.

The residential areas in the Mid-Georges River study area fall under two different Council LAPs – the South West and South East LAPs. The South West LAP covers the suburbs of East Hills, Milperra, Panania and Picnic Point while the South East LAP covers Padstow, Padstow Heights, Revesby and Revesby Heights.

The LAPs identified the most appropriate locations for new housing to be concentrated and specified town and neighbourhood centres that would be the focus of renewal and development. Within the Mid-Georges River study area, these locations are: Panania Small Village Centre, East Hills Neighbourhood, Revesby Village Centre and The River Road area. These areas had rezoning outlines and guidance on residential growth.

This information was used to assess the implications of future development on water quality, using the MUSIC model.

2.3 Georges River Estuary Coastal Zone Management Plan

The Georges River Estuary Coastal Zone Management Plan (CZMP) was prepared for the Georges River Combined Council's Committee (GRCCC) in 2012. The key purpose of the CZMP was to *"provide strategic direction and guidance on future actions within the estuary and its catchment, which will help to achieve long term balanced environmental sustainability*" (BMT WBM, 2012 p. I).

The Mid-Georges River study area forms part of the region considered in the Georges River Estuary CZMP. As such, the CZMP forms a key strategic document for the management of the Mid-Georges River study area and development of a CAP. Further information about the CZMP and how it has been integrated into the Mid-Georges River CAP is provided in Section 6.

3. Catchment Vision and Objectives



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3 Vision and Objectives for the Mid-Georges River Study Area

No specific community vision, values and objectives have been identified for the Mid-Georges River study area. As such, the broader community vision and city directions documented in the Bankstown Community Plan 2023 (herein referred to as the "Community Plan") have been adopted as a basis to work towards in this CAP. It is recommended that consultation with the community within the study area be undertaken in the future to identify more specific vision and objectives to work towards.

The Bankstown community vision as documented in the Community Plan is shown in Box 1.

Box 1: Bankstown Community Plan 2023 Vision (BCC, 2013)

"Bankstown is a thriving centre of Greater Sydney. We enjoy the services and facilities of a prosperous, growing city with lively neighbourhoods and a proud history. Our diverse population live and work together in harmony.

Bankstown is a modern, active community with quality transport infrastructure, clean waterways, pristine bushland and great community spaces and parks."

The above vision highlights the importance of healthy waterways, a key driver of the strategies recommended in this CAP.

One of the five key strategic directions of the Community Plan is Green – to be a sustainable City that respects its natural environment. The Community Plan identified the following community aspirations (shown in Box 2) for a green city, which further support the strategies recommended in this CAP.

Box 2: Community Aspirations for a Green City (BCC, 2013)

"The community wants clean waterways, healthy green corridors and to produce a smaller environmental footprint. The community also wants Bankstown to be leader in environmental protection and management. Protecting waterways and environmental education are areas in which the Community wants further investment"

The Georges River CZMP is a key strategic document for assisting to achieve the Bankstown Community's Vision and aspirations for a Green City. The goal of the CZMP is outlined below in Box 3.

Box 3: Georges River Estuary CZMP Goal (BMT WBM, 2012)

> *"To conserve and improve the existing natural environment of the Georges River Estuary, and to improve the water quality of the estuary through targeted pollutant reduction"*

This goal is consistent with the Community's vision and aspirations for a green city, with a focus on the protection of its receiving waterways (Georges River Estuary). Appropriate catchment management forms an integral component of ensuring the protection of receiving waters of the Georges River Estuary. As such, the broad aims and objectives for future management identified in the CZMP have been adopted as a basis for the development of this CAP.

The top ten management objectives identified in the CZMP are shown in priority order in Table 3-1.

Table 3-1 Georges River Estuary Coastal Zone Management Plan Management Objectives (Adapted from BMT WBM 2012)

Aim Being Addressed	Objective
Water Quality	Reduce the volume & pollutant load of stormwater runoff through the study area
Water Quality	Improve the performance of sewer overflows
Water Quality	All greenfield and redevelopments should have a minimal negative impact on flow and water quality, meeting targets for water quality proposed in the Botany Bay WQIP
Water Quality	Strive to protect undeveloped areas of the broader study area that act as a buffer to water quality
Water Quality	Minimise the negative impacts of new and existing commercial operations in the study area and estuary on flow and water quality
Bank Erosion and Sedimentation	Reduce the extent and severity of bank and foreshore erosion while minimising the impacts on estuary health
Water Quality	Minimise build-up of gross pollutants and illegal dumping of waste into and along the estuary foreshore and waterways
Bank Erosion and Sedimentation	Reduce the causes and impacts of sedimentation in the estuary
Aquatic and Riparian Habitat	Protect and improve the extent and condition of estuarine and riparian vegetation
Aquatic and Riparian Habitat	Minimise the cause and spread of invasive species in aquatic and terrestrial habitats

Of particular note, a key objective for water quality is that all greenfield and redevelopments should meet specific targets for water quality proposed in the Botany Bay WQIP (SMCMA, 2011). These targets are important on a regional scale as they have been scientifically demonstrated to help ensure

the protection of environmental values associated with ultimate receiving waters of Botany Bay. They are also used as a tool to manage and protect water quality in local catchment waterways. Hence the objectives are recommended for adoption in this CAP, and are reproduced below in Table 3-2.

Table 3-2 Stormwater Reduction Targets for Urban Development in the Botany Bay Catchment (Source: SMCMA, 2011)

Stormwater Pollutant	Greenfield Developments Large Redevelopments	Multi-Unit Dwellings Commercial Developments Industrial Developments Small Redevelopments
Gross Pollutants (GP)	90%	90%
Total Suspended Solids (TSS)	85%	80%
Total Phosphorus (TP)	60%	55%
Total Nitrogen (TN)	45%	40%

4. Existing Conditions



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4 Existing Conditions

The Mid-Georges River study area is located in Western Sydney, approximately 21 km west of the Sydney Central Business District within the LGA of Bankstown City Council (refer to Figure 4-1).

The study area incorporates the entire suburbs of Bankstown Airport, Milperra, Panania, East Hills, Picnic Point, Revesby Heights and parts of the suburbs of Georges Hall, Bass Hill, Yagoona, Condell Park, Revesby, Padstow and Padstow Heights, as shown in Figure 4-1.

The Mid-Georges River study area is approximately 2,990 ha, a significant portion (almost 40%) of the Bankstown LGA which covers approximately 7,600 ha. The study area is comprised of seven individual sub-catchments which drain into the Georges River:

- Milperra;
- Kelso Swamp;
- East Hills:
- Lucas Road;
- Picnic Point;
- Morris Gully; and
- Little Salt Pan Creek.;

The sub-catchments are based on natural topographical divides and are bounded by the Georges River along the west and south of the study area. The topography of the study area ranges from over 65m AHD in the north east (Condell Park) to 0m AHD along the banks of the Georges River.

Land use within the study area primarily consists of urban residential development with large open spaces and undeveloped land present along the Georges River. Significant open spaces and undeveloped areas include Bankstown Airport, the Georges River National Park, several golf courses and numerous reserves (refer to Figure 4-1).

The seven sub-catchments all drain individually to the Georges River, generally in a west or south direction. From the study area, the Georges River flows in a south-easterly direction, discharging into Botany Bay.

A brief description of the catchment characteristics for each of the seven sub-catchments which comprise the Mid-Georges River study area is provided in Section 2.1.1 to Section 2.1.7 of the Floodplain Risk Management Study and Plan for Sub-Catchments of the Mid-Georges River.

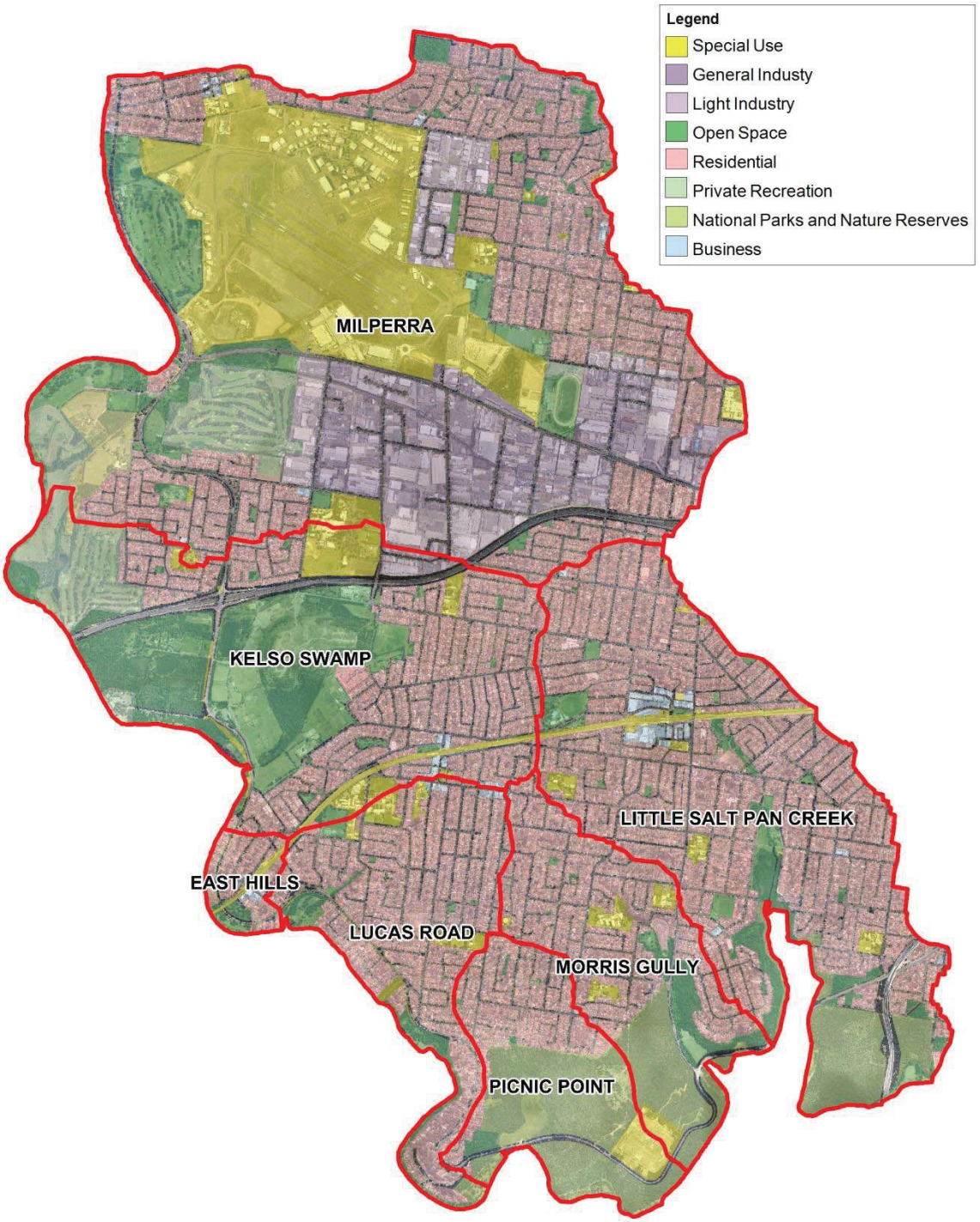


Figure 4-1 Mid-Georges River Sub-Catchments and Study Area

4.1 Catchment Waterways and Waterway Health

The Mid-Georges River study area has a number of waterways throughout the catchment, including both natural and altered channels. All watercourses run in a general southerly or westerly direction to the Georges River. Figure 4-2 shows catchment waterways.



Figure 4-2 Waterways within the Mid-Georges River Study Area

4.1.1 Key Catchment Waterways

Within the Mid-Georges River study area there are three notable creeks, Little Salt Pan Creek, Kelso Creek and Morgans Creek; these are highlighted on the map in Figure 4-2 and shown in photos in Figure 4-3 and Figure 4-4. All of these waterways are tributaries of the Georges River and as such influence water quality within the Georges River, and subsequently Botany Bay.

These three creeks along with the Milperra Drain are identified as key waterways for the Mid-Georges CAP and discussed in this section. The three creeks have been identified as they are the prominent within the study area, with Bankstown City Council previously completing estuary management plans (EMP) for both Little Salt Pan Creek and Kelso Creek. These plans were intended to encourage the responsible and sustainable use of these estuaries.

The Milperra Drain is noted as a key waterway as it is the largest altered channel in the study area. It is also a waterway where pollution is reported to build-up and Council has indicated this area is marked for investigation.



Figure 4-3 Little Salt Pan Creek (left) and Kelso Creek showing Kelso Levee (right)



Figure 4-4 Morgans Creek from The River Road, Picnic Point

Little Salt Pan Creek is approximately 2.7km in length, running in a general north to south direction from Revesby down through Revesby Heights and Padstow Heights to the Georges River.

Kelso Creek has two branches extending from Panania travelling north and south around the perimeter of the former Kelso Landfill. Kelso Creek is a Class 2 waterway with aquatic and riparian habitat of fair condition (NSW DPI, 2007). A key feature of this creek is the levee bank and flood levee gates constructed in 1986 to protect properties from flood events on the Georges River. The Kelso levee however, can result in reduced tidal flushing of the creek system, blocked fish passage and backing up of stormwater from Kelso Creek during wet weather periods.

The most extensive altered channel reaches are located in the Milperra sub-catchment. Milperra Drain runs east to west from Queen Street, Revesby, through the commercial business units at Milperra and Bankstown Golf Club, Milperra, before joining the Georges River approximately one kilometre downstream of the Bankstown Golf Club, Milperra. Milperra Drain has been canalised from Queen Street, Revesby to approximately 300m downstream of Ashford Avenue, Milperra. Photos of Milperra Drain are shown in Figure 4-5; the photo on the left shows the drain facing upstream from Ashford Avenue and the photo on the right shows the drain from Bankstown Golf Club.



Figure 4-5 Milperra Drain, Milperra

There is a history of flooding along Milperra Drain and a number of reported issues of pollution. Most notably the community have reported high visibility of gross pollutants, as readily seen in Figure 4-6.



Figure 4-6 Gross Pollutants in Milperra Drain Observed during a Site Visit (March 2015)

4.1.2 Waterway Barriers

As part of this study all potential waterway fish passage barriers have been identified through a desktop assessment using GIS mapping, aerial photography and the TUFLOW flood model. Waterway barriers to fish passage may be caused by physical blockages such as a floodgate, weir, dam or debris caught in culverts, or from the alteration of natural flow conditions in a waterway caused by the construction of crossings (e.g. road culverts and bridges) that restrict the passage of fish (Fairfull and Witheridge, 2003).

Information available from flood study models for the sub-catchments of the Mid-Georges River indicate that there are 65 potential waterway barriers to fish passage in the study area, as shown in Figure 4-9. The barriers are primarily located in the Milperra sub-catchment. Most waterway barriers were identified to be in the form of culverts, apart from the following locations:

- Kelso levee - actively managed floodgates;
- Milperra floodgates; and
- Yeramba Lagoon Weir (with box culverts immediately downstream)

Photos of the above structures are shown in Figure 4-7 and Figure 4-8.



Figure 4-7 Kelso Levee, Panania (left) and Milperra Floodgate, Milperra (right)



Figure 4-8 Yeramba Lagoon, Picnic Point Weir and Box Culverts



Figure 4-9 Waterway Barriers within the Mid-Georges River Study Area

A review of a previous investigation that the NSW Department of Primary Industries (NSW DPI) undertook to assess and address the impact of floodgates on stream connectivity and fish passage in coastal catchments on the NSW South Coast indicates that the Kelso Levee is a significant waterway barrier to fish passage in the study area. As such, a brief summary of the study findings is provided in Section 4.1.2.1.

However, as the assessment of management options for identified waterway barriers is not within the scope of the current study, it is recommended that further investigations be undertaken as part of a future study by a suitably qualified expert in fish passage to assess the implications of potential waterway barriers on fish passage and possible management options. The study should refer to investigation, design and rehabilitation considerations for fish passage as outlined by Fairfull and Witheridge (2003).

4.1.2.1 Kelso Levee

Current policy in NSW legislates that all new instream structures must incorporate fish passage into the design. However, prior to this, poorly designed and managed floodgate structures exist that are detrimental to fish migrations (such as Kelso Levee, refer to Figure 4-7).

As a result, the NSW DPI undertook a comprehensive investigation to assess and address the impact of floodgates on stream connectivity and fish passage in coastal catchments on the NSW South Coast. The study identified and prioritised floodgate structures for remediation (categorised by Catchment Management Authority (CMA) area). Prioritisation was based on the structures impact on aquatic biodiversity with sites classified as either 'high', 'medium' or 'low' priority sites.

Within the Sydney Metro CMA area only one (of the three assessed) floodgates was recommended for remediation. This floodgate is located on the Kelso Flood Levee within the Mid-Georges River study area. The Kelso Flood Levee is located on a Class 2 waterway that possesses aquatic and riparian habitat in fair condition, increasing its impact on fish passage and strengthening the need for active management at the site. Modification to the management of the flood gates on the Kelso Flood Levee would allow fish passage to approximately 3 km of upstream aquatic habitat. The recommendation made for the Kelso Flood Levee was to modify active management (NSW DPI, 2007).

Table 4-1 provides the details of the Kelso Flood Levee, as per the NSW DPI report.

Table 4-1 Kelso Flood Levee Details (NSW DPI, 2007)

Structure ID	SYDN001F
Waterway	Kelso Creek
Subregion	Georges River
LGA	Bankstown City Council
Ownership	Local Government
Location	Latitude: -33.954834 Longitude: 150.984500
Structure Type	Winch
Stream Class	2
Habitat U/S (km)	3.0
Wetland U/S (Ha)	0
Recommendation	Modify active management

4.1.3 Waterway Health

Waterways are a major feature of the Bankstown LGA landscape, forming a natural boundary around the area. Additionally water from the Mid-Georges study area feeds into the Georges River, which has significant environmental and recreational values (BMT WBM, 2012). As such, water quality plays an important role within the Mid-Georges study area and Bankstown LGA as a whole. Bankstown City Council is committed to preserving and enhancing the environment and thus invests in water quality monitoring and programs.

The Mid-Georges River study area is assessed as part of the Georges River Combined Councils' Committee (GRCCC) water quality monitoring program River Health. River Health is a community-based monitoring program that assesses the health of the Georges and Cooks Rivers through monitoring of water quality, macroinvertebrate assemblages and riparian vegetation within the two catchments (GRCCC, 2014). The program assigns 'report card' grades to help interpret and present the results of waterway health monitoring to the community.

River Health monitors over 40 sites within the Georges River, including both freshwater and estuarine sites. There is one freshwater site in the Bankstown LGA that is currently monitored; this is the Little Salt Pan Creek site which is located within the study area (Bankstown, 2014). Previously a site in Morgan's Creek (within the Morris Gully sub-catchment) had also been monitored. Additionally, there is one estuarine site monitored within the study area in Little Salt Pan Creek Estuary. It is also noted that Kelso Creek (estuarine site) was temporarily monitored for 2013-14. Locations monitored within the study area are shown in Figure 4-11.

The results of recent report cards for the Mid and Lower Georges River catchments show a loss of riparian vegetation and deterioration in water quality and macroinvertebrate diversity, likely due to the high level of recent urbanisation and development in the area. Overall, the ecological health of the Georges River is rated fair, with the river reach within the Mid-Georges River study area also achieving a fair freshwater site result (Bankstown City Council, 2014).

Despite this, the results of the two locations that have been monitored within the study area show poor results, with Morgan's Creek achieving an overall grade of E in 2012-13 and Little Salt Pan Creek receiving a D+ grade for 2013-14 (as shown in Figure 4-10).



Figure 4-10 River Health Monitoring Program Results – Morgan's Creek 2012-13 and Little Salt Pan Creek 2013-14 (GRCCC, 2014)



Figure 4-11 River Health Monitoring Locations within the Mid-Georges River Study Area

It is evident from the River Health monitoring program results that these freshwater sites are experiencing adverse water quality conditions resulting from the effects of urban and industrial run-off. Bankstown City Council is actively trying to improve water quality across the LGA by undertaking stormwater treatment projects and creek restoration works (Bankstown City Council, 2014).

In 2007 the Sydney Metro Catchment Management Authority (SMCMA) conducted a study to assess waterway health and prioritise management activities to protect and rehabilitate Sydney's waterways

and waterway biodiversity corridors. The resulting report "*Sydney Metropolitan CMA Waterways Health Strategy Report*" delivered this information for the entire metropolitan area including the Mid-Georges River study area.

The SMCMA applied a multi-criteria process to assess waterway condition, incorporating stream type, riparian vegetation condition and social values. Based on the findings of this analysis a primary management option was recommended for each waterway reach, as follows: (HCCREMS, 2015).

- Conservation / Protection: The site is in a good condition and regarded as a high priority area for on-ground works. Sites in this category may require an increased protection status.
- Assisted Regeneration: The site has a good waterway structure and stability, with little potential for significant future erosion and good to moderate vegetation (some weed invasion). The primary focus for work is the implementation of a bush regeneration program.
- Revegetation: The site has sub-optimal buffer widths. The creek may be experiencing some erosion and the riparian vegetation is not creating a significant corridor for fauna passage or aquatic habitat.

The waterways assessed and the primary management options recommended for the Mid-Georges River study area are shown in Figure 4-12. All of the recommendations (except one) were revegetation or assisted regeneration. The one exception was a recommendation for conservation protection of the Georges River.



Figure 4-12 Waterways Health Strategy Management Actions (Adapted from SMCMA, 2007)

4.2 Biodiversity

Although Bankstown Council LGA, like much of Sydney is a fully urbanised area, it still exhibits a wealth of biodiversity. Within Bankstown LGA there is known to be over 590 plant species, 230 bird species, 15 frog species, 12 mammal species and 14 vegetation communities (Bankstown City Council, 2015a).

To help protect Bankstown's biodiversity, Council has developed a Biodiversity Strategy. This strategy set the future management direction for the protection and enhancement of biodiversity within Bankstown (Bankstown City Council, 2002). A number of individual strategies were recommended for managing biodiversity, these included strategies focusing on:

- Planning;
- Corridors;
- Core Habitat Enhancement;
- Ongoing Conservation Management;
- Aquatic;
- Community Participation;
- Education;
- Funding and Resources; and
- Monitoring.

In addition to the Biodiversity Strategy, Council has developed Biodiversity Corridor Masterplans. The outcome of these plans was to provide recommendations that can be implemented to enhance biodiversity and recreational values of various corridors within Bankstown, including the Little Salt Pan Creek Corridor within the study area.

The Little Salt Pan Creek Biodiversity Corridor Masterplan was completed in 2004, with a key objective being to provide maintenance, protection and enhancement of biodiversity along the corridor. It is of particular importance for the conservation of three endangered ecological vegetation communities, two flora species and two fauna species (Bankstown City Council, 2004).

In order to provide effective management and incorporate all aspects of the Little Salt Pan Creek Biodiversity Corridor, the following facets of the corridor were targeted for enhancement;

- Water quality;
- Vegetation communities;
- Flora and fauna habitat;
- Threatened species;
- Recreational opportunities;
- Aesthetic and intrinsic environmental value;
- Flood management; and
- Environmental restoration (Bankstown City Council, 2004).

The Biodiversity Strategy (Bankstown City Council, 2002) identifies numerous biodiversity corridors within the Mid-Georges River study area. Biodiversity corridors were mapped in two categories – core and minor. The biodiversity corridors identified within Bankstown LGA are shown in Figure 4-13.

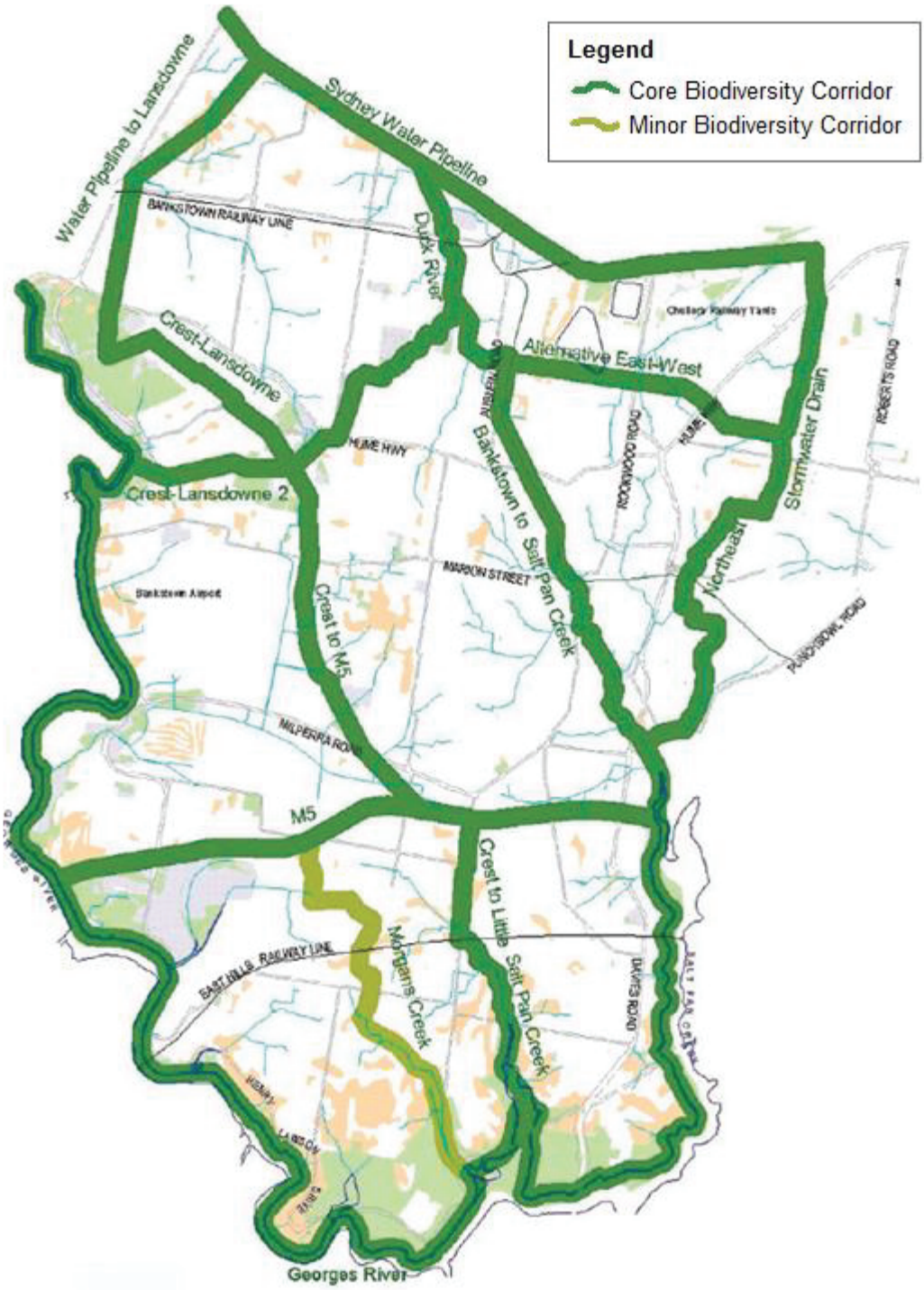


Figure 4-13 Biodiversity Strategy Biodiversity Corridors (Bankstown City Council, 2002)

The Biodiversity Strategy shows the Mid-Georges River study area has four core corridors and one minor corridor. The biodiversity corridors are:

- The Georges River;
- M5 Motorway;

- Crest (M5) to Little Salt Pan Creek;
- Crest (North of study area) to M5; and
- Morgan's Creek (minor corridor).

The Sydney Metropolitan CMA Waterways Health Strategy Report also identified and mapped waterway biodiversity corridors. The Mid-Georges River study area waterway biodiversity corridors mapped by SMCMA are shown in Figure 4-14.

The SMCMA described the Mid-Georges River study area as having three core corridors and two minor corridors. The core corridors are the M5 Motorway, running horizontally through the study area from east to west, the Crest to Little Salt Pan Creek, running vertically from north of Bankstown Airport down to meet Little Salt Pan Creek in the south of the study area and the Georges River. The minor corridors are the Milperra Drain Corridor and the Morgan's Creek to M5 Corridor. These corridors are shown on the map in Figure 4-14 along with the supplementary corridor areas or buffer areas. The buffer is formed 200m on either side of the waterway biodiversity corridor.

The SMCMA areas were similar to the Bankstown City Council Biodiversity Strategy corridors with the only difference being the inclusion of the Milperra Drain as a minor corridor.



Figure 4-14 Waterway Health Strategy Biodiversity Corridors (Adapted from SMCMA, 2007)

Within the Mid-Georges River study area one area is mapped as a biodiversity protection zone under the Bankstown 2015 LEP. This area falls within the Morris Gully sub-catchment and occupies an area of approximately 4.3 ha. The biodiversity protection area is located between The River Road and Thomas Street in Picnic Point / Revesby Heights as shown in Figure 4-15.

Clause 6.4 of the Bankstown LEP 2015 outlines the objectives of the biodiversity protection zone. The overarching aim of this clause is to protect and maintain terrestrial and aquatic biodiversity and regulate development in these zones so no adverse impact is had on biodiversity (Bankstown City Council, 2015).



Figure 4-15 Biodiversity Protection Zone (Bankstown City Council, 2015)

4.3 Key Pollutant Generation

The e-water MUSIC modelling software has been used in this study to quantify the pollutant loads being generated for the study area and each sub-catchment. A detailed description of the

methodology and parameters used to construct the rainfall runoff and pollutant export model is detailed in Appendix A.

Total average annual pollutant loads predicted for the Mid-Georges River study area for both pre-European and existing conditions are presented in Table 4-2. This shows the total impact of development on the study area pollutant loads and sets the benchmark for natural conditions. The results in Table 4-2 show that urbanisation of the study area since European settlement has resulted in a significant increase in pollutant loads.

Table 4-2 Total Average Annual Pollutant Loads for Pre-European and Existing Conditions

Pollutant	Pre European Scenario (kg/yr)	Existing Scenario (kg/yr)	Increase (kg/yr)
TSS	74,790	1,698,932	1,624,142
TP	231	3,045	2,814
TN	2,454	23,004	20,550
GP	0	283,715	283,715

Results from the MUSIC model have been graphed in Figure 4-16 to show the total average annual pollutant generation (TSS, TP, TN and GP) for each individual sub-catchment in both pre-European and existing case scenarios. These results are also tabulated in Appendix A.

Thematic maps showing existing sub-catchment pollutant loads in kg/ha/yr are also presented in Figure 4-17. These maps show the sub-catchments that generate the highest concentration of pollutants (pollutant 'hot spots') and are effective for assisting in identifying target sub-catchments for pollution treatment.

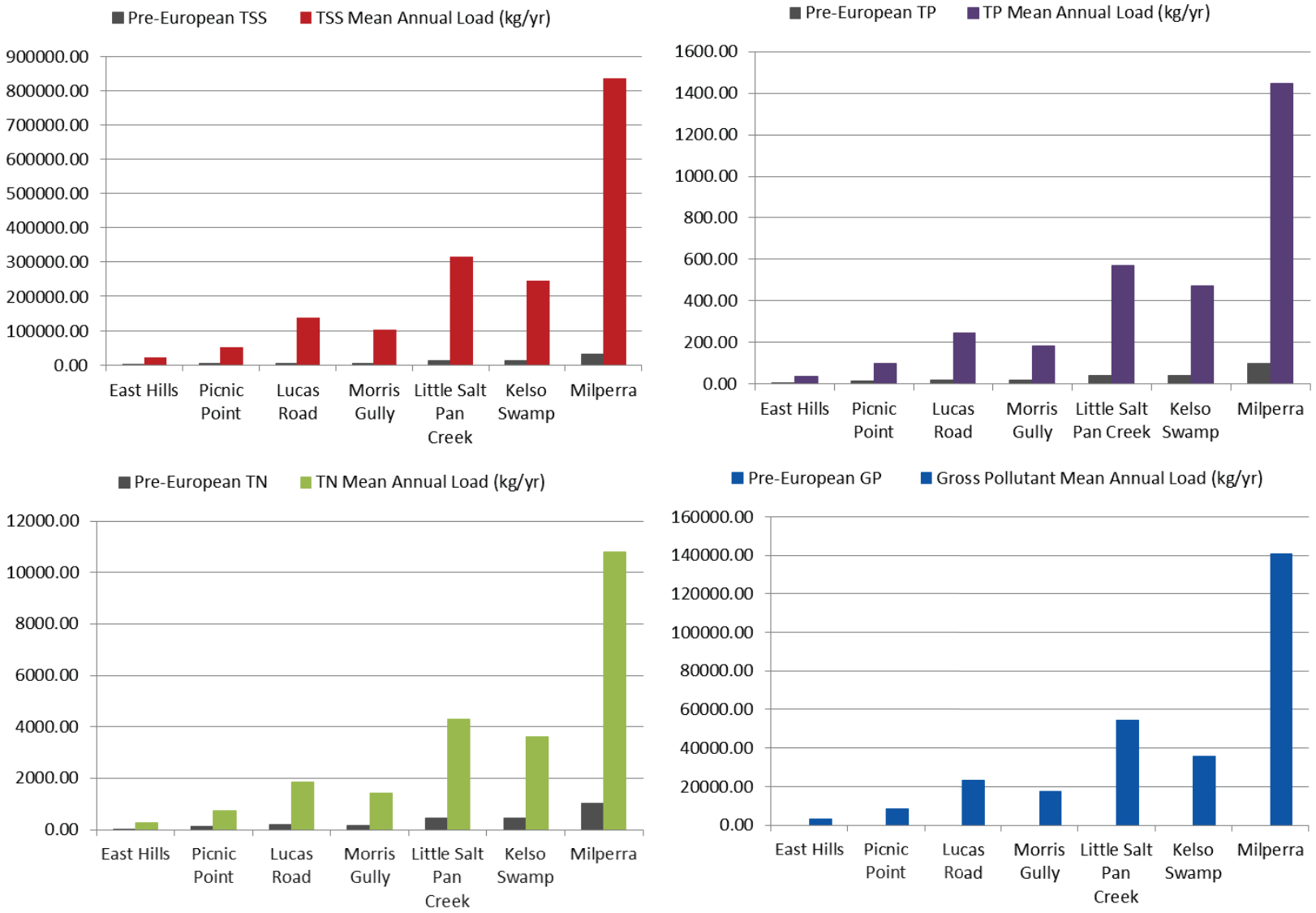


Figure 4-16 Existing Case Sub-Catchment Pollutant Loads (kg/yr)

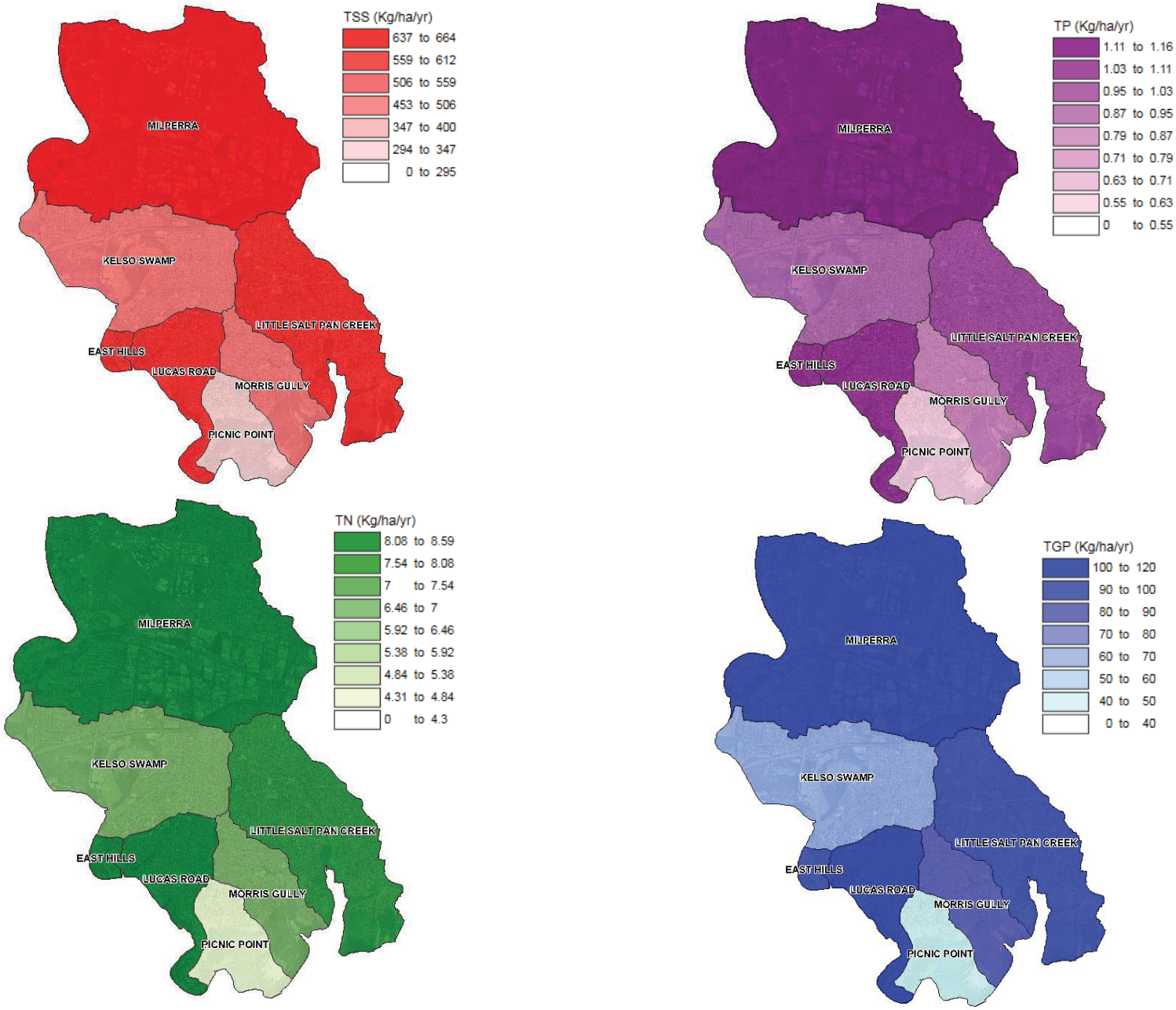


Figure 4-17 Thematic Map showing Existing Sub-Catchment Pollutant Loads in kg/ha/yr within the Mid-Georges River Study Area

From Figure 4-16, it can be seen that currently, pollutant load generation of TSS, TP, TN and gross pollutants is highest from the Milperra sub-catchment. This is due to the large sub-catchment size and large area of industrial land use. Furthermore, as to be expected considering the urbanised nature of each sub-catchment, Figure 4-16 shows that the total quantity of pollutant loads generated from each sub-catchment is generally proportionate to its size, with the highest pollutant loads generated from the Milperra sub-catchment, and the smallest pollutant loads generated from the East Hills sub-catchment.

However, when comparing sub-catchment loads produced per hectare, the highest concentrations of TSS, TP, TN and gross pollutants (kg/ha/yr) are generated by the Milperra, East Hills and Lucas Road sub-catchments. This is attributed to the land use characteristics within the sub-catchments, with Milperra having a large industrial area (characteristic of high impervious areas and pollutant generation) and East Hills and Lucas Road sub-catchments being primarily residential but with limited green and open spaces (i.e. pervious areas) that other residential catchments benefit from. For example, the Picnic Point sub-catchment generates the lowest catchment pollutant loads per hectare due to a large portion of the catchment being green spaces (National Parks and Reserves).

The high pollutant generation per hectare combined with the high total pollutant load generated by the Milperra sub-catchment identify it as a target catchment for locating future treatment measures.

4.4 Water Balance

A water balance budget was developed for the Mid-Georges River study area by quantifying the key elements of the water cycle, including:

- Rainfall. Accounts for all rainfall on the study area and is based on mean annual rainfall (MAR) values;
- Evapotranspiration. Volume of water evaporating from the ground and surface waters, along with transpiration losses from vegetation;
- Stormwater Runoff. Surface runoff and groundwater (baseflow) entering receiving waters;
- Potable Water Demand. Residential and non-residential reticulated water demand;
- Water Leakage. Volume of drinking water lost from the water distribution system due to leakage; and
- Wastewater Discharges. Volume of wastewater generated in the study area.

A water balance for the study area was developed to investigate existing conditions.

The following section outlines the methodology used to quantify the key inflows and outflows for the water balance. It is noted that the e-water MUSIC modelling software was used to provide estimates of rainfall, evapotranspiration and stormwater runoff for the water balance. Further information on the MUSIC modelling methodology is described in Appendix A.

A summary of the methodology and key assumptions used to develop the water balance for the study area is outlined in Table 4-3.

Table 4-3 Summary of Water Balance Methodology and Key Assumptions

Water Cycle Element	Methodology & Key Assumptions
Rainfall	• MUSIC modelling used to quantify • Rainfall sourced from Bankstown Airport rainfall station to quantify average weather conditions
Evapotranspiration	• MUSIC modelling used to quantify. Calculated as the difference between modelled inflows (rainfall) and modelled outflows (stormwater runoff plus extractions)
Stormwater Runoff	• MUSIC modelling used to quantify
Potable Water Demand	• Water use data sourced from Sydney Water by Bankstown City Council between 2013 - 2014 for various land uses within the suburbs that make up the Mid-Georges River study area. Potable water is imported to the study area via Sydney Water's supply network.
Water Leakage	• Assumed to be 8.2% of annual water use (Sydney Water, 2012)
Wastewater	• No data available to quantify, therefore estimated based on study area potable water use provided by Sydney Water. • Wastewater from residential properties assumed to be 78% of consumption, based on Sydney Water advice. • Wastewater rates for other land use types provided by Sydney Water wastewater monitoring.
Non-Urban Water Demand	• NSW Government Office of Water database checked • No bores present in the study area
Groundwater Infiltration	• Baseflow (contributing to stream flow) quantified in MUSIC • Deep seepage (water lost to the system) assumed to be zero.

The existing case water balance for the Mid-Georges River study area is shown in Figure 4-18.

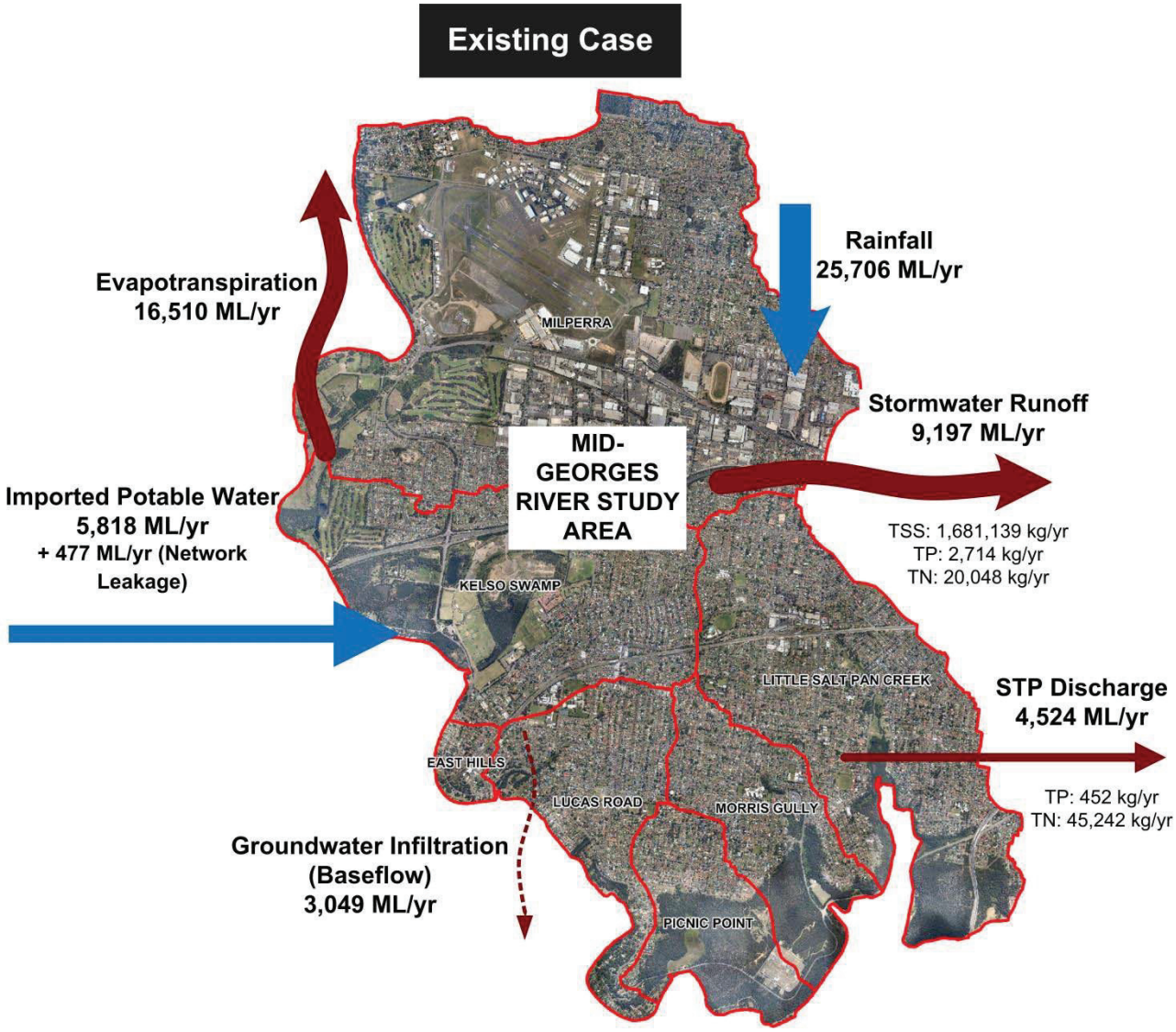


Figure 4-18 Water Balance (2015) within the Mid-Georges River Study Area

4.4.1 Rainfall

Rainfall data for the water balance model and hydrological assessment of the study area was sourced from a Rainfall Station (No. 066137) located at Bankstown Airport. Rainfall for a 10 year period between 1975 and 1984 was used to represent the long term average conditions, with MAR of 869 mm. This compares well with the MAR of 873 mm, which is the long term average for Bankstown Airport (-0.4% difference).

MUSIC was used to assess the volumes runoff in the study area.

4.4.2 Evapotranspiration

Evapotranspiration is the amount of water that outflows from the study area via surface evaporation and transpiration of water from plant leaves. It is one of the major components of the water cycle.

Potential evapotranspiration (PET) for the study area was obtained through a point inspection of PET monthly MapInfo tables in the centre of the study area. The PET data used is shown in Figure 4-19, and can be seen to vary from 37 mm in June to 170 mm in January.

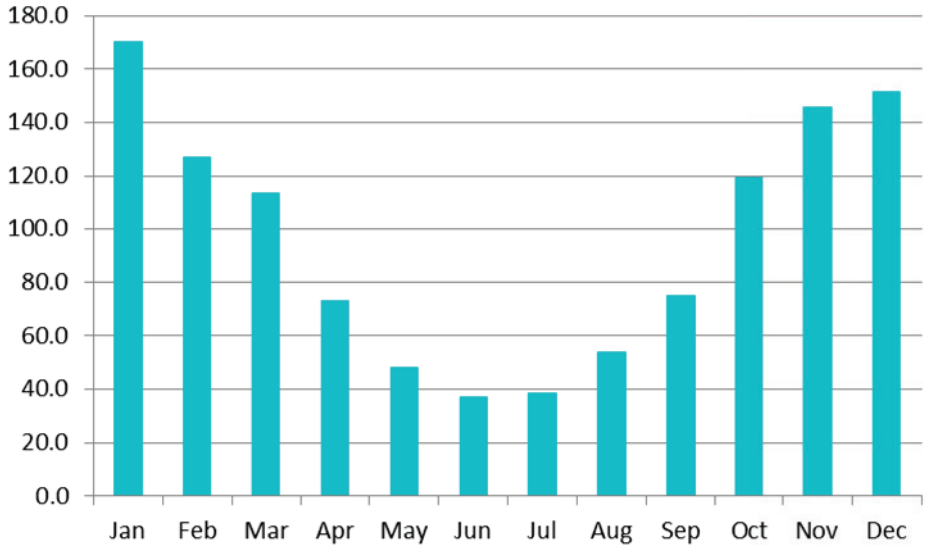


Figure 4-19 Potential Evapotranspiration for Mid-Georges River Study Area

The above data was used in MUSIC to estimate evapotranspiration in the water balance prepared. Actual evapotranspiration in each scenario was determined by calculating the difference between modelled inflows (rainfall) and modelled outflows (stormwater runoff plus extractions).

4.4.3 Stormwater Runoff

Stormwater discharges relate to surface runoff after rainfall events as well as groundwater flow (i.e. baseflow) from all land uses in the study area. In the water balance, these stormwater discharges are represented by average annual flow volume and associated pollutant loads into receiving waterways at the outlets of the sub-catchments.

Within the Mid-Georges study area urban stormwater is collected and conveyed by a network of surface pits and underground pipelines, which generally discharge to an open channel, creek, river or other waterway before draining to the Georges River.

Figure 4-20 shows the stormwater drainage infrastructure (data supplied by Bankstown City Council).



Figure 4-20 Stormwater Drainage Infrastructure within the Mid-Georges River Study Area

MUSIC modelling was used to quantify stormwater discharges and pollutant loads.

4.4.4 Potable Water Demand

Potable water is supplied to the Mid-Georges River study area via the Prospect and/or Kurnell supply systems. Water is treated at Prospect Water Filtration Plant (WFP) or the Kurnell Desalination Plant before entering the study area (Sydney Water, 2015). Figure 4-21 shows a schematic of the Mid-Georges River study area water supply system.

Prospect WFP is one of the world's largest water filtration plants, with capacity to treat approximately 3,000 ML/day, supplying approximately 80% of Sydney's potable water demand (Sydney Water, 2015a). Current potable water demand in the Mid-Georges River study area is approximately 5,818 ML/yr.

Kurnell Desalination Plant supplies drinking water (when it is needed) to approximately 1.5 million people in Sydney and has the ability to produce an average of 250 million litres per day. That is equivalent to 15% of Sydney's total drinking water supplies (Sydney Desalination Plant, 2015).

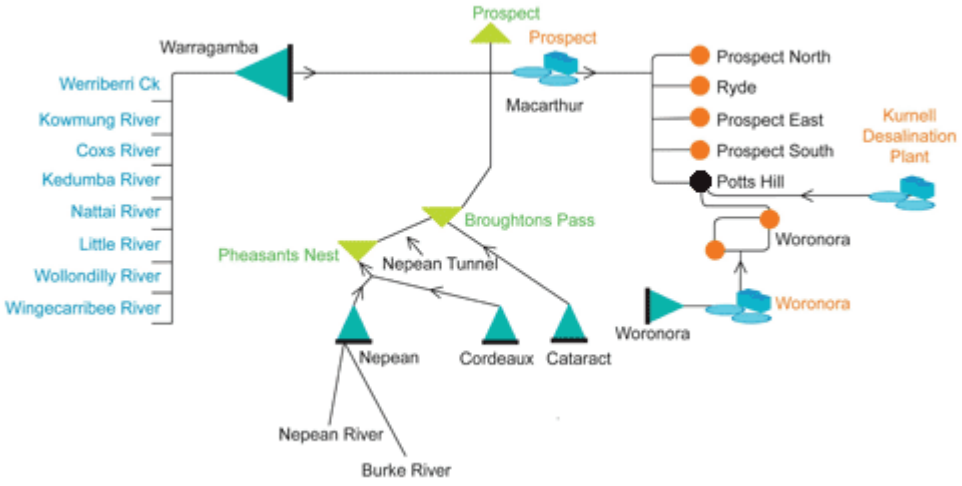


Figure 4-21 Mid-Georges River Study Area Water Supply System (Sydney Water, 2015)

Sydney Water have provided total potable water use for the suburbs within the study area by land use from 2013-2014, which has been used to estimate typical water demands for the water balance.

Data provided by Sydney Water shows annual potable water use between 2013 and 2014 for the study area was 5,818 ML.

4.4.5 Water Leakage

Water leakage refers to potable water lost from the system through leaks in the water distribution system (e.g. pipes). Based on estimates by Sydney Water (2012), network leakage was assumed to be 8.2% of the study area's annual water demand. It is noted that this has an uncertainty band of ±25%.

4.4.6 Wastewater

There is no Sewage Treatment Plant (STP) located within the Mid-Georges River study area. Sydney Water operates 30 wastewater treatment plants and water recycling plants that treat over 1.5 billion litres of wastewater every day (Sydney Water, 2015c).

Wastewater from the study area is treated at the Malabar Wastewater Treatment Plant (WTP), as per the Sydney Water wastewater treatment systems map shown in Figure 4-22. Malabar WTP provides primary treatment prior to discharging effluent 3.6km offshore at a depth of 60m. On an average day Malabar treats 470 million litres of wastewater (Sydney Water, 2015b).



Figure 4-22 Wastewater Treatment Systems Map (Sydney Water, 2015c)

No information on effluent flows for residential properties was available for use in this investigation; therefore this has been estimated according to proportions of total potable water use. Sydney Water advised that 78% of residential consumption being discharged as wastewater is appropriate to use.

For all other land uses, Sydney Water provided discharge volumes per land use category which were used to calculate the wastewater volume for the study area.

Using the above assumptions, it was calculated that the Mid-Georges River study area generates approximately 4,524 ML of sewage per year, as outlined in Table 4-4.

Table 4-4 Estimation of Annual Sewage Discharged from Mid-Georges River Study Area

Land Use	Avg. Potable Water Use 2013-2014 (kL/yr)	Sewage Usage Discharge Factor (SUDF)	Estimated Sewage Discharge (kL/yr)
Residential	4,879,603	78%	3,806,090
Business / Commercial	22,983	89%	20,383
Industrial	446,204	93%	417,043
Open Space / Parks	383,288	71%	273,109
Bankstown Airport	85,889	9%	7,606
TOTAL	**5,817,967**		**4,524,232**

Pollutant loads generated from treated sewage originating from the Mid-Georges River study area and discharging to receiving waters was estimated using predicted sewage volumes and approximate water quality treatment standards at a typical WTP. Results are high level estimates only and are provided in Table 4-5 below.

Table 4-5 Estimate of Mid-Georges River Study Area Sewage Effluent Pollutant Loads Discharged to the Environment from Malabar WTP

Pollutant	Estimate of Effluent Load (kg/yr)[1]
TN	45,242
TP	452

[1] Assumes sewage discharge of approximately 4,254.2 ML/yr and annual median effluent discharge concentrations of 10 mg/L TN and 0.1 mg/L TP

4.4.7 Non-Urban Water Demand

Non-urban water demand includes water extracted from both surface water and groundwater sources, generally for irrigation and stock watering purposes.

A survey of the bore database maintained by NSW Government Office of Water[1] found no licenced bores within the study area, indicating groundwater is not a significant component of the water cycle in the Mid-Georges River study area. It may also be that the potable water and current stormwater harvesting supplies are sufficient. As the study area is largely urbanised, minimal surface and groundwater extractions for rural use are to be expected.

4.4.8 Groundwater Infiltration

Groundwater infiltration in the study area has been represented as baseflow. Baseflow includes groundwater infiltration which discharges from the study area as a component of stream flow. Due to the uncertainty surrounding deep seepage properties in the study area (groundwater lost permanently from the system), no deep seepage has been assumed.

[1] NSW Government Office of Water, Groundwater, Real Time Data – Bores
http://waterinfo.nsw.gov.au/water.shtml?ppbm=GROUND_WATER&gw&3&gwkm_url

5. Future Pressures



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5 Future Pressures

As the Mid-Georges River study area is already a heavily urbanised, the key future pressure for the study area is the unmitigated redevelopment and increased densification of urban development. As outlined in Section 2.2, the Bankstown City Council LAPs have identified various locations within the study area where renewal and development will be focused. These areas are located within Kelso Swamp, Little Salt Pan Creek, Morris Gully, Lucas Road and East Hills sub-catchments. If redevelopment goes ahead with no water quality management measures in place, it has potential to worsen existing water quality, which is already demonstrated to be poor. However, if stormwater pollutant load reduction targets are effectively implemented through Council policies and plans, there exists the opportunity to improve water quality from these existing areas.

The redevelopment planned for these town centres includes converting areas currently zoned as low density residential or business to medium and high density residential and medium and high density mixed use zones.

Within the Milperra sub-catchment, Bankstown Airport has proposed to undertake a significant development of their site. This involves a large portion of the site being developed into business zone with small areas of aviation-business zones and environmentally significant zones. A large portion of the site including the runways will remain as aviation zone (Bankstown Airport Limited, 2014).

Additional major development in the Kelso Swamp sub-catchment is planned at the Riverlands Golf Course with 15.5 ha of private recreational land being transformed into a low density residential area. This is the only greenfield development area identified in the Mid-Georges River study area, although it is noted that the proposed airport expansion can also be considered as greenfield development due to existing open space land use. As such, it is anticipated that these areas are likely to result in a net increase of pollutant loads, and need to be appropriately managed to contain the impact on receiving waters.

The only sub-catchment unaffected by any future development plans is Picnic Point. As such, WSUD retrofit opportunities will form an important component in the strategy to improve water quality from the Picnic Point sub-catchment, which discharges to Yeramba Lagoon and the Georges River Estuary within the Georges River National Park.

The map in Figure 5-1 shows planned future development areas in the study area. This information was used to assess the implications of future development on water quality, using e-water MUSIC modelling software. The MUSIC modelling methodology is outlined in Appendix A.

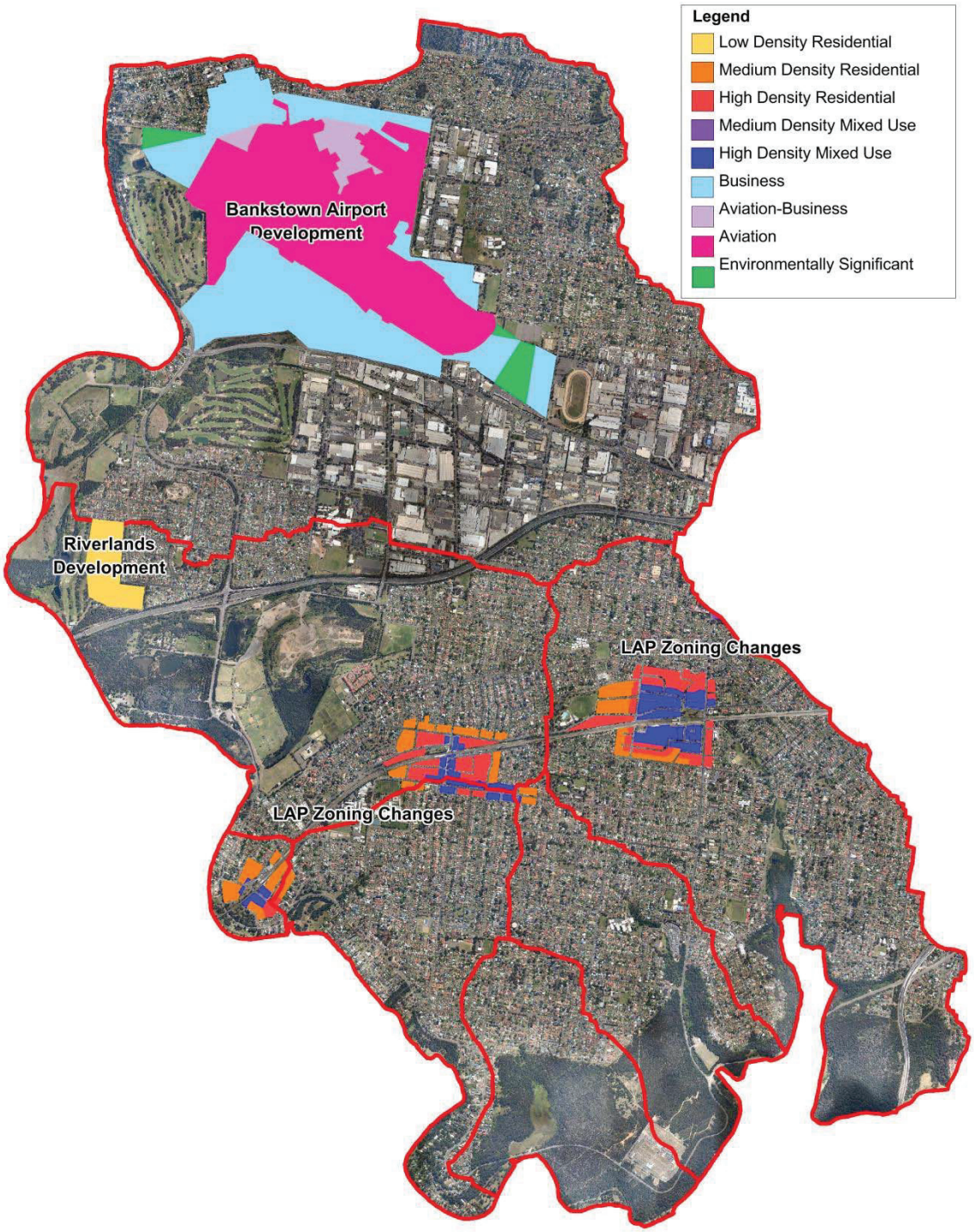


Figure 5-1 Areas Planned for Future Development within the Mid-Georges River Study Area

Future development areas shown in Figure 5-1 will have an impact on the pollutant load leaving the Mid-Georges River study area and entering the Georges River.. The impact of future unmitigated development on TSS, TP, TN and GP is shown in Figure 5-2.

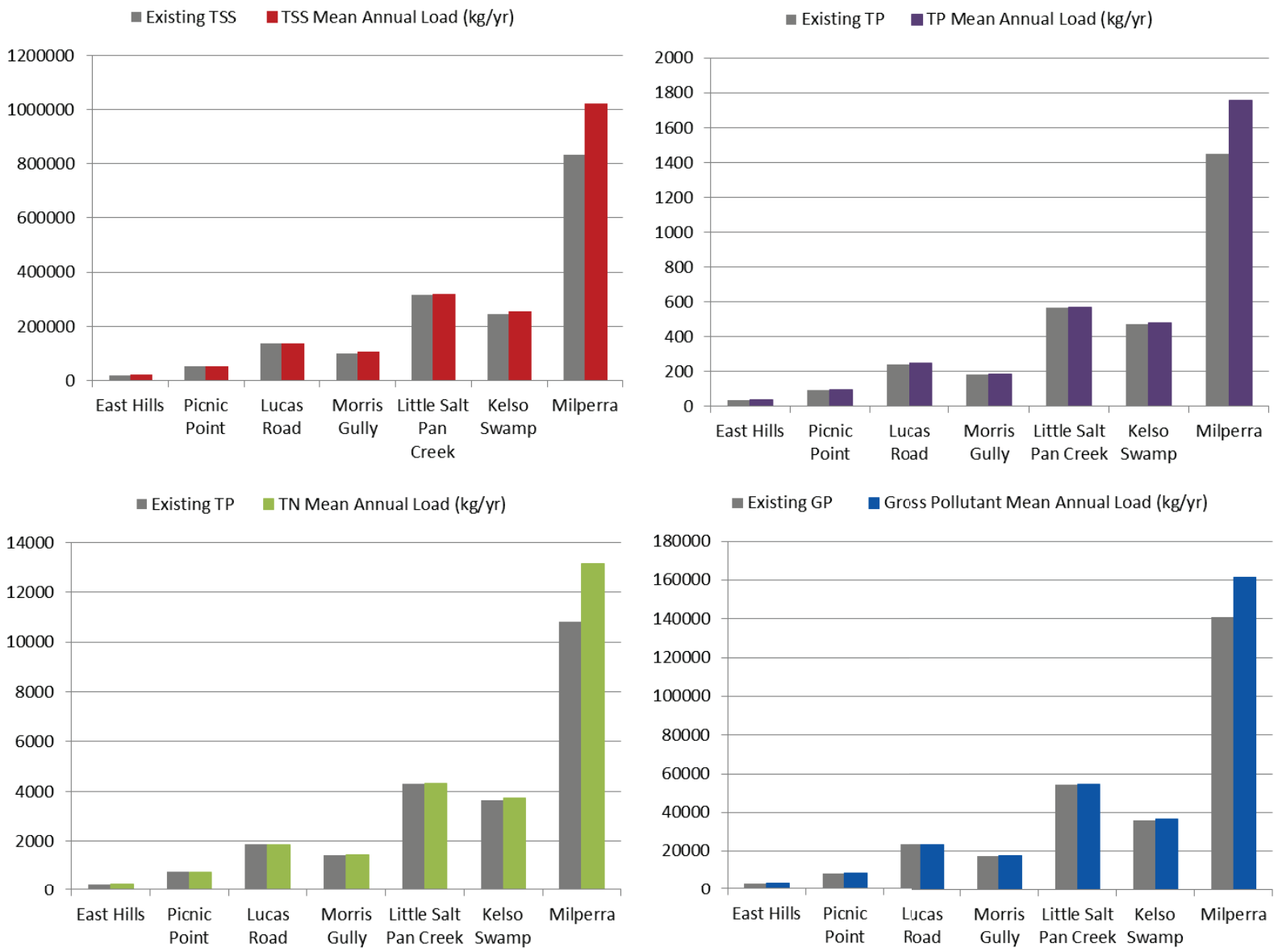


Figure 5-2 Existing and Unmitigated Future Development Scenario Sub-Catchment Pollutant Loads (kg/yr)

As can be seen by Figure 5-2, the Milperra sub-catchment is predicted to have the greatest increase in pollutants, with TSS, TP, TN and GP increasing by 22%, 21%, 22% and 15% respectively. These increases are attributed to development at Bankstown Airport and are due to the greatly increased impervious area and hence higher runoff volumes and pollutant loads.

East Hills had the next highest overall pollutant load increases with TSS, TP, TN and GP increasing by 9%, 9%, 8% and 10% respectively. This is expected as such a large proportion of the East Hills sub-catchment is marked for development and increasing residential densification.

The predicted increase in total catchment pollutant loads due to future unmitigated development in the study area as a whole are presented in Table 5-1. These increases are considered substantial considering that water quality monitoring in the study area indicates current water quality to be poor. Hence they present a key future pressure in the study area to be managed.

Appropriately managed redevelopment of these areas also offer the opportunity to enhance existing water quality and waterway health in the Mid-Georges River study area and receiving waters.

Table 5-1 Predicted Increase in Future Pollutant Loads from Unmitigated Development

Pollutant	Existing Scenario (kg/yr)	Future Unmitigated Scenario (kg/yr)	Predicted Increase in Loads (kg/yr)	Predicted Increase in Loads (%)
TSS	1,698,932	1,903,072	204,141	12.0%
TP	3,045	3,374	329	10.8%
TN	23,004	25,541	2,537	11.0%
GP	283,715	305,753	22,038	7.8%

6. Review of Existing Management Actions



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6 Review of Existing Management Actions

As part of this study, actions recommended in previous plans including Kelso Creek and Little Salt Pan Creek Estuary Management Plans (EMP), Little Salt Pan Creek Biodiversity Corridor Master Plan and the Georges River Coastal Zone Management Plan were reviewed.

Consultation with Council (Meeting on 17 September 2014) in regards to the actions contained in these plans indicated that only the Georges River CZMP actions were relevant for incorporation into the Mid-Georges River CAP. The three other reports do not need reviewing / incorporation into the Mid-Georges River CAP for the following reasons:

- Kelso Creek EMP – Actions in this report have been integrated into the Georges River CZMP.
- Little Salt Pan Creek EMP – Actions in this report have been completed and were largely incorporated into the Little Salt Pan Creek Biodiversity Corridor Master Plan.
- Little Salt Pan Creek Biodiversity Corridor Master Plan (2006) – Review not required as all of the actions in this report have nearly been fully implemented by Council. Actions in one area (B2) are ongoing but plans are in place to complete these.

The Georges River Estuary CZMP provides a strategic framework and action plan for the future management of the Georges River Estuary, which is the receiving waterway for the Mid-Georges River study area. The CZMP aims to redress current issues, and conserve existing values, using a range of implementation mechanisms, including planning instruments, on-ground works, and education programs. The CZMP includes an indicative costing, potential funding sources, and identifies key agencies and Councils for responsibility of implementation and future monitoring.

Existing values and concerns of the estuary, along with the future desirable conditions within the waterways were used to set overarching aims and objectives for the Georges River CZMP.

The Georges River CZMP was developed in consultation with key stakeholders and the community. The Georges River Estuary Management Committee (EMC), which has representatives from all relevant Councils including Bankstown City Council, as well as key state agencies and other stakeholders, were involved in workshops to develop and assess the aims, objectives and management options of the CZMP.

Nine broad “Aims” were developed and agreed by consensus of participants at the EMC workshops for the future management of the Georges River Estuary. These aims cover the range of pertinent issues identified for the estuary, including water quality, habitats, recreation and infrastructure and are reproduced in Table 6-1. The Aims seek to address the fundamental goal of the CZMP, which is to achieve a balance between the demands on the estuary from ecological needs and from recreational (human) pursuits.

Table 6-1 Aims of the Georges River CZMP (BMT WBM, 2012)

	Description	*Associated Risk if aim not achieved*
A	To optimise water quality within the Georges River Estuary and its tributaries	Intolerable
B	To protect, enhance and restore aquatic habitats and foreshore vegetation	Intolerable
C	To protect and enhance public access to the foreshore	Tolerable
D	To minimise the negative impacts of development in the catchment on waterway health	Intolerable
E	To actively manage bank erosion and sedimentation	Intolerable
F	To manage existing built foreshore assets while maximising environmental values	Tolerable
G	To identify, acknowledge and protect natural and cultural heritage	Tolerable
H	To plan for and adapt to the potential impacts of climate change on the natural and built environments of the estuary	Intolerable
I	To develop and support coordinated monitoring, reporting and evaluation programs for the Georges River Estuary	Tolerable

For each of the Aims, a series of management objectives were developed to assist to highlight the management measures required to achieve the Aim. An initial 'long-list' of possible Management Options was developed, under each Management Aim.

The potential merit of each option was assessed by determining which objectives were targeted by each option, the priority ranking (importance) of these objectives, and how well the option satisfied the particular objectives. The technical evaluation led to an overall 'total potential' score for each possible Management Option, which accounts for its contribution to all aims and objectives of the CZMP, including environmental conservation, pollution reduction and recreational enhancement.

A multi-criteria rapid assessment tool was developed to assess the positive and/or negative costs and benefits of the various management options. These costs and benefits consider more than the technical merits of the options (i.e. total potential), by including aspects such as cost, timeframe, community acceptance, ease of implementation, and considering whether there would be 'no regrets'.

The rapid assessment tool is based on a "traffic light" colour system for a range of variables, to clearly display if an aspect of an option should be cause to "stop" and reconsider, "slow" to proceed with caution or "go" with few trade-offs expected. The assessment was conducted for each possible Management Option. It was aimed at presenting quickly and clearly the benefits and trade-offs of a particular option, to assist in the selection of a preferred option.

Using the multi-criteria rapid assessment process described above, management options were prioritised and categorised as 'Best Management Options', 'Next Best Options' and 'Other Options'

The 'Best Management Options' were those highest priority options considered to create the best outcomes for the Georges River Estuary without undue constraints such as costs, practicalities of implementation and acceptance by the community. The Best Management Options also included a large number of 'No Regrets' actions. Best Management Options only were adopted in the formulation of the Georges River CZMP. The Best Management Options within the Mid-Georges River study area are shown in Figure 6-1.

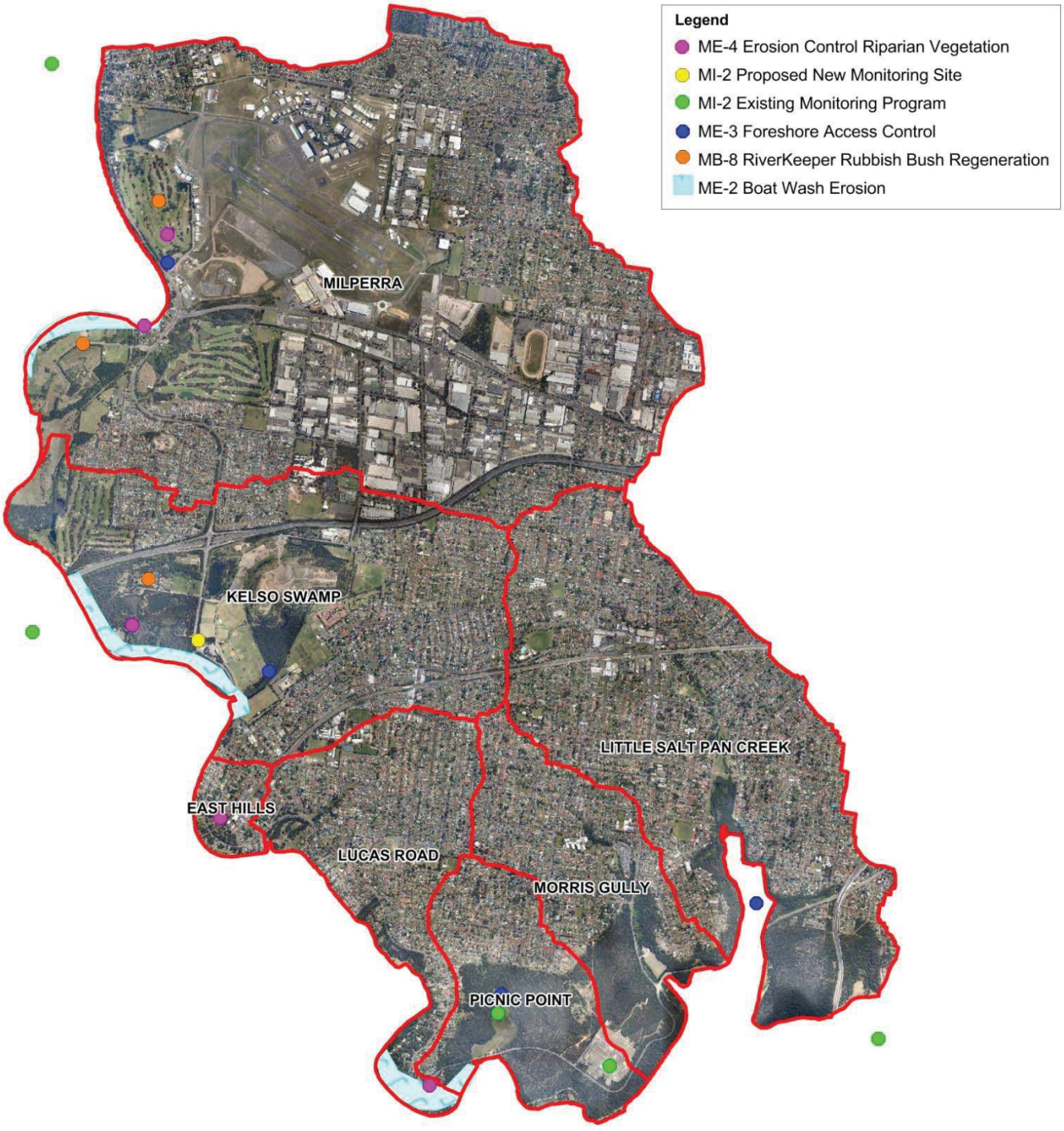


Figure 6-1 CZMP Best Management Options within the Mid-Georges River Study Area

As sub-catchments from the Mid-Georges River study area drain directly to the Georges River Estuary, the aims and management options formulated by the CZMP form an integral component for management of the Mid-Georges River study area.

As such, the aims and management options have been adopted as the basis for development of this CAP. Recommendations included in the development of the Mid-Georges River CAP have however, been reviewed and screened to remove the following:

- Those actions that relate mostly to coastal management (rather than catchment management); and
- Those actions that are not relevant to the Mid-Georges River study area.

In developing the Mid-Georges River CAP, a number of additional actions were also identified to assist in achieving the aims and objectives of the CZMP and the Mid-Georges River CAP. These additional actions have been integrated into the existing aims and best management options of the CZMP.

In reviewing the priority of existing best management options (herein referred to as 'actions'), the work undertaken to formulate the CZMP was reviewed. The prioritisation process results in the CZMP were used to formulate a list of prioritised actions in the Mid-Georges River CAP. This was done using the following process:

- Actions were firstly ranked based on the priority of the management objectives the action targets.
- A second filter was then applied to rank actions based on the rapid cost benefit assessment score determined for each action.

This resulted in a prioritised list of actions to address overarching aims and objectives of the CZMP.

Due to the rigorous assessment and prioritisation of actions undertaken for the CZMP, and the consistency of management objectives within each plan (i.e. CZMP and Mid-Georges River CAP), the prioritisation was deemed appropriate for adoption within the Mid-Georges River CAP.

7. Identification of Additional/Specific Management Actions



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7 Identification of Additional/Specific Management Actions

7.1 Water Sensitive Urban Design Retrofit

Retrofit of Water Sensitive Urban Design (WSUD) measures in existing urban areas was identified as a high priority management option ('MA3') in the Georges River Estuary CZMP to help optimise water quality within the Georges River Estuary and its tributaries. Implementing such measures will assist to achieve the number one ranking objective, which is to reduce the volume and pollutant load of stormwater runoff through the study area. It will also assist to achieve other high priority objectives such as reducing the cause and impact of sedimentation within the Georges River estuary.

Examples of the types of WSUD retrofit measures recommended in the CZMP include wetlands, swales, bioretention systems, channel naturalisation and GPTs. As such, the current study has examined opportunities to retrofit such devices throughout the study area. As a concurrent investigation was being undertaken to identify and assess the condition of GPTs within the study area, this assessment was divided into two key components:

- Identification of Green Infrastructure; and
- Identification of GPTs.

Further details on the identification of these WSUD retrofit actions within the study area are provided below.

7.1.1 Green Infrastructure

A review of opportunities to retrofit green infrastructure throughout the study area was undertaken using the following methodology:

- A site visit, undertaken with Council on 19 March 2015, to gain an appreciation of the existing catchment conditions and opportunities. Key locations visited are shown in Appendix B.
- Examination of mapping and available GIS data for the study area to assist in reviewing opportunities and constraints, including topography and aerial imagery, community land (i.e. parks), the location of stormwater and sewerage infrastructure, Potential Acid Sulfate Soils (PASS) risk classifications, contaminated land and biodiversity corridors.
- Discussion of opportunities with Council, including a 'virtual tour' of the study area, undertaken with Council staff on 11 May, 2015.

A key limitation to identifying suitable locations for large end of pipe treatments (such as wetlands and bioretention basins) was the lack of available land, difficulty in daylighting deep stormwater pipes for treatment and the presence of PASS.

As such, it is suggested that a small scale distributed streetscape approach be undertaken to gradually implement WSUD measures throughout the study area. This involves retrofitting small bioretention basins or raingardens into community lands (such as parks / public open spaces) and road reserves throughout the study area. A good example of an existing streetscape system in the study area is shown in Figure 7-1. Four of these systems were constructed in the Kelso Swamp sub-catchment as part of the Panania town centre urban renewal. Interpretive signage was also

constructed to help educate the community about raingardens and their benefits. These systems are good demonstration sites providing environmental education and showing how Council is assisting to protect waterways; areas that the Community have indicated they want further investment in (refer to Box 2 Section 3). Other examples of streetscape raingarden applications are shown in Figure 7-2.



Figure 7-1 Examples of Panania Town Centre Raingardens

Advantages of retrofitting raingardens / small bioretention basins throughout the study area include:

- Small footprint means they can easily be retrofitted in many locations throughout the study area;
- Small size means they are cheaper to construct than larger systems, and can be progressively constructed as funding becomes available to Council;
- Targeting treatment of pollutants 'at source', prior to entering the stormwater system. This also enables them to be more easily integrated with existing stormwater infrastructure; and
- Are most cost effective when implemented through the study area as part of infrastructure upgrade works (i.e. road widening/resurfacing, park and urban renewal projects).



Figure 7-2 Other Examples of Streetscape Raingarden Retrofits

A number of opportunities to retrofit WSUD measures throughout the study area were identified using the methodology outlined above. Figure 7-4 shows the locations of those opportunities that were deemed viable, however it is noted that further investigations will be required to confirm these opportunities. A summary of these viable opportunities is also provided in Appendix C.

It is noted that due to the small and distributed nature of such systems, many more opportunities are likely to exist throughout the study area, but were not identified due to project time and budget constraints. It is recommended that further assessment be undertaken for opportunities in conjunction with any proposed future infrastructure upgrade / flood mitigation / park / urban renewal works or as budget becomes available to undertaken such works. Opportunities that were investigated but deemed not viable are also summarised in Appendix C.

Furthermore, during the site visit, a notable opportunity was viewed to widen and revegetate the Milperra Drain running through Bankstown Golf Club, Milperra (refer to Figure 7-3 and Site 9 and 10 shown in Appendix B). Council has already committed funding to the investigation and detailed design of this action. This action has therefore been included as an action in the Mid-Georges River CAP.



Figure 7-3 Milperra Drain, Planned Widening and Revegetation Works

From the list of new viable opportunities identified in Figure 7-4 & Table C-1 a screening process together with Council consultation was undertaken to identify preferred options for prioritising as future short term management actions. The screening process considered the following factors:

- Environmental: Provides a good opportunity to improve water quality (a key community desire) in a target sub-catchment and increase ecological values;

- Financial: Predicted cost effectiveness, including opportunities to integrate with other future planned works, particularly where systems could help provide multiple benefits (e.g. with future planned flood mitigation works), or where opportunity exists for joint funding; and
- Social: High visibility projects providing educational benefits and improving amenity (a key community desire).

From the screening, the following sites listed in Table 7-1 were identified for more detailed assessment.

A further description of each opportunity and preliminary designs are provided in the following section. A typical cross section showing the general arrangement of proposed bioretention systems / raingardens considered in this study is shown in Figure 7-5.

Table 7-1 Summary of Preferred Options for Retrofit of Green Infrastructure

Opportunity ID	Sub-Catchment	Type of Treatment	Key Opportunity/Constraint Notes[1]
Park Road	East Hills	Raingarden	• Convert existing landscaped area • High visibility site close to town centre and train station • Target 'pollutant hotspot' sub-catchment • PASS Class 5 (low risk) • May be rail land
Montgomery Reserve Creek Filtration	Little Salt Pan Creek	3 x Vegetated Swales	• Daylight pipes and treat via vegetated swales prior to discharge to creek • High priority sub-catchment for WSUD retrofit and water quality treatment • Cost effective to integrate as part of larger future residential development around bowling club • OEH / developer funding opportunities • Good educational opportunity • Crossing required for one swale
Revesby Preschool	Little Salt Pan Creek	Bioretention Basin	• Council proposes to resume this land as park to manage flood risk • Large area available for water quality treatment • Flow velocities <0.5m/s • High priority sub-catchment for WSUD retrofit and water quality treatment • High visibility site near Revesby Town Centre • Avoid sewerage and stormwater pipes
Deverall Park	Milperra	Bioretention Basin	• Possible funding available for investigation in conjunction with airport (located on airport land) • High visibility site adjacent to Deverall Park (netball courts) • Targets 'pollutant hotspot' sub-catchment

Opportunity ID	Sub-Catchment	Type of Treatment	Key Opportunity/Constraint Notes[1]
			• Large area available for water quality treatment • Opportunity to enhance Endangered Ecological Communities (footprint to be on cleared area, avoid disturbing EEC)
Grace Avenue, Condell Park	Milperra	Bioretention Basin	• Opportunity to integrate with flood detention works • Park and high visibility site • Measure would be implemented as part of any future Council upgrades to the park • Targets 'pollutant hotspot' sub-catchment • Avoid sewerage and stormwater pipes
Surrey Reserve	Milperra	Bioretention Basin	• Opportunity to integrate with flood detention works • Park and high visibility site • Measure would be implemented as part of any future Council upgrades to the park • Targets 'pollutant hotspot' sub-catchment • Avoid sewerage and stormwater pipes • Avoid disturbance of significant remnant trees

[1]Note that Dial Before You Dig (DBYD) investigations area required to ascertain the location of all services



Figure 7-4 Green Infrastructure Opportunities

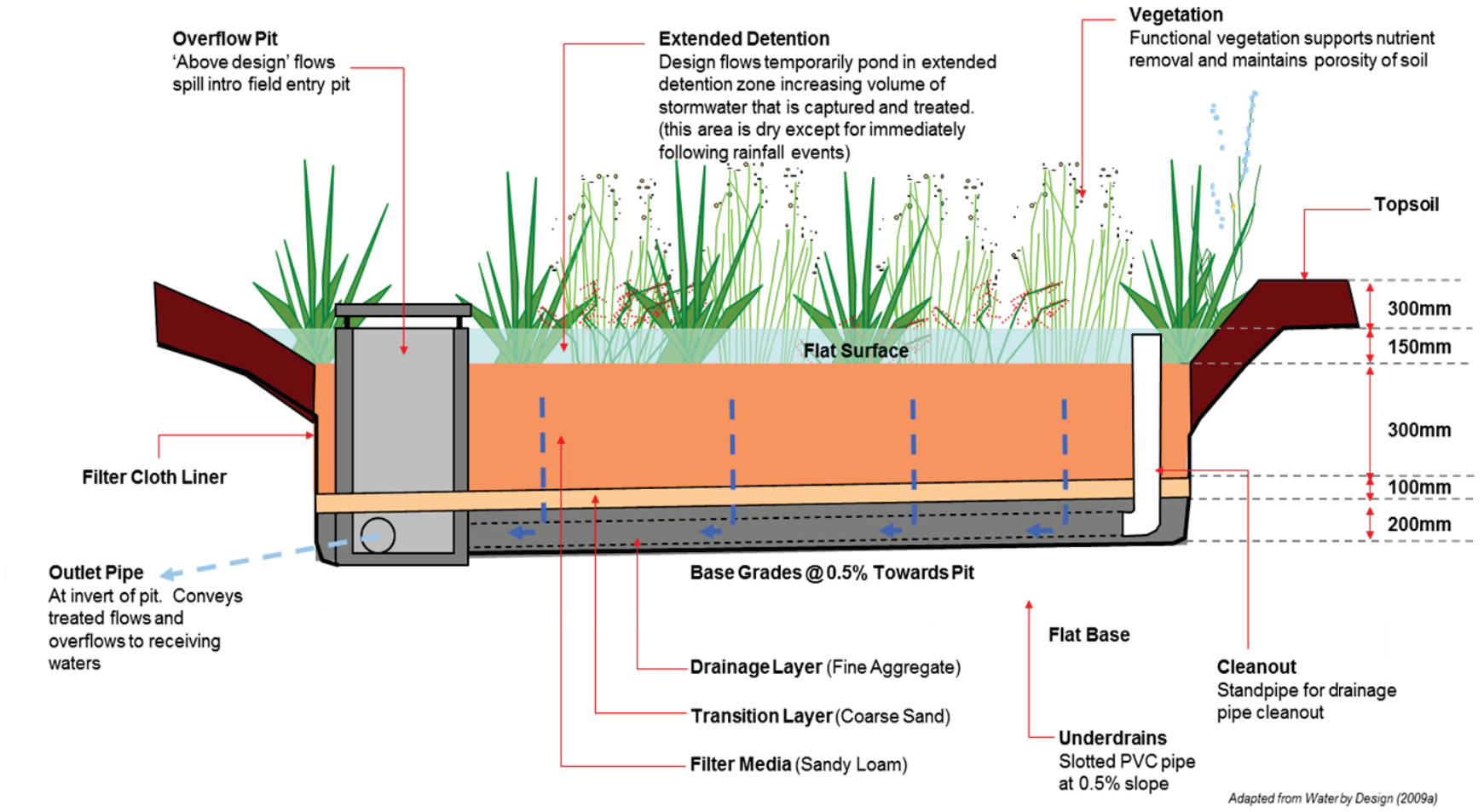


Figure 7-5 Cross Section Detail of a Typical Raingarden / Bioretention Basin

7.1.1.1 Park Road

A concept design showing the location of the raingarden along Park Road, East Hills is shown in Figure 7-6.

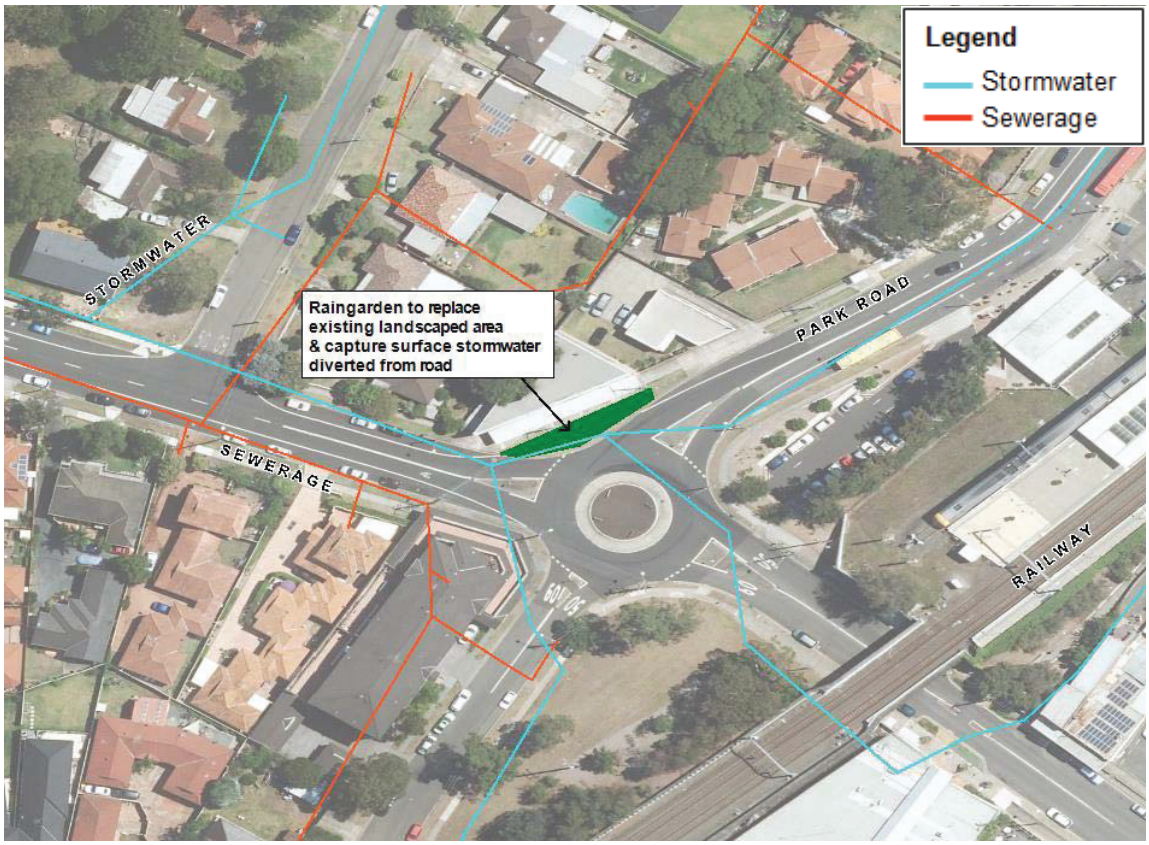


Figure 7-6 Park Road Raingarden, East Hills

The Park Road raingarden is proposed to replace an existing landscaped area in the road reserve. Stormwater draining to the road from the upstream catchment would be diverted into the raingarden for treatment via overland kerb and channel flows. An existing stormwater side entry pit is located adjacent to the raingarden, which could be incorporated into the design to accept overflows (rather than construct an overflow pit). Council road engineers would need to be further consulted in the design of this system.

An advantage of the streetscape raingarden over conventional landscaping is that they are passively irrigated by stormwater inflows.

Key opportunities identified for this option include:

- Existing landscaped area can be converted without any additional land take;
- Landscaping in raingarden doesn't require watering once established;
- High visibility site close to town centre and train station provides good educational opportunity (e.g. through interpretive signage);
- Located in a sub-catchment identified to be a 'pollutant hotspot' (East Hills); and

- Use of existing stormwater inlet may reduce construction costs (for new pit and pipe).

Key constraints identified for this option include:

- Class 5 Potential Acid Sulfate Soils. The elevation of this site is approximately 7.3 m AHD, so the risk of encountering ASS is low, however testing would be required prior to works commencing; and
- Land ownership. Council has indicated that this may be rail land, therefore consultation with RMS may be required. However opportunity exists for the project to be jointly funded if it is located on RMS land.

7.1.1.2 *Montgomery Reserve Creek Filtration*

A concept design showing the location of the Montgomery Reserve Creek Filtration opportunity in Revesby is shown in Figure 7-7.

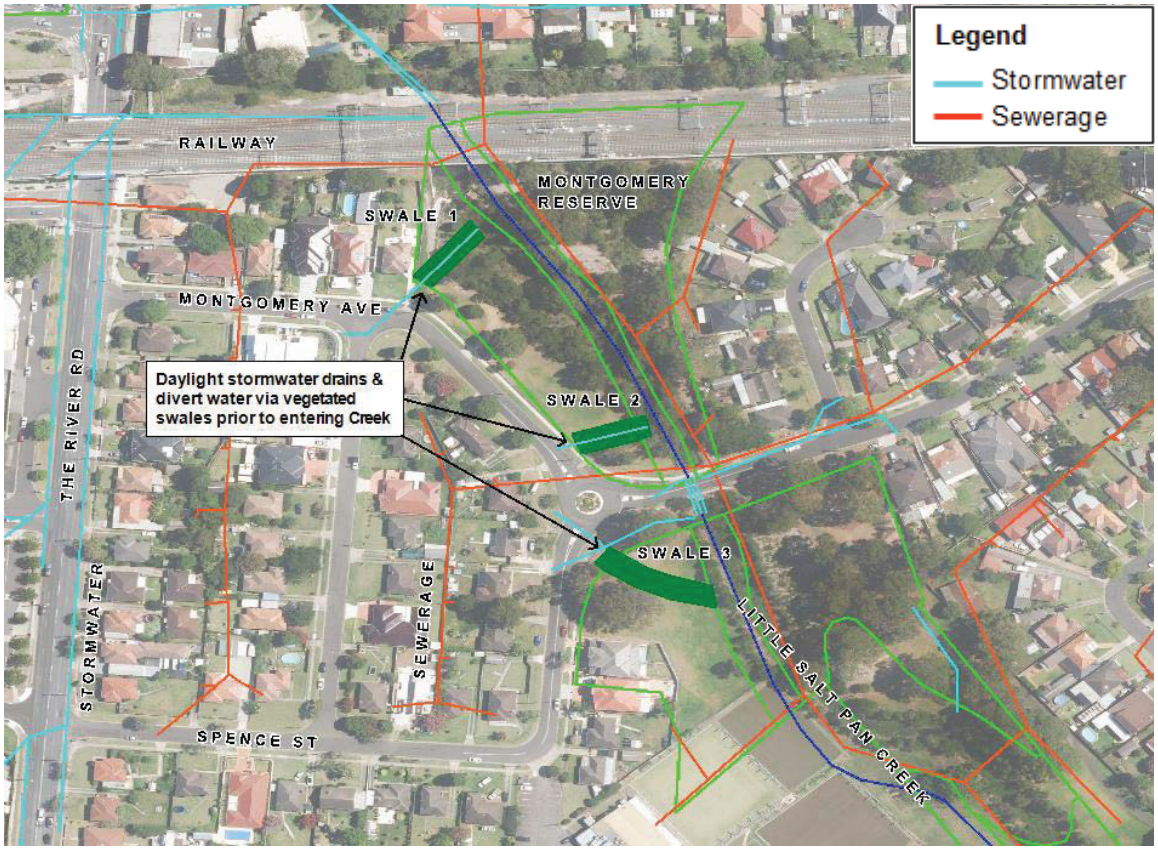


Figure 7-7 Montgomery Reserve Creek Filtration

The Montgomery Reserve Creek Filtration opportunity involves daylighting three 375mm stormwater pipes located within Montgomery Reserve and constructing vegetated swales downstream of each pipe to treat and convey stormwater to Little Salt Pan Creek. To ensure access to the GPT located in the reserve is not restricted, a crossing would likely need to be constructed across Swale 1. The Revesby Bowling club located downstream of Swale 3 along the Creek corridor is zoned residential and is likely to be developed in the short to medium term. Therefore this opportunity should be

scheduled to be undertaken as part of larger development works and consolidation of Council land along the creek.

Key opportunities identified for this option include:

- Identified as a high priority sub-catchment (Little Salt Pan Creek) for WSUD retrofit and water quality treatment in the Georges River Estuary Coastal Zone Management Plan (CZMP). This was also a high priority action for the CZMP;
- Good potential to obtain funding from the Office of Environment and Heritage (OEH) under the Estuary Management Program due to being in a priority catchment in CZMP;
- Integrating as part of the larger future residential development around the bowling club and consolidation of Council land is likely to reduce construction costs. Potential to also receive developer funding;
- High visibility site and space to provide interpretive signage / artwork for community education; and
- Located along core biodiversity corridor, with opportunity to enhance.

Key constraints identified for this option include:

- Crossing is likely required for Swale 1 to ensure maintenance access in Montgomery reserve; and
- Timing of works dependent on future development.

7.1.1.3 KU Revesby Preschool

The preschool site is located along a high hazard overland flow path and as such it has been recommended in the Mid-Georges River FRMS&P that the site be rezoned for a flood compatible use. This could entail the creation of community open space.

Creation of open space at the site presents an opportunity to construct a bioretention basin to treat overland flows to the site prior to discharge to Little Salt Pan Creek. Two potential areas have been identified in Figure 7-8 bedow, each of similar area. Treated water from the basin in the west may be discharged to the existing stormwater pipe, while treated water from the basin in the east may be discharged directly to the creek. The suitability of each option would need to be further assessed in consultation with Council and through detailed design investigations.

Key opportunities identified for this option include:

- Council proposes to resume this land as park to manage flood risk;
- Large area available for water quality treatment;
- Overland flow velocities <0.5m/s are suitable for bioretention basin;
- High priority sub-catchment for WSUD retrofit and water quality treatment in the Georges River Estuary CZMP (Little Salt Pan Creek). This was also a high priority action for the CZMP;
- Good potential to obtain funding from the Office of Environment and Heritage (OEH) under the Estuary Management Program due to being in a priority catchment in CZMP;

- High visibility site near Revesby Town Centre and space to provide interpretive signage / artwork for community education; and
- Located along core biodiversity corridor, with opportunity to enhance.

Key constraints identified for this option include:

- Design needs to avoid existing sewerage and stormwater pipes;
- Design should ensure it can be successfully integrated with flooding constraints; and
- Existing trees on site to be avoided where possible.

A concept design showing the potential locations to site a bioretention basin at KU Revesby Preschool, Revesby is shown below in Figure 7-8. Given issues with gross pollutants in this catchment and the need to protect the bioretention basin, it is recommended that consideration be given to incorporating a major GPT upstream of the basin. Supply and installation of a GPT could cost in the order of $300,000.

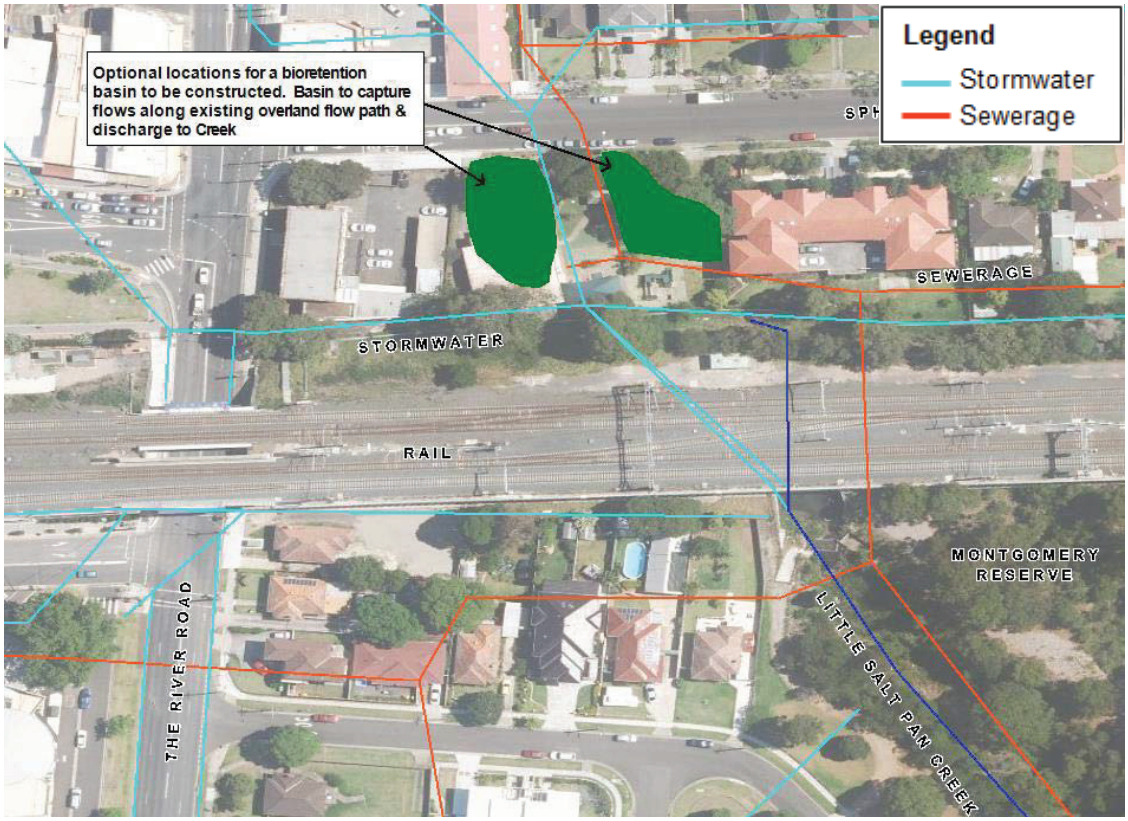


Figure 7-8 KU Revesby Preschool, Revesby, Bioretention Basin

7.1.1.4 Deverall Park

A concept design showing the location of the bioretention basin located on airport land adjacent to the Deverall Park netball courts in Condell Park is shown in Figure 7-9. Stormwater from the upstream catchment is currently discharged into two open channels that merge into one approximately 130 m downstream. The stormwater pipe sizes are 750 mmm (western pipe) and 1200 mm (eastern pipe). Due to the depth of the pipe invert levels and natural topography upstream,

daylighting the pipes within Deverall Park (i.e. on Council land) would not be possible / practical, therefore the location of the basins have been located immediately downstream on airport land.

Due to a sewerage pipe traversing the site, it is proposed that two basins be built to avoid crossing the sewer. One basin would treat design flows from the eastern stormwater pipe, and the other basin would treat design flows from the western stormwater pipe. As the systems are not on line, high flows would be bypassed through the existing drainage channel. It is noted that due to the large size of each basin, they would need to be split into a number of cells. Treated water would then be discharged into the existing channel downstream or infiltrate soils, depending on soil conditions (the presence of ASS may restrict the viability of this option).

The site is located within a core biodiversity corridor and contains endangered ecological communities (EEC). However the location of the basins are in an area that looks to have been cleared of vegetation (from aerial imagery). Opportunity exists to regenerate EECs as part of the project.

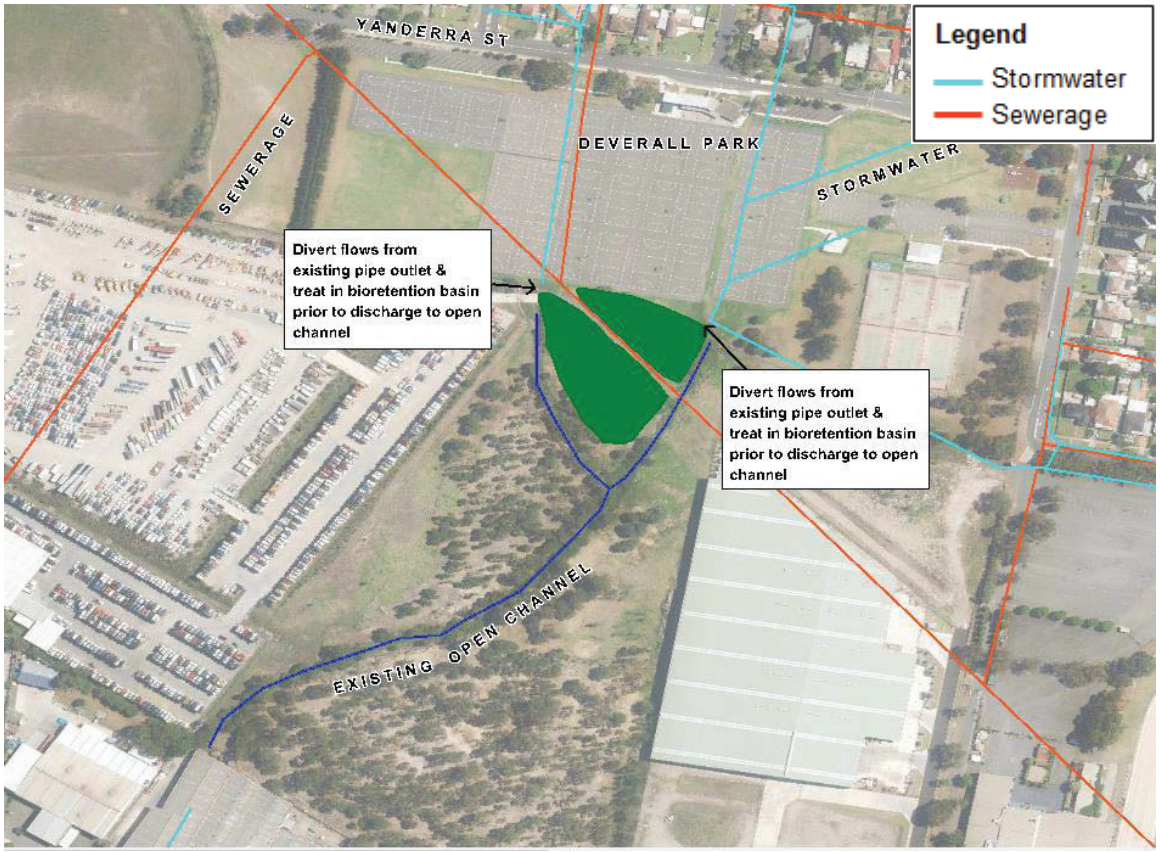


Figure 7-9 Deverall Park, Condell Park, Bioretention Basin

Key opportunities identified for this option include:

- High visibility site adjacent to Deverall Park (and netball courts), with opportunity to provide interpretive signage within the parkland (overlooking the bioretention basins);
- Targets a 'pollutant hotspot' sub-catchment (Milperra);
- Large area available for water quality treatment;

- Located along core biodiversity corridor, with opportunity to enhance EEC; and
- Could involve / further educate the community through a bioretention planting day.

Key constraints identified for this option include:

- Bioretention basins are located on airport land;
- Design needs to avoid existing sewerage pipes;
- Design should avoid disturbing EEC; and
- Class 5 Potential Acid Sulfate Soils. The elevation of this site is approximately 13 m AHD (IL of pipe outlets), so the risk of encountering ASS is low, however testing would be required prior to works commencing.

7.1.1.5 *Grace Avenue, Condell Park*

A concept design showing the location of the proposed bioretention basin located within parkland along Grace Avenue, Condell Park is shown in Figure 7-10.



Figure 7-10 Grace Avenue, Condell Park, Bioretention Basin

A diversion embankment within the park alongside Grace Avenue, Condell Park has been proposed as a risk management measures in the FRMS&P for Sub-catchments of the Mid-Georges River as part of future park upgrades. As part of the proposed flood risk management measure, there are opportunities to incorporate a bioretention basin into the design to achieve multiple outcomes (flooding and water quality). The basin would likely receive overland flows only, although water may also be diverted from the road (via a swale or cutoff drain). It is unlikely that stormwater would be

diverted from the existing stormwater pipe due to the depth of the invert level beneath the ground surface (approx. IL at 23.6 m AHD, ground level 25.75 m AHD). Further design investigations will be required to ensure the suitable integration of the bioretention basin with the flood detention basin.

Key opportunities identified for this option include:

- Opportunity to integrate with flood detention works, providing multiple benefits;
- Measure would be implemented as part of any future Council upgrades to the park, reducing construction costs;
- Targets a 'pollutant hotspot' sub-catchment (Milperra);
- Park provides ample space to construct a small basin;
- High visibility site near playground with space to provide interpretive signage / artwork for community education;and
- Could involve / further educate the community through a bio-retention planting day.

Key constraints identified for this option include:

- Design to avoid existing sewerage and stormwater pipes; and
- Design to be integrated with flood detention basin.

7.1.1.6 Surrey Reserve

A concept design showing the location of the proposed bioretention basin located within Surrey Reserve, Georges Hall is shown in Figure 7-11.



Figure 7-11 Surrey Reserve, Georges Hall, Bioretention Basin

Increases to the existing detention storage within Surrey Reserve, Georges Hall, has been proposed as a risk management measures in the FRMS&P for Sub-catchments of the Mid-Georges River as part of future park upgrades. It is proposed that a bioretention basin could be incorporated into the design to achieve multiple outcomes (flooding and water quality) and reduce construction costs. The basin would receive overland flows and may also receive runoff be diverted from the road. The location of the basin has been sited to avoid key existing sewerage and stormwater infrastructure, while also avoiding the disturbance of significant remnant trees on site. Further design investigations will be required to ensure the suitable integration of the bioretention basin with the flood detention basin.

Key opportunities identified for this option include:

- Opportunity to integrate with flood detention works, providing multiple benefits;
- Measure would be implemented as part of any future Council upgrades to the park, reducing construction costs;
- Targets a 'pollutant hotspot' sub-catchment (Milperra);
- Park provides ample space to construct a small basin;
- High visibility site near playground with space to provide interpretive signage / artwork for community education;
- Could involve / further educate the community through a bio-retention planting day; and
- Located along core biodiversity corridor, with opportunity to enhance.

Key constraints identified for this option include:

- Design to avoid disturbance of significant remnant trees;
- Design to avoid existing sewerage and stormwater pipes; and
- Design to be integrated with flood detention basin.

7.1.2 Gross Pollutant Traps

Locations for new gross pollutant traps (GPTs) were identified through review of concurrent study results from a GPT audit undertaken by Optimal Stormwater (2014). The GPT audit reviewed the effectiveness and condition of existing GPTs throughout the study area, and identified opportunities for new GPTs to be located or where GPTs needed rectification / maintenance works.

In instances that new GPTs were proposed, comment was received from Council on the recommendations. New GPTs were then assessed and prioritised as future management measures where appropriate.

Table 7-2 summarises the details of the proposed future GPTs assessed as additional management actions for WSUD retrofit in the study area. The location of each GPT is shown in Figure 7-12.

Table 7-2 Details of Proposed GPTs

GPT ID	Sub-Catchment	Location	Treated Catchment Area	Notes
PCD 4 / SWC 18556	Picnic Point	Amberdale Reserve (Amberdale Avenue, Picnic Point)	52.45 ha	Study recommends following: • Decommission existing GPT • Install P1009 CDS unit on flow down Ambervale • Install P2018 CDS unit on the flow through the park
PCD 5/ SWC 18557	Lucas Road	41 Lucas Road, East Hills	54.75 ha	Study recommends: • Removal of the trashracks at PCD18558, PCD18558 and the downstream boom PCD18543 • Installing a single GPT or trashrack Council recommends locating upstream of tidal impacts and not in riverside park. Possible location in park on Duke St.
PCD 8 / SWC 18559	Little Salt Pan Creek	1 Neptune Street, Revesby	9.10 ha	Study recommends following new GPT: • P1012 CDS unit or VC80 VortCapture
PCD 9 / SWC 18560	Little Salt Pan Creek	Virginius Reserve (Virginius Street, Padstow)	29.96 ha	Study recommends following new GPTs: • Boom to capture litter on LSPC • New GPT in Lang St instead
PCD 12 / SWC 18563	Kelso Swamp	167 Horsley Road, Panania	35.90 ha	Study recommends: • Maintenance /service only
PCD 17 / SWC - 18568	Milperra	Newland Reserve (Newland Avenue, Milperra)	2.90 ha	Study recommends following GPT: • P0708maxi CDS unit located back behind the headwall could provide greatly enhanced treatment
PCD 19 / SWC 18570	Milperra	21 Daisy Street, Revesby	39.9 ha	Study recommends: • A correctly sized GPT with significant pollutant storage be investigated upstream between 6 and 8 Queen Street



Figure 7-12 Location of Proposed GPTs within the Mid-Georges River Study Area

7.3 Riparian Revegetation / Regeneration

In order to assist in the protection and enhancement of waterways and their aquatic and riparian habitat, it is recommended that riparian revegetation or assisted regeneration works be progressively undertaken throughout the study area.

As previously discussed (refer to Section 4.1.3 for further detail), the former Sydney Metro Catchment Management Authority (SMCMA), now known as Greater Sydney Local Land Services (LLS) conducted a study in 2007 to assess waterway health and prioritise management activities to protect and rehabilitate Sydney's waterways and waterway biodiversity corridors. Based on the findings of this study, the following management options were recommended for waterways in the Mid-Georges River study area:

- **Assisted Regeneration:** This option was recommended where it was identified that the site has good waterway structure and stability, with little potential for significant future erosion and good to moderate vegetation (some weed invasion). The primary focus for work is the implementation of a bush regeneration program.
- **Revegetation**: This option was recommended where it was identified that the site has sub-optimal buffer widths. The creek may be experiencing some erosion and the riparian vegetation is not creating a significant corridor for fauna passage or aquatic habitat.

It is recommended that the results of these management options be included in the Mid-Georges River CAP to assist in the aim of protecting, enhancing and restoring aquatic and riparian habitat. These actions are thought to be consistent with the following existing actions and have subsequently been included as subtasks of these actions:

- **Action MB-8**: Utilise the Riverkeeper Program rubbish removal and bush regeneration teams to provide rubbish removal, weed control, bush regeneration and ongoing site maintenance to complement and support NPWS and council activities
- **Action MB-4:** Identify locations for and undertake targeted rehabilitation, creation and enhancement of estuarine wetland communities and adjacent riparian vegetation.

Recommended assisted regeneration of waterways has been included in Action MB-8 of the Mid-Georges River CAP.

Recommended revegetation of waterways has been included under Action MB-4 of the Mid-Georges River CAP. In the CZMP, this action previously focussed on estuarine environments, however in the CAP this action has been broadened to consider freshwater habitats.

The locations for waterway revegetation and assisted regeneration are shown in Figure 7-15. This figure also provides an indication of whether the in stream habitat is freshwater or estuarine, based on tidal limits documented by MHL (2006).

The Georges River CZMP also identifies removal of Yeramba Lagoon weir (refer to Figure 7-13) as a high priority action to restore estuarine flows and improve aquatic and riparian habitat (within action MB-4). Currently, the weir restricts estuarine flows upstream and results in pooling of stagnant, nutrient enriched water upstream in the lagoon, contributing to weed infestations of Salvina. Salvinia is a weed of National Significance and is regarded as a serious threat to waterways. Restoration of

estuarine flows through removal of the weir may assist to reduce weed infestation and help restore natural habitat, while also removing a waterway barrier to fish passage. It is noted that past management practices have pumped estuarine waters into the lagoon, and a pumping station was seen on site. This action needs to be investigated further and undertaken in cooperation with NPWS and DPI Fisheries.



Figure 7-13 Yeramba Lagoon Weir



Figure 7-14 Salvina Weed Infestation in Yeramba Lagoon



Figure 7-15 Riparian Revegetation and Assisted Regeneration (Adapted from SMCMA 2006)

7.4 Water Sensitive Urban Design for Future Development

As discussed previously in Section 2 and 6, a key management action (Action MA-2) recommended by the Georges River Estuary CZMP and the Botany Bay WQIP is the incorporation of pollutant load reduction targets in Council planning controls (such as DCPs and the LEP) to ensure WSUD is applied where practicable to all future infill and greenfield developments.

To identify the extent of this management action, future development areas in the study area were identified to include the following:

- Infill development as shown by the Bankstown LAPs for:
  - The River Road Area.
  - Revesby Village Centre.
  - Panania Small Village Centre.
  - East Hills Neighbourhood.
- Bankstown Airport commercial development; and
- Riverlands Golf Course greenfield development.

Further detail about the above future development can be viewed in Section 5 and Figure 5-1. For the purposes of assessing future implications of these developments, it was assumed that all development was fully implemented.

To assess the implications of this management measure on future development, it was assumed that all future rezoned development within the LAPs that was previously zoned residential would meet the recommended target objectives applied for multi-unit dwellings, commercial, industrial and small redevelopments (refer to Section 2.2 and Table 3-2). These objectives were applied in MUSIC by simply reducing the pollutant loads accordingly.

To assist Council in interrogating the implications of targets applicable to the Airport (commercial targets) and Riverlands Golf Course (greenfield targets) in more detail, MUSIC modelling was undertaken to assess the potential land area required to meet proposed pollutant load reduction targets (refer to Section 8.1). Further details on the modelling methodology used are provided in Appendix A.

8. Assessment and Prioritisation of Management Actions



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8 Performance and Prioritisation of Management Actions

8.1 Performance of Management Actions

Where possible, the performance of future proposed management actions in improving water quality was assessed using e-water MUSIC modelling software (refer to Appendix A).

The following management actions were assessed using MUSIC in a future 'mitigated' scenario:

- MA2: Implementation of best practice load reduction targets to future development in the study area (redevelopment and greenfield)
- MA3: WSUD retrofit opportunities identified in this investigation, including all potential locations identified for green infrastructure and proposed new GPTs.

A summary of the predicted treatment performance of these management actions on total study area pollution loads is shown in Table 8-1 and Figure 8-1.

Table 8-1 Predicted Treatment Performance of Management Actions on Catchment Loads

Pollutant	Existing Scenario (kg/yr)	Future Unmitigated Scenario (kg/yr)	Future Mitigated Scenario (kg/yr)	Study Area Load Reduction (kg/yr)	Study Area Load Reduction (%)
TSS	1,698,932	1,903,072	1,388,800	514,272	27.0%
TP	3,045	3,374	2,748	626	18.5%
TN	23,004	25,541	22,230	3,311	13.0%
GP	283,715	305,753	223,550	82,203	26.9%

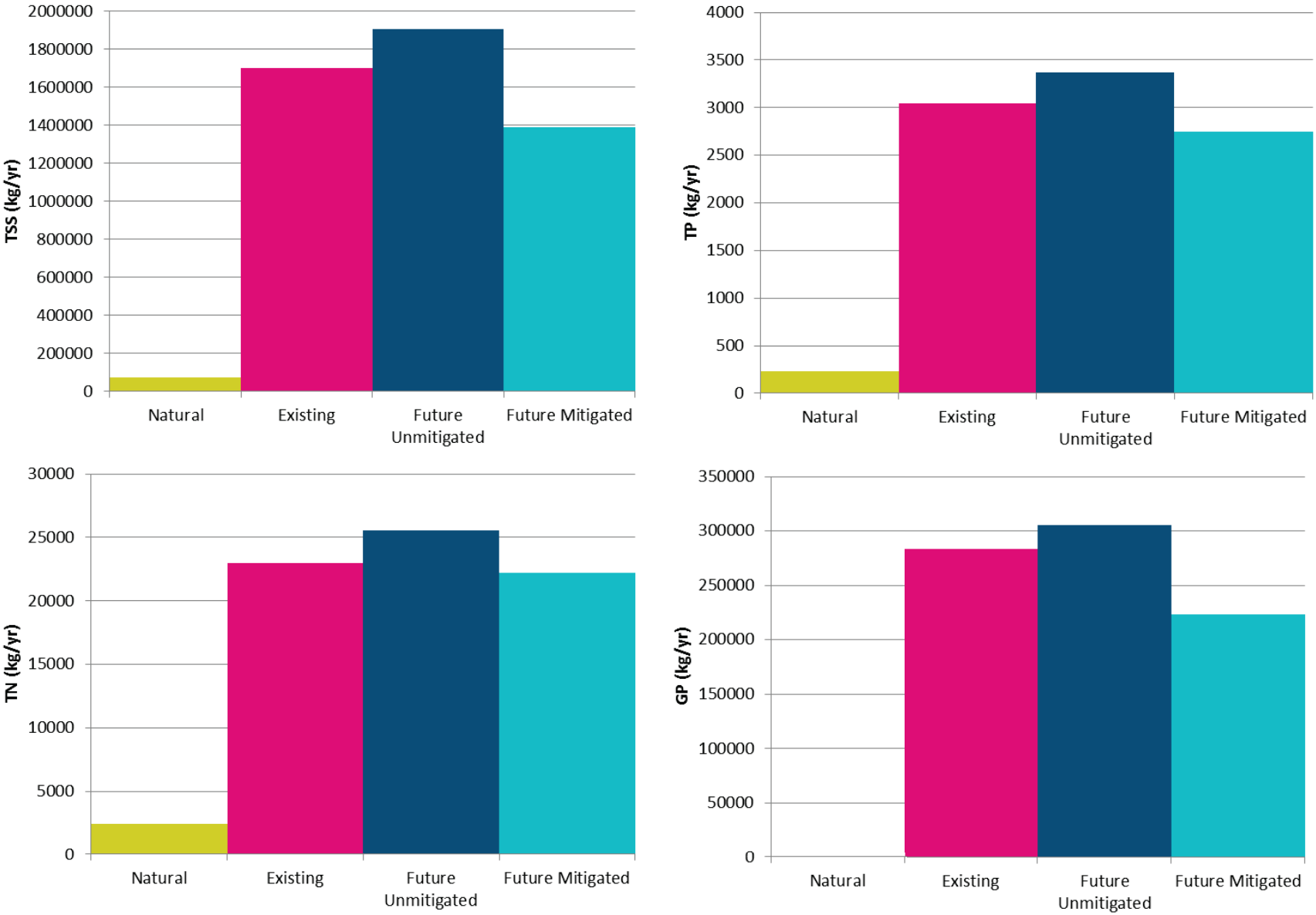


Figure 8-1 Predicted Study Area Loads and Treatment Performance of Management Actions

BMT WBM

Figure 8-1 shows that by implementing these management actions, a significant reduction in study area pollutant loads can be achieved, with predicted loads less than the existing scenario pollutant loads. As a result, this is likely to result in improvements to the existing state of receiving water quality and waterway health. The relative contribution of each management action (i.e. MA2 and MA3) in achieving these results is also presented in Figure 8-2.

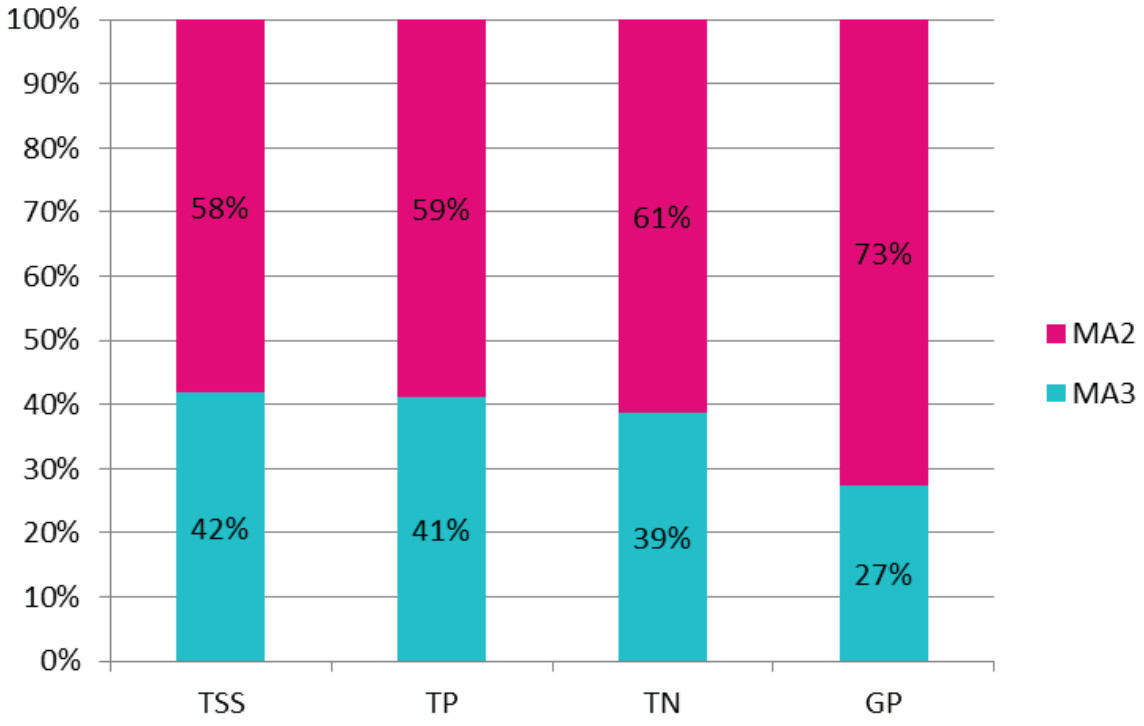


Figure 8-2 Contribution of Management Actions to Predicted Future Load Reductions

Figure 8-2 shows that a large proportion of the predicted treatment is achieved due to Action MA2, ensuring that best practice load reduction targets are applied to all future development / redevelopment in the study area. For modelling purposes, it was assumed that all future planned redevelopment in the study area was undertaken within the planning period (2050).

It is important to note that while the study identifies the largest potential reduction in study area pollutants loads from applying water quality controls on future development, the time it takes to see these benefits will depend on the redevelopment rate in the study area. Hence an effective strategy for improving water quality in the study area would be to focus on targeting WSUD retrofit throughout the study area in the interim and as opportunity arises such as in conjunction with other infrastructure upgrade works (i.e. road widening/ resurfacing, park and urban renewal projects, flood mitigation projects).

As outlined in Section 7.4, MUSIC modelling was also undertaken to assess the potential land area required to meet proposed best practice pollutant load reduction targets for future ultimate development of Bankstown Airport and Riverlands Golf Course.

Assuming bioretention systems are used to meet proposed pollutant load reduction targets (refer to Table 3-2), it was determined that the land take (for the bioretention filter area) would be

approximately 1% of the total development area. This is considered to be a small impost to development that could easily be integrated on both these development sites. Furthermore, it is noted that Total Suspended Solids is the pollutant governing the size of the treatment areas required.

8.2 Prioritisation of Management Actions

As outlined in Section 6, existing management actions and priorities contained in the CZMP were reviewed and used as a basis for developing a prioritised CAP for the Mid-Georges River study area.

Additional management actions identified for the Mid-Georges River CAP were firstly prioritised based on the priority of the action's management aim and objectives, which were established from detailed investigations undertaken in the CZMP.

As part of developing the Mid-Georges River CAP, a key component was to identify additional WSUD management measures to implement throughout the study area. WSUD retrofit was identified as a high priority action to improve waterway health in the Mid-Georges River study area and receiving Georges River Estuary.

A number of WSUD retrofit opportunities were identified for green infrastructure (bioretention systems and swales) and GPTs. As discussed in Section 7.1, a screening process together with Council consultation was undertaken to identify preferred WSUD retrofit options for prioritising as future short term management actions to be included in the Mid-Georges River CAP.

An assessment framework was then used to assist in the prioritisation of these management actions that considered the environmental, ecological, financial and social performance of the option. Criteria used in the assessment framework are shown in Table 8-2. A weighting was assigned to each criteria category and individual criteria to assess the performance of each action. The adopted catchment vision and performance indicators for The Bankstown Community Plan's "Green" theme were considered in the development of criteria.

Opportunities were quantitatively assessed against the criteria using MUSIC modelling results, GIS information and levelised treatment costs. Levelised treatment costs were calculated as the ratio of the Net Present Value (NPV) of the projected capital and operating costs of an option, to the projected annual pollutant load treated by the option. NPV was calculated to be the total cost incurred over the planning period (until 2050) for establishment (i.e. capital) and during the operational phase (i.e. maintenance), discounted to provide the cost in today's dollars ($2015). Capital and operating costs were derived from information sourced from Melbourne Water (2013), and a discount rate of 7% was assumed.

A qualitative assessment of social benefits was made for each solution. Scores for each criteria were then normalised using the minimum – maximum approach and weighted scores were calculated using the assigned criteria and category weightings shown in Table 8-2. Overall scores were then compared and opportunities were prioritised based on this score. The final scores and prioritisation of WSUD retrofit options are summarised in Table 8-3. Performance results are included in more detail in Appendix D.

Table 8-2 Assessment Framework Criteria and Weightings

Criteria Category & Weighting	Criteria	Criteria Weighting
Environmental 25%	Reduction of Total Suspended Solids to waterways (kg/yr)	25%
	Reduction of Total Nitrogen to waterways (kg/yr)	25%
	Reduction of Total Phosphorus to waterways (kg/yr)	25%
	Reduction of Gross Pollutants to waterways (kg/yr)	25%
	Total Environmental Criteria Weighting	*100%*
Ecological 15%	Potential to enhance habitat values (m^2 vegetation)	50%
	Potential to enhance habitat values within a Biodiversity Corridor / EEC (m^2 vegetation)	50%
	Total Ecological Criteria Weighting	*100%*
Financial 30%	Levelised TSS Treatment Cost ($/kg/yr)	25%
	Levelised TN Treatment Cost ($/kg/yr)	25%
	Levelised TP Treatment Cost ($/kg/yr)	25%
	Levelised GP Treatment Cost ($/kg/yr)	25%
	Total Financial Criteria Weighting	*100%*
Social 30%	Potential to improve public amenity / recreational values	50%
	Potential to provide environmental education and enhance community understanding, engagement and ownership	50%
	Total Social Criteria Weighting	*100%*

Table 8-3 Prioritised Options Using the Assessment Framework

Option	Score[1]
Deverall Park Bioretention Basin	77.2
Revesby Preschool Bioretention Basin	63.8
Grace Avenue Bioretention Basin	57.4
Surrey Reserve Bioretention Basin	54.2
PCD 5 - Lucas Road 1 (upstream)	38.1
PCD 4 - Amberdale Avenue (Amberdale Reserve)	38.0
PCD 19 - Daisy Street	37.7
PCD 9 - Virginius Street (Virginius Reserve)	32.1
Montgomery Reserve Creek Filtration	29.8
Park Road Raingarden	25.0
PCD 8 - Neptune Street	20.8
PCD 17 - Newland Reserve	9.2

[1] Highest score indicates highest priority

The Results in Table 8-3 show that the proposed bioretention basin at Deverall Park is the highest scoring and hence highest priority option to further investigate / construct. The prioritisation of options in Table 8-3 have been adopted for inclusion in the Mid-Georges River CAP.

9. Catchment Action Plan



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9 Catchment Action Plan

The aims and management options formulated by the Georges River CZMP form an integral component for management of the Mid-Georges River study area.

As such, the aims and management options have been adopted as the basis for development of this CAP. Recommendations included in the development of the Mid-Georges River CAP have however, been reviewed and screened to remove the following:

- Those actions that relate mostly to coastal management (rather than catchment management).
- Those actions that are not relevant to the Mid-Georges River study area.

In developing the Mid-Georges River CAP, a number of additional actions were also identified to assist to achieve the aims and objectives of the CZMP and the Mid-Georges River CAP. These additional actions have been integrated into the existing aims and best management options adopted from the CZMP. Catchment modelling and costing of treatment options undertaken as part of this study were used to assist in prioritising additional WSUD retrofit options identified throughout the study area.

The resulting CAP for the Mid-Georges River is provided in Table 9-1, providing a list of prioritised actions for catchment management.

Table 9-1 Mid Georges River Catchment Action Plan

Aim	Action	Action Description	Action Subtask		Catchment	Capital Cost	Operational Cost	Potential Funding	Primary Responsibility (Bankstown Council)	Supporting Implementation
Water Quality	MA-2	Councils to incorporate WSUD principles in developments of urban areas, including public and private development, through updating of existing and preparation of new DCPs.	MA-2.1	The Existing WSUD DCP and LEP (for statutory authority) needs to be implemented with WSUD guidelines to facilitate meeting water quality targets for BBWQIP and applied to Council works.	All	Staff time			Strategic Planning and Development Controls	GRCCC DP&E LLS
			MA-2.2	Inclusion of WSUD Principles in other Council policies and plans.	All	Staff time				
			MA-2.3	To assist with Task 2.2, development of a Vision and Objectives for Catchment Management. This should be done via community consultation sessions.	All	Staff time Consultant $20K		Stormwater Levy GS LLS Grants		
Water Quality	MA-3	Retrofit appropriate new WSUD devices in existing urban areas including measures such as artificial wetlands, vegetated swales and channel naturalisation.	MA-3.1	Milperra Creek Widening and Revegetation Works. Undertake detailed design investigations to widen and revegetate the Milperra Drain adjacent to the Bankstown Golf Course.	Milperra	Funding already committed to investigation $240,000			Engineering Works and Asset Management	GRCCC OEH LLS
			MA-3.2	Deverall Park Bioretention Basin: Undertake detailed design investigations to construct a bioretention basin on airport land immediately downstream of Deverall Park, Condell Park. This will require consultation with Bankstown Airport.	Milperra	$1,000,000	$70,400 / yr establishment $20,000 / yr ongoing	•Stormwater Levy • OEH Estuary Management Grant • GS LLS Grants • Bankstown Airport		
			MA-3.3	Revesby Preschool Bioretention Basin: Undertake detailed design investigations to construct a bioretention basin on Council resumed parkland at Revesby Preschool.	Little Salt Pan Creek	$120,000	$6,000 / yr establishment $1,700 / yr ongoing	• OEH Estuary Management Grant • Stormwater Levy • GS LLS Grants		
			MA-3.4	Grace Avenue Bioretention Basin: Undertake detailed design investigations to construct a bioretention basin in parkland along Grace Avenue, Condell Park. Design to be integrated with proposed flood detention works and future park upgrades.	Milperra	$173,000	$9,100 / yr establishment $2,600 / yr ongoing	• OEH Estuary Management Grant • Stormwater Levy • GS LLS Grants		
			MA-3.5	Surrey Reserve Bioretention Basin: Undertake detailed design investigations to construct a bioretention basin in Surrey Reserve, Georges Hall. Design to be integrated with proposed flood detention works and future park upgrades.	Milperra	$113,000	$6,000 / yr establishment $1,700 / yr ongoing	• OEH Estuary Management Grant • Stormwater Levy • GS LLS Grants		
			MA-3.6	PCD 5 (SWC 18557) - Lucas Road, East Hills. Removal trashracks at PCD18558, PCD18558 and the downstream boom PCD18543. Replacement with GPT upstream of tidal influence, possibly park in Duke St.	East Hills	$250,000	$4,400 / yr	• Stormwater Levy • OEH Estuary Management Grant • GS LLS Grants		
			MA-3.7	PCD 4 (SWC 18556) - Amberdale Avenue (Amberdale Reserve), Picnic Point: Decommission existing GPT & install P1009 CDS unit on flow down Ambervale & P2018CDS unit on the flow through the park	Picnic Point	$150,000	$4,400 / yr	• OEH Estuary Management Grant • Stormwater Levy • GS LLS Grants		

Aim	Action	Action Description	Action Subtask		Catchment	Capital Cost	Operational Cost	Potential Funding	Primary Responsibility (Bankstown Council)	Supporting Implementation
			MA-3.8	PCD 19 (SWC 18570) - Daisy Street, Revesby. Investigate additional GPT to be constructed between 6-8 Queen St.	Milperra	$150,000	$4,400 / yr	• Stormwater Levy • OEH Estuary Management Grant • GS LLS Grants	Engineering Works and Asset Management	GRCCC OEH LLS
			MA-3.9	PCD 9 (SWC 18560) - Virginius Street (Virginius Reserve). Investigate constructing: • New GPT in Lang St • Boom to capture litter on LSPC (not costed)	Little Salt Pan Creek	$50,000	$4,400 / yr	• Stormwater Levy • OEH Estuary Management Grant • GS LLS Grants		
			MA-3.10	Montgomery Reserve Creek Filtration: Undertake detailed design investigations to daylight 3 stormwater pipes in Montgomery Reserve and treat stormwater via vegetated swales prior to discharge to Little Salt Pan Creek.	Little Salt Pan Creek	$125,000	$4,100 / yr	• OEH Estuary Management Grant • Stormwater Levy • GS LLS Grants • Developer contributions		
			MA-3.11	Park Road Raingarden: Undertake detailed design investigations to construct raingarden in existing landscaped area along Park Road, East Hills.	East Hills	$80,000	$4,200 / yr establishment $1,200 / yr ongoing	• OEH Estuary Management Grant • Stormwater Levy • GS LLS Grants		
			MA-3.12	PCD 8 SWC 18559 - Neptune Street: Investigate replacing existing GPT with P1012 CDS unit or VC80 VortCapture	Little Salt Pan Creek	$50,000	$4,400 / yr	• Stormwater Levy • OEH Estuary Management Grant • GS LLS Grants		
			MA-3.13	PCD 17 (SWC - 18568) - Newland Reserve, Milperra: Consider installing a P0708maxi CDS unit located behind the headwall to provide enhanced treatment & reduce visual impact.	Milperra	$50,000	$4,400 / yr	• Stormwater Levy • OEH Estuary Management Grant • GS LLS Grants		
			MA-3.14	Catchment WSUD Retrofit: Investigate other opportunities for implementing WSUD retrofit throughout catchments in conjunction with capital works (e.g. infrastructure upgrades, urban renewal) or as funding becomes available. General prioritisation of catchments to be targeted for works include: 1. Little Salt Pan Creek 2. Milperra 3. Lucas Road 4. East Hills 5. Kelso Swamp 6. Morris Gully 7. Picnic Point	All	Indicative costs for catchment opportunities identified: • Little Salt Pan Creek: $300K • Milperra: $170K • Lucas Road: $320K • Kelso Swamp: 380K • Morris Gully: $320K • Picnic Point: $115K	Indicative ongoing maintenance for catchment opportunities identified: • Little Salt Pan Creek: $4.5K • Milperra: $2.5K • Lucas Road: $4.8K • Kelso Swamp: 5.7K • Morris Gully: $5.6K • Picnic Point: $1.7K Establishment phase costs between 2-5 times ongoing costs.	• OEH Estuary Management Grant • Stormwater Levy • GS LLS Grants		

Aim	Action	Action Description	Action Subtask		Catchment	Capital Cost	Operational Cost	Potential Funding	Primary Responsibility (Bankstown Council)	Supporting Implementation
Water Quality	MA-6	Enforce implementation and maintenance of effective sediment controls during the subdivision and building phases of all developments (including infrastructure projects) by undertaking regular audits of developments during construction.	MA-6.1	Review DCP to ensure adequate sediment and erosion control measures are specified	All	Staff time only			Compliance	GRCCC OEH
			MA-6.2	Provide education to the community and development / building industry regarding the requirements for erosion and sediment control.	All		Staff time only $100,000 / yr if additional FTP required)			
			MA-6.3	Conduct on-going site investigations to ensure sediment and erosion control measures are properly implemented and maintained.	All					
			MA-6.4	Enforce requirements for sediment and erosion controls, including issuing fines for non-compliance	All					
Bank Erosion and Sedimentation	ME-4	Prioritise active eroding foreshore areas and undertake erosion management works using techniques that maximise the use of riparian vegetation.	ME-4.1	Undertake detailed investigations to identify and prioritise key erosion sites within study area foreshores to undertake erosion management works, and make recommendations as to the type of works required, with preference given to natural solutions. Targeted Sites: • E64. Opposite Hind Park (property north of Vale of Ah in private ownership) • Kentucky Reserve • Deepwater Park – banks of the Georges River and creeks within the Park (levelling and vegetating), • Picnic Point Reserve / East Hills Park	Milperra Kelso Swamp East Hills	Investigation: Staff time if resources / expertise available or Engagement of suitably qualified consultant:$60K Works: Very significant capital costs: • $1,000 - $3,000 / m^2 (depending on bank height)		• OEH Estuary Management Program grant • National Landcare Program grants • GS LLS Grants	Engineering Works & Assets Management	GRCCC OEH GS LLS
			ME-4.6	Apply erosion and sediment controls in DCPs in areas identified to be prone to streambank erosion	All	Staff time			Engineering Works & Assets Management Strategic Planning and Development Controls	
Water Quality	MA-4	Undertake adequate and appropriate maintenance of existing WSUD devices to maintain their effectiveness, in particular GPTs and other stormwater quality improvement devices.	MA-4.1	Maintenance schedule of stormwater devices and GPTs in the catchment needs to be reviewed and implemented.	All	Review / development of maintenance schedules - Council staff time or Consultant fee $100K	Large annual costs for undertaking maintenance - To be determined with review / development of maintenance schedule Asset Management Plan		Engineering Works and Asset Management	GRCCC GS LLS
			MA-4.2	Review and update Drainage Asset Management plan for all WSUD devices in catchment. Include GIS table identifying all measures. Ensure process in place to update as new measures are constructed	All	Staff time				

Aim	Action	Action Description	Action Subtask		Catchment	Capital Cost	Operational Cost	Potential Funding	Primary Responsibility (Bankstown Council)	Supporting Implementation
Water Quality	MA-15	Liaise with Sydney Water when sewers are observed to be causing water quality problems.	MA-15.1	Encourage residents to report suspected sewer overflow events to Council staff (e.g. via website, newsletters, rates)	All	Staff time only			Environmental Planning	GRCCC OEH GS LLS
			MA-15.2	Identify a Council contact responsible for liaising with Sydney Water and ensure Council staff report suspected overflows to this contact.	All	Staff time only				
			MA-15.3	Support a collaborative relationship between Sydney Water and Council contact to pass information on suspected overflows to Sydney Water. Encourage information sharing about known problem areas and plans for these to be managed.	All	Staff time only				
Aquatic and Riparian Habitat	MB-4	Identify locations for and undertake targeted rehabilitation, creation and enhancement of estuarine wetland communities (saltmarsh, mangrove, seagrass) and adjacent riparian vegetation.	MB-4.1	City-wide assessment required to identify sites for establishing wetland habitat, and for combining habitat outcomes with water quality improvement objectives. Note high level recommendations from Sydney Metropolitan CMA Waterways Health Strategy for Revegetation works have been included as a basis for these investigations.	Milperra Kelso Swamp Little Salt Pan Creek Morris Gully Picnic Point	Staff time Community volunteers (Landcare, GRCCC teams, Conservation Volunteers, Greening Australia etc) Riparian weed control, rehabilitation and regeneration typically costs between $2,000 - $10,000 /ha		• National Landcare Program grants • GS LLS grants • OEH Estuary Management Program grant	Environmental Rehabilitation & Monitoring	OEH (National Parks and Wildlife) DPI Fisheries GRCCC GS LLS
			MB-4.2	Assess the implications of potential waterway barriers identified on fish passage and recommend possible management options. The study should refer to investigation, design and rehabilitation considerations for fish passage as outlined by Fairfull and Witheridge (2003).	Milperra Kelso Swamp Little Salt Pan Creek Morris Gully Lucas Road Picnic Point	$25,000				
			MB-4.3	Removal of abandoned structures on eastern bank of Prospect Creek mouth.					Engineering Works and Asset Management	OEH (National Parks and Wildlife) DPI Fisheries GRCCC GS LLS
			MB-4.4	Consider the removal of groyne at S40 Lambeth Reserve (subject to heritage assessment).						
			MB-4.5	Removal of Yeramba Lagoon weir (in cooperation with NPWS and DPI Fisheries) to restore estuarine flows.						
			MB-4.6	Removal of abandoned structures on eastern bank of Prospect Creek (subject to heritage assessment).						

Aim	Action	Action Description	Action Subtask		Catchment	Capital Cost	Operational Cost	Potential Funding	Primary Responsibility (Bankstown Council)	Supporting Implementation
Aquatic and Riparian Habitat	MB-7	Support the establishment and continuation of local groups to assist with revegetation works on both public and private bushcare/landcare and other lands.	MB-7.1	Maintain current database of bush care / landcare contacts and their activiities. Inform them of funding, training and other opportunities	All	Staff time			Environmental Rehabilitation & Monitoring	GRCCC GS LLS Landcare Australia
			MB-7.2	Help to raise the profile of bushcare / landcare groups operating in the catchment using media and other communications opportunities (e.g. events, newsletters, website, rates etc)	All	Staff time				
			MB-7.3	Provide support to new and existing bushcare / landcare groups through provision of funding, technical advice, equipment and training as appropriate.	All	Staff time and grants		• National Landcare Program grants • GS LLS grants • OEH Estuary Management Program grant		
Water Quality	MA-8	Continue the GRCCC Riverkeeper Program to remove gross pollutants from foreshores and waterways, help minimise the impact of, and monitor incidences of, illegal dumping (on land and in water).	MA-8.1	Continue current GRCCC Riverkeeper Program to remove gross pollutants	All		Continue existing funding + add funding for large or special projects	• GRCCC Member Councils • National Landcare Program grants • GS LLS grants • OEH Estuary Management Program grant	Environmental Rehabilitation & Monitoring	GRCCC
Aquatic and Riparian Habitat	MB-8	Utilise the Riverkeeper rubbish removal and bush regeneration teams to provide rubbish removal, weed control, bush regeneration and ongoing site maintenance to complement and support NPWS and council activities.	MB-8.1	Identify priority areas for weed control, bush regeneration, rubbish removal and other ongoing site maintenance. Note high level recommendations from Sydney Metropolitan CMA Waterways Health Strategy for Assisted Regeneration have been included as a basis for identifying regeneration sites.	Milperra Kelso Swamp Little Salt Pan Creek Morris Gully Picnic Point	Staff time Riverkeeper Teams time Community volunteers (Landcare, GRCCC teams, Conservation Volunteers, Greening Australia etc) Riparian weed control, rehabilitation and regeneration typically costs between $2,000 - $10,000 /ha Continue existing funding + add funding for large or special projects		• GRCCC Member Councils • National Landcare Program grants • GS LLS grants • OEH Estuary Management Program grant • OEH NPW (for Georges River National Park site)	Environmental Rehabilitation & Monitoring	GRCCC GS LLS OEH (NPWS)
			MB-8.2	Regularly review and update the Riverkeeper program, site selection and works in conjunction with Councils.						
			MB-8.3	Work with the Riverkeeper teams to develop projects to compliment Council works in these priority areas.						
			MB-8.4	Target large rubbish such as tyres and car parts, particularly after heavy rain Target areas to include in catchment: • Yeramba Lagoon (also in National Park section) • Little Salt Pan Creek • Kelso Creek • Georges River.	Target: Picnic Point Little Salt Pan Creek Kelso Swamp Milperra					

Aim	Action	Action Description	Action Subtask		Catchment	Capital Cost	Operational Cost	Potential Funding	Primary Responsibility (Bankstown Council)	Supporting Implementation
Aquatic and Riparian Habitat	MB-9	Provide information to private landowners that have key habitat and vegetation communities on their properties to describe the community, its importance to the estuary and options for its protection and management.	MB-9.1	Maintain an inventory of private lands containing key EEC's or habitat for threatened species / populations. Include private assets located in key vegetation communities in the inventory.	All	Staff time			Communications & Education	GRCCC GS LLS OEH (NPWS) DPI (Fisheries), RMS
			MB-9.2	Inform property owners of the presence of EEC's or habitat for threatened species / populations and their importance / obligations, including: • Develop and distribute information packages on key habitat and vegetation communities, and steps that can be followed by property owners to minimise impacts and maximise conservation; • Educate surrounding properties about garden escapees and continued bush regeneration in the area; • Educate private property owners of the importance of foreshore vegetation and warn against removal;	All	Staff time + printing costs				
			MB-9.3	Identify what support can be provided to assist landowners in the management of these areas and assets	All	Staff time				
			MB-9.4	Support and investigate potential for conservation agreements, biobanking or covenants with interested landholders	All	Staff time				
Bank Erosion and Sedimentation	ME-3	Control ad hoc access along the foreshore to limit vegetation trampling and bank destabilisation, targeting sites of high environmental significance.	ME-3.1	Design and implement program / systems for identifying points of ad-hoc access / impact on foreshores. Appropriate impact mitigation measures to be based on site characteristics and nature of access. • Potential priority locations include: • Deepwater Park • Kentucky Reserve • Vale of Ah	All Priority locations Kelso Swamp Milperra	Staff Time $5,000 materials			Engineering Works & Assets Management, assistnace from OEH (NPWS)	OEH (NPWS), GRCCC, LLS
Landuse Planning and Development	MD-5	New and revised Plans of Management and/or other specific Council and NPWS environmental plans and policies should be compatible with the recommendations of the Georges River Estuary Coastal Zone Management Plan	MD-5.1	Integrate this Coastal Zone Management Plan with other strategic environmental initiatives, including EECs, threatened populations, and habitat for threatened species, NSW Threatened Species "Priority Action Statements" (PAS), and Biodiversity Strategies and Community Plans of Management.	All	Staff time only			Strategic Planning and Development Controls	OEH (NPWS) GRCCC
			MD-5.2	Consider identifying Bankstown City Council boating infrastructure	All	Staff time only				

Aim	Action	Action Description	Action Subtask		Catchment	Capital Cost	Operational Cost	Potential Funding	Primary Responsibility (Bankstown Council)	Supporting Implementation
Landuse Planning and Development	MD-4	When undertaking reviews of strategic planning instruments and initiatives (including LEPs and DCPs) and development proposals, ensure consistency with the Coastal Zone Management Plan aims and objectives	MD-4.1	When undertaking reviews of strategic planning instruments and initiatives (including LEPs and DCPs) and development proposals, ensure consistency with the Coastal Zone Management Plan aims and objectives	All	Staff time only			Strategic Planning and Development Controls	OEH GRCCC
Landuse Planning and Development	MD-3	Councils should ensure that best management practices to limit the export of pollutants including sediments, nutrients and acid runoff from Council projects are applied through the use of recognised checklist/part 5 assessment	MD-3.1	Use a recognised process to develop a set of best practice environmental control guidelines for the councils in the Georges River catchment which consider generation and export of sediments, nutrients and acid runoff both during and following construction. The GRCCC should play a role in coordinating the development of a consistent set of guidelines that can be applied across all Councils in the Georges River Catchment.	All	Staff time only	Staff time only		Strategic Planning and Development Controls	GRCCC OEH GS LLS RMS other infrastructure providers
			MD-3.2	Apply these guidelines and associated conditions to all Council projects.						
			MD-3.3	Monitor project implementation to ensure guidelines and conditions are being adhered to.						
Monitoring and Evaluation	MI-2	Ongoing support of the Georges River Health Monitoring Program coordinated by the GRCCC.	MI-2.1	Continue to support Georges River Estuary Health Monitoring program through ongoing funding past 2013.	Picnic Point		Continue existing funding		Environmental Rehabilitation & Monitoring GRCCC	LLS OEH (NPWS)
			MI-2.2	Identify ways in which additional value can be added to this program. For example, monitoring of the foreshore area and bank erosion, or actions undertaken to implement the Coastal Zone Management Plan / this CAP can be incorporated into the program. Recommended monitoring location includes proposed management option ME2 for CZMP (M5 Motorway to Kelso Creek). NB this relates largely to Coastal works rather than catchment works.	All	Staff time only (to make recommendations)	Depends on recommendations	National Landcare Program		
			MI-2.3	Development of periodic report cards or other mechanism to convey the health of the estuary and pressures from the catchment to the community.	All		Staff time only			

Aim	Action	Action Description	Action Subtask		Catchment	Capital Cost	Operational Cost	Potential Funding	Primary Responsibility (Bankstown Council)	Supporting Implementation
Monitoring and Evaluation	MI-3	Support the implementation and monitoring of the effectiveness of Plan.	MI-3.1	Maintaining and update a data base on the status and completion of all projects/actions from this CAP, and provide to GRCCC for updating status of CZMP actions which it's derived from.	All		Staff time only		Environmental Rehabilitation & Monitoring	GRCCC, LLS
			MI-3.2	Monitor the effectiveness of WSUD devices in catchment in accordance with guidelines.	All		Can be costly for laboratory fees.			
Natural and Cultural Heritage	MG-4	Work with Aboriginal Groups and others to determine options for threatened heritage sites	MG-4.1	Identification of Aboriginal groups and individuals with knowledge of heritage sites and their values and an interest in their protection.	All	Staff time only			Recreation and Heritage OEH (NPWS) GS LLS GRCCC	Local Aboriginal Groups / Lands Councils
			MG-4.2	Working with these groups and individuals to confirm the location of sites and identify threats. Working with these groups and individuals to develop site management strategies and an implementation action plan for undertaking these strategies in a timely and responsible manner.	All	Staff time only				
			MG-4.3	Implementation of Action Plan developed in MG-4.2	All					

GRCCC: Georges River Combined Councils' Committee
GS LLS: Greater Sydney Local Land Services
DP&E: Department of Planning & Environment
OEH: Office of Environment and Heritage
NPWS: National Parks & Wildlife Services
RMS: Roads and Maritime Services
DPI: Department of Primary Industries

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Appendices



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Appendix A MUSIC Modelling

A.1 Methodology

A.1.1 Introduction

The Mid-Georges River study area is comprised 7 major sub-catchments contributing to a total area of 2,990 ha.

Three MUSIC models were developed to assess water quality, pollutant load generation and treatment train effectiveness. The three models included a natural case, an existing case and a future development case. All three models had the same meteorological data; the differences were demonstrated through the source nodes.

A.1.2 Software

The eWater CRC MUSIC software (Version 6.1.0) and GIS software MapInfo (Version 11.5) have been used in this assessment.

A.1.3 Meteorological Data

A.1.3.1 Rainfall Data

Six minute timestep rainfall data was sourced from the Bankstown Airport BOM station (066137). The quality of this data was checked to confirm periods with missing and accumulated data was kept to a minimum.

To select the most appropriate rainfall period, a moving average calculation was conducted to compare the Bankstown Airport annual rainfall over 20, 15 and 10 year intervals to the long term average (1969 – 2014).

A continuous ten year period of data that was within approximately 0.4% of the local long term average was selected to undertake the rainfall runoff and pollutant export modelling (1st January 1975 to 31st December 1984). Table A-1 shows a comparison of the average annual rainfall and the ten year period selected for modelling.

Table A-1 Average Annual Rainfall Comparison

	Bankstown Airport (1969-2014)	Bankstown Airport (1975-1984)	Difference
Average Annual Rainfall 10 year period	873.3mm	869.7mm	0.41%

To confirm the daily distribution of the annual rainfall for the selected period, the average annual number of days where rainfall exceeds 5mm, 10mm, 25mm, 50mm and 100mm was calculated. The average annual rain days for the Bankstown Airport full data set and the ten year modelling period was then compared – this showed that the daily distribution of the annual rainfall for the selected modelling period is similar to the average local conditions for the Mid-Georges River study area.

Refer to Figure A-1 for the daily rainfall distribution comparison.

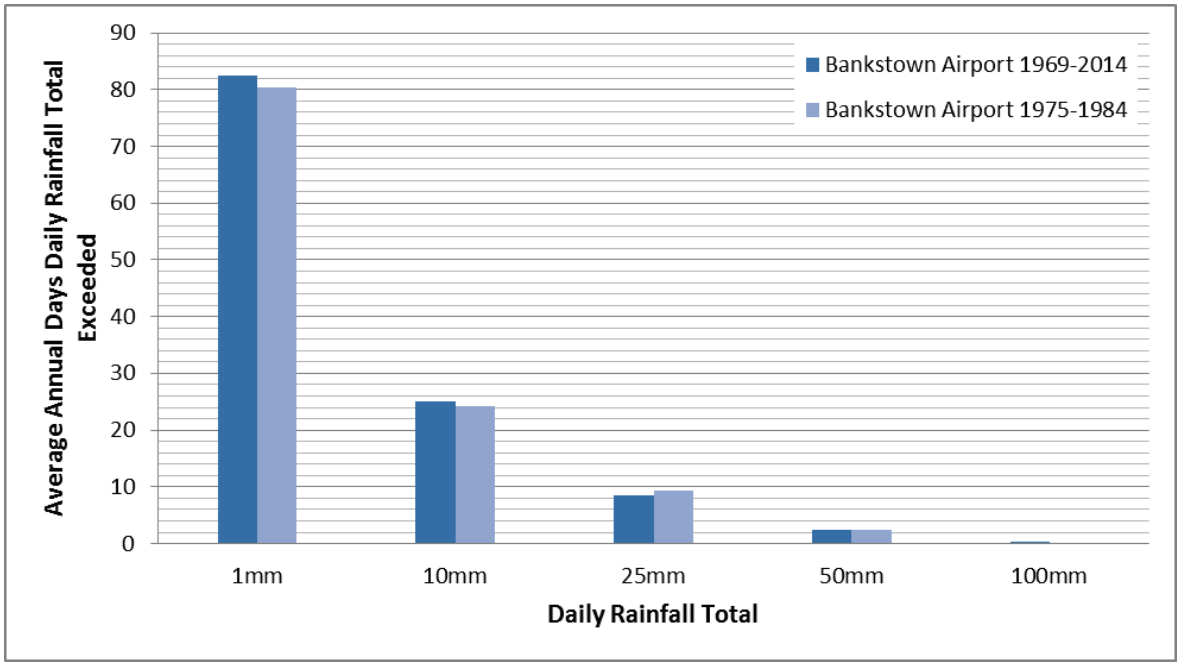


Figure A-1 Daily Rainfall Distribution Comparison

A.1.3.2 Areal PET Data

Average monthly areal potential evapotranspiration (PET) rates for the study area were estimated from the Bureau of Meteorology's gridded data. The adopted PET values are shown in Table A-2..

Table A-2 Adopted Average Monthly Areal PET Rates

Month	Areal PET Value
January	170.0
February	127.0
March	113.6
April	73.0
May	48.4
June	37.0
July	38.4
August	53.8
September	75.2
October	119.1
November	145.5
December	151.6

A.1.4 Model Timestep

A 6-minute model time step was adopted for the MUSIC models – as is recommended for carrying out water quality investigations.

A.1.5 Catchment Delineation

There are 7 main sub-catchments. These were further divided where necessary to ascertain impacts from individual developments i.e. Riverlands and Bankstown Airport and for inputting water quality devices.

The sub-catchments were split into the areas shown in Table A-3 for the future modelling scenario. These areas were derived in MapInfo using Bankstown City Council existing land use zoning, future LAP land use zoning plans, Bankstown Airport Masterplan and Riverlands Masterplan (all data provided by Bankstown City Council).

Table A-3 Future Developed Sub-Catchment Areas

MUSIC Areas	Sub-Catchment Area Breakup including Future Development (ha)						
	East Hills	Picnic Point	Lucas Road	Morris Gully	Kelso Swamp	Little Salt Pan Creek	Milperra
National Parks		94.14	2.47	54.02		63.34	
Open Space / Parks	3.81	1.18	20.15	6.63	221.72	33.14	232.83
Low Density Residential	11.53	51.17	153.62	112.98	186.05	311.78	309.17
LAP Medium Density Residential	5.20		1.17	0.95	6.25	6.45	
LAP High Density Residential	0.71		0.86		8.42	12.12	
Industrial					6.59		253.55
Business / Commercial	1.35	0.13	1.61	0.15	2.42	11.06	127.81
Bankstown Airport - Aviation							156.51
Electricity Station		10.08		5.20			
Railway Corridor	2.97		0.46		7.27	7.93	
MD Mixed Use						0.14	
HD Mixed Use			0.61		0.52	0.74	
Roads	6.67	18.25	43.23	34.88	89.96	110.46	177.63
Total Area	**32.24**	**174.96**	**224.19**	**214.82**	**529.19**	**557.17**	**1257.50**

A.1.6 Source Nodes

Rainfall-runoff and pollutant export characteristics as given by the Draft NSW MUSIC Modelling Guidelines (Sydney CMA 2010) and Using MUSIC in Sydney's Drinking Water Catchments (Sydney Catchment Authority, 2012) have been applied for the existing land usage classifications.

For the natural scenario the forest node was used with 100% pervious area for all sub-catchments.

For the existing/current scenario, the effective impervious percentages for all land use areas were based on aerial photography as recommended in the Draft NSW MUSIC Modelling Guidelines 2010.

For the developed/future scenario, areas that are highlighted for land use changes in the LAPs were altered to represent these future changes. The LAPs indicated that some existing low density residential and business / commercial areas were going to have land use zoning changes to medium and high density residential and medium and high density mixed use.

The effective impervious are percentages for these changing land use zones were based upon lot area breakups provided by Bankstown City Council.

The future scenario also had the Bankstown Airport and Riverlands Development included. Both developments were modelled as fully developed based upon their current master plans. Effective impervious areas for the Airport were based on catchment characteristics and existing land use EIAs. Riverlands effective impervious area percentages were based on advice from Council regarding average lot impervious area.

The effective impervious area percentages used for each land use type are shown in Table A-4.

Table A-4 Effective Impervious Areas Used for MUSIC Modelling

Surface Type	EIA %	MUSIC Model
Forest (Pre-European Development)	0%	Pre-European / Natural Case
Roads	70%	Existing and Future Cases
Roofs	100%	Existing and Future Cases
Low Density Residential	29%	Existing and Future Cases
Medium Density Residential	53%[1]	Future Case
High Density Residential	64%[2]	Future Case
Parks and Open Space	0%	Existing and Future Cases
National Parks	0%	Existing and Future Cases
Industrial	89%	Existing and Future Cases
Business / Commercial	76%	Existing and Future Cases
Electricity Station	6%	Existing and Future Cases
Railway Corridor	0%	Existing and Future Cases
Bankstown Airport	30%	Existing Case
Riverlands Development LDR	30%	Future Case
Aviation Business	76%	Future Case
Airport Aviation Zone	69%	Future Case
Medium Density Mixed Use	76%[3]	Future Case
High Density Mixed Use	76%[3]	Future Case

[1] Assumes 75% total impervious area with 70% directly connected (i.e. 75%*0.7=53%)

[2] Assumes 85% total impervious area with 75% directly connected (i.e. 85%*0.75=64%)

[3] Mixed Use zones based on business / commercial EIAs, as discussed with Council.

A.1.7 Existing Treatment Nodes

Existing treatment nodes were only included in the MUSIC model for measures where the necessary modelling details were provided by Council. The key input for existing treatment nodes were results from the GPT Audit (Optimal Stormwater, 2014) received from Council on 13/05/2015.

From review of the information provided, the only treatment node modelled in the existing catchment is one GPT (PCD 12) in the Kelso Swamp sub-catchment. Other existing trash racks and sediment basins identified throughout the study area were not modelled, in accordance with MUSIC modelling guidelines. Existing GPTs at Virginius Reserve and Bridge St were also not included in the existing model due to the GPT Audit noting them as ineffective / not operational (Optimal Stormwater, 2014).

The design properties of the existing treatment device were modelled in accordance with the Draft NSW MUSIC modelling Guidelines, and are given in Table A-5.

Table A-5 Existing GPT Treatment Node Properties Applied in MUSIC Modelling

Treatment Device	Properties	Value	Source
PCD 12 GPT (Humeguard HG45A)	Low Flow Bypass	0 m^3/s	Manufacturer Design Specifications
	High Flow Bypass	1.78 m^3/s	
	TSS	0 (Input), 0 (Output) mg/L	Draft NSW MUSIC Modelling Guidelines 2010
		75 (Input), 75 (Output) mg/L	
		1000 (Input), 350 (Output) mg/L	
	TP	0 (Input), 0 (Output) mg/L	
		0.5 (Input), 0.5 (Output) mg/L	
		1.0 (Input), 0.85 (Output) mg/L	
	TN	0 (Input), 0 (Output) mg/L	
		0.5 (Input), 0.5 (Output) mg/L	
		5.0 (Input), 4.3 (Output) mg/L	
	Gross Pollutants	0 (Input), 0 (Output) mg/L	
		15 (Input), 1.5 (Output) mg/L	

A.1.8 Future Treatment Nodes

The following treatment nodes were included in the future developed model to test the recommended CAP options:

A.1.8.1 Gross Pollutant Traps

Locations and details for new gross pollutant traps (GPTs) were identified through review of concurrent study results from a GPT audit undertaken by Optimal Stormwater (2014) and through consultation with Council. All GPTs were modelled using parameters as per the Draft NSW MUSIC

Modelling Guidelines 2010 (refer to Table A-5) – only the high flow bypass was altered as per Manufacturer design specifications and/or TUFLOW pipe flow results. Where manufacturer design specifications were not available, design flows for GPTs were estimated to be half of the peak 1 year ARI pipe flow (approximate 3 month ARI), as extracted from TUFLOW modelling undertaken for the Mid-Georges River FRMS. High flow bypass details are provided in Table A-6.

Table A-6 Gross Pollutant Trap High Flow Bypass

Device	Description	High Flow Bypass
PCD 4	One new GPT modelled – 52.45 ha catchment	1.5 m^3/s
PCD 5	One new GPT modelled in the park on Duke Street upstream of Lucas Road – 54.75 ha catchment	2.6 m^3/s
PCD 8	One new GPT modelled – 9.1 ha catchment	0.149 m^3/s
PCD 9	One new GPT modelled – 29.96 ha catchment	0.149 m^3/s
PCD 12	Existing GPT	1.78 m^3/s
PCD 17	One new GPT modelled – 2.9 ha catchment	0.149 m^3/s
PCD 19	One new GPT modelled – 39.94 ha catchment	1.407 m^3/s

A.1.8.2 Bioretention

Streetscape bioretention systems and bioretention basins were modelled using the parameters outlined in Table A-7.

Table A-7 Streetscape Bioretention System Parameters

MUSIC Parameter	Value Adopted
Low Flow By-pass	0.00 m^3/s
High Flow By-pass	100 m^3/s
Extended Detention Depth	0.15 m^2
Surface Area (square metres)	Equal to Filter Area
Filter Area (square metres)	Sized based on opportunity. Retrofit system footprints outlined in MapInfo.
Unlined Filter Media Perimeter	0.01m
Saturated Hydraulic Conductivity	100 mm/hr
Filter Depth	0.4m
TN Content of Filter media	400 mg/kg
o-P Content of Filter Media	40 mg/kg
Exfiltration Rate	0 mm/hr
Is base lined	Yes
Vegetation Properties	Vegetated with effective nutrient removal plants
Overflow weir width (metres)	Equal to filter area divided by 10
Underdrain	Yes

MUSIC Parameter	Value Adopted
Submerged zone	No

The size of each bioretention system varied depending on the available space and constraints at each location. Table A-8 provides the approximate size assumed for each bioretention system. Due to the high level assessment undertaken, viable opportunities (excluding the preferred opportunities), identified throughout the study area were lumped together in each sub-catchment and modelled as one area at the bottom of that sub-catchment. Therefore results are indicative only, however due to the conceptual nature of the investigation they are deemed to provide a reasonable estimate of performance. Due to this approach, the treatment of gross pollutants from the systems was ignored, as MUSIC assumes the majority of gross pollutants are captured in a bioretention system (and would hence assume all gross pollutants in the sub-catchment are removed when modelled on a lumped basis). Further detailed assessment should be undertaken for all measures as part of detailed design investigations.

Table A-8 Bioretention System Sizes

Bioretention ID	Sub-Catchment	Filter Size (m^2)
Park Rd Raingarden	East Hills	81
KU Revesby Preschool Bioretention Basin	Little Salt Pan Creek	343
Deverall Park Bioretention Basin	Milperra	4021
Grace Avenue, Condell Park Raingarden	Milperra	172
Surrey Reserve Raingarden	Milperra	112
Lumped Catchment Raingardens	Kelso Swamp	288
Lumped Catchment Raingardens	Little Salt Pan Creek	149
Lumped Catchment Raingardens	Lucas Road	255
Lumped Catchment Raingardens	Milperra	139
Lumped Catchment Raingardens	Morris Gully	375
Lumped Catchment Raingardens	Picnic Point	91

A.1.8.3 Vegetated Swales

The four vegetated swale options were modelled using the system parameters outlined in Table A-9. Swale length, base width and top width were obtained from MapInfo interrogation of the site.

Table A-9 Vegetated Swale System Parameters

MUSIC Parameter	Value Adopted			
	Montgomery Reserve 1	Montgomery Reserve 2	Montgomery Reserve 3	Milperra McDonalds
Low Flow By-pass	0.00 m^3/s			
Length	26m	26m	12m	70m
Bed Slope	1%			
Base Width	1m	1m	1m	15m

MUSIC Parameter	Value Adopted			
	Montgomery Reserve 1	Montgomery Reserve 2	Montgomery Reserve 3	Milperra McDonalds
Top Width	9m	9m	9m	23m
Depth	0.15m			
Vegetation Height	0.250m			
Exfiltration Rate	0 mm/hr			

A.1.8.4 Generic Treatment Node

The generic treatment node was used to model the LAP pollutant target objectives. The parameters adopted are shown in Table A-10.

Table A-10 Generic Treatment Node Parameters used for LAP Pollutant Reductions

MUSIC Parameter	Value Adopted
Low Flow By-pass	0.00 m^3/s
High Flow By-pass	100 m^3/s
Flow	No Capture
TSS (Flow Based Capture Efficiency)	80% of all inflows
TP (Flow Based Capture Efficiency)	55% of all inflows
TN (Flow Based Capture Efficiency)	40% of all inflows
GP (Flow Based Capture Efficiency)	90% of all inflows

A.2 MUSIC Modelling Results

Table A-11 Pre-European Natural Case Model Results

Sub-Catchment Area (ha)	*32.24*	*174.96*	*224.19*	*214.82*	*557.17*	*529.19*	*1257.50*	
Pollutants	East Hills	Picnic Point	Lucas Road	Morris Gully	Little Salt Pan Creek	Kelso Swamp	Milperra	**TOTAL**
TSS (kg/yr)	810.00	4,290.00	5,620.00	5,370.00	13,500.00	12,900.00	32,300.00	74,790
TP (kg/yr)	2.49	13.70	17.30	16.40	41.50	39.80	99.40	231
TN (kg/yr)	27.90	142.00	191.00	179.00	458.00	436.00	1,020.00	2,454
GP (kg/yr)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0

Table A-12 Existing Case Model Results

Sub-Catchment Area (ha)	*32.24*	*174.96*	*224.19*	*214.82*	*557.17*	*529.19*	*1257.50*	
Pollutants	East Hills	Picnic Point	Lucas Road	Morris Gully	Little Salt Pan Creek	Kelso Swamp	Milperra	**TOTAL**
TSS (kg/yr)	19,187	51,495	135,342	100,308	314,340	243,860	834,400	1,698,932
TP (kg/yr)	34	96	244	182	569	472	1,447	3,045
TN (kg/yr)	263	754	1,859	1,413	4,291	3,627	10,797	23,004
GP (kg/yr)P	3,146	8,517	23,395	17,578	54,335	35,785	140,960	283,715

Table A-13 Future Unmitigated Case Model Results

Sub-Catchment Area (ha)	*32.24*	*174.96*	*224.19*	*214.82*	*557.17*	*529.19*	*1257.50*	
Pollutants	East Hills	Picnic Point	Lucas Road	Morris Gully	Little Salt Pan Creek	Kelso Swamp	Milperra	**TOTAL**
TSS (kg/yr)	20,835	51,440	134,871	103,664	317,588	253,339	1,021,335	1,903,072
TP (kg/yr)	37	97	247	186	568	480	1,757	3,374
TN (kg/yr)	284	756	1,870	1,431	4,329	3,711	13,160	25,541

Sub-Catchment Area (ha)	*32.24*	*174.96*	*224.19*	*214.82*	*557.17*	*529.19*	*1257.50*	
GP (kg/yr)P	3,444	8,506	23,588	17,623	54,419	36,683	161,489	305,753

Table A-14 Future Mitigated Case Model Results

Sub-Catchment Area (ha)	*32.24*	*174.96*	*224.19*	*214.82*	*557.17*	*529.19*	*1257.50*	
Pollutants	East Hills	Picnic Point	Lucas Road	Morris Gully	Little Salt Pan Creek	Kelso Swamp	Milperra	**TOTAL**
TSS (kg/yr)	16,000	34,900	104,000	82,900	276,000	213,000	662,000	1,388,800
TP (kg/yr)	32	89	219	152	515	421	1,320	2,748
TN (kg/yr)	251	679	1,680	1,280	4,080	3,360	10,900	22,230
GP (kg/yr)P	2,646	3,257	17,435	17,500	49,638	29,518	103,556	223,550

Appendix B Site Visit Locations



Figure B-1 Site Visit Locations

Locations visited during a site visit on March 19, 2015 included:

- Site 1 – Lower reaches of Little Salt Pan Creek.
- Site 2 – Thomas Road to Prince Street / The River Road.
- Site 3 – River Road to Henry Lawson Drive, Revesby.
- Site 4 – Yeramba Lagoon.
- Site 5 – Amberdale Avenue Swale.
- Site 6 – Raingardens, Panania Town Centre.
- Site 7 – Kelso Levee / Floodgates.
- Site 8 – Newland Reserve, Milperra.
- Site 9 – Milperra Creek Widening, Downstream of Ashford Avenue.
- Site 10 – Bankstown Golf Course, Milperra.
- Site 11 – 345 Milperra Road, McDonalds.
- Site 12 – Deverall Park Detention Basin.

Appendix C Opportunities for WSUD Retrofit (Green Infrastructure)

Table C-1 Viable Opportunities Identified for WSUD Retrofit

ID	Sub-Catchment	WSUD Type	Opportunity Notes	Constraints	Council Comments
Park Road Raingarden	East Hills	Raingarden	Convert existing landscaping area to raingarden, high visibility	PASS Class 5. 7.3 m AHD may be ok? Ownership?	Not 100% on where this is proposed so it may be partly on rail land. Depending on location it may require approval from council engineers. Rebecca Bell (RB): Good location, rail land.
Flanders Avenue	Kelso Swamp	Raingarden	Raingarden adjacent park	ASS Class 5	Doesn't rainwater from Flanders end up in Kelso pond before re-use? What is the value? Pers Comm Cherie Blackburn (CB) 18/06 - Misunderstanding ok to include this as an option RB: No reuse at Kelso
Fenton Street	Kelso Swamp	Raingarden	Raingarden adjacent park, recreation & education opportunities	ASS class 5 8.4 m AHD ok?	Potentially could be located west of play equipment, eastern area being developed for garden. RB agrees.
McKevitte Avenue East Hills	Kelso Swamp	Raingarden	Raingarden in park	ASS Class 5 - may be ok? 10.2m AHD for sale	Maybe opportunity in rail corridor - not owned by BCC
Marshall Lane Panania	Kelso Swamp	Raingarden	In park near car park and town centre high visibility	ASS class 5 (14.7m OK?) other raingardens in town centre	RB: Possible
Panania Diggers	Kelso Swamp	Raingarden	ID'd by BCC (SM). Council owned, leased, expiring 2017, future resurfacing	negotiate with leaseholder, ASS Class 3 - Below 5 m AHD	Proposal was to incorporate into upcoming carpark works
Neptune Park	Little Salt Pan Creek	Raingarden	Car Park Raingarden. Sports field (soccer), potential s/w harvesting?	ASS class 5, small catchment for s/w harvesting. Parking may limit potential	Possible. Cost/benefit? Not reuse just treats car park runoff.
Johnston Reserve Bioretention Basin	Little Salt Pan Creek	Bioretention Basin	Alternative option to park basin - note LATM that could be integrated as raingarden	High use area limited space (Pers comm Sean Mooney (SM), therefore proposed smaller system. May affect car park space however parking looks plentiful	Not supported / unviable. Pers Comm CB 18/06 - smaller streetscape option ok. May also reassess the opportunity for a larger option in future. RB: Is it irrigated? Could use park area for bigger measure. Prefers this option to smaller option.

ID	Sub-Catchment	WSUD Type	Opportunity Notes	Constraints	Council Comments
Fox Crescent - Raingarden	Little Salt Pan Creek	Raingarden	Basin probably not feasible because of pipe depth 2.4m RL 12.65. Streetscape pod around inlet on street	Pipe depth for basin.	RB: Would prefer in park
Presland Avenue	Little Salt Pan Creek	Raingarden	Raingarden adjacent park to treat road	Aerial photo looks like services in close vicinity	RB: Possible
Montgomery Reserve Creek Filtration	Little Salt Pan Creek	Vegetated Swale	Daylight stormwater pipes and treat via vegetated swales.	Pipe IL approximately 1m below natural SL. Potential future development in park adjacent bowls limits use	Bowling club is zoned residential and likely to be developed in short to medium term so any drainage in this area should happen as part of larger development and consolidation of council land along creek. RB agrees
Johnston Reserve Raingarden	Little Salt Pan Creek	Raingarden	Alternative option to park basin - note LATM that could be integrated as raingarden	May affect car park space however parking looks plentiful	Will depend on location and size. There is limited open space opportunity at this site. RB: Prefers larger park option
Wilburforce Road	Little Salt Pan Creek	Raingarden	Raingarden pod opportunity adjacent to park	Services Unknown	RB: Pods in street difficult
Sphinx Avenue location 2	Little Salt Pan Creek	Raingarden	Raingarden Pod Opportunity adjacent to park	Services Unknown	RB: Pods in street difficult
Voluntary Purchase of KU Revesby Preschool	Little Salt Pan Creek	Bioretention Basin	Potential opportunity for returning school to parkland. Peak 1% AEP velocities - approx. 0.5m/s	Flood affected. Sewerage infrastructure to avoid. Further detailed investigations required to assess feasibility of incorporating bioretention basin in high flood hazard area.	Council is proposing to close this kindergarten to manage the flooding risk.

ID	Sub-Catchment	WSUD Type	Opportunity Notes	Constraints	Council Comments
Matthews Avenue Raingarden	Lucas Rd	Raingarden	Can make larger by combining 2 across inlets. Park.	ASS Class 5, confirm council land	RB: Great opportunity
Matthew Avenue & Moore Lane	Lucas Rd	Streetscape raingarden	Raingarden - lots room between footpath and road. Close to school	ASS class 5 10 m AHD - ok?	If there's enough room. RB: prefers Matthews avenue option
Duke Street Bioretention Basin	Lucas Rd	Bioretention Basin	Area in park in front of playground. Good opportunities. Collect from street pipe 525mm depth 1.5	ASS class 5. Approximately 6m AHD. Telegraph pole. Other services unknown	Ok. RB: Agrees.
Phillip Street Raingarden	Lucas Rd	Raingarden	Adjacent park with playground	Trees	Ok, best if incorporated into existing gardens. RB: Agrees
Deverall Park & Airport	Milperra	Bioretention Basin or Wetland	Possible airport contribution. High Visibility site good for education. ECC revegetation opportunities	Airport Land. ASS Class 5 RL13m. Deep pipe ILs. Vegetation restricts opportunity to extend downstream	EEC as additional constraint Small rain garden is possible on council land. Pers Comm CB 18/06 - Ok to use airport land option - avoids ECC & may be able to help regenerate ECC. Can also negotiate use with Airport. NR noted option on Council land not viable - pipe IL too deep to surface (2m+). RB: Agrees good site, airport land.
Milperra Road, McDonalds	Milperra	Swale	Large area looks like shallow detention basin.	Private land, Airport / McDonalds? ASS On line system so needs to be resilient to high flows, not	Could be incorporated into Airport Study later. RB: Agrees

ID	Sub-Catchment	WSUD Type	Opportunity Notes	Constraints	Council Comments
Nowill Street Condell Park	Milperra	Raingarden	In park, near industrial and residential zone	services unknown	Extremely small site in area with very low open space ratio. Rain garden would need to very small
Grace Avenue, Condell Park	Milperra	Bioretention Basin (within detention basin)	Park. Opportunity to integrate with flood detention works. Measure would be implemented as part of any future Council upgrades to the park	Sewer and stormwater pipes to avoid. Further detailed investigations required to assess feasibility of incorporating bioretention with flood mitigation measure.	Agree this is possible but it will only a small volume. RB: Looks good.
Investigator Avenue / Reliance Reserve	Milperra	Raingarden	In park, playground high visibility and education opportunities	Services Unknown	RB: Better in park than adjacent to road
Surrey Reserve	Milperra	Bioretention Basin (within detention basin)	Opportunity to integrate with flood management measure (detention basin). Measure would be implemented as part of any future Council upgrades to the park.	Avoid sewer & s/w infrastructure in park. Need to break into existing s/w infrastructure. Tree removal required. Further detailed investigations required to assess feasibility of incorporating bioretention with flood mitigation measure.	Possible but there are significant remnant trees onsite that have to be protected
Milperra Drain Channel Improvement	Milperra	Channel naturalisation (with channel widening)	To be undertaken as part of future widening works. Consistent with waterways health strategy regeneration strategy. Forms part of biodiversity support corridor.	Traverses private golf course land. Limited width.	Ok

ID	Sub-Catchment	WSUD Type	Opportunity Notes	Constraints	Council Comments
Thomas Street Car Park	Morris Gully	Raingarden	Raingarden treat car park runoff - sports ground. Note in biodiversity protection zone so opportunity to improve WQ and protect high environmental values here.	ASS Class 5	RB: cost / benefit? Not big enough catchment
Garnsey Avenue	Morris Gully	Raingarden	Raingarden adjacent park - education opportunity	Services unknown	RB: Possible
Victor Avenue	Morris Gully	Raingarden	Raingarden adjacent Bruce Reserve - playground. Cheaper alternative to Bruce Reserve	Services unknown	RB: Would constrain parking in front of park
Bruce Reserve	Morris Gully	Bioretention Basin / Wetland. Possibly GPT	Wetland / Bioretention Basin. Promote biodiversity corridor, education, recreation	Upstream catchment 18ha. Difficult to daylight pipes 2.2 m below surface. Divert via pump?	Wetland not supported, bioretention basin most practical options RB: bioretention basin possible
Samoa Avenue	Picnic Point	Raingarden	Raingarden cul-de-sac and park.	ASS Class 5 approximately 10 m AHD	RB: Possible. Check sewer overflows in catchment.
Eileen Street	Picnic Point	Raingarden	Raingarden adjacent park	ASS class 5. Services? No rec facilities in park just grass	RB: Possible. Check sewer overflows in catchment.

Table C-2 Unviable Opportunities Reviewed for WSUD Retrofit

ID	Sub-Catchment	WSUD Type	Opportunity Notes	Constraints	Council Comments
Maclaurnin Avenue Raingarden	East Hills	Raingarden	Space, close to town centre for visibility. Better opportunity other side roundabout.	Land ownership - rail land. Council (SM) identified not viable. PASS class 5 9.2 m AHD	
Revesby Football Club	Kelso Swamp	Wetland	Wetland Stormwater harvest opportunity (note kelso park ID'd in EMP)	ASS Class 3	
Kelso Stormwater Harvesting Project	Kelso Swamp	Stormwater Harvesting	Action investigated as result of EMP	ASS. High water table and salinity - project not viable	
Braesmere Street	Kelso Swamp	Raingarden	Open Space area	Ownership? Levels - elevated so deep batters. ASS class 5	
Park Road Swale	Kelso Swamp	Swale		Limited width between road and rail. Existing Veg. ASS Class 5	
Ogilvie Street Park	Kelso Swamp	Bioretention Basin	Council owned	Rock, flat, ASS Class 3/5 - below 5m AHD	
Killara Reserve	Kelso Swamp		Identified by Council - big issues odour, funding opportunities, passive recreation so space available	ASS Class 3 = 2m AHD, pumps required - Best option to revegetation instead due to ASS (as per waterway health strategy)?	
M5 S Western Motorway	Kelso Swamp		Bioretention basin / swale to treat road runoff	ASS class 5	

ID	Sub-Catchment	WSUD Type	Opportunity Notes	Constraints	Council Comments
UWS	Kelso Swamp	Bioretention / Infiltration Basin	Future campus development, existing detention basin	Private land, no drainage info, ASS class 5 - 4 m AHD hence low viability	
M5 S Western Motorway	Kelso Swamp		Bioretention basin / swale to treat road runoff	ASS class 5. Looks like upgraded to 3 lanes since aerial 2011 - no room for WSUD. Topography side of road steep doesn't integrate well.	Opportunity lost, should have been done with upgrade
Simons Street Car Park	Little Salt Pan Creek		Car park treatments	Private property - multi-storey car park too - difficult	
Able Reserve	Little Salt Pan Creek		High profile. Potential capture and treat Marco Avenue or train car park runoff? Purple pipe exists	Has recently been renewed. No more $ to be spent in Revesby (CB)	
Marco Avenue	Little Salt Pan Creek		Streetscape potential. Road strip in medium already contain? Pervious pavement. Inlets converted to	Has recently been renewed. No more $ to be spent in Revesby (CB)	
LSP Creek Biodiversity Mgmt. Plan	Little Salt Pan Creek		maintain existing WQ pond and plant out for use as frog habitat sediment basin	Check flow velocities. Note Council mentioned actions in this plan complete - disregard	
Virginius Reserve	Little Salt Pan Creek		Open space near open channel corridor and community use	ASS Class 5 (scalds on aerial?),Bushland, no s/w infrastructure	
Armour Park	Little Salt Pan Creek		Sports field (cricket), other sporting activities high profile site.	Top of catchment difficult to capture water - not viable	

ID	Sub-Catchment	WSUD Type	Opportunity Notes	Constraints	Council Comments
Sphinx Avenue	Little Salt Pan Creek	Raingarden	Raingarden Pod Opportunity, better opportunity at location 2		
Montgomery Reserve	Little Salt Pan Creek		Potential for small BR or just revegetation. Put in Revegetation layer opportunity	Existing vegetation /bushland.	
Revesby Bowling Club	Little Salt Pan Creek	Stormwater Harvesting	Potential stormwater harvest and reuse on lawns? Note adjacent vacant property	Private property, $$	
Cuthbert Crescent	Little Salt Pan Creek		Park	No existing s/w infrastructure	
Tyalgum Avenue, Panania	Little Salt Pan Creek		Park	Small catchment - mostly park	
Singleton Avenue Bioretention Swale	Lucas Rd		Along school no footpath on side of road	School consultation, catchment largely open space - not much directly connected impervious to collect	
Monash Avenue	Lucas Rd	Swale or streetscape raingarden	Raingardens around inlets. Bioretention swale along road? Note vacant property adjacent - ownership	ASS Class 5	
Harcourt Avenue Raingardens	Lucas Rd	Raingarden	Around existing stormwater inlets. Corner block and park has plenty room	ASS class 5 2 m AHD	
Harcourt Avenue Raingardens	Lucas Rd		Around existing stormwater inlets. Corner	ASS class 5	

ID	Sub-Catchment	WSUD Type	Opportunity Notes	Constraints	Council Comments
			block and park has plenty room		
Henry Lawson Drive Park	Lucas Rd	Raingarden or swale		ASS	
Philip Street Raingarden / Basin	Lucas Rd	Raingarden / Basin	Park with plenty open space. Inlet on corner	Trees, services unknown (applies to all opportunities)	Land proposed for sale, notification in LAP
Harcourt Avenue Raingardens	Lucas Rd	raingarden	Around existing stormwater inlets. Corner block with room	ASS class 5 8.3 m AHD may be ok. No park as previously thought; need to integrate in road reserve. Not priority catchment therefore not high priority	RB: Too hard in street
Reliance Avenue Park	Milperra	Bioretention Basin	Surface pipe for treatment	Pipe too far below ground (3m)	
Kinch Reserve & Airport	Milperra	Bioretention Basin	Partly Council Land, behind Basketball courts	Airport Land - potential to use limited (Pers com SM). ASS Class 5 (15m ahd). Visibility to pu	
Deverall Park Car Park (Netball Court)	Milperra	Raingarden	High Visibility, tie into existing gully pit.	Space - close to courts & w/e coffee van. Restricts public access not viable (pers comm SM)	
Eldon Avenue, Georges Hall	Milperra	Raingarden	Good Visibility, in park	Elevated park - not contaminated land (pers comm SM). Opportunity to tie in with	I think the elevation of this site will restrict any use.

ID	Sub-Catchment	WSUD Type	Opportunity Notes	Constraints	Council Comments
				flood control on other side of road?	
Douglas Street Park	Morris Gully	Raingarden	Park	Tree, space, small catchment	
Morris Gully	Morris Gully		Wetland - off line	ASS class 5, levels & space constraints	
Karen Street	Picnic Point	wetland / bioretention basin	Wetland / Bio Basin. Pipe IL 1.5 - 2m below surface (RL 8-10).	ASS Class 5, sewage OF (existing swale), levels, vegetation	
Victor Avenue	Picnic Point	Raingarden	Raingarden Pod, near park	Tree	RB: Too constrained

Appendix D Prioritisation Assessment Results

Table D-1 Prioritisation Assessment Results

Primary Criteria	Primary Criteria Weighting	Secondary Criteria		Secondary Criteria Weighting	PERFORMANCE VALUES											
					Park Road Raingarden	Montgomery Reserve Creek Filtration	Revesby Preschool Bioretention Basin	Deverall Park Bioretention Basin	Grace Avenue Bioretention Basin	Surrey Reserve Bioretention Basin	PCD 4 - Amberdale Avenue /Reserve	PCD 5 - Lucas Road 1 (upstream)	PCD 8 - Neptune Street	PCD 9 - Virginius Street /Reserve	PCD 17 - Newland Reserve	PCD 19 - Daisy Street
Environmental	25%	Pollutant Removal kg/yr	TSS	25%	742	802	16600	29270	8600	4330	12100	13800	1520	4700	730	13100
			TP	25%	1	1	25	41	13	6	0.4	0.4	0.05	0.2	0.03	0.3
			TN	25%	6	1	100	234	58	26	48	55	6.7	20	2.9	48
			GP	25%	N/A	N/A	N/A	N/A	N/A	N/A	5253	5795	664	2470	301	5130
Ecological	15%	Potential to enhance habitat values (m2)	Vegetation (m2)	50%	80	90	340	4000	170	110	0	0	0	0	0	0
			Biodiversity / ECC Vegetation (m2)	50%	0	90	340	4000	0	110	0	0	0	0	0	0
Financial	30%	Levelised Cost Treatment $/kg/yr	TSS	25%	$1.28	$1.97	$0.08	$0.42	$0.23	$0.30	$0.15	$0.20	$0.62	$0.20	$1.30	$0.14
			TP	25%	$949	$2,650	$54	$303	$152	$223	$4,596	$6,821	$18,969	$4,742	$31,615	$6,128
			TN	25%	$170	$2,357	$14	$53	$35	$51	$38	$50	$142	$47	$327	$38
			GP	25%	N/A	N/A	N/A	N/A	N/A	N/A	$1.05	$1.41	$4.29	$1.15	$9.44	$1.08
Social	30%	Amenity / Recreation		50%	1	1	2	1	2	2	0	0	0	0	0	0
		Education		50%	1	2	2	2	2	2	1	1	1	1	1	1

Primary Criteria	Primary Criteria Weighting	Secondary Criteria		Secondary Criteria Weighting	MIN-MAX NORMALISED SCORES													
					Min	Max	Range	Park Road Raingarden	Montgomery Reserve Creek Filtration	Revesby Preschool Bioretention Basin	Deverall Park Bioretention Basin	Grace Avenue Bioretention Basin	Surrey Reserve Bioretention Basin	PCD 4	PCD 5	PCD 8	PCD 9	PCD 17	PCD 19
Environmental	25%	Pollutant Removal kg/yr	TSS	25%	730	29270	28540	0	0	56	100	28	13	40	46	3	14	0.0	43
			TP	25%	0.03	40.6	40.57	2	1	62	100	33	14	1	1	0.0	0.4	0.0	1
			TN	25%	0.67	234	233.33	2	0	43	100	25	11	20	23	3	8	1.0	20
			GP	25%	301.4	5795	5493.6	N/A	N/A	N/A	N/A	N/A	N/A	90	100	7	39	0.0	88
Ecological	15%	Potential to enhance habitat values (m2)	Vegetation (m2)	50%	0	4000	4000	2	2	9	100	4	3	0	0	0	0	0	0
			Biodiversity / ECC Vegetation (m2)	50%	0	4000	4000	0	2	9	100	0	3	0	0	0	0	0	0
Financial	30%	Levelised Cost Treatment $/kg/yr	TSS	25%	$0.08	$1.97	$1.89	37	0	100	82	92	88	96	94	71	94	36	97
			TP	25%	$54	$31,615	$31,561	97	92	100	99	100	99	86	79	40	85	0	81
			TN	25%	$14	$2,357	$2,343	93	0	100	98	99	98	99	98	95	99	87	99
			GP	25%	$1.05	$9.44	$8.39	N/A	N/A	N/A	N/A	N/A	N/A	100	96	61	99	0	100
Social	30%	Amenity / Recreation		50%	0	2	2	50	50	100	50	100	100	0	0	0	0	0	0
		Education		50%	1	2	1	0	100	100	100	100	100	0	0	0	0	0	0

Primary Criteria	Primary Criteria Weighting	Secondary Criteria		Secondary Criteria Weighting	WEIGHTED SCORES											
					Park Road Raingarden	Montgomery Reserve Creek Filtration	Revesby Preschool Bioretention Basin	Deverall Park Bioretention Basin	Grace Avenue Bioretention Basin	Surrey Reserve Bioretention Basin	PCD 4 - Amberdale Avenue /Reserve	PCD 5 - Lucas Road 1 (upstream)	PCD 8 - Neptune Street	PCD 9 - Virginius Street /Reserve	PCD 17 - Newland Reserve	PCD 19 - Daisy Street
Environmental	25%	Pollutant Removal kg/yr	TSS	25%	0.0	0.0	3.5	6.3	1.7	0.8	2.5	2.9	0.2	0.9	0.0	2.7
			TP	25%	0.1	0.1	3.8	6.3	2.0	0.9	0.1	0.1	0.0	0.0	0.0	0.0
			TN	25%	0.1	0.0	2.7	6.3	1.5	0.7	1.3	1.5	0.2	0.5	0.1	1.3
			GP	25%							5.6	6.3	0.4	2.5	0.0	5.5
Ecological	15%	Potential to enhance habitat values (m2)	Vegetation (m2)	50%	0.2	0.2	0.6	7.5	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0
			Biodiversity / ECC Vegetation (m2)	50%	0.0	0.2	0.6	7.5	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Financial	30%	Levelised Cost Treatment $/kg/yr	TSS	25%	2.7	0.0	7.5	6.2	6.9	6.6	7.2	7.0	5.3	7.0	2.7	7.3
			TP	25%	7.3	6.9	7.5	7.4	7.5	7.5	6.4	5.9	3.0	6.4	0.0	6.1
			TN	25%	7.0	0.0	7.5	7.4	7.4	7.4	7.4	7.4	7.1	7.4	6.5	7.4
			GP	25%							7.5	7.2	4.6	7.4	0.0	7.5
Social	30%	Amenity / Recreation		50%	1	7.5	7.5	15	7.5	15	15	0	0	0	0	0
		Education		50%	1	0	15	15	15	15	15	0	0	0	0	0
Total Weighted Option Score					**25.0**	**29.8**	**63.8**	**77.2**	**57.4**	**54.2**	**38.0**	**38.1**	**20.8**	**32.1**	**9.2**	**37.7**

Option	Score
Deverall Park Bioretention Basin	77.2
Revesby Preschool Bioretention Basin	63.8
Grace Avenue Bioretention Basin	57.4
Surrey Reserve Bioretention Basin	54.2
PCD 5 - Lucas Road 1 (upstream)	38.1
PCD 4 - Amberdale Avenue (Amberdale Reserve)	38.0
PCD 19 - Daisy Street	37.7
PCD 9 - Virginius Street (Virginius Reserve)	32.1
Montgomery Reserve Creek Filtration	29.8
Park Road Raingarden	25.0
PCD 8 - Neptune Street	20.8
PCD 17 - Newland Reserve	9.2





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