

Water Management, Flood Modelling and Riparian Corridor Study Report

North West Growth Centre

59915128

Prepared for
Department of Planning and Environment

1 July 2015



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Please note that Land Use and Infrastructure Strategy (the Strategy), as referred to in this report, is now called Land Use and Infrastructure Implementation Plan (the Implementation Plan).

Executive Summary

The NSW Department of Planning & Environment (DPE) is currently undertaking a review of the structure plans for Priority Growth Areas in Western Sydney in order to update these structure plans and to develop a land use and infrastructure strategy to facilitate development of these areas.

The NSW Department of Planning & Environment engaged Cardno to provide Water Management, Flooding and Riparian Corridor Study services for the:

- South West Growth Centre (SWGC) Structure Plan, excluding any Precincts already released;
- Precincts not yet released in the North West Growth Centre (NWGC), including Shanes Park and West Schofields; and
- The Western Sydney Employment Area (WSEA).

This report focusses on the North West Growth Centre Precincts of Shanes Park and West Schofields.

This project will assist in facilitating the detailed planning and rezoning stages by providing strategies for flooding, water management and riparian corridor considerations along with frameworks for future studies and planning instruments.

Riparian Corridor Study

Constraints for urban development adjacent to rivers and creeks include physical constraints as well as requirements for additional assessment and approvals under the Water Management Act 2000. The NSW Office of Water released a new policy and set of guidelines for riparian corridors on waterfront land in 2013 that aim to provide greater flexibility in determining riparian protection areas and opportunities for more streamlined assessment processes under the WMA. The new process recognized that the constraints were potentially limiting opportunities for housing development, but there was also a need to ensure that riparian values were adequately protected. The policy included a new matrix of riparian zone widths based on stream ordering and recommendations as to what sort of activities could be included within the riparian zone.

The Policy also provided for the possibility of trading off or offsetting cleared riparian protection areas with other areas that were more suitable in the context of the development.

This report documents the outcomes from a review of existing information including the Guidelines and the existing mapping of riparian protection areas in the Growth Centres and provides a new riparian corridor map for West Schofields and Shanes Park base on the Guidelines and field verification of the stream ordering classification within the two Precincts.

The desktop riparian assessment involved:

- Obtaining the location of hydrolines from NSW Office of Water
- Allocating Strahler stream order to individual reaches to determine their value; and
- Using NSW Office of Water Guidelines determine appropriate buffers around streams

The assessment provides the basis for defining Riparian Protected Area maps and identifying opportunities for modifying riparian land boundaries consistent with the guidelines. Existing riparian protection zone maps for Shanes Park and West Schofields (SEPP 2013) are reproduced in **Appendix A**.

The width of the vegetated riparian zone (VRZ) within the riparian corridor is based on the watercourse order as defined in accordance with the Strahler System.

Streams in Shanes Park and West Schofields precincts were initially categorised based on the Strahler System and a riparian corridor width was assigned to each reach in accordance with the Guidelines (**Table 2-1**). Maps showing preliminary outlines of riparian corridors were produced based on hydroline maps and stream order classification provided by DWE.

A field inspection of streams within the Shanes Park and West Schofields Precincts was carried out to verify the stream classification, in particular for smaller streams identified in the Precincts.

Figure 2-10 and **Figure 2-11** show updated outlines of riparian corridors in Shanes Park and West Schofields recommended following field inspections of the first and second order streams in each Precinct.

Recommended updates to the stream ordering classification and riparian corridor width have been forwarded to Office of Water for confirmation of the proposed changes.

Opportunities for streamlining the statutory processes have been investigated for both the Shanes Park and West Schofields Precincts.

Currently the Riparian Corridor guidelines are advisory only and a controlled activity approval is required for each proposed activity. This means that there is minimal opportunity to provide an outcome over a broad precinct where priority riparian area for conservation could benefit from allowing offsets in other lower priority streams (this would vary depending on the scale of individual developments).

The biocertification order for the Growth centres provides an alternative model for consideration. In theory, a similar certification approach could be applied for riparian land within an identified area of land. The Water Management General Regulation (2011) provides for exemptions from the need to seek a controlled activity approval.

The approach would be to:

1. Identify on a plan the riparian zone widths subject to controlled activity approval based on the approach outlined in the Guideline
2. Identify the activities allowed within the inner and outer riparian zone in accordance with the Table
3. Identify priority riparian offset areas for a precinct/s so that the most beneficial outcome for riparian environments can be encouraged
4. Outline the process by which variations could occur for non-riparian zone activities within the outer riparian zone. This process would operationalise the offset rule in the guideline without the need to seek approval for each individual project. The process would include conditions such as offsetting is not allowed if clearing of riparian vegetation would occur within the riparian zone.
5. Require the need for approval for activities that fall outside of the agreed plan.

Further discussions between NSW Planning and Environment and the Office of Water are recommended to agree on a proposed approach. However, there are limited opportunities for improving developable land area in Shanes Park and West Schofields given the large areas of land inundated by flooding and the small number of low order streams and associated riparian corridors. It is recommended that streamlining the statutory process will not be significantly advantageous for aiding growth centre development in these two precincts.

Flooding

The relevant flood studies for the yet to be released NWGC precincts are:

- West Schofields – Eastern Creek Flood Study, Hawkesbury-Nepean Flood Study
- Shanes Park – South Creek Flood Study, Hawkesbury-Nepean Flood Study

GIS information for flood extents for Eastern Creek and South Creek has been provided by Blacktown City Council and these extents have been used to provide the flooding context.

Flooding within the Shanes Park area is influenced by both the South Creek local flooding as well as by backwater flooding from the Hawkesbury River. The 100yr ARI and PMF flood extents within Shanes Park are shown in **Figure 3-1**. It can be seen from this figure that approximately 55% of Shanes Park precinct is inundated for the 100 year ARI event and approximately 90% of the precinct is inundated in the PMF event, with only the middle southern portion remaining flood free.

Flooding within the West Schofields area is influenced by both the Eastern Creek and Bells Creek local flooding as well as by backwater flooding from the Hawkesbury River. The 100yr ARI and PMF flood extents within West Schofields are shown in **Figure 3-2**. It can be seen from this figure that approximately 50% of West Schofields precinct is inundated for the 100 year ARI event and approximately 75% of the precinct is

inundated in the PMF event. There is a ridgeline through the middle of the precinct which extends to the southern boundary and this portion remains flood free.

The NSW government's Floodplain Development Manual recommends that new residential development be located preferably on land at or above the 1% or 1 in 100 AEP flood level plus freeboard. As such, this renders significant areas of land undevelopable within both the Shanes Park and West Schofields Precincts.

In order to increase developable land within the Precincts, a limited degree of filling within the flood fringe areas of the floodplain may be undertaken to facilitate the creation of workable subdivision layouts. Filling should be restricted to areas within the floodplain that are outside the core riparian corridor zones and an assessment of the impact of any proposed filling should be undertaken in accordance with the requirements of the SEPP (2006) and the BCC DCP (2006).

There are a number of key flood considerations to be taken into account when planning development:

- Identifying flood behaviour
- Setting flood planning levels for different land use types
- Land use planning to reduce or eliminate flood risk and flood damages
- Management of stormwater
- Flood evacuation

Flood evacuation is of particular significance in the NWGC due to the widespread inundation resulting from the Hawkesbury River flooding. Emergency planning and response must be considered in the development of the site.

It would be expected that evacuation would be the primary emergency response, although some form of shelter in place / vertical evacuation may also need to be provided if the emergency assessment finds that a safe and orderly evacuation is not feasible for the entirety of the precinct.

Ideally, no critical infrastructure such as hospitals, retirement villages, child care centres, schools, etc. should be planned within the PMF extent. This will avoid the need for evacuation of such facilities which could prove problematic as well as removing the risk of flood damage for such services so they can continue to operate during and after a major flood event.

Planned transport infrastructure will need to consider the flood evacuation routes including the ability to provide flood immunity to such infrastructure so as they are not cut off during the flood. Some flood extents are quite significant and proposed transport routes will need to consider flood immunity of the infrastructure, minimising flood impacts on the floodplain and mitigation strategies (viaducts and flood relief bridges/ culverts).

Figure 3-3 shows the flood extents for broader NWGC showing the two Precincts within the flood evacuation context. Flood evacuation will largely be to higher ground in the centre of the Precinct or to the south if evacuation centres are situated outside the precinct.

Cumulative impacts of flooding when considering multiple developments is another key consideration, however, it is not considered beneficial to develop a regional flood model to examine cumulative impacts within the NWGC. Flood modelling has already been carried out for a large number of precincts within the NWGC and a regional flood model would not necessarily offer any advantages at this stage of the planning process. In addition, the area is dominated by the Hawkesbury River backwater and cut and fill activity has a negligible impact on reducing Hawkesbury River floodplain storage, particularly seeing as the majority of precincts avoid major cut and fill within the 100 year ARI flood extent.

Some practical approaches can be taken when considering adjacent precincts and appropriate examination of cross-boundary impacts or benefits can be applied to existing models through appropriate boundary conditions.

A reasonable and consistent approach has been adopted for flood modelling for previously released Precincts within the NWGC. A framework for future flood modelling for the Shanes Park and West Schofields Precincts is outlined within the report.

Water Cycle Management

Water cycle management is a holistic approach that addresses competing demands placed on a region's water resources, whilst optimising social benefits and enhancing and protecting the environmental values of receiving waters.

Developing a water cycle management strategy at the planning stage of the land development process provides guidance on urban water management issues to be addressed. This assists urban rezoning and infrastructure planning for new residential, commercial or industrial development (including redevelopment) areas.

This water cycle management strategy provides a framework for integrating land use and water management for the planning of Shanes Park and West Schofields Precincts. Water Cycle Management objectives (water quality and quantity) are recommended for development of Shanes Park and West Schofields precincts.

The objectives have been aligned with the adjoining NWGC precinct plans and Blacktown City Council's requirements. An approach has been developed to guide future developments in the precincts in a sustainable manner to help achieve the objectives. This includes:

- adoption of a combination of online and offline detention basins to mitigate the flood impacts on South Creek and Eastern Creek; and
- lot scale (rainwater tanks), street scale (swales) and regional scale (GPTs and bioretention basins) water treatment measures to achieve the required water quality.

The report identifies preliminary basin sizes, suggested parameters and potential locations for on-line and offline basins.

Recommendations

This report documents the review of flooding, water cycle management and riparian corridor considerations for the North West Growth Centre Precincts of Shanes Park and West Schofields. The outcomes of the study include the following set of recommendations for the structure plan review as well as a number of future actions to enhance the outputs from this report in coordination with other disciplines.

Riparian Corridor

- The preliminary mapping in SEPP 2013 have been reviewed. **Figure 2-10** and **Figure 2-11** show recommended updated outlines of riparian corridors in Shanes Park and West Schofields following field inspections of the first and second order streams in each Precinct.
- There appeared to be only limited opportunities for offsetting of riparian corridor land in Shanes Park and West Schofields Precincts.

Flooding

- Developable Land – There is limited opportunity for a cut and fill approach to maximise developable land however, should be considered to allow appropriate development layouts. Such cut and fill should be localised and minor and should not encroach on the riparian corridor zone.
- Land Use - Land within the 100 year ARI extents should be adopted as green space (agriculture, open space, recreation or conservation areas). This flood extent aligns with or exceeds riparian corridor zones and hence seeks to achieve the riparian corridor objectives as well.
- Overland Flows - Appropriate overland flow floodways should be provided within the catchment to compliment the underground drainage system and ensure that development has appropriate flood immunity with regards overland flows not just mainstream flooding. Ideally natural open waterways are preserved to serve this function. Flood planning controls on lots adjacent to floodways may be required.
- Flood evacuation - Land use planning and transport infrastructure planning need to have a strong consideration of flood evacuation, particularly for planned development on land between the 100

year ARI and PMF flood extents. Critical Infrastructure should be planned to be on land outside the PMF flood extent.

Water Cycle Management

- Set water management objectives which are consistent with the adjoining NWGC precinct plans and Blacktown City Council's requirements;
- A combination of online and offline detention basins to mitigate the flood impacts on South Creek and Eastern Creek from development in the precincts;
- Lot based on-site detention (OSD) for commercial/retail and industrial areas to reduce the requirement of developable land for detention basins. However it should be noted that OSD for greenfield development is not currently supported by Blacktown City Council;
- Adopt the design parameters for flood modelling in accordance with Blacktown City Council design requirements.
- Implement lot scale (rainwater tanks), street scale (swales) and regional scale (GPTs and bioretention basins) water treatment measures to achieve the required water quality.

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1 Introduction

The NSW Department of Planning & Environment (DPE) is currently undertaking a review of the structure plans for Priority Growth Areas in Western Sydney in order to update these structure plans and to develop a land use and infrastructure strategy to facilitate development of these areas.

The NSW Department of Planning & Environment engaged Cardno to provide Water Management, Flooding and Riparian Corridor Study services for the:

- South West Growth Centre (SWGC) Structure Plan, excluding any Precincts already released;
- Precincts not yet released in the North West Growth Centre (NWGC), including Shanes Park and West Schofields; and
- The Western Sydney Employment Area (WSEA).

This report focusses on the North West Growth Centre Precincts of Shanes Park and West Schofields.

1.1 Background and Objectives

The NSW Government is supporting the delivery of Priority Growth Areas to create more opportunities in Western Sydney for homes and employment. It is that by 2031 Sydney's population will grow by an expected 1.3 million and that Western Sydney will be home to more than half of Sydneysiders.

Prioritising growth in key areas allows for more efficient and cost effective infrastructure delivery promoting a more sustainable urban structure. *A Plan for Growing Sydney* identifies Sydney's North West and South West Growth Centres as Priority Growth Areas.

Growth Centre Structure Plans were released in 2005. They outline a broad framework for the development of the area including the location of future urban development, employment land, centres, and road and transport corridors.

Since its release the NSW Government has released and rezoned enough land in the NWGC to allow for a minimum of 46,000 homes and 43,000 jobs. The rezoned Precincts also facilitate development for schools, parklands and major transport infrastructure, such as the Sydney Metro Northwest (formerly the North West Rail Link) and Richmond Road upgrade. With a number of precincts now rezoned and other initiatives such as the Commonwealth Government announcement of the second Sydney airport at Badgerys Creek and roads package, the NSW Government will update its plan for the area to ensure the benefits prioritising growth in key areas are fully realised.

The review of the Growth Centre Structure Plan project is led by DPE in partnership with relevant City Councils, Sydney Water, Transport for NSW and other relevant agencies.

The overarching objective of the project is to update the strategic level land use and infrastructure delivery plan which, once implemented, will improve support of coordinated delivery of the area and deliver on Metropolitan Growth strategies identified for housing and employment.

The Minister for Planning in partnership with the relevant councils will release key areas of the Growth Centres for detailed planning and rezoning to support its delivery and achievement of these strategies.

This project will assist in facilitating the detailed planning and rezoning stages by providing strategies for flooding, water management and riparian corridor considerations along with frameworks for future studies and planning instruments.

1.2 Scope of Works

The scope of works for the structure plan review for NWGC Precincts of Shanes Park and West Schofields is:

- Collation and review of available data
 - flood modelling and mapping
 - review of water management strategies in released growth centre precincts
- Identify gaps and any additional flood modelling (if required)
- Preliminary advice memo/report and preliminary flood maps/GIS
- Identification of potential regional water management strategies
- Provide framework for future detailed flood modelling and water cycle management
- Development of regional water management strategy, parameters and design
- Riparian Corridor Study
- Flood modelling, water management and riparian corridor study report

This report addresses the above scope of works and addresses riparian corridor, flooding and water cycle management in separate sections.

2 Riparian Corridor Study

2.1 Background

Constraints for urban development adjacent to rivers and creeks include physical constraints as well as requirements for additional assessment and approvals under the Water Management Act 2000. The NSW Office of Water released a new policy and set of guidelines for riparian corridors on waterfront land in 2013 that aim to provide greater flexibility in determining riparian protection areas and opportunities for more streamlined assessment processes under the WMA. The new process recognized that the constraints were potentially limiting opportunities for housing development, but there was also a need to ensure that riparian values were adequately protected. The policy included a new matrix of riparian zone widths based on stream ordering and recommendations as to what sort of activities could be included within the riparian zone.

The Policy also provided for the possibility of trading off or offsetting cleared riparian protection areas with other areas that were more suitable in the context of the development.

This report documents the outcomes from a review of existing information including the Guidelines and the existing mapping of riparian protection areas in the Growth Centres and provides a new riparian corridor map for West Schofields and Shanes Park base on the Guidelines and field verification of the stream ordering classification within the two Precincts.

The desktop riparian assessment involved:

- Obtaining the location of hydrolines from NSW Office of Water
- Allocating Strahler stream order to individual reaches to determine their value; and
- Using NSW Office of Water Guidelines determine appropriate buffers around streams

The assessment provides the basis for defining Riparian Protected Area maps and identifying opportunities for modifying riparian land boundaries consistent with the guidelines. Existing riparian protection zone maps for Shanes Park and West Schofields (SEPP 2013) are reproduced in **Appendix A**.

2.2 Guidelines for riparian corridors on waterfront land

The Guidelines prescribe the width of the vegetated riparian zone (VRZ) within the riparian corridor (RC) (**Figure 2-1**) based on the watercourse order according to **Table 2-1**.

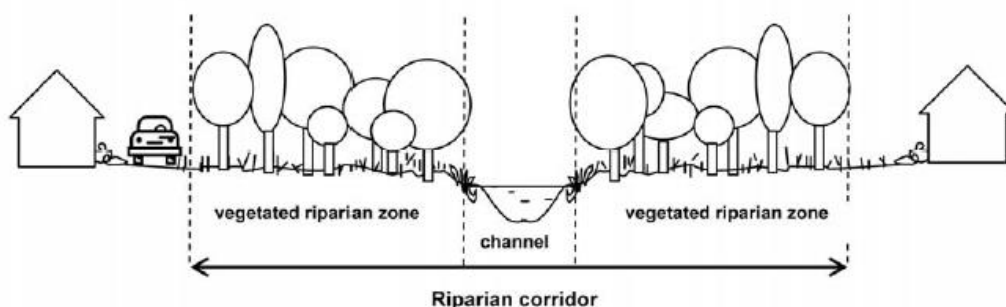


Figure 2-1 The riparian corridor and vegetated riparian zone (reproduced from NSW Office of Water 2013)

Table 2-1 Recommended riparian corridor widths (reproduced from NSW Office of Water 2013)

Watercourse type	VRZ width (each side of watercourse)	Total RC width
1 st order	10 meters	20 m + channel width
2 nd order	20 meters	40 m + channel width
3 rd order	30 meters	60 m + channel width
4 th order or greater (includes estuaries, wetlands and any parts of rivers influenced by tidal waters)	40 meters	80 m + channel width

The watercourse order is defined in accordance with the Strahler System (**Figure 2-2**).

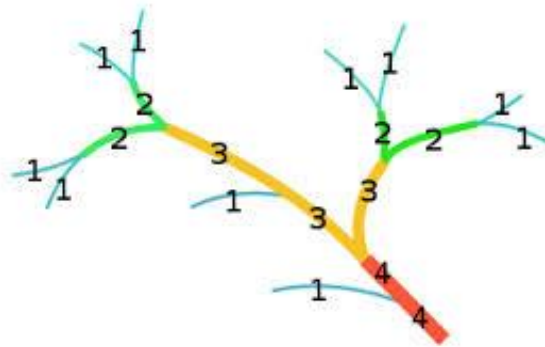


Figure 2-2 The Strahler stream ordering system

The guidelines recommend the following principles to maintain or rehabilitate the environmental functions of RCs:

- Identify whether or not there is a watercourse present and determine its order in accordance with the Strahler System (**Figure 2-2**).
- If a watercourse is present, define the RC/VRZ on a map in accordance with **Table 2-1**.
- Seek to maintain or rehabilitate a RC/VRZ with fully structured native vegetation in accordance with **Table 2-1**.
- Seek to minimise disturbance and harm to the recommended RC/VRZ.
- Minimise the number of creek crossings and provide perimeter road separating development from the RC/VRZ.
- Locate services and infrastructure outside of the RC/VRZ. Within the RC/VRZ provide multiple service easements and/or utilise road crossings where possible.
- Treat stormwater run-off before discharging into the RC/VRZ.

The overarching objective of the controlled activities provisions of the WM Act is to preserve the integrity of riparian corridors. The Office of Water however, does allow for a range of works and activities on waterfront land and in riparian corridors to better meet the needs of the community, so long as they cause minimal harm. These activities are provided in the riparian corridor matrix (**Table 2-2**).

Table 2-2 The riparian corridor matrix (reproduced from NSW Office of Water 2013)

Stream order	VRZ	Offsetting for non RC uses	Cycleways and paths	Detention basins		Stormwater outlet structures and essential services	Stream realignment	Road crossings		
				Only within 50% outer VRZ	Online			Any	Culvert	Bridge
1 st	10m	•	•	•	•	•	•			
2 nd	20m	•	•	•	•	•		•		
3 rd	30m	•	•	•		•			•	•
4 th +	40m	•	•	•		•			•	•

Non-riparian uses, such as Asset Protection Zones are allowed within the outer 50% of the VRZ, so long as offsets are provided in accordance with an averaging rule set out in the Guidelines.

2.3 Methods

2.3.1 Preliminary Desktop Mapping

Streams in Shanes Park and West Schofields precincts were initially categorised based on the Strahler System and a riparian corridor width was assigned to each reach in accordance with the Guidelines (**Table 2-1**). Maps showing preliminary outlines of riparian corridors were produced based on hydroline maps and stream order classification provided by DWE.

2.3.2 Field Investigations

A field inspection of streams within the Shanes Park and West Schofields Precincts was carried out on Monday 27 April 2015 to verify the stream classification, in particular for smaller streams identified in the Precincts.

Streams identified in the preliminary mapping exercise were assigned an identification code based on the Precinct (SP or WS) and preliminary stream order. First and second order streams in particular were visited to verify the presence of a defined bed. Visual inspections were done at the mapped intersections of each stream with the following roads:

Shanes Park:

- Stony Creek Road (stream SP1-3)
- Shanes Park Road (stream SP1-2 and view of SP2-1 from the road)
- Palmyra Avenue (stream SP2-1)
- South Creek Road (SP1-1)
- Eighth Avenue (SP1-1 and South Creek)

West Schofields:

- West Parade (WS1-1)
- Railway Terrace (WS2-1 and WS1-2)
- Bridge Street (WS2-2)
- Grange Avenue (WS1-3)

For first order streams extending into private land (SP1-1, SP1-2, WS1-2 and WS1-3) the probable extent of the bed was assessed based on riparian vegetation visible from the road.

2.4 Results

2.4.1 Preliminary Riparian Corridor Mapping

2.4.1.1 *Shanes Park Precinct*








According to GIS mapping provided by the Office of Water, Shanes Park Precinct is bounded on the western side by South creek (5th order stream, SP5-1) and is traversed by a second order stream in a north-south axis (SP2-1), and a third order stream in its the south-western corner (SP3-1). Three first order streams were also identified (SP1-1, SP1-2 and SP1-3). **Figure 2-3** shows preliminary outlines of riparian corridors in Shanes Park based on hydroline maps and stream order classification provided by DWE.

2.4.1.2 *West Schofields Precinct*

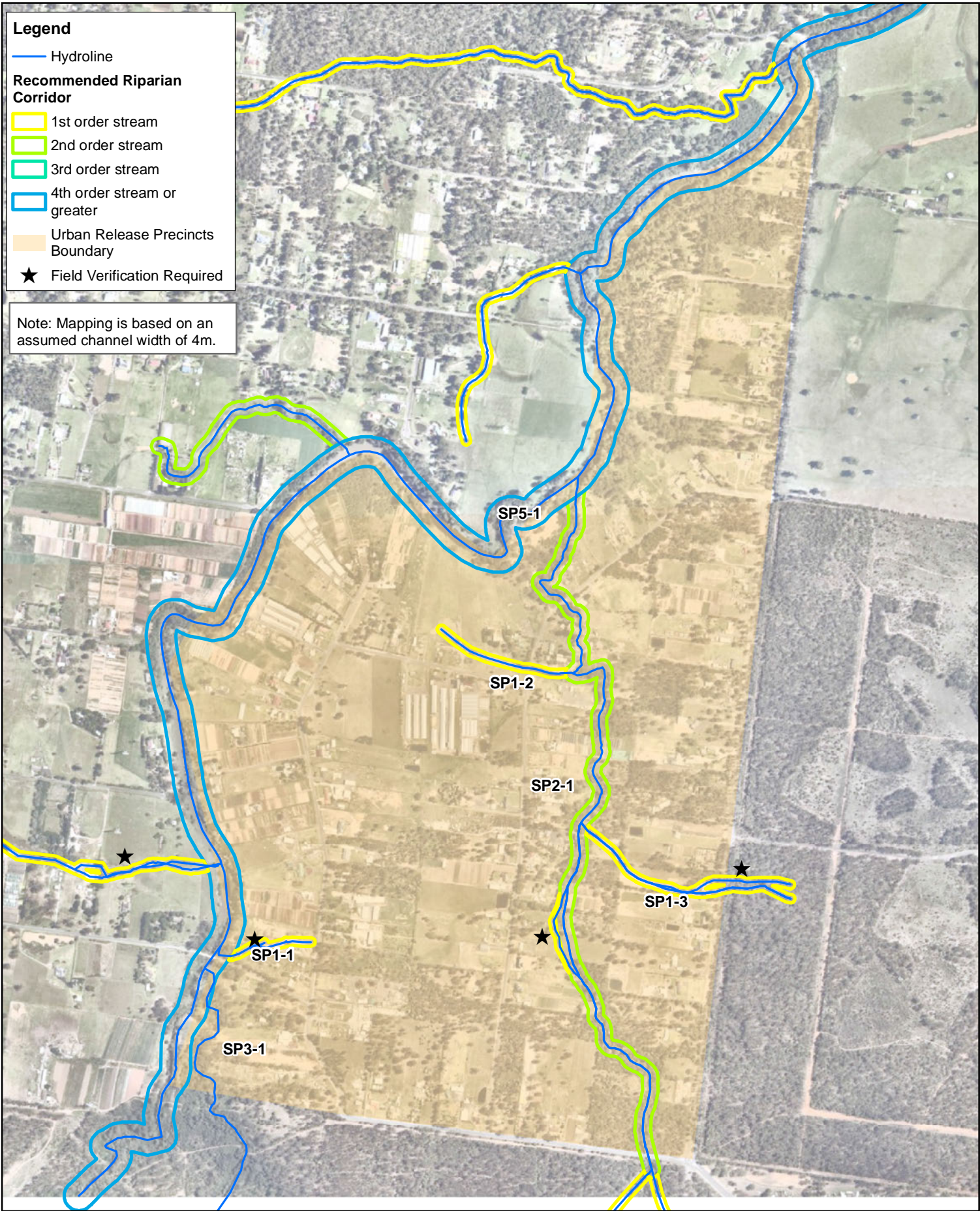
According to GIS mapping provided by the Office of Water, West Schofields Precinct is bounded to the west by Bells Creek (second order stream, WS2-3) and to the East by Eastern Creek (fourth order stream, WS4-1). A number of first order streams traverse the site as well as one second order stream (WS2-1).

Figure 2-4 shows preliminary outlines of riparian corridors in West Schofields based on hydroline mapping and stream order classification provided by DWE.

Legend

-  Hydroline
- Recommended Riparian Corridor**
-  1st order stream
-  2nd order stream
-  3rd order stream
-  4th order stream or greater
-  Urban Release Precincts Boundary
-  Field Verification Required

Note: Mapping is based on an assumed channel width of 4m.



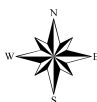
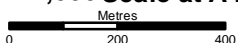
**Riparian Corridor Mapping -
Shanes Park**

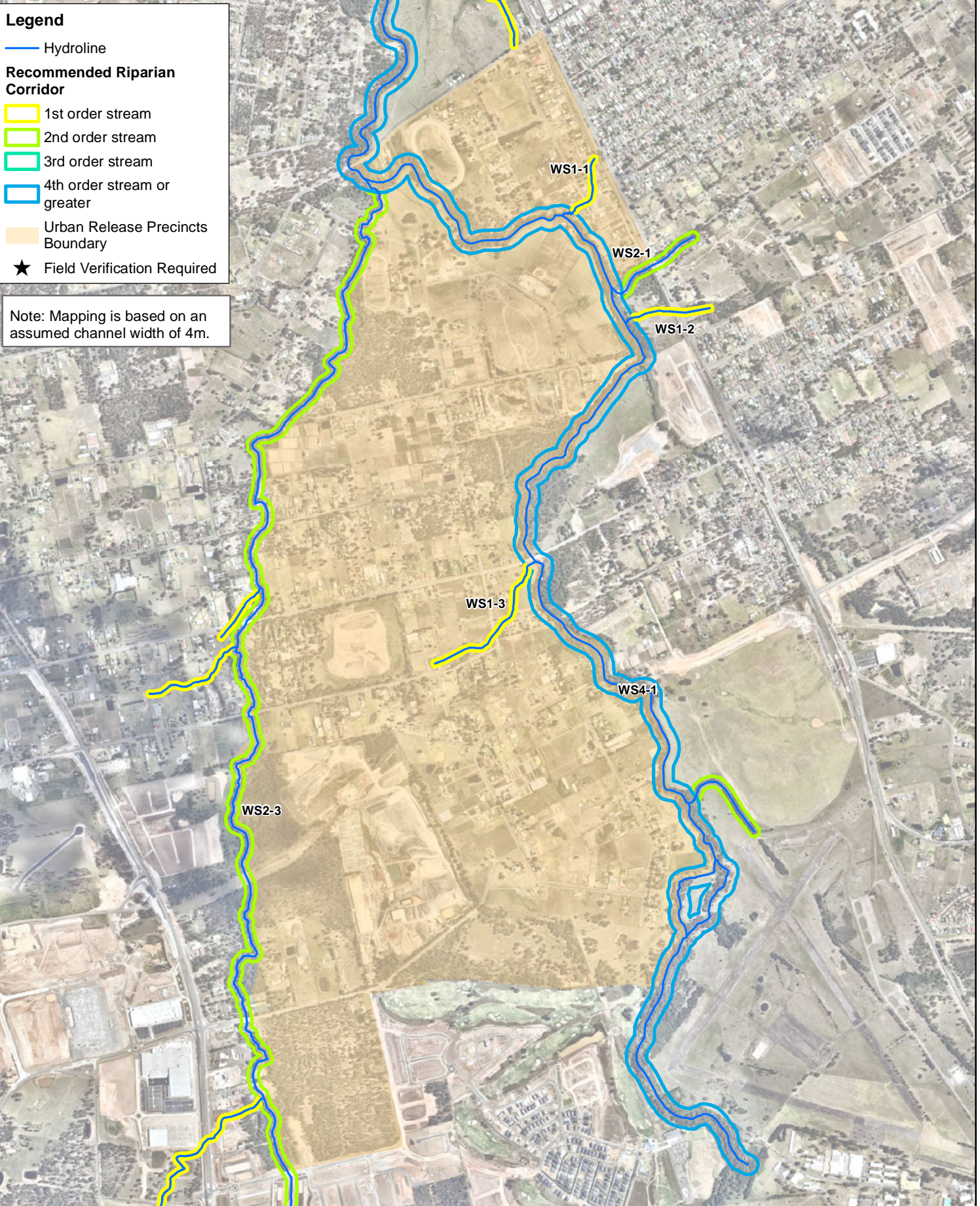
PRIORITY GROWTH CENTRES
STRUCTURE PLAN REVIEW
FIGURE 2-3



Map Produced by NSW/ACT (2812)
Date: 2015-05-29
Coordinate System: GDA 1994 MGA Zone 56
Project: 59915128
Map: 59915128_GS_001_NWGC_RiparianCorridors_Prelim.mxd 03
Aerial Image Source: Nearmap 2014

1:14,000 Scale at A4





Legend

- Hydroline
- Recommended Riparian Corridor**
- 1st order stream
- 2nd order stream
- 3rd order stream
- 4th order stream or greater
- Urban Release Precincts Boundary
- Field Verification Required

Note: Mapping is based on an assumed channel width of 4m.

**Riparian Corridor Mapping -
West Schofields**

PRIORITY GROWTH CENTRES
STRUCTURE PLAN REVIEW
FIGURE 2- 4



Map Produced by NSW/ACT (2812)
Date: 2015-05-29
Coordinate System: GDA 1994 MGA Zone 56
Project: 59915128
Map: 59915128_GS_001_NWGC_RiparianCorridors_Prelim.mxd 03
Aerial Image Source: Nearmap 2014

1:21,000 Scale at A4

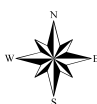
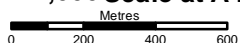




Figure 2-5 Upstream limit of SP1-1 northeast of Eighth Avenue bridge



Figure 2-6 Upstream (left) and downstream (right) view of SP1-2 from Shanes Park Rd



Figure 2-7 Downstream views of SP1-3 from Stony Creek Rd: Directly adjacent to the road (left) and a dam (right) behind the line of trees. The downstream section of the stream is outside of the Precinct boundaries.

2.4.2 Field Investigations

2.4.2.1 *Shanes Park Precinct*

The first order classification of streams SP1-1, SP1-2 and SP1-3 were confirmed during the field visit. A defined bed was noted for SP1-2 at the intersection with Shanes Park Road and could be seen extending approximately 200 m upstream. There was no formed channel further upstream from this point.

A defined bed was confirmed for SP1-3 at the intersection with Stony Creek Road with a dam visible on the western side of the road. On the eastern side of the road there was an ill-defined bed with multiple channels, however this was outside of the Precinct boundary.

The first order classification for SP1-1 was confirmed based on the presence of vegetation corridor adjacent to the Eight Avenue bridge over South Creek (SP5-1). The channel extent was however shorter than indicated by the hydroline maps.

Approximately one week prior to the field inspection, 119 mm of rain was recorded on 21 April 2015 in Sydney, the wettest 24 hr of the city since 2002. Evidence of flooding in South Creek was still evident at the time of the survey with scattered debris on the bridge on Eighth Avenue.

Table 2-3 Results of the field survey of stream order classification in Shanes Park Precinct

Stream ID	Order classification	Rationale for recommended change	Riparian Corridor (+ channel width)
SP1-1	1	Update stream extent based on the absence of defined channel and riparian vegetation in the upper reach indicated by the hydroline map	20 m
SP1-2	1	Update stream extent based on the absence of defined channel more than 200 m upstream from Shanes Park road	20 m
SP1-3	1	N/A	20 m
SP2-1	2	N/A	40 m
SP3-1	3	N/A	60 m
SP5-1	5	N/A	80 m

2.4.2.2 West Schofields Precinct

The first order classification of streams WS1-1 and WS1-3 was confirmed by the visible presence of a defined channel and riparian vegetation at their intersection with W Parade and Grange Avenue respectively.

For WS1-2, there was no obvious channel or riparian vegetation on either side of Railway Parade. Observations from Bridge Street into Lot 1 W Parade also indicated no defined channel or riparian vegetation (it was not possible to stop or access the stream location any closer due to road works in the area).

Table 2-4 Results of the field survey of stream order classification in West Schofields Precinct

Stream ID	Order classification	Rationale for recommended change	Riparian Corridor (+ channel width)
WS1-1	1	N/A	20 m
WS1-2	1 (remove)	No evidence of a channel or riparian vegetation to indicate the presence of a stream. Suggest remove	N/A
WS1-3	1	Update stream extent based on the absence of defined channel more than approximately 80 m upstream from Grange Avenue	20 m
WS1-4	1 (new)	Proposed new stream not present in the hydroline maps. Presence of riparian vegetation indicative of a first order stream	20 m
WS2-1	2	N/A	40 m
WS2-3	2	N/A	40 m
WS4-1	4	N/A	80 m



Figure 2-8 Stream WS1-1 viewed upstream (left) and downstream (right) from W Parade



Figure 2-9 Channel of stream WS1-3 viewed from Grange Avenue

2.4.3 Recommended Updates to Riparian Corridor Mapping

Figure 2-10 and **Figure 2-11** show updated outlines of riparian corridors in Shanes Park and West Schofields recommended following field inspections of the first and second order streams in each Precinct.

Recommended updates to the stream ordering classification and riparian corridor width have been forwarded to Office of Water for confirmation of the proposed changes.

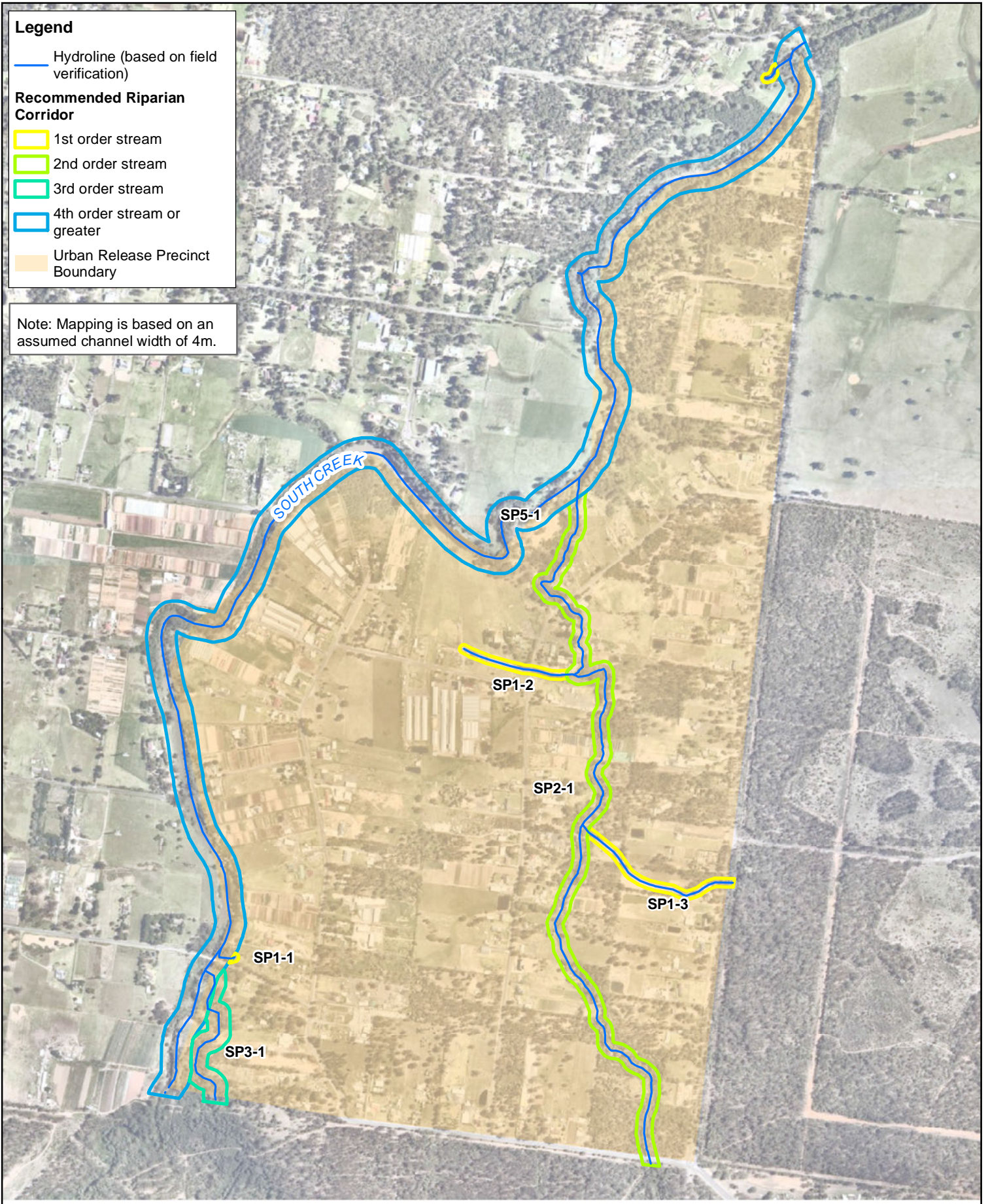
Legend

Hydroline (based on field verification)

Recommended Riparian Corridor

- 1st order stream
- 2nd order stream
- 3rd order stream
- 4th order stream or greater
- Urban Release Precinct Boundary

Note: Mapping is based on an assumed channel width of 4m.



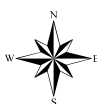
**Riparian Corridor Mapping -
Shanes Park**

PRIORITY GROWTH CENTRES
STRUCTURE PLAN REVIEW
FIGURE 2- 10



Map Produced by NSW/ACT (2812)
Date: 2015-05-29
Coordinate System: GDA 1994 MGA Zone 56
Project: 59915128
Map: 59915128_GS_002_NWGC_RiparianCorridors_AfterFieldVer.mxd 02
Aerial Image Source: Nearmap 2014

1:14,000 Scale at A4



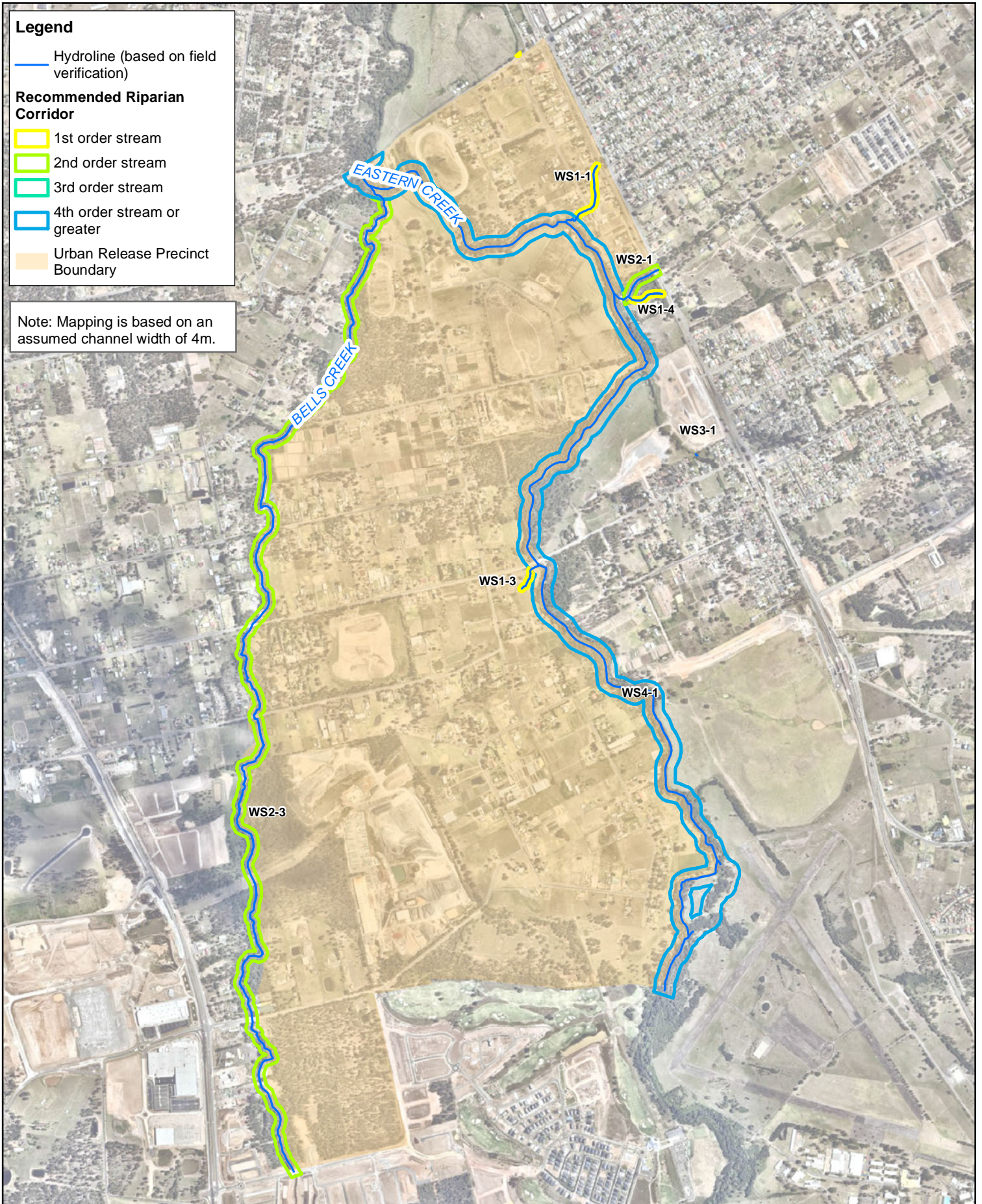
Legend

Hydroline (based on field verification)

Recommended Riparian Corridor

- 1st order stream
- 2nd order stream
- 3rd order stream
- 4th order stream or greater
- Urban Release Precinct Boundary

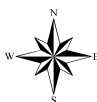
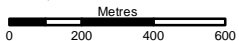
Note: Mapping is based on an assumed channel width of 4m.



**Riparian Corridor Mapping -
West Schofields**



1:21,000 Scale at A4



PRIORITY GROWTH CENTRES
STRUCTURE PLAN REVIEW
FIGURE 2- 11

Map Produced by NSW/ACT (2812)
Date: 2015-05-29
Coordinate System: GDA 1994 MGA Zone 56
Project: 59915128
Map: 59915128_GS_002_NWGC_RiparianCorridors_AfterFieldVer.mxd 02
Aerial Image Source: Nearmap 2014

2.5 Opportunities for streamlining statutory processes

The Riparian Corridor Guidelines allow for a range of works and activities on waterfront land and in riparian corridors to better meet the needs of the community, so long as they cause minimal harm (**Table 2-2**). In particular, non-riparian uses, such as Asset Protection Zones are allowed within the outer 50% of the VRZ, so long as offsets are provided in accordance with an averaging rule set out in the Guidelines.

2.5.1 Shanes Park Precinct

Of the streams investigated within Shanes Park Precinct, SP2-1 and SP3-1 had reaches within the proposed developable land to the south of the Precinct. As a second and a third order stream, their prescribed riparian corridors are characterised by 20 m and 30 m VRZ width respectively. However the riparian vegetation has been completely or primarily removed within a number of properties along SP2-1, namely 74, 84 and 173 Shanes Park Road. For land in accordance with the averaging rule set out in the Guidelines (**Figure 2-12**), non-riparian land uses such as Asset Protection Zones may be authorised within the outer 50% of the VRZ within these Lots, if they are offset by an equivalent area connected to the riparian corridor elsewhere in the Precinct. SP2-1 is largely vegetated within the riparian corridor at the southern end of the precinct (Lots 66, 68, 72 and 74 Stony Creek Road, and Lot 613 Palmyra Avenue) and these areas may be assigned a wider VRZ than the prescribed 20 m, to offset for non-riparian uses in the cleared waterfront lands identified above. This would result in a reduced corridor width assigned to the identified cleared waterfront lands, and a wider corridor width in the southern end of the Precinct (**Figure 2-13**). No other suitable options for offsetting were identified for SP2-1 within the Precinct. Note also that the further north along SP2-1 the more potentially flood affected the land.

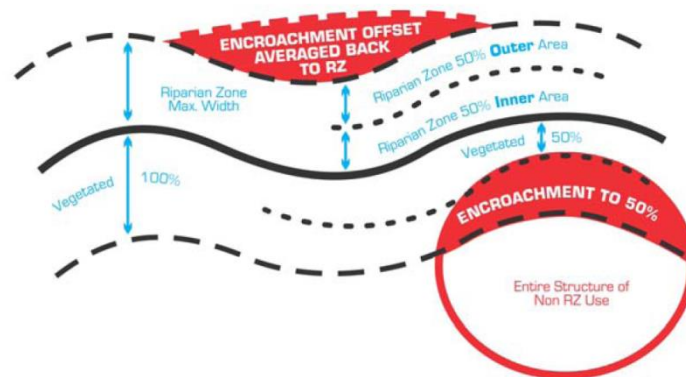
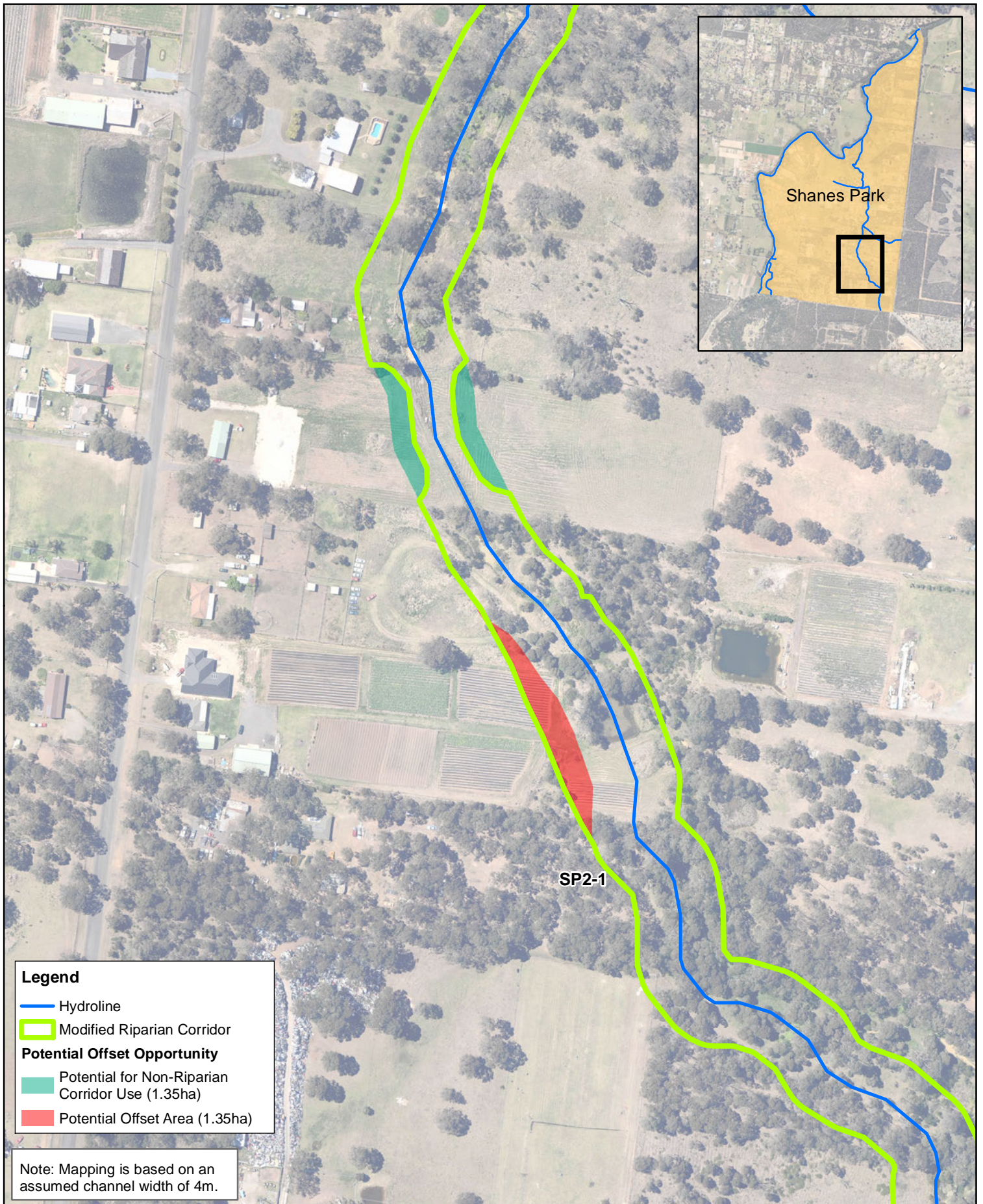


Figure 2-12 Riparian corridor averaging rule (reproduced from NSW Office of Water 2013). The Guidelines state that non riparian corridor works and activities can be authorised within the outer riparian corridor, so long as the average width of the VRZ can be achieved over the length of the watercourse within the development site

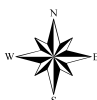
SP3-1 (or Ropes Creek) is a third order stream with a largely intact riparian corridor. No suitable options for offsetting were identified for this stream.

Although the riparian vegetation along the upstream reach of SP1-2 (west of Shane Park Road) is also largely cleared, there was no offsetting opportunity in other areas connected to the riparian corridor further downstream (east of Shane Park Road).



Example Potential Offset Area Shanes Park

1:2,500 Scale at A4



PRIORITY GROWTH CENTRES
STRUCTURE PLAN REVIEW



Map Produced by NSW/ACT (2812)
Date: 2015-05-21
Coordinate System: GDA 1994 MGA Zone 56
Project: 59915128
Map: 59915128_GS_007_NWGC_ExampleOffsetArea.mxd 02
Aerial Image Source: Nearmap 2014

2.5.2 West Schofield Precinct

WS4-1 (Eastern Creek) and WS2-3 (Bells Creek) were the main streams within the West Schofields Precinct. Both of these streams had substantial riparian vegetation coverage through the precinct. Limited offsetting opportunities were identified for these watercourses within the Precinct, except potentially along WS2-3 towards the southern end of the precinct. The riparian vegetation has been primarily removed within Lot 17 South Street, and this cleared waterfront land could be suitable for non-riparian corridor land uses with an equivalent offset area connected to the riparian corridor (e.g. at 74 and 81 Vine Street E).

Between WS4-1 and WS2-3 only one stream was identified in the field (WS1-3). This stream extended only a short distance (< 100m) from WS4-1, and did not provide opportunities for riparian corridor offsets.

The small streams between Eastern Creek and the rail line were largely vegetated although there was an opportunity to enhance the vegetation along WS1-1. WS 1-2 was no longer an identifiable stream.

2.5.3 Broader opportunities for streamlining approvals

Currently the Riparian Corridor guidelines are advisory only. They provide advice to planners/developers that, if followed, there is an expectation that a streamlined assessment will be provided by the Office of Water to a controlled activity application. The guidelines are valuable in that they provide greater certainty as to what is likely to be approved through an application and an expectation that if the proposed activity is consistent with the guidelines there will be a quicker approval process. Ultimately, however a controlled activity approval is required for each proposed activity.

This means that there is minimal opportunity to provide an outcome over a broad precinct where priority riparian area for conservation could benefit from allowing offsets in other lower priority streams (this would vary depending on the scale of individual developments).

The biocertification order for the Growth centres provides an alternative model for consideration. This model identifies areas of high conservation value land to be preserved, areas subject to assessment, areas subject to agreed offset requirements and areas that can be cleared without the need for further assessment. The order applies across the growth centres and provides clear outcomes for any development regardless of the scale. It removes the need for any separate assessment for threatened species or potential requirement for a Species Impact Statement as long as the proposal is consistent with the certification conditions. In addition, the certification process places an obligation on the Growth Centres to achieve overall outcomes for conservation both within and outside of the growth centres.

In theory, a similar certification approach could be applied for riparian land within an identified area of land. The Water Management General Regulation (2011) provides for exemptions from the need to seek a controlled activity approval. There are two relevant exemptions listed in Schedule 5 of the regulation – development at Rouse Hill Regional Centre and development at Oran Park and Turner Road. These exemptions operate where development is undertaken in accordance with a published development control plan (Rouse Hill) or a waterfront land strategy as published in the Government Gazette (Oran Park).

The approach would be to:

1. Identify on a plan the riparian zone widths subject to controlled activity approval based on the approach outlined in the Guideline
2. Identify the activities allowed within the inner and outer riparian zone in accordance with the Table
3. Identify priority riparian offset areas for a precinct/s so that the most beneficial outcome for riparian environments can be encouraged
4. Outline the process by which variations could occur for non-riparian zone activities within the outer riparian zone. This process would operationalise the offset rule in the guideline without the need to seek approval for each individual project. The process would include conditions such as offsetting is not allowed if clearing of riparian vegetation would occur within the riparian zone.
5. Require the need for approval for activities that fall outside of the agreed plan.

Further discussions between NSW Planning and Environment and the Office of Water are recommended to agree on a proposed approach. However, there are limited opportunities for improving developable land area in Shanes Park and West Schofields given the large areas of land inundated by flooding and the small

number of low order streams and associated riparian corridors. It is recommended that streamlining the statutory process will not be significantly advantageous for aiding growth centre development in these two precincts.

3 Flooding

3.1 Introduction

Cardno has undertaken a search of relevant available flood studies and has requested data from Councils through DPE. This included:

- Online search for publicly available flood study information and flood maps
- Request for flood studies and data from Councils through DPE
- Request for GIS information for flood extents, levels and depths for 100 year ARI and PMF events (from Councils)
- flood study catchment boundaries (from Councils)
- access to copies of existing flood models (hydrology and hydraulic models) as necessary from relevant Councils

The relevant flood studies for the yet to be released NWGC precincts are:

- West Schofields – Eastern Creek Flood Study, Hawkesbury-Nepean Flood Study
- Shanes Park – South Creek Flood Study, Hawkesbury-Nepean Flood Study

GIS information for flood extents for Eastern Creek and South Creek has been provided by Blacktown City Council and the following assessment utilises this information along with additional flood information and maps from relevant flood studies.

3.2 Existing Flooding Regime

3.2.1 Shanes Park Precinct

The Shanes Park precinct lies within the South Creek catchment which is part of the broader Hawkesbury-Nepean catchment. South Creek runs along the western and northern boundaries of the precinct and joins Eastern Creek further north before discharging into the Hawkesbury River. The study that covers the Shanes Park Precinct is the **Updated South Creek Flood Study** undertaken by Worley Parsons (2014) for Penrith City Council (PCC). The primary objective of the study was to define the existing flood behaviour for the South Creek catchment.

The South Creek study catchment extends from its headwaters near Narellan in the south, to its confluence with the Hawkesbury River near Windsor covering 240 km² and drains predominantly from south to north collecting flows from a number of tributaries along its length.

An XP-RAFTS model and RMA-2 model was used for hydrologic and hydraulic modelling respectively for the flood study.

Flooding within the Shanes Park area is influenced by both the South Creek local flooding as well as by backwater flooding from the Hawkesbury River. The 100yr ARI and PMF flood extents within Shanes Park are shown in **Figure 3-1**. It can be seen from this figure that approximately 55% of Shanes Park precinct is inundated for the 100 year ARI event and approximately 90% of the precinct is inundated in the PMF event, with only the middle southern portion remaining flood free.

The **Updated South Creek Flood Study** (Worley Parsons, 2014) provides further definition of the flood characteristics including flood extents, depths, velocities, hydraulic categories and hazard. As such, figures from the WorleyParsons report are reproduced in **Appendix B** to illustrate the flood characteristics. As noted above, approximately 55% of Shanes Park precinct is inundated for the 100 year ARI event. The majority of inundation is categorised as high hazard and the hydraulic category is predominantly flood storage in 100yr ARI event according to Figure 7.10 and 7.27 of the WorleyParsons report (reproduced in **Appendix B**) respectively. This indicates that there is likely limited opportunity for cut and fill to be carried out within the floodplain in Shanes Park.

3.2.2 West Schofields Precinct

The West Schofields precinct is bounded by Eastern Creek to the east and Bells Creek to the west. The two creeks join at a confluence in the north of the Precinct before Eastern Creek continues north to flow to the

Hawkesbury River. Flood extents for the 100yr ARI and PMF events were provided by Blacktown City Council and are shown in **Figure 3-2**.

The study that covers the West Schofields Precinct is the **Eastern Creek Flood Study** currently being undertaken by Catchment Simulation Solutions for Blacktown City Council (BCC). The primary objective of the study is to define the existing flood behaviour for the South Creek catchment. XP-RAFTS and TUFLOW models are being used for hydrologic and hydraulic modelling respectively for the analysis. It is anticipated that the study will be completed during 2015, however, BCC have advised that preliminary results indicate similar flood extents to those already provided due to the dominance of the Hawkesbury River flooding in this area. At present, only flood extents are available and there is no direct flood information available to inform the flood levels, depths, hydraulic category or hazard for Eastern Creek in this area.

Flooding within the West Schofields area is influenced by both the Eastern Creek and Bells Creek local flooding as well as by backwater flooding from the Hawkesbury River. The 100yr ARI and PMF flood extents within West Schofields are shown in **Figure 3-2**. It can be seen from this figure that approximately 50% of West Schofields precinct is inundated for the 100 year ARI event and approximately 75% of the precinct is inundated in the PMF event. There is a ridgeline through the middle of the precinct which extends to the southern boundary and this portion remains flood free. Interrogation of Blacktown City Council online maps shows that there are some areas along Eastern Creek which are between the Medium and High flood hazard that may be candidate areas for cut and fill.

Further consultation with Blacktown City Council will be required in future to obtain flood information from the Eastern Creek Flood Study when available.

3.3 Flood Considerations for Development

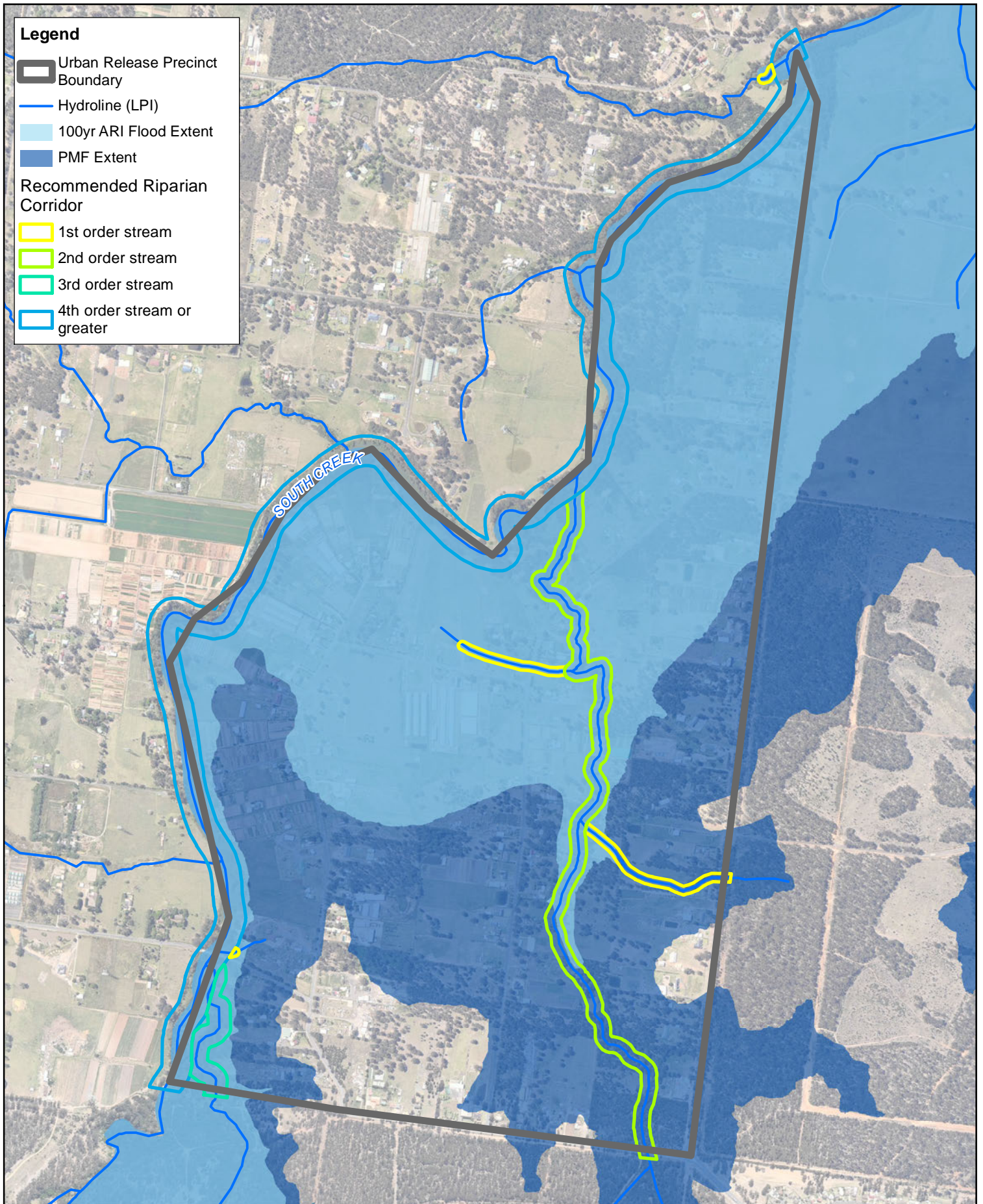
There are a number of key flood considerations to be taken into account when planning development:

- Identifying flood behaviour
- Setting flood planning levels for different land use types
- Land use planning to reduce or eliminate flood risk and flood damages
- Management of stormwater
- Flood evacuation

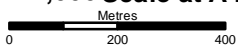
The Hawkesbury-Nepean Flood Management Advisory Committee commissioned the production of flood-specific planning guidelines which are available on the NSW State Emergency Services (SES) website (<http://www.floodsafe.com.au/information-for-councils/information-for-land-use-planners-and-developers>):

1. MANAGING FLOOD RISK THROUGH PLANNING OPPORTUNITIES: Guidance On Land Use Planning In Flood Prone Areas
2. DESIGNING SAFER SUBDIVISIONS: Guidance On Subdivision Design In Flood Prone Areas
3. REDUCING VULNERABILITY OF BUILDINGS TO FLOOD DAMAGE: Guidance On Building In Flood Prone Areas

The above references provide useful guidance on the considerations for development within the Hawkesbury River floodplain, however, much of the guidance is applicable more generally to all floodplains.



1:14,000 Scale at A4

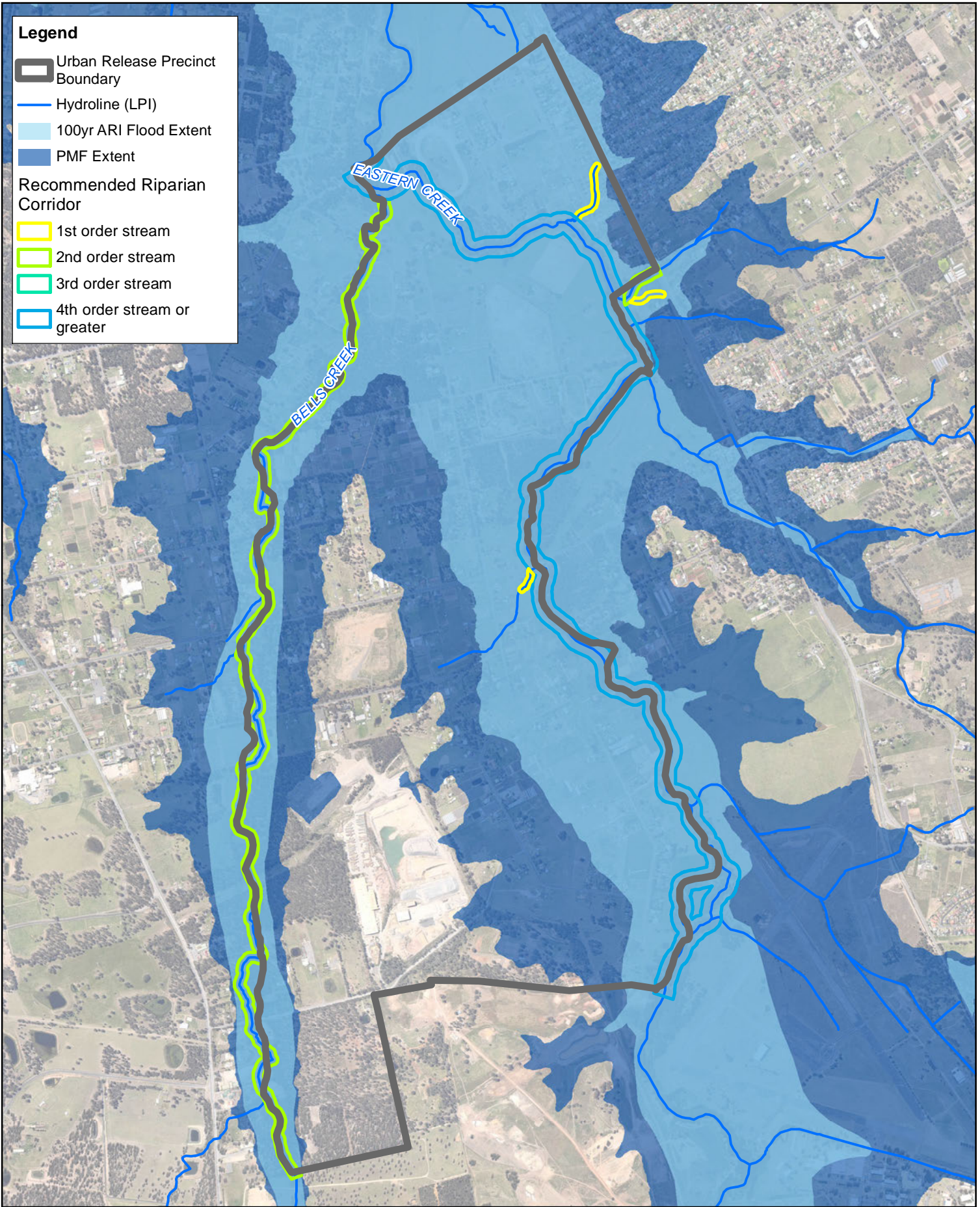


Flood Extents Shanes Park









PRIORITY GROWTH CENTRES
STRUCTURE PLAN REVIEW
FIGURE 3-1



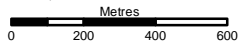
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Date: 2015-05-29
Coordinate System: GDA 1994 MGA Zone 56
Project: 59915128
Map: 59915128_GS_003_NWGC_FloodExtents_wRipCorr.mxd 02
Aerial Image Source: Nearmap 2014



Legend

-  Urban Release Precinct Boundary
-  Hydroline (LPI)
-  100yr ARI Flood Extent
-  PMF Extent
- Recommended Riparian Corridor**
-  1st order stream
-  2nd order stream
-  3rd order stream
-  4th order stream or greater

1:21,000 Scale at A4



**Flood Extents
West Schofields**

PRIORITY GROWTH CENTRES
STRUCTURE PLAN REVIEW
FIGURE 3-2



Map Produced by NSW/ACT (2812)
Date: 2015-05-29
Coordinate System: GDA 1994 MGA Zone 56
Project: 59915128
Map: 59915128_GS_003_NWGC_FloodExtents_wRipCorr.mxd 02
Aerial Image Source: Nearmap 2014

3.4 Flood Planning Policies and Plans

3.4.1 SEPP (Sydney Region Growth Centres) 2006

The SEPP (Sydney Region Growth Centres) 2006 includes heads of consideration in Part 5 - Development Controls – flood prone and major creeks land.

Part 5 Clause 19 – “Development on flood prone and major creeks land—additional heads of consideration” outlines the requirements for demonstrating the impacts of development on flooding regarding the consent of such development.

3.4.2 Blacktown City Council Development Control Plan (2006)

The BCC DCP 2006 contains two sections which relate to flood controls:

- 8.0 Development on Flood Prone Land
- 9.0 Local Overland Flooding – Major Drainage and Local Runoff

The DCP highlights that in general, Council will not support development, including the filling of land, within the floodway, but will accept filling in the flood fringe. Specific requirements must be met and any impacts of proposed developments must be demonstrated through flood modelling.

Flood planning levels are defined by a "Design Floor Level" - A level which is 500mm above the Designated Flood Level for residential buildings and is 300mm above that level for commercial and industrial buildings.

3.5 Flood Evacuation

While the 100 year ARI event is used in determining flood planning levels for development, flood events larger than the 100 year ARI will also result in properties becoming flood affected. Consequently, emergency planning and response must be considered in the development of the site.

Emergency planning will be required to consider:

- Flood timings and peak flood depths for large flood events;
- Levels at which local and regional access roads become cut by floodwaters;
- Access from individual lots to local and regional evacuation routes, and how this access is impacted by rising flood waters;
- Rate of rise of flood waters;
- Warning times available; and,
- The flood preparedness of the community.

The outcomes of the above assessments will enable the development of an appropriate emergency response plans to be prepared for the developments.

It would be expected that evacuation would be the primary emergency response, although some form of shelter in place / vertical evacuation may also need to be provided if the emergency assessment finds that a safe and orderly evacuation is not feasible for the entirety of the precinct.

Ideally, no critical infrastructure such as hospitals, retirement villages, child care centres, schools, etc. should be planned within the PMF extent. This will avoid the need for evacuation of such facilities which could prove problematic as well as removing the risk of flood damage for such services so they can continue to operate during and after a major flood event.

Planned transport infrastructure will need to consider the flood evacuation routes including the ability to provide flood immunity to such infrastructure so as they are not cut off during the flood. Some flood extents are quite significant and proposed transport routes will need to consider flood immunity of the infrastructure, minimising flood impacts on the floodplain and mitigation strategies (viaducts and flood relief bridges/ culverts).

SES (2006) states that “Identifying the evacuation requirements arising from an increase in households and assessing the practicality and feasibility of providing adequate evacuation routes, is an essential part of any

rezoning or large-scale residential development proposal on the floodplain. Care should be taken to ensure that the evacuation of new residents from the floodplain does not adversely impact on any evacuation strategy already in place for existing floodplain communities. If new development would result in traffic conflict on existing evacuation routes resulting in evacuees being trapped in areas below the PMF unable to drive out in the time available, then alternative evacuation routes should be found for the new development”.

This document along with the Hawkesbury-Nepean River Floodplain Risk Management Plan (Bewsher, 2012), also indicates that current Hawkesbury floodplain evacuation routes from the Windsor Downs and Bligh Park areas are to the South via Richmond Road to identified evacuation centres at Rooty Hill and Blacktown. Flood evacuation route maps from these reports are reproduced in **Appendix B**.

Figure 3-3 shows the flood extents for broader NWGC showing the two Precincts within the flood evacuation context. Flood evacuation will largely be to higher ground in the centre of the Precinct or to the south if evacuation centres are situated outside the precinct.

3.6 Developable Land

The NSW government’s Floodplain Development Manual recommends that new residential development be located preferably on land at or above the 1% or 1 in 100 AEP flood level plus freeboard. As such, this renders significant areas of land undevelopable within both the Shanes Park and West Schofields Precincts. **Table 3-1** shows the areas of land outside the 100 year ARI event and PMF flood extents which may be considered developable.

Table 3-1 Land areas not affected by flooding

Precinct	Precinct Area (ha)	Area not affected by 100 year ARI (ha)	Area not affected by PMF (ha)
Shanes Park	319	145	27
West Schofields	576	280	143

In order to maximise the developable area, filling may be proposed, however, this potentially has the effect of altering the flood behaviour and may lead to increases in flood levels on adjoining properties as well as changing the distribution of flow and velocities. Such outcomes are adverse impacts and hence any filling must be offset by an equivalent amount of cut (excavation) within the same vicinity to maintain the same floodway and flood storage volumes. This will ensure that any flood impacts are kept to a minimum or mitigated.

The area of developable land must not increase the quantity of runoff entering waterways so as to minimise flood impacts of the development. New developments change the land use and generally increase the amount of impervious areas, thereby increasing runoff. As such, the land use mix must consider the total percentage impervious which can be managed and the layout plans must also include sufficient space for detention storage measures for flood management. This topic is further addressed in Section 4.5.1 of this report.

3.6.2 Filling in the Floodplain

In order to increase developable land within the Precincts, a limited degree of filling within the flood fringe areas of the floodplain may be undertaken to facilitate the creation of workable subdivision layouts. Filling should generally be restricted to those areas of the floodplain where the 100 year ARI flood depth is less than 300 mm to minimise any increase in flood risk for future developments. The filling above the 100 year ARI flood level should be minimised such that larger flood events are permitted to overtop the fill areas in a similar manner to existing conditions.

Cut and Fill within flood storage areas may also be acceptable, but should be limited to areas within the same ownership and/or tract of land to maintain floodway and storage volumes. i.e. wholesale cut and fill across the precinct or on opposite sides of the waterway is generally undesirable unless this is part of a

major subdivision development and it is demonstrated that there are no impacts outside this development. Changes to flood behaviour should be localised and not shift the velocity or hazard to another locality.

No cut and fill will be permitted in high hazard areas and no new development will be permitted within the 100 year ARI flood extents.

Filling should be restricted to areas within the floodplain that are outside the core riparian corridor zones and an assessment of the impact of any proposed filling should be undertaken in accordance with the requirements of the SEPP (2006) and the BCC DCP (2006).

3.6.3 Cumulative Impacts and Regional Flood Model

Each precinct within the NWGC other than Shanes Park and West Schofields is either currently being modelled or has already had flood modelling undertaken for tributaries discharging to the Hawkesbury River floodplain.

The main item which has not been considered widely in precinct modelling is the cumulative impacts of the development within one precinct on other precincts. This interconnectedness of flooding between precincts is particularly significant in the NWGC area where peak flooding is dominated by the Hawkesbury River backwater flood behaviour.

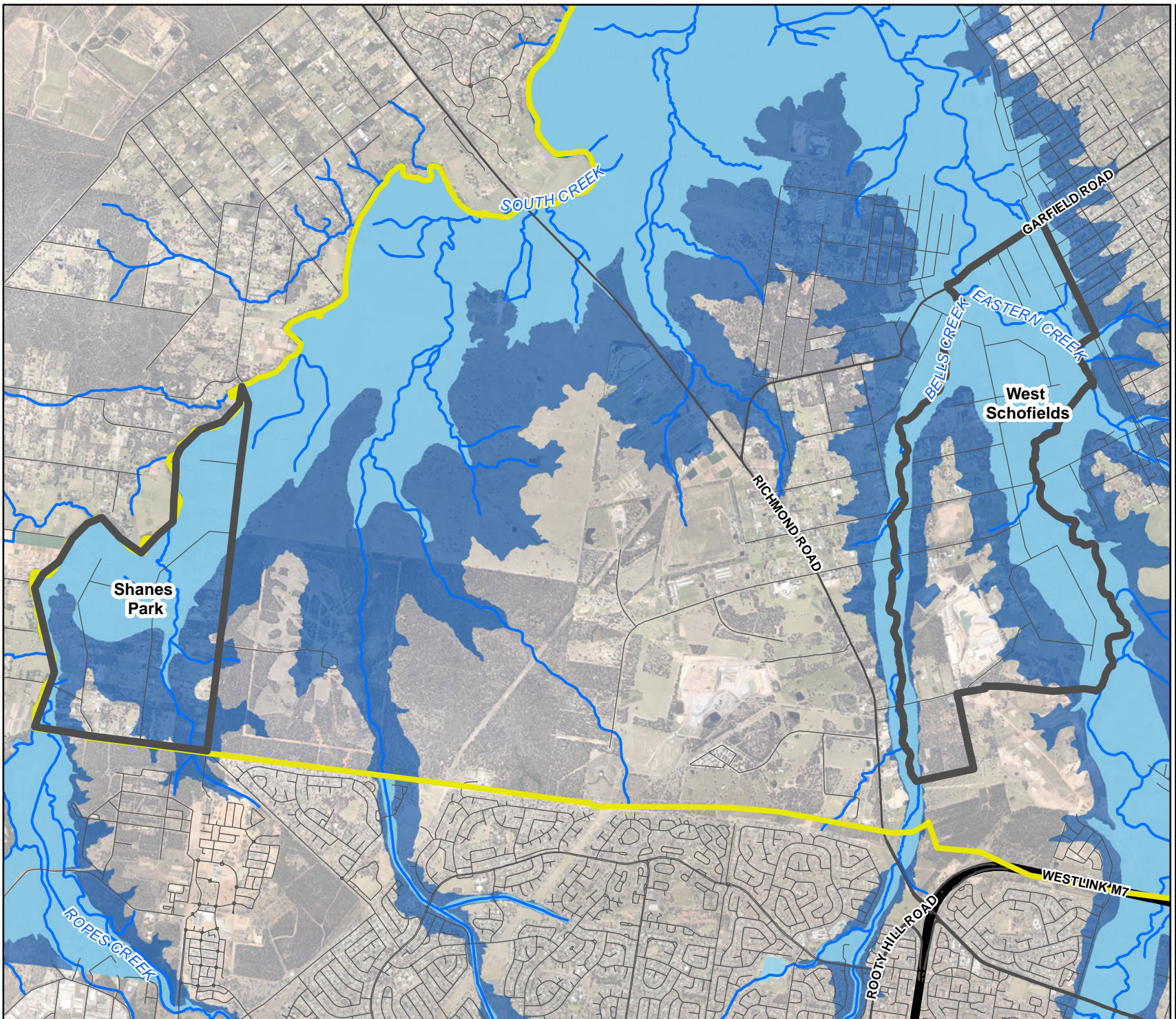
Minor flood impacts from individual developments can add up to more significant cumulative impacts to adjacent areas. Further, reasonably large changes to developable area through use of cut and fill techniques may have a relatively minor impact in the immediate vicinity of the changes, however, such impacts may have a more pronounced change in an adjacent tributary or precinct or for the local catchment flood.

In previous precinct modelling, it has generally been assumed that flows from an upstream precinct would have to be managed to maintain pre-development (existing) flows and so existing flows are assumed to apply at the upstream boundary and downstream boundary. However, this may overlook the potential for cross precinct boundary benefits, whereby detention in an upstream precinct may benefit a downstream precinct and offer additional developable land opportunities. Further, development is often limited in the downstream precinct in order to maintain no impact on an upstream precinct. However, this may not consider a situation where flood impacts from a downstream precinct are abated over a relatively short distance within the upstream precinct. In this situation, a greater area of developable land may be achieved in the downstream precinct compared with the land area that is now flood affected in the upstream precinct. Flood results from one precinct may need to be employed as the Boundary conditions for an adjacent precinct.

Notwithstanding the above commentary, it is not considered beneficial to develop a regional flood model to examine cumulative impacts within the NWGC. Flood modelling has already been carried out for a large number of precincts within the NWGC and a regional flood model would not necessarily offer any advantages at this stage of the planning process. In addition, the area is dominated by the Hawkesbury River backwater and cut and fill activity has a negligible impact on reducing Hawkesbury River floodplain storage, particularly seeing as the majority of precincts avoid major cut and fill within the 100 year ARI flood extent.

The exception is Riverstone Precinct, which has had detailed modelling of a significant cut and fill balance proposal and a specific Clause in the SEPP 2006 (Part 5, Clause 20) has been included to address this area. This modelling demonstrates that there is no impact on the peak maximum 100 year ARI flood levels resulting from the filling proposal.

Eastern Creek and Bells Creek are the main creeks which run through multiple precincts, such that the Eastern Creek Flood Study model is effectively a sub-regional model. It is recommended that when the Eastern Creek Flood Study is completed that this model be utilised for incorporating the ILPs of the individual Precincts such that this model is used as the baseline for future impact assessments as individual developments come online. A central master model could be managed through Blacktown City Council with a regular update to the model as developments occur. The master model can be updated regularly with new developments and the new revision made available for future developers.



Flood Extents Overview

PRIORITY GROWTH CENTRES
STRUCTURE PLAN REVIEW

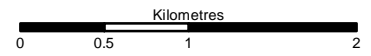
Legend

- Urban Release Precinct Boundary
- North West Growth Centre Boundary
- Hydroline (LPI)
- 100yr ARI Flood Extent
- PMF Extent
- Roads (LPI)
 - Motorway
 - Primary Road
 - Arterial Road
 - Road



FIGURE 3-3

1:45,000 Scale at A4



Map Produced by NSW/ACT (2812)
Date: 2015-05-29
Coordinate System: GDA 1994 MGA Zone 56
Project: 59915128
Map: 59915128_GS_004_NWGC_FloodExtents_Overview.mxd 02
Aerial Image Source: Nearmap 2014

3.7 Framework for Future Modelling

A reasonable and consistent approach has been adopted for flood modelling for previously released Precincts within the NWGC.

The following framework for future flood modelling of the precincts is proposed:

- Flood modelling is to build on existing flood models developed for South Creek (Shanes Park) and Eastern Creek and Bells Creek (West Schofields). This will ensure consistency of results when comparing with existing conditions.
- Flood Modelling is to consider both the local catchment flood scenarios as well as the maximum flood scenario (backwater from the Hawkesbury River = 17.3mAHD at Windsor)
- Modelling should consider overland flows within the precinct to enable identification of trunk drainage requirements and floodways should be established.
- Any proposed cut and fill scenarios need to consider the existing flood extents, hydraulic category and hazard in determining suitability for a cut and fill balance approach.
- Cut and Fill should be limited to localised areas of single ownership land or a tract of land where development will be occurring at the same time such that there are no significant impacts to adjoining properties and to avoid cumulative impacts
- No cut and fill should be permitted in floodways or high hazard areas
- Any proposed basins (on-line or offline) should be included in the model to demonstrate the retarding function and compliance with not increasing runoff from the development areas
- Modelling is to demonstrate that there is no adverse impacts in accordance with the requirements of Part 5, Clause 19 of the Sydney Growth Centres SEPP (2006) and Section 8 and Section 9 of the BCC DCP (2006)
- Flood impact assessments should consider the impacts of Blockage and Climate Change
- Any sub-precinct scale flood modelling for determining flood impacts for individual developments should be integrated in the precinct wide flood modelling to check the cumulative impacts are acceptable.

3.8 Recommendations

It is recommended that the Structure Plans and Precinct Indicative Layout Plans (ILPs) need to consider:

- **Developable Land** - There is limited opportunity for a cut and fill approach to maximise developable land within Shanes Park and West Schofields, however, should be considered to allow appropriate development layouts. Such cut and fill should be localised and minor and should not encroach on the riparian corridor zone.
- **Land Use** - Land within the 100 year ARI extents should be adopted as green space (agriculture, open space, recreation or conservation areas). This flood extent aligns with or exceeds riparian corridor zones and hence seeks to achieve the riparian corridor objectives as well.
- **Overland Flows** - Appropriate overland flow floodways should be provided within the catchment to compliment the underground drainage system and ensure that development has appropriate flood immunity with regards overland flows not just mainstream flooding. Ideally natural open waterways are preserved to serve this function. Flood planning controls on lots adjacent to floodways may be required.
- **Flood evacuation** - Land use planning and transport infrastructure planning need to have a strong consideration of flood evacuation, particularly for planned development on land between the 100 year ARI and PMF flood extents. Critical Infrastructure should be planned to be on land outside the PMF flood extent.

Often development within the precincts occurs in a piecemeal fashion, where in some cases, individual lots are purchased and developed or in other cases multiple land parcels are developed together as part of a

major subdivision development. The former case, in particular, represents challenges in aligning the individual development interim flood impacts with the Ultimate ILP proposed flood regime.

The ultimate precinct wide development ILPs should be kept in mind when formulating DA conditions of approval. Council may need to give consideration to adopting an interim acceptable flood impact on individual parcels of land during development where parcels of land are being developed in a non-sequential, piecemeal fashion.

Alternatively, consideration may be given to a more coordinated land purchase and release within pockets or tracts of land to control the concentration of development to manage impacts. This may be necessary where a significant cut and fill approach is proposed across multiple lots in order to achieve a net zero floodplain storage loss and meet flood objectives. This is effectively the approach and outcome associated with a single ownership large-scale subdivision development.

4 Water Cycle Management

4.1 Introduction

Water cycle management is a holistic approach that addresses competing demands placed on a region's water resources, whilst optimising social benefits and enhancing and protecting the environmental values of receiving waters.

Developing a water cycle management strategy at the planning stage of the land development process provides guidance on urban water management issues to be addressed. This assists urban rezoning and infrastructure planning for new residential, commercial or industrial development (including redevelopment) areas.

This water cycle management strategy provides a framework for integrating land use and water management for the planning of Shanes Park and West Schofields Precincts. A precinct's water characteristics (both pre- and post-development) – including groundwater, waterways, drinking-water-source areas, stormwater and wastewater – are an important consideration when determining its final urban form.

4.2 Precinct Analysis

An analysis of the following North West Growth Centre Precincts Water Cycle Management Plans was undertaken to develop the water cycle management strategy:

- Area 20;
- Box Hill and Box Hill Industrial;
- Marsden Park Industrial;
- Marsden Park;
- Vineyard;
- Riverstone and Alex Avenue;
- Riverstone West;
- Riverstone East; and
- Schofields.

Water Cycle Management Plans for the following Precincts were not available to include in the review process:

- Marsden Park North;
- North Kellyville; and
- Colebee.

A summary of the analysis identifying the water cycle management measures and parameters is provided in **Table 4-1**.

Table 4-1

Analysis of North West Growth Centre Precinct Water Cycle Management Plans

		PRECINCT								
		SCHOFIELDS	RIVERSTONE & ALEX AVENUE	RIVERSTONE EAST	VINEYARD	MARSDEN PARK	MARSDEN PARK INDUSTRIAL	BOX HILL & BOX HILL INDUSTRIAL	AREA 20	RIVERSTONE WEST
Local Government Area		Blacktown Council	Blacktown Council	Blacktown Council	Hawkesbury City Council	Blacktown Council	Blacktown Council	The Hills Shire Council	Blacktown Council	Blacktown Council
Post development impervious percentages used in the model		Overall fraction impervious - 85%	Low density impervious area - 75% Medium Density/ Commercial impervious area - 90%	Urban residential fraction impervious - 85% Parklands fraction impervious - 15%	Urban residential fraction impervious - 85% Parklands fraction impervious - 5%	Overall fraction impervious - 85%	Data not available in the report	Average impervious area - 75%	Overall fraction impervious - 85%	Information not available in the report
QUANTITY	Targets	Pre & Post development peak flood levels to match for all events upto 100yr Env flows Stream Forming Ratio 3.5-5.0:1.0	Pre & Post development peak flood levels to match for all events upto 100yr Env flows Stream Forming Ratio 3.5-5.0:1.0	Pre & Post development peak flood levels to match for all events upto 100yr	Pre & Post development peak flood levels to match for all events upto 100yr	Data not available in the report	Pre & Post development peak flood levels to match for all events upto 100yr Env flows Stream Forming Ratio 3.5-5.0:1.0	Pre & Post development peak flood levels to match for all events upto 100yr Env flows Stream Forming Ratio 3.5-5.0:1.0	No peak flow targets because a trunk drainage strategy already implemented. Env flows Stream Forming Ratio 3.5-5.0:1.0	Due to location, focus is on prompt stormflow discharges to the creek Pre & Post development peak flood level attenuation requirement waived.
	Treatment Measures	No lot scale detention Combination of online and offline regional detention basins							No detention required	No basins provided
QUALITY	Pollution Reduction Targets	Gross Pollutants - 90% Total Suspended Solids - 85% Total Phosphorus - 65% Total Nitrogen - 45%				Data not available in the report	Gross Pollutants - 90% Total Suspended Solids - 85% Total Phosphorus - 65% Total Nitrogen - 45%			
	Treatment Measures - Lot Scale	Rainwater tanks - minimum BASIX requirement				Data not available in the report	Gross Pollutant Traps and bioretention systems - Industrial and commercial lots	Rainwater tanks - minimum BASIX requirement		
	Treatment Measures - Regional Scale	Gross Pollutant Traps Swales Bioretention (Raingardens)	Gross Pollutant Traps Bioretention (Raingardens)	Gross Pollutant Traps Swales Bioretention (Raingardens)	Gross Pollutant Traps Bioretention (Raingardens)	Data not available in the report	Bioretention (Raingardens)	Gross Pollutant Traps Bioretention (Raingardens)	Gross Pollutant Traps Bioretention (Raingardens)	Gross Pollutant Traps Filter Strips and Grass Swales Spill Containment Systems
Cut and Fill		Due to flat terrain and located at the edge of the floodplain, upto 300mm minor filling depths proposed	Stepped basins proposed to reduce costs of soil disposal	Stepped basins proposed to reduce costs of soil disposal	Localised filling proposed in existing widespread shallow flow areas to increase developable land	Opportunities investigated to reduce imported fill requirement	Data not available in the report	Limited filling in the floodplain	Data not available in the report	Cut and fill approach proposed to increase developable land. Cut in the low lying areas and fill in areas proposed for development.

4.3 Catchment Drainage

4.3.1 Shanes Park

Shanes Park Precinct is located directly adjacent to South Creek. The Precinct either drains directly to South Creek or to it via minor tributaries located within the Precinct. Majority of the Precinct is affected by flooding in the South Creek and its tributaries. The existing flow directions for the local catchments outside the mainstream 100 year ARI flood extents are shown in **Figure 4-1**.

4.3.2 West Schofields

West Schofields Precinct is located between Bells Creek on the west and Eastern Creek on the east. Majority of the Precinct is affected by flooding in the Eastern Creek and the confluence of Bells Creek with Eastern Creek. The existing flow directions for the local catchments outside the mainstream 100 year ARI flood extents are shown in **Figure 4-2**.

4.4 Water Cycle Management Objectives

The following objectives are recommended for development of Shanes Park and West Schofields Water Cycle Management Plans as part of precinct planning process. These objectives are consistent with the adjoining NWGC precinct plans and Blacktown City Council’s requirements.

4.4.1 Water Quantity

- Limit post development peak flow rates to pre development values for flows up to the 50% AEP and the 1% AEP. For best management practice do not exceed peak flows for the full range of AEP up to the 1% AEP.
- For flood evacuation routes, the 0.2%AEP (500 year ARI) level of service needs to be maintained/ achieved.
- No residential allotments are to be below the 1% AEP flood planning level (1% AEP flood level plus 0.5m freeboard)

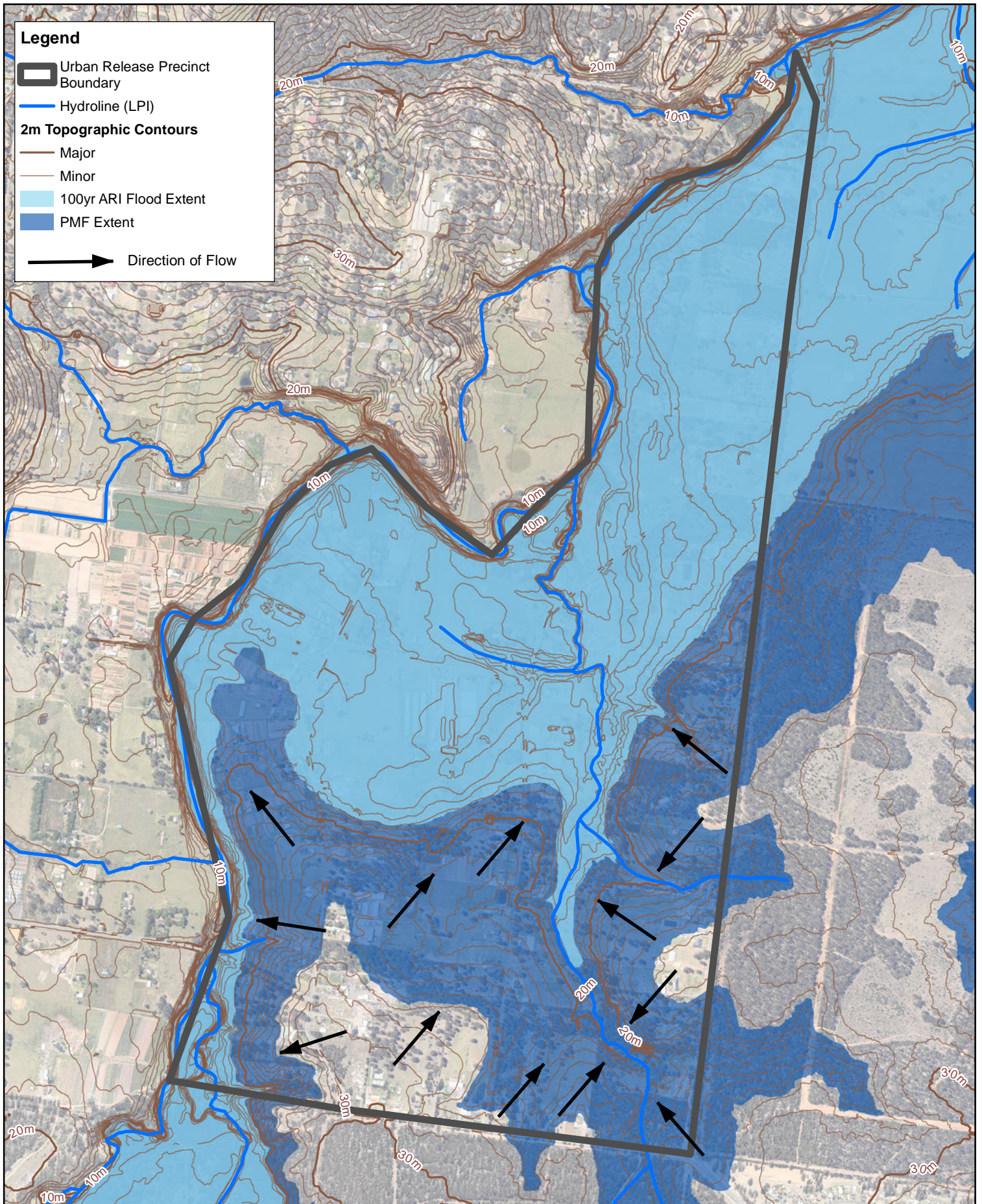
4.4.2 Water Quality

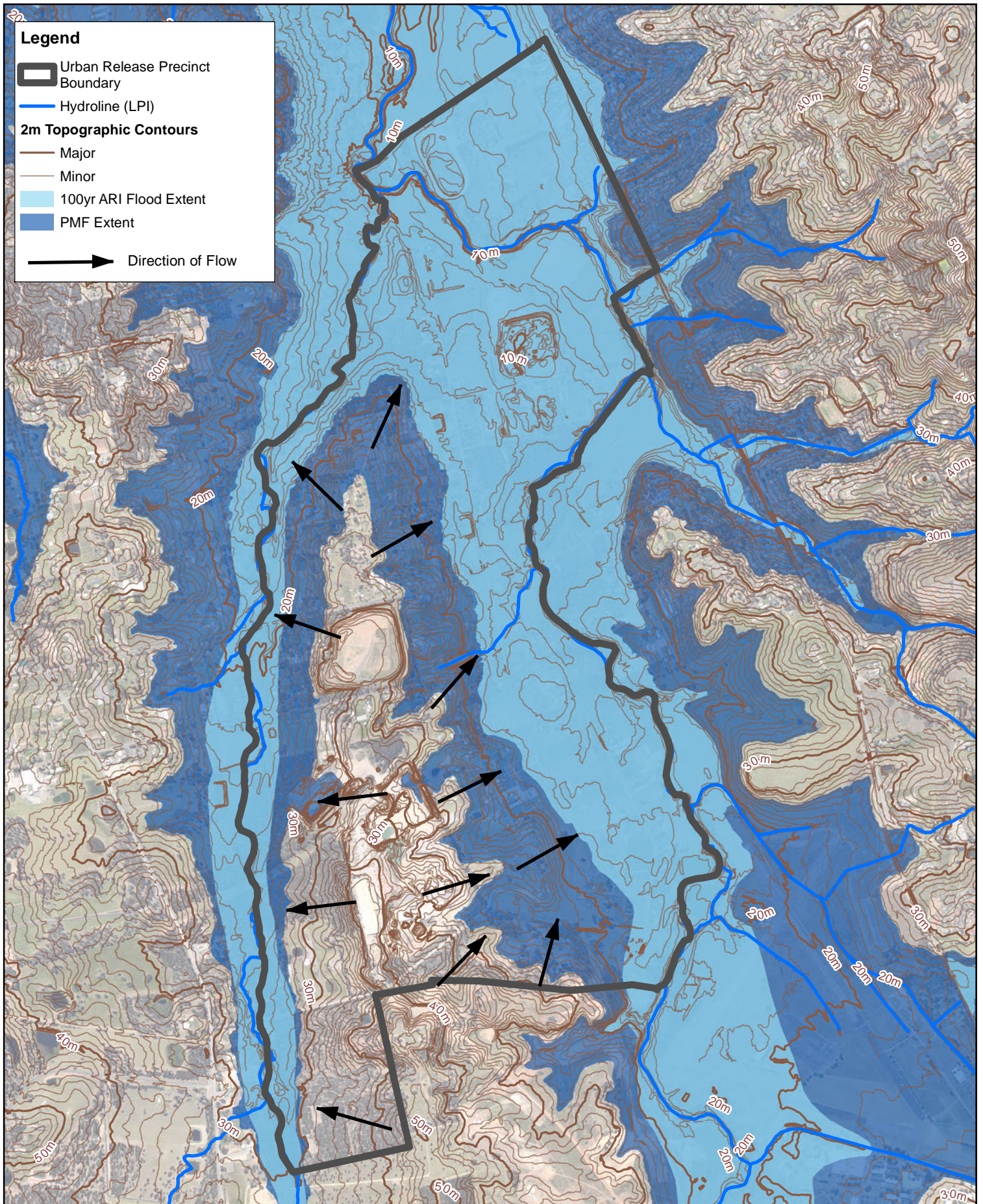
- Achieve a minimum percentage reduction of the post development average annual pollutant loads as set out in **Table 4-1**.

Table 4-1 Pollutant Reduction Targets

Pollutant	Post development load reduction
Gross Pollutants	90%
Total Suspended Solids	85%
Total Phosphorus	65%
Total Nitrogen	45%

- The post development duration of stream forming flows shall be no greater than 3.5 times the pre developed duration of stream forming flows with a stretch target of 1. The comparison of post development and pre-development stream forming flows is commonly referred to as the Stream Erosion Index (SEI).





Catchment Drainage - West Schofields

PRIORITY GROWTH CENTRES
STRUCTURE PLAN REVIEW
FIGURE 4-2



Map Produced by NSW/ACT (2812)

Date: 2015-05-29

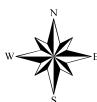
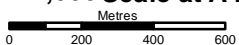
Coordinate System: GDA 1994 MGA Zone 56

Project: 59915128

Map: 59915128_GS_005_NWGC_WatCycwithArrows.mxd 02

Aerial Image Source: Nearmap 2014

1:21,000 Scale at A4



4.5 Water Cycle Management Approach

This water cycle management approach has been developed to guide future developments in the precincts in a sustainable manner with regards to water cycle and help achieve the water cycle management objectives.

4.5.1 Stormwater Quantity Management

The primary constraint of Shanes Park and West Schofields is that the Precincts are influenced by flooding in South Creek and Eastern Creek respectively. The majority of Shanes Park Precinct and the eastern portion of West Schofields Precinct is subject to PMF (Probable Maximum Flood) inundation as shown in **Figure 4-1** and **Figure 4-2**.

4.5.1.1 Stormwater Detention for Flood Management

Strategically placed regional stormwater detention basins (online and offline) will be required to mitigate the flood impacts on South Creek and Eastern Creek from development in the precincts.

The NSW Office of Water (NOW) allows a range of activities/land uses within the outer edge of riparian corridors so long as they have minimal environmental harm. Detention basins, online and within the other 50% of the Vegetated Riparian Zone (VRZ) width, is permissible for 1st and 2nd Stream Order. The stream order categorisation for Shanes Park and West Schofields precincts is provided in **Figure 2-10** and **Figure 2-11** respectively. Based on the stream order, there is limited opportunity to locate online detention basins within the precincts.

Offline detention basins to mitigate flood impacts will result in uptake of developable land. Typical detention basin volumes and areas can be approximated based on the catchment area draining to the basin. Approximate basin sizes required for Shanes Park and West Schofields is provided in **Table 4-2**. This is based on the developable land available which is outside the 100 year ARI flood extent.

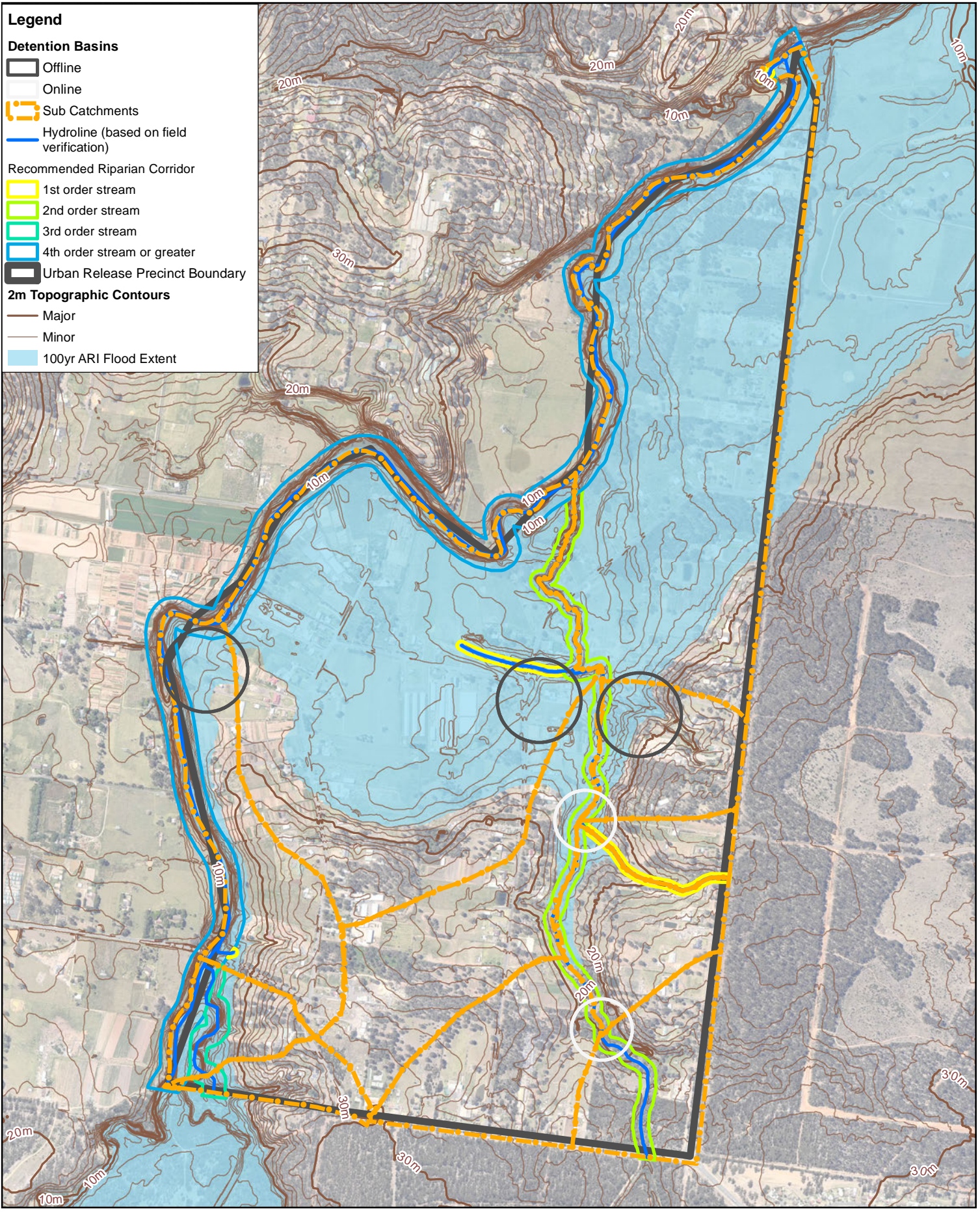
Table 4-2 Approximate detention basin sizes

Precinct	Total Area (ha)	Approximate Developable Area (ha)	Approximate basin area (ha)
Shanes Park	319	145	7
West Schofields	576	280	14

Proposed detention basins can be located in areas that are outside local flooded areas but within regionally flooded areas in order to maximise developable land. Suitable locations for the online and offline detention basins are shown in **Figure 4-3** and **Figure 4-4**. Online basins on Bells Creek, which is a 2nd Order Stream, has not be included due to the possible impacts on the neighbouring Precincts - Marsden Park, Marsden Park North and Marsden Park Industrial.

Lot based on-site detention (OSD) is an option that could be adopted to mitigate flood impacts on the private domain. This approach will require detention to be provided on individual private lots and will reduce requirements for regional detention. There is opportunity for this option to be adopted for commercial/retail and industrial areas.

However it should be noted that OSD for greenfield development is not currently supported by Blacktown City Council.



Legend

Detention Basins

- Offline
- Online
- Sub Catchments
- Hydroline (based on field verification)

Recommended Riparian Corridor

- 1st order stream
- 2nd order stream
- 3rd order stream
- 4th order stream or greater
- Urban Release Precinct Boundary

2m Topographic Contours

- Major
- Minor
- 100yr ARI Flood Extent

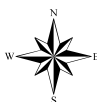
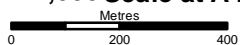
Feasible Basin Locations - Shanes Park

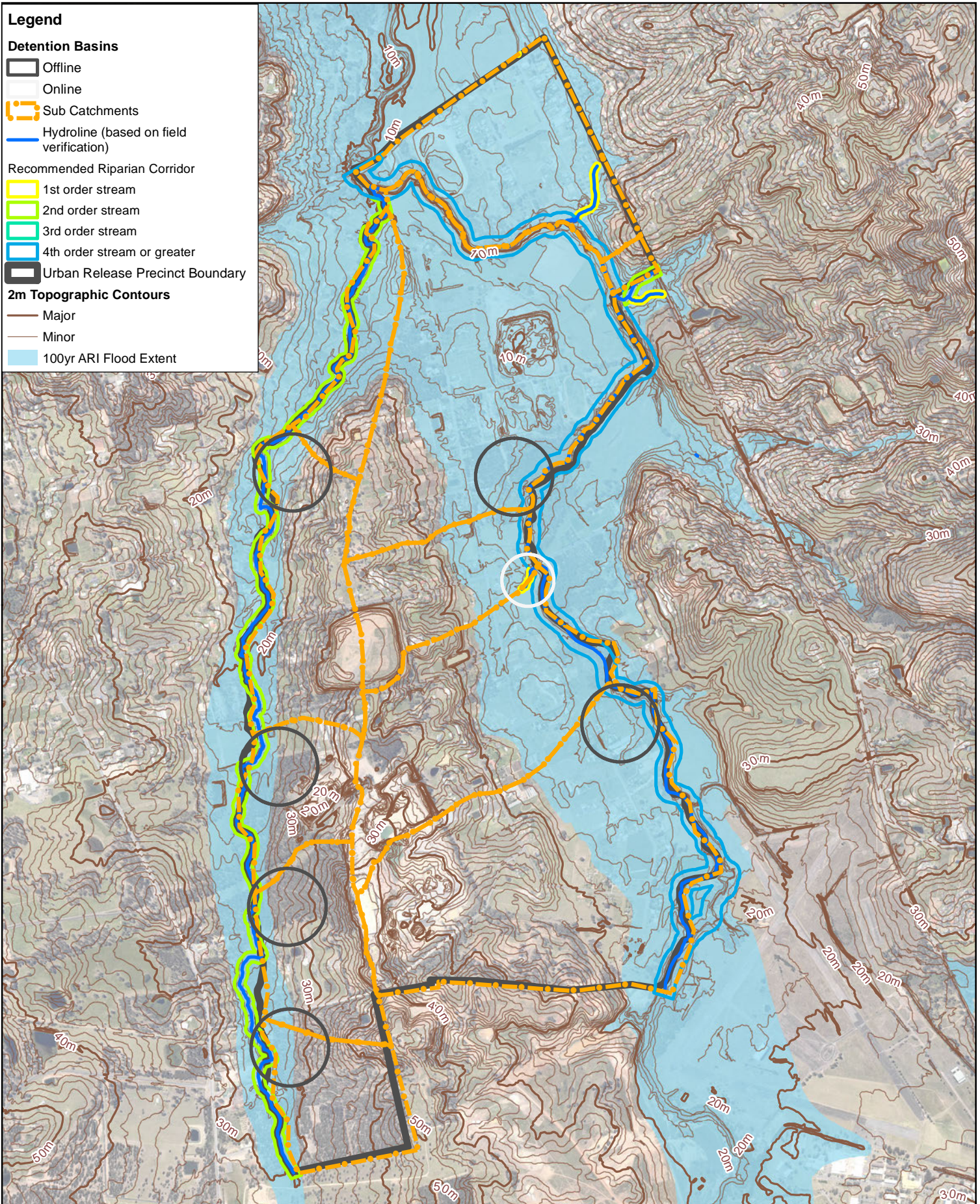
PRIORITY GROWTH CENTRES
STRUCTURE PLAN REVIEW
FIGURE 4-3



Map Produced by NSW/ACT (2812)
Date: 2015-05-29
Coordinate System: GDA 1994 MGA Zone 56
Project: 59915128
Map: 59915128_GS_005_NWGC_WatCyc.mxd 03
Aerial Image Source: Nearmap 2014

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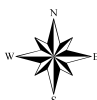
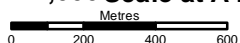
Feasible Basin Locations - West Schofields

PRIORITY GROWTH CENTRES
STRUCTURE PLAN REVIEW
FIGURE 4-4



Map Produced by NSW/ACT (2812)
Date: 2015-05-29
Coordinate System: GDA 1994 MGA Zone 56
Project: 59915128
Map: 59915128_GS_005_NWGC_WatCyc.mxd 03
Aerial Image Source: Nearmap 2014

1:21,000 Scale at A4



4.5.1.2 Design Parameters

It is recommended to adopt the catchment design parameters provided in **Table 4-3** for basin sizing and flood modelling. These are in accordance with Blacktown City Council design guidelines (2005) requirements.

Table 4-3 Flood modelling catchment design parameters

Parameters	Value
PERN (Catchment Roughness)	
Existing Pervious	0.035-0.08
Urban Pervious	0.025
Urban Impervious	0.015
Losses (Existing Rural)	
Pervious Initial Loss	15
Pervious Continuing Loss	2.5
Impervious Initial Loss	1.5
Impervious Continuing Loss	0
Losses (Developed Urban)	
Pervious Initial Loss	5
Pervious Continuing Loss	2.5
Impervious Initial Loss	1
Impervious Continuing Loss	0
Impervious Percentages	
Existing Rural Residential	5% or as measured from aerial photography
Existing Urban	As measured from aerial photography
Residential (Low and Medium Density)	85%
Industrial	90%
Commercial & High Density Residential	95%
Active Open Space	50%
Passive Open Space	10%

4.5.2 Stormwater Quality Management

A key component of water cycle management is Water Sensitive Urban Design (WSUD). WSUD manages the impacts of stormwater from development with the aim of protecting and improving waterway health by mimicking the natural water cycle as closely as possible.

4.5.2.1 *Management Measures*

The principles of WSUD have been adopted for the rezoned NWGC precincts to meet the water quality objectives. The WSUD measures that have been adopted for the rezoned precincts are presented in **Table 4-4**.

Table 4-4 NWGC WSUD Measures

WSUD Measure	Description
Rainwater Tanks	Rainwater tanks reduce potable water demand by supplying roof water for toilet flushing, laundry use and garden irrigation around homes in excess of the BASIX requirement for potable water consumption reductions.
Gross Pollutant Trap	GPTs are structures that trap litter and coarse sediment.
Grass Swale	Grass swales are a method of replicating a more natural water cycle, whereby nutrients, sediments and other pollutants with potential to cause water quality issues are captured or absorbed by the vegetation as the stormwater runoff flows through the swale.
Bioretention Basins	Bioretention basins, also known as raingardens, filter stormwater runoff through densely planted surface vegetation and an engineered filter media such as sand. Bioretention basins can have the added benefit of providing detention to alleviate flooding issues as well as treating stormwater runoff.

It is recommended to adopt similar management measures for Shanes Park and West Schofields Precincts. The bioretention basins can be located within the offline detention basins depending on their location.

Typical bioretention areas can be approximated based on the catchment area draining to the system. Approximate bioretention sizes required for Shanes Park and West Schofields is provided in **Table 4-5**. This is based on the developable land available.

Table 4-5 Approximate bioretention area

Precinct	Total Area (ha)	Approximate Developable Area (ha)	Approximate bioretention area (m ²)
Shanes Park	330	150	3
West Schofields	620	295	6

4.5.2.2 *Design Parameters*

It is recommended to adopt impervious area percentages provided in **Table 4-3** for water quality modelling. In addition the typical bioretention design parameters to be adopted is provided in **Table 4-6**. These are consistent with the adjoining NWGC precinct plans.

Table 4-6 Typical bioretention basin parameters

Parameters	Value
Extended detention depth	200-300mm
Filter media depth	500-600mm
Filter material	Loamy sand
Saturated hydraulic conductivity	100-120 mm/hr

4.5.2.3 Salinity Management

Salinity management measures will be required for the West Schofields Precinct due to presence of moderate soil salinity and moderate to high salinity concentration in the groundwater in the areas adjacent to Bells Creek and Eastern Creek.

Appropriate water treatment measures will be required to manage stormwater runoff without exacerbating the existing salinity levels. Design of bioretention systems should be such that they prevent seepage losses and avoid groundwater salinity impacts.

5 Conclusions

This report documents the review of flooding, water cycle management and riparian corridor considerations for the North West Growth Centre Precincts of Shanes Park and West Schofields. The outcomes of the study include a set of recommendations for the structure plan review as well as a number of future actions to enhance the outputs from this report in coordination with other disciplines.

5.1 Summary of Recommendations

Recommendations from the review of riparian corridor, flooding and water cycle management are addressed in turn below:

Riparian Corridor

- The preliminary mapping in SEPP 2013 have been reviewed. **Figure 2-10** and **Figure 2-11** show recommended updated outlines of riparian corridors in Shanes Park and West Schofields following field inspections of the first and second order streams in each Precinct.
- There appeared to be only limited opportunities for offsetting of riparian corridor land in Shanes Park and West Schofields Precincts.

Flooding

- **Developable Land** – There is limited opportunity for a cut and fill approach to maximise developable land however, should be considered to allow appropriate development layouts. Such cut and fill should be localised and minor and should not encroach on the riparian corridor zone.
- **Land Use** - Land within the 100 year ARI extents should be adopted as green space (agriculture, open space, recreation or conservation areas). This flood extent aligns with or exceeds riparian corridor zones and hence seeks to achieve the riparian corridor objectives as well.
- **Overland Flows** - Appropriate overland flow floodways should be provided within the catchment to compliment the underground drainage system and ensure that development has appropriate flood immunity with regards overland flows not just mainstream flooding. Ideally natural open waterways are preserved to serve this function. Flood planning controls on lots adjacent to floodways may be required.
- **Flood evacuation** - Land use planning and transport infrastructure planning need to have a strong consideration of flood evacuation, particularly for planned development on land between the 100 year ARI and PMF flood extents. Critical Infrastructure should be planned to be on land outside the PMF flood extent.

Water Cycle Management

- Set water management objectives which are consistent with the adjoining NWGC precinct plans and Blacktown City Council's requirements;
- A combination of online and offline detention basins to mitigate the flood impacts on South Creek and Eastern Creek from development in the precincts;
- Lot based on-site detention (OSD) for commercial/retail and industrial areas to reduce the requirement of developable land for detention basins. However it should be noted that OSD for greenfield development is not currently supported by Blacktown City Council;
- Adopt the design parameters for flood modelling in accordance with Blacktown City Council design requirements.
- Implement lot scale (rainwater tanks), street scale (swales) and regional scale (GPTs and bioretention basins) water treatment measures to achieve the required water quality.

5.2 Future Actions

The following list outlines future actions which would enhance the outputs from this report in the development of a land use and infrastructure strategy for the NWGC:

- General constraints coordination across the various disciplines should be undertaken including:
 - Coordination with housing analysis to determine whether projected population and proposed developable land areas are constrained by flooding and water management considerations;
 - Coordination with transport planning to ensure that flood evacuation considerations are incorporated in transport corridors as well as the ability to provide flood immunity to such infrastructure. Some flood extents are quite significant and proposed transport routes will need to consider flood immunity, flood impacts and mitigation strategies.
- Development of regional water management strategy, parameters and design - there is opportunity to refine and identify preliminary suitable locations of water management measures (detention and water quality) within the Precincts following further coordination with other disciplines. This will be subject to the following information being made available for the Precincts:
 - Transport and connectivity;
 - Water supply and wastewater servicing;
 - Social infrastructure including open spaces, community centres, etc.; and
 - Possible zoning.
- Final outlines of riparian corridors should be surveyed during precinct planning to take into account variable channel widths (see definition of the VRZ based on top of banks).
- Bells Creek on the western border of West Schofields precinct is defined as a second order stream according to the Strahler classification, however there may be a case to revise the stream order to three, due to the length and extent of riparian vegetation (and consistency with nearby second and third order streams).

6 References

Bewsher (2012), Hawkesbury Floodplain Risk Management Study and Plan, Volume 1 – Main Report, for Hawkesbury City Council’s Floodplain Risk management Advisory Committee, July 2012

Hawkesbury-Nepean Floodplain Management Steering Committee (2006), Managing Flood Risk Through Planning Opportunities: Guidance On Land Use Planning In Flood Prone Areas; ISBN 0 7347 5650 X

NSW Department of Planning (2006), ‘State Environmental Planning Policy (Sydney Region Growth Centres) 2006’.

NSW Department of Planning (2013), ‘State Environmental Planning Policy (Sydney Region Growth Centres) 2006 with Riparian Protection Areas maps.

NSW Government (2005), Floodplain Development Manual: the Management of Flood Liable Land; ISBN 07313 0370 9.

NSW Office of Water (2012), NSW New Riparian Corridor Guidelines, <http://www.water.nsw.gov.au/water-licensing/approvals/controlled-activity/case-study-applying-the-new-riparian-corridor-guidelines>

NSW Office of Water (2013) Controlled Activities on Waterfront Land - Guidelines for riparian corridors on waterfront land

North West Growth Centre

APPENDIX A
SEPP 2013 – RIPARIAN PROTECTION
AREA MAPS

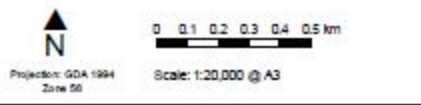
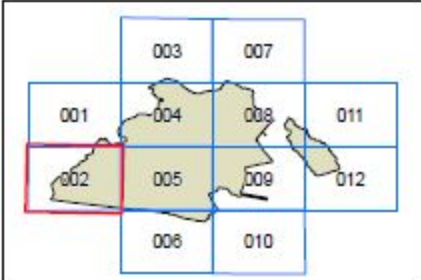
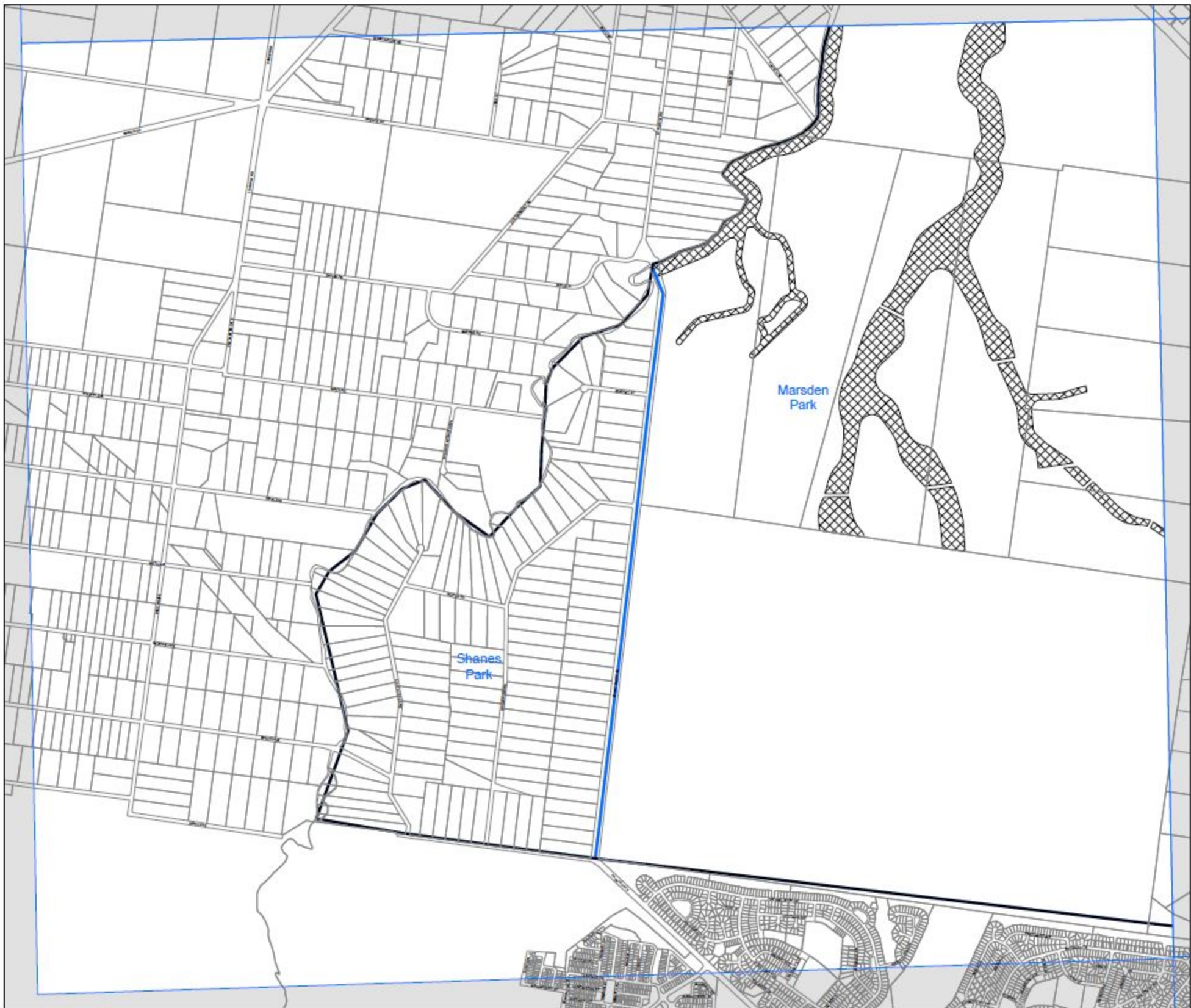


State Environmental Planning Policy (Sydney Region Growth Centres) 2006

North West Growth Centre
Riparian Protection Area Map
Sheet RPN_002

LEGEND

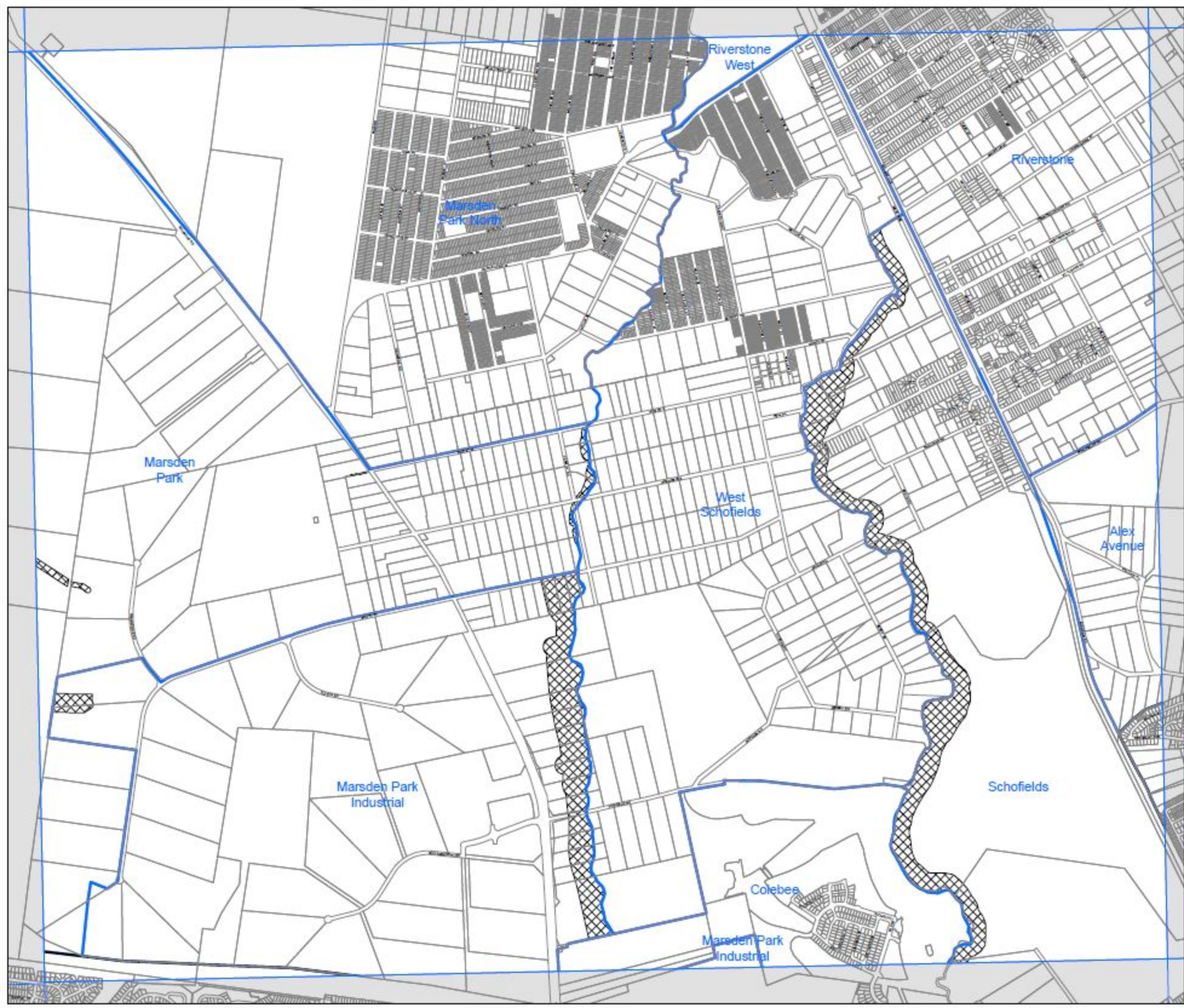
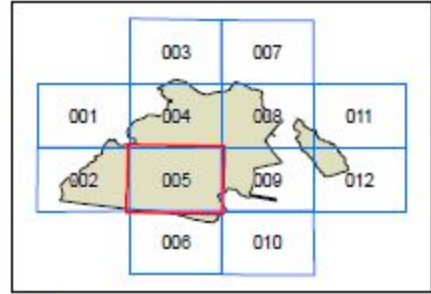
- Riparian Protection Area
- Growth Centre Boundaries**
 - North West Growth Centre Boundary
 - North West Growth Centre Precinct Boundary
- Cadastre**
 - Cadastre © 24/09/2013 NSW LPI



State Environmental Planning Policy (Sydney Region Growth Centres) 2006

North West Growth Centre
Riparian Protection Area Map
Sheet RPN_005

- LEGEND**
-  Riparian Protection Area
 - Growth Centre Boundaries**
 -  North West Growth Centre Boundary
 -  North West Growth Centre Precinct Boundary
 - Cadastral**
 -  Cadastral © 24/09/2013 NSW LPI

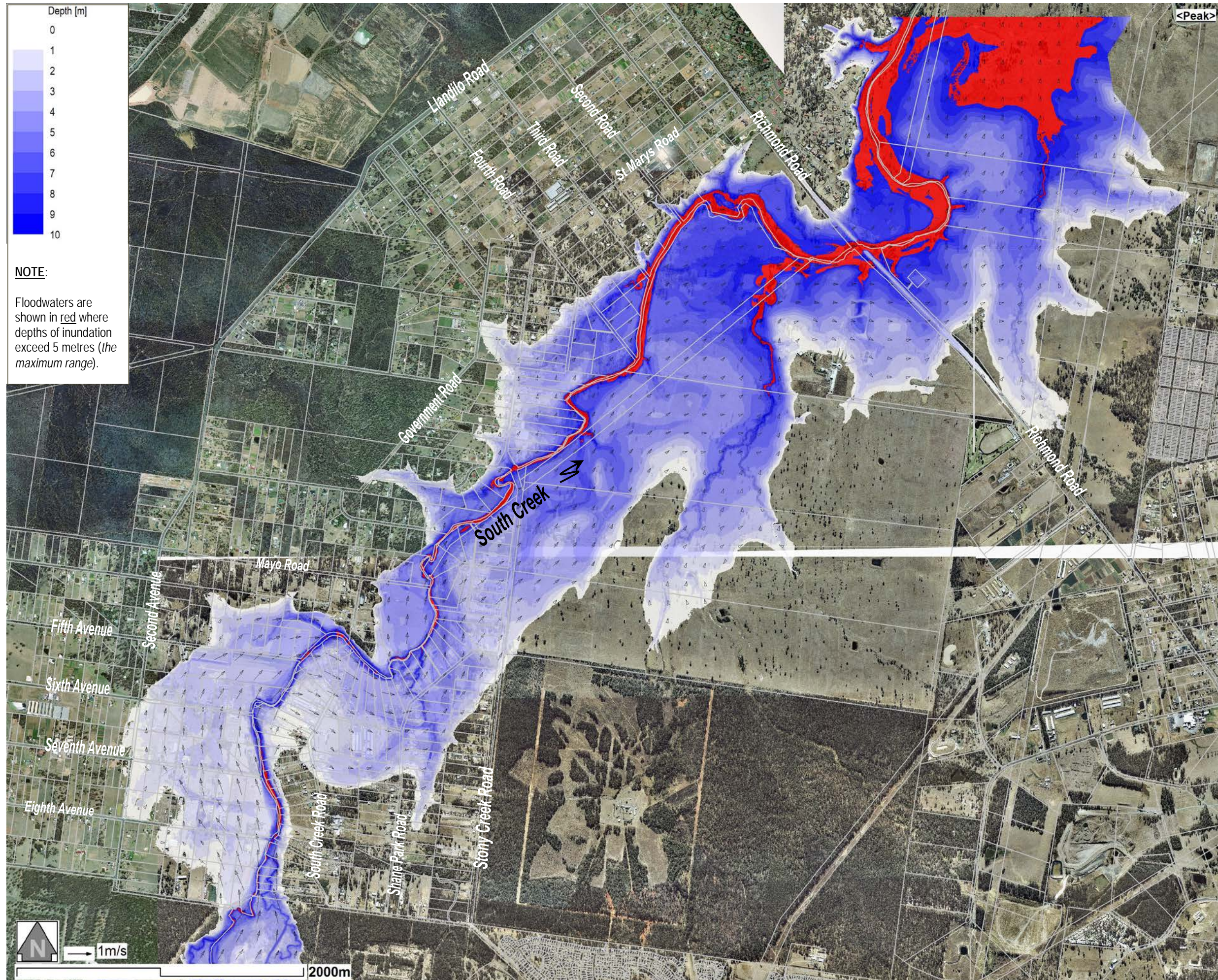


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APPENDIX B
ADDITIONAL FLOOD MAPS
REPRODUCED FROM OTHER FLOOD
STUDY REPORTS

FIGURE 6.116

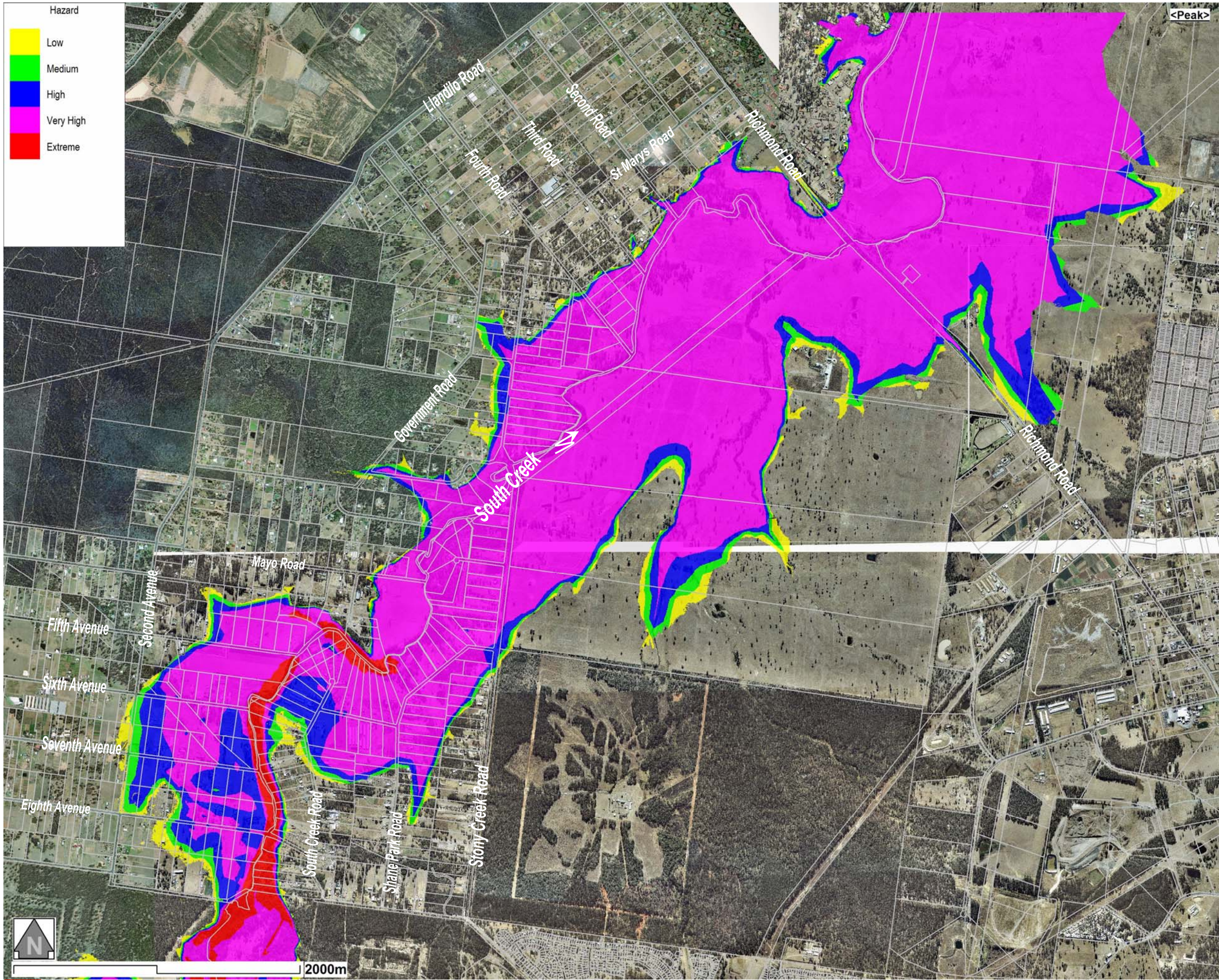
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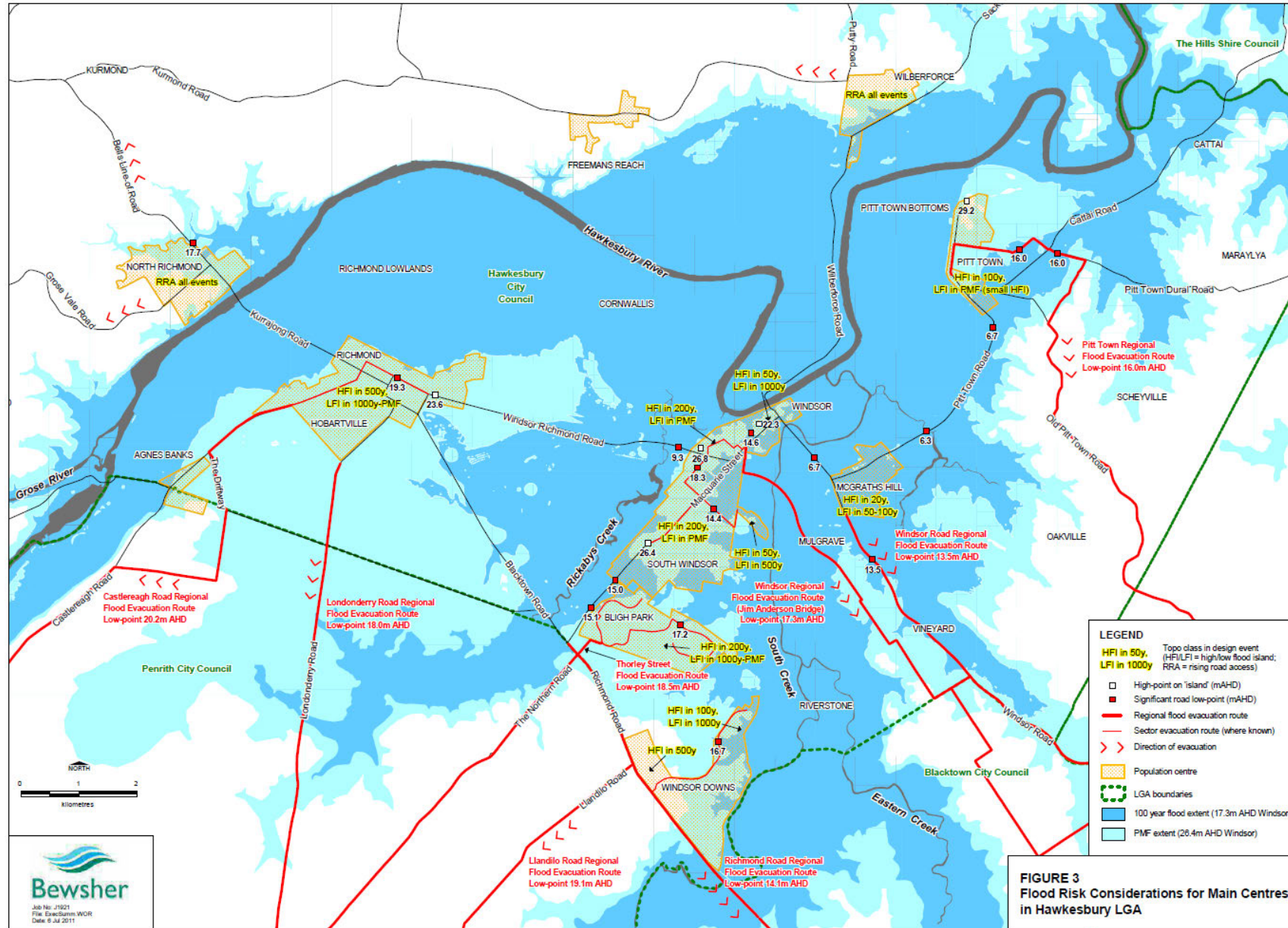


PREDICTED FLOOD DEPTHS AND VELOCITIES AT THE PEAK OF THE 100 YEAR RECURRENCE FLOOD [EXTENT 10 OF 17]

FIGURE 7.10

DRAFT





Source: Bewsher, 2012 – Hawkesbury Floodplain Risk Management Study and Plan, Volume 1

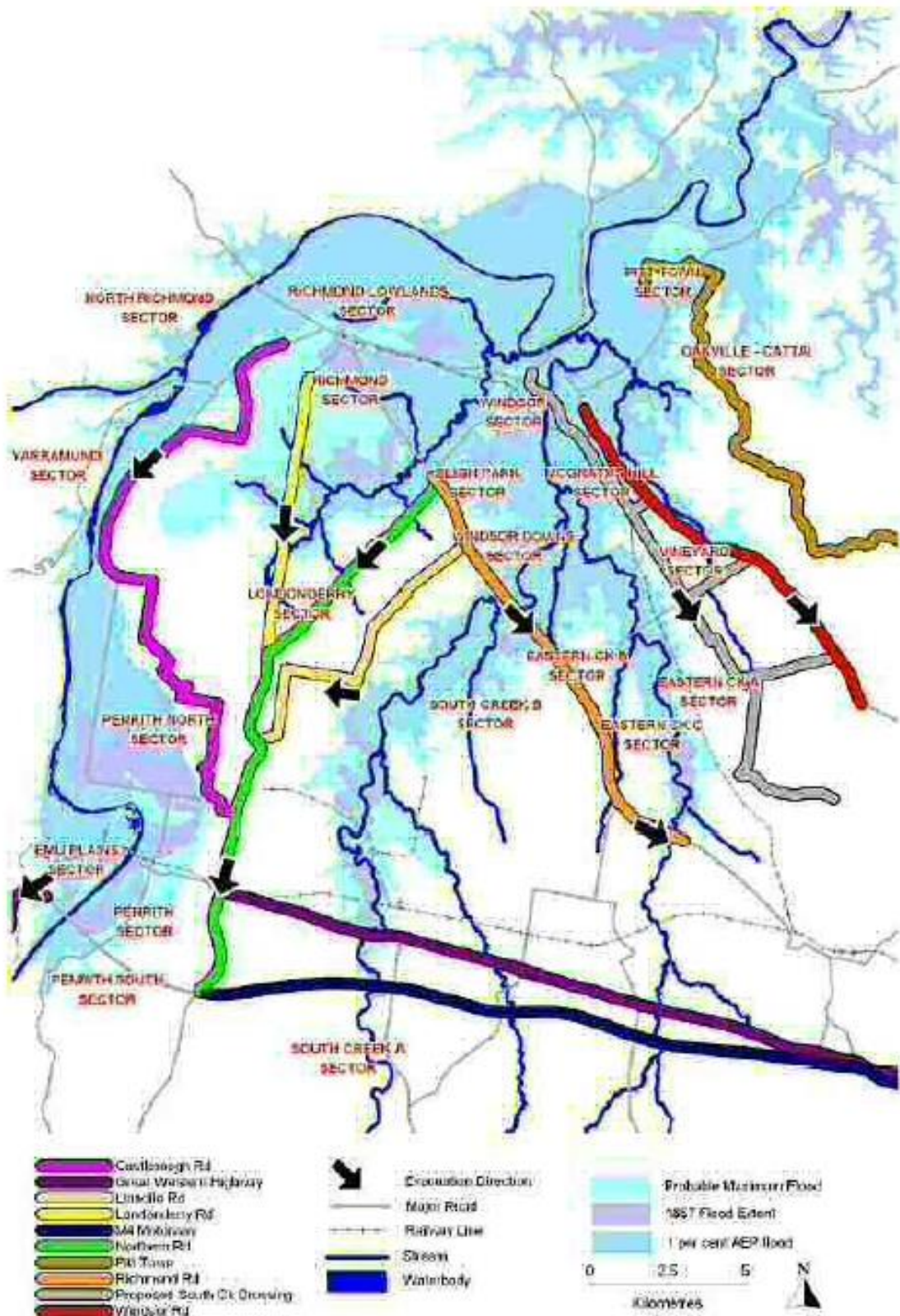
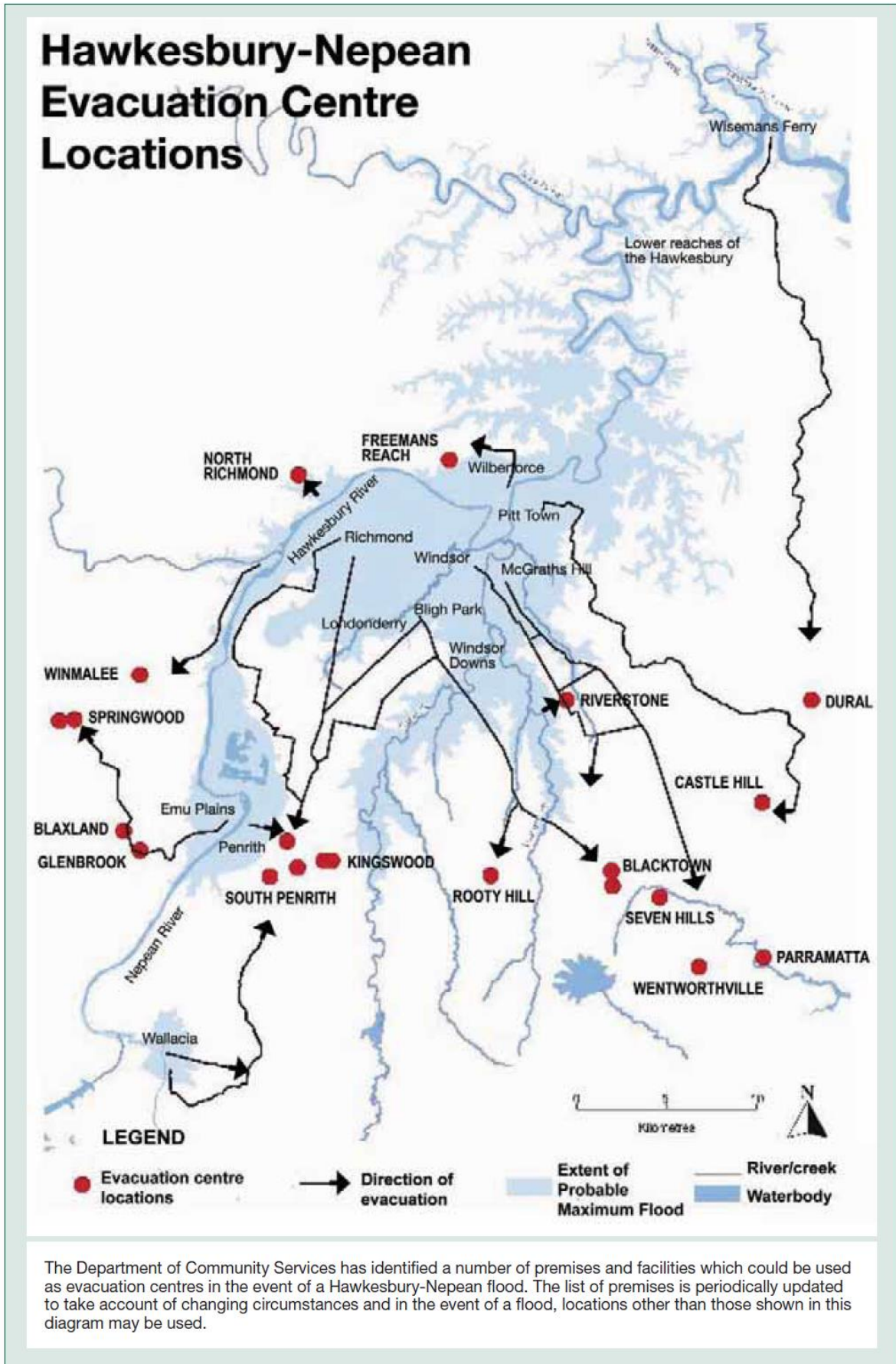


FIGURE 2.8 – Hawkesbury-Nepean Flood Evacuation Routes

Source: SEMC, 2005

Source: Bewsher, 2012 – Hawkesbury Floodplain Risk Management Study and Plan, Volume 1

Figure 20 Hawkesbury-Nepean Evacuation Centre locations 2004



Source: Hawkesbury-Nepean Floodplain Management Steering Committee, 2006