

ASSESSING CUMULATIVE FLOOD RISK IN LARGE URBAN RELEASE AREAS IN THE CAMDEN LOCAL GOVERNMENT AREA IN SYDNEY'S SOUTH WEST

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Abstract

With Sydney's population expected to grow to almost 6 million by 2036, the North West and South West Growth Centres were identified in Sydney's west in the mid-2000s to accommodate more than 180,000 new dwellings over the next 25 to 50 years.

The South West Growth Centre lies within the Local Government Areas (LGAs) of Liverpool, Campbelltown and Camden and, with an area around the same size as Canberra, is proposed to cater for 110,000 new dwellings and 300,000 people. Development in the South West Growth Centre has been staged through the designation of 18 Planning Precincts.

Eleven of the 18 Planning Precincts in the South West Growth Centre are located within the Upper South Creek Catchment within the Camden LGA. South Creek is a large creek system with its headwaters in the Camden LGA, which flows some 70km north, before joining the Hawkesbury River at Windsor.

Camden Council has recently completed, and had adopted by Council, a flood study for the Upper South Creek Catchment based solely on pre-development catchment conditions. Meanwhile, flood studies for several of the Planning Precincts have been undertaken independently by consultants acting for the developers.

While fundamental criteria of individual flood studies for the Planning Precincts is to maintain post-development flood behaviour at pre-development conditions, there is a need for a wholistic evaluation of cumulative impacts of the total potential development.

This paper outlines how the Upper South Creek Floodplain Risk Management Study and Plan will assist Camden Council to understand if and how flood behaviour may change when the Planning Precincts are developed through the catchment, and how the Council can use this information to adopt suitable flood-related development controls across this large urban release area.

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Sydney's Growth Centres

With Sydney's population expected to grow to almost 6 million by 2036, the North West Growth Centre and the South West Growth Centre were identified in Sydney's West by the NSW Government in 2005 to accommodate more than 180,000 new dwellings over the next 25 to 50 years. **Figure 1** shows the North West and South West Growth Centres in the context of the Sydney Region.

The North West Growth Centre is located within the Local Government Areas (LGAs) of Baulkham Hills, Blacktown and Hawkesbury and covers an area of about 10,000 hectares. It will be supported by a major centre at Rouse Hill and will contain about 70,000 new dwellings.

The South West Growth Centre is located within the LGAs of Liverpool, Camden and Campbelltown and will cover an area about 17,000 hectares, about the same size as Canberra. It will be supported by a major centre at Leppington, be serviced by the new South West Rail Link and will contain around 110,000 dwellings. (NSW Department of Planning and Infrastructure — Sydney Growth Centres, 2013)

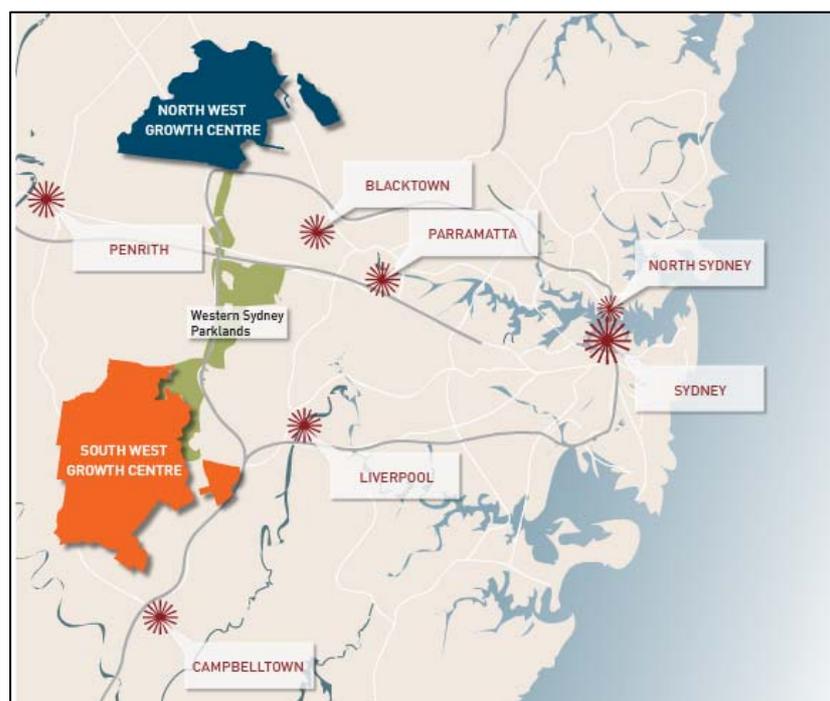


Figure 1: North West and South West Growth Centres in the Context of the Sydney Region (Source: NSW Department of Planning and Infrastructure — Sydney Growth Centres, 2013)

Planning Process for Sydney's Growth Centres

The *State Environmental Planning Policy (Sydney Region Growth Centres) 2006*, known as the *Growth Centres SEPP*, is the legal instrument that establishes the planning rules and objectives for the North West and South West Growth Centres. Local Councils, as the consent authorities for most land-use planning decisions, must apply the *Growth Centres SEPP* when making any land-use planning decisions with the Growth Centre areas.

To facilitate and help accelerate development in the Growth Centres, each Growth Centre has been divided into a number of Precincts. Precinct Planning is the detailed process used to analyse the development potential of each Precinct by investigating appropriate land use options, infrastructure requirements and physical environmental constraints such as topography, bushfire hazard and flood risk. Precinct Plans include the optimal location of town centres, key transport routes, the mix and types of housing as well as conservation and riparian zones, within each Precinct.

The Precinct Plan is prepared by the NSW Department of Planning and Infrastructure (NSW DoPI) with input from the relevant local council. The Precinct Plan is exhibited and the submissions assessed by the NSW DoPI and approved by the NSW Minister of Planning. Once approved, the Precinct Plan becomes part of the amended *Growth Centres SEPP*.

A Development Control Plan (DCP) is also developed as part of the Precinct Plan to provide detailed development controls for the Precinct. Once exhibited and adopted, the DCP also becomes part of the amended *Growth Centres SEPP*.

Once the Precinct Plan and DCP are adopted and are included in the *Growth Centres SEPP*, Council's Local Environmental Plan (LEP) and any DCPs no longer apply to land in that Precinct. Also, once the Precinct Plan and DCP are adopted, Development Applications for proposed developments may then be lodged with the local council, and the local council becomes the consent authority for all future development in that Precinct. (*NSW Department of Planning and Infrastructure — Sydney Growth Centres, 2013*)

South West Growth Centre and the Upper South Creek Catchment in the Camden Local Government Area

The South West Growth Centre is divided into 18 Precincts, as shown on **Figure 2**. **Figure 2** shows that more than half the area of the South West Growth Centre lies within the Camden LGA, south of Bringelly Road, while just under half the area of the Growth Centre lies in Liverpool LGA north of Bringelly Road as far north as Elizabeth Drive. A small proportion of the South West Growth Centre lies in the north-west regions of the Campbelltown LGA.

South Creek is a large creek system of around 400 square kilometres (*WMAwater, 2012*) that has its headwaters in the Camden LGA and flows some 70 kilometres north, before joining the Hawkesbury River at Windsor. Upper South Creek refers to that part of the South Creek catchment located within the Camden LGA, that is, south of Bringelly Road.

The Upper South Creek catchment includes the following tributaries, from west to east: Thompsons Creek, Lowes Creek, South Creek, Rileys Creek, Kemps Creek and Bonds Creek. Thompsons Creek, Kemps Creek and Rileys Creek all flow into South Creek downstream (north) of Elizabeth Drive (refer **Figure 3**).

Table 1 lists the Precincts together with their Local Government Area, the status of the Precinct Plan and whether the Precinct lies within the Upper South Creek catchment of the Camden LGA.

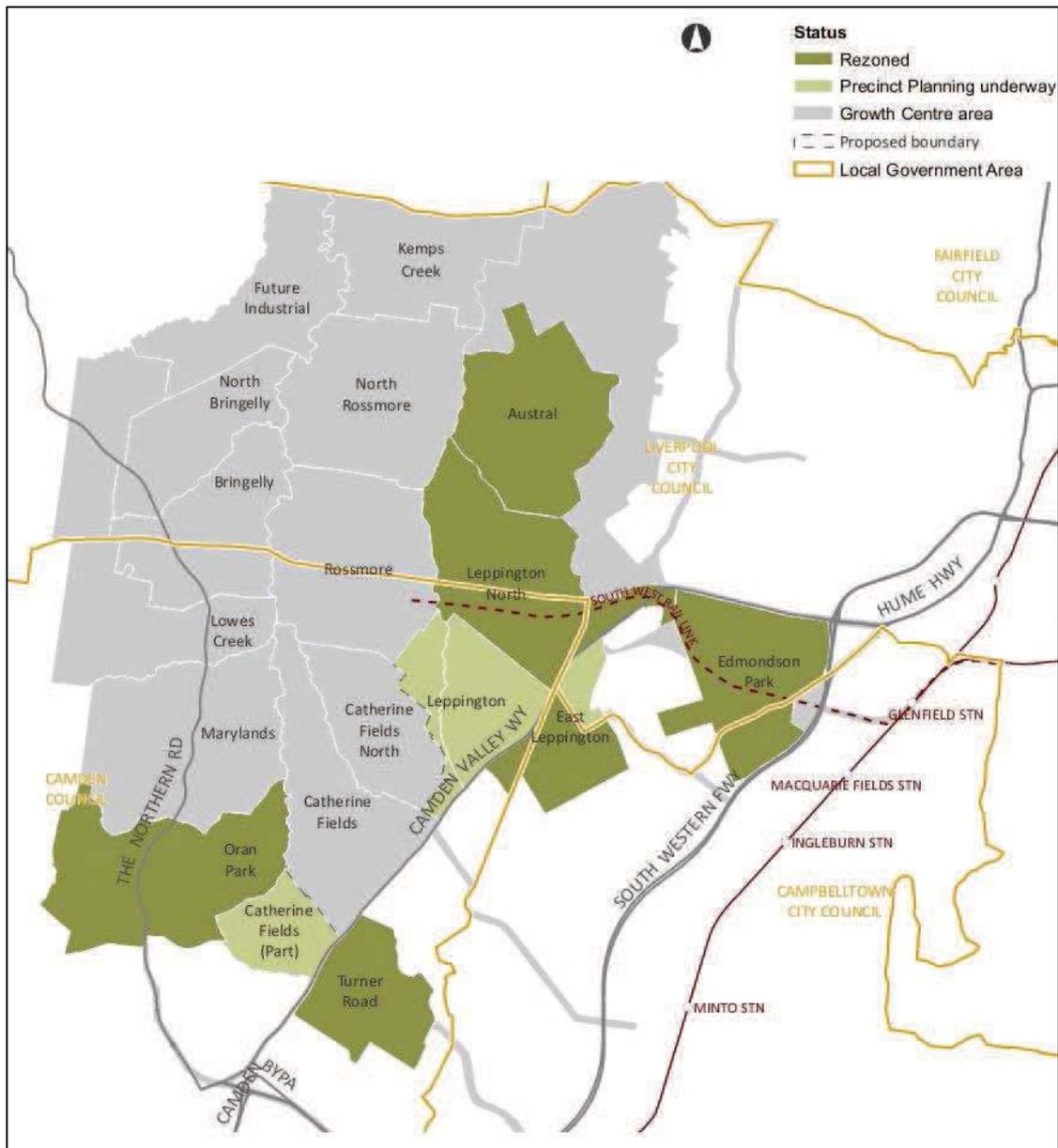


Figure 2: South West Growth Centre Precincts and Status of Precinct Planning as at March 2013 (Source: NSW Department of Planning and Infrastructure, 2013a, in draft)

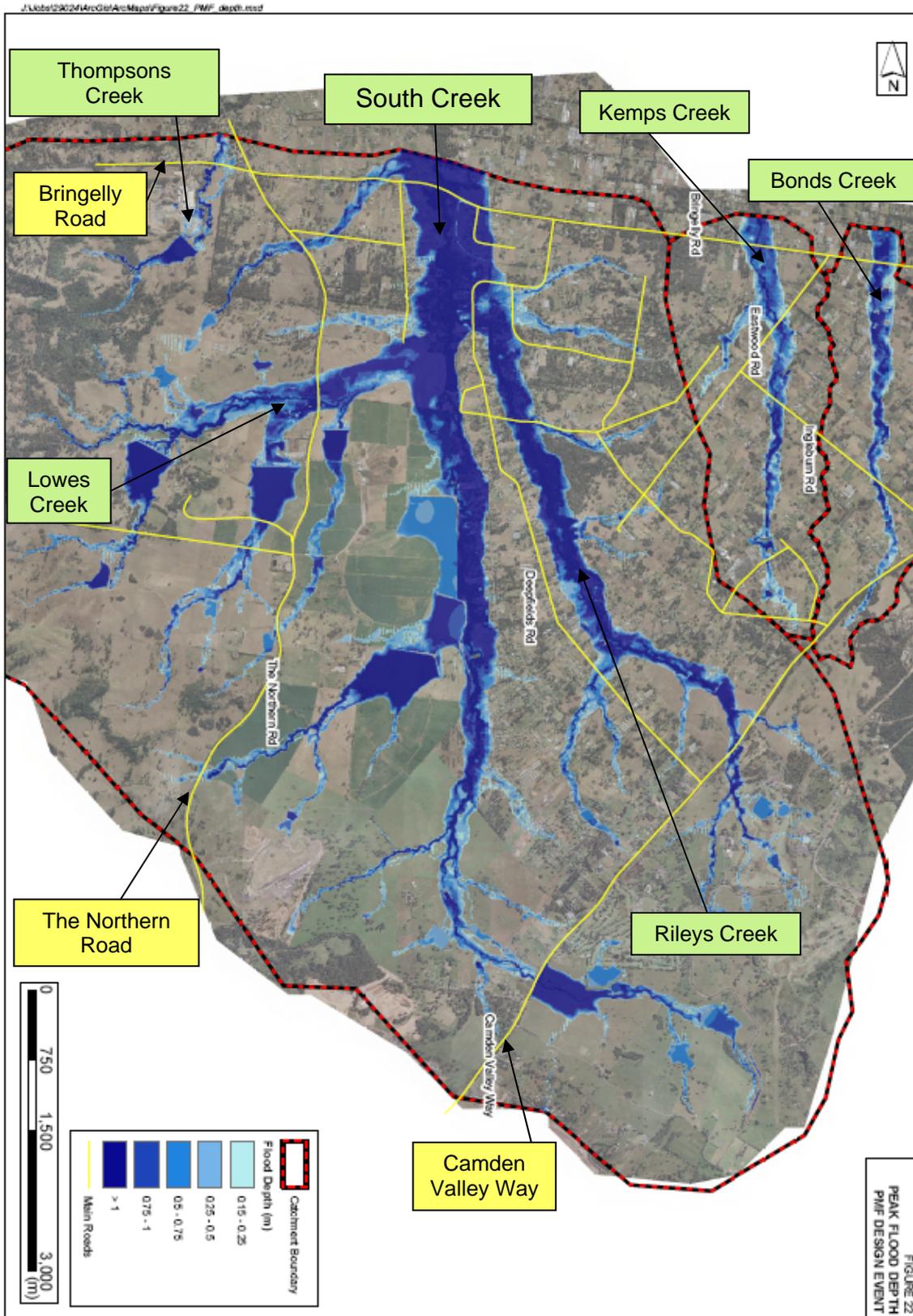


Figure 3: Upper South Creek Floodplain — showing depths and extents of the Probable Maximum Flood (Source: adapted from WMAwater, 2012)

TABLE 1: South West Growth Centre Precincts and Status of Precinct Planning (as at March 2013)

Precinct	Local Government Area	Status of Precinct Planning	Upper South Creek Catchment in Camden LGA
Kemps Creek	Liverpool		
North Bringelly	Liverpool		
North Rossmore	Liverpool		
Austral	Liverpool	Rezoned for Development	
Bringelly	Camden Liverpool		✓
Rossmore	Camden Liverpool		✓
Lowes Creek	Camden		✓
Leppington North	Camden Liverpool	Rezoned for Development	✓
Leppington	Camden	Precinct Planning in progress	✓
East Leppington	Camden Campbelltown Liverpool	(Part) Rezoned for Development	
		(Part) Precinct Planning in progress	
Edmondson Park	Campbelltown Liverpool	Rezoned for Development	
Marylands	Camden		✓
Catherine Fields North	Camden	Precinct Planning in progress	✓
Catherine Fields	Camden		✓
Catherine Fields (Part)	Camden	Precinct Planning in progress	✓
Oran Park	Camden	Rezoned for Development	✓
Turner Road	Camden	Rezoned for Development	✓
Future Industrial	Liverpool		

Flood-related Development Controls for the Southwest Growth Centres

Once a Development Control Plan (DCP) is adopted for particular Precinct, the DCP becomes part of the *Growth Centres SEPP*. Any Council DCP that applies to land in that Precinct then no longer applies and Council, as the consent authority, must then assess the merits of any proposed development against the development controls in the DCP that forms part of the *Growth Centres SEPP*.

Therefore it is important for local Councils to be actively involved in the preparation of DCPs for the Precinct Planning Process.

Camden Council adopted a comprehensive *Flood Risk Management Policy* in April 2006 (Camden Council, 2006). The *Camden Flood Risk Management Policy* establishes planning and development procedures for flood risk management for all flood-prone land in the Camden LGA. The *Camden Flood Risk Management Policy* states that flood-prone land covers all land susceptible to flooding by the Probable Maximum Flood (the largest flood that could conceivably occur), which is in accordance with the *NSW Floodplain Development Manual* (NSW Government, 2005). The primary method of flood risk management in the Camden LGA is through the application of development controls on flood prone land as set out in their Flood Risk Management Policy.

The *Camden Growth Centre Precincts Development Control Plan* (NSW DoPI, 2013a, in draft) was on public exhibition at the time of writing this paper (April 2013). Instead of individual DCPs for each Precinct in the South West Growth Centre (as was the case for the Turner Road Precinct (NSW DoPI, 2013b) and the Oran Park Precinct (NSW DoPI, 2013c), the *Camden Growth Centre Precinct DCP* will apply to all current and future Precinct Plans located with the Camden LGA. This will consolidate and greatly simplify planning controls across much of the South West Growth Centre.

During the preparation of the *Camden Growth Centre Precincts DCP*, Camden Council was proactive in ensuring that the intentions of the flood-related development controls in their *Flood Risk Management Policy* were carried through into the *Camden Growth Centre Precincts DCP*. The flood-related development controls in the *Camden Growth Centre Precincts DCP* are quite broad and refer back to Council's *Flood Risk Management Policy* for more detailed requirements.

Because Council's *Flood Risk Management Policy* is referred to specifically in the *Camden Growth Centre Precinct DCP*, these flood-related development controls can continue to apply in the South West Growth Centre (NSW DoPI, 2013a, in draft). This provides a consistency of approach to planning and development procedures for flood risk management for all flood-prone land across the Camden LGA.

Upper South Creek Flood Risk Studies

1990 South Creek Flood Study and 1991 South Creek Floodplain Management Study

Although not the first Flood Study for South Creek, the *1990 South Creek Flood Study* (NSW Department of Water Resources, 1990) was the first detailed flood study for the entire South Creek catchment, that included the main tributaries shown on **Figure 3** and included flood data from large floods in 1986 and 1988. The *1990 South Creek Flood Study* involved the survey of 480 cross-sections and structures to establish a one-dimensional (1D) hydraulic MIKE-11 model for almost all of South Creek and the lower sections of Badgerys and Kemps Creek, together with one-dimensional (1D) HEC-2 models (the predecessor of HEC-RAS) for the other tributaries. RAFTS (the predecessor of XP-RAFTS) was used to model the hydrology of the South Creek catchment (WMAwater, 2012).

The *1990 South Creek Flood Study* was followed by the South Creek Floodplain Management Study in 1991 (NSW Department of Water Resources, 1991).

2011 Upper South Creek Flood Study

The *1990 South Creek Flood Study* and *1991 South Creek Floodplain Management Study* remained as the best available information and formed the basis for establishing flood levels for land use planning purposes in the Camden LGA until the completion of the *Upper South Creek Flood Study* in November 2011. The *Upper South Creek Flood Study* was adopted by Camden Council in November 2011.

The two-dimensional (2D) model TUFLOW was used as the hydraulic modelling software for the *2011 Upper South Creek Flood Study*, using the direct rainfall on the grid method for estimating hydrology. The rainfall on the grid approach allows a much higher resolution for the mapping of flood risk and so, as shown on **Figure 3**, the *2011 Upper South Creek Flood Study* provides information on overland flows as well as mainstream flooding. For all those overland flow areas outside the main tributaries shown on **Figure 3**, this was the first time that mapping of flood affectation had been shown in these areas.

At the time of the preparation of the *2011 Upper South Creek Flood Study*, the Oran Park and Turner Road Precincts had recently completed their Precinct Planning phase and had been rezoned for development. As the topography of these Precincts was uncertain and as it was assumed that any outflows from these Precincts would match pre-development conditions, only pre-development ground conditions were included in the TUFLOW modelling for the Upper South Creek Flood Study (Cardno, 2012).

2013 Upper South Creek Floodplain Risk Management Study and Plan

With development proceeding rapidly within the Upper South Creek Catchment, Camden Council commenced the *Upper South Creek Floodplain Risk Management Study and Plan* almost immediately upon completion of the *Upper South Creek Flood Study* at the end of 2011. This project was in progress at the time of writing of this paper.

Three key components of the *Upper South Creek Floodplain Risk Management Study* were to:

- review the water management strategies prepared for the Oran Park, Turner Road, Catherine Fields (part) and Leppington as part of the Precinct Planning process for the South West Growth Centre. Separate water management studies for each Precinct were prepared to determine flood risk and suitable flood-related development controls. These independent water management studies were commissioned by the NSW DoPI, with each Precinct considered in isolation to the wider catchment.
- update the *Upper South Creek Flood Study* to include the most up-to-date information about the landform, and hence flood risk, of the Oran Park, Turner Road, Catherine Fields (part) and Leppington Precincts.
- review the *Camden Council Flood Risk Management Policy (2006)*, in conjunction with the *Camden Growth Centre Precincts DCP*, with the aim to prepare updated draft flood-related development controls suitable for the large amount of development proposed across the Camden LGA, particularly in the Upper South Creek catchment.

The Need to Assess Cumulative Flood Risk

While the fundamental criteria of the individual water management strategies for the Precinct Planning process is to maintain post-development flood behaviour at pre-development conditions, following the review of the water management strategies for the Oran Park, Turner Road and Catherine Fields (part), it was found that there was a need for a wholistic evaluation of the cumulative impacts of the total potential development in the Upper South Creek catchment. Such a wholistic approach to potential future flood impacts in Upper South Creek had not been undertaken to date.

One of the main issues in the assessment of cumulative flood impacts in the South Creek catchment is the loss of floodplain storage. As shown by the inundation extents on **Figure 3**, there are currently many large farm dams within the floodplains of the Upper South Creek catchment. It is understood from the Precinct Plans that many of these farm dams will be removed and replaced with filling to increase the area available for urban development.

As a result, the scope of the *Upper South Creek Floodplain Risk Management Study and Plan* was revised to include the following two development scenarios:

- **interim development condition** — this scenario would include the proposed/constructed land forms of the adopted Precincts of Oran Park, Turner Road, Catherine Fields (part) and Leppington
- **ultimate development condition** — the scenario would not only include the interim development condition but also a consideration of likely future land forms of all other Precincts within the South West Growth Centre that could potentially impact on the flood behaviour in the Upper South Creek catchment.

Modelling Cumulative Impacts on Flood Risk from Future Development

Methodology

The existing two-dimensional TUFLOW model was used to model the cumulative impacts on flood risk from future development. A cost-effective and time efficient modelling methodology had to be developed to replicate the development in a broad-scale model covering such a large catchment.

The proposed/constructed land forms for the adopted Precincts are quite detailed, including earthworks, drainage systems, detention basins and overland flowpaths. To include such features would have required detailed changes to the existing TUFLOW rainfall on the grid model and would have resulted in significantly longer computational run times. Also, the 10 metre grid size of the existing TUFLOW model would not have been fine enough to adequately model many of these detailed features.

Therefore, to model the interim development condition, development of the Precincts was replicated through the use of refined rainfall losses, changes in surface roughness and filling within the floodplain. Adjustments to initial rainfall loss and surface roughness were used to replicate the loss of floodplain storage (including the filling of small farm dams), increase in flow volume and changes to land surfaces. The impacts of removing larger farm dams were modelled by assuming a riparian corridor size based on the Precinct Plan and assuming the remaining area of the farm dam was filled to above a level that would permit development in that area (Cardno, 2013).

Results

The results of the modelling showed that the flood behaviour in the Upper South Creek catchment is more sensitive to loss of floodplain storage, currently provided by farm dams, than to changes to initial loss and surface roughness (i.e. changes to land surface). A particular impact of loss of floodplain storage is more pronounced flooding at downstream hydraulic controls, such as road crossings. This is likely to be as a result of changes in the timing of the runoff from the different catchments, with more volume of floodwaters reaching downstream areas more quickly from the developed areas, combining with other flows from less developed catchments (Cardno, 2013).

Recommendations for Future Precinct Planning

The results of the modelling of the interim development condition have highlighted the importance of having a hydraulic model for the entire Upper South Creek catchment to assess the cumulative flood risk impacts of the widespread development in the catchment.

It has been recommended that the following tools be developed to be used as guiding principles in the preparation of each future Precinct's Water Management Strategy:

- An XP-RAFTS hydrological model of the entire Upper South Creek catchment, with parameters consistent with the Upper South Creek Flood Study (WMA, 2012), would be developed to determine a suite of on-site detention (OSD) parameters that would be used by individual precincts to size their flow detaining storages, whether that be in the form of small on-site detention tanks, subcatchment detention basins and/or larger regional detention basins.
- The existing TUFLOW hydraulic model would be used to develop a suite of flow hydrographs throughout the catchment, for a range of flood sizes, to act as conditions that will need to be met by each precinct.
- Once detailed modelling by the individual precincts had been undertaken using the guiding principles provided, the TUFLOW model would be used as an assurance check to test the flood behaviour of proposed Precinct's Water Management Strategy to ensure that there will be no adverse impact elsewhere within the South Creek catchment.

Conclusions and Input into Future Precinct Planning

Flood-related Development Controls

The *State Environmental Planning Policy (Sydney Region Growth Centres) 2006*, known as the *Growth Centres SEPP*, is the legal instrument that establishes the planning rules and objectives for Sydney's North West and South West Growth Centres. To facilitate and help accelerate development in the Growth Centres, each Growth Centre has been divided into a number of Precincts. Precinct Planning is the detailed process used to analyse the development potential of each Precinct by investigating appropriate land use options, infrastructure requirements and hazards such as flood risk.

Once the Precinct Plan and the Development Control Plan (DCP) are adopted for a particular Precinct, they are included in the *Growth Centres SEPP*, and Council's Local Environmental Plan (LEP) and any DCPs no longer apply to land in that Precinct. Therefore it is important for local Councils to be actively involved in the preparation of DCPs for the Precinct Planning Process.

During the preparation of the *Camden Growth Centre Precincts DCP*, Camden Council was proactive in ensuring that the intentions of the flood-related development controls in their *Flood Risk Management Policy* were carried through into the *Camden Growth Centre Precincts DCP*.

Because Council's *Flood Risk Management Policy* is referred to specifically in the *Camden Growth Centre Precinct DCP*, these flood-related development controls can continue to apply in the South West Growth Centre (NSW DoPI, 2013a, in draft). This provides a consistency of approach to planning and development procedures for flood risk management for all flood-prone land across the Camden LGA.

Assessment of Cumulative Flood Risk

The rapid urban development of the Sydney's South West Growth Centre in the Upper South Creek catchment has highlighted the importance of a wholistic approach to the assessment of potential cumulative future flood impacts from urban development.

Councils can utilise a 'standard' Flood Study (as described in the Floodplain Development Manual (NSW Government, 2005)) to not only determine the flood behaviour for existing catchment conditions but also to model the impacts for all future development. Cost effective and time efficient modelling techniques are available to replicate future urban development. The impacts on flood behaviour can be determined by the catchment-wide Flood Study for any number of interim development scenarios, as well as the ultimate development condition.

The criteria for acceptable development should be more than a simple requirement that 'post-development peak flow rate should not exceed the pre-development flow rate for a particular flood size'. Therefore, it has been recommended that

- a suite of on-site detention (OSD) parameters be developed that can be used by individual precincts to size their flow detaining storages, whether that be in the form of small on-site detention tanks, subcatchment detention basins and/or larger regional detention basins.
- a suite of hydrographs from the catchment-wide Flood Study be developed that can act as conditions that will need to be met by each future development precinct.
- once detailed modelling by the individual precincts had been undertaken using the guiding principles provided, the catchment-wide Flood Study can be used as an assurance check to test the flood behaviour of proposed Precinct's Water Management Strategy to ensure that there will be no adverse impact elsewhere in the greater catchment.

When staged development is proposed for a catchment, such as the Upper South Creek catchment in the South West Growth Centre, it is important that the detailed Water Management Strategies for individual precincts are undertaken in accordance with best-practice techniques used for 'standard' Flood Studies. Local Councils and the NSW Office of Environment and Heritage can assist with preparation of consultant briefs in this regard.

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