Western Sydney Aerotropolis (Initial Precincts)

Stormwater and Water Cycle Management Study

Interim Report – October 2020

Sydney WATER

Acknowledgement of Country

Sydney Water respects the traditional 'Caring for Country' restorative approaches practiced over tens of thousands of years by Aboriginal people and play our part to improve the health of the landscape by recognising and nurturing all values of water in our environment.

In doing so, we acknowledge the traditional custodians and their ancestors of the lands and waters in Western Sydney where we are working and learning: the D'harawal and Dharug nations, as well as their neighbours the Gundungurra. Their lore, traditions and customs nurtured and continue to nurture the sweet waters in this area, creating wellbeing for all. We also pay our respects to Elders, past and present.

Executive summary

This *Stormwater and Water Cycle Management Study* is an interim document that outlines how stormwater, wastewater, recycled water as well as trunk drainage and riparian zones should be managed to achieve the Western Parkland City vision within the Agribusiness, Aerotropolis Core, Badgerys Creek and Northern Gateway precincts.

These precincts account for approximately half of the Western Sydney Aerotropolis and most of the mixed use, enterprise, recreation and environment lands as well as transport infrastructure corridors. The Aerotropolis lies mostly within the Wianamatta-South Creek catchment. Wianamatta is the Dharug name for South Creek and means 'mother's place' or 'mother's creek.' Wianamatta is highly significant to First Nations people who have cared for Country, including the waters of Wianamatta for thousands of years. Planning for the Aerotropolis must also respect and care for these waters *'to the most insignificant jet.'*[1]

The waterways of the Wianamatta-South Creek catchment are unique and highly vulnerable to the impacts of urbanisation. The creeks, floodplains and landscapes of Wianamatta-South Creek are valuable natural assets which underpin the future amenity and liveability of the Aerotropolis and broader Western Parkland City. The management of water in the Aerotropolis is therefore a critical component of precinct planning.

The *State Environmental Planning Policy (Western Sydney Aerotropolis) 2020* requires that Precinct Plans be prepared and approved by the Minister. Section 40 (3) states that the precinct plan for each precinct must be spatially based, include performance criteria for development and identify public utility infrastructure. Importantly, the plans must contain *"proposals for total water cycle management of the precinct."*

This report identifies the agreed total water cycle management proposal for the four initial precincts. The Wianamatta-South Creek corridor has been considered where it is adjacent to the four initial precincts only.

Integrated water servicing

This study integrates supply of mains water, wastewater, stormwater and recycled water into water balances for the precincts. Within this interim report several scenarios have been identified for testing. Each servicing scenario is differentiated with key concepts relating urban form outcomes and levels of recycled water and stormwater servicing. A final water balance scenario will be refined to ensure infrastructure can be identified for agreed total water cycle solutions for each precinct.

Recommendation: Water servicing for precincts are to feature total water cycle management that integrates and balances drinking water, wastewater, recycled wastewater and harvested stormwater in line with the finalised scenario. All open spaces, areas of landscaping, parks and streets must be developed to include irrigation infrastructure to ensure demand and provide expected urban cooling benefits.

A final water balance will be provided that ensures water servicing will minimise demands on potable water supplies through alternative water sources. Recycled wastewater will be provided to the area. The final balance of recycled water and harvested stormwater will be calibrated to achieve waterway health outcomes.

[1] Sydney Gazette and NSW Advertiser, Saturday 2nd September 1826 (page 4). Resolution of extraordinary meeting, Windsor Courthouse, 28th August 1826, chaired by Coleby (https://dharug.dalang.com.au/plugin_wiki/page/Colebee). Citation provided by Dr Daniele Hromek.

Waterway health

Landscape led planning is being applied to orient new urban development around the network of waterways that provide the central landscape features for the region. This planning recognises the cultural, ecological and recreational values of those waterways and includes Government waterway health objectives that will preserve those values. These objectives have been developed through the application of the NSW Government's Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions (risk-based framework).

Importantly, these objectives work towards managing waterway health within the Wianamatta-South Creek by capping the volume of erosive stormwater flows discharged from new development, as well as setting water quality requirements.

This Stormwater and Water Cycle Management Study adopts these objectives and demonstrates how a range of integrated water cycle strategies are required and have been integrated with other government objectives regarding open space, active transport, native vegetation, riparian vegetation policy, urban cooling, flooding and airport specific risk management.

Achieving a reduction in stormwater runoff volumes represents a shift in stormwater management that requires a combination of at-source controls, rainwater and stormwater harvesting and vegetated Water Sensitive Urban Design (WSUD) elements including biofiltration and wetlands, that can mimic the existing hydrologic characteristics of the rural catchment.

Recommendation: Development within the Western Sydney Aerotropolis is to ensure waterways, riparian corridors, selected farm dams, open water bodies and other water dependent ecosystems are protected, restored and maintained. All development and public infrastructure must comply with and contribute towards the waterway health objectives developed by NSW government under the Risk Based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions (OEH/EPA 2017). Development is to ensure that the stormwater pollution removal and flow management requirements identified in this study are achieved by inclusion of infrastructure, systems and urban layouts identified in the precinct plans.

Stormwater system

A range of trunk drainage and preferred Water Sensitive Urban Design (WSUD) stormwater management elements have been developed through consultation with Penrith and Liverpool Council. These WSUD elements work together to preserve the local waterways that cross the precincts as well as waterways in the lower catchment. A coordinated approach will be required to ensure that that land-take and maintenance efforts are minimised to a consolidated number of effective stormwater assets located strategically. A comparison of indicative life cycle costs of these WSUD elements and their effectiveness at achieving stormwater management objectives is provided in this study.

Recommendation: Stormwater systems including on private lots, within the streetscape and trunk drainage must be designed to achieve the waterway health, urban cooling, tree canopy and open space outcomes through Water Sensitive Urban Design treatment trains developed with key stakeholders and outlined in this report. Urban layouts, streets and drainage are to utilise effective perviousness to achieve the flow and water quality objectives identified in this study. Trunk drainage is to be through natural creek-lines or constructed natural drainage channels to help detain flows and contribute to biodiversity, public amenity and safety. The indicative layout of the regional trunk drainage network, including treatment "water in the landscape" wetlands is identified in the blue green mapping layer and is to be allowed for in any development lay out. The ongoing ownership and management of these assets must ensure adequate and sustainable funding for maintenance is available.

Precinct scale stormwater quantity management

The stormwater system also aims to manage peak flows for frequent events (e.g. 50% Annual Exceedance Probability) to minimise the risk of impacts to stream morphology as a result of increase in imperviousness due to development. Strategies have been developed that aim to meet these broad objectives. The focus of this work has been on sizing stormwater detention using a combination of methods at suitable locations to retard flows to meet existing case peak flows.

Recommendation: To manage local runoff and the impact that the Western Sydney Aerotropolis has on downstream areas, stormwater flows will need to be detained within the landscape. In consultation with stakeholders this study has shown that a combination of on-site detention (for industrial areas), on-line detention (on 1st and 2nd order creeks) through natural drainage design and local stormwater assets can sufficiently manage precinct scale runoff and must be employed throughout the Western Sydney Aerotropolis. An allocation of sufficient, suitably located land area to allow for stormwater assets must be provided. Detention assets in the public realm should be designed as multifunctional also contributing to waterway health, biodiversity and public amenity. It is important to note that the Flood Risk and Impact Assessment will consider the impacts of development on overall timings of flows from contributing tributaries of Wianamatta-South Creek. This work and the subsequent strategy derived from this work may result in changes to the precinct-scale stormwater quantity management strategy and will inform the final report.

Riparian land management

The protection, restoration and maintenance of waterways, riparian corridors, and water dependent ecosystems is essential in achieving the cultural, social and biodiversity aspirations as well as tree canopy targets of the Western Parkland City. Creeks within the initial precincts are being validated and mapped with associated vegetated riparian zones to support waterway health. Water dependant ecosystems and key fish habitat is also being identified and mapped. A riparian revegetation strategy will be developed once fieldwork is complete, recommending the areas and likely costs of riparian land that should be revegetated. Figures are provided in section 4 depicting proposed vegetated riparian zone and farm dam prioritisation.

Recommendation: Vegetated riparian zones (VRZ) adjacent to creeks and other water bodies mapped must be protected, restored and maintained. Opportunities to revegetate beyond standard VRZs should be explored to maximize biodiversity outcomes and achieve urban canopy targets, particularly within the Wianamatta Precinct. The ongoing ownership and management of these assets must ensure adequate access and sustainable funding for maintenance is available. Figures are provided in section 4 depicting on-going and completed field surveys.

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1 Introduction

In September 2020, the Minister for Planning and Public Spaces approved *State Environmental Planning Policy (Western Sydney Aerotropolis) 2020* (*Aerotropolis SEPP*) to enable the rezoning of lands surrounding the proposed Western Sydney Airport, known as the Western Sydney Aerotropolis (Aerotropolis). The rezoning is for a mix of employment, residential and community uses.

The Aerotropolis lies mostly within the Wianamatta-South Creek catchment. Wianamatta is the Dharug name for South Creek and means 'mother's place' or 'mother's creek.' Wianamatta is highly significant to First Nations people who have cared for Country, including the waters of Wianamatta for thousands of years. Planning for the Aerotropolis must also respect and care for these waters *'to the most insignificant jet.'*[2]

The waterways of the Wianamatta-South Creek catchment are unique and highly vulnerable to the impacts of urbanisation. The creeks, floodplains and landscapes of Wianamatta-South Creek are valuable natural assets which underpin the future amenity and liveability of the Aerotropolis and broader Western Parkland City. The management of water in the Aerotropolis is therefore a critical component of precinct planning.

1.1 Total Water Cycle Management

The *Aerotropolis SEPP* requires that Precinct Plans be prepared and approved by the Minister for Planning and Public Spaces. Section 40 (3) states that the precinct plan for each precinct must be spatially based, include performance criteria for development and identify public utility infrastructure.

Importantly, the plans must contain *"proposals for total water cycle management of the precinct."*

This *Stormwater and Water Cycle Management Study* (the study) identifies the agreed total water cycle management proposal for each of four of the initial precincts, noting that Wianamatta-South Creek corridor has been considered only where it is adjacent to these four precincts. The study integrates the water, wastewater, recycled water and stormwater servicing as well as the riparian corridor management for these initial precincts. and responds to the scope defined by the Western Sydney Planning Partnership (WSPP).

1.2 Interim report

This version of the *Stormwater and Water Cycle Management Study* is an interim report for public consultation and a finalised version will be provided in early 2021 that includes more detail and refinement once key decisions have been made on waterway health objectives and targets, the role that stormwater harvesting will play in delivering those objectives and demands for recycled water within the precincts.

The roadmap for completing this work is outlined as Figure 1-1 on the next page.

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[2] Sydney Gazette and NSW Advertiser, Saturday 2nd September 1826 (page 4). Resolution of extraordinary meeting, Windsor Courthouse, 28th August 1826, chaired by Coleby (https://dharug.dalang.com.au/plugin_wiki/page/Colebee). Citation provided by Dr Daniele Hromek.

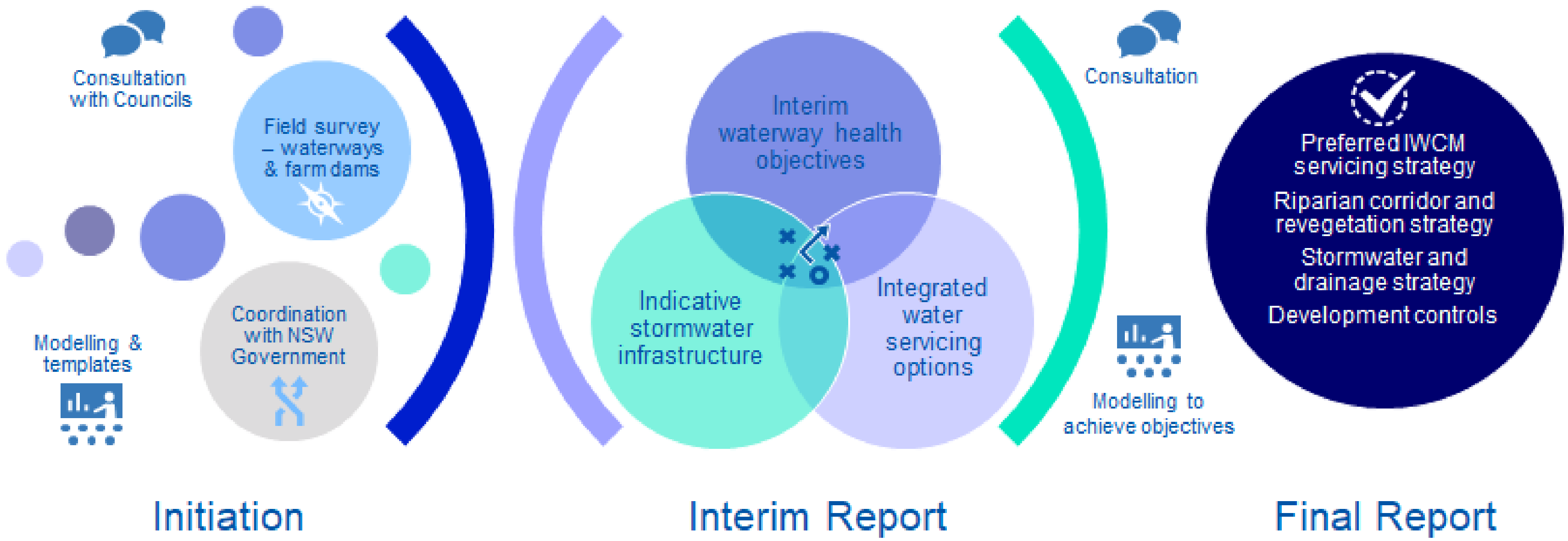


Figure 1-1 Study road map

1.3 Initial precincts

Five precincts surrounding the proposed Western Sydney Airport in the Aerotropolis have been planned for initial release/rezoning (shown in Figure 1-2):

- Northern Gateway
- Agribusiness
- Badgerys Creek
- Aerotropolis Core
- Wianamatta-South Creek (where it adjoins the precincts above)

The initial precincts are intersected by several creeks:

- Badgerys Creek
- South Creek
- Thompsons Creek
- Science Creek
- Cosgroves Creek
- Duncans Creek

The existing character of the five precincts is summarised below (shown in Figure 1-3 and Figure 1-4):

1. **Agribusiness**: This precinct is largely dominated by an open rural landscape with sparse buildings and roads and interspersed with pockets of forested vegetation and agricultural dams.

   The rural village of Luddenham is located within this zone and the adjacent land is generally higher than surrounding precincts providing long distance views towards the Blue Mountains to the north.

   Duncans Creek follows the western boundary of this precinct and there are significant areas of existing vegetation and existing dams associated with this corridor. Key vegetation types include Forest Red Gum and Grey Box woodland.

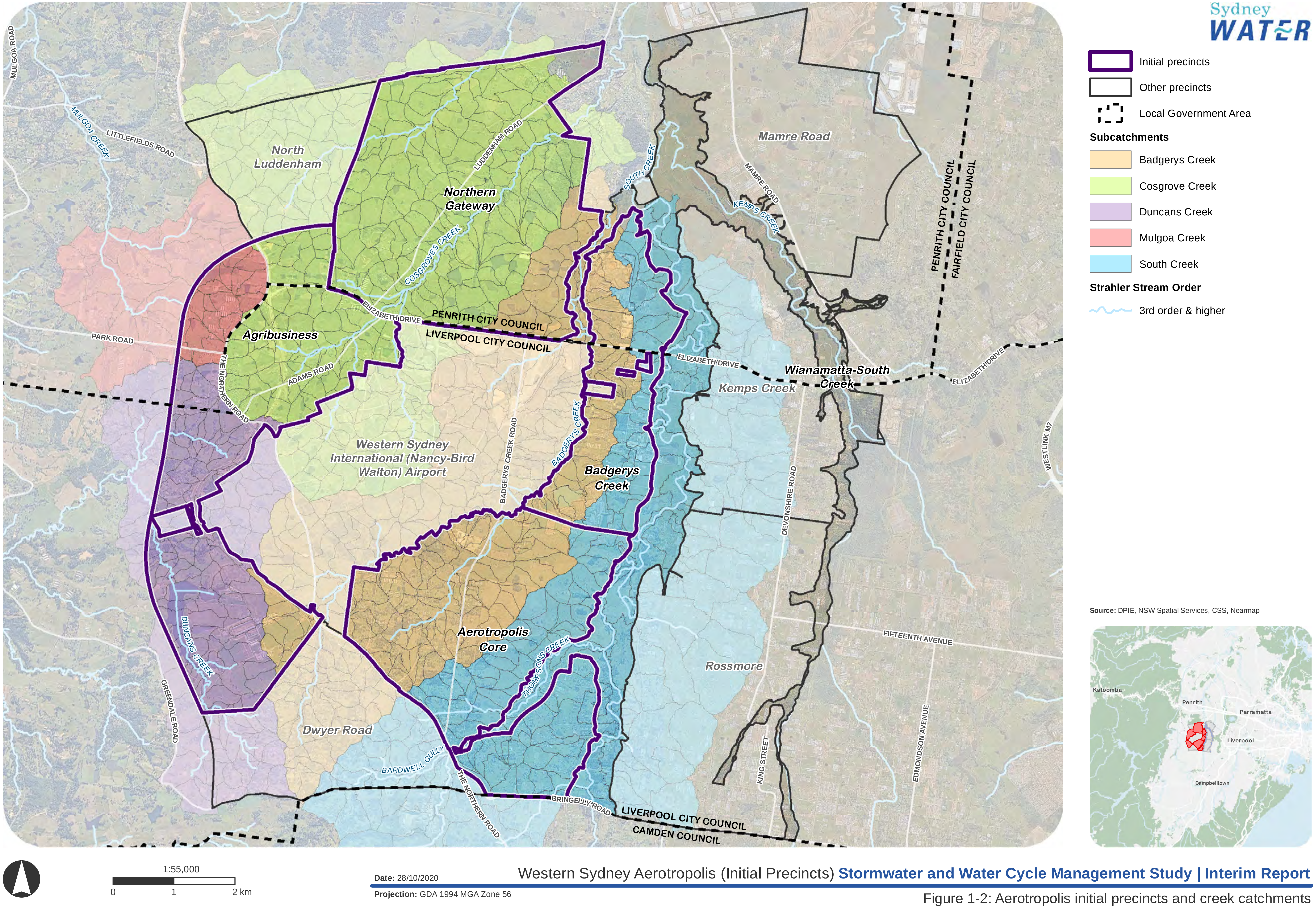
2. **Aerotropolis Core**: Badgerys Creek follows the northern boundary of this precinct and Thompsons Creek and Wianamatta-South Creek form the southern boundary. The precinct is largely low lying with higher terrain located along the western boundary. The area is dominated by well vegetated small agricultural plots with frequent farm buildings and road infrastructure. Significant Cumberland Plain vegetation is found towards the west of the zone and includes primarily Grey box woodland.

3. **Northern Gateway**: This precinct borders a residential estate associated with the Twin Creeks Golf and Country Club and is predominantly a flat rural landscape with large agricultural lots. The Cosgroves Creek corridor dissects the zone from south-west to north-east and a second creek runs along the northern boundary of the precinct and contains a number of small existing farm dams.

   The highest terrain is located in the south-western corner of the precinct and a large segment of this precinct is also designed as 'Environmentally Sensitive Land' and follows the Cosgroves Creek corridor and the southern boundary of the precinct. Existing blocks of Cumberland Plain vegetation are scattered across the area and consist primarily of Broad-leaved Iron Bark and Grey Box woodland.

4. **Badgerys Creek**: This precinct is a low-lying area between the well vegetated Wianamatta-South Creek and Badgery's Creek corridors. The land use consists of small agricultural plots with frequent farm buildings and road infrastructure. A strip of 'Environmentally Sensitive Land' runs through the centre of this zone and significant Cumberland Plain vegetation is focussed along the creek corridors.

5. **Wianamatta-South Creek**: This precinct follows the riparian corridors of Wianamatta-South Creek and Kemps Creek and is dominated by significant areas of Forest Red Gum woodlands and associated grasslands. The plots of woodland become smaller and more sparsely located as the two creeks join in the north of the precinct. The vegetated corridors are generally bordered by agricultural plots and infrastructure towards the edges of the precinct.



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Projection: GDA 1994 MGA Zone 56

Figure 1-2: Aerotropolis initial precincts and creek catchments

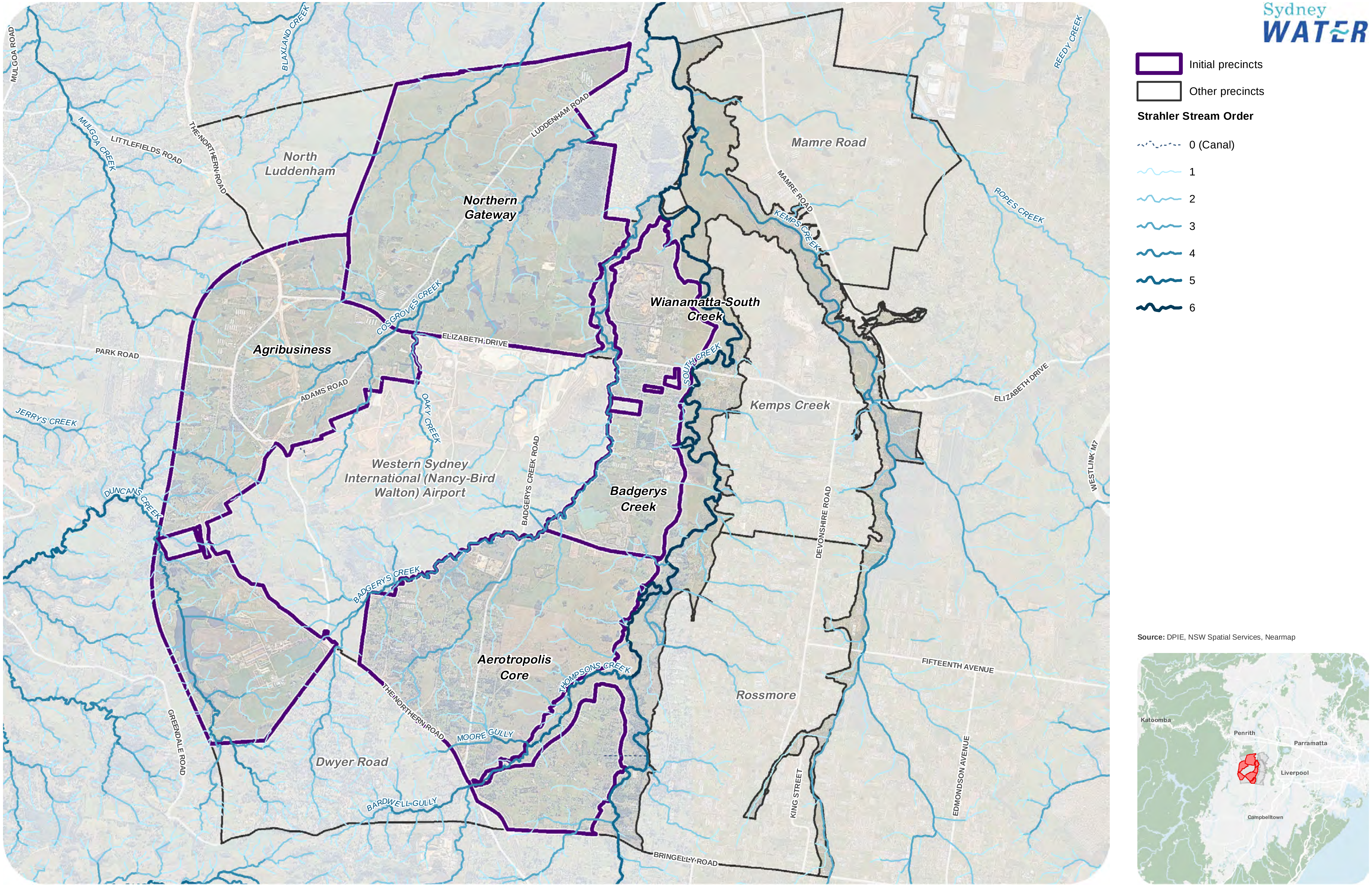

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Figure 1-3: Aerotropolis creeks and associated tributaries

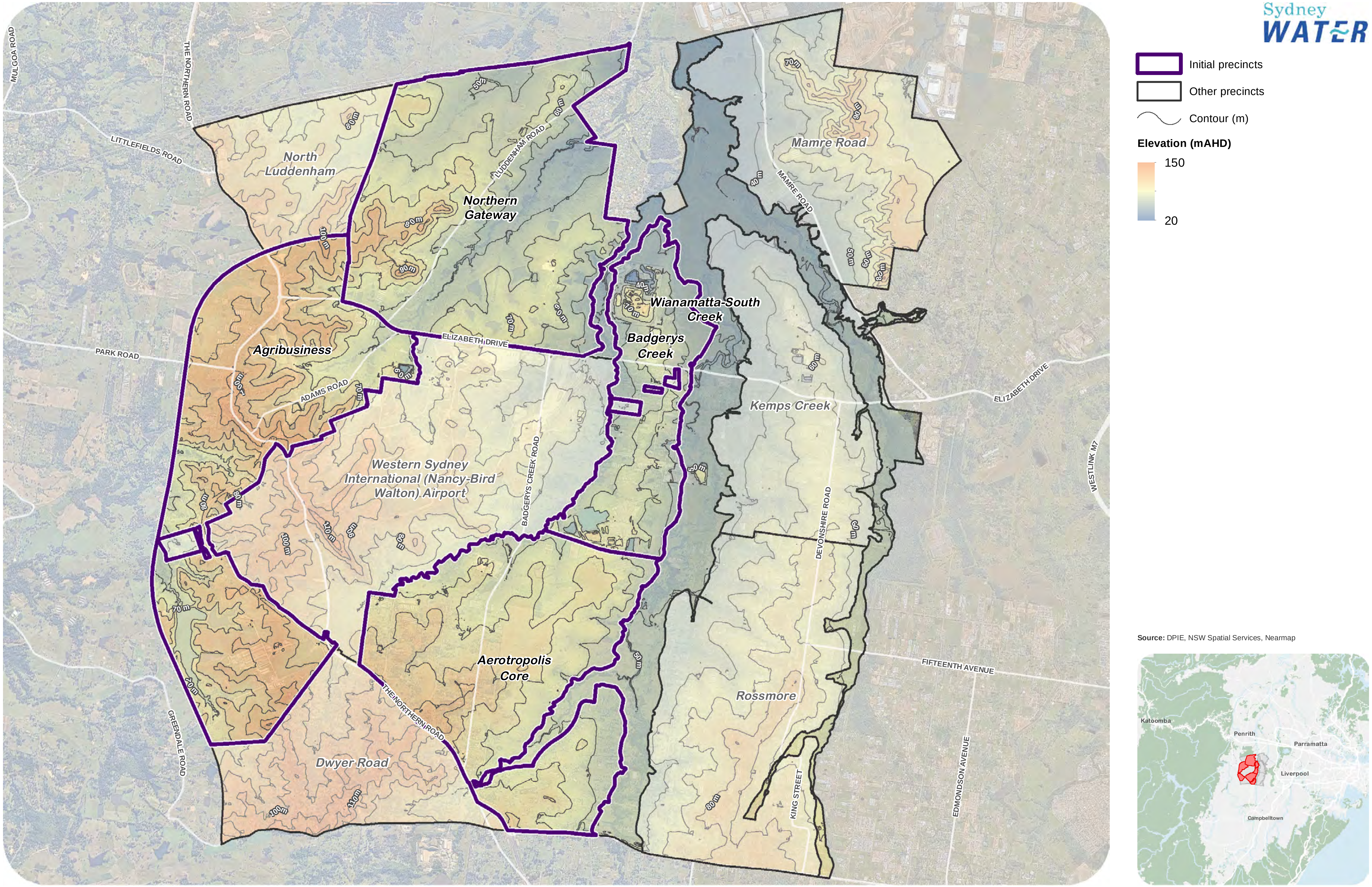

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Figure 1-4: Aerotropolis terrain

1.4 NSW Government waterway health objectives

The vision for Wianamatta-South Creek (and its tributaries) is to become a cool green corridor through the Western Parkland City, and be the core element of liveability and amenity for the residents. This vision relies on urban planners to explicitly keep water in the landscape by integrating waterways into the design of the city and residential neighbourhoods, and for the waterways to be healthy so they can provide the essential services and functions expected of a cool green corridor.

Currently, the Wianamatta-South Creek catchment is the most degraded catchment in the Hawkesbury-Nepean River system due to historical vegetation clearing and urbanisation. Increased urbanisation will further degrade the waterways if stormwater, wastewater and flooding regimes are not managed, upfront through an integrated ecosystem approach. This approach requires the waterways and hydrological cycle to be central considerations in both land use and water infrastructure planning.

To help deliver the vision, the NSW Government has developed performance criteria relevant to:

i. the protection, maintenance and/or restoration of waterways, riparian corridors, water bodies and other water dependent ecosystems that make up the 'blue' components of the Blue-Green Infrastructure Framework
ii. a landscape led approach to integrated stormwater management and water sensitive urban design

The performance criteria (Table 1-1, Table 1-2) are referred to as water quality and flow objectives and apply to all urban developments on land in the precinct. Compliance towards achieving the performance criteria must follow the protocol outlined in the *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions* (OEH/EPA, 2017).

Table 1-1 Ambient water quality of waterways and waterbodies in the Western Sydney Aerotropolis

Water Quality Objectives	
*Total Nitrogen (TN, mg/L)	1.72
Dissolved Inorganic Nitrogen (DIN, mg/L)	0.74
Ammonia (NH_3-N, mg/L)	0.08
Oxidised Nitrogen (NOx, mg/L)	0.66
*Total Phosphorus (TP, mg/L)	0.14
Dissolved Inorganic Phosphorus (DIP, mg/L)	0.04
Turbidity (NTU)	50
Total Suspended Solids (TSS, mg/L)	37
Conductivity (µS/cm)	1103
pH	6.20 - 7.60
Dissolved Oxygen (DO, %SAT)	43 - 75
Dissolved Oxygen (DO, mg/L)	8

* when showing compliance towards TN and TP through industry models, the DIN and DIP performance criteria should be instead to recognise that stormwater discharges of nutrients are mostly in dissolved form

Table 1-2 *Stream flows objectives for waterways and water dependent ecosystems based on averaged daily flow rates

Flow Objectives	Current Condition	Tipping Point for Degradation
To be applied in Strahler ranked waterways as follows	1-2 Order Streams	3rd Order Streams or greater
Median Daily Flow Volume (L/ha)	71.8 ± 22.0	1095.0 ± 157.3
Mean Daily Flow Volume (L/ha) Mean Annual Runoff Volume (ML/Ha/yr)	2351.1 ± 604.6 (0.9 ML/Ha/yr)	5542.2 ± 320.9 (2.0 ML/Ha/yr)
High Spell (L/ha) ≥ 90th Percentile Daily Flow Volume	2048.4 ± 739.2	10,091.7 ± 769.7
High Spell - Frequency (number/y) High Spell - Average Duration (days/y)	6.9 ± 0.4 6.1 ± 0.4	19.2 ± 1.0 2.2 ± 0.2
Freshes (L/ha) ≥ 75th and ≤ 90th Percentile Daily Flow Volume	327.1 to 2048.4	2642.9 to 10091.7
Freshes - Frequency (number/y) Freshes - Average Duration (days/y)	4.0 ± 0.9 38.2 ± 5.8	24.6 ± 0.7 2.5 ± 0.1
Cease to Flow (proportion of time/y)	0.34 ± 0.04	0.03 ± 0.007
Cease to Flow – Duration (days/y)	36.8 ± 6	6 ± 1.1

* numerical values for performance criteria will be finalised following public exhibition of the Precinct Plan

The performance criteria are responsive to the protection and improvement of the condition of high ecological value waterways and water dependent ecosystems in the Western Sydney Aerotropolis. These ecosystems include some existing native vegetation (i.e. groundwater dependent vegetation) that are protected under the *Biodiversity Conservation Act 2016* and *Environment Protection and Biodiversity Conservation Act 1999*, and some identified as environmentally sensitive waterways and riparian in existing Local Environment Plans. These ecosystems are mostly located in the floodplain, and are home to many threatened, critically endangered and high ecological value species of fauna and flora, including those considered iconic to the area (bass, bats and a range of birds) or are totems for the local Aboriginal communities (e.g. water dragons).

The Riparian Revegetation Strategy for the Western Sydney Aerotropolis will identify a strategy for the protection and improvement of riparian corridors and other water dependent vegetation (see section 4). The strategy will explicitly account for the high ecological value waterways and water dependent ecosystems and development constraints, while achieving the Western Parkland City vision using vegetation communities that are endemic to the Cumberland Plain.

In this interim report, Sydney Water has adopted the "mean daily flow volume" as the critical path for stormwater infrastructure sizing. This figure was translated into an annual objective for Strahler stream order 1-2 and order 3 and greater streams expressed as a Mean Annual Runoff Volume (MARV) in ML or runoff per hectare per year.

Sydney Water has demonstrated how trunk drainage elements that can work towards achieving the mean daily flow volume objective at local and catchment wide scales and through urban design, water conservation measures (rainwater tanks), green infrastructure and drainage system (including treatment ponds/basins). Further work is being undertaken to finalise this approach with DPIE EES and clarify development targets, street design and trunk design requirements in the final version of the report. Further work will also be undertaken to ensure the other flow and water quality objectives are being met through required stormwater infrastructure.

1.5 Study objectives

The aim of the *Stormwater and Water Cycle Management Study* (the study) is to develop a water masterplan for the Precincts, as part of and in conjunction with the precinct planning process to:

- Outline the stormwater drainage strategy for the precinct, identifying major and minor drainage approach.
- Develop feasible strategies for the detention and treatment of post-development stormwater runoff volume that meets required performance criteria for the precincts.
- Identify and size elements of a stormwater treatment train to meet the waterway health objectives and stormwater quantity and quality targets identified by DPIE EES, for the precincts.
- Identify stormwater reuse options and investigate the potential for a regional stormwater and wastewater reuse strategy(ies);
- Determine maintenance requirements and arrangements for stormwater management assets.
- Ensure high value riparian corridors are retained and integrated into the precincts

The study has been prepared to inform and support the rezoning of the Aerotropolis Initial Precincts. Controls prescribed by this study will inform the Aerotropolis Phase 2 Development Control Plan (DCP) and ensure that:

- Essential water servicing is provided in a timely manner
- The Western Parkland City vision can be achieved through an integrated approach to water services
- Resilience (water and climate) is considered in development of integrated water approach
- Stormwater detention approaches are effective across the study area
- Water sensitive urban design approaches achieve pollution reduction and waterway health targets in a flexible and cost-effective way
- Sufficient land is allocated for stormwater management on private lots and in the public domain
- Trunk drainage is designed in a way that protects and improves biodiversity and is integrated into the public domain
- Sustainable funding for ongoing stormwater management is coordinated across catchments.

1.5.1 Integrated water servicing strategy

Integrated water servicing approaches linking the supply of drinking water, stormwater and recycled water with wastewater services have been developed to assess the water balances and infrastructure requirements for the initial precincts. The integrated servicing approaches are primarily based on the Water Cycle City pathway of Sydney Water's Western Sydney Regional Master Plan, the water servicing pathway delivering the greatest economic value at least cost for realising the Western Parkland City vision. The approach blends in elements of the Water Sensitive City pathway through more integrated stormwater management.

The ultimate water demands for the Precincts have been compiled for residential and non-residential uses, irrigation and urban cooling. These demands have been used to inform the planning, sizing and staging of water servicing infrastructure in the Aerotropolis.

The non-drinking, irrigation and urban cooling demands have been used to inform the size of stormwater harvesting elements and contribute to stormwater volume reductions.

1.5.2 Riparian corridor management strategy

Waterways across the site are being 'ground-truthed' to determine the presence and extent of riparian lands and those that are to be retained. A riparian corridor strategy is being developed for the Precincts that recommends the retention of waterways based on ground-truthing and consultation with key stakeholders including the NSW Natural Resources Access Regulator. This work will also identify areas of key aquatic habitat, farm dams recommended to be retained based on high ecological value and will recommend a riparian revegetation strategy.

1.5.3 Stormwater management for waterway health

This planning recognises the cultural, ecological and recreational values of waterways and contemplates how interim waterway management can work towards preserving those values. These interim objectives have been considered in this study for the purpose of earmarking land and funding that may be necessary to deliver the waterway outcomes.

The waterway health objectives and targets will be finalised through a consultation process outlined in the NSW Government's *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions* (risk-based framework) These will include flow linked to interim Water Quality Objectives that have been set for Wianamatta-South Creek.

Importantly, these objectives are based on data collected from the local waterways and work towards managing waterway health within the Wianamatta-South Creek by capping the volume of erosive stormwater flows discharged from new development, as well as setting water quality requirements.

1.5.4 Stormwater quantity management for precinct-scale storm events

Hydrological modelling of the existing catchments in conjunction with proposed developments has been used to inform the strategy for managing stormwater at a precinct scale.

Scenarios modelling the proposed developments have shown that the stormwater can be managed using a combination of On-Site Detention (OSD) and detention basins. The strategy works by retaining flow from proposed developments and thereby ensuring that flows discharged into waterways are consistent with the existing conditions.

This strategy requires consistency with the Flood Risk and Impact Assessment which has a stronger focus on flood risks at a regional Wianamatta-South Creek scale. The stormwater quantity management strategy discussed in this report is at a precinct-scale is also focussed on more frequent events (e.g. 50% AEP) that play a major role in stream morphology (as discussed above in the stormwater management for waterway health objectives).

It is important to note that the Flood Risk and Impact Assessment will consider the impacts of development on overall timings of flows from contributing tributaries of Wianamatta-South Creek. This work and the subsequent strategy derived from this work may result in changes to the precinct-scale stormwater quantity management strategy.

2 Proposed land use and impacts

2.1 Land use zoning

For the purposes of this study, the precincts have been categorised in accordance with their land use zoning under the Aerotropolis SEPP, being:

1. Enterprise
2. Agribusiness
3. Environmental and Recreation
4. Mixed-use
5. SP2 - Infrastructure

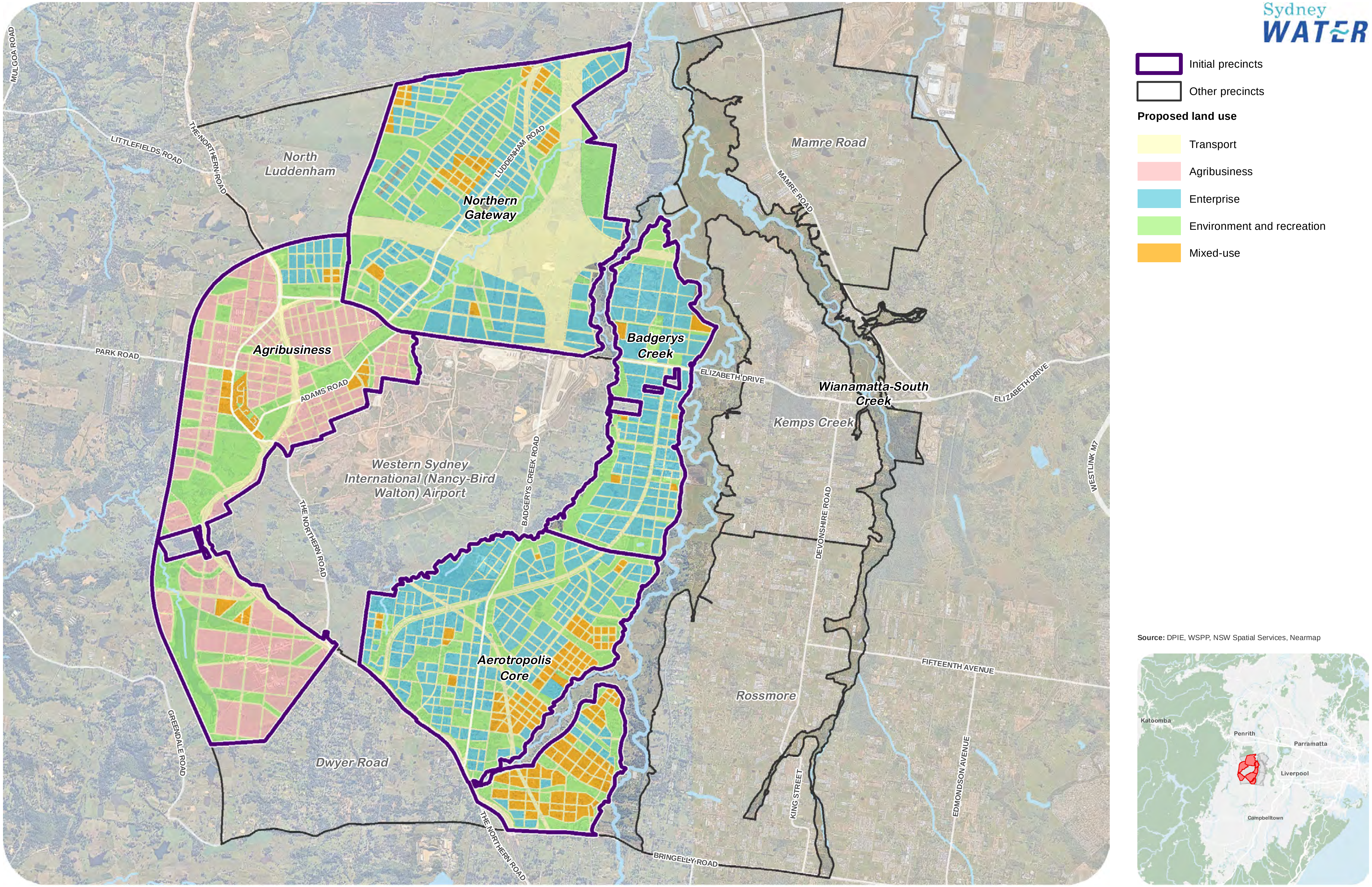
The proposed character of each land use zone is summarised below (refer to Figure 2-1 below):

1. **Enterprise:** This zone will permit land uses that supplement or complement the functions of the city and the Western Sydney International (Nancy-Bird Walton) Airport (Airport) as a 24-hour transport hub. The zone will enable uses typically associated with employment lands, supporting a range of commercial and industrial sectors that will benefit from proximity to the airport such as distribution centres, landscape material supplies and vehicle repair workshops. Residential development and other noise sensitive uses such as schools and hospitals will not be permitted in this zone.
2. **Agribusiness:** This zone will support new agribusiness opportunities. The development of agribusiness so close to the Airport requires design controls to ensure land uses are compatible with Airport operations. Specific statutory controls are proposed to guide appropriate development locations and form.

   While this zone is proposed to apply to the Luddenham Village, the village will not necessarily be limited to Agribusiness activities. The future vision, role and function of the village will be further explored during precinct planning.
3. **Environmental and Recreation lands:** Narrow/linear parks following ephemeral creeks; Ridge Top Parks connected to riparian zones with green boulevards; Formal recreation spaces located near schools and community uses
4. **Mixed-use**: Extensive private / public realm connected to water infrastructure; productive landscapes in the private realm
5. **Infrastructure:** This zone will be applied to new and existing road and rail corridors, transport facilities, and land required for utilities throughout the Aerotropolis. The Aerotropolis SEPP will need to be amended to accommodate infrastructure as it is planned and as corridor and site boundaries are further refined. It is noted that tree canopies are an integral part of the streetscape. Road design should emphasise parkland experience and views and streets provided with an upper canopy for shade and understorey softening street edges. This also contributes to water management, waterway health and biodiversity.

Precinct plans have been developed for each of the initial precincts showing the spatial distribution of land use zones, as well as transport, water and green infrastructure. The initial precincts account for approximately 60% of the Aerotropolis. These precincts include the majority of the Aerotropolis mixed use, enterprise, environment and recreation lands and transport infrastructure corridors.

Table 2-1 shows that approximately one third of the precincts is enterprise zone. The entire Wianamatta-South Creek precinct accounts for a significant amount of undeveloped land across the initial precinct areas.



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Projection: GDA 1994 MGA Zone 56

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Figure 2-1: Aerotropolis land use zoning

Table 2-1 Breakdown of land use zones in each of the Precincts (Ha)

		Land-use Zone					
Precinct	**Total Area (Approx. ha)**	**Enterprise Zone (%) - industrial and commercial**	**Mixed Use (%) - integrate commercial and residential**	**Environment and Rec (%)**	**Low / Med Density Residential (%)**	**Agribusiness (%)**	**Infrastructure / Transport Corridors as per GSC GIS**
Aerotropolis Core	1,382	54%	36%	0%	0%	0%	10%
Agribusiness	1,560	2%	0%	10%	0%	75%	14%
Badgerys Creek	634	86%	0%	5%	0%	0%	9%
Northern Gateway	1,616	43%	11%	17%	0%	0%	28%
Wianamatta-South Creek	1,330	0%	0%	95%	0%	0%	5%
Precinct	**Total Area (Approx. ha)**	**Enterprise Zone (Ha)**	**Mixed Use (Ha)**	**Environment and Rec (Ha)**	**Low / Med Density Residential (Ha)**	**Agribusiness (Ha)**	**Infrastructure / Transport Corridors as per GSC GIS**
Aerotropolis Core	1,382	746	498	0	0	0	138
Agribusiness	1,560	47	0	157	0	1164	204
Badgerys Creek	634	526	0	31	0	0	55
Northern Gateway	1,616	695	178	291	0	0	452
Wianamatta-South Creek	1,330	0	0	1322	0	0	70
Total area	6,522	2,015	675	1,801	0	1,164	920
Percentage of the Precincts		31%	10%	27%	0%	18%	14%

2.2 Imperviousness

The WSPP is endorsing new urban forms that reduce the level of imperviousness and provide more landscaped areas in line with the Greater Sydney Commission's vision for the Western Parkland City. Urban form is an important factor in urban water demand and stormwater runoff volumes. For the purpose of consistency between the stormwater modelling and the Flood Risk and Impact Assessment, the following assumptions for imperviousness was provided by the WSPP and has been adopted for business as usual (BAU) and Western Parkland City urban development scenarios. A summary of the imperviousness values adopted is provided in Table 2-2 showing the potential reduction in imperviousness possible when more compact urban forms are delivered to support the Western Parkland City vision of a greener and cooler landscape for Western Sydney than current urban forms being delivered under business as usual (BAU).

Table 2-2 Imperviousness values typically adopted (e.g.Wianamatta-South Creek Flood Model) - across a precinct / catchment

Post development land use zone	Impervious values (%)	
	Business as Usual	Western Parkland City
Enterprise Zone - industrial and commercial (large format)	80%	60%
Mixed Use - integrated commercial and residential (high density)	85%	65%
Environment and Recreation	15%	10%
SP1 - Airport and Associated*	80%	70%
SP2 - Transport Corridors	85%	75%
Agribusiness	60%	50%
Residential - typical low and medium density	65%	50%

* SP1 Airport zoned land is not part of the study and is shown for information only.

2.3 Urban typologies

Each land use zone comprises different urban typologies that reflect the character and potential layout of development.

Urban typologies demonstrate how urban form and stormwater infrastructure can come together at a block, street and precinct scale to achieve urban design and water management objectives. Through the precinct plans, the WSPP has defined the land distribution split of urban typologies for each land use zone which informs where the potential stormwater harvesting end uses and WSUD approaches can be deployed. This provides the basis of water demand and wastewater load forecasts across the precincts. The precincts plans show that:

- Large format and strata industrial typologies account for most of the land use in the initial precincts, having a dominant role in both the Enterprise and Agribusiness land use zones.
- Ridge top parks and public open space associated with the floodplains, including the entire Wianamatta-South Creek precinct, will account for a significant amount (up to one third) of the land in the initial precincts. These will include regionally significant vegetation, riparian corridors, farm dams, regional parks, and a mix of active and passive open space.
- Transport corridors reserved for the M12 and M9 account for large (15%) proportion of the precincts. It is a noted that a fraction of this land take is likely to be the active corridors with the remainder provide ancillary land and vegetated batter slopes.
- Business park and commercial typologies will account for a relatively small of the land in the initial precincts (5%).
- An equal mix of high density and medium density residential typologies within Mixed Use zones in the Northern Gateway and Aerotropolis Core make up a relatively small proportion of land use.

Table 2-3 Typology split comprising each land use zone

	Typology split (%) per land use zone			
Land use zone	**Agribusiness**	**Enterprise**	**Mixed Use**	**Environment and recreation**
Medium Density Residential	-	-	25%	-
High Density Residential	-	-	25%	-
Strata Industrial	-	50%		-
Large Form Industrial	80%	50%		-
Commercial (Business Park)	-	-	50%	-
Environment and Recreation	10%	-	-	100%
Transport Corridors	10%	-	-	-

Table 2-4 Total area of typologies in initial precincts

Land use zone	Total area (Ha)	% of initial precincts
Medium Density Residential	170	3%
High Density Residential	170	3%
Strata Industrial	1001	15%
Large Form Industrial	2054	31%
Commercial (Business Park)	340	5%
Environment and Recreation	1912	29%
Transport Corridors	926	14%

2.4 Stormwater runoff from initial precincts

Each typology is split into different land use surfaces. The following land surface splits have been developed for each typology to reflect the imperviousness rates provided by the WSPP and presented above in Table 2-1. These have been used to determine stormwater runoff rates, stormwater quality and opportunities for rainwater harvesting.

Table 2-5 Adopted surface cover splits for Western Parkland City typologies

	Adopted surface cover split for modelling (%)					
Land use zone	Roof	Pavements and driveways	Asphalt and footpaths	Gardens	Verges	Public Open Space
Medium Density Residential	30%	5%	20%	22	11%	14%
High Density Residential	20%	18%	25%	7%	9%	20%
Strata Industrial	21%	15%	18%	21%	12%	14%
Large Form Industrial	30%	22%	15%	9%	10%	14%
Commercial (Business Park)	25%	25%	20%	7%	6%	18%
Environment and Recreation	0%	10%	0%	90%	0%	-
Transport Corridors			30%		70%	

* % as remnant vegetation and riparian corridor TBC

Table 2-6 Adopted imperviousness for Western Parkland City typologies

Land use zone	Adopted imperviousness (%) Including open space	Adopted imperviousness (%) Excluding open space
Medium Density Residential	54%	63%
High Density Residential	63%	76%
Strata Industrial	54%	64%
Large Form Industrial	67%	71%
Commercial (Business Park)	70%	72%

Figure 2-2 shows mean annual runoff volumes (MARV) from new urban development adopting a mean annual rainfall depth of 691 mm/yr based on Penrith Council's preferred continuous modelling time series and the impervious values presented in Table 2-6. The figure illustrates that runoff rates from urban development under the current, business as usual (BAU) urban typologies is significantly higher than the interim MARV stormwater target for waterways. As well, the figure shows significant increases in stormwater runoff volumes after development, which presents a significant problem to be managed. Emerging evidence from the Wianamatta-South Creek catchment shows a strongly negative correlation between stormwater runoff volumes and waterway health, in a non-linear relationship with a clear threshold or tipping point.

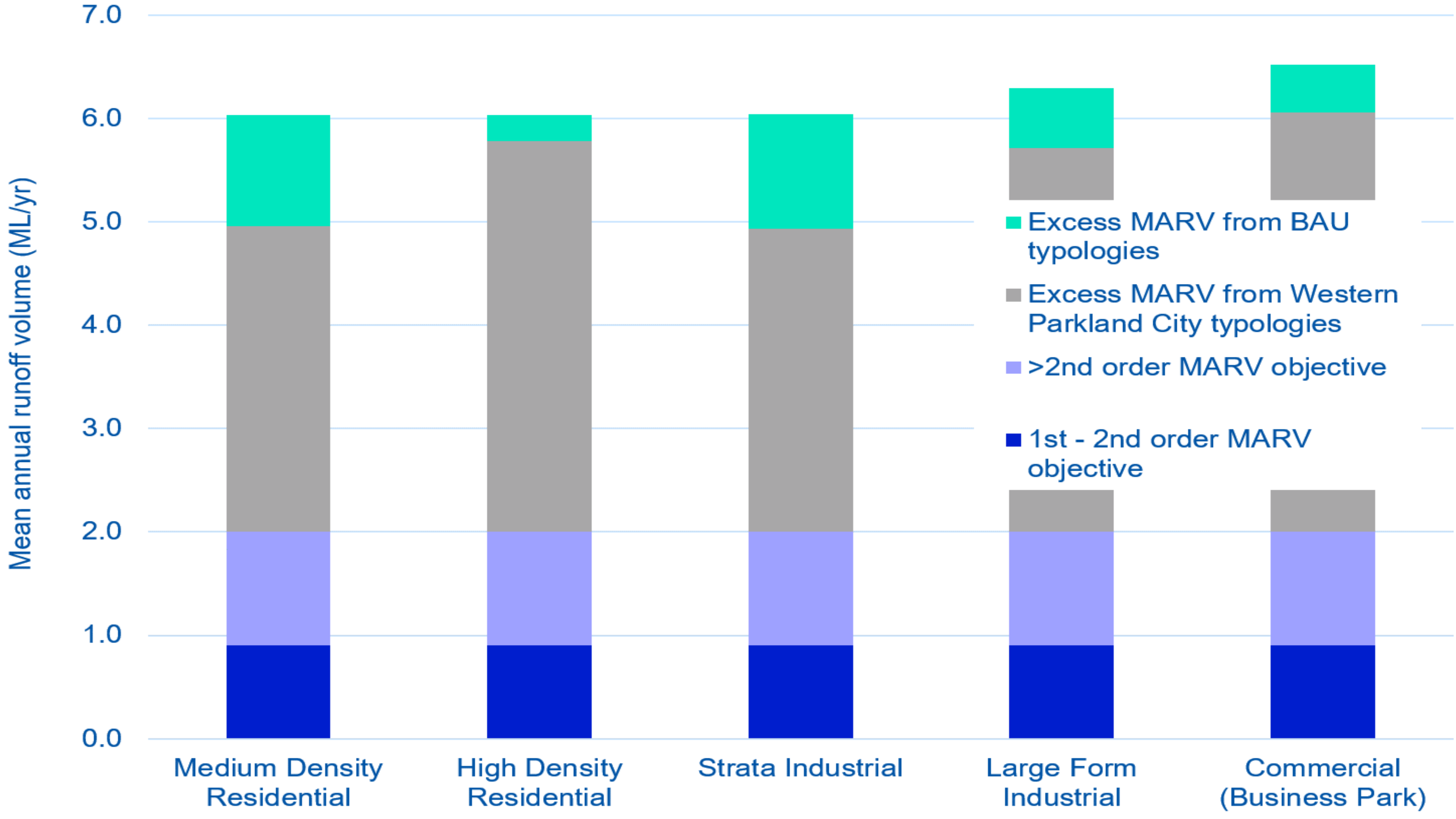


Figure 2-2 Notional stormwater discharge rates from each typology compared to waterway mean annual runoff volume (MARV) objectives

By adopting Western Parkland City typologies stormwater volumes will be reduced; however the stormwater runoff volumes from the adopted Western Parkland City typologies must be reduced by 3 to 4 ML/Ha/yr to achieve the draft MARV target (2 ML/Ha/yr) for third order waterways. Stormwater volumes need to be reduced further still for first and second order waterways.

Table 2-6 and Figure 2-3 provides the contribution of runoff from each typology to illustrate the scale of the stormwater contributions from each typology by factoring the contribution of each land use zoning.

Table 2-7 Scale of stormwater runoff contributions from different typologies and land use zones

Total areas in Initial Precincts	Medium Density Residential	High Density Residential	Strata Industrial	Large Form Industrial	Commercial (Business Park)	Environment and Recreation	Transport Corridors	Total
Footprint of lots and roads excluding public open space (Ha)	147	139	866	1777	279	191	926	4325
Stream flow mean annual runoff volume objective for 1st and 2nd order waterways (ML/yr)	132.3	125.5	779.3	1599.0	250.9	172.1	833.8	**3893**
Stream flow mean annual runoff volume objective for 3rd order waterways and greater (ML/yr)	323.0	323.0	1901.9	3902.6	646.0	3632.8	1760.2	**12489**
Total runoff from precincts as Western Parkland City development typologies (ML/yr)	**538**	**643**	**3492**	**8560**	**1308**	**236**	**917**	**15694**
Total runoff from precincts as Western Parkland City development typologies (ML/yr)	688	652	4691	9626	1511	236	1145	**18550**

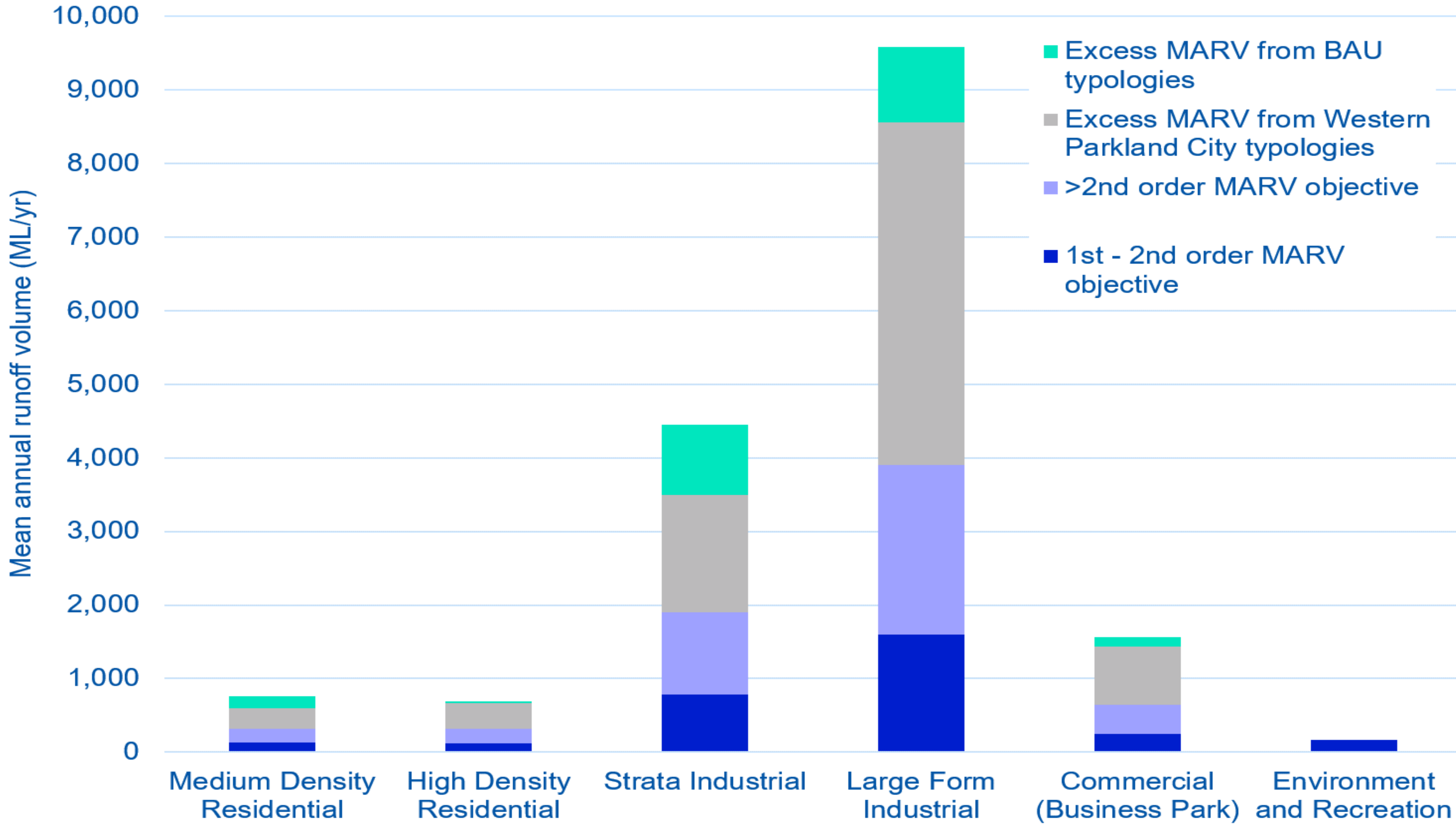


Figure 2-3 Relative contribution of stormwater runoff from land uses within the Initial precincts (excludes Wianamatta-South Creek precinct)

This analysis shows the magnitude and relative change in stormwater volumes generated by new development. The scale of the stormwater volume reductions required to achieve the waterway management objectives for waterways is significant and it is known that this cannot be achieved by conventional stormwater filtration approaches alone. While it may be possible to divert excess stormwater volumes around first and second order waterways, there is a limit to the feasibility of this on major streams such as Wianamatta-South Creek. Approaches to increase the capture, reuse, evaporation and evapotranspiration of stormwater volumes must be utilised at a range of scales to achieve the interim stormwater volume reductions.

2.5 Potential water demands

Potential water demands below provide opportunities for reducing stormwater and wastewater volumes discharged to waterways. More detail on integrated water cycle management strategies are provided in Section 5.

The relatively low residential population associated with development means a lower baseline water demand, however there may be higher water users moving into the precincts such as industrial scale agriculture. A build-up of potential daily and annual water demands is provided below to show the potential for end water uses within the precincts to reduce the volumes of stormwater and wastewater generated within the initial precincts.

Actual water demands will potentially vary, based on the urban planning outcomes and provision of open spaces. A hierarchy of water irrigation rates that manage the salinity risk of the soils and hydrogeologic landscapes will also factor into the final water balance.

A detailed assessment of integrated water cycle management is provided in Section 5.

Table 2-8 Notional water demand summary

		Potential water demands		
Land use zone	**Occupancy (EP/Ha and jobs/Ha)**	**Internal uses (kL/d/Ha)**	**Gardens and landscaping (ML/Ha/yr)***	**Public Open Space (ML/Ha/yr)***
Medium Density Residential	87.5	4,900	2.5	3.2
High Density Residential	175	9,800	2.5	3.2
Strata Industrial	107	5,564	2.5	3.2
Large Form Industrial	44	2,288	2.5	3.2
Commercial (Business Park)	113 to 235	12,220	2.5	3.2
Environment and Recreation	0	0	0 for native vegetation 3.2 passive open space 4.5 for active open space	
Transport Corridors	0	0	0	0

*Based on an estimate of 50% as areas/vegetation not suitable for irrigation

2.6 Initial precinct water balance

Figure 2-4 provides a high level potential water balance for the range of land use zones slated for the initial precincts. The water balance provides an order of magnitude estimate of annual water demands and water sources generated by the precincts and illustrates that initial precincts will generate significantly more stormwater and wastewater than could be feasibly be recycled and reused. An excess of stormwater is likely to be generated that must be managed in other ways.

Management of these water streams through a single-issue approach makes balancing economic, social and environmental factors in decision-making challenging. The *Stormwater and Water Cycle Management Study* promotes integrated approaches to deliver sustainable outcomes for the Western Parkland City by integrating stormwater and wastewater management into the landscape to support the blue-green grid and Greater Sydney Commission's vision for the Western Parkland City.

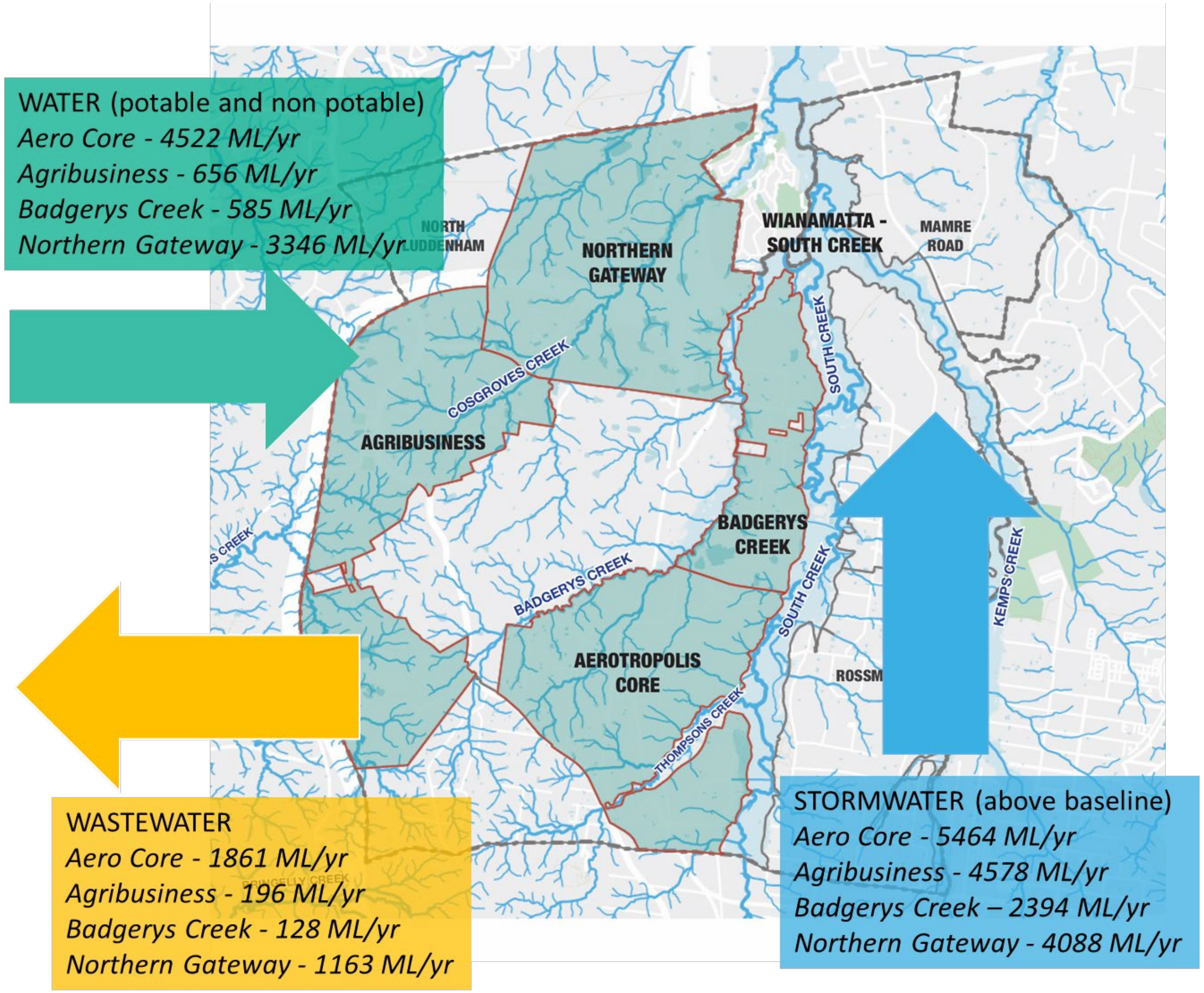


Figure 2-4 Total water demands and sources (without integrated water management)

Strategies for integrated water cycle management are provided in Section 5, which integrates and balances drinking water, wastewater, recycled wastewater and harvested stormwater under a number of servicing pathways.

In the final version of this report, an integrated servicing water balance will be provided that minimises demands on potable water supplies through alternative water sources. Recycled wastewater will be provided to the Aerotropolis. The final balance of recycled water and harvested stormwater will be calibrated to achieve waterway health objectives and targets agreed to by the NSW Government.

3 Planning context

The following section provides an overview of the planning and environmental context within which the Stormwater and Water Cycle Management Study has been developed.

3.1 Planning framework

A strategic planning package has recently been adopted for the Aerotropolis Growth Area comprising:

- *Aerotropolis SEPP* – establishes a statutory planning framework for the Aerotropolis including identifying precincts for release, rezoning of land and high level planning provisions and controls;
- *Western Sydney Aerotropolis Plan* (WSAP) - establishes the strategic vision for the Aerotropolis including principles for future growth and development;
- *Stage 1 Development Control Plan* outlining high level planning controls to guide early development proposals.

The next stages of planning for the Aerotropolis involve more detailed planning of the initial precincts with input from a range of government agencies and key stakeholders. The precinct planning package for the Aerotropolis will include detailed precinct plans, a planning report and a Phase 2 Development Control Plan (DCP) which will shape the design and delivery of new development in the initial precincts. This package will be publicly exhibited, alongside certain technical studies.

This Stormwater and Water Cycle Management Study forms one of the technical inputs to the precinct plans and will also shape development controls to be incorporated into the Phase 2 DCP. These controls will ultimately inform the size, distribution and function of water sensitive stormwater design and stormwater detention elements in the landscape and will take the form of Objectives, Performance Outcomes and Benchmark solutions.

Related work programs being delivered by DPIE and other agencies will develop other objectives, performance outcomes and benchmark solutions for water cycle management as described below.

3.2 Waterway health

The NSW Government is developing waterway health management objectives, using the *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions*. These objectives will provide appropriate water quality and flow measures to achieve the vision and community environmental values and uses for waterways within the Aerotropolis and downstream catchment.

New stormwater objectives will cap mean annual runoff volumes and low flow rates to match existing low flow characteristics. Targets will be differentiated based on category of stream order. These will be different to the Stream Erosion Index, but will address the impacts of frequent flow events on channel form, geomorphology and ecological processes that are commonplace within the existing urban areas of the lower Wianamatta-South Creek catchment. Interim waterway health objectives have been reflected in the initial precinct plans and finalised objectives will be embedded into the final precinct plans to ensure statutory compliance. Precinct specific waterway health targets will also be incorporated into the Phase 2 DCP, along with performance outcomes and benchmark solutions.

3.3 Stormwater detention management

A Flood Risk and Impact Assessment (FRIA) is being developed to inform precinct planning for the Aerotropolis. This strategy forms a key component of the broader water cycle management strategy for the catchment developing stormwater flow management objectives, performance outcomes and benchmark solutions in accordance with the Aerotropolis FRIA.

The performance outcomes will be based on catchment wide modelling and a coordinated approach to managing floods. This approach has the potential to reduce the overall number of stormwater assets.

Appropriate flow management objectives and stormwater detention targets will inform the size, function and distribution of on-site stormwater detention and stormwater flow management basins across the Aerotropolis and is therefore a key reference for the Stormwater and Water Cycle Management Study.

3.4 Riparian corridors

Freshwater waterways are important features of Western Sydney and riparian areas are the interface between land-based and waterway ecosystems. NSW Office of Water (now DPIE) defines a riparian corridor as "a transition zone between the land, also known as the terrestrial environment, and the river or watercourse or aquatic environment".

Riparian corridors provide a variety of functions within urban landscapes. They play a major role in bank stabilisation, reducing erosion scour and sedimentation problems within rivers and creeks. Vegetated areas along the creek lines function as 'buffer zones' to surrounding land and help filter nutrients, pollutants and sediments before they reach the creek itself and degrade the quality of water flowing throughout the Aerotropolis.

A riparian corridor strategy is currently being completed that will include top of bank mapping that will inform setbacks for development and stormwater assets.

3.5 Salinity

Salinity within the Aerotropolis has been exacerbated where groundwater has mobilised naturally occurring salts and caused concentration of sale at the ground surface. Such movements are caused by changes in the natural water cycle. In these areas, activities, infrastructure and resources on and above the soil surface may be affected. In urban areas the processes which cause salinity are intensified by the increased volumes of water added to the natural system in urban areas.

The *Stormwater and Water Cycle Management Study* proposes careful management of irrigation and infiltration to ensure no significant increase in groundwater recharge or mobilisation of salts. This is a significant constraint to balance against the objective of a green and cool Western Parkland City.

Consultation with DPIE EES on salt risks has identified the need for appropriate shallow groundwater management in accordance with the Hydrologic Landscapes Mapping. This includes the use of vegetation and trees as a mitigation measure against the generation of shallow groundwater flows that would increase the salt budget to the downstream waterways. This mitigation is to be implemented as biofiltration street trees and riparian corridor plantings.

Controls are required to prevent excessive additional water in the from the irrigation of gardens, lawns and parks, and concentrated infiltration of stormwater from adding to existing salinity issues. These issues are best addressed at a precinct scale, with integrated water cycle management provisions being included in the Phase 2 DCP for the Aerotropolis.

3.6 Farm dams & water bodies

Farm dams are an important hydrologic feature of the Western Parkland City that reduce runoff volumes in waterways while recharging the local and regional groundwater table. They also provide significant aesthetic benefits and ecological habitat.

A key part of the landscape-led design approach for the Western Parkland City is to, where appropriate, repurpose or rebuild farm dams as water in the landscape features. The retention or replacement of farm dams is an important approach to preserving hydrologic characteristics of the local waterways.

As most farm dams have not been designed for amenity functions or to be located near residential developments, many will need to be redesigned to address issues such as dam stability, safe access, water quality, algal bloom risk, water level fluctuations and wildlife attraction.

Planning will also need to address ownership, responsibility and funding arrangements for retained artificial water bodies.

3.7 Wildlife risk mitigation

Farm dams and ponds support large populations of water birds (e.g. duck, teal, swan, cormorant, pelican) that pose a risk to aircraft strike. Construction of the airport and changes to land use within the Aerotropolis will alter many of these habitat sources.

Controls will be required to reduce the risk of new or existing permanent water bodies (wetlands), along with the revitalisation of natural water courses, to facilitate the distribution of large populations of birds across flight paths.

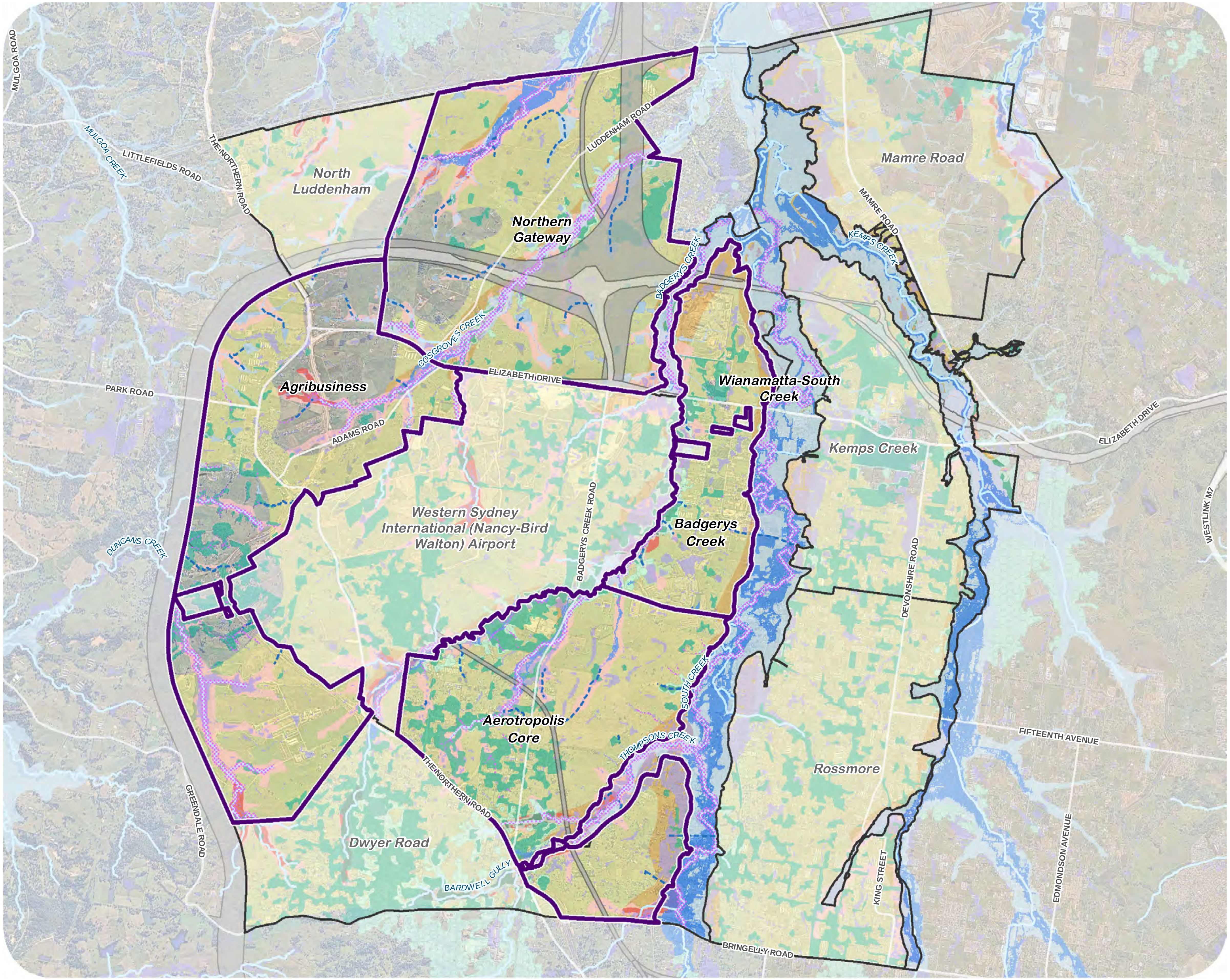
Appropriate controls will be included in the Phase 2 DCP for the Aerotropolis.

3.8 Heat and climate

Variable rainfall and climate conditions are a significant factor for water management in Western Sydney. Heat causes major liveability and resilience problems with critical impacts for human health, infrastructure, emergency services and the natural environment.

Planning must ensure that reliable and cost-effective water supplies are available to support urban green cover and mitigate extreme heat.

Planning must also ensure that the level of service provided by stormwater assets is not compromised by the potential impacts of climate change on rainfall intensity.



Sydney WATER

- Initial precincts
- Other precincts
- Riparian corridors
- HEV protect
- 1% AEP
- 50% AEP
- Blacktown Soil Landscape
- South Creek Soil Landscape
- Cumberland Plain West Vegetation
- Grade <2%
- Future Western Sydney Transport Corridors
- Proposed M12 Corridor

Salinity Potential Risk

- Known Salinity
- High

All other areas within precincts moderate salinity risk

Strahler Stream Order

- 3rd order & higher
- Trunk drainage channels without VRZs

*Infiltration permissible where groundwater is greater than 2m below ground surface beneath South Creek & alluvial soils

Source: DPIE, NSW Spatial Services, CTE, OEH, Aurecon, Arup, Nearmap

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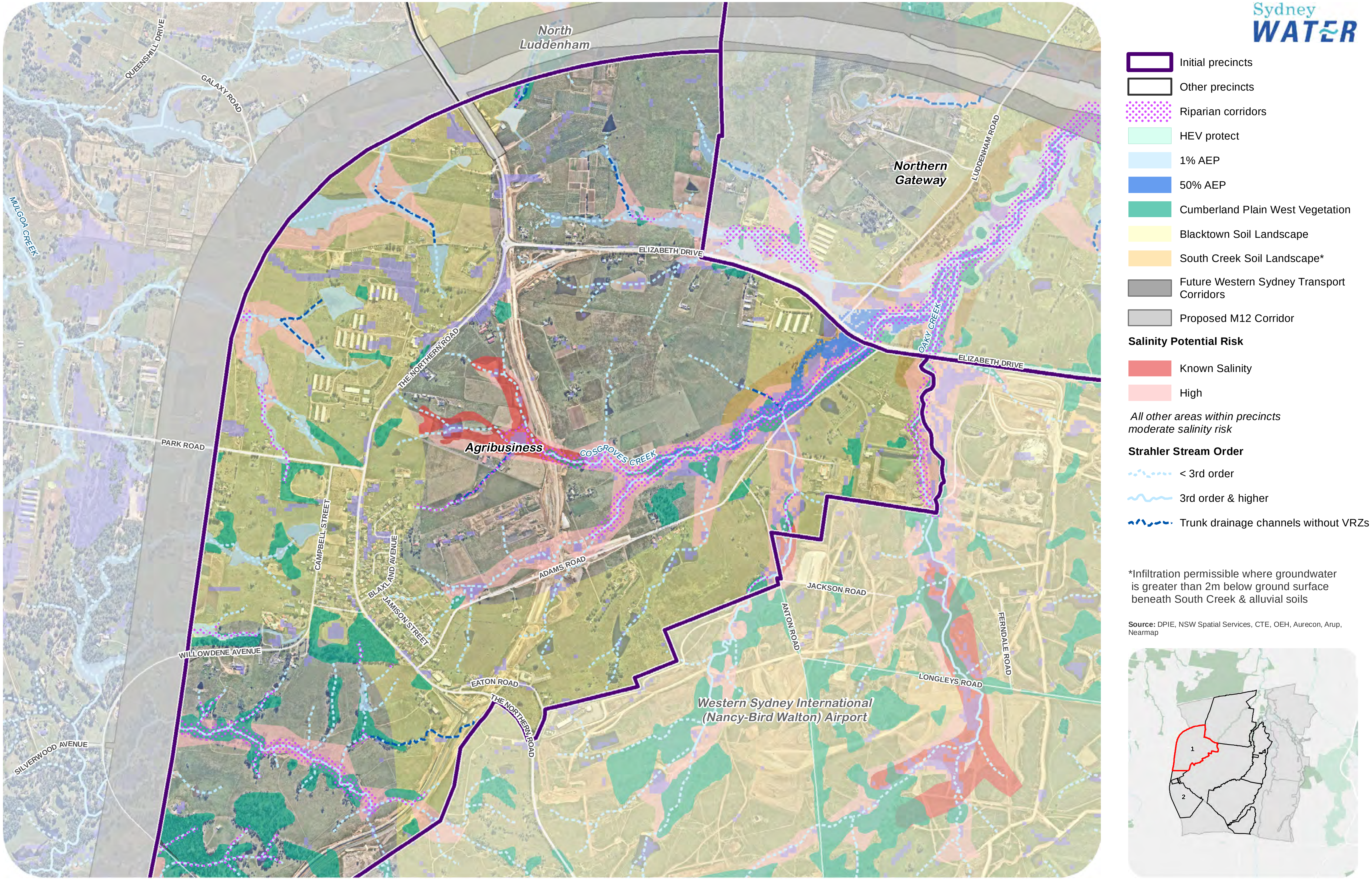
Date: 28/10/2020

Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 3-1: Constraints: whole of study area



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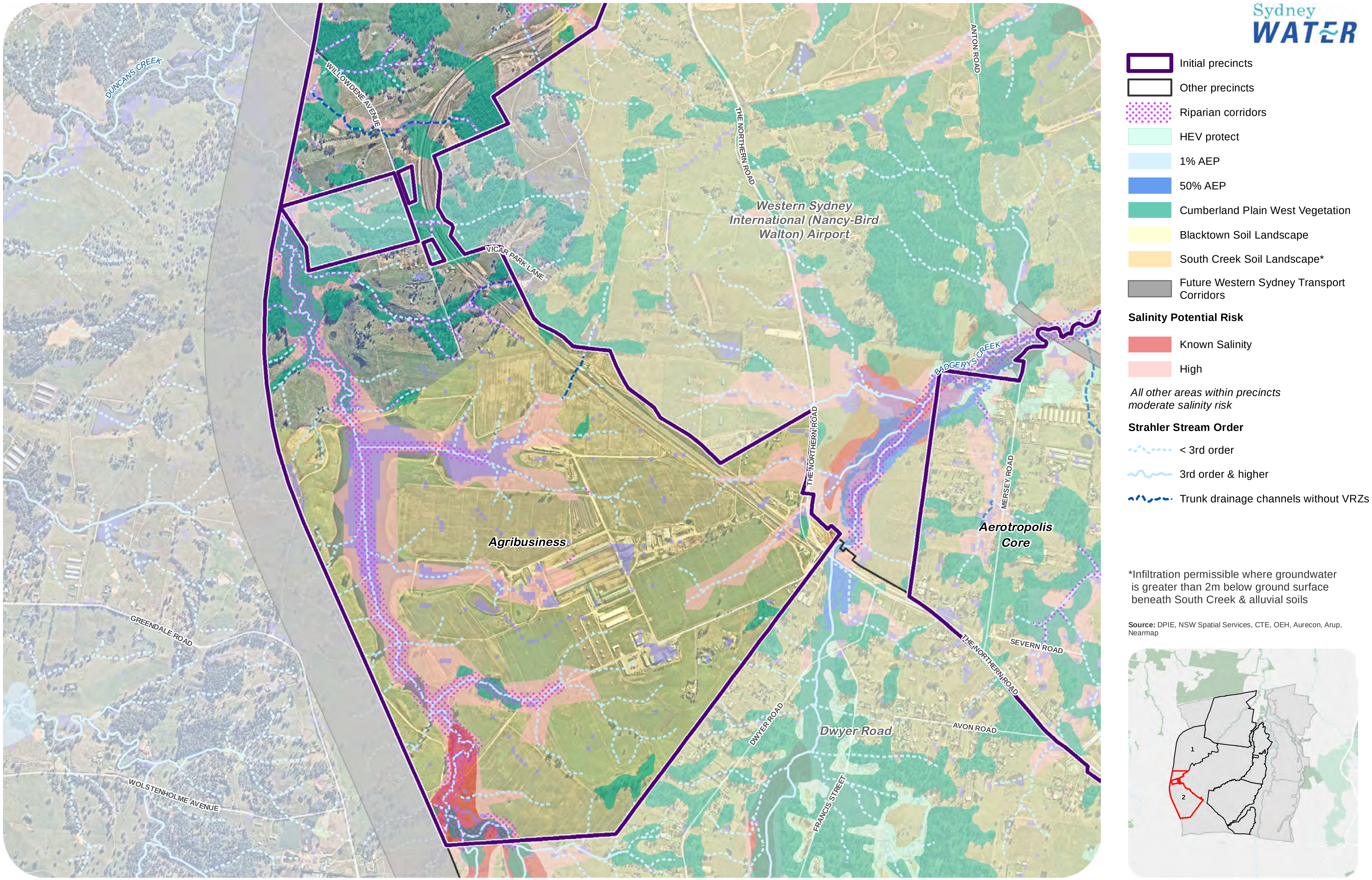
Date: 28/10/2020

Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 3-2: Constraints: Agribusiness (North)



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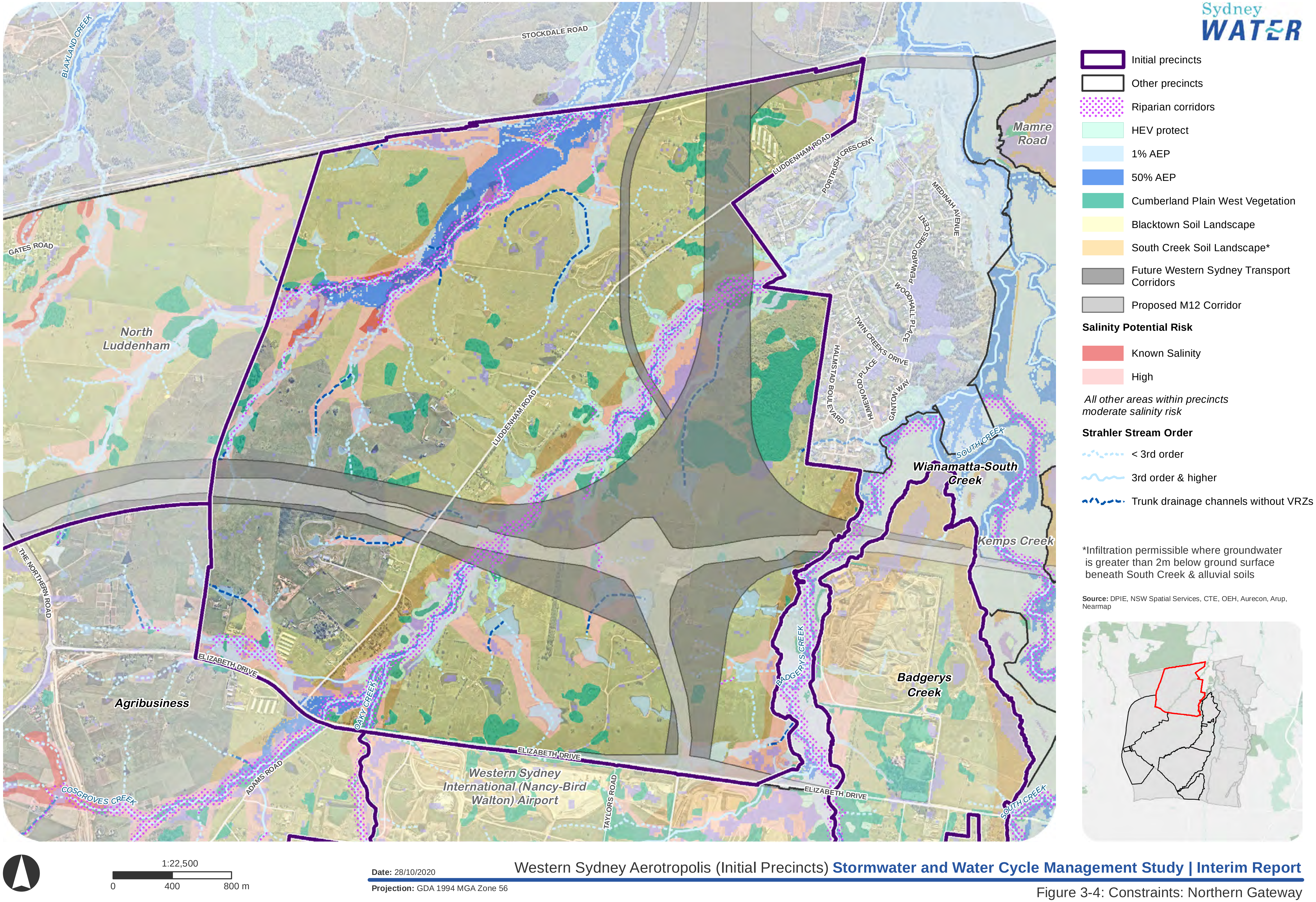
Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 3-3: Constraints: Agribusiness (South)

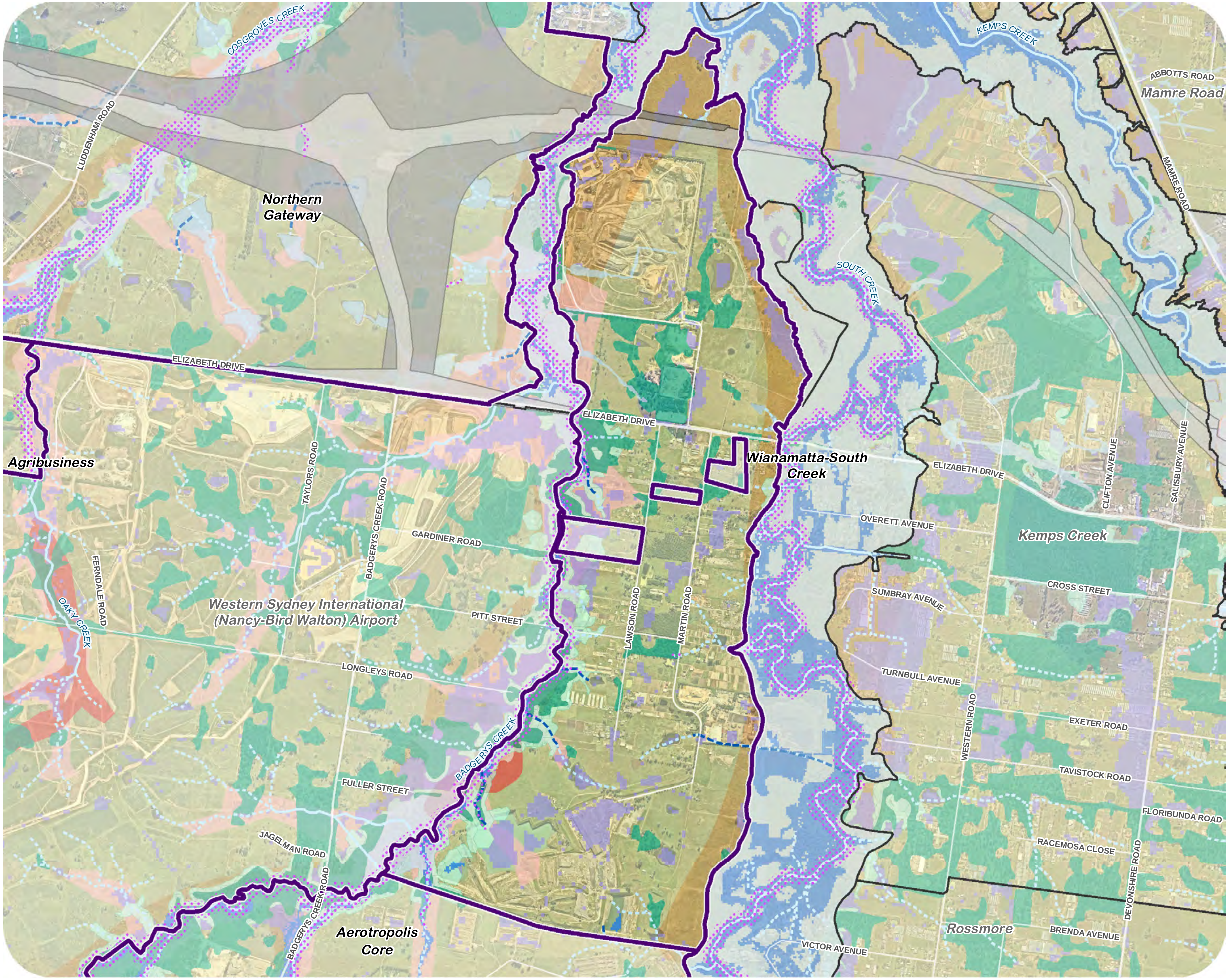


Date: 28/10/2020

Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 3-4: Constraints: Northern Gateway



Sydney WATER

- Initial precincts
- Other precincts
- Riparian corridors
- HEV protect
- 1% AEP
- 50% AEP
- Cumberland Plain West Vegetation
- Blacktown Soil Landscape
- South Creek Soil Landscape*
- Future Western Sydney Transport Corridors
- Proposed M12 Corridor

Salinity Potential Risk

- Known Salinity
- High

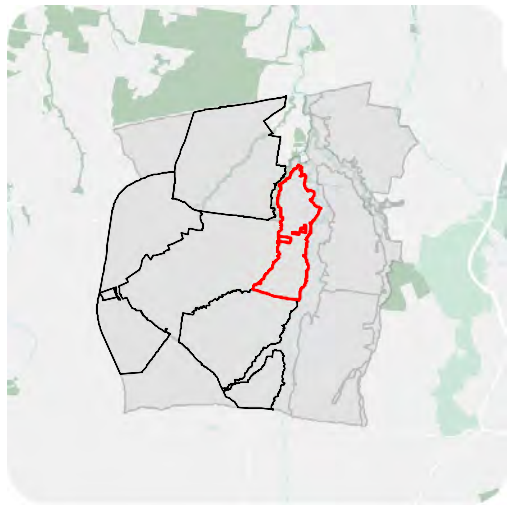
All other areas within precincts moderate salinity risk

Strahler Stream Order

- < 3rd order
- 3rd order & higher
- Trunk drainage channels without VRZs

*Infiltration permissible where groundwater is greater than 2m below ground surface beneath South Creek & alluvial soils

Source: DPIE, NSW Spatial Services, CTE, OEH, Aurecon, Arup, Nearmap



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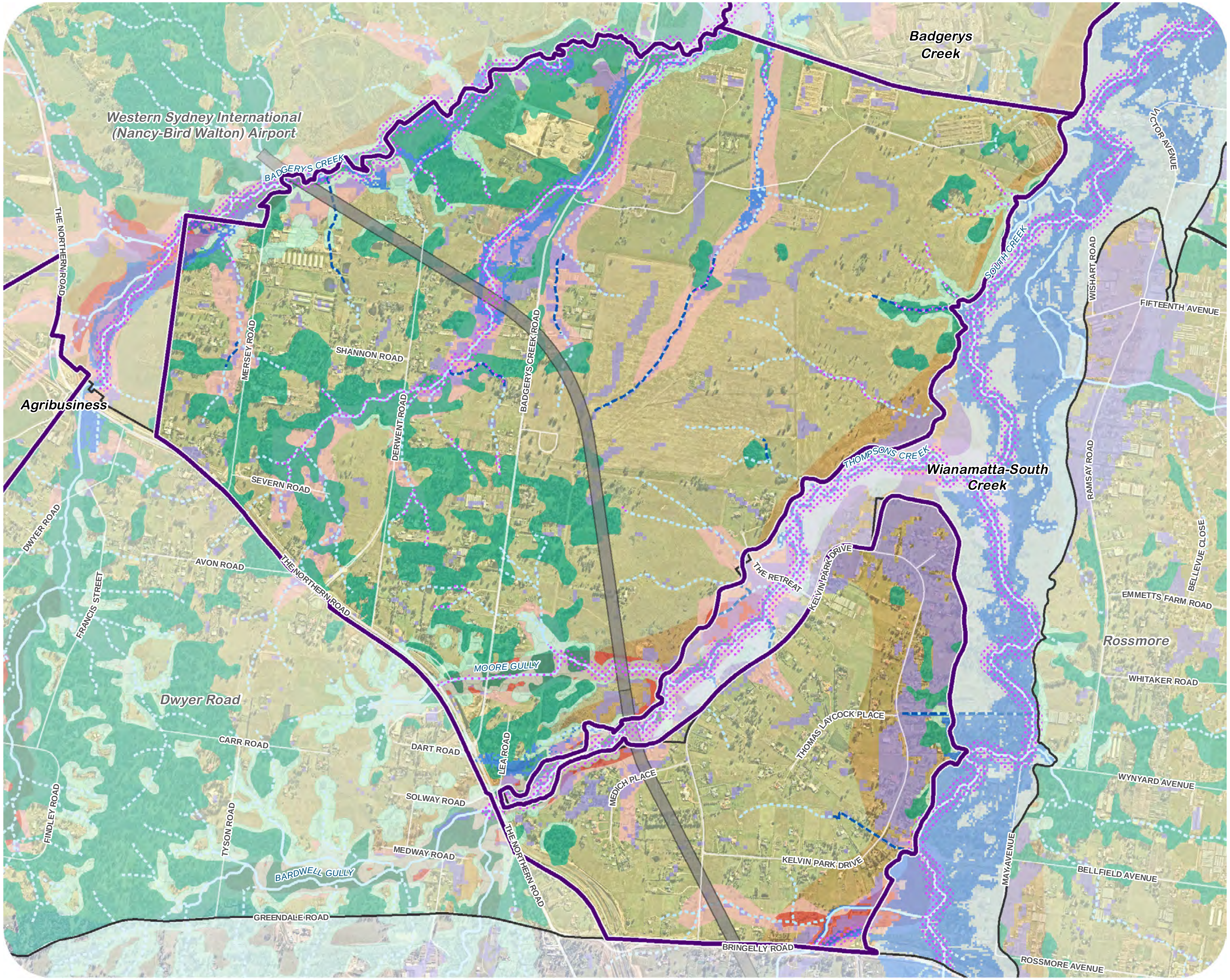
Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 3-5: Constraints: Badgerys Creek



Sydney WATER

- Initial precincts
- Other precincts
- Riparian corridors
- HEV protect
- 1% AEP
- 50% AEP
- Cumberland Plain West Vegetation
- Blacktown Soil Landscape
- South Creek Soil Landscape*
- Future Western Sydney Transport Corridors

Salinity Potential Risk

- Known Salinity
- High

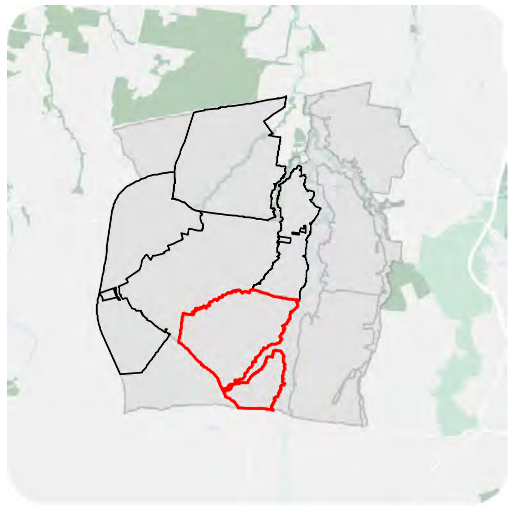
All other areas within precincts moderate salinity risk

Strahler Stream Order

- < 3rd order
- 3rd order & higher
- Trunk drainage channels without VRZs

*Infiltration permissible where groundwater is greater than 2m below ground surface beneath South Creek & alluvial soils

Source: DPIE, NSW Spatial Services, CTE, OEH, Aurecon, Arup, Nearmap



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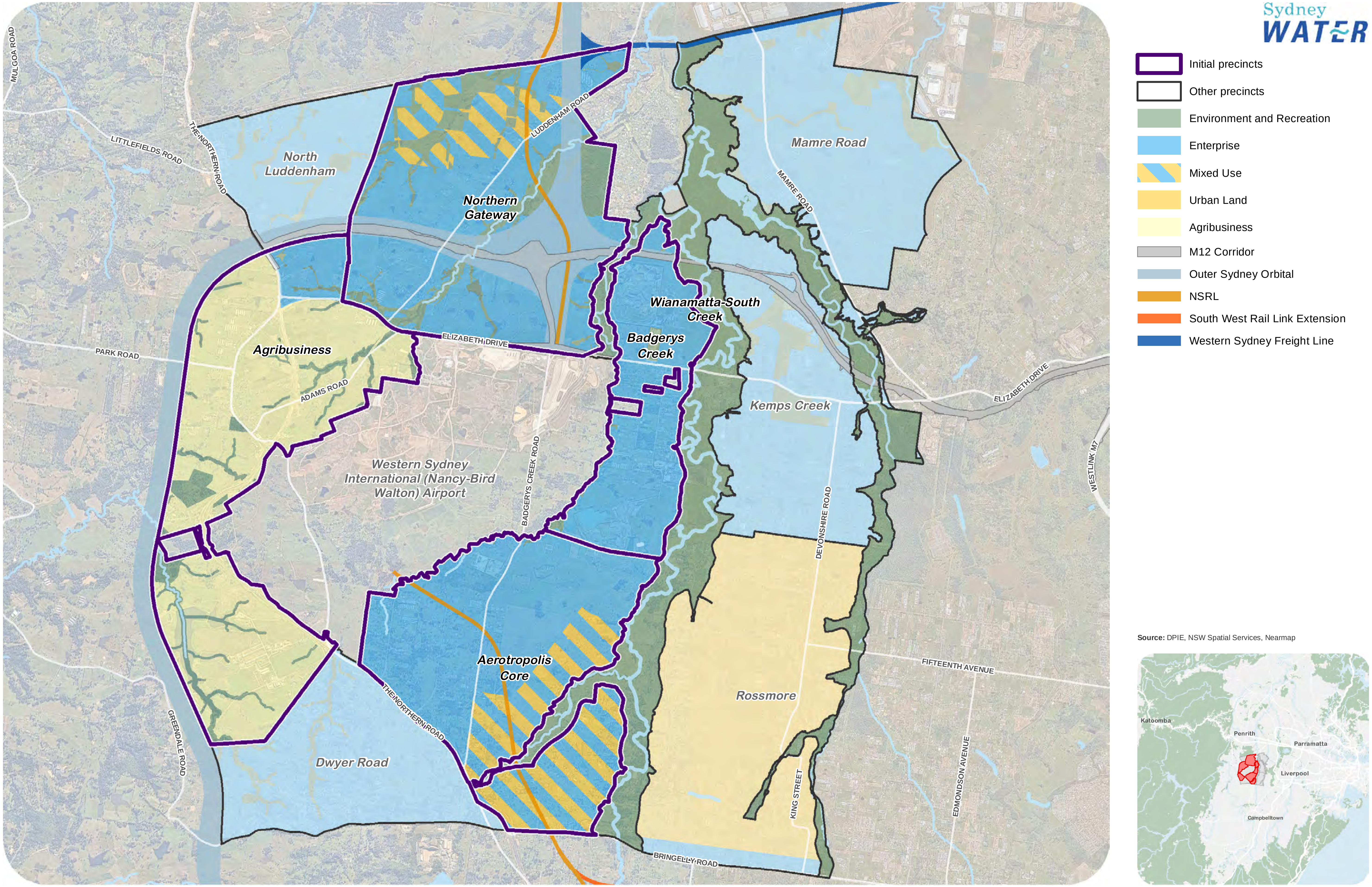
0 400 800 m

Date: 28/10/2020

Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 3-6: Constraints: Aerotropolis Core



Source: DPIE, NSW Spatial Services, Nearmap

Date: 28/10/2020

Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 3-7: Proposed land use and future transport corridors

There are over 4,200 farm dams across the Wianamatta-South Creek catchment (2019). The farm dams are diverse in shape and range in size from 60m² to 350,000m² (35ha). Many also feature significant native bushlands, providing important habitat for native wildlife.[1]

1 Alluvium (2020), Western Parkland City: Farm Dams as Water in the Landscape Guide – Final Report, prepared for Infrastructure NSW.

Figure 3-8 Existing farm dams

4 Proposed riparian corridor and farm dam management

The landscape led approach to developing the Aerotropolis precincts requires the preservation of key features to ensure that geology, geomorphology and natural features are respected and incorporated in the planning approach. Riparian corridors, ground water dependant ecosystems and farm dams have particular significance as waterway features that require protection to preserve the unique ecology of the Cumberland Plain. As well, these water bodies enhance the liveability of the area through amenity and urban cooling. To advise precinct planning, work is underway to:

- Validate waterways and map riparian zones to be protected
- Identify groundwater dependent ecosystems and Key Aquatic Habitat
- Assess ecological value of selected farm dams
- Riparian revegetation analysis

Field work is nearing completion. Preliminary mapping has been incorporated into the draft precinct plans as appropriate. Once complete the field validated mapping will advise final recommendations, precinct plans and development controls.

4.1 Waterway validation

The primary objective of the Water Management Act 2000 (WM Act) is to manage NSW water in a sustainable and integrated manner that will benefit current generations without compromising future generations' ability to meet their needs.

Since 2018, the Water Management Act has been administered by Natural Resources Access Regulator (NRAR) and establishes an approval framework for activities within waterfront land which is defined as land 40 m from the highest bank of a river, lake, wetland or estuary.

The definition of a 'river' as per the Water Management Act is as follows;

a. any watercourse, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved;

b. any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows; and

c. anything declared by the regulations to be a river.

In relation to point (c) of the definition of 'river' in the Dictionary to the Act, the following are declared to be a river as per the *Water Management (General) Regulation 2018* (WM Regulation):

- any watercourse, whether perennial or intermittent, comprising an artificial channel that has changed the course of the watercourse,
- any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows.

The *Guidelines for Controlled Activities on waterfront land—Riparian corridors* (NRAR 2018) provides guidance to establish Vegetated Riparian Zones (VRZ) along watercourses which are based on the Strahler stream ordering system. The VRZ is measured from the top of the creek bank and also includes the creek channel. The minimum required VRZ width for a first order stream is 10 m either side of the creek (measured from top of bank) plus the width of the creek channel. The maximum required VRZ is 40 m either side of the creek (measured from top of bank) plus the channel width and this is applied to 4th order and greater streams, wetlands, estuaries and tidal influenced waters.

Waterways in the Aerotropolis Initial Precincts are being assessed via a mix of aerial photography, drone photography and ground survey. The creeks that will be assessed are limited to those within the initial precincts and adjoining areas of the Wianamatta-South Creek Precinct. Following field assessment Vegetated Riparian Zones (VRZ) have been assigned to waterways according to those required by *NSW Water Management Act 2000*. Figure 4-1 shows the waterways that have been assessed including VRZs.

4.2 Groundwater dependent ecosystems and Key Aquatic Habitat

Field validations will also encompass assessment of groundwater dependent ecosystems and Key Aquatic Habitat within the initial precincts. The field validations will:

a. Identify existing aquatic habitat and any groundwater dependent ecosystems occurring in the Precinct. Identifying any species, populations or ecological communities listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, the NSW *Biodiversity Conservation Act 2016 Act* or the *Fisheries Management Act 1994*.

b. Identify any requirements for further work under the relevant legislation.

c. Identify any noxious aquatic weed species listed under the Biosecurity Act 2015.

d. Ground-truth and validate habitats and identify threatened species (aquatic and groundwater dependent) through field surveys.

Following field assessment high value ecosystems and habitat will be included in precinct mapping and will inform revegetation strategies and development controls. Field survey undertaken to date, and planned for completion, is shown in Figure 4-1 through Figure 4-6

4.3 Ecological value of selected farm dams

Farm dams as they currently exist in the Wianamatta-South Creek catchment primarily provide water for stock and domestic uses in agricultural areas, and as a secondary consequence, provide aesthetic and ecological habitat functions. They have typically been constructed as private works to store supplementary water for use on properties. This storage function results in significant areas of water in the landscape which can be highly beneficial for the Aerotropolis.

To facilitate this, the location, size and operation of existing farm dams need to be considered and where possible, dams should be retained and enhanced to provide water in the landscape functions for the future urbanised landscape. Critical to the success of retaining farm dams is to understand how they can best operate in a future urban environment.

Key benefits of retained farm dams could be:

- Storage and evaporation of stormwater runoff
- Control of the release of stormwater to minimise hydrologic impacts
- Retain/provide key ecological habitat features (e.g. chain of ponds, open water bodies and wetting of native vegetation communities)
- Provision of alternative sources of water for reuse opportunities and irrigation
- Water quality treatment (if properly configured)
- Aesthetic features of water in the landscape
- Recreational opportunities (walking trails etc)
- Reduction in urban heat island impacts due to water presence in the landscape enhancing evaporative cooling

In 2020, Alluvium and C T Environmental developed a decision framework applied to farm dams across Wianamatta-South Creek catchment to determine whether the water body could be retained in the landscape or removed. This framework considers the following metrics:

- Size (surface area and likely depth), including a water balance of typical farm dams to determine appropriate sizing
- Contributing catchment area
- Ecological condition or if the farm dam provides ecological services
- Amenity provisions
- Land use and zoning, such as development areas, EECs, riparian zones

Application of the framework provides an informed approach to the decision-making process regarding future management of farm dams across the catchment.

To assess the ecological condition of farm dams across the Precincts a combination of desktop and field assessment will be undertaken, the results of which will feed into the decision framework as a component of the “retain or remove” process (undertaken at a later stage by Sydney Water).

A four-stage process will be used to undertake the ecological assessment of farm dams.

Stage 1: Desktop assessment to identify eligible dams for assessment.

Spatial data sets and aerial photography has been used to determine which farm dams would be considered for field assessment.

Criteria applied included:

- Dam surface area of 0.2 – 3% of the upstream catchment
- Located on a 1st, 2nd or 3rd order stream
- Located within the DPIE HEV mapped areas

Stage 2: Development of rapid ecological assessment method for farm dams

Prior to field assessment, a rapid assessment method was developed to enable a rapid qualitative assessment of the ecological value of farm dams. Metrics considered include;

- Distance of dam to native vegetation
- Connectivity to creek
- Presence/extent of native macrophytes
- Presence of native water dependent fauna (mapped on BIONET and observed)
- On or adjacent to mapped Key Aquatic Habitat
- Presence/extent of fringing wetland ecosystem

A ranking system has been developed which scores farm dams according to their ecological value, which will be applied during the field assessment stage.

Stage 3: Field assessment to assess ecological value of farm dams

Farm dams identified for assessment by Stage 1 will then be assessed using the method developed in Stage 2. The dams for assessment are shown in Figure 4-1. Each dam is being visited on foot, or where access is restricted or time constrained, a drone fly over will be used to capture up close aerial photos and the assessment performed remotely. Assessment data is being consolidated with farm dams ranked according to the method applied and a shapefile generated for mapping of results.

Stage 4: Mapping of assessment and recommendation for retention or removal based on ecological value

Following field assessment, results will be mapped by Precinct and recommendations for retention or removal based on ecological data made.

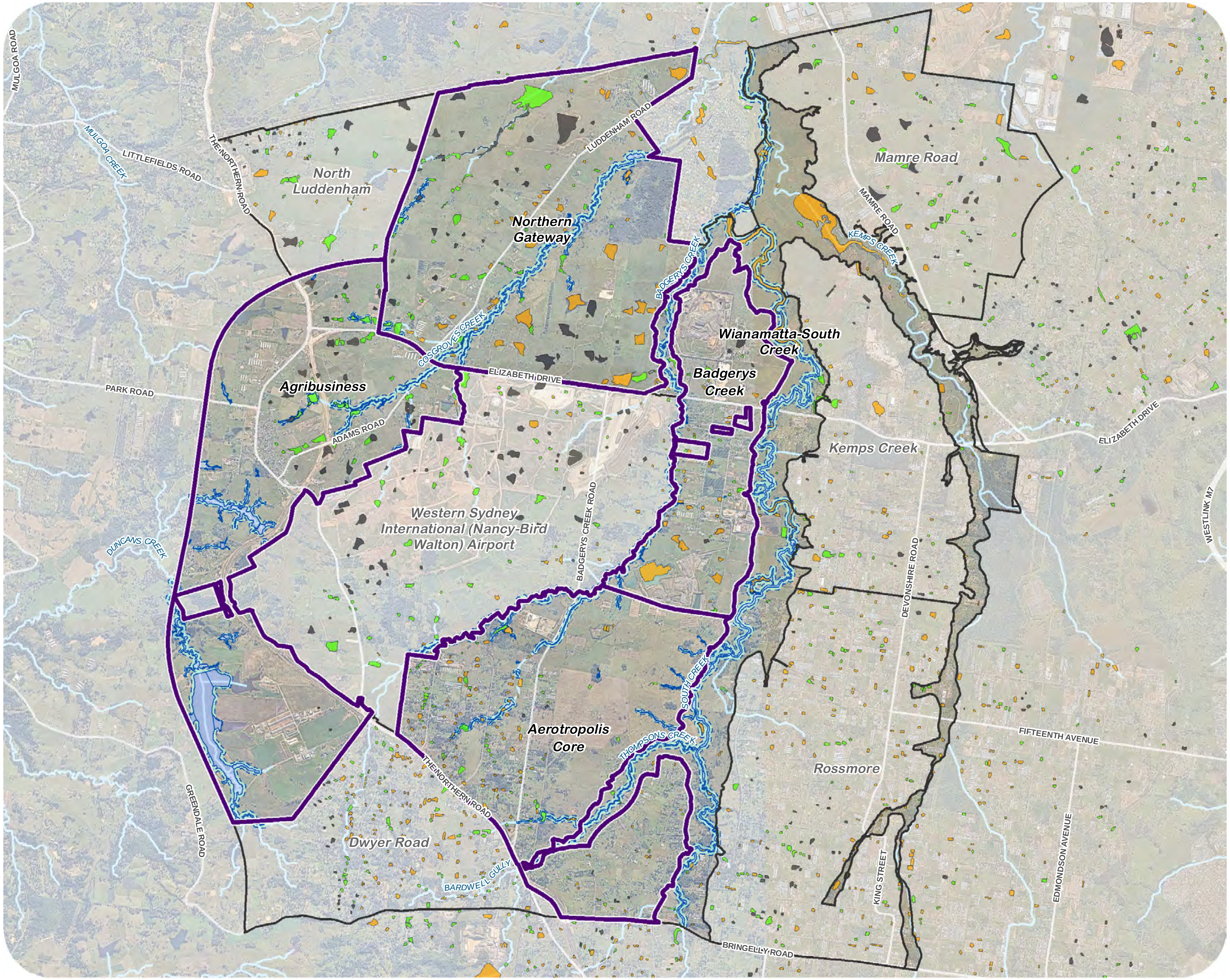
It is noted that the dams are unlikely to provide any meaningful retardation of flows as it would be valid to assume that the dams would be full at the start of a storm event. This is even more likely if the dams are required for visual appeal.

Regarding dam safety, the majority of farm dams are privately constructed with no regulation of the construction material and techniques, and no on-going monitoring; therefore, the geotechnical stability of the dam embankment walls is unknown. If identified for retention, the potential impact in case of failure will need to be assessed through hydraulic modelling in accordance with Dam Safety NSW requirements. Since these dams will be located in an urban environment, it is likely some of the retained dams would create a safety hazard if they failed. This may influence their viability where potential risks posed to future development are not acceptable. If assessed as having failure consequences, the dams would need to be registered with Dam Safety NSW, remediated structurally, and require ongoing asset management and reporting. Dams to be retained will need to be integrated with the urban fabric and public safety will need to be ensured.

4.4 Riparian revegetation analysis

Native revegetation of the VRZs is required to protect and restore these areas and help achieve the waterway outcomes identified for the aerotropolis. Revegetation of additional land outside the standard VRZs could provide significant additional benefits (such as habitat and canopy cover). A Riparian Revegetation Strategy (RRS) for the four initial Precincts as well as adjoining areas of the Wianamatta-South Creek Precinct is being developed by Sydney Water in collaboration with DPIE to provide high level guidance on the extent and cost of riparian management actions and potential biodiversity credit generation.

The RRS will be completed in late 2020.



Sydney WATER

Initial precincts

Other precincts

Top of Bank Mapping (CTE)

Creek

Creek channel polygon

WMA VRZ buffers

Strahler Stream Order

3rd order & higher

Farm Dam Prioritisation

Not suitable

Not suitable but with HEV area

Suitable

Source: DPIE, NSW Spatial Services, CTE, Nearmap

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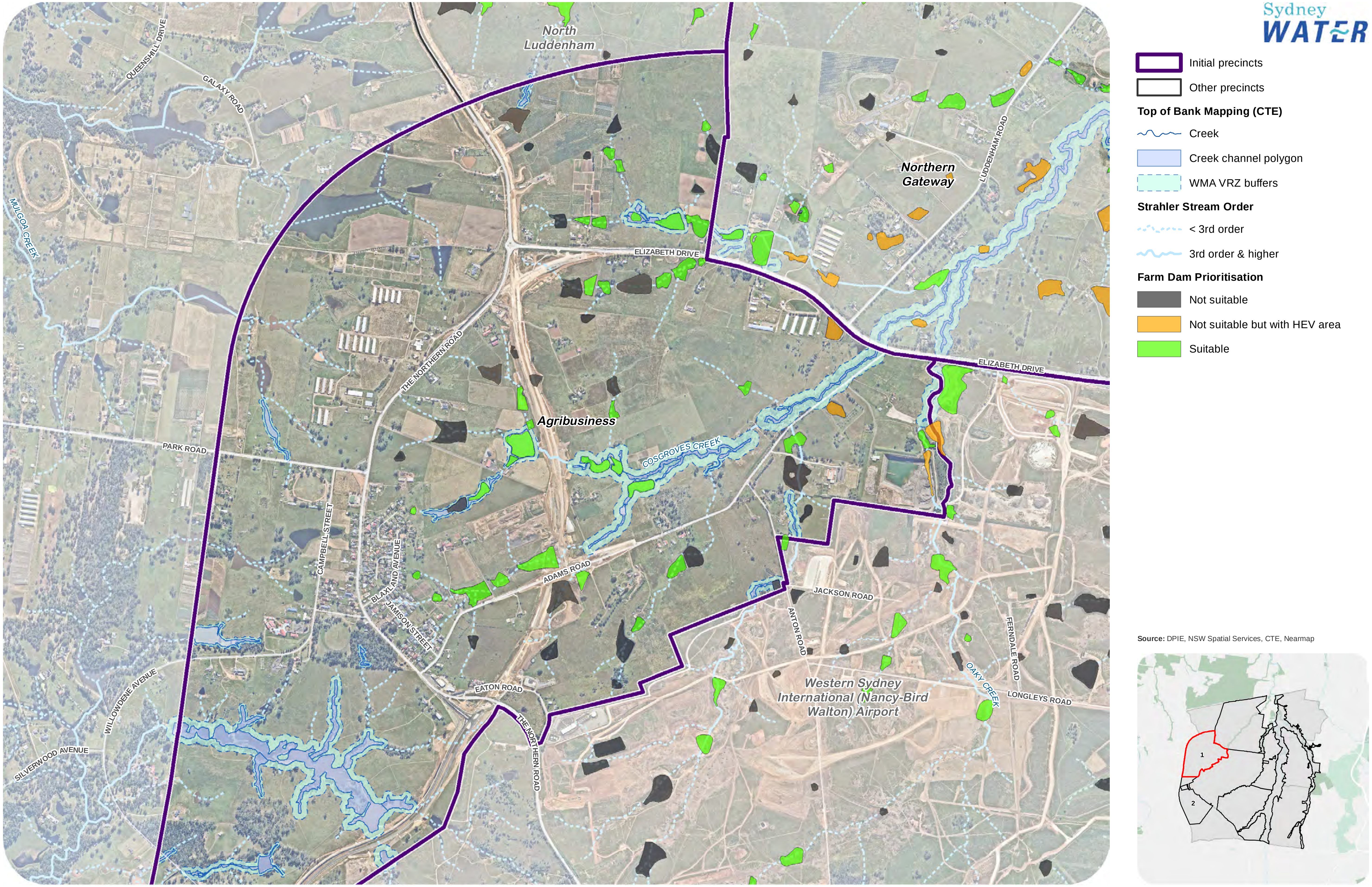
Date: 28/10/2020

Projection: GDA 1994 MGA Zone 56

Figure 4-1: Riparian corridor and farm dam assessment: whole of study area



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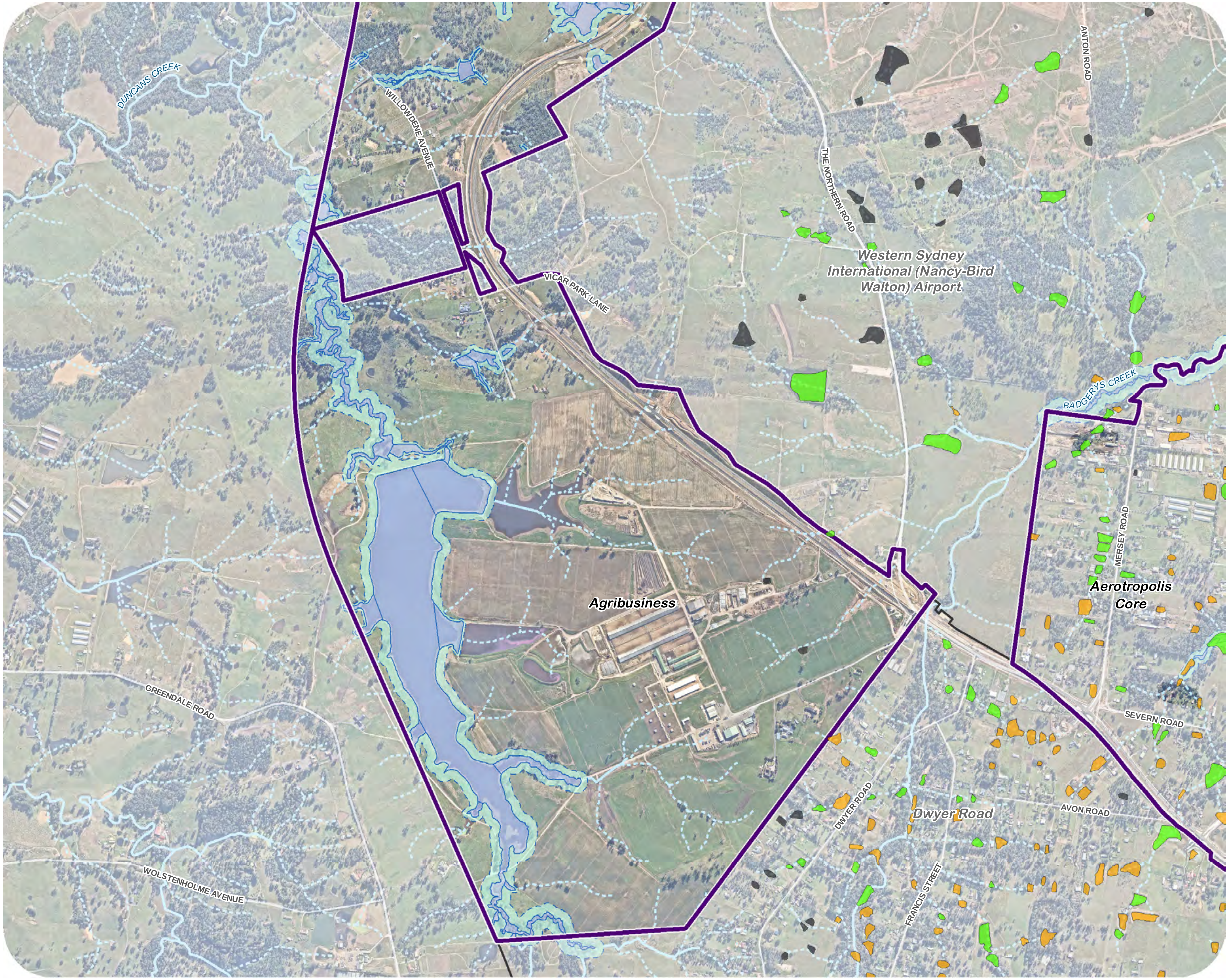
Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 4-2: Riparian corridor and farm dam assessment: Agribusiness (North)

Sydney WATER



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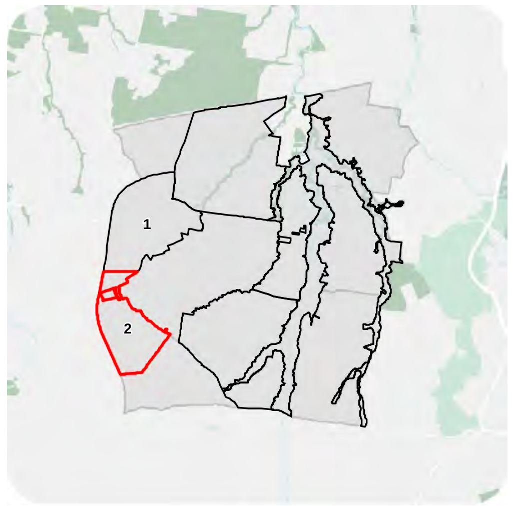

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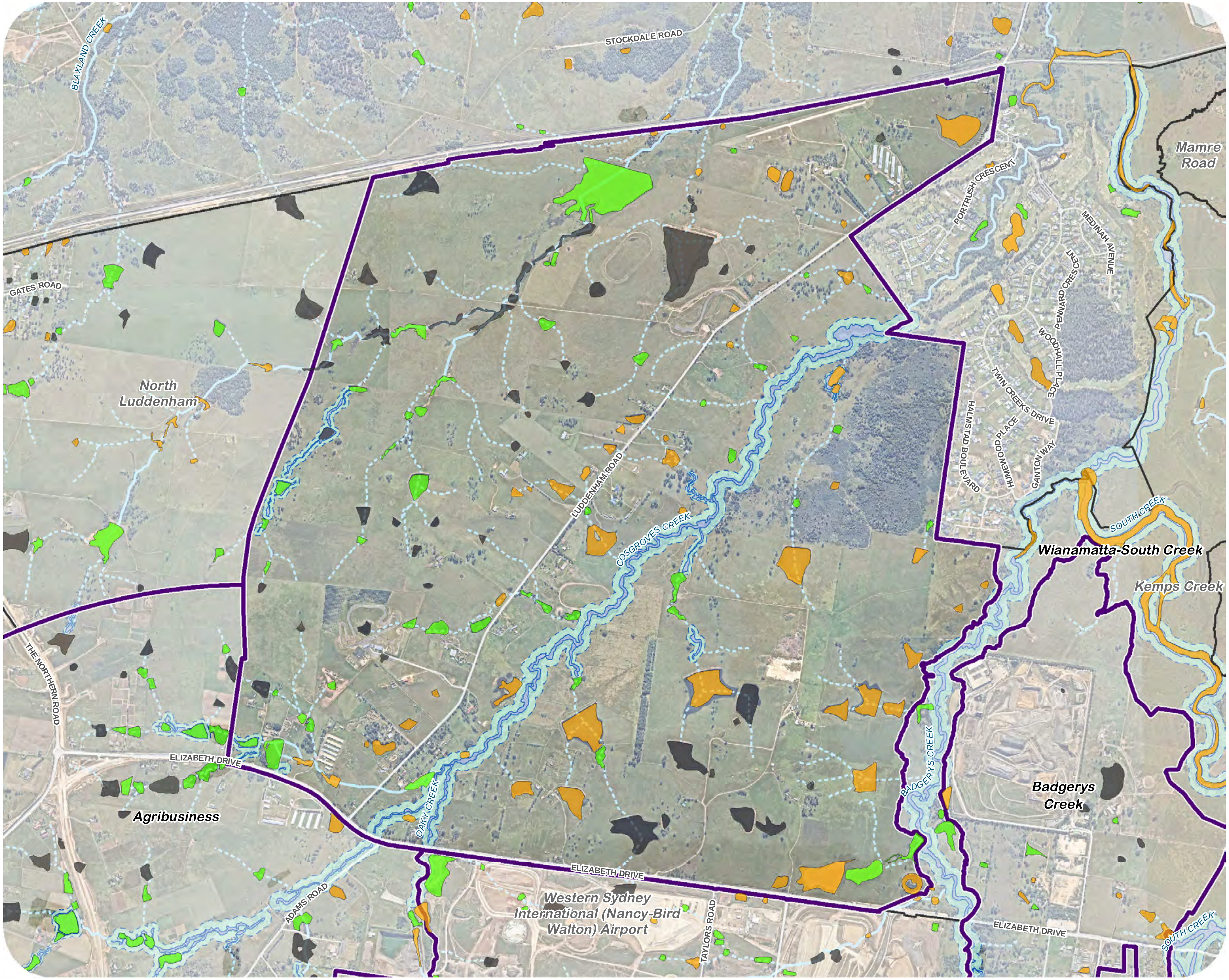
Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 4-3: Riparian corridor and farm dam assessment: Agribusiness (South)



Sydney WATER

Initial precincts

Other precincts

Top of Bank Mapping (CTE)

Creek

Creek channel polygon

WMA VRZ buffers

Strahler Stream Order

< 3rd order

3rd & higher

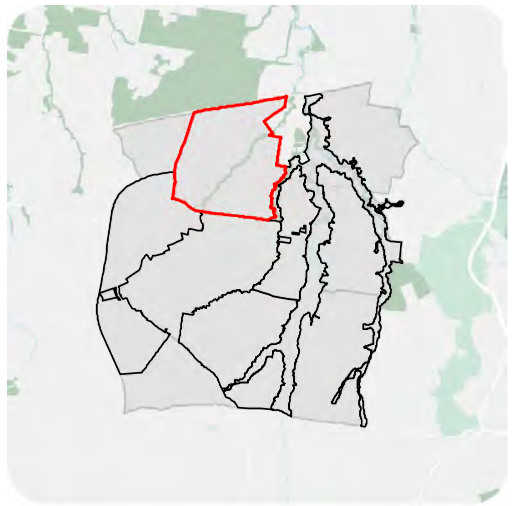
Farm Dam Prioritisation

Not suitable

Not suitable but with HEV area

Suitable

Source: DPIE, NSW Spatial Services, CTE, Nearmap



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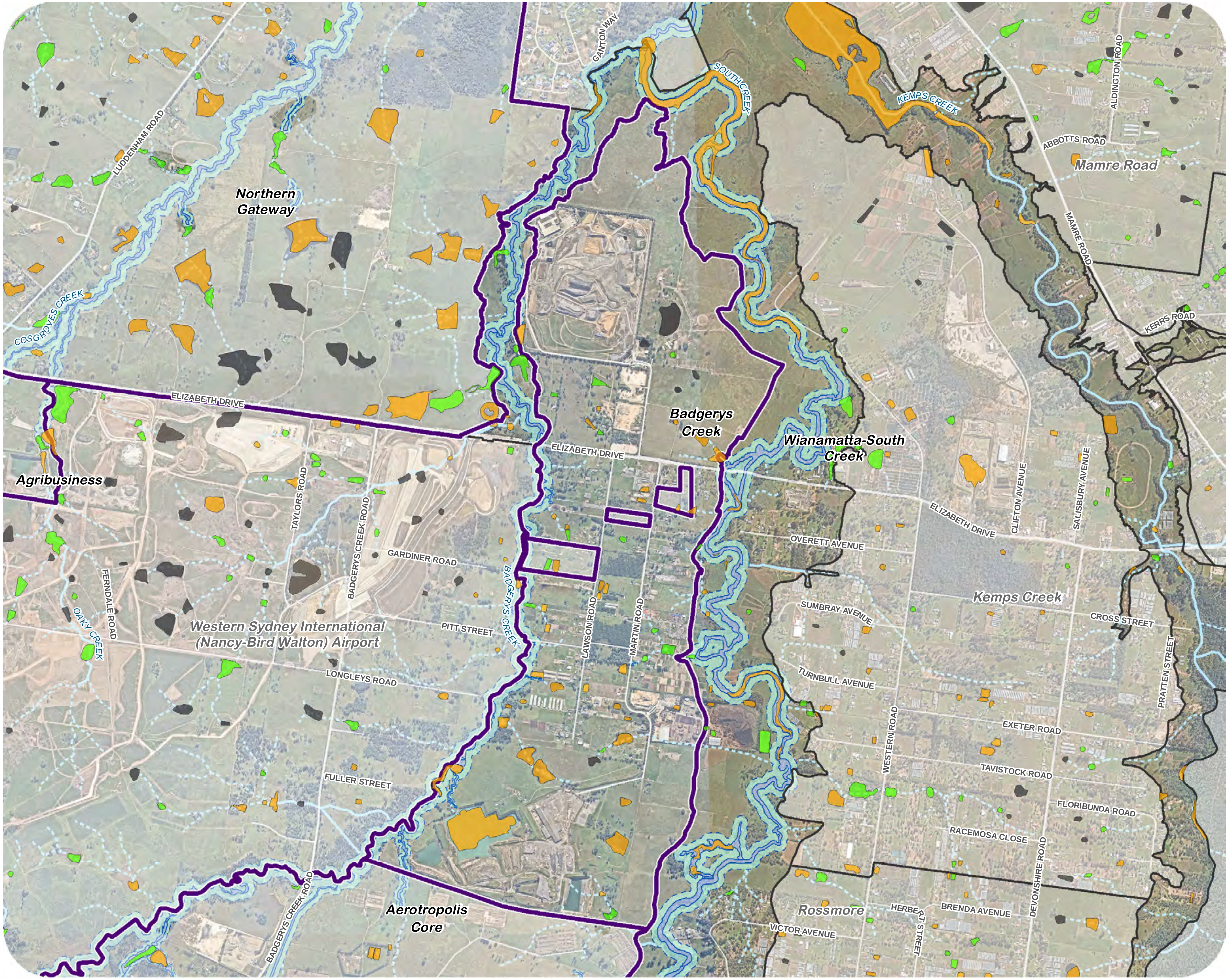
Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 4-4: Riparian corridor and farm dam assessment: Northern Gateway



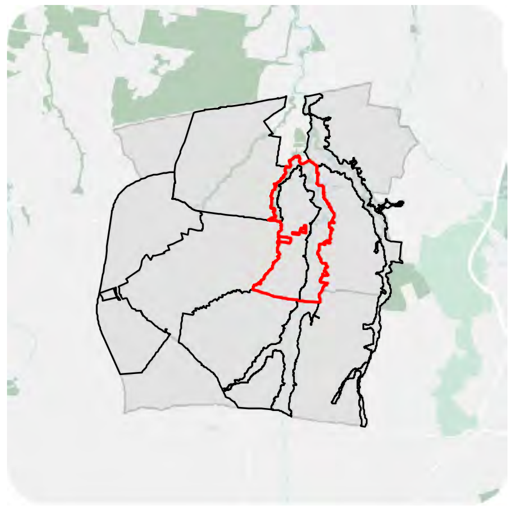
Initial precincts
Other precincts

Top of Bank Mapping (CTE)
Creek
Creek channel polygon
WMA VRZ buffers

Strahler Stream Order
< 3rd order
3rd order & higher

Farm Dam Prioritisation
Not suitable
Not suitable but with HEV area
Suitable

Source: DPIE, NSW Spatial Services, CTE, Nearmap



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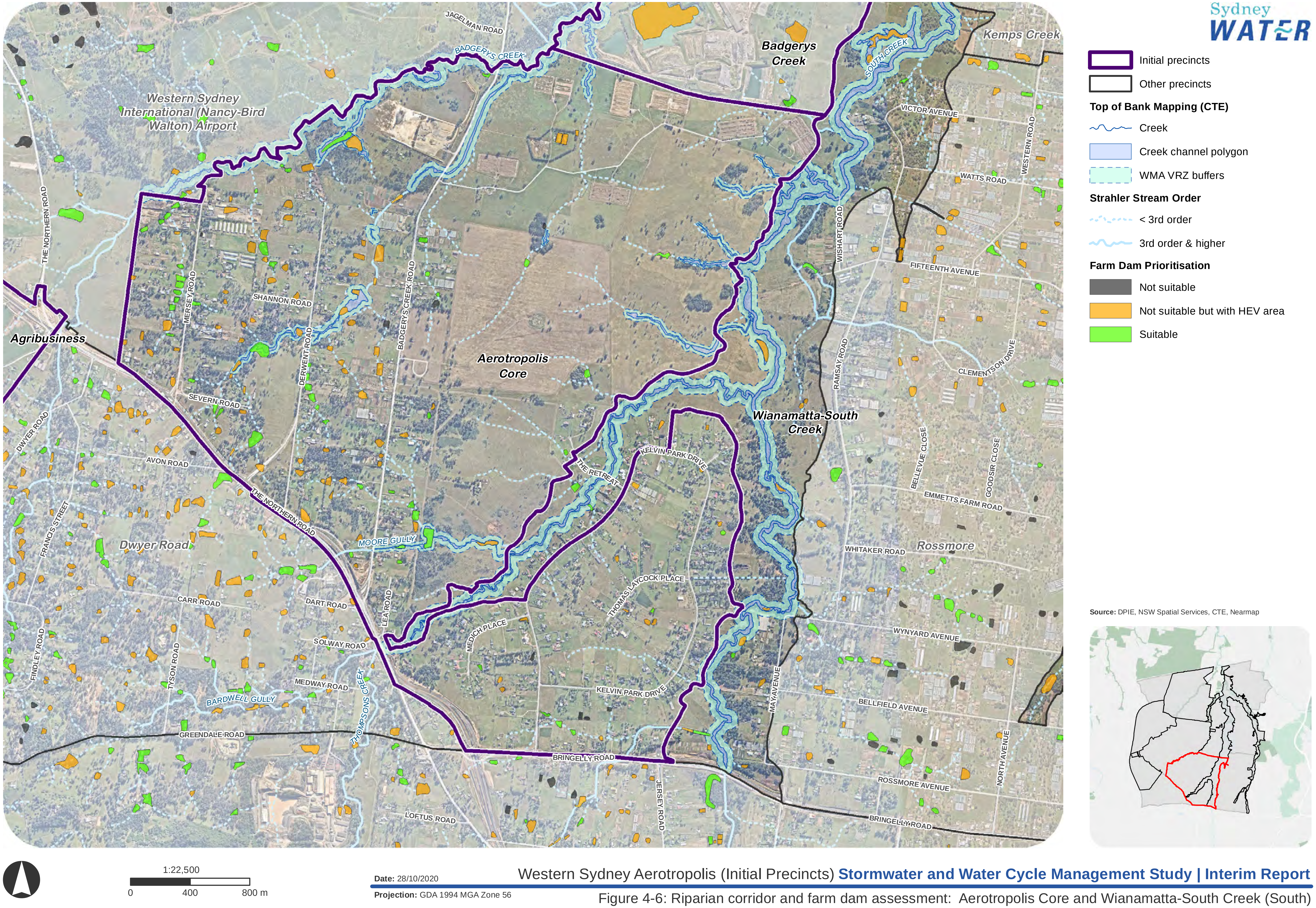
Date: 28/10/2020
Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 4-5: Riparian corridor and farm dam assessment: Badgerys Creek and Wianamatta-South Creek (North)



Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 4-6: Riparian corridor and farm dam assessment: Aerotropolis Core and Wianamatta-South Creek (South)

5 Integrated Water Cycle Management

The information provided within this section is high level in nature and provided as an indication of potential locations and land requirements of key integrated water servicing infrastructure. Detailed planning at the Precinct level will continue over coming months based on direction and outcomes of Sub Regional integrated water service planning for the region. The total demands and water balances presented in this section are based on Sydney Water's growth data.

5.1 Population and growth basis

The forecasts in Table 5-1 reflect the current adopted ultimate growth basis at 2056 for planning in the Aerotropolis initial precincts.[3]

Table 5-1 Aerotropolis initial precincts - ultimate growth forecasts

Precinct	Single dwellings	Multi dwellings	Jobs
Aerotropolis Core	-	8,000	60,000
Agribusiness	550	-	10,000
Badgerys Creek	-	-	11,000
Northern Gateway	-	3,598	55,011

5.2 Water demands

Water demands for different uses adopted in the integrated water balance modelling are summarised in Table 5-2. Evidence based demands will continue to be assessed based on the typologies as it becomes known. Staged delivery of assets allows flexibility to continually assess demands and servicing requirements.

Table 5-2 Water demand unit rates

Use	Water demand unit rates	Proportion of demand that could be met by a non-drinking supply[4]
Residential	200 L/EP/day	50%
Non-residential	104 L/job/day	50%
Irrigation	~2.5 ML/Ha/yr private gardens ~3.2 ML/Ha/yr for public open space ~4.5 ML/Ha/yr for playing fields	100%

[3] These growth projections are those currently adopted in Sydney Water's infrastructure planning and include commercial projections.

[4] Non-drinking supply sources include stormwater or recycled water

5.2.1 Residential and non-residential demands

The residential usage demand of 200 L/EP/day includes all internal residential uses along with irrigation of private open spaces. Up to 50% of this demand can be met by non-drinking water sources if connected for toilet flushing, washing machine use and irrigation.For non-residential demands, an evidence-based average day demand rate of 104 L/job/day was applied across all precincts. Up to 50% of this total demand can be met by non-drinking water sources if available.

5.2.2 Irrigation

Irrigation demands associated with additional landscaping and vegetated set back areas on the lot will be higher for Western Parkland City typologies where irrigation rates of 2.5 ML/Ha/yr are adopted[5]. Irrigation water is likely to be sourced from a mix of water sources.

Active open space and public open space can feasibly be irrigated at 4.5 ML/Ha/yr and as high as 8 ML/Ha/yr subject to suitable hydrologic landscapes. Some areas in the Aerotropolis may be less suitable for irrigation due to soil salinity risks and other soil properties without additional measures. Reduced irrigation rates of 2.5 and 3.2 ML/Ha/yr have been adopted for residential and public open space respectively.

5.2.3 Urban cooling

Misting and evaporative cooling is an emerging method for reducing ambient temperatures inside and outside of buildings (notionally 4.5 ML/NHa/yr) which is promoted by the Low Carbon Living CRC (2017) as an urban cooling strategy to reduce the impacts of extreme heat and as a means of reducing stormwater runoff volumes.

Water sources would be high quality where there is a risk of human contact and ingestion, but stormwater from ground surfaces could be utilised to mist rooftops of large format industrial buildings.

5.3 Integrated water servicing

Sydney Water has undertaken daily time-step water balance modelling on a Sub Regional level for the Aerotropolis and for each of the precincts to understand the ultimate system and infrastructure requirements under various approaches to integrated water servicing. Each servicing scenario is differentiated with key concepts relating to urban form outcomes and levels of recycled water and stormwater servicing in the Aerotropolis, as shown in Figure 5-1.

Individual precincts may be more suited to certain servicing approaches due to land uses, locations, Council preferences and timing.

The preferred integrated servicing approaches across the region are in planning and subject to economic and regulatory approvals. Sydney Water's adaptive approach to planning and servicing will help achieve the best outcomes for customers.

An overview of a sub-set of the integrated water servicing approaches analysed is presented here, with the results shown assuming the servicing approach is consistent across all the Aerotropolis initial precincts.

The volume of each water product that would be supplied under each of the above integrated water servicing approach at 2056 is shown in Figure 5-2. All volumes are indicated in megalitres per year (ML/yr).

Outcomes from integrated water balance modelling will continue to inform Sydney Water's planning for servicing the Aerotropolis.

[5] Irrigation rates are adopted from Table 2 of Sydney Water's *Best practice guidelines for holistic open space turf management in Sydney (2011)*.

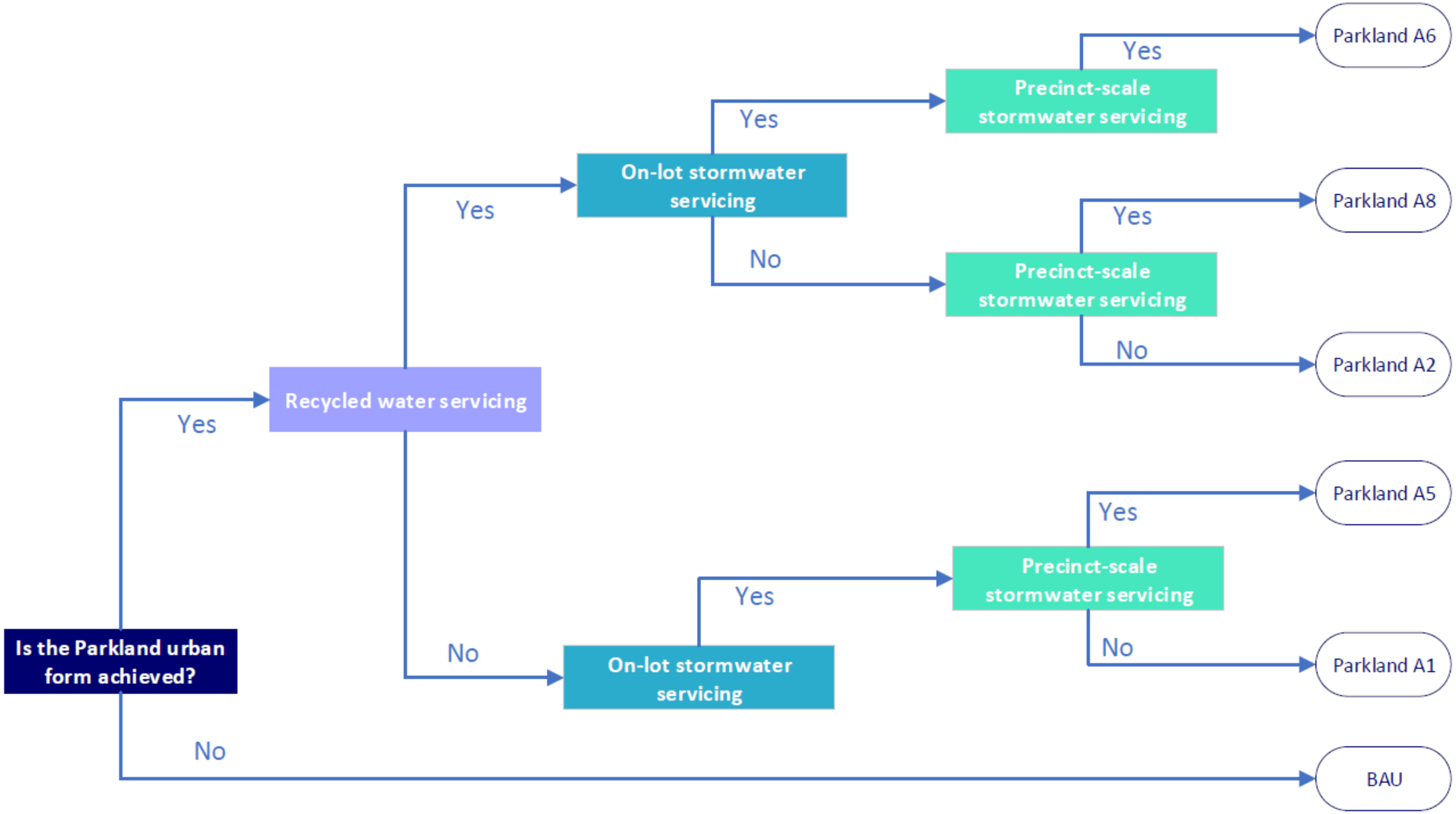


Figure 5-1 Integrated water servicing scenarios

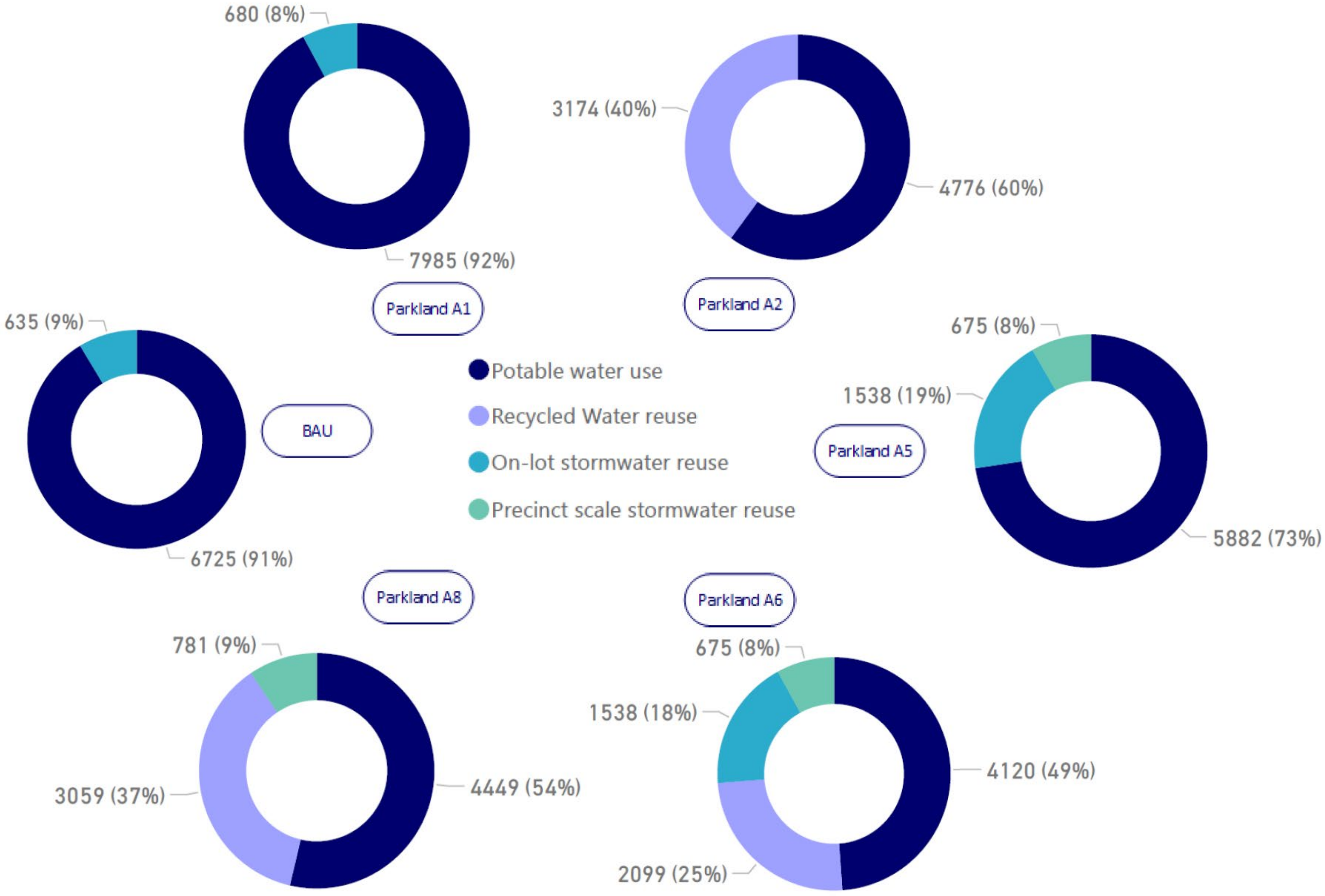


Figure 5-2 Water supply mix under various integrated water servicing approaches for the initial precincts

5.4 Drinking water servicing

5.4.1 Existing drinking water servicing

Each of the initial precincts fall in Cecil Park Water Supply Zone within the Prospect South Delivery System and currently have limited to no water services available.

Cecil Park Reservoirs are currently at capacity and cannot accommodate demands from new developments without the additional proposed amplification work to transfer flow from Liverpool and trunk infrastructure proposed within Cecil Park Water Supply Zone (WSZ).

Drinking water in the Cecil Park WSZ is supplied from Prospect Water Filtration Plant, which gets its source water from Warragamba Dam and Prospect Reservoir.

5.4.2 Interim drinking water servicing

Sydney Water is committed to provide services to early developments. Sydney Water are currently delivering the following trunk drinking water infrastructure to increase supply to the area:

- Rising Main (DN900) and pump WP0432 at Liverpool
- DN1200/DN1050 from Cecil Park reservoir up to Western Rd, with offtakes at Range Rd and Western Rd connecting existing mains in Elizabeth drive

This work is in delivery and proposed to be operational in 2022.

Sydney Water is also planning to deliver trunk infrastructure to support growth and major projects along Elizabeth Drive and Luddenham Road. Interim servicing may include offtakes from proposed mains in Elizabeth Drive to Badgerys Creek, Agribusiness and Northern Gateway precincts.

Interim servicing for Aerotropolis Core precinct would be through proposed Oran Park Reservoir via Northern Road mains.

5.4.3 Ultimate drinking water servicing

Drinking water servicing for the Aerotropolis initial precincts is linked to the Western Sydney Regional Master Plan and draft *Western Sydney Aerotropolis Sub Regional Plan*. The current ultimate drinking water supply strategy for these precincts is to supply from Prospect South delivery system via the Cecil Park water supply zone and a proposed new water supply zone. A new reservoir (60ML) is proposed in the west at the end of Elizabeth Drive within the Agribusiness precinct. Detailed planning for options assessment and staging requirements has recently been completed.

Trunk drinking water infrastructure is planned to be delivered to meet DPIE growth forecasts. New drinking water reservoirs, pumping stations and trunk mains are required to fully service the precincts. The trunk infrastructure identified is the skeleton trunk infrastructure and additional precinct trunk infrastructure and reticulation mains will be identified when Indicative Layout Plans are available. Refer to Appendix A for maps indicate the ultimate drinking water trunk infrastructure network.

Purified recycled water could also be introduced as a source for the drinking water supply however this would be a city-wide decision and has not been considered locally.

5.4.4 Integrated servicing infrastructure impacts

Depending on the preferred integrated servicing approaches for each precinct, the drinking water infrastructure requirements to service the Aerotropolis may be impacted as outlined in Table 5-3.

Table 5-3 Integrated servicing impacts on drinking water infrastructure

Integrated servicing scenario	Effect on drinking water infrastructure requirements
BAU	No changes
Parkland A1	The increased overall water demand requires additional consideration of the requirements to meet the Western Parkland City greening requirements which will increase trunk sizing
Parkland A2	If recycled water is supplied, there is the opportunity to reduce the sizing of some trunk infrastructure. Additional top-up infrastructure requirements with potential co-location of recycled water and drinking water reservoirs
Parkland A5	There may be an opportunity to reduce sizing of some trunk infrastructure with optimised stormwater harvesting for irrigation uses, however the reliability of stormwater harvesting may mean that full drinking water infrastructure is required.
Parkland A6	Opportunity to reduce sizing of trunk infrastructure with recycled water supply and optimised stormwater harvesting. Additional top-up requirements with potential co-location of recycled water and drinking water reservoirs
Parkland A8	Opportunity to reduce sizing of trunk infrastructure with recycled water supply and optimised stormwater harvesting. Additional top-up requirements with potential co-location of recycled water and drinking water reservoirs.

5.5 Wastewater servicing

5.5.1 Residential and non-residential flows

For residential flows 150 L/EP/day average dry weather flow (ADWF) rate has been applied. For non-residential flows, an evidence-based average dry weather flow rate of 30EP/NHa for expected typology has been applied across all precincts.

Evidence based demands will continue to be assessed based on the typology as it becomes known. Staged delivery of assets allows flexibility to continually assess demands and servicing requirements.

5.5.2 Existing wastewater servicing

Each of the initial precincts currently have very limited wastewater servicing available, with most areas relying on septic tanks for wastewater disposal.

5.5.3 Interim wastewater servicing

Sydney Water is committed to working with developers for interim servicing to early developments prior to 2025/26. Interim servicing may include decentralised wastewater treatment, tankering or interim pumped transfer. Interim servicing would be designed for transition to long term servicing with the timing of transition to be assessed on a case by case basis.

5.5.4 Ultimate wastewater servicing

Wastewater servicing for the Aerotropolis initial precincts is linked to the draft Western Sydney Regional Master Plan and draft *Western Sydney Aerotropolis Sub Regional Plan*. To fully service the region requires several wastewater pumping stations (WWPS) and deep gravity trunk mains. Several new pressure mains will transfer flows to the proposed Upper South Creek Advanced Water Recycling Centre (USC AWRC). The USC AWRC first stage completion is targeted for mid-2025. Trunk wastewater infrastructure is planned to be delivered in stages based on DPIE growth forecasts.

The first stages are planned to be delivered in line with operation of the USC AWRC. Detailed planning for options assessment and staging requirements is nearing completion. Refer to the maps in Appendix A showing indicative location for ultimate trunk wastewater infrastructure for each of the four initial precincts.

5.5.5 Integrated servicing infrastructure impacts

Depending on the preferred integrated servicing approaches for each precinct, the wastewater infrastructure requirements to service the Aerotropolis may be impacted.

Table 5-4 Integrated servicing impacts on wastewater infrastructure

Integrated servicing scenario	Effect on wastewater infrastructure requirements
BAU	No changes
Parkland A1	Some potential (still to be assessed) for the reduction in hydraulic capacity of the wastewater system and plant through reduction of infiltration to sewer.
Parkland A2	As for Parkland A1
Parkland A5	As for Parkland A1
Parkland A6	As for Parkland A1
Parkland A8	As for Parkland A1

5.6 Recycled water servicing

Sydney Water is committed to the provision of recycled water in the Western Parkland City from the USC AWRC. Recycled water servicing for the initial precincts is linked to Sydney Water's Western Sydney Regional Master Plan and draft Western Sydney Aerotropolis Sub Regional Plan. Sub Regional planning work has developed adaptive pathways for integrated product servicing and an economic assessment of each of these pathways against key drivers is currently under evaluation and will be provided in the final report for the *Stormwater and Water Cycle Management Study*.

Sydney Water has developed a proposed recycled water supply network from USC AWRC at the Sub Regional planning level to service non-drinking uses across the Aerotropolis. In the proposed configuration, recycled water storages within the network would be provided and be topped-up from the drinking water network when recycled water supply cannot meet demand.

Recycled water supply for non-drinking uses is closely related to the stormwater servicing approaches due to competing end uses. Table 5-5 shows the ultimate recycling potential under each integrated servicing scenario as levels of service against Average Daily Demand (ADD) and Maximum Daily Demand (MDD). The reuse proportions presented assume that:

- in scenarios where recycled water is supplied, there is full recycled water supply coverage across the all of the initial precincts (i.e. 100% recycled water uptake)
- any wastewater flows above 3×ADWF are not treated to a quality suitable for use as recycled water and are instead discharged to Wianamatta-South Creek subject to satisfaction of waterway health objectives
- the level of service within the recycled water system is as assumed in Sub Regional planning as shown in Figure 5-3.

Table 5-5 Recycled water system level of service

RW Trunk infrastructure	Criteria
Surface Reservoirs	ADD
Elevated Reservoirs	1/6 MDD
Recycled Water Pumping Stations	MDD[1]
Surface to Elevated reservoir recycled water pumping station	MHD
Rising mains	MDD[1]
Outlet Mains	MHD[2]

[1] Based on the maximum recycled water flow achievable from the AWRC
[2] Exception for Scenario A6 where SMART tanks could be utilised as distributed storages within the recycled water network

This level of service within the recycled water supply system would provide a high level of service and a further optimised system with a lower but acceptable level of service may provide the best value solution for recycled water servicing in the initial precincts. Lower levels of service and the impacts on infrastructure requirements are currently being assessed at the individual precinct level to understand optimal recycled water servicing for the Aerotropolis.

Sydney Water is also assessing alternate uses for highly purified recycled water such as environmental flows and augmentation of the drinking water supply. These potential uses are not reflected as recycled water reuse in the figures above.

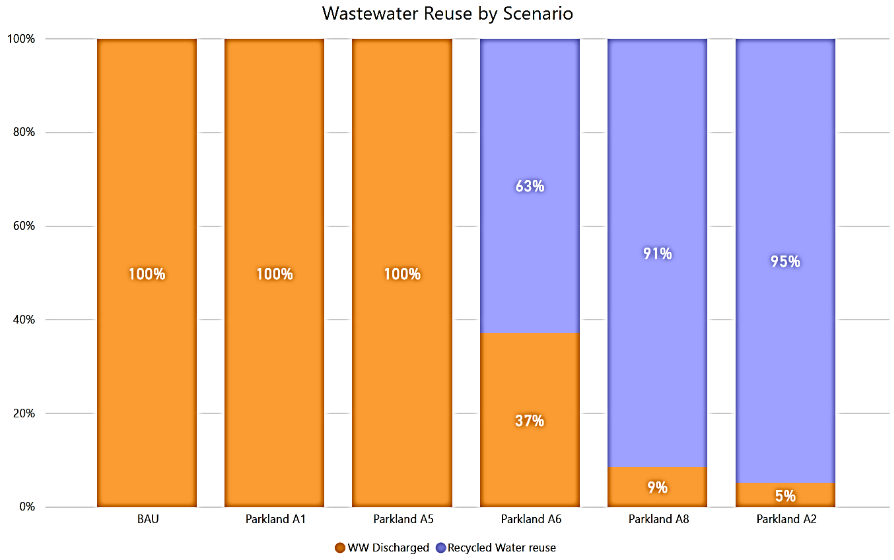


Figure 5-3 Recycled water use under different integrated servicing approaches

To provide the best value for recycled water servicing, it may be more cost-effective to limit recycled water supply to certain precincts or for certain uses. The effect of reducing the proportion of development serviced by recycled on the water balances in terms of water supply mix and wastewater discharged under each scenario that includes recycled water servicing is shown in Figure 5-4 and Figure 5-5. Use of purified recycled water for drinking can reduce challenges relating to as the reuse is fully integrated into the drinking water supply system.

Sydney Water's adaptive planning and servicing approach will allow for flexibility to provide recycled water servicing in the Aerotropolis that provides the greatest economic value.

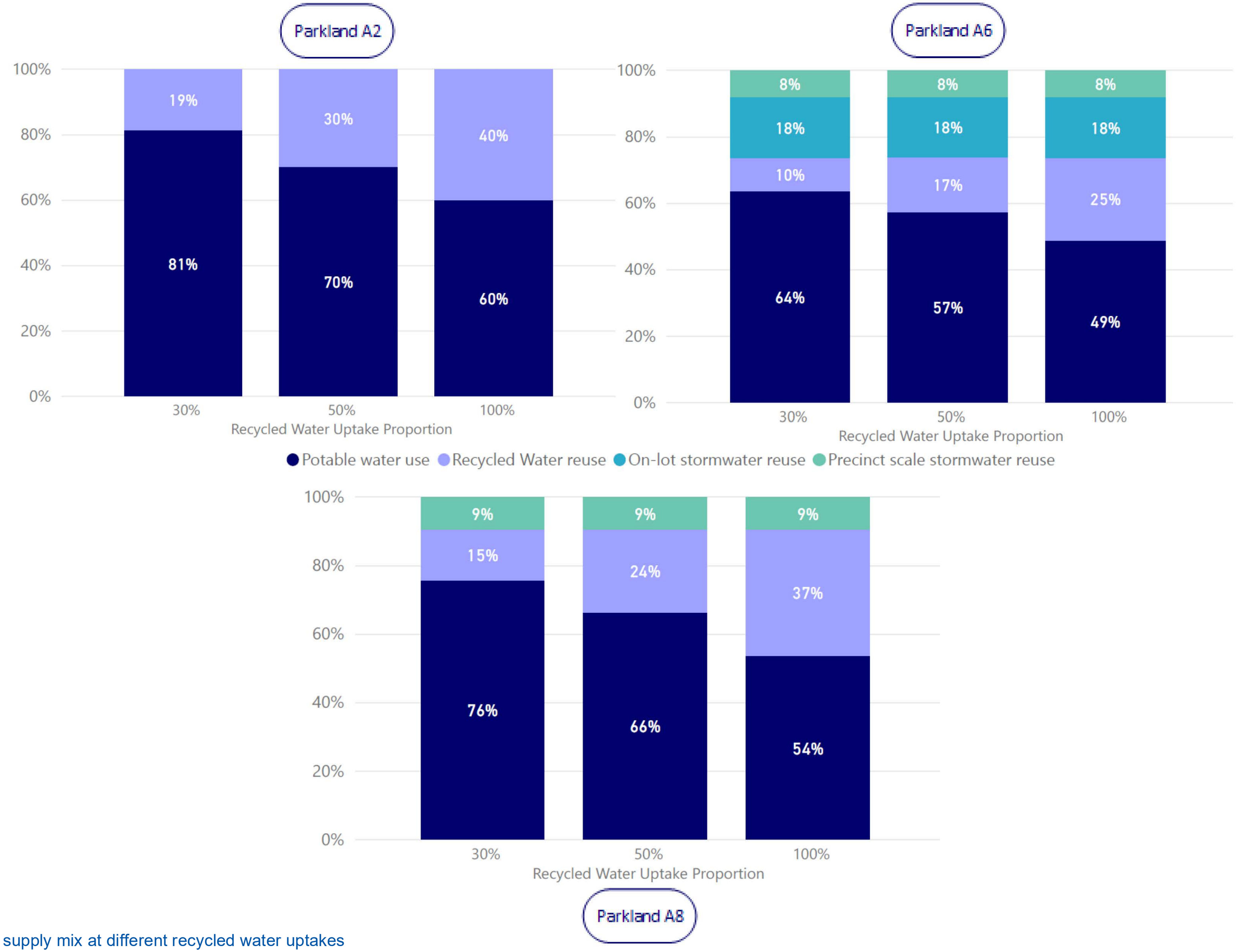


Figure 5-4 Water supply mix at different recycled water uptakes

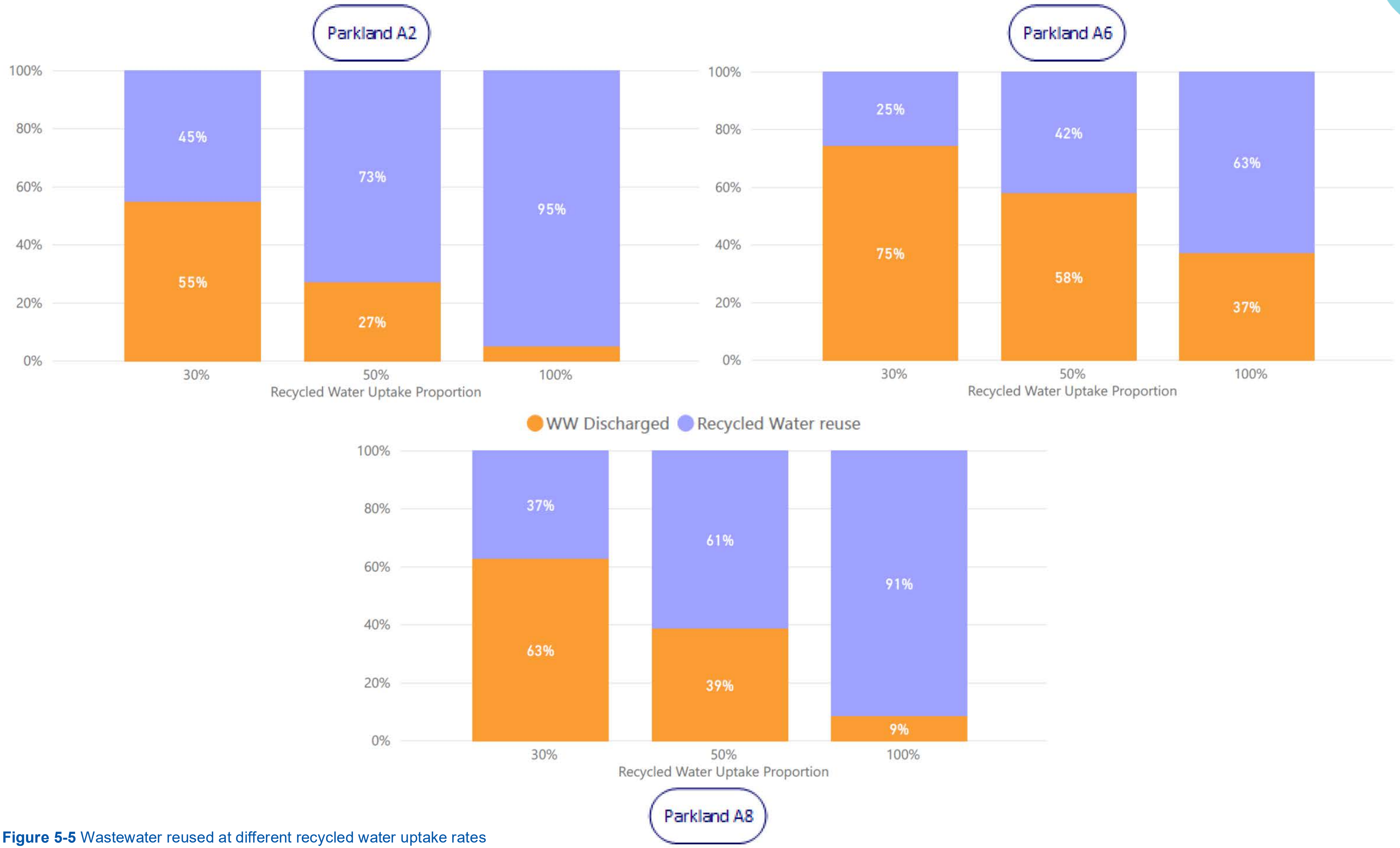


Figure 5-5 Wastewater reused at different recycled water uptake rates

5.6.1 Integrated servicing infrastructure impacts

Depending on the preferred integrated servicing approaches for each precinct, the recycled water infrastructure requirements to service the Aerotropolis may be impacted.

Table 5-6 Integrated servicing impacts on recycled water infrastructure

Integrated servicing scenario	Effect on recycled water infrastructure requirements
BAU	Not applicable – recycled water not supplied
Parkland A1	Not applicable – recycled water not supplied
Parkland A2	No changes
Parkland A5	Not applicable – recycled water not supplied
Parkland A6	There may be opportunity to sizing of reduce recycled water trunk infrastructure with optimised stormwater harvesting both at the lot and regional scale
Parkland A8	Opportunity to reduce sizing of recycled water trunk infrastructure with optimised stormwater harvesting

5.7 Stormwater harvesting and reuse

Stormwater generated within the precincts will be managed through a range of on-lot, street scape and end of pipe stormwater management elements to deliver the proposed controls outlined in Section 6.

Of significance to this Stormwater and Water Cycle Management Study is the consideration of draft stormwater objectives that seeks to cap the annual contribution of stormwater from the Aerotropolis to 2.0 ML/Ha/yr.

To achieve this stormwater volume reduction target, stormwater harvesting is required on the lot and at the end of pipe, particularly for industrial and commercial land uses where typical stormwater runoff rates are as high as 4 to 5 ML/Ha/yr.

5.7.1 Harvesting and reuse

The precinct-scale stormwater harvesting in the Parkland A5, A6 and A8 scenarios is such that the stormwater harvesting, and reuse is provided to achieve the mean annual runoff volume (MARV) target of 2.0 ML/ha/yr.

5.7.2 Integrated servicing infrastructure impacts

Depending on the preferred integrated servicing approaches for each precinct, the stormwater infrastructure requirements to service the Aerotropolis may be impacted.

Table 5-7 Integrated servicing impacts on stormwater infrastructure

Integrated servicing scenario	Effect on stormwater infrastructure requirements
BAU	Increased stormwater detention basin sizing and creek protection would be required under the BAU urban form outcomes
Parkland A1	No changes; however depending on land uses, the annual stormwater contribution targets may not be met without additional end of pipe harvesting
Parkland A2	Additional end of pipe harvesting volumes would likely be required to achieve the same runoff targets as in the following scenarios.
Parkland A5	No changes
Parkland A6	Same stormwater infrastructure requirements as scenario A5 above.
Parkland A8	Increased stormwater harvesting volumes required to meet the same runoff targets due to removal of on-lot storages

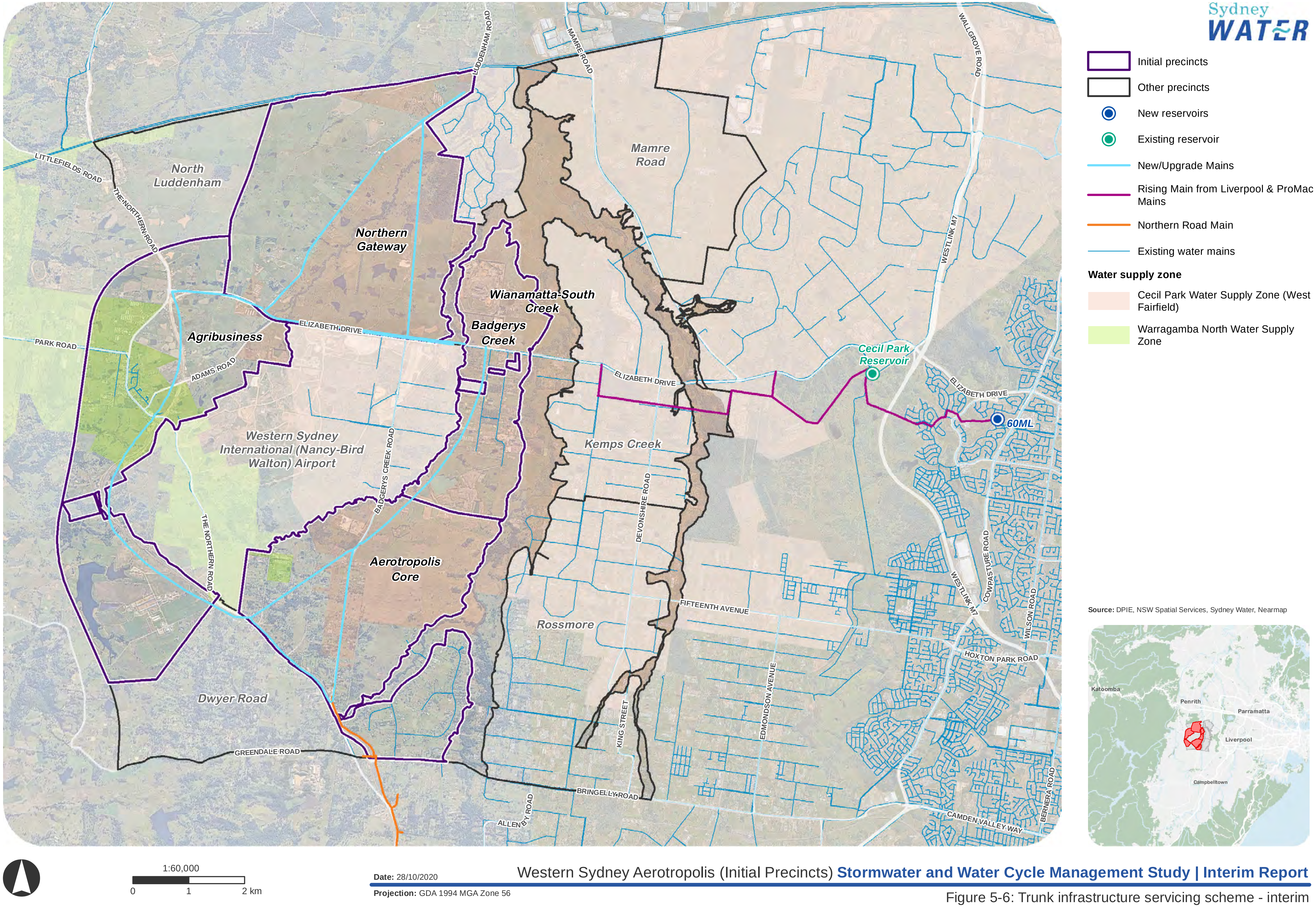


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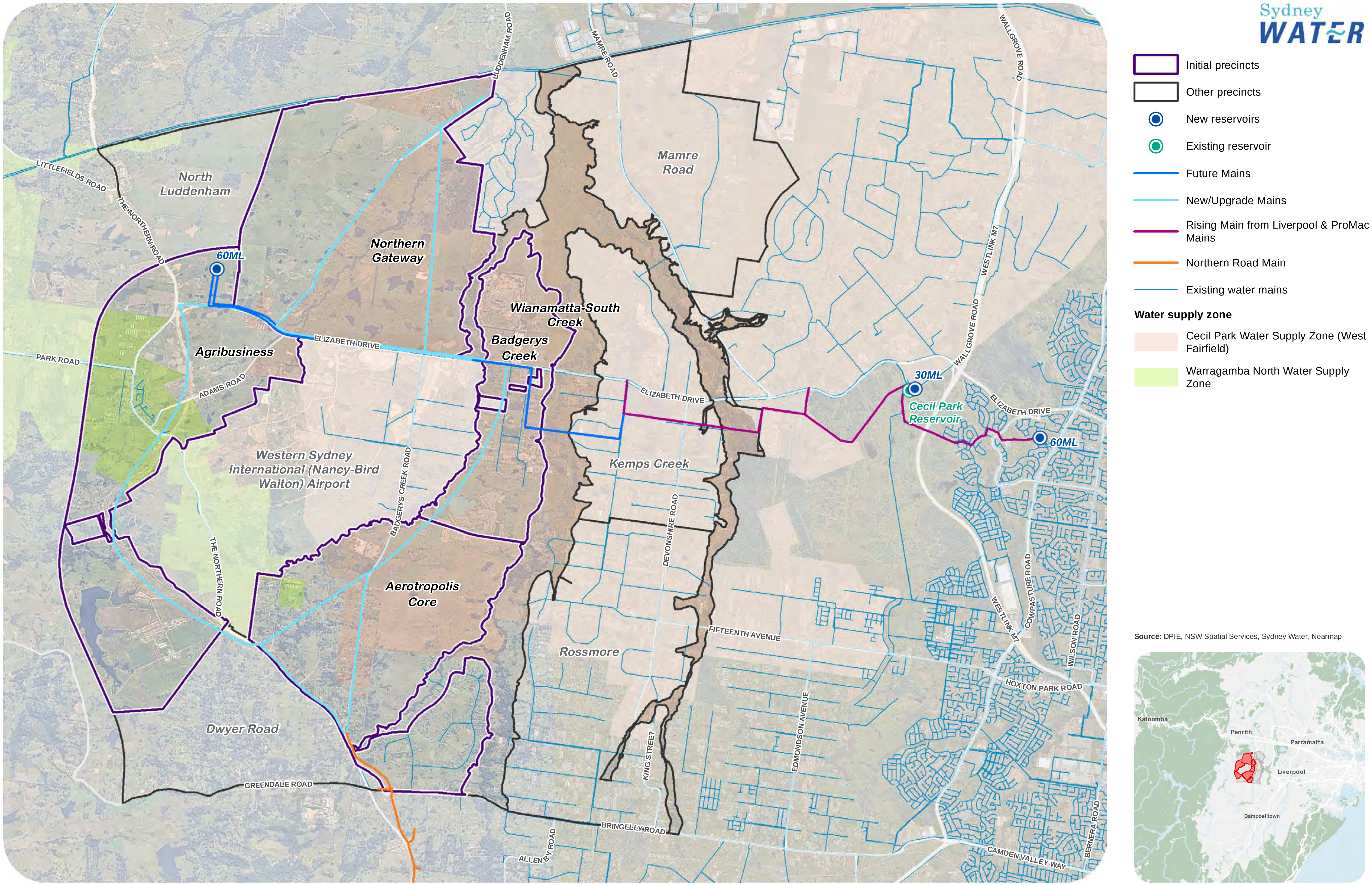
Figure 5-6: Trunk infrastructure servicing scheme - interim



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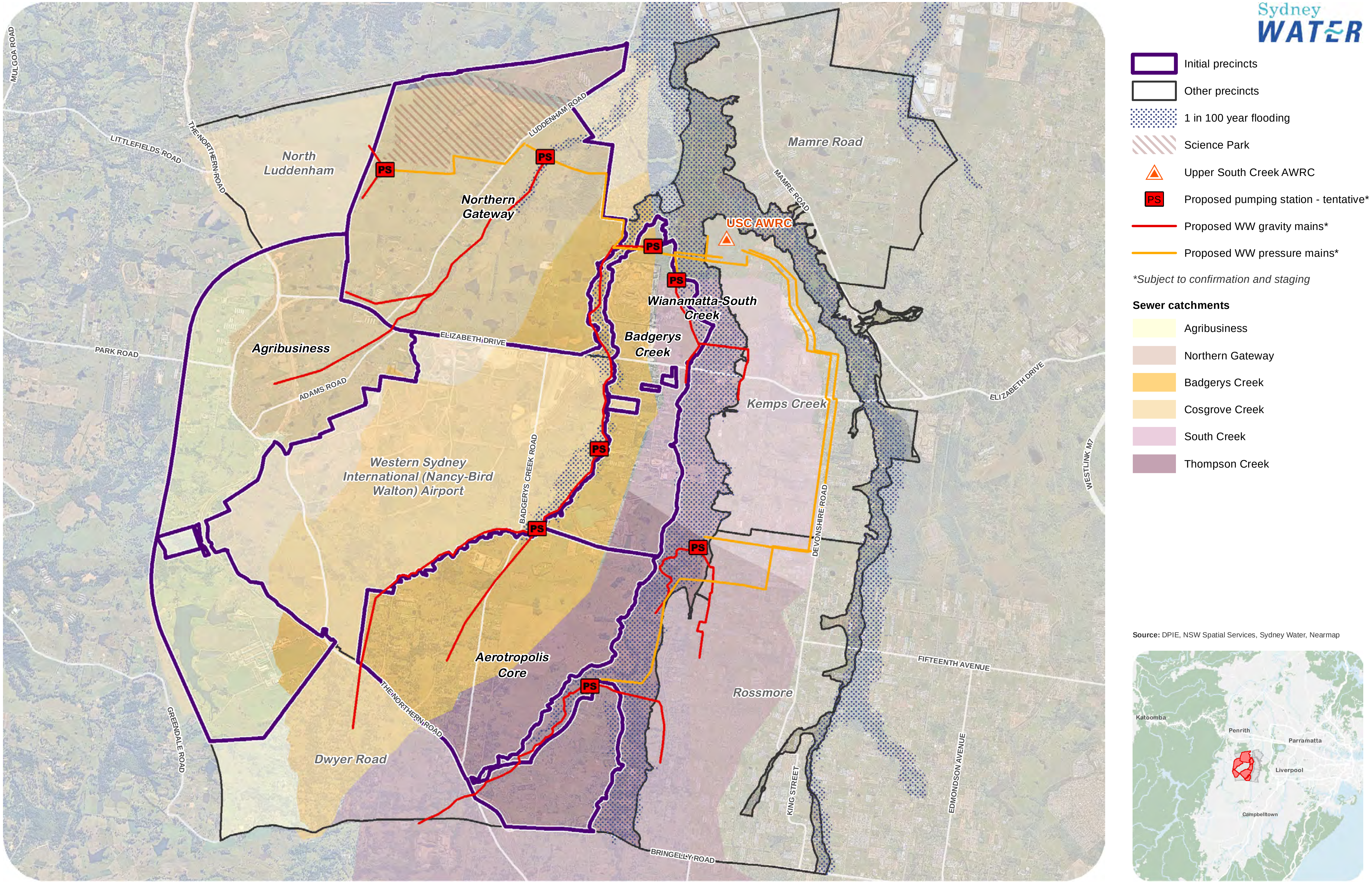
Date: 28/10/2020

Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 5-7: Trunk infrastructure servicing scheme - ultimate



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Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 5-8: Proposed wastewater infrastructure

6 Stormwater management for waterway health

The Integrated Water Cycle Management Plan prescribes management of frequent flow events (approximately 1-2 exceedances per year) to minimise water quality and waterway health impacts on waterways. This section of the report discusses the development of strategies to:

- avoid or minimise adverse impacts of urban stormwater flows on land, native vegetation, waterways, groundwater dependent ecosystems and groundwater systems
- protect and enhance water quality, by improving the quality of stormwater runoff from urban catchments to help achieve local water quality and health objectives.
- Integrate stormwater management systems into the landscape in a manner that provides multiple benefits, including public open space, habitat improvement and recreational and visual amenity.

6.1 Meeting new development controls

Stormwater management targets are being developed by DPIE that will put controls on both stormwater volumes and stormwater pollution concentrations.

Water quality objectives will be achieved through conventional stormwater filtration via biofiltration or wetlands to reduce the dominant storm flow concentrations of Dissolved Inorganic Nitrogen and Phosphorous to below

Volumetric controls require that stormwater is prevented from entering creeks. This is often achieved through stormwater harvesting, evaporation and evapotranspiration from vegetation and represents a change in stormwater management from current practice. The business as usual approach, without volumetric controls, can achieve pollution reduction targets through filtration without any significant stormwater volume reductions.

The draft stormwater objectives specify that development upstream of 1st and second order waterways must discharge only 0.9 ML/Ha/yr to waterways. Figure 6-1 shows that the preservation of baseline stormwater discharge rates would most likely require a reduction in stormwater volumes by approximately up to 80% which may not be achievable. This will likely require that stormwater exceeding this annual flow rates must be diverted around 1st and 2nd order waterways to downstream waterways. In doing so, this effectively concentrates the collection of stormwater at the number of basins as shown in

Interim stormwater management objectives for 3rd order waterways allow a moderate flow volume objective of 2.0 ML/Ha/yr. While this objective is more achievable, it would still require that new industrial development reduces stormwater runoff volumes by more than half.

Final stormwater management objectives and targets developed by DPIE will ultimately inform the size, distribution and function of stormwater management elements across the precincts. This Study demonstrates how stormwater management measures could work towards achieving the stormwater volume reductions outlined above to provide an indication of likely treatment scenarios.

6.2 Consultation with councils

A workshop was held on 6 August with Sydney Water, Penrith and Liverpool Councils (and other government agencies including DPIE, INSW and PPO) to understand Councils' preferences for water management infrastructure in their local government areas. Councils presented what has and hasn't worked well, lessons learnt and potential innovations for consideration. A follow up session was held in September to provide a project status update and to seek additional input and comment from Councils.

Councils recognised that well designed water sensitive urban design (WSUD) measures provide a range of benefits including enhanced stormwater quality and retention, biodiversity, urban greening and heat reduction. They can be multifunctional, for example incorporate recreational use and be co-located within open space elements.

Councils raised the importance of designing assets with adequate access for maintenance and minimising maintenance requirements and costs. Scale is important and consolidating assets may reduce maintenance burdens. Consideration of grades, tailwater, vegetation constraints, safety were also raised as key considerations when siting and designing WSUD elements.

6.3 Treatment train shortlist

A shortlist of stormwater management elements has been developed based upon Council preferences, stormwater volume reduction potential, ability to mimic natural flow regimes and cost effectiveness.

Consultation with Penrith and Liverpool Councils has ultimately shaped the formation of preferred treatment trains for each land use zone. Outcomes of the workshop with councils have been synthesised in a preferred treatment train shortlist presented in Table 6-1

The following approaches have been adopted in developing the treatment trains:

- There is a preference for regional scale biofiltration and wetlands to be well integrated into the landscape and co-located within detention basins as appropriate.
- For industrial and commercial development, on-lot measures may include a combination of robust and low maintenance elements including of rainwater tanks, biofiltration basins and proprietary filtration devices. While regional basins are not supported, it is likely that wetlands and open water bodies would be better managed as centralised facilities with appropriate funding.
- Street scale WSUD measures should be avoided but biofiltration street trees may be incorporated into the streetscape and are considered to be an important mitigation approach to managing shallow groundwater and salinity risk associated with over irrigation across the landscape, especially on private lands.

Table 6-1 Treatment train shortlist

WSUD Approach		Medium Density Residential	High Density Residential	Commercial	Large Format Industrial	Strata Industrial
Lot scale OSD	Private Lots				Yes	Yes
Regional / end of pipe detention basins	For Roads Only				Yes	Yes
	For Private Lots and Roads	Yes	Yes	Yes		
Rainwater tanks		Yes	Yes	Yes	Yes	Yes
Lot scale WSUD	GPTs				Yes	Yes
	Bioretention				Yes	Yes
	SQID				Yes	Yes
	Permeable pavement			Yes	Yes	Yes
Street Scale WSUD	Bioretention street trees	Yes	Yes	Yes	Yes	Yes
	Permeable pavements					
End of pipe WSUD	Bioretention basins	Yes	Yes	Yes	Yes	Yes
	Constructed wetlands / pond	Yes	Yes	Yes	Yes	Yes
	Harvesting	Yes	Yes	Yes	Yes	Yes

6.4 WSUD Effectiveness

MUSIC modelling has been undertaken to demonstrate the effectiveness of stormwater management elements to reduce generic stormwater pollution loads and stormwater volumes. Table 6-2 below shows the feasibility of reducing stormwater runoff rates through these measures.

Table 6-2 Reductions achievable through stormwater reuse or vegetated WSUD elements

WSUD Element	Mean annual runoff Reduction (ML/yr)	TSS Reduction (kg/yr)	TP Reduction (kg/yr)	TN Reduction (kg/yr)
Rainwater tank for internal water use (1.5 kL / dwelling or 45 kL/Ha industrial)	0.75	21	0.1	1.7
Rainwater tank for internal and external water use (3 kL / dwelling or 80 kL tank / Ha)	0.9	23	0.13	1.9
Street Trees - highly urban areas structural cells (35 trees / Ha)	0.5	470	0.7	2.8
End of pipe bioretention (0.6% of lots and roads as necessary to achieve conventional pollution reductions)	0.2	595	0.96	4.35
Wetland (5% of catchment)	0.7	515	0.93	3.9
Wetland with limited stormwater harvesting for irrigation	0.9	29	0.13	0.8
Stormwater Harvesting Tank for limited irrigation	0.6	33	0.085	0.72

This assessment shows that it may be possible to reduce mean annual runoff rates by up to 3 ML/Ha/yr through a range of WSUD and modest stormwater harvesting and reuse approaches. As illustrated in Figure 6-1 several typologies will require mean annual runoff volume reductions up to 3.8 ML/Ha/yr to achieve the interim mean annual runoff volume target for third order waterways. This implies that a catchment made up entirely of large format industrial, strata industrial and commercial typologies would fall short achieve the interim target discharge of 2.0 ML/Ha/yr.

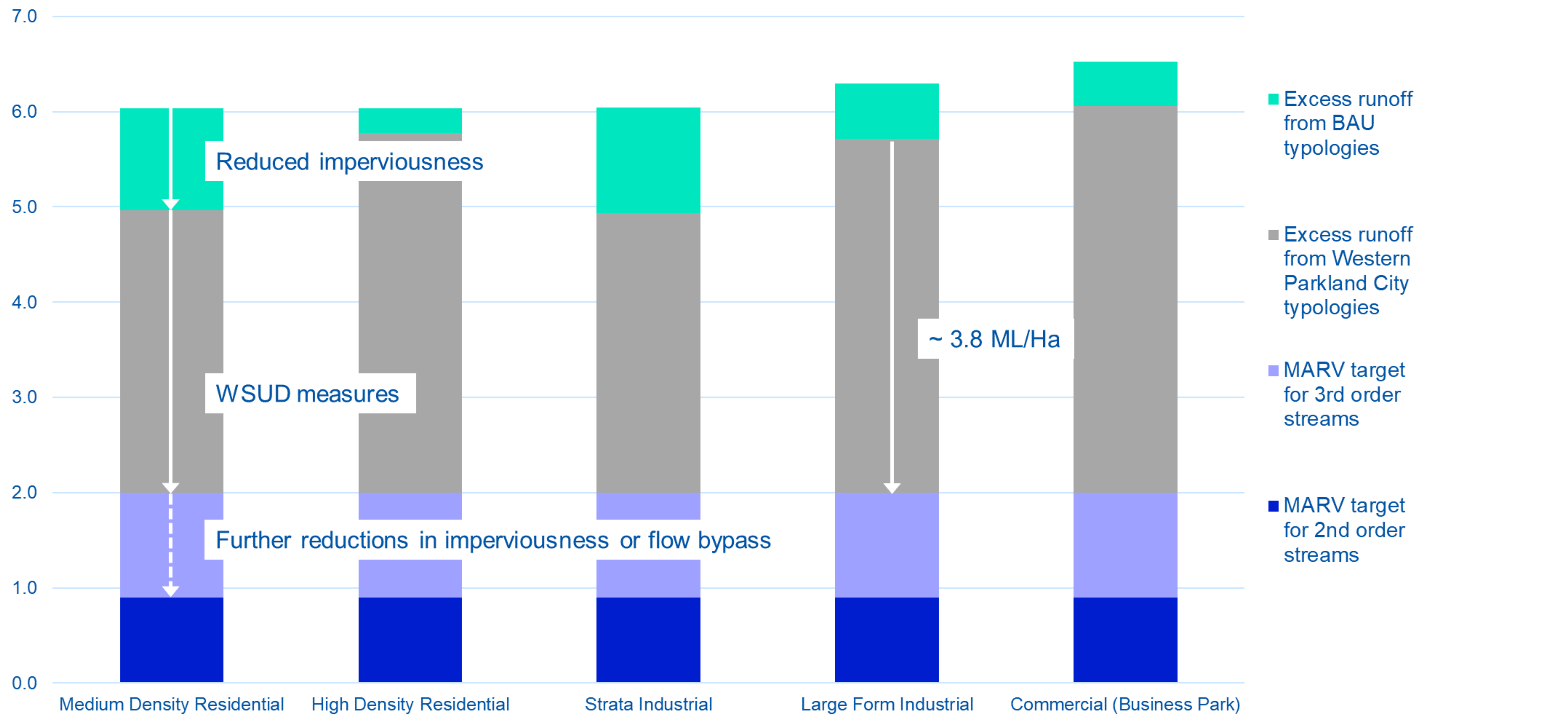


Figure 6-1 MARV reductions required to achieve interim stormwater management targets

During the finalisation of the precinct plans, it will be necessary to account for the contribution of undeveloped land on precinct wide mean annual runoff rates and to exploit additional opportunities for stormwater losses through higher rates of irrigation on suitable public open space. This approach requires a coordinated approach to stormwater management across a precinct with appropriately sized basins tailored for the mix of land uses in each sub catchment and the opportunities for stormwater harvesting. Further reductions in mean annual runoff volumes may be achieved with:

- Optimising the evaporative losses of WSUD elements
- Harvesting and reusing stormwater for urban cooling by irrigating large industrial roofs, street verges and deeper irrigation on public open space where the hydrogeologic landscape allows
- Further reducing the proportion of impervious surfaces on new development by adopting more compact urban forms.
- The use of stormwater bypass pipelines may also be effective in bypassing stormwater around sensitive waterways.

The combined impact of WSUD approaches and land use is being tested as part of the establishment of stormwater management targets, due to be completed in October 2020.

6.5 Strategic impact assessment of stormwater volume and pollution reductions

This section provides a strategy for the most cost-effective way to achieve stormwater volume and pollution reductions through the shortlisted WSUD elements. Stormwater management construction and maintenance costs for vegetated WSUD elements have been developed from industry rates and are provided for comparing the cost effectiveness of measures only. They should not be relied on for costing or feasibility assessments. Due to the range of proprietary devices on the market, these cannot be summarised in one table and have been omitted for brevity. The focus of this exercise is to establish a least-cost approach to managing stormwater volumes and pollutant loads.

It is important to note that the costs below do not include an allowance for land acquisition for end of pipe stormwater elements and do not include the cost of co-locating WSUD elements within stormwater detention basins.

From the list of measures considered Table 6-3 and Table 6-4, the following is noted:

- While biofiltration is a cost-effective means of reducing pollutants, it is not as cost effective in reducing stormwater volumes.
- Biofiltration street trees are an expensive measure, however it should be noted that the trees costed include allowance for an 8m^3 soil void for each tree which is likely to be a more generous planting trench than is provided for most street trees under a business as usual approach, but is likely to be less than ideal for large canopy trees. Advice from DPIE EES has pointed to the need for regular grids of trees to manage groundwater and biofiltration street trees are considered to provide this function as well as providing shading and cooling of urban streets.
- Rainwater tanks on the lot are also an effective means of managing stormwater runoff volumes in frequent events, however it is acknowledged that these are not entirely reliable as a single source of non-potable water and a top up supply is required to make up the shortfall in reliability across prolonged dry spells.
- Wetlands and stormwater harvesting are the most cost-effective means of reducing stormwater volumes in frequent events.
- Pipes may be utilised to divert stormwater around 1st and 2nd order waterways to ensure that those waterways receive no more than the interim flow volume objective, These pipe costs have not been included at this time but will be included once the waterway management objectives are finalised.
- There may be residual need for bed and banks stabilisation works where waterways have begun and continue to erode, despite revegetation of riparian corridors. The costs of revegetation and stabilisation have not been included at this time.

Table 6-3 Life cycle costs of short listed, vegetated stormwater management elements

WSUD Element	Rate $/m2	WSUD Footprint		Total CAPEX	OPEX Rate	OPEX ($/yr)	Life Cycle	NPV ($)	NPV ($/yr)
		Per 1 Ha	Unit						
Rainwater tank for internal water use (1.5 kL / dwelling or 45 k/Ha industrial)	$7000 / dw	45	kL	$210,000	2.5%	$5,250	25	$334,000	$13,360
Rainwater tanks for internal and external water use (3kL / dwelling)	$8500 / dw	80	kL	$240,000	2.5%	$6,000	25	$382,000	$15,280
Rainwater tank for strata or large format industrial	$240,000	80	kL	$240,000	2.5%	$6,000	25	$382,000	$15,280
Street Trees - highly urban areas structural cells	$1,753	280	m^2	$490,875	2.5%	$12,272	25	$781,000	$31,240
Street Trees – within grassed verges with no structural cells	$772	144	m^2	$111,150	2.5%	$2,779	25	$177,000	$7,080
End of pipe bioretention	$708	60	m^2	$42,458	2.5%	$1,061	25	$68,000	$2,720
Wetland	$205	500	m^2	$102,461	6.0%	$6,148	25	$248,000	$9,920
Wetland with limited stormwater harvesting at end-of-pipe	$205	500	m^2	$102,461	6.0%	$6,148	25	$248,000	$9,920
Stormwater Harvesting Tank + Irrigation	$4,000	60	kL	$240,000	2.5%	$6,000	50	$524,000	$10,480

Table 6-4 Cost-effectiveness of short listed, vegetated stormwater management elements

WSUD Element	NPV ($/yr)	MARV Reduction (ML/yr)	$/ML Reduction ($/ML/yr)	TSS Reduction (kg/yr)	$/kg TSS Reduction ($/kg/yr)	TP Reduction (kg/yr)	$/kg TP Reduction ($/kg/yr)	TN Reduction (kg/yr)	$/kg TN Reduction ($/kg/yr)
Rainwater tank for internal water use (1.5 kL / dwelling or 45 kL/Ha industrial)	$13,360	0.75	$18,000	21	$1,000	0.1	$134,000	1.7	$8,000
Rainwater tank for internal and external water use (3 kL / dwelling)	$15,280	0.9	$17,000	23	$1,000	0.13	$118,000	1.9	$9,000
Rainwater tank for strata or large format industrial (80 kL tank / Ha)	$15,280	0.85	$18,000	24	$1,000	0.14	$110,000	2	$8,000
Street Trees - highly urban areas structural cells (35 trees / Ha)	$31,240	0.5	$63,000	470	$1,000	0.7	$45,000	2.8	$12,000
Street Trees – within grassed verges with no structural cells (18 trees / Ha)	$7,080	0.3	$24,000	308	$1,000	0.45	$16,000	1.7	$5,000
End of pipe bioretention (0.6% of lots and roads)	$2,720	0.14	$20,000	595	$1,000	0.96	$3,000	4.35	$1,000
Wetland (5% of catchment)	$9,920	0.7	$15,000	515	$1,000	0.93	$11,000	3.9	$3,000
Wetland with limited stormwater harvesting	$9,920	0.9	$12,000	29	$1,000	0.13	$77,000	0.8	$13,000
Wetland with limited stormwater harvesting at end-of-pipe	$10,480	0.6	$18,000	33	$1,000	0.085	$124,000	0.72	$15,000

6.6 Implementation

The assessment shows that a combination of reduced imperviousness, rainwater capture and reuse, stormwater harvesting and vegetated WSUD elements that maximise evaporative losses to achieve stormwater discharges reductions and contribute to interim objectives of 2.0 ML/Ha/yr.

A notional treatment train will include rainwater tanks, biofiltration street trees and end-of-pipe wetlands with stormwater harvesting to irrigate public open spaces at a rate of at least 2.5 ML/Ha/yr, and potentially more depending on salinity risks.

It will also be necessary to divert stormwater around sensitive receiving environments using pipelines that are optimised to convey low flows (notionally 3-month flows) in parallel to protected waterways. This approach will also be useful in consolidating end of pipe WSUD elements, achieve economies of scale and reducing the total effort and costs required to maintain stormwater assets.

6.6.1 Council design considerations

As described in sections 6.2 and 6.3, consultation with Penrith and Liverpool Councils has ultimately shaped the formation of preferred treatment trains for each land use zone within the initial precincts.

Councils have emphasised the importance of designing water assets to minimise ongoing maintenance requirements and corresponding costs while achieving the stormwater management, biodiversity, urban greening and cooling functions. It is critical that the ownership and ongoing management arrangements of these assets ensure adequate and sustainable funding is available for ongoing maintenance. Establishment of the responsibilities, ownership and funding arrangements will require detailed development and commitment from the parties involved.

Other key considerations when siting and designing WSUD elements include:

- safety, including ensuring adequate and safe access for maintenance
- scale - consolidating assets may reduce maintenance costs
- vegetation constraints
- tailwater management
- ensuring appropriate grades.

These considerations will be incorporated into the location of stormwater treatment train elements in the final precinct planning.

6.6.2 Wildlife attraction

The Western Sydney Planning Partnership has developed a set of landscape wildlife strike mitigation guidelines for development within a 13km radius of the future Western Sydney Airport (refer to Appendix B – Landscape for design guidelines). These design and management initiatives aim to discourage the attraction of bird life to ensure the safety of aircraft whilst embodying the vision of a ‘city in landscape’.

The stormwater treatment design will mitigate wildlife strike through the following approaches:

- Minimisation of open water wetland zones to 100m^2 through the use vegetation and berms
- Provision of low vertical walls (500mm) at the edges of permanent water zones
- Locating permanent water bodies to limit flocks of birds from travelling across flight paths

6.6.3 Interim footprints and general arrangements

For the purposes of informing precinct planning, notional footprints of WSUD elements have been provided which have been mapped in Section 7. These are based on notional WSUD element arrangements for biofiltration, wetlands and street trees are provided in Appendix A.

These stormwater asset footprints are identified as a potential means to achieve the stormwater volume reduction objectives. These footprints are subject to change once the basin functions have been confirmed to achieve the final stormwater targets and all constraints data becomes available.

7 Stormwater quantity management

7.1 Overview

The *Stormwater and Water Cycle Management Study* aims to manage peak flows for frequent events (e.g. 50% AEP) to minimise the risk of impacts to stream morphology.

It is important to note that the Flood Risk and Impact Assessment (FRIA) will consider the impacts of development (increasing flows and faster response) as well as detention (lower flows with a delayed response) on overall timings of flows from contributing tributaries of Wianamatta-South Creek. This work and the subsequent strategy derived from this work may result in a change in the degree of detention required across the precincts. Hence, the stormwater quantity management strategy discussed in this section is subject to change following further consideration of the overall effect of this strategy on the broader Wianamatta-South Creek system.

Therefore, this section discusses the development of strategies that aim to meet broad but preliminary objectives of peak flow management. The focus of this work has been on sizing stormwater detention basins at suitable locations to retard flows to meet existing case peak flows for a range of events up to the 1% AEP.

7.2 Hydrologic model development

7.2.1 Catchments modelled in XP-RAFTS

Hydrologic models (XP-RAFTS) have been developed for this study for:

- Badgerys Creek
- Cosgrove Creek
- Duncans Creek
- Mulgoa Creek
- A portion of Wianamatta-South Creek (downstream of Bringelly Road to Twin Creeks estate)

These models have been created to simulate the distribution and volume of stormwater runoff generated at key locations within the Precincts under existing (i.e. mainly rural) and post development conditions.

The models will be used to simulate changes in 50% AEP and 1% AEP hydrographs at the precinct boundaries.

7.2.2 Rainfall data

The *Australian Rainfall and Runoff* (ARR) 1987 (ARR87) was adopted for water quantity and stormwater management. This is consistent with planning in the Penrith LGA and has been adopted in this study for consistency and through consultation with the Western Sydney Planning Partnership Flood and Stormwater Management Technical Working Group.

Examples of the intensity frequency duration data adopted for the precincts is shown in Figure 7-1.

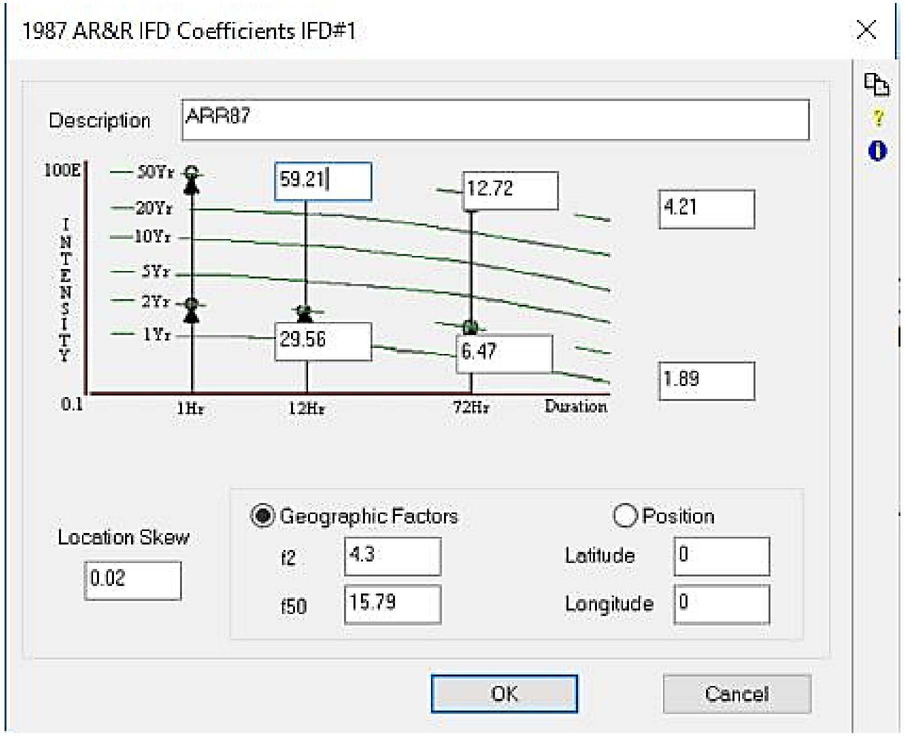


Figure 7-1 Typical IFD parameters adopted in RAFTS modelling

7.2.3 Sub-catchment areas

Catchment boundaries were discretised using LiDAR survey of the precinct catchments. Catchment mapping is shown in Figure 1-1.

Changes in local sub-catchment boundaries are likely following regrading of the Precinct for industrial land uses. However, changes to the total creek catchment areas will not be significant due to an expected match of gains and losses.

Approximate sub-catchment areas of 15 ha were adopted to reflect the notional catchment size at which stormwater networks would generally be considered as trunk drainage systems.

7.2.4 Assumed catchment parameters

Post development catchment conditions will be modelled using the imperviousness rates shown in Table 2-2.

7.3 Stormwater conveyance

Naturalised trunk drainage has increasingly become a part of greenfield development. It is often adopted when considering the safe and economic conveyance of overland flows (often referred to as pluvial flows).

In part of the Aerotropolis precincts, it will be necessary to use designated trunk drainage channels to safely convey stormwater from upstream catchments through land that would be zoned as developed land (e.g. enterprise, industrial, mixed use).

Assessments of conveying flows through a trunk drainage network comprising of open channels needs to consider the costs and the safety elements.

While the issues defining the upstream limit of these trunk drainage systems are varied, a maximum point of commencement can be seen to be about where 15 ha of catchment contribute flows and the street drainage system is designed for a 5% AEP peak flowrate. This drops to 12 ha of contributing catchment where the street drainage system is designed for a 10% AEP peak flowrate.

Application of this principle to the proposed land-use designations for the Aerotropolis precincts has indicated that there are very few, if any, locations where the catchment area exceeds 15 ha prior to the transition from developed land (e.g. enterprise, industrial, mixed use) to open space. Hence, with the proposed urban design, there would appear to be limited constraints in the urban form to utilising naturalised trunk drainage elements.

7.4 Detention basin template development

In order to inform the sizing of detention basins across the Precincts, a number of basin sizes were derived for varying catchment size, slope and degree of imperviousness (for the developed case).

The catchment slopes assessed were 1%, 3% and 5%. This range was chosen as representing the typical range of catchment slopes across the Precincts.

The catchment sizes assessed covered 30ha, 60ha and 90ha as these were deemed to be indicative of the catchment sizes requiring basins. Any areas larger than 90 ha typically include Strahler Level 3 watercourses which are not deemed suitable for on-line basins.

The degree of imperviousness was assessed for 50% and 90% impervious. The 50% and 90% imperviousness values were adopted to represent bounds of blended imperviousness fractions. While specific land-use zones may have fractions in the order 80% or 85%, the fraction of open space in the precinct can lower this to a blended values closer to 50%.

A data set of basin sizes was derived for the 70% imperviousness case using an average of the 50% and 90% impervious results.

The typical basin arrangement included the following features:

- 1V:6H batter slopes
- 0.5% longitudinal slopes on bed of basin (to allow suitable drainage)
- Two stage outlet with:
  - A low-level outlet at the bed of the basin with a 0.6m high RCBC (variable width) to discharge all flows up to approximately the 50% AEP local runoff event
  - A high-level outlet that engages at a depth of 1m via a drop inlet structure with two additional 0.6m high RCBC (variable width but assumed to be same dimension as low level culvert) to discharge all flows up to the 1% AEP local runoff event in conjunction with the low-level culvert.

The stage-discharge curves were then developed for this outlet arrangement assuming inlet control. An example stage-discharge curve is presented below for a 1.0m wide RCBC.

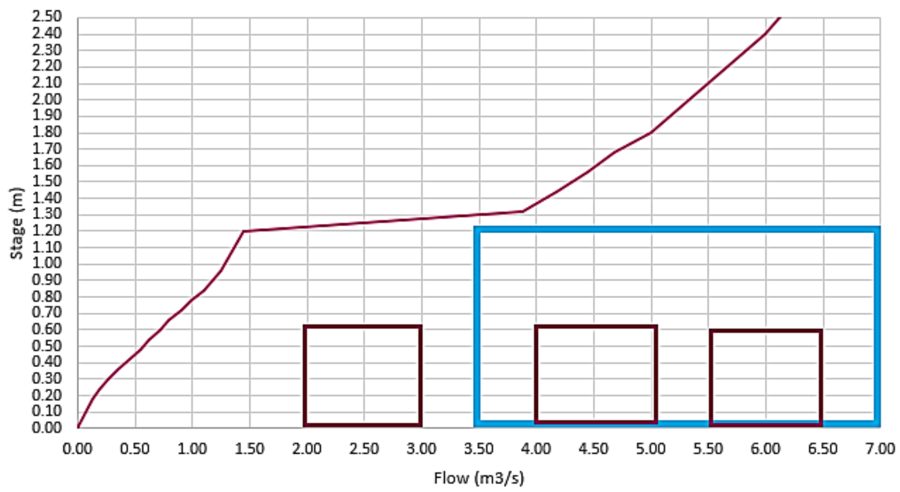


Figure 7-2 Typical Stage-Storage curve used in RAFTS modelling

A total of 18 RAFTS-XP models were developed that represented the combinations of three slopes, three areas and two impervious fractions.

Basin sizes and outlet sizes were iterated until the peak 1% AEP flow and the peak 50% AEP flow for the developed case was reduced to the corresponding flows for the existing case.

Peak depths in the basins were limited to 1.5m for the 1% AEP event. While this is higher than a nominal 1.2m which is sometimes used to manage hazard to individuals, the 1V:6H side slopes somewhat mitigate this risk.

These results were then used to derive a series of relationships that enabled development of tables for detention basin size and outlet arrangements. The basin sizes were documented in terms of the fraction of the catchment.

Table 7-1 RAFTS-XP Basin areas for 90% imperviousness case

	1% slope		3% slope		5% slope	
Area (ha)	Basin area ratio (%)	Net Basin Top Area (ha)	Basin area ratio (%)	Net Basin Top Area (ha)	Basin area ratio (%)	Net Basin Top Area (ha)
30	1.80	0.540	1.60	0.480	1.60	0.480
60	3.90	2.340	3.40	2.040	3.40	2.040
90	6.70	6.030	5.60	5.040	3.90	3.510

Table 7-2 RAFTS-XP Basin areas for 50% imperviousness case

	1% slope		3% slope		5% slope	
Area (ha)	Basin area ratio (%)	Net Basin Top Area (ha)	Basin area ratio (%)	Net Basin Top Area (ha)	Basin area ratio (%)	Net Basin Top Area (ha)
30	1.20	0.360	1.10	0.330	1.10	0.330
60	2.90	1.740	2.50	1.500	2.30	1.380
90	3.40	3.060	2.60	2.340	2.50	2.250

The outcomes from these 18 basin sizing exercises were used to establish relationships for outlet size and basin area (top area at 1.5m depth not including area for other elements such as bio-retention, access or other WSUD elements).

The relationship between catchment area and culvert widths (i.e. the total width of all three 0.6m high box culverts including the one low-level culvert and the two high-level culverts) are presented below. It was found that the culvert width was generally insensitive to the fraction imperviousness.

The relationships between catchment area and basin size were also developed and are presented in Table 7-3.

Table 7-3 Template Culverts Widths (m) for Various Slopes

Area (ha)	1% slope	3% slope	5% slope
30.00	1.78	2.15	2.31
32.50	1.91	2.32	2.49
35.00	2.04	2.48	2.67
37.50	2.17	2.64	2.85
40.00	2.30	2.81	3.03
42.50	2.43	2.97	3.21
45.00	2.55	3.12	3.38
47.50	2.67	3.28	3.56
50.00	2.79	3.44	3.73
52.50	2.91	3.59	3.90
55.00	3.03	3.75	4.07
57.50	3.15	3.90	4.25
60.00	3.26	4.05	4.42
62.50	3.38	4.20	4.59
65.00	3.49	4.35	4.76
67.50	3.60	4.50	4.92
70.00	3.71	4.65	5.09
72.50	3.82	4.80	5.26
75.00	3.93	4.95	5.43
77.50	4.04	5.10	5.59
80.00	4.15	5.24	5.76
82.50	4.26	5.39	5.93
85.00	4.37	5.54	6.09
87.50	4.47	5.68	6.26
90.00	4.58	5.83	6.43
92.50	4.69	5.98	6.59
95.00	4.80	6.13	6.76
97.50	4.90	6.27	6.92
100.00	5.01	6.42	7.09

Table 7-4 Template of Basin areas for 90% imperviousness case

	1% slope		3% slope		5% slope	
Area	Basin Area ratio	Net Basin Top Area	Basin Area ratio	Net Basin Top Area	Basin Area ratio	Net Basin Top Area
(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)
30.0	1.80	0.540	1.60	0.480	1.60	0.480
32.5	1.95	0.633	1.73	0.563	1.80	0.585
35.0	2.10	0.736	1.87	0.654	1.99	0.697
37.5	2.26	0.847	2.01	0.754	2.17	0.815
40.0	2.42	0.969	2.15	0.861	2.34	0.938
42.5	2.59	1.101	2.30	0.976	2.51	1.066
45.0	2.76	1.243	2.45	1.100	2.66	1.198
47.5	2.94	1.397	2.60	1.233	2.81	1.334
50.0	3.12	1.561	2.75	1.375	2.95	1.473
52.5	3.31	1.738	2.91	1.526	3.07	1.613
55.0	3.50	1.926	3.07	1.686	3.19	1.755
57.5	3.70	2.127	3.23	1.856	3.30	1.898
60.0	3.90	2.340	3.40	2.040	3.40	2.040
62.5	4.11	2.567	3.56	2.225	3.49	2.183
65.0	4.32	2.807	3.73	2.424	3.57	2.323
67.5	4.53	3.061	3.90	2.634	3.65	2.462
70.0	4.76	3.329	4.08	2.855	3.71	2.599
72.5	4.98	3.612	4.26	3.086	3.77	2.731
75.0	5.21	3.910	4.44	3.328	3.81	2.860
77.5	5.45	4.223	4.62	3.582	3.85	2.985
80.0	5.69	4.552	4.81	3.846	3.88	3.103
82.5	5.94	4.896	5.00	4.123	3.90	3.216
85.0	6.19	5.258	5.19	4.411	3.90	3.315
87.5	6.44	5.636	5.38	4.711	3.90	3.413
90.0	6.70	6.030	5.60	5.040	3.90	3.510

Table 7-5 RAFTS-XP Basin areas for 50% imperviousness case

Area ha	1% slope Basin Area ratio %	1% slope Net Basin Top Area ha	3% slope Basin Area ratio %	3% slope Net Basin Top Area ha	5% slope Basin Area ratio %	5% slope Net Basin Top Area ha
30.0	1.20	0.360	1.10	0.330	1.10	0.330
32.5	1.39	0.451	1.27	0.412	1.24	0.402
35.0	1.57	0.549	1.43	0.499	1.37	0.479
37.5	1.74	0.652	1.57	0.590	1.49	0.560
40.0	1.90	0.760	1.71	0.685	1.61	0.644
42.5	2.05	0.873	1.84	0.783	1.72	0.731
45.0	2.20	0.990	1.96	0.884	1.82	0.821
47.5	2.34	1.111	2.08	0.986	1.92	0.912
50.0	2.47	1.234	2.18	1.090	2.01	1.005
52.5	2.59	1.359	2.27	1.194	2.09	1.099
55.0	2.70	1.485	2.36	1.298	2.17	1.192
57.5	2.80	1.613	2.44	1.400	2.24	1.286
60.0	2.90	1.740	2.50	1.500	2.30	1.380
62.5	2.99	1.868	2.56	1.601	2.35	1.471
65.0	3.07	1.994	2.60	1.690	2.40	1.561
67.5	3.14	2.118	2.60	1.755	2.44	1.648
70.0	3.20	2.240	2.60	1.820	2.48	1.733
72.5	3.25	2.360	2.60	1.885	2.50	1.814
75.0	3.30	2.475	2.60	1.950	2.50	1.875
77.5	3.34	2.587	2.60	2.015	2.50	1.938
80.0	3.37	2.694	2.60	2.080	2.50	2.000
82.5	3.39	2.795	2.60	2.145	2.50	2.063
85.0	3.40	2.890	2.60	2.210	2.50	2.125
87.5	3.40	2.979	2.60	2.275	2.50	2.188
90.0	3.40	3.060	2.60	2.340	2.50	2.250

7.5 Detention basin sizing process

A set of guiding principles and rules were used in this sizing exercise.

a) Co-locate detention basins with WSUD elements where possible with a recognition that some WSUD elements may reduce the efficacy of detention basins.

a) Locate basins on existing trunk drainage lines\creeks and outlets to the main creek. Assume open drainage for catchments greater than 15ha.

b) Identify opportunities and constraints including:

- i) Precinct Layouts (preliminary)
- ii) Regional Roads
- iii) New proposed roads (regional, motorways etc)
- iv) New and existing railway lines
- v) Major services
- vi) Flood extents for 1% AEP and 20% AEP for the major watercourse floodplains (e.g.Wianamatta-South Creek, Cosgrove Creek etc). Keep basins out of the floodway and flood fringe unless they are online in 2nd order waterways
- vii) Environmental lands
- viii) Proximity to airport
- ix) Proposed parkland spaces – integrate basins within open parkland areas
- x) Existing bodies of water
- xi) Contaminated sites
- xii) Aboriginal heritage
- xiii) Riparian corridors

c) General rules for basin siting:

   i) Fewer and larger basins for maintenance purposes.

   ii) Small catchments discharging directly into major creeks (e.g. Cosgrove Ck, Wianamatta-South Ck) will not be viable. Use a feasible catchment range of 20 ha to 100 ha for locating basins.

   iii) Larger basins may be needed to offset smaller catchment areas where flows would not pass through any detention basin. This can be considered at a later stage of IWM strategy development when more detail is available.

   iv) Consider off-line basins that can be integrated into active open spaces and corridors. These should be placed where grades are greater than 2%, outside of the 1% AEP floodway and upstream of farm dams.

   v) Consider on-line basins that follow natural riparian paths (e.g. a series of weirs along a meandering creek). These should be placed at the start of Strahler 3rd order streams, and at road crossings where grades are less than 2%.

   vi) The siting and number of basins is likely to be revised following the assessment of the impacts of development on the overall impact on hydrograph timings in the broader Wianamatta-South Creek system.

d) Riparian Corridor requirements:

   i) Place basins in suitable locations based on Vegetated Riparian Zone (VRZ) requirements of 10m for Strahler 1st order streams and 20m for Strahler 2nd order streams.

   ii) Preference is for placing basins within designated green space areas and in visible locations (e.g. not at the back of developments).

e) Add additional basins or consolidate as needed depending on site constraints.

7.6 Preliminary detention basin sizes and locations

The guidance above and the basin sizing templates were then used to size detention basins for each of the four Precincts. At this stage of project development, a 90% imperviousness was assumed, recognising that this will provide an upper limit of basin size.

A total of approximately 60 stormwater detention basins (not including WSUD only features) have been sized and located across the four initial precincts. Figure 7-9 shows the location and size of basins across the study area. Figure 7-10 to Figure 7-14 show the indicative basin locations for the four individual precincts. These indicative locations and configurations of WSUD and detention basin footprints and will be refined. More detailed investigation and design resolution of basins will be required at detailed design stage with consideration to terrain as well as conflicts with avoided lands, riparian zones and open space.

Further modelling is required to assess the cumulative performance of these basins at locations throughout the study area. This modelling would identify where additional storage is required to mitigate the increase in flows due to the development.

7.7 Issues with preliminary detention basin sizes and locations

There are some issues with the size of basins identified in this process. Basins in the order of 2 ha top area will require dimensions of approximately 100m wide x 200m long. With a 0.5% longitudinal slope to allow drainage, these basins would have a 1.5m depth at the outlet (a limit for safety) but only 0.5m depth at the upstream end. Hence, the basin storages become less efficient with size.

As well, basins of this size would require considerable volumes of excavation due to the existing slopes of the land exceeding 0.5%. Batter slopes of 1V:6H would also add considerably to the footprint of the basins and is likely to lead to more open space than originally planned.

Hence, it is considered that a reliance upon only end-of-pipe detention basins is unlikely to yield a suitable balance between flow management performance and viable land yield and economical development.

So, a focus on a mix of detention strategies including on-line detention basins and On-Site Detention (OSD) has been assessed. However, the siting and number of OSD elements and detention basins is likely to be revised following the assessment of the impacts of development on the overall impact on hydrograph timings in the broader Wianamatta-South Creek system

7.8 OSD and vegetated channels trial

In order to assess the efficacy of including On Site Detention (OSD) in combination with other detention strategies, a XP-RAFTS model of a typical 58 ha catchment in the Aerotropolis Core Precinct was developed.

This model was developed to a much higher level of detail to enable modelling of individual lots with individual OSD elements modelled as detention basins.

This model was used to derive flows for a range of 1% AEP storms for the existing case and three developed cases:

- Developed with no detention
- Developed with only OSD
- Developed with only OSD and increased vegetation in open spaces (i.e. vegetated channels).

The model layout for the developed case is shown in Figure 7-3.

The existing case 1% AEP flows are shown below for a range of event durations. Peak flows for the critical duration of 2 hours are approximately 7.7 m^3/s.

The case with the catchment developed (assumed 90% imperviousness for the areas proposed for industrial use) resulted in the following 1% AEP flows, shown below for a range of event durations. For this case of development only (no detention), peak flows for the critical duration of 2 hours are approximately 16.0 m^3/s.

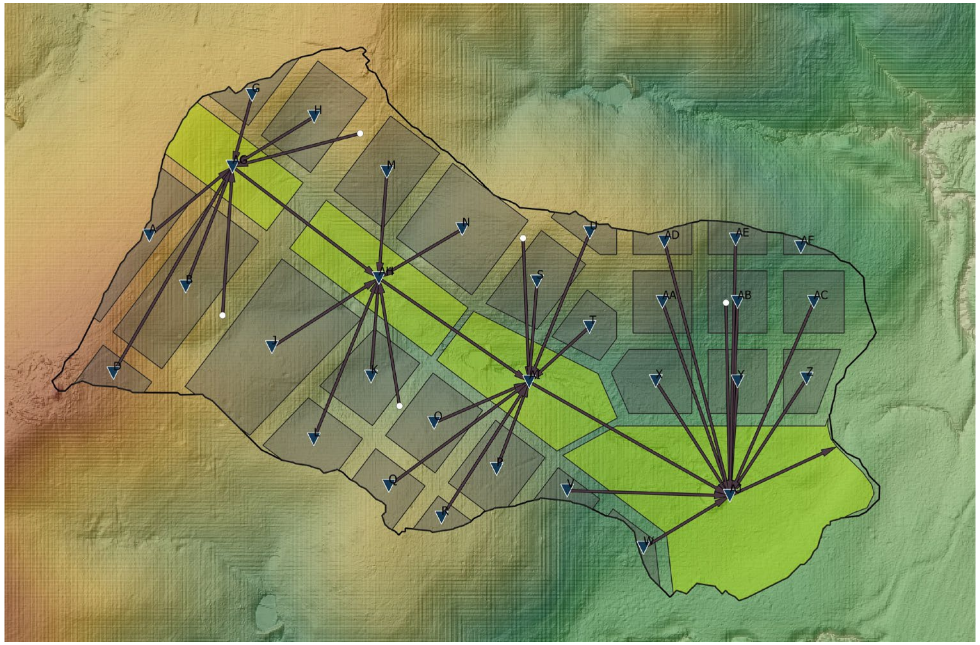


Figure 7-3 Model Layout for OSD Trial

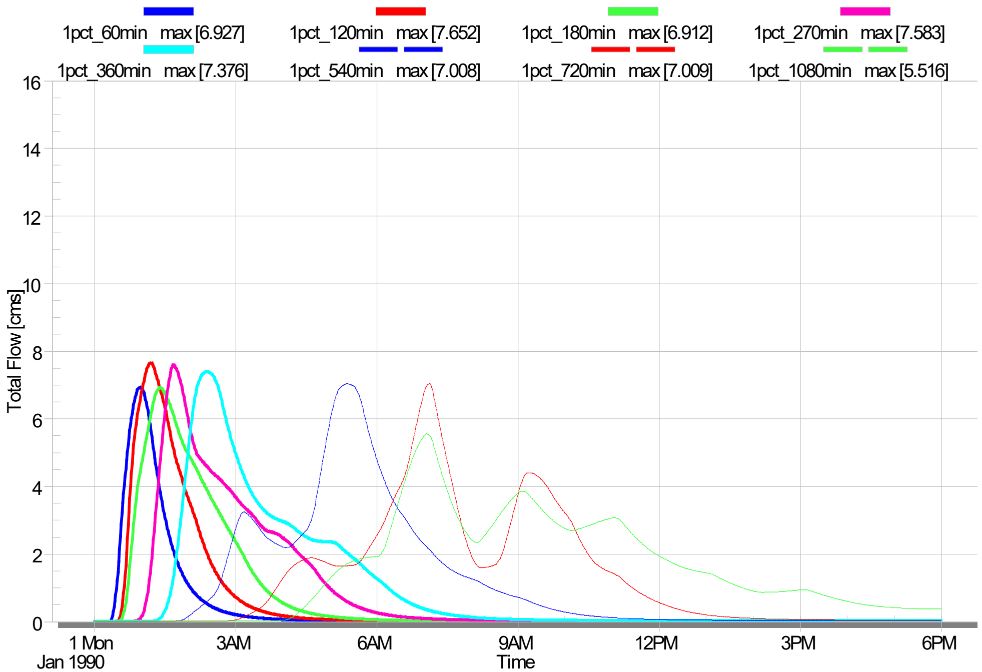


Figure 7-4 1% AEP peak flows at outlet (existing case/undeveloped case)

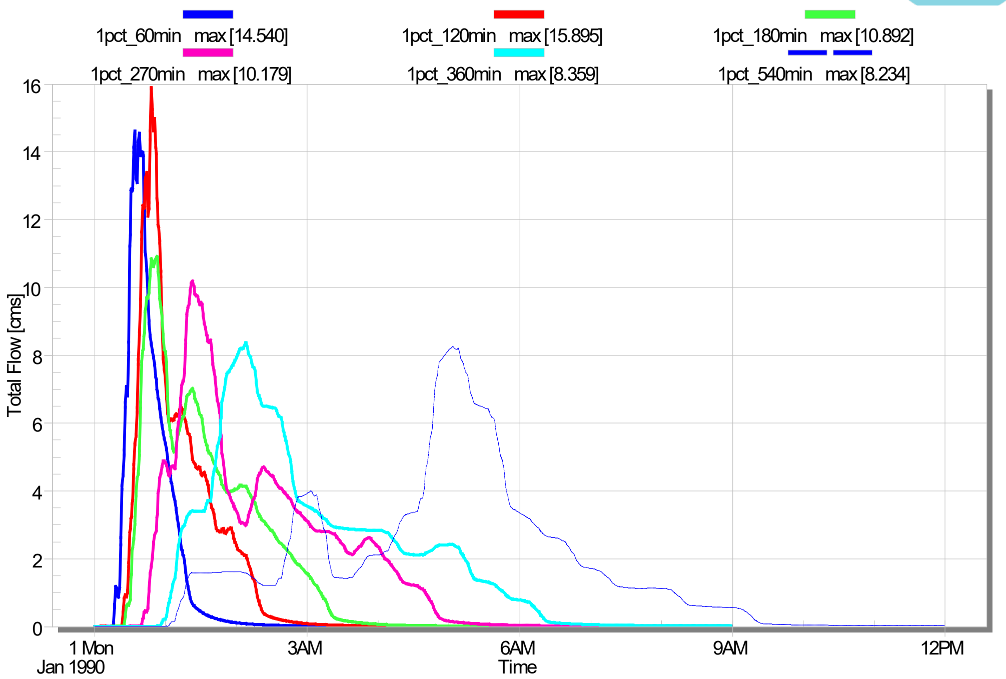


Figure 7-5 1% AEP Peak flows at outlet (developed case with no detention)

The OSD was based on a storage rate of approximately 390 m^3/ha and outflow performance of:

- 30 l/s for a depth of 0.8m (and 240 m^3/ha) for 50% AEP events
- 165 l/s for a depth of 1.3m (and 390 m^3/ha) for 1% AEP events

The catchment outflows for the same range of 1% AEP storm durations is shown below. For this case of development and only OSD, peak flows for the critical duration of 2 hours are approximately 7.8 m^3/s. Hence, the OSD volumes of approximately 390 m^3/ha would mitigate the effect of the development.

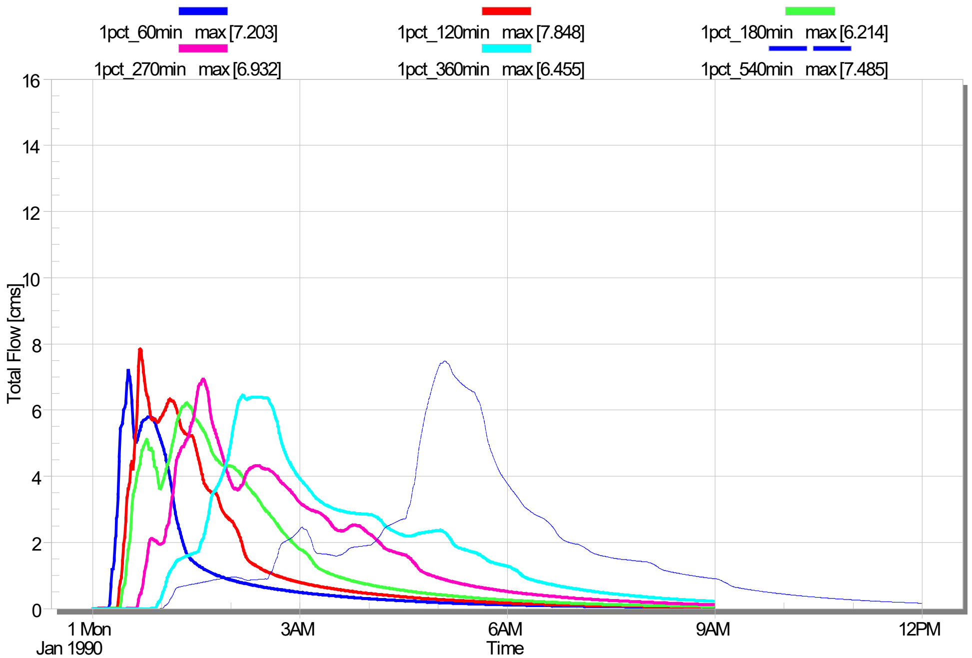


Figure 7-6 1% AEP Peak flows at outlet (developed case with only OSD)

A third development case of using OSD (as above) as well as vegetated channels in the open spaces was assessed. The Mannings n was increased from 0.03 to 0.08 to represent this management measure.

Increasing the vegetation within the channels works to effectively reduce the outflows from the catchments in two ways. Firstly, the wave celerity is reduced due to the increased roughness of the channel. In the test scenarios the average peak velocities in the channels were reduced to about 0.6 m/s due to the increased vegetation, compared to an average of 1.4 m/s for the strategy only incorporating OSD. Hydrograph peaks were also seen to be delayed by 10 minutes due to the increased vegetation.

Secondly, increasing the vegetation results in increasing the flood depths, thereby increasing the storage within the channels. Depths were seen to increase from an average of 0.23 m to 0.37 m. Over a total length of 1.1 km of vegetated channels, this results in a total increased storage of 170 m^3 per ha of urban development.

This increase in hydrograph lag and decrease in peak flows is shown below for the case with OSD only and the case with OSD and vegetated channels.

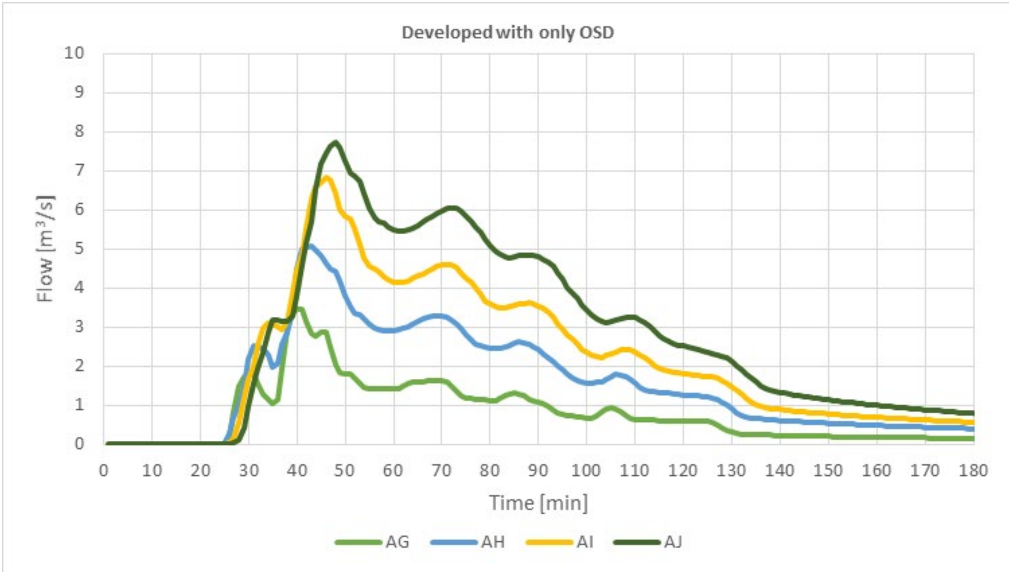


Figure 7-7 1% AEP flows with only OSD

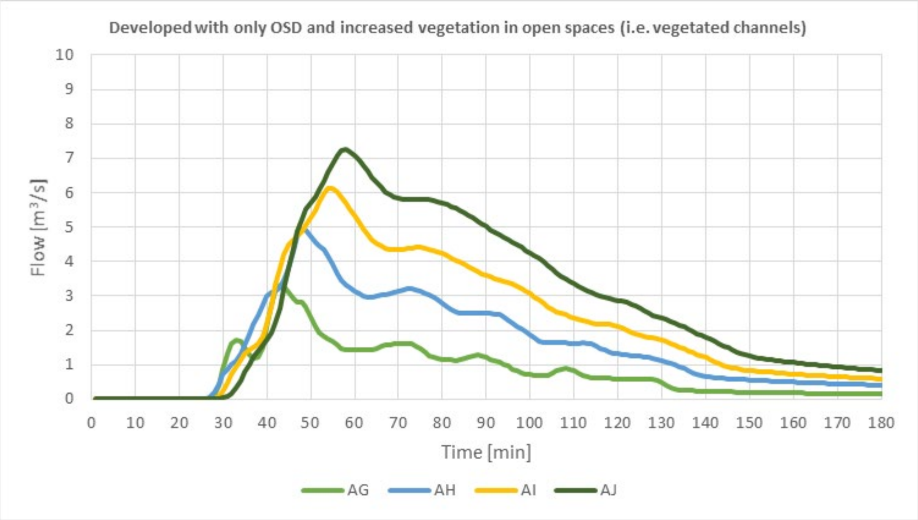


Figure 7-8 1% AEP flows with OSD and vegetated channels

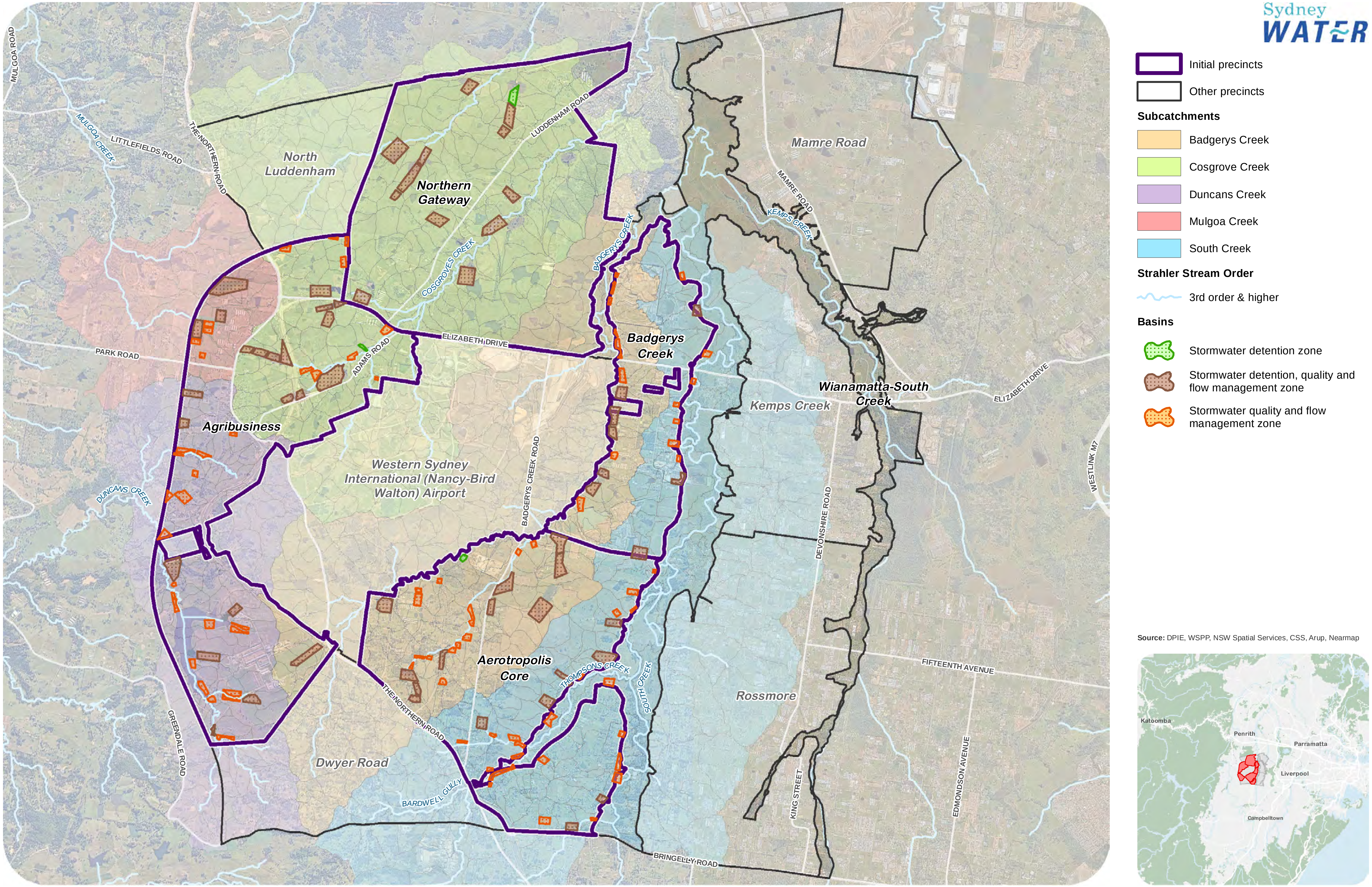
Hence, in this typical trial, the combination of OSD as well as vegetated channels in the open spaces was more than sufficient to mitigate the effect of the development.

Similar trials were also conducted for the 50% AEP event. The trials demonstrated that the developed case peak flows for the 50% AEP event could be mitigated from an unmitigated flow of 6.2 m^3/s down to 3.2 m^3/s with OSD alone. This is compared to the existing case peak flow of 3.1 m^3/s.

Hence, it is concluded that there is considerable scope to reduce end-of-pipe detention basin sizes by incorporating OSD and vegetated channels into the developments.

7.9 Coordination with Flood Risk and Impact Assessment

There is a need for significant coordination between this study and the FRIA. The required coordination between the FRIA and this study is for the FRIA to provide flow data to enable this study to utilise stormwater quantity and quality detentions and management strategy, and for the FRIA to assess the performance and impacts of the proposed stormwater works and detentions identified by this study.



1:55,000

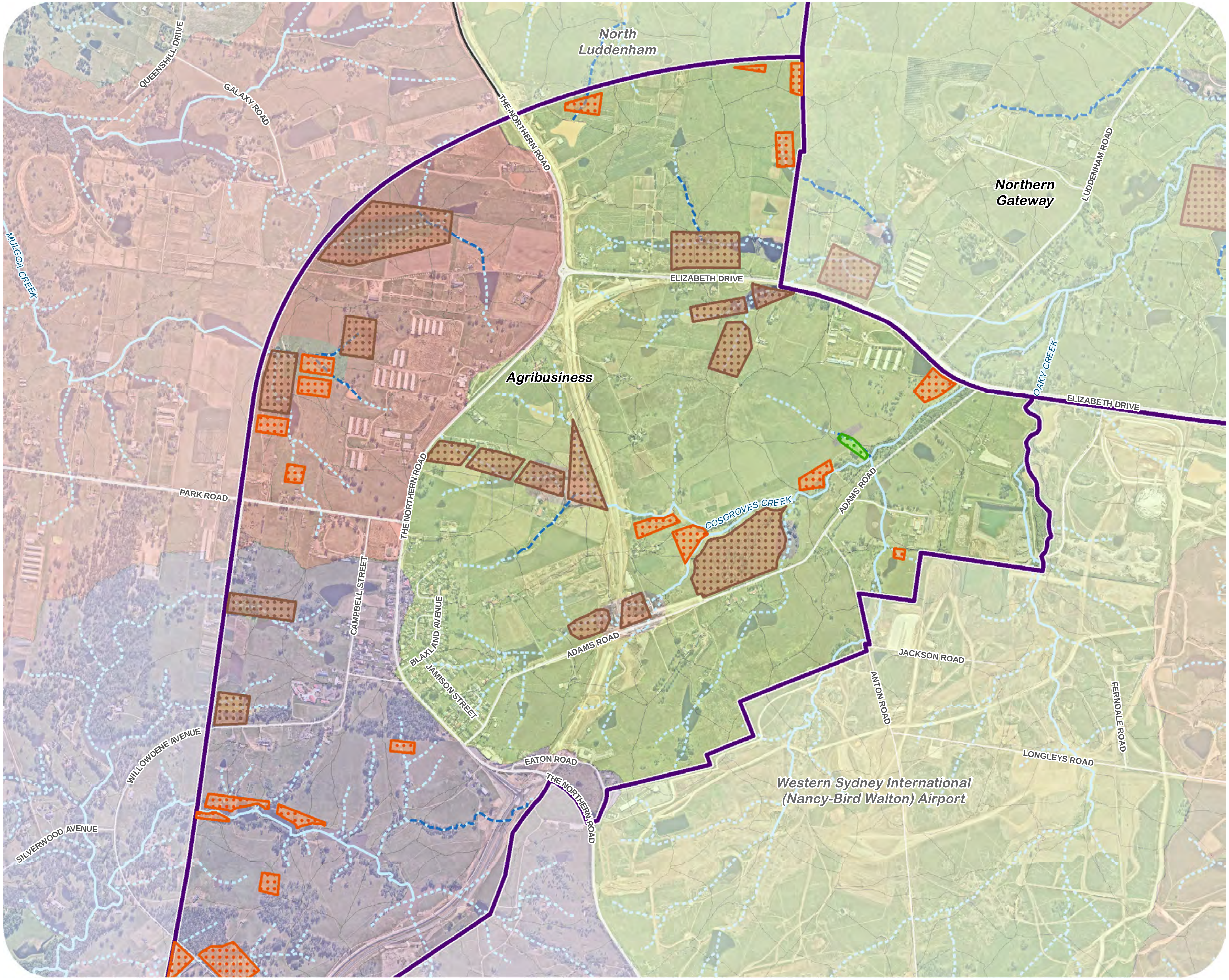
0 1 2 km

Date: 28/10/2020

Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 7-9: Catchments and basin locations (indicative): whole of study area



Sydney WATER

- Initial precincts
- Other precincts

Subcatchments

- Badgerys Creek
- Cosgrove Creek
- Duncans Creek
- Mulgoa Creek

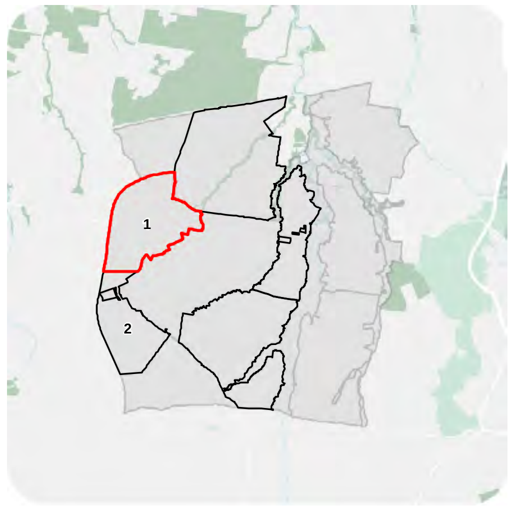
Strahler Stream Order

- < 3rd order
- 3rd order & higher
- Trunk drainage channels without VRZs

Basins

- Stormwater detention zone
- Stormwater detention, quality and flow management zone
- Stormwater quality and flow management zone

Source: DPIE, WSPP, NSW Spatial Services, CSS, Aurecon, Arup, Nearmap



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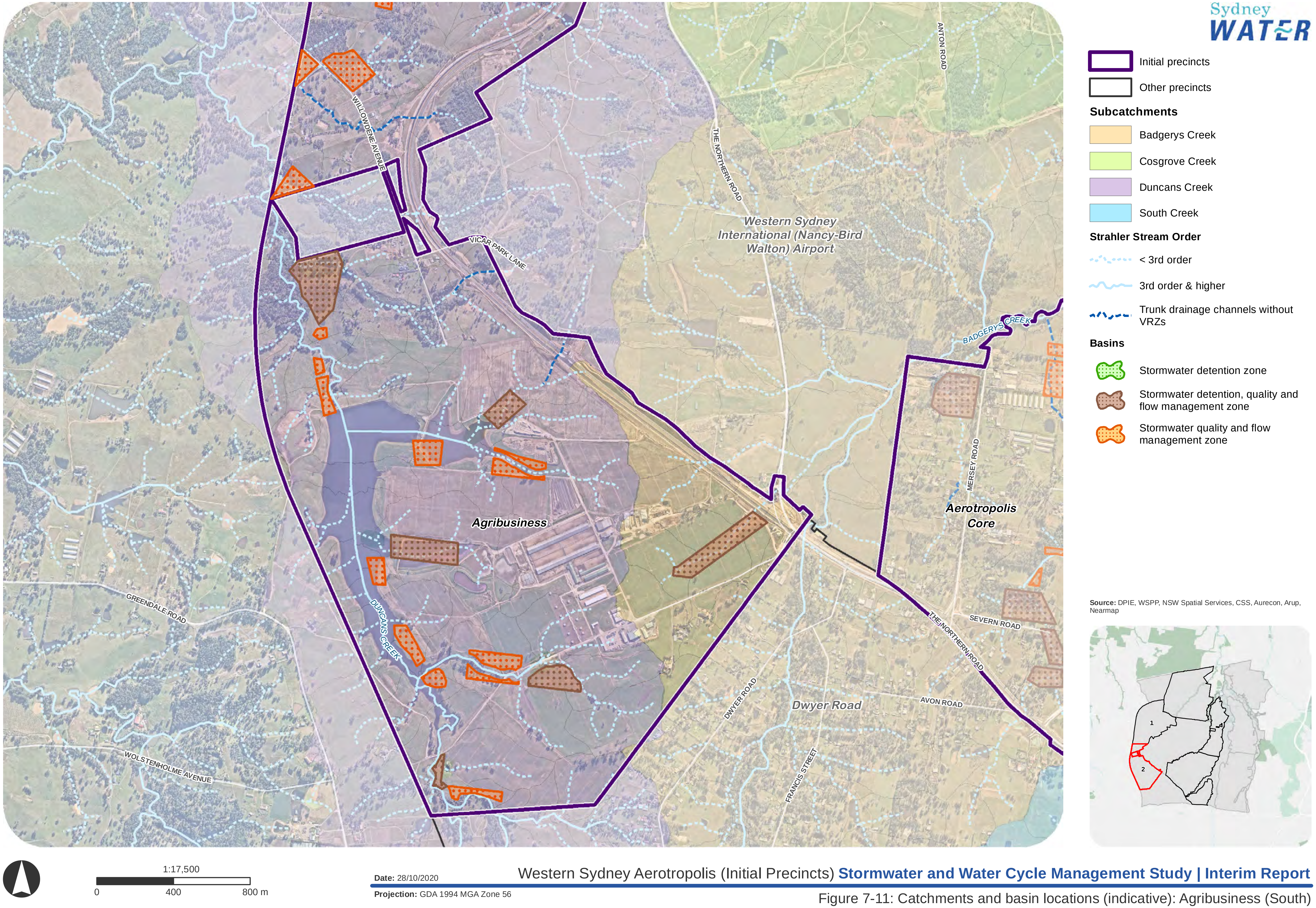
Date: 28/10/2020

Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

Figure 7-10: Catchments and basin locations (indicative): Agribusiness (North)

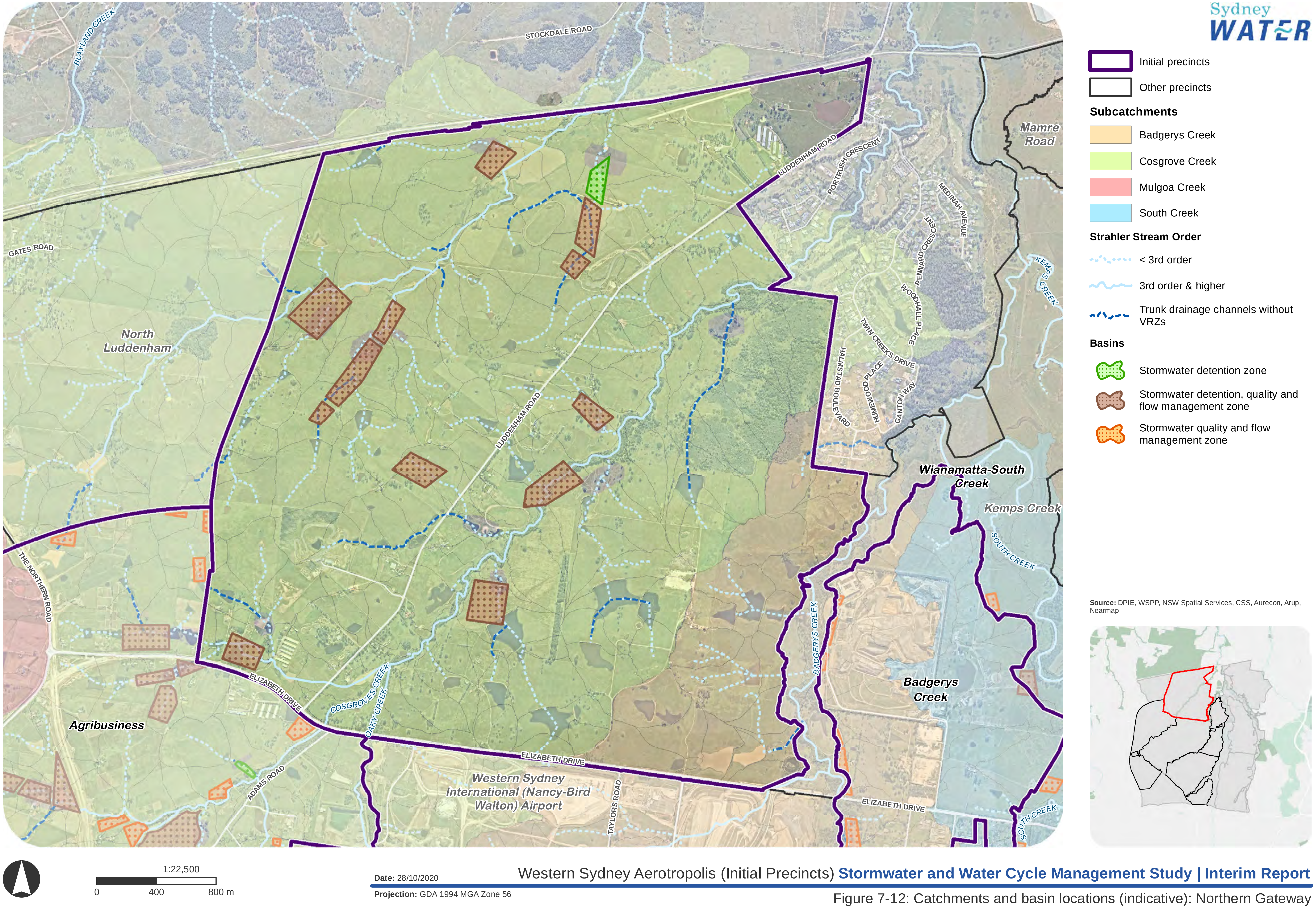


Date: 28/10/2020

Projection: GDA 1994 MGA Zone 56

Western Sydney Aerotropolis (Initial Precincts) **Stormwater and Water Cycle Management Study | Interim Report**

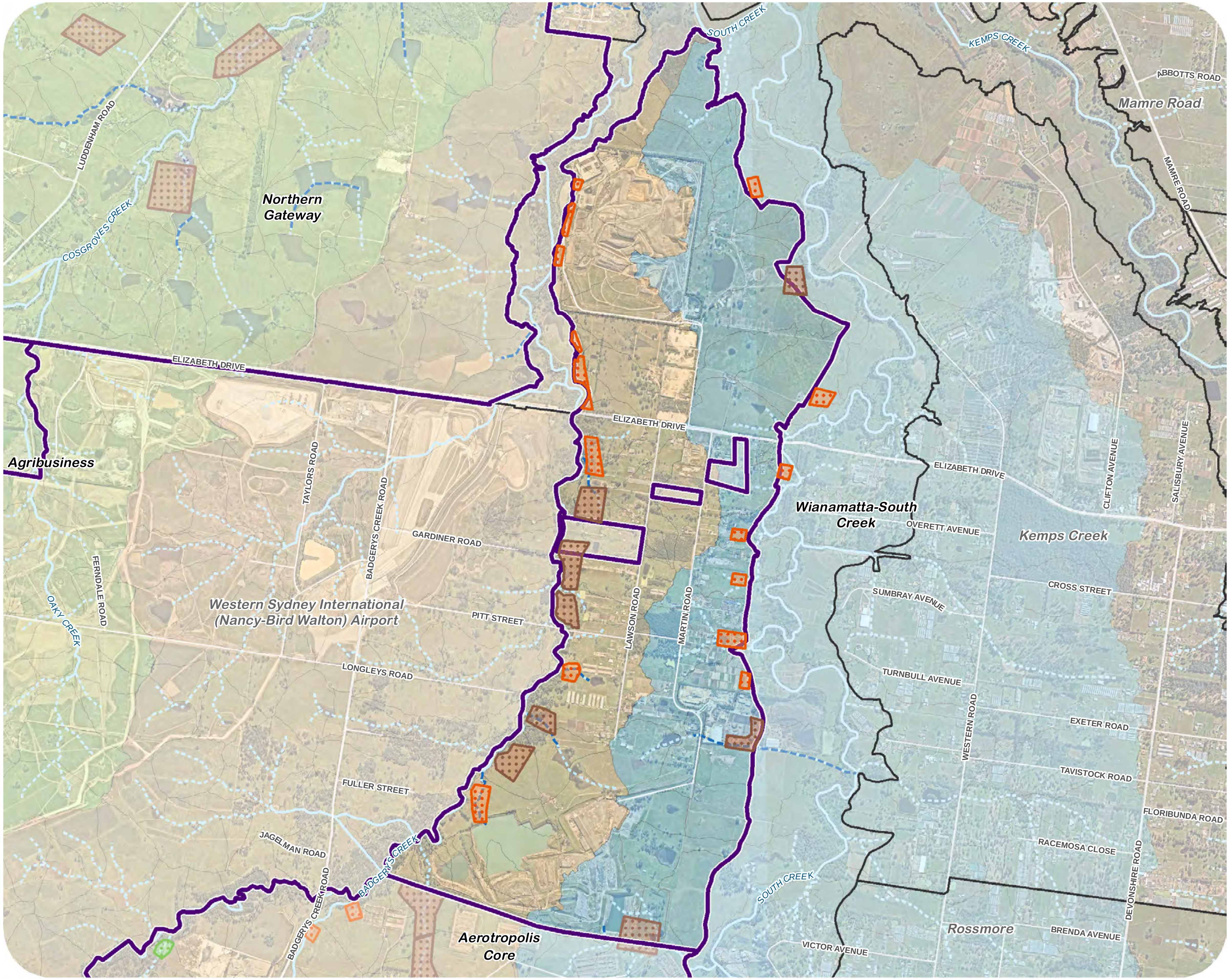
Figure 7-11: Catchments and basin locations (indicative): Agribusiness (South)



Date: 28/10/2020

Projection: GDA 1994 MGA Zone 56

Figure 7-12: Catchments and basin locations (indicative): Northern Gateway



Sydney WATER

Initial precincts

Other precincts

Subcatchments

Badgerys Creek

Cosgrove Creek

South Creek

Strahler Stream Order

< 3rd order

3rd order & higher

Trunk drainage channels without VRZs

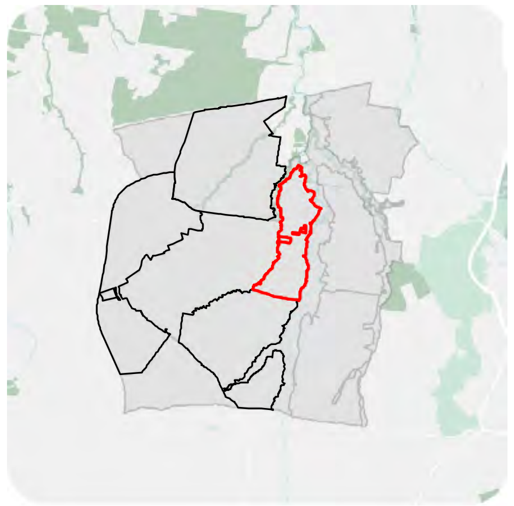
Basins

Stormwater detention zone

Stormwater detention, quality and flow management zone

Stormwater quality and flow management zone

Source: DPIE, WSPP, NSW Spatial Services, CSS, Aurecon, Arup, Nearmap



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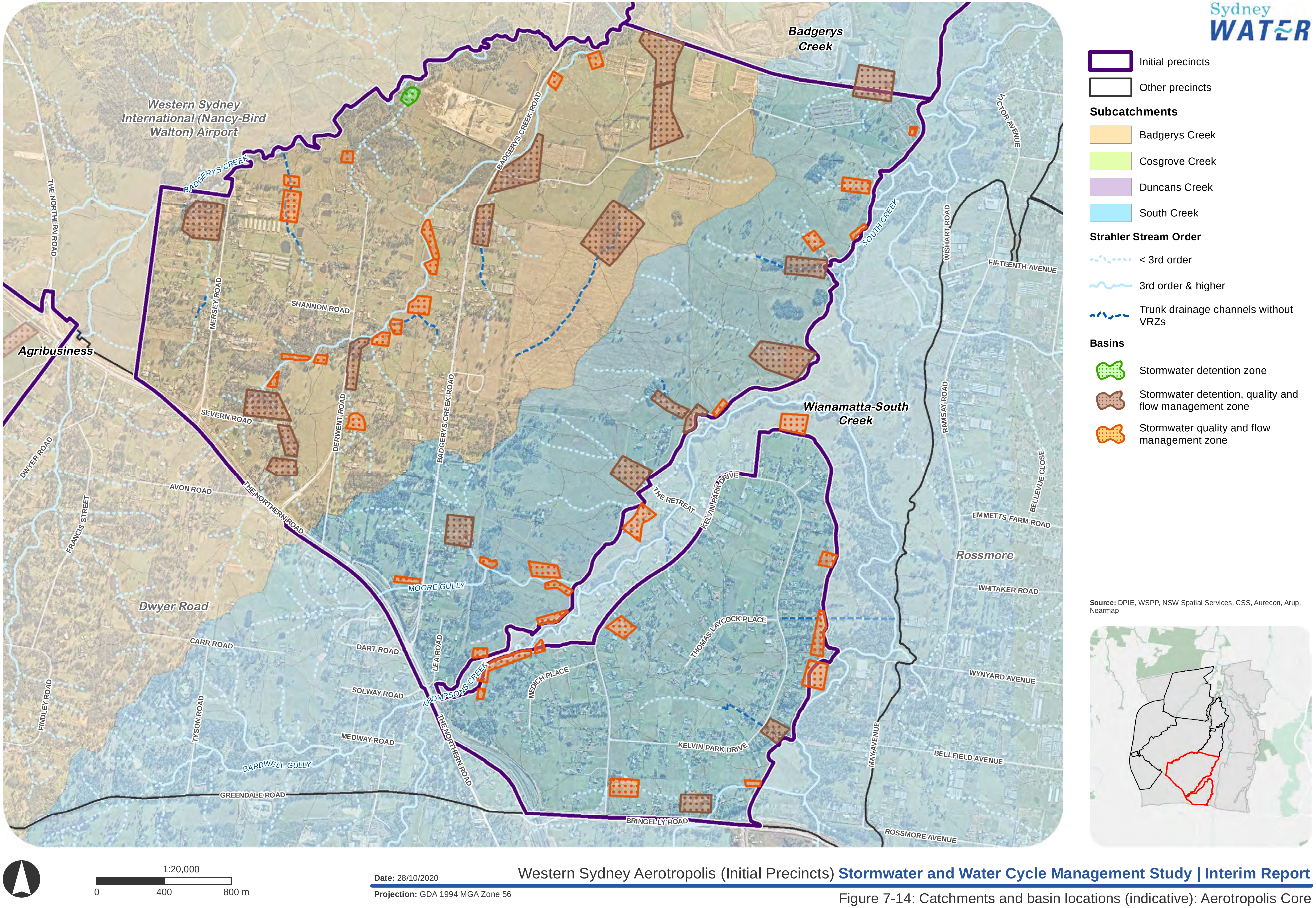
0 400 800 m

Date: 28/10/2020

Projection: GDA 1994 MGA Zone 56

Figure 7-13: Catchments and basin locations (indicative): Badgerys Creek



Date: 28/10/2020

Projection: GDA 1994 MGA Zone 56

Figure 7-14: Catchments and basin locations (indicative): Aerotropolis Core

8 Integration

This Stormwater and Water Cycle Management Study adopts interim stormwater management targets for the purpose of identifying the potential land requirements for stormwater management assets across the initial precincts and the Wianamatta-South Creek precinct where it is adjacent to those precincts.

At this time, many constraints are still being mapped, interpreted and understood and have not informed the location, orientation or function of those stormwater management assets. In lieu of this constraints analysis being completed, the following provides the principles that will be used to integrate water sensitive urban design and detention basin elements into open space while accommodating riparian corridors and native vegetation, soils and salinity, heritage, public safety and mobility, urban heat, flooding and airport specific risk management.

8.1 Landscape led principles

By adopting a landscape led approach to the design of all future water assets we can ensure that the design and management of the future storm water management system is appropriate to context and also maximises benefits for the local economy, environment and population.

Using principles from the Western Sydney Aerotropolis Plan (September 2020)[6] and the more detailed design principles developed the Western Sydney Planning Partnership the following five design principles have been developed to guide the integration of the stormwater assets (Refer to Figure 8-1 for flow chart of these principles)

i) Conserve and enhance the existing Aerotropolis landscape
ii) Extend and strengthen the Aerotropolis green and blue grid
iii) Enhance education, health and recreation opportunities for the Aerotropolis community
iv) Support movement and access within Aerotropolis
v) Optimise water infrastructure provision, operation and maintenance

These design principles will help guide the integration of multiple place-based benefits into every planned storm water asset.

The table below provides examples of land-use specific initiatives that respond to each of the principles and will help ensure that stormwater assets achieve multiple benefits:

Table 8-1 Landscape led stormwater asset design initiatives

Land Use	Landscape led design initiatives
Enterprise	■ Design with existing landform to reduce cut and fill and help integrate assets into landscape ■ Provide shelter belts and screen planting as part of storm water features to improve visual and noise buffers, air quality, and reduce urban heat ■ Provide outdoor amenity and recreational opportunities as part of storm water features ■ Provide viewing opportunities and improve connectivity to the creek corridors

[6] https://www.planningportal.nsw.gov.au/draftplans/made-and-finalised/western-sydney-aerotropolis-planning-package

Land Use	Landscape led design initiatives
Agri-business	■ Embed traditional water and land management practices in the design of water assets ■ Include water management assets as integral components of agri-business operation ■ Retain agricultural dams/ existing water bodies and associated woodlands high in ecological value ■ Embed sustainable land management and agro-forestry principles as part of WSUD ■ Create opportunities for research and collaboration between WSUD and agriculture ■ Provide local employment opportunities for construction and management of WSUD (agri-business related)
Environmental + recreation	■ Design with landforms to enhance view corridors and vistas and safeguard existing native vegetation ■ Restore native habitat within storm water features and enhance biodiversity within recreational corridors by incorporating diverse planting ■ Collaborate with local Aboriginal communities on design and programming of water assets ■ Locate and orientate water bodies to maximise down wind cooling and ensure tree canopy cover to improve micro-climate conditions ■ Design storm water features as a diverse and connected network ■ Integrate storm water features as innovative and diverse recreation spaces - playscapes, sporting amenity, fitness

Land Use	Landscape led design initiatives
	■ Explore opportunities for knowledge sharing, exchange and education promoting more sustainable environments and water management ■ Extend and strengthen the walking and cycling network across all storm water assets
Mixed Use	■ Collaborate with local Aboriginal communities on design and programming of water assets ■ Embed planting into the water assets to improve environmental quality and reduce urban heat ■ Strengthen biodiversity through re-vegetating storm water features, linking to existing habitats and linear parklands along ephemeral creeks ■ Extend the stormwater features to connect with community allotments and open spaces to provide passive irrigation
Infrastructure	■ Provide visual connections between transport corridors and existing water environments ■ Integrate placemaking and wayfinding features into stormwater feature (art work or landform as markers and gateways) ■ Maximise integration of features into road and infrastructure network ■ Design assets to maximise ease of access, maintenance and safety

Collaboration is key at all stages of the design and management process as will be the measurement of the success of each asset against these principles.

The ambition will be to achieve at least two additional place-based benefits on each water asset to their primary function of storm-water management.

8.2 Engineering principles

The following sections outline how stormwater management elements will be configured in the landscape. At this time, mapping basin footprints has been undertaken on an indicative basis and more detailed investigation and design resolution of basins will be provided in the final report with consideration to terrain as well as conflicts with avoided lands, riparian zones and open space. An indicative layout for these elements are provided as Figure 8-2 and Figure 8-3.

8.2.1 Salinity and groundwater

Regional groundwater has been mapped as 2m below ground surface. It is not anticipated any WSUD elements will intercept deep, regional groundwater tables. Biofiltration street trees are an important mitigation measure against the generation of shallow groundwater and would be designed to intercept shallow lateral groundwater only.

WSUD elements will be designed to:

- Avoid infiltration or over irrigation unless it is deemed appropriate by the relevant Hydrogeologic Landscape guidance
- Encourage infiltration in an appropriate way where it is necessary to the preservation of existing stands of Cumberland Plain species and groundwater dependent ecosystems
- Match baseflow contributions or provide equivalent opportunities for groundwater expressed flows in waterways through appropriate means (infiltration or direct discharge as trickle flows)

8.2.2 Safety

WSUD elements will be designed to:

- Ensure inundation free pedestrian/bicycle routes and playground facilities up to the 10% AEP (1 in 10-year) flood level
- Ensure no more than 1.2m deep stormwater over pedestrian/bicycle routes, active open space and playground facilities up to the 1% AEP (1 in 100-year) flood level
- Ensure pedestrian egress paths lead away from high flood hazards, along grades no steeper than 1(V):6(H)
- Minimise risk of drowning and fall injury with appropriate level changes, internal batter slope and balustrades

8.2.3 Ownership and management

Appropriate ownership and management arrangements will need to be determined for the following elements of stormwater and green infrastructure:

- Stormwater drainage assets
- Bioretention street trees
- Trunk drainage
- Stormwater detention assets
- Stormwater quality assets (bioretention and wetlands)
- Farm dams to be retained
- Natural creek lines, riparian zones and areas of native bushland.

The preference by councils and other stakeholders is to have the majority of these assets in public ownership and/or management. This will enable systems of assets to be better designed to be multifunctional and integrate with the urban fabric.

Having these assets in public ownership and/or management will also allow adequate funding to be provided for asset management and ongoing maintenance.

8.2.4 Maintenance

WSUD elements and other stormwater assets and green infrastructure will be designed to minimise maintenance and lifecycle costs whilst still achieving their intended benefits, for example:

- Allow for wet weather access to the top of any extended detention zone using a 9m long rigid vehicle
- Consolidate maintenance activities into areas of easy and safe access
- To be drained without the use of pumps (where practicable) or physical attendance of maintenance staff at site
- Allow staged maintenance without taking an entire WSUD element offline
- Avoid materials that can be vandalised or broken, or provide protection of vulnerable elements (e.g. wetland outlet risers)

Adequate funding for maintenance needs to be provided by the authority responsible for ongoing management/maintenance.

8.2.5 Hydraulic performance considerations

WSUD elements will be designed to:

- Function with an uninhibited inlet and outlet in events up to the 6 month or (2 EY) event
- Be bypassed by flows exceeding the 6-month flow and up to the 1-year flow
- Be embedded within the street profile wherever possible

8.2.6 Wildlife attraction

WSUD elements will be designed to:

- Minimise the length of clear open water zones (free of macrophytes) to deter larger water birds
- Include edge treatments that minimise foraging zones for wading birds
- Avoid the need for netting as much as is practicably possible

8.2.7 Farm dams

WSUD elements around farm dams will be designed to:

- Meet water quality objectives prior to discharge to farm dams
- Utilise farm dam footprints where feasible
- Ensure integration with surrounding landuse and public safety is protected
- Replace farm dams where appropriate or where the farm dam is deemed to be unsafe or unsound during later investigations

8.2.8 Riparian corridors

WSUD elements will be designed to:

- Achieve pollution reduction and flow management targets prior to discharging to waterways. This may require that stormwater is diverted around/along reaches of creeks to WSUD basins
- Adhere to the controls placed on waterfront lands, particularly with regard to the location of detention basins and embankments
- Prioritise the use of riparian corridors as stormwater detention zones by forming online stormwater detention basins as second order waterways.

AEROTROPOLIS PRINCIPLES

A set of principles and corresponding objectives have been identified in the Western Sydney Aerotropolis Plan (September 2020) to guide the future development.

RECOGNISE COUNTRY

Acknowledge Traditional Custodians and provide opportunities to Connect with Country, Design for Country and Care for Country when planning for the Aerotropolis

SUSTAINABILITY

A landscape-led approach to urban design and planning

A sustainable, low carbon Aerotropolis that embeds the circular economy

A resilient and adaptable Aerotropolis

PRODUCTIVITY

An accessible and well-connected Aerotropolis

High-value jobs growth is enabled, and existing employment enhanced

Safeguard airport operations

LIVEABILITY

Diverse, affordable, healthy, resilient and well-located housing

Social and cultural infrastructure that strengthens communities

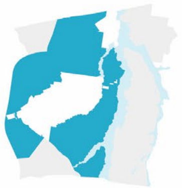
Great places that celebrate local character and bring people together

INFRASTRUCTURE AND COLLABORATION

Infrastructure that connects and services the Western Parkland City as it grows

A collaborative approach to planning and delivery

PRECINCT PLANNING PRINCIPLES



A set of more detailed Precinct Planning Principles have been developed forming the development foundations for the Agribusiness, Northern Gateway and Badgerys Creek, Wianamatta and Aerotropolis Core precincts

RECOGNISE COUNTRY

Connect with Country

Design with Country

Care for Country

SUSTAINABILITY AND RESILIENCE

Enhance the Wianamatta ecology

Extend and strengthen the Aerotropolis Green and Blue Grids; Link the north south creek systems with east west green connections

Facilitate a holistic approach to water

The public space system (streets and open spaces) and urban development contributes to urban cooling and greening

Develop net zero neighbourhoods

Design precincts that are flexible and adaptable

Develop a circular economy

PRODUCTIVITY AND LIVEABILITY

Support the expected job creation in the Aerotropolis

Enable equitable access to jobs and social infrastructure (i.e.... education, health and recreation)

Use all land productively to optimise:

- Infrastructure provision and services
- Open and public space provision and ecosystems wellbeing
- Subdivision patterns in relation to expected uses and topography (employment, recreational, mixed uses)

Provide the conditions for a night economy to flourish

Optimise the movement of people and goods (not vehicles) and minimise congestion

MOVEMENT, ACCESS AND CONNECTIVITY

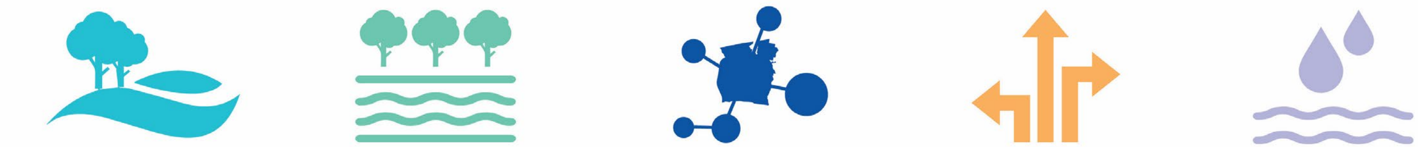
Provide attractive and sustainable transport options for workers, visitors and residents:

- Public transport
- Active transport (walking and cycling)

Design the street network to connect places and celebrate the Aerotropolis' geography and ecology

Support sustainable and healthy mobility systems

LANDSCAPE LED PRINCIPLES



CONSERVE AND ENHANCE THE EXISTING AEROTROPOLIS LANDSCAPE

EXTEND AND STRENGTHEN THE AEROTROPOLIS GREEN AND BLUE GRID

ENHANCE EDUCATION, HEALTH AND RECREATION OPPORTUNITIES FOR THE AEROTROPOLIS COMMUNITY

SUPPORT MOVEMENT AND ACCESS WITHIN AEROTROPOLIS

OPTIMISE WATER INFRASTRUCTURE PROVISION, OPERATION AND MAINTENANCE

Figure 8-1 Aerotropolis landscape led principles

1. Flows exceeding target low flows (0.9 ML/Ha/yr etc.) bypass 1st and 2nd order waterways and discharge to WSUD elements. Low flow pipes consolidate number of basins, reduce WSUD asset land take and associate maintenance.
2. GPTs for pre treatment.
3. Biofiltration to remove majority of nutrients before discharge to harvesting tank or open water. Bio footprint to be as small as 0.6% of catchment and located on-lots where preferred by Council
4. Wetland/macrophyte zone to manage algal blooms in open water during dry spells. Normal water level located at 1 EY flood level. Open water may be substituted for greater water harvesting as required for wild life strike mitigation.
5. Open water edge treatments and orientation to minimise bird habitat
6. Wet weather maintenance access provided to all sides of biofiltration and wetland
7. Wetland extended detention provided to control discharges to meet freshes and high spell flows
8. Detention provided behind road or active transport corridor. Multi stage outlet to provide target discharge. Active flood storage provided over vegetated riparian zone. Bollards for blockage control provided at upstream edge of culvert. Multi-stage culvert provides flow control and flood immunity to road crossing
9. Road embankments tie into flood free land or new roads

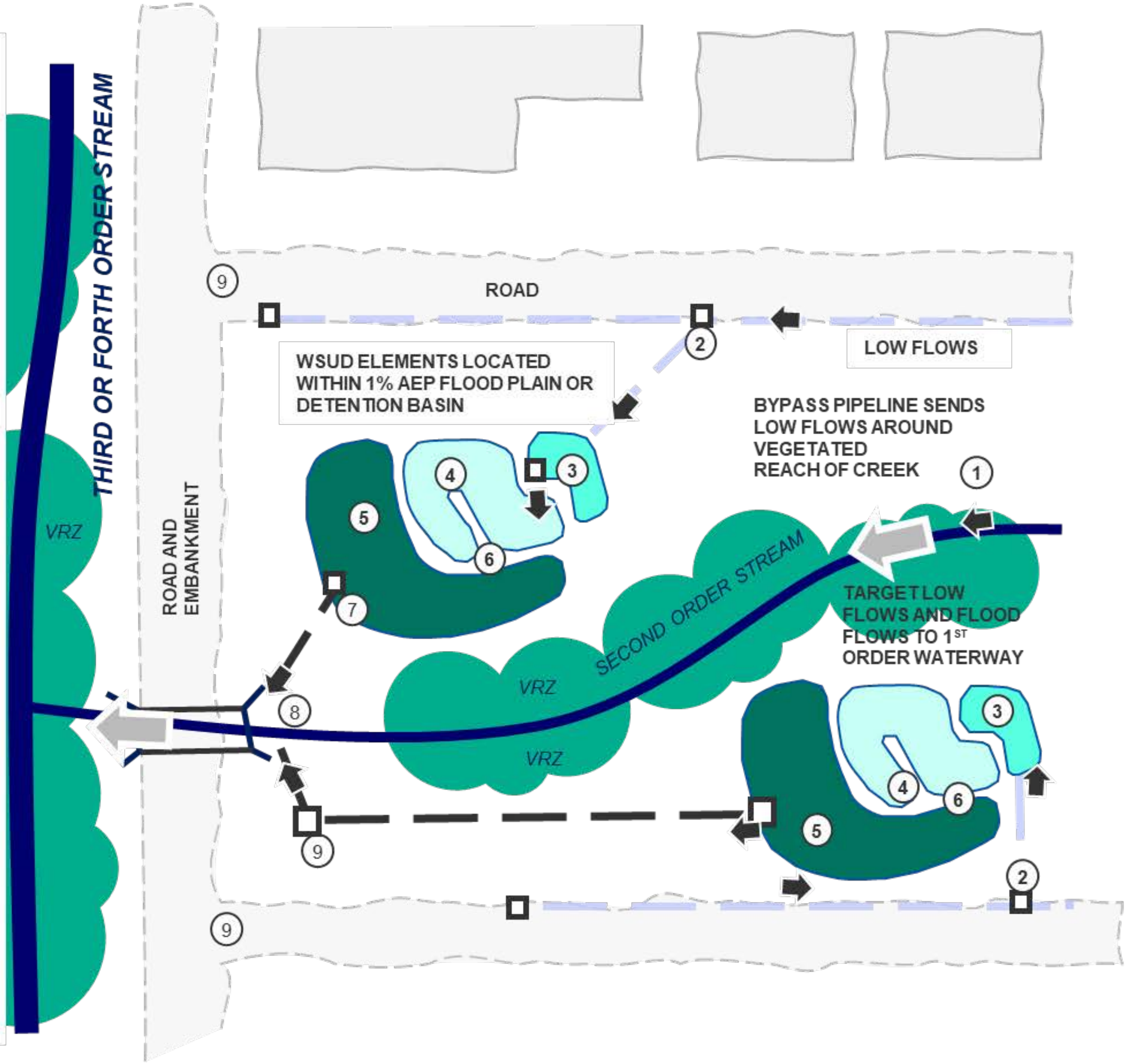
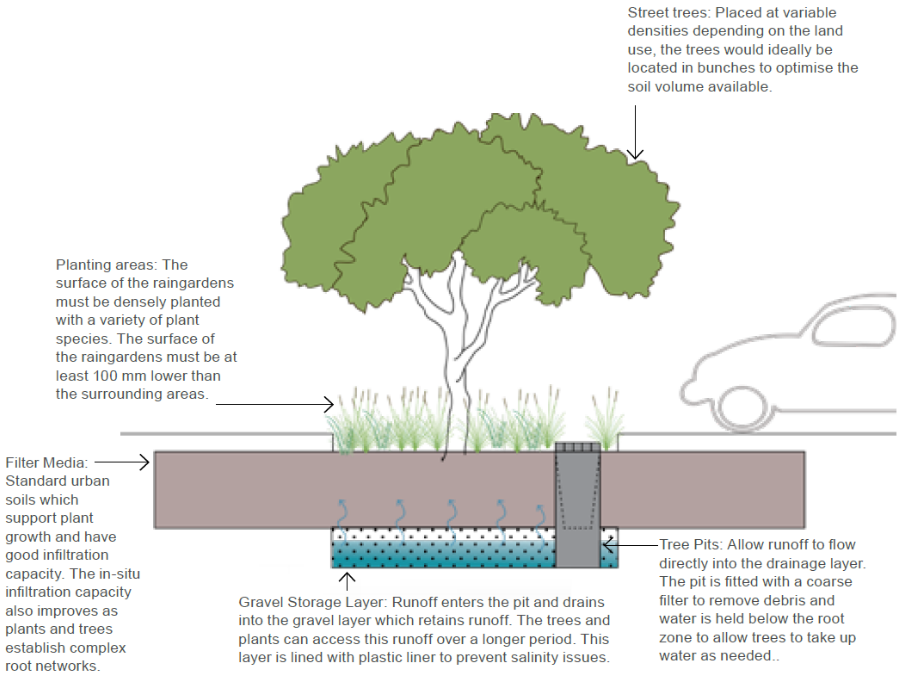


Figure 8-2 Combined bioretention and wetland treatment layout



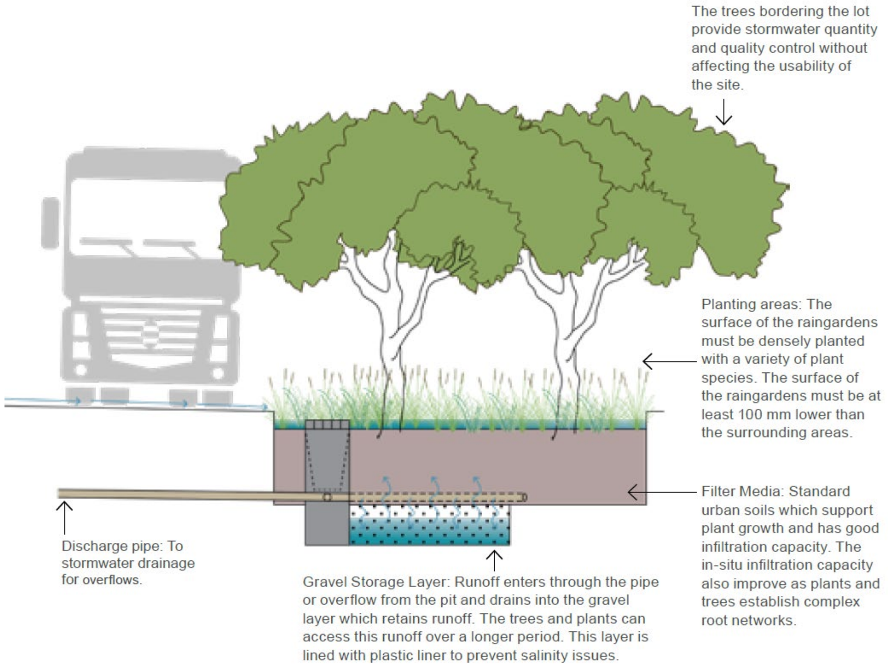


Figure 8-3 Tree pit typical details

9 Conclusion

This Plan promotes integrated water management approaches to deliver sustainable outcomes for the Western Parkland City by integrating stormwater and wastewater management into the landscape to support the blue-green grid. Management of the urban water network through an integrated approach makes balancing economic, social and environmental factors in decision-making challenging more feasible.

Integrated water servicing

This study integrates supply of mains water, wastewater, stormwater and recycled water into water balances for the precincts. Within this interim report several scenarios have been identified for testing. Each servicing scenario is differentiated with key concepts relating urban form outcomes and levels of recycled water and stormwater servicing. A final water balance scenario will be refined to ensure infrastructure can be identified for agreed total water cycle solutions for each precinct.

Recommendation: Water servicing for precincts are to feature total water cycle management that integrates and balances drinking water, wastewater, recycled wastewater and harvested stormwater in line with the finalised scenario. All open spaces, areas of landscaping, parks and streets must be developed to include irrigation infrastructure to ensure demand and provide expected urban cooling benefits.

A final water balance will be provided that ensures water servicing will minimise demands on potable water supplies through alternative water sources. Recycled wastewater will be provided to the area. The final balance of recycled water and harvested stormwater will be calibrated to achieve waterway health outcomes.

Waterway health

Landscape led planning is being applied to orient new urban development around the network of waterways that provide the central landscape features for the region. This planning recognises the cultural, ecological and recreational values of those waterways and includes Government waterway management objectives that will preserve those values. These objectives are being developed through the application of the NSW Government's *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions* (risk-based framework).
Importantly, these objectives work towards managing waterway health within the Wianamatta-South Creek by capping the volume of erosive stormwater flows discharged from new development, as well as setting water quality requirements.

This Stormwater and Water Cycle Management Study adopts these objectives and demonstrates how a range of integrated water cycle strategies are required and have been integrated with other government objectives regarding open space, active transport, native vegetation, riparian vegetation policy, urban cooling, flooding and airport specific risk management.

Achieving a reduction in stormwater runoff volumes represents a shift in stormwater management that requires a combination of at-source controls, rainwater and stormwater harvesting and vegetated Water Sensitive Urban Design (WSUD) elements including biofiltration and wetlands, that can mimic the existing hydrologic characteristics of the rural catchment.

Recommendation: Development within the Aerotropolis is to ensure waterways, riparian corridors, selected farm dams, open water bodies and other water dependent ecosystems are protected, restored and maintained. All development and public infrastructure must comply with and contribute towards the waterway health objectives. developed by DPIE under the Risk Based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions (OEH/EPA 2017).

Development is to ensure that the stormwater pollution removal and flow management requirements identified in this study are achieved by inclusion of infrastructure, systems and urban layouts identified in this study.

Stormwater system

A range of trunk drainage and preferred WSUD stormwater management elements have been developed through consultation with Penrith and Liverpool Council representatives. These WSUD elements work together to preserve the local waterways that cross the precincts as well as waterways in the lower catchment.

Findings: Achieving the interim waterway health objectives is challenging for the initial precincts that comprise a mix of land uses dominated by large format industrial and commercial typologies traditionally associated with high levels of imperviousness, few opportunities stormwater harvesting and low demands for recycled water.

Achieving the stormwater management objectives will require a shift away from stormwater filtration to an approach that is more focussed on the retention of stormwater in the landscape through a combination of

- rainwater tanks to supply non potable and irrigation demands on private lands and in street verges
- maximising the retention and evaporative losses of stormwater through vegetated systems including passive irrigation, biofiltration street trees and wetlands
- exploiting opportunities for stormwater harvesting across the catchments where constraints permit.

A coordinated approach will be required to ensure that that land-take and maintenance efforts are minimised to a consolidated number of effective stormwater assets located strategically. A comparison of indicative life cycle costs of these WSUD elements and their effectiveness at achieving stormwater management objectives is provided in this study.

Recommendation: Stormwater systems including on private lots, within the streetscape and trunk drainage must be designed to achieve the waterway health, urban cooling, tree canopy and open space outcomes through Water Sensitive Urban Design treatment trains developed with key stakeholders and outlined in this report. Urban layouts, streets and drainage are to achieve effective perviousness and flow targets identified in this study. Passively irrigated street trees are to be adopted to reduce stormwater volumes, intercept shallow lateral groundwater and. Trunk drainage is to be through natural creek lines or constructed natural drainage channels to help detain flows and contribute to biodiversity, public amenity and safety. The indicative layout of the regional trunk drainage network, including treatment "water in the landscape" wetlands is identified in the blue green mapping layer and is to be allowed for in any development lay out. The ongoing ownership and management of these assets must ensure adequate and sustainable funding for maintenance is available.

Notional WSUD basin footprints provided to as part of this interim report will need to be confirmed once stormwater targets are confirmed and all constraints mapping becomes available.

Precinct scale water quantity management

The stormwater system also aims to manage peak flows for frequent events (e.g. 50% AEP) to minimise the risk of impacts to stream morphology as a result of increase in imperviousness due to development. Strategies have been developed that aim to meet these broad objectives. The focus of this work has been on sizing stormwater detention using a combination of methods at suitable locations to preserve existing peak flows.

Findings: In consultation with stakeholders this study has shown that a combination of on-site stormwater detention (for industrial areas), on-line detention (on 1st and 2nd order creeks) through natural drainage design and basins can sufficiently manage precinct scale events and must be employed throughout the Aerotropolis precincts.

Recommendation: An allocation of enough, suitably located land area to allow for stormwater assets must be provided. Detention assets in the public realm should be designed as multifunctional also contributing to waterway health, biodiversity and public amenity.

Riparian land management

The protection, restoration and maintenance of waterways, riparian corridors, and water dependent ecosystems is essential in achieving the cultural, social and biodiversity aspirations as well as tree canopy targets of the Western Parkland City. Creeks within the initial precincts are being validated and mapped with associated vegetated riparian zones to support waterway health. Water dependant ecosystems and key fish habitat is also being identified and mapped. A riparian revegetation strategy will be developed once fieldwork is complete, recommending the areas and likely costs of riparian land that should be revegetated.

Recommendation: Vegetated riparian zones (VRZ) adjacent to creeks and other water bodies will be mapped and must be protected, restored and maintained. Opportunities to revegetate beyond standard VRZs should be explored to maximize biodiversity outcomes and achieve urban canopy targets, particularly within the Wianamatta-South Creek Precinct. The ongoing ownership and management of these assets must ensure adequate access and sustainable funding for maintenance is available

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Appendices

Appendix A – Stormwater Assumptions

Land Use Parameter	Standard/Source	Adopted	Comment
Typologies split for Mixed Use	PPO guidance	High Density Residential - 25% Medium Density Residential - 25% Commercial - 50%	For use in water balance modelling
Typology split for Enterprise zone		Large format ndustrial - 50% Strata industrial - 50%	
Typology split for Agribusiness		Large format ndustrial - 6% Enviro and rec - 10% SP1 and SP2 - 9% Agribusiness 75%	
Total imperviousness for Base Case	Typologies areas permiability.pdf provided by Phill Grause via email on Monday, 3 August 2020	Enterprise Zone (%) - 80% Mixed Use (%) - 85% Enviornment and Rec (%) - 15% SP1 (%) - Airport and Associated - 80% SP2 (%) - Transport Corridors - 85% Low / Med Density Residential (%)65% Agribusiness (%) - 60% Infrastructure / Transport Corridors as per GSC GIS- 85%	For use in XP RAFTS modelling
Total imperviousness for Parkland	*Typologies areas permiability.pdf* provided by Phill Grause via email on Monday, 3 August 2020	Enterprise Zone (%) - 60% Mixed Use (%) - 65% Enviornment and Rec (%) - 10% SP1 (%) - Airport and Associated - 70% SP2 (%) - Transport Corridors - 75% Low / Med Density Residential (%) - 50% Agribusiness (%)- 50% Infrastructure / Transport Corridors as per GSC GIS- 75%	For use in MUSIC modelling
Road coverage (percentage of rezoned land that will be road corridors)	PPO Guidance beyond BAU	High and medium density residential – 20% Commercial – 20% Industrial – 7%	Draft based on business as usual development need confirmation from PPO/Urban designers. For use in XP RAFTS and MUSIC modelling
Grades of redeveloped lands	Association of Consulting Structural Engineers – Hail Loading on Rooves	Roof Grade >3% Lots - 2 % Roads – as existing	Roof slopes below 3 degrees are at significant risk of hail ponding and failure
Number of street trees per Ha	TBC by others	Enterprise zone - Mixed Use – 9 trees / Ha Agribusiness –	To be developed with guidance from PPO/Urban designers
Public open space (percentage of rezoned land that will be road park excluding riparian corridors and South Creek Wianamatta precinct)	*Typologies areas permiability.pdf* provided by Phill Grause via email on Monday, 3 August 2020	Enterprise zone - 15% Mixed Use – 20% Agribusiness –	Guidance required from PPO/Urban designers

Land Use Parameter	Standard/Source	Adopted	Comment
Design rainfall for stormwater modelling	Australian Rainfall and Runoff	ARR1987 for hydrologic modelling for consistency with regional planning	Adopt ARF=1 due to scale of precinct based assessments
Rural Rainfall Losses	As endorsed by DPIE/OEH for new rezoning studies	Callibrated to existing data sets	For consistency with existing stormwater and flood planning
Urban Rainfall Losses	As endorsed by DPIE/OEH for new rezoning studies	Urban initial loss = 10mm Pervious CL = 2.5mm/h Imperv. IL = 1.0 mm Imperv. CL = 0.0 mm/h	Applied in stormwater modelling
Pervious Catchment Roughness (PERN)		Rural 0.035 Urban pervious 0.025 Urban impervious 0.015	
Existing culvert capacity	Councils/ARR2019	Apply Council's blockage and freeboard criteria	
Appropriate Safety Criteria for People	Stormwater Drainage Specifications for Building Developments	Max. Depth x Velocity = 0.4m2s-1 Max. Depth = 0.8m Max. Velocity = 2.0ms-1	
Manning's Coefficient	Flood impact risk assessment	Where required, these would be consistent with FIRA	
MUSIC Rainfall and nodes for standard treatment train		As per MUSICLink for Penrith and Liverpool. Local hourly data may be nescessary for long term modelling of stormwater harvesting	MUSICLink or to be agreed with TWG
Biofiltration street tree water demand	Wianamatta Street Tree	Annual water demand – 18.25kL/tree	Biofiltration street tree water demand
Irrigation rates for public open space		The following to be adopted for **plant survival** and scaled for seasonal variations in PET and where soils are suitable: Local passive open space ~ 2.5 ML/Ha/yr Lcoal active open space ~ 4.5 ML/Ha/yr Elite sports fields ~ 9 ML/Ha/yr Additional, higher irrigation rates for cooling are to be confirmed with DPIE EES	Irrigation rates for public open space
Industrial and Commercial Lands Pipe Drainage Network (Minor)	Design Guidelines for Engineering Works on Subdivisions and Developments, 1997 Liverpool and Penrith Engineering Standards.	5% Annual Exceedance Probability (Penrith) 10% Annual Exceedance Probability (Liverpool)	Minor drainage network capacity
Residential Lands Pipe Drainage Network (Minor)	Design Guidelines for Engineering Works on Subdivisions and Developments, 1997 Liverpool and Penrith Engineering Standards.	20% Annual Exceedance Probability	Minor drainage network capacity
Trunk Drainage Network (Major)	Design Guidelines for Engineering Works on Subdivisions and Developments, 1997	1% Annual Exceedance Probability	Flows exceeding minor drainage network capacity overflow to streets
Stormwater detention basins - offline	Council guidance	1% AEP flood depth at the discharge point < 1.2m Internal side batter – 1(V):6(H) ideal	Performance and typical details to be developed and agreed with TWG

Land Use Parameter	Standard/Source	Adopted	Comment
Stormwater detention basins - online	Council guidance	Only on 2nd order waterways Debris racks	To be agreed with Council Performance and typical details to be developed agreed with TWG
OSD for industrial lots	Council guidance	On-site detention to match agreed flow performance requirements	To be developed and agreed with Council Performance and typical details to be agreed with TWG
OSD for roads	Council guidance	Council controlled basins where possible with on-lot measures to compensate for the shortfall	To be developed and agreed with Council Performance and typical details to be agreed with TWG
Overland flow paths / vegetated trunk drainage channels	Council guidance	Inverts – match existing Base width – Varies Side batter – 1(V):4(H) Benched to provide Low flow channel – 1EY capacity Bike path/access track – 10% AEP immunity Overland flow path width – 1% AEP capacity	To be developed and agreed with Council
Stormwater management targets	DPIE EES guidance	TBC	Bering developed by DPIE EES
Waterway health targets	DPIE EES guidance	TBC	Bering developed by DPIE EES

Landuse Zone	Imperviousness values typically adopted (eg South Creek Flood Model) - across a precinct / catchment		
	Base Case impervious Values (%)	Parkland Impervious Values (%)	NEW Parkland Impervious Values (%), based on feedback from PPO
Enterprise Zone (%) - industrial and commercial (large format)	80%	70%	60%
Mixed Use (%) - integrated commercial and residential (high density)	85%	75%	65%
Environment and Rec (%)	15%	5%	10%
SP1 (%) - Airport and Associated	80%	70%	70%
SP2 (%) - Transport Corridors	85%	75%	75%
Agribusiness (%)	60%	20%	50%
Residential - typical low and medium density	65%	50%	50%

Urban Typologies

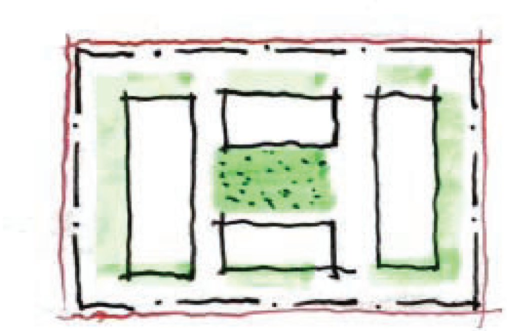
- Urban Typologies explore how development can achieve the Parkland City benchmarks of *permeable area and canopy cover*, at a range of scales:
  - from an individual lot (or amalgamated lots);
  - a super lot large enough to create a public domain of streets and public open space;
  - or at a large master plan or sub precinct scale.

- The more land is amalgamated the more flexibility there is for development footprint:
  - the public domain can work harder
  - individual lot requirements can be simpler

Urban Typologies - Scales

Individual sites ~<10ha

(one title or amalgamated titles)

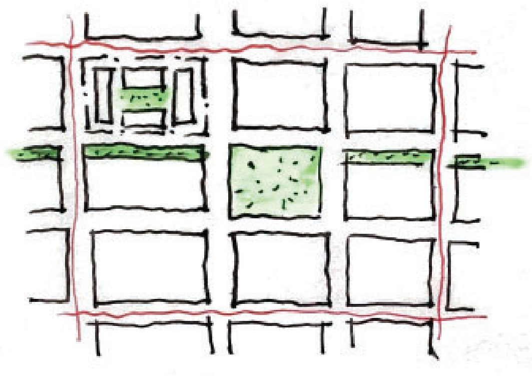


Lot	% perm*	% canopy

* *Permeable area*

Super lots ~>10 ha/title

(lots +local streets + local public open space)

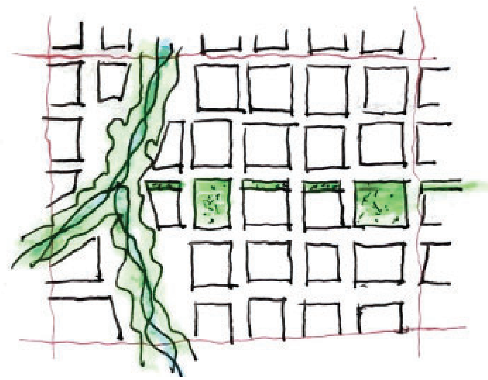


Lots	% perm*	% canopy
Streets	% perm	% canopy
Open space	% perm	% canopy
Total	% perm	% canopy

green grid (Streets, Open space)

Precincts /sub precincts

(All lots + major blue/green infrastructure)



Total individual and super lots	% perm*	% canopy
Major blue & green infrastructure	% perm	% canopy
Grand total	% perm	% canopy

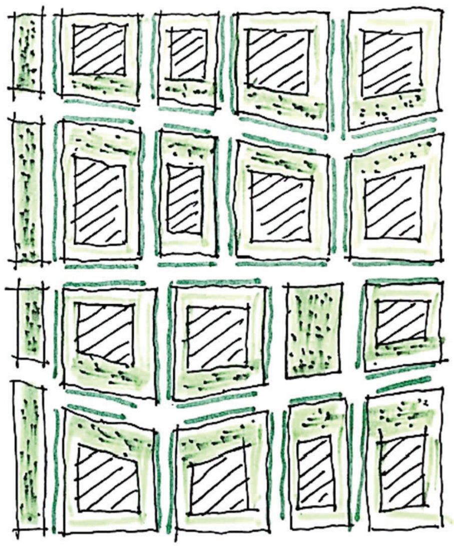
Urban Typologies - Variants

DCP Benchmark solution

Compliant series of individual lots where each complies with permeability and canopy targets

<u>**Large format industrial**</u>

25% streets	@40% perm*
15% P.O.S	@90% perm
60% lots	@30% perm
	~40% perm



Precinct building footprint 42%

<u>Public space</u>

- Green streets
- Minor park
- Linear park

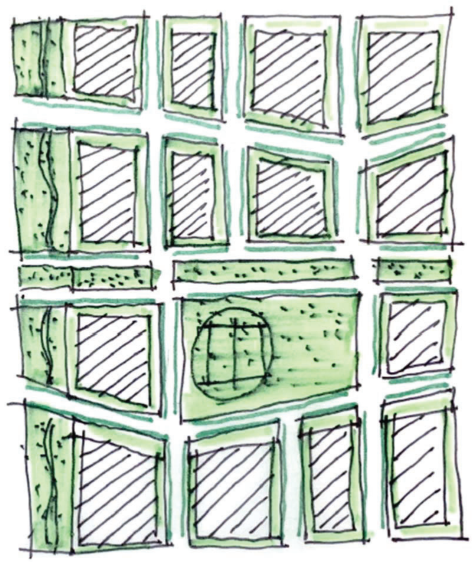
** Permeable area*

DCP Performance solution

Amalgamated land tiles/ super lot/ masterplan. Permeability and canopy targets are mostly delivered through public realm (streets & P.O.S) enabling simpler development controls.

<u>**Large format industrial**</u>

22% streets	@40% perm*
28% P.O.S	@90% perm
50% Lots	@~~30~~% perm
	~40% perm



Precinct building footprint 42%

<u>Public space</u>

- Green streets
- Usable recreational space
- Generous linear park

Urban Typologies – by use

Initial testing to inform INSW flood model to establish how the Parkland City will perform overall.

Average site area 10ha

Assumptions based on
- previous work by Architectus and WCAA.
- street calculations from the Western Sydney Street Guidelines

** Permeable area*

Medium density residential	30% streets	3 ha	@35% perm*	1.05 ha - p	~ 50% perm
	15% P.O.S	1.5 ha	@90% perm	1.35 ha - p	
	55% lots	5.5 ha	@50% perm	2.75 ha - p	
				5.15 ha - p	
High density residential -not in centres	35% streets	3.5 ha	@35% perm*	1.2 ha - p	~ 50% perm
	20% P.O.S	2 ha	@90% perm	1.8 ha - p	
	45% lots	4.5 ha	@40% perm	2.8 ha - p	
				5.8 ha - p	
Strata industrial	30% streets	3 ha	@40% perm*	1.2 ha - p	~ 45% perm
	15% P.O.S	1.5 ha	@90% perm	1.35 ha - p	
	55% lots	5.5 ha	@40% perm	2.2 ha - p	
				4.75 ha - p	
Large format industrial	25% streets	2.5 ha	@40% perm*	1.0 ha - p	~ 40% perm
	15% P.O.S	1.5 ha	@90% perm	1.35 ha - p	
	60% lots	6 ha	@30% perm	1.8 ha - p	
				4.15 ha - p	

SW100 10/20

For more info email multimedia@sydneywater.com.au