Stormwater Scheme Infrastructure Design Guideline DRAFT

Western Sydney

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sydneywater.com.au

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Acknowledgement of Country

We acknowledge and pay our respects to the Traditional Custodians of Country within the Aerotropolis, the Dharug people. We extend that respect to many others who have custodial obligations for Country and have been connected to this place for many generations including the Dharawal and Gundungurra. We acknowledge other surrounding groups that came to this Country to do business including the Darkinjung, coastal Sydney, Wiradjuri and Yuin people. We recognise that the Gandangara, Deerubbin and Tharawal Local Aboriginal Land Councils have land holdings and responsibilities to communities within this area.

We also acknowledge and respect the vibrant and diverse Aboriginal population that call Western Sydney home. They have been established in the Western Parkland City for many generations and have strong cultural values associated with this Country.

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Acronyms

Acronym	Definition
AEP	Annual Exceedance Probability. The probability of an event being equalled or exceeded within a year. Typically, the AEP is estimated by extracting the annual maximum in each year to produce an Annual Maxima Series.
ARR1987	Australian Rainfall and Runoff 1987 Guidelines
ARR2019	Australian Rainfall and Runoff 2019 Guidelines
CPESC	Certified Professional in Erosion and Sediment Control Individuals who demonstrate an established minimum level of competence through the application review process and an examination process.
DCP	Development Control Plan – precinct planning instrument
DSP	Development Servicing Plan
EDD	Extended detention depth – the depth of water allowed to pond above the normal water level (NWL) in a pond or wetland.
EY	Exceedances per Year (EY). For example, 2 EY is equivalent to a design event with a 6 month recurrence interval when there is no seasonality in flood occurrence
FFA	Flood Frequency Analysis
GPT	Gross pollutant trap
GSDM	Generalised Short Duration Method
LGA	Local Government Area
MARV	Mean annual runoff volume
NOR	Notice of Requirements
NOAR	Notice of Anticipated Requirements
NRAR	NSW government department - Natural Resources Access Regulator
O&M	Operation and Maintenance
OSD	On-site stormwater detention
PMF	Probable Maximum Flood
REF	Review of Environmental Factors
SEPP	State Environmental Planning Policy – a regional planning instrument.
TSS	Total Suspended Solids
WSUD	Water sensitive urban design (WSUD) is an approach to planning and designing urban areas to make use of stormwater and reduce the harm it causes to waterways.

WH&S	Work Health and Safety

General Terms and Definitions

Acronym	Definition
Bioretention systems	Vegetated sunken garden bed areas that collect and treat stormwater as it percolates through a sandy loam soil media. They can be a range of sizes and located in private allotment or local parks and support a wide range of vegetation types.
Bioretention street trees	Bioretention systems associated with a single street tree located in road verges that collect and treat stormwater from the road kerb. These systems come in several different engineering and landscape forms.
Blue Green (natural)	A network of waterways, water bodies, wetlands, groundwater ecosystems, and vegetation that are water dependent (this includes the riparian vegetation in the Wianamatta-South Creek catchment).
Blue-Green Grid	A network of high-quality green areas and waterways, from regional natural assets to local natural assets, that connect to centres, public transport and public spaces.
Blue-Green Infrastructure Framework	Blue-green infrastructure is the interconnected network of natural and semi-natural landscape elements. For example, blue includes water bodies, creeks and dams. Green includes trees, parks and native vegetation.
Coarse sediment	Particles larger than 0.125mm transported in stormwater
Consent Authority	The same meaning as in Section 4.5 of the Environmental Planning and Assessment Act 1979.
Construction phase	Construction period during a development until at least 80% of the allotment buildings are complete – with occupation certification
Declared Catchment Area	this is the area where Sydney Water can charge customers a stormwater charge, and developers a contribution under the DSP. In the Aerotropolis area, the declared catchments are aligned to the precinct borders and were declared 18 March 2022 under the Sydney Water (Stormwater Drainage Areas) Order 2011. The maps can be viewed on the NSW legislation website.
Green roof	Roof areas that are covered with soil and vegetation. They act to capture rainwater, promote evaporation, reduce runoff volumes and cool the buildings
Irrigated street trees	Street trees that are irrigated form a reticulated supply (can be recycled water supply)
Operational phase	Period when development is complete – with occupation certification
Passively irrigated street trees	Stormwater diverters installed in kerbs to direct small amounts of stormwater into soils around street trees for irrigation (not bioretention)
Practitioners	An individual actively engaged in a profession – in this context – these are individuals such as stormwater engineers, flood engineers or landscape architects
Proponent (development)	A person or entity who puts forward a proposition or proposal for an urban development.
Stormwater Infrastructure	Refers to stormwater infrastructure under the care and control of the Regional Stormwater Authority i.e. natural trunk drainage, wetlands and harvesting ponds etc.

Storages	Storage for water reuse systems to collect treated stormwater and store it until it is required. They can be open water storages (dam or lakes) or in enclosed tanks that are either above or below ground.
Water and Stormwater Management Plan	A document that addresses urban stormwater from a management perspective to ensure that the stormwater management targets and other related controls are achieved.
Waterway	The whole or any part of a watercourse, wetland, waterbody (artificial) or waterbody (natural).
Waterway health objectives	The community environmental values and long-term goals for managing waterways. The objectives consisting of three components i) values and uses of waterway, and ii) indicators and iii) numerical criteria needed to protect the values and uses. In this context, they are the environmental guidelines for delivering healthy waterways, riparian corridors and other water dependent ecosystems
Wetlands (for stormwater management)	Shallow vegetated waterbodies that are intended for stormwater treatment. They can be a variety of scales and are generally configured to capture an initial volume of stormwater and slowly release it over two to three days.
WSUD measures	Built structure or landscape feature that is designed to slow and disperse runoff from storm events by promoting onsite retention, infiltration or evapotranspiration while cleaning the runoff of pollutants including litter and harmful chemicals
WSUD strategy/strategies	Method (strategy) of delivering WSUD measures are various scales – allotment, precinct, catchment/regional

Appendices

ID	Title	Revision	Format	Comment
A	Typical Concept Sketches	B	PDF	DRAFT
B	Planting Palette Draft	A	PDF	DRAFT
C	Engineering Requirements Checklist	A	PDF	DRAFT
D	Indigenous Design Considerations	TBC	TBC	TBC
E	Safety in Design Workshop – Actions and Minutes	TBC	TBC	TBC

Disclaimer

This handbook has been developed in good faith, after careful review and consultation.

While every care has been taken in compiling this handbook, we accept no liability whatsoever for any loss (including without limitation direct or indirect loss and any loss of profit, data, or economic loss) occasioned to any person nor for any damage, cost, claim or expense arising from reliance on this handbook or any of its content.

The handbook will be reviewed and updated periodically, and the updated version will be available on Sydney Water's website. Please ensure you are using the current version.

Table 1: Revision History

Version No.	Section	Description of Revision
2022-1.0	-	Document Creation
2024-1.0	All	Revised Documention

Notes:

1. An electronic database stores and control the current electronic versions of this document.
2. Relevant personnel will be notified of changes to the guideline.
3. Holders of printed controlled copies must check the Sydney Water website to ensure they are using the latest copy.
4. An electronic database manages the controlled printed copy distribution list for this document.
5. If printed controlled copies will cease to be a controlled copy.

This document has been prepared on behalf of Sydney Water. No liability or responsibility is accepted whatsoever in respect of and use or reliance upon this document by any third party.

1. Introduction

1.1 Background Context

The NSW Governments' statutory and planning documents for the Aerotropolis and Mamre Road Precincts have adopted a new land-use planning and urban design approach to achieve the Parkland City vision for Western Sydney. As part of this major shift, new waterway health objectives and targets for the Wianamatta South Creek Catchment have been set, based on the Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions.

In response to this planning change, Sydney Water developed an integrated water cycle management (**IWCM**) approach to meet the new stormwater flow and quality targets through large, regional scale infrastructure. This approach will be instrumental in achieving the Government's vision for a cool, green, liveable Western Sydney.

In March 2022 NSW Government declared Sydney Water the Regional Stormwater Authority, in effect, accepting and endorsing the IWCM approach across the Aerotropolis Initial Precincts and Mamre Road Precinct. Sydney Water has since developed Stormwater Schemes and, in collaboration with Government, has been working through the strategic, technical, financial, and operational changes necessary to implement them. Sydney Water is listening to the challenges that stakeholders are facing as we transition into a new era of water management in Western Sydney.

1.1.1 Document Purpose

This Draft Guideline addresses the need for design guidance around major infrastructure elements of the Stormwater Scheme. It aims to assist developers and design consultants in understanding Sydney Water's expectations and technical requirements for the stormwater infrastructure. The Guideline does not replace requirements specified in other Sydney Water standards or specifications.

Developers may implement stormwater infrastructure on their property concurrently with their development to expedite the process.

Additional documentation for operation and maintenance plans will be developed to ensure consistent management by developers during the establishment phase and once Sydney Water takes ownership.

1.1.2 What's included?

This guideline includes design requirements and standard drawings for the following elements of the stormwater scheme:

Table 2: Stormwater Scheme Planned Infrastructure

Element	Purpose	Use
Naturalised trunk drainage channels (Constructed)	Convey stormwater to regional system or major waterway.	> 15 ha Catchments.
Existing waterways (within regional scheme)	Convey stormwater to regional system or major waterway.	2^{nd} order and above streams are to remain intact.
Gross pollution trap	Remove litter	Only for drainage channels/pipes that have a potentially high litter load.

Regional stormwater treatment system including sediment basin, wetland, bioretention, storage pond	Achieve operational phase targets for stormwater quality and quantity.	Upstream of the major waterways.

For more information on the Integrated Water Cycle Management approach for the Aerotropolis please refer to Refer to the Innovative water management for the Aerotropolis Precincts (Sydney Water, 2022).

The level of detail in this document will assist primarily in the concept, masterplan, and Development Application phases of design as well as detailed design and construction requirements. This document is to be read in conjunction with other relevant Sydney Water standards and specifications (such as Technical Specifications - Civil).

1.2 Vision, Objectives and Design Principles

1.2.1 Vision

The vision for the Stormwater Scheme is to preserve, protect and enhance the natural processes of the Country in the Wianamatta-South Creek catchment while providing safe, sustainable, and cost-efficient stormwater infrastructure to allow for urban development.

1.2.2 Design Principles and Objectives

The broad outcomes and design objectives for the Stormwater Scheme are summarised in Table 3. The subsequent sections describe design principles.

Table 3: General Design Principles and Objectives

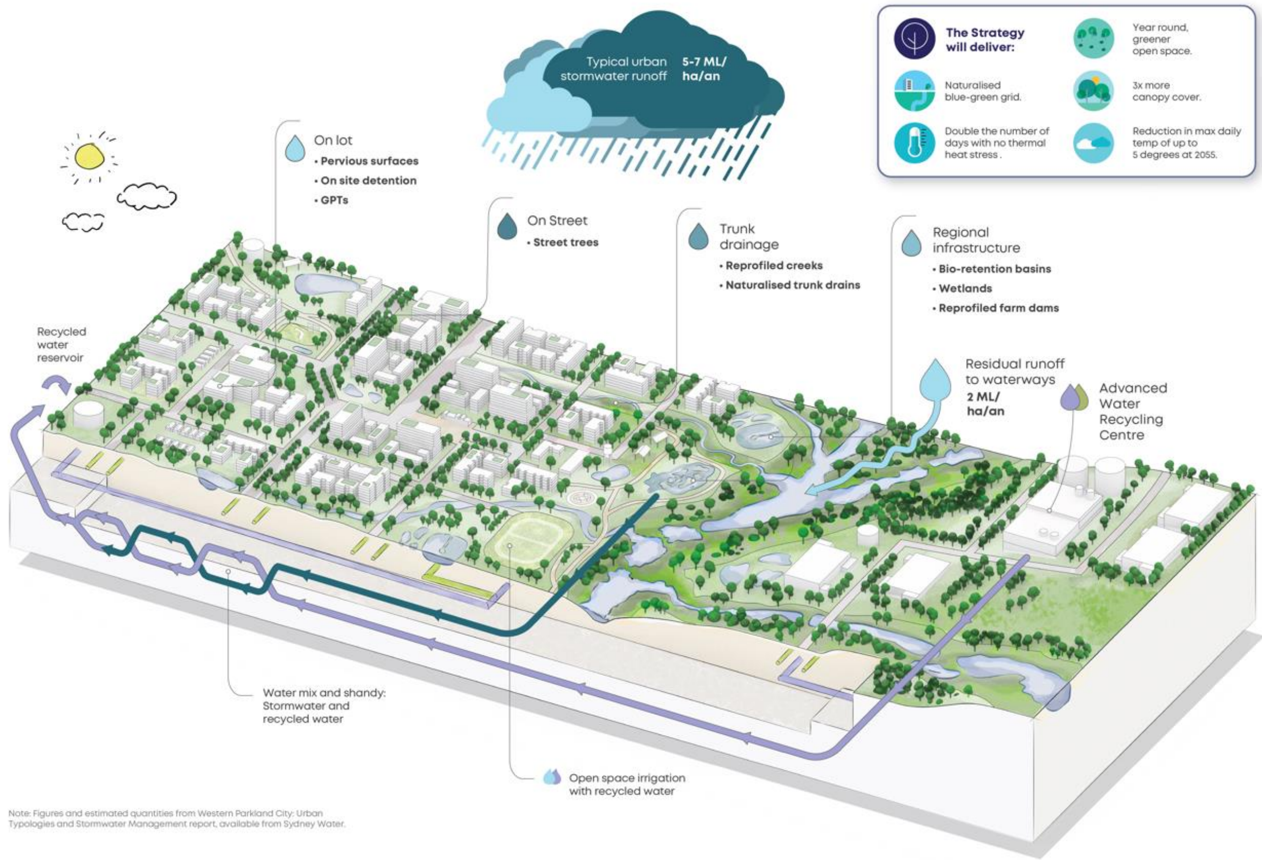
Design Principle	Objectives	Description
Functional, Efficient and Sustainable Assets	Maintain flood conveyance capacity	Ensure assets can safely convey runoff and not adversely impact surrounding infrastructure or properties.
	Maintain channel stability	Ensure the channels or waterways are appropriately designed to be able withstand stormwater velocities/volumes without causing erosion or scour.
	Financial sustainability	All infrastructure is fit for purpose and designed to achieve their objective with the funding available. The design is to actively seek ways to minimise cost without impacting infrastructure performance or longevity.
	Maintainability	Infrastructure is to be designed to be efficient, safe and easily maintained. This means ease of access, suitable storage areas, ability to isolate, and implementing best practice safety requirements.
Health and Wellbeing	Safe access management	Ensure the infrastructure can be isolated to allow for maintenance to occur to protect the public and staff.
	Urban greening	Maximise urban greening, when possible, without increasing the risk of bird strike.
	Localised cooling	Optimise irrigation of vegetation to maximise evapotranspiration and vegetation growth (greening),

		when possible, without impact soil salt levels or ground water.
Cultural connection to Country	Design to the existing topography and land features	Minimise cut and fill that will drastically change the topography and landscape features.
	Enhance local ecological communities	Use local vegetation communities/species, when possible, without increasing the risk of bird strike.
	Maintain water in landscape	When possible, protect local intact waterways and other systems that retain water.
	Flora and fauna connectivity	Ensure open drainage channels, existing waterways, and existing vegetation is protected and connected to maximise connectivity and corridors.
	Minimise soil profile disturbance	When excavation is required, ensure the soil profiles are kept separate or maintained, so that when it re-instated, they are installed correctly to match the original profile.
Waterway Health	Achieve waterway health targets at precinct boundaries	Ensure the design of the regional stormwater scheme and upstream treatment measures achieve the waterway health targets prior to entering regional waterways.
	Maximise length of waterways	Ensure all waterways are as long as possible to maximise plant contact time and to keep water in the landscape for as long as possible.
Wildlife strike management	Minimise wildlife strike hazard to Western Sydney Airport	Ensure all infrastructure have been designed to minimise risk of attracting birds that can increase the wildlife strike hazard for the Western Sydney Airport.
Social amenity	Opportunities for active transport	Ensure the waterways can be used by the community to actively move around the area and to key destinations (schools, shops, transport links).
	Facilitate opportunities for passive recreation	Ensure the channels, existing waterways, and regional stormwater system can be used by the community for passive recreation, such as picnics and nature watching.
	Facilitate public access to green, natural places	Ensure all infrastructure in the public domain have suitable access for the community, especially using universal design as foundation approach.
Multiple benefit outcomes	Balanced achievement of multiple objectives	Ensure the design of the stormwater scheme is undertaken by a suite of relevant and suitably qualified consultants from multiple disciplines.

2. Stormwater Scheme Overview

The Stormwater Scheme Plans comprise of infrastructure from private lots, down to the floodplains of the larger waterways across the Precincts. The main infrastructure elements that play a role in the management of stormwater throughout the scheme are outlined in Figure 1.

Figure 1: Stormwater Scheme Overview



2.1 Implementation of the Regional Stormwater System

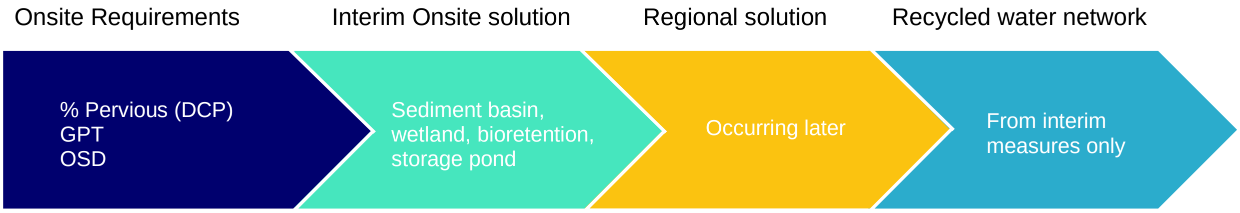
The "*technical guidance for achieving Wianamatta–South Creek stormwater management targets*" outlines two scenarios to achieve the operational phase water quality targets. The two scenarios provided are:

- Interim Onsite Measures.
- Regional Stormwater System.

2.1.1 Interim Onsite Measures

In the first scenario, shown in Figure 2, developers are required to implement interim onsite stormwater measures to meet both the construction and operational targets. These interim measures are the landowner's responsibility until the regional stormwater system is operational, at which point they will be removed. This option allows development to proceed but can be costly and is temporary only. Approvals are subject to other Government bodies.

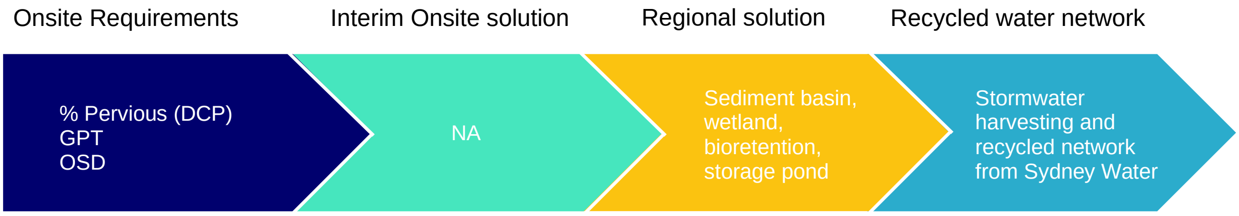
Figure 2: Interim Onsite Strategy



2.1.2 Regional Stormwater Systems

In the second scenario, shown in Figure 3, developers can collaborate with Sydney Water to design and construct the regional stormwater system, and by doing so will create stormwater scheme service area which will likely allow full development without onsite interim measures. The developer is to contact their Sydney Water case manager to request more information on this option as early as possible, ideally before their development application submission. This is the preferred method by Sydney Water as it allows development to occur in full (minimising staging) and allows the spoil to be used by developers, reducing the DSP charge.

Figure 3: Sydney Water Scheme Strategy



3. Project Approval Process

The trunk drainage system and Regional Stormwater Scheme are assets to be managed by Sydney Water, after handover. Regular consultation with Sydney Water and relevant authorities is critical to ensure consistency and to reduce design time and costs.

3.1 Asset Ownership Matrix Framework

Asset ownership is a critical component of infrastructure management, determining responsibility for maintenance and liability. Within the Aerotropolis and Mamre Road Precincts asset ownership and maintenance are shown in Figure 3. Note that pits and pipes within Council roads are Council assets.

Figure 4: Asset Ownership Matrix Framework

Asset	Location	Consent Authority	Ownership	Management responsibility
Gross Pollutant Trap / OSD / Perviousness %	Private Property	Council / NSW Government	Private	Private
Passively Watered Street Trees / Road Drainage	Road Reserve	Council / NSW Government	Council / TfNSW	Council / TfNSW
Naturalised Trunk Drainage Channel / Pipe	Trunk Drainage	Council / NSW Government / Sydney Water	Private	Sydney Water
GPT, Sediment basin, wetland, bioretention, storage pond, harvesting Scheme	Regional Stormwater System	Council / NSW Government via DA/SSD / Sydney Water via REF	Sydney Water	Sydney Water
Stormwater treament and distribution	Regional Recycled Water Supply	Sydney Water	Sydney Water	Sydney Water

3.2 Design Process

When designing and constructing Sydney Water stormwater infrastructure, it is advisable to arrange a meeting with your Sydney Water case manager or request a feasibility letter as early as possible. This preliminary consultation will provide guidance on the availability of Sydney Water services (or estimated timing of availability) and specify the infrastructure requirements the developer must meet to obtain their Section 73 certificate. At this stage, the developer has the following options regarding stormwater infrastructure on their land:

(a) Design stormwater infrastructure according to the Integrated Stormwater Scheme Plan.

If the developer follows the scheme plan without modifications, as indicated in a strategic (10%) design, Sydney Water will provide a feasibility response, including a letter of intent. This letter can be included in the development application to demonstrate engagement with Sydney Water alignment with the Scheme Plan. Table 4 outlines the required design detail for each stage with this option.

Table 4: Design Process 1

Component	Strategic (10%)	Functional (50%-75%)	Detailed (90%)	For Construction
DA Stage	Pre-DA and before SEAR's	During exhibition/ submissions	After determination	After determination
Sydney Water Section 73 processes	Feasibility (including letter of intent)	NOAR or NOR	Letter of offer	
Consultation plan		Yes (if required)	Finalised	
Hydrologic, hydraulic and water quality models		Yes (detailed)	Finalised	
Levels across the site and key points (AutoCAD/12D)	Yes (basic)	Yes (detailed)	Finalised	
Designing with Country plan	Yes (outline)		Finalised	
Landscape and irrigation plan		Yes basic	Finalised	
Safety in Design report (including bird strike)		Yes (basic)	Yes (detailed)	Finalised
Design report (meeting design objectives)	Yes (basic)	Yes (detailed)	Finalised	
Asset operation plan and maintenance*		Yes (basic)	Yes (detailed)	
Construction environmental management plan			Yes (draft)	Finalised
Construction and Inspection plan			Yes (draft)	Finalised

(b) Propose changes to the Integrated stormwater scheme plan.

If the developer seeks to alter the scheme plan, such as relocating, reducing, or modifying the trunk drainage channel alignment or width, they must negotiate these changes through a flexible planning agreement (or similar) until Sydney Water endorses the design. Once endorsed, Sydney Water will issue a letter of intent that can be included in the development application. If not endorsed, Sydney Water will reject any referral included in the development application and will not issue a Section 73 certificate. Table 5 outlines the level of detail required for each stage of design with this option.

Table 5 Design Process 2

Component	Strategic (10%)	Functional (50%-75%)	Detailed (90%)	For Construction
DA stage	Pre-DA and before SEAR's	During exhibition/ submissions	After determination	After determination
Sydney Water Section 73 processes	Flexible Planning Agreement and Feasibility (including letter of Intent)	NOAR or NOR	Letter of offer	
Consultation plan	Yes (if required)	Yes (if required)	Finalised	
Calculations and assumptions	Yes (basic to detailed[2])	Yes (detailed)	Finalised	
Hydrologic, hydraulic and water quality models	Yes (basic to detailed[2])	Yes (detailed)	Finalised	
Levels across the site and key points (AutoCAD/12D)	Yes (basic to detailed[2])	Yes (detailed)	Finalised	
Designing with Country plan	Yes (outline)		Finalised	
Landscape and irrigation plan		Yes basic	Finalised	
Safety in Design report (including bird strike)		Yes (basic)	Yes (detailed)	Finalised
Design report (meeting design objectives)	Yes (basic to detailed[2])	Yes (detailed)	Finalised	
Asset operation plan and maintenance[1]		Yes (basic)	Yes (detailed)	
Construction environmental management plan			Yes (draft)	Finalised

Note: Sydney Water in principle support and endorsement is not an approval.

1. Operation and maintenance plan will unlikely be finalised after construction has occurred and then updated before handover.
2. The level of detail required will depend on the changes being proposed and is at Sydney Water's discretion.

3.3 Construction to Handover Process

The construction and handover process are being developed as part of the Developer Works Policy.

4. Technical Guidelines

The following sections outline Sydney Water's technical requirements for designing Stormwater Scheme infrastructure. It provides guidance for concept, masterplan, DA phases, detailed design and construction. Sydney Water will update this document with the latest design guidance. This document is to be read in conjunction with other relevant Sydney Water standards and specifications (such as Technical Specifications – Civil).

The guideline provides the following information for each asset:

- The purpose and role in scheme.
- Performance outcomes.
- Modelling requirements.
- Design requirements.
- Construction, operation, and maintenance considerations.

4.1 MUSIC Modelling

There is no requirement to undertake MUSIC modelling when developments are integrating with a Stormwater Scheme proposed by Sydney Water. MUSIC modelling is required for the following scenarios:

- The proponent is proposing an alternative design inconsistent with a Stormwater Scheme Strategy.
- Developments that are outside a Stormwater Scheme.
- Master planning proposes changes to the Stormwater Scheme strategy.
- When a Stormwater Scheme isn't available then MUSIC modelling is required to demonstrate how the targets are achieved.

DPHI has prepared a MUSIC modelling toolkit for the Wianamatta South-Creek catchment. All developments within the catchment must use this toolkit (MUSIC V6) to access the rainfall and evapotranspiration data. Assets that do not belong to the Stormwater Scheme are required to follow the guidance provided in the Technical guidance for achieving Wianamatta-South Creek stormwater management targets (DPE 2022).

5. On-Lot and In-Street Stormwater Measures

5.1 On-Lot Stormwater Management Measures

5.1.1 Purpose and Role in Scheme

These assets play an important role to reduce the impact of the development on the downstream environment for gross pollution and flood mitigation. They also unlock areas for irrigation that help achieve the regional flow reduction target.

5.1.2 Performance Outcomes

Development is required to meet the following performance outcomes in accordance with the relevant DCP and approved by the relevant consent authority. Sydney Water may provide feedback on the following elements:

- Minimum on-lot perviousness percentage (refer to specific DCP requirements).
- Gross pollution trap to remove >90% of gross pollution generated from the lot.
- On-site detention if required to achieve the LGA requirements.

5.1.3 Modelling Requirements

Refer to the relevant LGA for modelling requirements.

5.1.4 Design Requirements

Refer to the relevant LGA for design requirements.

5.1.5 Construction, Operation, and Maintenance Considerations

Sydney Water is not responsible for the construction, operation and maintenance of on-lot assets. It is recommended that the landowner engage a suitably qualified contractor to regularly inspect and maintain these systems to ensure longevity of the systems. For operation and maintenance guidance refer to the manufacturers specification or relevant Council for information, however if there isn't any refer to Blacktown City Council's WSUD Inspection and maintenance guidelines.

5.2 Passively Watered Street Trees

5.2.1 Purpose and Role in Scheme

Passively watered street trees allow for passive irrigation and capturing urban stormwater to reduce the runoff volume. These assets are an important component of the stormwater system and influence the size of the regional stormwater system by:

1. Collecting stormwater runoff from within the road network to reduce stormwater runoff volumes into regional stormwater system, without impact ground water or soil condition.
2. Increasing tree health, canopy cover and survival rates.
3. Increasing the greening and cooling of the area.
4. Increasing local harvested stormwater demands through irrigation.

5.2.2 Performance Outcome

Passively watered street trees do not have a specific performance requirement in the DCP.

5.2.3 Modelling Assumptions

Sydney Water has adopted the following modelling assumptions in the Stormwater Scheme:

- Street trees are to be modelled as biofiltration nodes with a filter depth of 0.5m and a saturated hydraulic conductivity of 100mm/hr.
- Trees are to be spaced along each side of roads at 8m centres except where cross overs and other infrastructure occur (i.e. 2 trees per 8 linear metres of street centreline).
- A target minimum tree density of 5.25 passively irrigated street trees/ha of industrial (IN1) land in the catchment.
  - Tree density and EDD storage volume differ from the Mamre Road Flood, Riparian Corridor and Integrated Water Cycle Management Strategy (August 2021) due to the refined street network and passively irrigated tree design endorsed through consultation with Penrith Council.
  - Tree density for other land zoning types will be subject to consultation with Sydney Water.
- 2.8 m^2 of surface area per tree to facilitate filtration/infiltration of stormwater to the root zone.
- An extended detention storage volume of 0.06 m3 per tree which can be modelled as an equivalent extended detention depth (e.g. 0.02 m across 2.8 m2 filter/infiltration zone).
- Areas outside of precinct plan will need to be justified by their own calculations as specified in the relevant consent authority specification but should refer to an average tree spacing of 2 trees per 8 linear metres of street centreline.

Street trees can be modelled as lumped quantities and are not expected to be modelled individually. If lot drainage reaches the street trees, it may be modelled so, otherwise only runoff from the road and verge must be directed to street trees (biofiltration) nodes.

5.2.4 Design Requirements

The design of these trees is to comply with the relevant SEPP, DCP and Council requirements. These trees will ultimately be Council or Transport for NSW owned and maintained assets. Refer to the relevant authority for further design requirements.

5.2.5 Construction, Operation and Maintenance Considerations

The inlets to these systems should be protected during construction and development within their catchment areas to minimise sediment entering and clogging the system.

6. Trunk Drainage

6.1 Purpose and Role in Scheme

Trunk drainage channels collect and convey stormwater runoff from development areas. They must be adequately sized to manage runoff from their total catchment area for the 1% AEP storm event.

The Aerotropolis and Mamre Road DCPs aim to achieve Integrated Water Cycle Management (IWCM) by emphasising stormwater management through naturalised water assets and maintaining water in the landscape. All trunk drainage will be implemented as naturalised, open channels following the design guidance in this section.

6.1.1 Requirements for Trunk Drainage

Trunk drainage will be required when the stormwater contributing catchment exceeds an area of 15 hectares within a declared catchment area.

6.1.2 Conditions of Implementation

Naturalised trunk drainage channels are required under the following conditions:

1. There is a requirement for trunk drainage and no defined existing waterway.
2. There is a requirement for trunk drainage, but the existing waterway does not have sufficient capacity to convey the required flows.
3. An existing waterway re-alignment has been approved by NRAR.

6.1.3 Compound Trunk Drainage Systems

Sydney Water has adopted a compound waterway geometry approach for the design of trunk drainage systems in the Aerotropolis and Mamre Road Precincts. Compound waterways are required to have:

1. A low flow channel designed to accommodate flows up to 4EY storm event.
2. A high flow channel designed to accommodate flows exceeding the 4EY storm event and contain the 1% AEP storm event.
3. A Minimum freeboard of 500mm is required.

1.2.3 Performance Outcomes

The hydraulic performance of the trunk drainage system is crucial for the safety and sustainability of the developed area, as well as for achieving environmental, cultural, and stream health objectives.

The following are the main performance outcomes for trunk drainage channels:

1. Safely convey the 4EY into the regional Stormwater Scheme infrastructure
2. Safely convey all stormwater flows up the 1% AEP within the naturalised channel from the contributing catchment.
3. Increase the contact time with vegetation by increasing the channel sinuosity length.
4. Increase the greening and cooling of the area through irrigation and increasing canopy/vegetation cover.

6.2 Modelling Requirements

6.2.1 Catchment Delineation

Catchment delineation is to be provided in the following manner:

- Predevelopment catchments are to be presented on plans demonstrating catchment areas, overland flow paths and boundaries. Post-development catchments are to be presented on plans and must not change the predevelopment catchments area by more than 10%.
- A plan that has the post-development overlayed with the predevelopment catchments is to be provided in the stormwater management plan.
- A table showing predevelopment and post-development catchment areas is required to ensure compliance with the ± 10% change.

This value was selected to ensure the redistribution of catchment flows does not excessively change the volume of runoff to the downstream environment and is essential for accurate hydrological modelling, effective flood and erosion management, water quality protection and ecosystem health. This approach ensures that development projects are sustainable and resilient.

6.2.2 Rainfall Data

6.2.2.1 ARR1987 IFD

The Wianamatta South Creek Catchment has been extensively modelled and assessed by Sydney Water, NSW Government, Penrith City Council, and the Stormwater Management Technical Group. These bodies recommended adopting the ARR1987 IFD data sets and corresponding temporal patterns for the region. The recommendation is due to the data set achieving a closer peak flow to the existing FFA of the area. The nine IFD parameters in Table 6 are to be used when using ARR1987 rainfall.

Table 6: ARR1987 IFD Parameters

Catchment	G	F_2	F_{50}	${}^{2}I_{1}$	${}^{2}I_{12}$	${}^{2}I_{72}$	${}^{50}I_{1}$	${}^{50}I_{12}$	${}^{50}I_{72}$
Mamre Road Precinct	0.01	4.29	15.80	30.07	6.45	1.90	59.04	12.59	4.21
Elizabeth Road	0.01	4.29	15.80	30.00	6.15	1.90	59.30	12.30	4.10
Badgerys Creek	0.01	4.29	15.80	30.00	6.46	1.93	59.10	12.60	4.20

6.2.2.2 ARR2016 IFD

While designers are permitted to use the ARR2016 IFD data for post development modelling, the data needs to be calibrated for predevelopment conditions. This validation is required due to previous assessments demonstrating the IFD data results in a lower peak flow runoff than both the FFA and ARR1987 IFD data. IFD must be derived from ARR2019, including the probability neutral pre-burst from ARR datahub.

6.2.2.3 Rainfall Losses

For catchments discharging into the following creeks, adopt the losses specified in Table 7 when using initial and continuing loss method.

Table 7: Initial and Continuing Losses

Catchment / Creek	Initial Loss (mm)	Continuing Loss (mm/hr)
Wianamatta-South Creek (South of Elizabeth Drive), Kemps, Bonds	35.9	0.94
Wianamatta-South Creek (North of Elizabeth Drive), Badgerys, Oaky, Cosgroves	37.1	0.94
Ropes	32.6	0.94
Thompsons	15	0.94
All Impervious Area	1	0

6.2.3 Hydrological modelling

Acceptable digital hydrologic models include runoff routing, storage routing and time area models such as XP-RAFTS, RORB, WBNM and DRAINS (ILSAX). Modelling requirements include:

1. Time of concentration:
    a. Minimum time is 5 minutes, with a maximum of 20 minutes. Times over 14 minutes require justification.
    b. Use of the Kinematic Wave equation is limited to flow paths no longer than 30m and shall be over surfaces that are homogeneous in surface and grade.
2. Use of the Rational Method will not be considered.

6.2.3.1 Storm Event Selection

The following storm events are required to be modelled to demonstrate functional design of the trunk drainage channel.

1. Minor Storm – The 12EY or 4EY critical storm event is required to size the low flow channel. The 12EY storm event may be suitable to trunk drainage channels in the upper reaches of the catchment for sizes up to 30ha. The 4EY storm event may be suitable to trunk drainage channels in the lower reaches of the catchment where size is greater than 30ha.
2. Major Storm – The 1% AEP critical storm event is required to size the high flow component of the trunk drainage channel.
3. Flood Risk Management – The Probable Maximum Flood event is required to manage high risk flooding within the channel. Refer to the GSDM for calculating peak flow rate.

Additional checks may be required for the following scenarios at Sydney Water's discretion.

4. Potential erosion – The 5% AEP critical storm event may be required where erosion of the trunk drainage channel is likely to occur. This is likely to occur in areas where:
    a. Longitudinal grades are greater than 1%.
    b. Velocities exceed 1.4m/s.
5. Climate Change Assessment – Sydney Water has adopted the ARR2019 RCP 4.5 for adaptation measures and RCP 8.5 for risk impact cost and future capacity.

6.2.4 Hydraulic Modelling

All flow paths and channels must be analysed using industry-standard 1D/2D software. Acceptable software includes TUFLOW, HEC-RAS 2D, and Mike-21. The use of other software may be acceptable but must be approved by Sydney Water. The hydraulic modelling requirements change subject to the proponent's proposal to amend the layout, length, or width of the trunk drainage channel as follow:

- If there are no significant alterations proposed to the Stormwater Scheme Plan, the following section requirements may be addressed during the detailed design phase.
- If substantial changes are made to the Stormwater Scheme Plan, Sydney Water may request additional modelling during the strategic and functional design stages, due to the high level of risk and uncertainty involved.
- If no Stormwater Scheme Plan is available at the time, Sydney Water may request additional modelling during the functional design stage, due to the high level of risk and uncertainty involved.

6.2.4.1 Downstream Boundary Conditions

The inclusion of downstream boundary conditions is critical to ensure accurate and reliable modelling results. The downstream boundary condition represents the state of the water body at the model's exit point, significantly influencing flow patterns, water levels and velocities within the system. Without an appropriate downstream boundary, the model may produce unrealistic or unstable results, leading to incorrect assessments of flood risks, infrastructure performance and environmental impacts.

6.2.4.2 Flood Result Mapping

Flood mapping is a crucial aspect of flood risk management and urban planning. It involves the detailed assessment and mapping of various flood parameters to understand and mitigate the potential impacts of flooding events. The following maps are required for assessment:

- Flood extents and velocities for the 1% AEP, 0.2% AEP and the PMF.
- Shear stress for the 4EY, 5% AEP, 1% AEP and climate change scenario.
- Identifying flood planning areas that are below the flood planning level when relevant.
- Flood hazards mapping as per the Flood Risk Management Guideline FB03 hazard definitions Figure 1.
- Topographical roughness mapping.

6.2.4.3 Mannings 'n' values

The channels shall be designed and modelled to a Manning's roughness (n) of **0.08** with sensitivity testing of 0.03 and 0.10 to assess the impacts of flows on newly constructed channels where vegetation is in its establishment phase, and the potential for overgrown channels. Should the designer wish to modify the Manning's n coefficient, they are to provide calculations in accordance with the Modified Cowan Method for determining channel roughness, where:

$$n = (n_b + n_1 + n_2 + n_3 + n_4)\, m$$

Table 8: Modified Cowans Method Values

Boundary Category	Material	n and m values	Description
Channel Material (n_b)	Earth	0.02	Clay based channels
	Bed Rock	0.025	Channels cut into bedrock

	Sand-fine gravel	0.024	Sandy creeks
Degree of Irregularity (n_1)	Smooth	0.0	Smooth channel
	Minor	0.005	Excavate channels in good condition
	Moderate	0.006 - 0.010	Channels with considerable bed roughness and some bank erosion
	Gradual	0.001 – 0.005	Large and small cross sections alternate occasionally
	Severe	0.010 – 0.015	Large and small cross sections alternate frequently.
	Minor	0.005 – 0.015	Obstructions occupy 5% - 15% of the channel and the obstructions are generally isolated
	Appreciable	0.020 – 0.030	Obstructions occupy 15% - 50% of the channel and the obstructions
	Medium	0.010 – 0.025	Grass and/or weeds with the flow one to two times the height of the vegetation; or reeds or tree seedlings growing with the flow two to three time the vegetation height; or minor bed vegetation with medium bank vegetation.
	Large	0.025 – 0.050	Grasses and/or weeds with flow depth equal to vegetation height; or weedy beds with thick bank vegetation; or moderate shrub growth across the bed and banks
	Very Large	0.050 – 0.100	Grass and/or weeds more than twice the height of flow depth; or dense, strong reed growth; or significant shrub growth within the channel; or significant inflexible vegetation within channel.
Degree of Meandering (m)	Minor	1.00	Channel sinuosity is 1.0 to 1.2
	Appreciable	1.15	Channel sinuosity is 1.2 to 1.5
	Severe	1.30	Channel sinuosity is > 1.5

It is important to note that a manning's roughness of 0.03 represent a typical deep water short grass channel where high flow velocities of around 2 m/s are expected to cause only minor damage. However, a manning's roughness of 0.08 is representative of the densely vegetated natural channel. A velocity exceeding 1.4 m/s flowing through this vegetation, would be expected to cause significant damage to the vegetation.

6.2.4.4 Drop Structures

Drop structures must be supported by hydraulic modelling or calculations. Preferences for the following models are provided below:

- Chutes: Chute (eWater), HEC-RAS(1D), or industry-standard rock sizing calculations.
- Vertical drop structures: HEC-RAS (1D).

6.2.4.5 Shear Stress Modelling

Shear Stress modelling is a critical component when designing these channels, particularly in assessing the stability and erosion potential during storm events. The following is required for assessment:

- Ensure that velocities and shear stresses are within acceptable limits as shown in Table 9.
- Limit the maximum allowable velocity within the low flow channel to 1.4m/s.
- Preliminary shear stress can be calculated using the following equation to check compound geometry is within the limits of Table 10.

$$\tau = \gamma RS$$

Where τ = Shear Stress N/m^2, γ = the specific weight of water (N/m^3), R = hydraulic radius (m) and S = friction gradient (equal to channel bed gradient for uniform flow, m/m).

- Ensure surface treatment of constructed trunk drainage channels are appropriate for the modelled velocities and shear stresses expected in the channel. Shear stress value limits provided in Table 9.
- The low flow channel must use a combination of short and long native grasses. Alternatives designs may be selected at Sydney Waters discretion and in limited scenarios.

Table 9: Acceptable Stream Stress Values

Boundary Category	Boundary type	Shear stress erosion threshold (N/m²)
Soils	Fine colloidal sand	1.5
	Alluvial silt and silty loam (non-colloidal)	3
	Firm loam and fine gravel	4
	Stiff clay and alluvial silts (colloidal)	12
Gravel/cobble	25mm, 51mm, 152mm and 305mm	16, 32, 96, and 192 respectively
Vegetation	Turf (not to be used)	45 to 177
	Long native grass	80
	Short native and bunch grass	45

The applied (average) shear stress calculated by HEC-RAS needs to be factored up to estimate the maximum shear stresses occurring on the bed and sides of the cross section.

Table 10: Shear Stress Thresholds

Design Event (AEP)	Low Flow Channel	High Flow Waterway
4 EY	Below threshold for boundary material	Below threshold for boundary material
1 EY	Below threshold for boundary material	Below threshold for boundary material
5%	Threshold not exceeded by more than 5%	Below threshold for boundary material

1%	Threshold not exceeded by more than 10%	Below threshold for boundary material

The threshold for long native grasses should be limited within the low flow channel. A high shear stress exceeding the short native grass threshold on the upper banks will only be considered at the discretion of Sydney Water.

6.2.4.6 Hydraulic Flow Types (Froude Number)

The channels shall be designed to achieve subcritical flow. Calculations demonstrating compliance may be requested during the detailed design phase when other flow characteristics are insufficient to make an assessment, non-conformances would need to be suitably justified.

- Subcritical Flow ($0.1<Fr<0.6$): Ensures stable flow conditions, which are ideal for vegetation growth and sediment transport. Vegetated channels should aim for subcritical flow to avoid erosion and support vegetation.
- Transitional Flow ($Fr \approx 1$): Not recommended as it can lead to unstable flow conditions and increased erosion.
- Super Critical Flow ($Fr > 1$): Should be avoided within the channel as it can lead to high velocities and turbulent flow.

6.2.4.7 Hydraulic Flow Regime (Reynolds number)

The channels shall be designed to achieve turbulent flow with low velocities. Calculations demonstrating compliance may be requested during the detailed design phase when other flow characteristics are insufficient to make an assessment, non-conformance would need to be suitably justified.

- Laminar Flow ($Re < 500$): May lead to excessive sediment deposition within channel and is not acceptable.
- Transitional Flow ($500<Re<2000$): Suitable for vegetated channels, especially at the higher end of the range as it allows for mixing without excessive turbulence.
- Turbulent Flow ($2000<Re<20000$): Most open channels operate in this range, providing sufficient mixing and oxygenation of water while supporting vegetation and sediment transport.

6.2.4.8 Street/Site Drainage

Street/site drainage, that connects to the trunk drainage, shall be modelled to ensure that it is not adversely impacted by 1% AEP critical flows in the trunk drainage channels. Points of connection shall be minimised and located on the downstream side of road crossings. On-grade pit inlet capacities should be carefully assessed as most "real life" kerb inlets have limited capacity, often not reflected in the curves provided in hydraulic models.

6.2.5 Design Requirements

6.2.5.1 Connections to Trunk Drainage

All stormwater connections to the naturalised trunk drainage channels must preserve the amenity and stability of the channel while effectively and safely conveying minor to major flows. These connections will be subject to approval by Sydney Water. Outlet arrangement design principles, positioning and general requirements are documented in Stormwater Connections to Natural Waterways (2014).

6.2.5.2 Slope

Typically streams in Western Sydney have a longitudinal slope of 0.4% - 0.8%. the absolute minimum slope on a longitudinal channel will be 0.4%. It is understood that in the upper reaches of the catchment the grades may be steeper. Energy dissipation will be required where grades exceed 1% with a maximum allowable grade of 2% and calculations undertaken to ensure that shear forces generated are suitable for the soils and vegetation.

6.2.5.3 Channel Corridor Width

Channels constructed as part of site development must be designed to fit the corridor widths and locations specified in the planning instruments. Typically, these widths are 20m, 25m, 30m, 40m and can be adjusted to a value between these specified widths, provided the hydraulic modelling and all other requirements are met.

Should the proponent wish to reduce an already planned corridor width, as specified in an existing scheme plan, detailed hydraulic modelling will be requested. This modelling is essential to demonstrate that the reduced corridor width meets all required criteria and the equivalent area lost for biodiversity, ecology and cooling will need to be provided elsewhere within the site. Sydney Water will not provide endorsement or support for these works to be undertaken at a later stage as they are fundamental to the scheme plan.

6.2.5.4 Channel Cross-Section

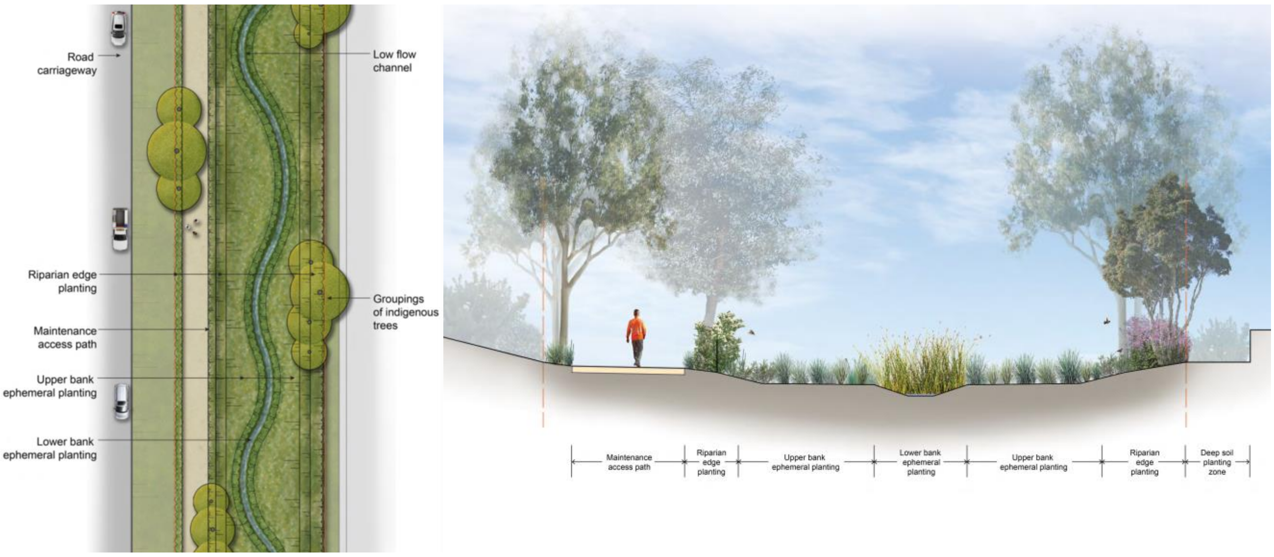
Sydney Water has developed two typical concept sketches for trunk drainage channels:

1. Trunk Drainage Channel Design Typical 1: This design features a compound channel geometry which is the preferred design approach. A rendered graphic of this design is shown in Figure 5, concept sketches are provided in Appendix A.
2. Trunk Drainage Channel Design Typical 2: This design should only be considered where flow or grade constraints make a compound channel unfeasible. An example of such a situation may be in the transition reach between frequent drop structures. A meander in the channel base must still be achieved in this design through continuous variation of the channel bank grades.

When providing cross sections, the designer is to ensure the following details are included:

1. Cross sections are to be provided:
    a. At 20m intervals at strategic and functional design stages or as required to highlight significant changes in site grades, alignment, and anomaly situations.
    b. To indicate 'worst case situations', such as:
        i. Locations where retaining walls are unavoidable or at highest point of a proposed retaining wall (noting that use of and height of retaining walls should be minimised).
        ii. Locations where services are proposed across the channel.
2. Extend cross sections beyond the channel boundaries to show the proposed interface with development adjacent the trunk drainage corridor.
3. Include the minor event water level and flow rate within the channel.
4. Demonstrate a 5% AEP flood immunity level for the proposed maintenance tracks, noting it does not need to be above the 1% AEP level.
5. Include the 1% AEP water level within the channel plus 500 mm freeboard.

Figure 5: Naturalised Trunk Drainage Channel Plan (left) and Cross Section (right) (Typical 1).



6.2.5.5 Channel Long Section

The following details are required to be shown on channel long sections:

- Inverts and top of bank along each reach that demonstrate adherence to max grades and/or inclusion of drop structures as required.
- Tie-ins with critical points i.e. existing grades at upstream and downstream points of the development.
- Proposed major infrastructure crossings or parallel with trunk drainage within the corridor including:
  - Road grades.
  - Retaining walls top and bottom (both sides).
  - Maintenance access track.
- Stormwater pipe long sections connecting to the trunk drainage channels.

6.2.5.6 Solar Access

Solar access must be considered to ensure adequate light penetration for vegetation during winter. Sydney Water requires a minimum of 1 hour of sunlight in mid-winter over the trunk drainage area. Any retaining walls with a height above 2m on the north-eastern, northern, and north-western sides of the channel that do not allow for the 1hour criteria should be set to a maximum slope of 1V:1.5H. This can be accomplished using stepped level planting areas (minimum width of 1500 mm).

These solar access requirements can be challenging for deep trunk drainage channels located on the southern side of high retaining walls or large industrial buildings that cast significant shadows. To evaluate this impact, shadow diagrams may be necessary for assessment.

6.2.5.7 Drop Structures

Drop structures will be required for slopes steeper than 2% to maintain vegetated channel grades. Channels with a slope of less than 2% should avoid using drop structures or use drops at road crossing points. Designers should consult with Sydney Water during the project's early concept design stage to determine the appropriate use of these structures.

Key design criteria for drop structures are as follows:

Flood Resilience:

- Drop structures must be designed to withstand all events up to and including the 1% AEP flood event.
- Designs are to be supported by hydraulic modelling and/or appropriate hydraulic calculations.

Preferred Materials:

- Sandstone logs are preferred for rock chutes or near vertical rock drop structures.
- Wood or grouted structures will generally not be accepted.

Scour Protection:

- All drop structures must include appropriate scour protection and dissipation to protect the upstream and downstream channels.

Frequency and Vegetation:

- Aim to maximise the extent of vegetated channel and minimise the use of rock.
- Consultation with Sydney Water is required where the length of drop structure and associated rock lined channel exceeds the length of vegetated channel, or the length of the vegetated channel is less than 50m between drop structures.
- Low flow channels that are entirely rock lined are a poor outcome and should be designed out as much as possible.

Vertical Drop Structures:

- The recommended drop across the system is 500 mm.
- Larger drops up to a maximum of 900 mm may be accepted subject to local constraints and safety in design protocol.

Rock Chutes:

- Rock chutes should generally be 1V:5H or flatter with a maximum height of 1.2m from chute crest level to base level (excluding pool depth).
- Vertical drop structures are preferred where these criteria do not suit local conditions.
- Rock placed in chutes must be placed over a layer of suitably graded filter rock or geotextile filter cloth (min bidim A24 or equivalent). The geotextile filter cloth must have sufficient strength and must be suitably overlapped to withstand the placement of the rock.

Soil Considerations:

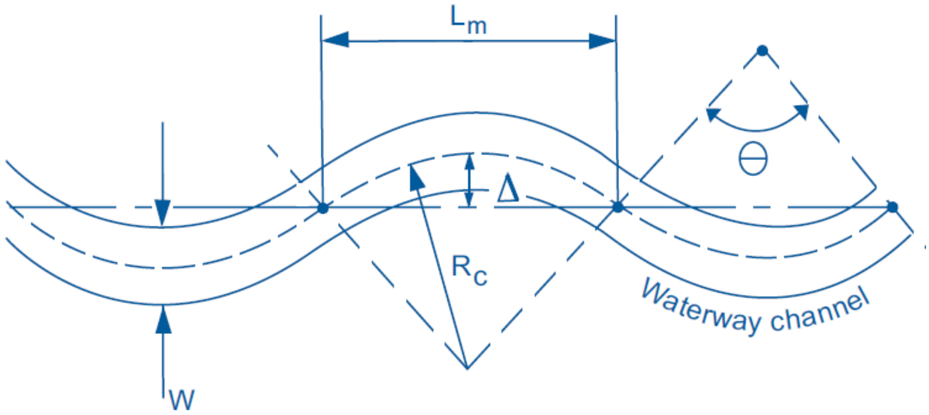
- The design must account for potential dispersive in-situ soils.
- A geotechnical engineer will need to assess additional treatment for dispersive soils, typically requiring a layer of non-dispersive soil at the interface with underlying in-situ soils for the full length of the drop structure and associated scour protection.
- If the rock is placed on a dispersive soil, then prior to placing the filter cloth, the exposed bank must first be covered with a layer of non-dispersive soil of 300mm thickness.

6.2.5.8 Planform (sinuosity)

In urban waterways, space constraints due to development and infrastructure necessitate controlling the natural processes of erosion and deposition. The constructed waterway form is designed to remain constant over time. While sinuosity is encouraged for the high flow channel, the focus is on the low flow channel.

Design for sinuosity should avoid perfectly smooth and repetitive 'sine curve' meanders as shown in Figure 6. Irregular channel meanders are preferred, as they provide greater stream diversity and ecological benefits.

Figure 6: Sinuosity diagram (Brisbane City Council, 2000)



Sinuosity calculations and are to be provided at detailed design that clearly show a value > 1.05. If not achievable during the strategic design stage, the designer should engage Sydney Water for advice. Sydney Water will not support a reduction in channel width justified by a reduction in sinuosity. The following equations are to be utilised for calculating sinuosity:

Average wavelength

$$L_m \geq 10 \times Low\ Flow\ Channel\ Top\ Width\ (W)$$

Minimum sinuosity of 1.05, where:

$$Sinuosity = \frac{Low\ Flow\ Channel\ Length\ (m)}{Corridor\ Length\ (m)}$$

Minimum centreline radius of curvature

$$R_c \geq 3 \times Low\ Flow\ Channel\ Top\ Width\ (W)$$

Minimum outer radius of curvature

$$R_o \geq 3.5 \times Low\ Flow\ Channel\ Top\ Width\ (W)$$

Where, L_m = Average Wavelength, R_c = Centreline Radius Curvature, R_o = Outer Radius Curvature

It may not be feasible to achieve the above sinuosity criteria where a Trunk Drainage Channel Design Typical 2 is required for flow or grade constraints. In this instance the sinuosity of the low flow channel should be maximised as much as practical.

6.2.5.9 Rock Lined Low Flow Channel

Rock armouring should be avoided wherever possible considering the natural character of Cumberland Plains waterways. Instead, designs should focus on minimizing shear stresses and velocities through shallow longitudinal grades, stream meanders, and using drop structures to manage elevation changes.

A rock lined low flow channel should only be used where velocities and shear stresses exceed the acceptable values in Section 6.2.4 for a fully vegetated low flow channel and for limited distances. If these values are likely to be exceeded, consult with Sydney Water early in the design process. Sydney Water will provide design advice and requirements on a site-by-site basis. Sydney Water will not endorse a low flow channel that is completely rock lined.

If rock lining is required, the thickness of rock armouring should be sufficient to allow at least two overlapping layers of the nominal rock size. The thickness of rock protection must also be sufficient to accommodate the largest rock size. The additional thickness will not compensate for undersized rock.

6.2.5.10 Culvert Outlet Energy Dissipation

Energy dissipation will be required downstream of a culvert entering a Sydney Water trunk drainage channel. The energy dissipation will need to account for both minimum and maximum tailwater conditions to minimise downstream erosion as much as practicably possible. Consult with Sydney Water for further information.

6.2.5.11 Retaining Walls

Sydney Water will not support 1% AEP water levels against retaining walls supporting developments or roads (public or private). Sydney Water will only accept 1% AEP water levels against retaining walls when they are caused by backwater effects created by restricting flow through a culvert into regional stormwater basins.

While it is acknowledged that structural design of retaining walls and footings can be engineered to minimise or prevent damage during flooding events, issues with retaining walls present a significant risk to channel performance during large/major rainfall events.

Sydney Water intends to take ownership of retaining walls within the channel reserve when:

- leading up to culverts, drop structures or other drainage related infrastructure.
- supporting a Sydney Water maintenance track.

Sydney Water will not take ownership of retaining walls which:

- support public or private roads.
- support adjacent development (including private roads).

These walls are to be situated on private land and remain a private asset. Ownership of the retaining wall is to be clearly marked on the drawings. The extent of the Trunk Drainage channel should be shown on plan.

Design criteria for Sydney Water owned retaining walls are as follows:

- Redi-rock or equivalent sandstone look retaining walls at culvert locations.
- In other areas of the channel design (e.g. drop structures) other approaches such as sandstone log walling is acceptable.
- Footing design is to be signed off by a suitably experienced and qualified engineer.

6.2.5.12 Maintenance Access

A maintenance access track should be provided to allow easy and safe access for:

- Regular maintenance into the channel by foot with a service vehicle (Ute or small truck) parked on the maintenance access track to minimise lifting heavy equipment or moving material on long distances (such as garden waste bags).
- Regular inspection of critical assets/components by foot with a car or Ute parked on the maintenance access track to minimising walking long distances.
- Infrequent maintenance, such as sediment/blockage removal (etc.), that might require a small excavator, or spider excavator, with a small truck to access the channel via the track.

Design hierarchy:

- Optimal - No maintenance track required subject to all the requirements below are met:
  - Trunk drainage that borders a road with a shared user path (minimum 3 m wide for full length) and has suitable areas to park a maintenance vehicle on path/verge (not on road) safely without forcing public onto road.
  - Has no continuous retaining walls (no part can be >500 mm) or other access constraints (fencing etc.) from shared user path to channel. Ideally there should be no retaining wall in sections every 50 m, allowing easy access for maintenance equipment (small excavator etc.).
  - No reversing required.

- Preferred - a drive through system.
  - Can be private road to private road or private to public road.
  - No reversing is required.
- Optional with SWC approval.
  - Drive in and have the ability to perform a turnaround (“T” section) with minimal reversing (max 50m)
- Not acceptable maintenance access:
  - Access to channel via stairs or ladder.

Standard requirements:

- Minimum 3.5m wide.
- Constructed using crushed sandstone or road base or equivalent approved by SWC.
- Suitable subgrade to withstand 5 tonne.
- Located above or within the upper bank level (can be within 1% AEP but above the 5% AEP).
- Cross-fall towards channel min 1% max 3%.
- Longitudinal grade max of 1:6 and will require scrape tests for all sections of the track between 1:6 to 1:10.
- No sharp bends, suitable for a service vehicle as per Ausroad guidelines.
- Suitable driveway and layback from local or private road and not be located where it could be considered dangerous to enter/exist driveway, generally near a major intersection or traffic congestion point (roundabout or similar)
- Ensure that egress from the driveway is safe to the public (sightlines and similar).
- Needs to allow easy access for maintenance operators (pedestrian access < 100m from vehicle) to the full channel length.
- Retaining walls might be required to support the maintenance access track (mainly for ramps in and out and near drop structures). If required, they are to designed and certified by a structural engineer and be designed in consultation with Sydney Water civil specifications. Sydney Water will own and manage these retaining walls as part of the trunk drainage channel.
- Suitable access to essential infrastructure components including pipe/culverts, headwalls, drop structures and rip rap areas.

Other requirements include:

- Lockable gate or bollards to exclude un-authorised vehicle access.
- Be signposted “authorised access only”.
- Be signposted with Sydney Water approved Flood Zone Warning signs.

6.2.5.13 Irrigation Requirements

A permanent irrigation system is required to assist in plant establishment and longevity, as well as to increase cooling benefits. This system must use recycled water from the purple pipe network and have its own independent or direct connection. Private development recycled water supply is not permitted for use in the trunk drainage channel.

The irrigation system is to be located on both sides of the channel and provide a minimal of 600 mm/year over a minimum of 50% of the area.

The specific design requirements include: TBC.

6.3 Modification to Existing Waterways

6.3.1 Purpose and role in scheme

Existing waterways and their riparian zones are crucial for maintaining the ecological health of the Wianamatta – South Creek catchment. Rehabilitating these waterways protects the health and structure of the receiving waters, mitigates erosion impacts, and restores flows to a more natural state, benefiting the ecological environment and providing cooling to the surrounding area. All existing waterway treatment must be referred to NRAR and comply with their publication Guidelines for controlled activities on waterfront land – Riparian corridors. Other document that may be helpful are Good practices in riparian rehabilitation.

Prior to commencing any feasibility or development applications, Sydney Water recommend the developer submit a request to NRAR relating to the works proposed to understand their requirements. The outcomes below will impact the advice provided from Sydney Water.

(a) If NRAR imposes conditions, present these to Sydney Water as part of a feasibility assessment.

(b) If NRAR does not impose any conditions, present a letter from NRAR confirming these positions.

Note that the developer may provide a feasibility assessment without a letter from NRAR but should be advised that any advice from Sydney Water would be subject to NRAR approval.

6.3.2 Modelling Requirements

For areas covered by Wianamatta – South Creek Catchment Flood Study “Existing Conditions” (Advisian, 2022), refer rehabilitation concept designs to INSW and the relevant local government authority to ensure compliance with the floodplain management plan and controls. For areas outside this study, hydraulic modelling will be required to achieve floodplain management controls. Refer to the latest ARR for process and procedure for flood modelling hierarchy. Modelling requirements for these areas are provided in Section 6.2.2.

6.3.3 Design Requirements

6.3.3.1 Connections to Natural Waterways

All stormwater connections to the existing waterways shall be made in a manner to preserve the amenity and stability of the channel while effectively and safely conveying minor to major flows. All connection points to existing waterways will be subject to NRAR approval.

Requirements for connections to natural waterways are documented in Stormwater Connections to Natural Waterways.

6.3.3.2 Corridor Width

The corridor width for existing waterways will be in line with the waterways Strahler order and the riparian width requirements documented in the Guidelines for controlled activities on waterfront land – Riparian corridors. The designer must also confirm that the critical 1% AEP flows are contained within the riparian corridor.

Note that the design flows (based on the undeveloped peak flowrates) must consider the impact of OSD requirements provided in the Mamre Road and Aerotropolis DCPs respectively. If OSD is not provided on site, then the corridor width may need to be increased to accommodate the additional flow. Designers will need to assess these constraints prior to commencing design.

6.3.3.3 Maintenance Access

It is recommended that the designer discuss maintenance access requirements with Sydney Water early to get a better understanding of what may be requested.

6.3.4 Construction, operation, and maintenance considerations

6.3.3.4 Construction Staging

As there should be only minimal construction works within the existing waterway, there is minimal ability to stage construction works. The revegetation of a channel bed or low banks should be delayed if there is an expectation of significant development upstream within 5 years. Contact Sydney Water to determine if a staging plan is required.

6.3.3.5 Operation and maintenance

The existing waterway dedicated to Sydney Water will need to be maintained by the developer from practical completion to handover, which would typically be 2 years (24 months).

Please refer to the Scheme Reporting Requirements for more information about the requirements during this period. Sydney Water will not accept this asset until all requirements are completed to Sydney Waters satisfaction.

6.4 Gross pollutant traps

Regional “end of pipe” gross pollutant traps (GPT) in the previous draft scheme plan included a GPT upstream of each regional basin. This requirement has been updated to only require GPT upstream of potentially high litter catchments, due to reduce:

- High costs for diversion structure and gross pollution trap (CAPEX and OPEX) that did not lead to significant size reduction of the downstream assets.
- Duplication of GPT assets on industrial/commercial lots and regional stormwater scheme. GPT is to be provided on lot.

6.4.1 Purpose and Role in Scheme

The primary purpose of these devices is to remove floating litter, minimising the need for manual removal by Sydney Water from the downstream sediment basin/wetland, will lead to poor aesthetics and wildlife outcomes.

Regional GPT’s are only required on catchments that are predicted to generate high volumes of litter. High litter load catchments are those that have:

- A primary or high school.
- More than 1 fast food outlets or petrol station.
- A commercial shopping centre with more than 5 shops.
- Has more than 4 ha of sporting fields or is considered a regional recreation area.

The design of the channel and GPT configuration, either online or offline, will determine the type of GPT to use.

6.4.2 Online System GPT

Online systems have an open channel that flows directly into an online sediment basin. The GPT should be a litter trap, such as a Baramy device, that can be installed within the channel without a solid diversion structure. It should store material outside the main flow path and incorporates provision for maintenance access.

6.4.3 Offline System GPT

Offline systems typically use a stormwater pipe with diversion weir to direct treatable flows into the offline sediment basin. This configuration is used when there is no open trunk drainage channel or a direct connection from a development to the regional system. Underground devices such a continuous deflective separator (CDS) system, may be used but will need to be discussed with Sydney Water.

6.4.4 Performance Outcomes

Online GPT System

The following are the main performance outcomes for trash/litter rack are:

- Remove up to 90% of trash or litter over 5mm in size.
- Treat flows up to the 4EY storm event.
- Ensure the device is easy to inspect and maintain with minimal manual handling.
- Store litter and other pollutants (organic matter and gravel etc.) in a dry state to allow for disposal without additional drying. This is not achievable for underground assets.

GPTs which store gross pollutants in line with screens are not acceptable due to the reduction in conveyance capacity when full.

Offline GPT System

The following are the main performance outcomes for an underground GPT downstream of a diversion weir:

- 45% removal of Total Suspended Solids (TSS) incoming loads from:
  - All private land excluding land zoned as IN1 /commercial as they should have their own GPT.
  - Public land excluding the residual TSS load from tree pits.
- 90% of gross pollutants where gross pollutants are defined as particles larger than 5 mm in diameter.
- The design is to ensure the downstream extended detention depths are considered when sizing the GPT (i.e. having a submerged outlet).

6.4.5 MUSIC Modelling Requirements

The following requirements shall be adopted:

- The GPT shall have a treatable flow rate greater than the 4EY. A MUSIC model is required to demonstrate compliance with the performance targets.
- Online GPTs are to be located above the regional floodplain to ensure the litter collected is not going to be suspended by the regional flood waters.
- The storage area shall be designed to store the gross pollutant and course sediment load assuming maintenance twice per annum. The designer shall assume a minimum sediment and GPT loading rate of 1 m^3/ha/annum.

6.4.6 Components and Design Requirements

Table 11: Online GPT's Components and Design Consideration

Component	Purpose	Requirements/considerations
Diversion system or vanes	Divert treatable flows to the pollution storage area.	This may require bank protection on the outside end of the vane to prevent erosion or scour. The vanes are to be installed as per the manufacturers and Sydney Waters recommendations.
Gross pollution collection area and screen	Capture litter and organic matter within the storage area for easy removal.	As per manufacturer's requirements.
Access ramp	Allow plant to easily and safely enter the collection area and in front of the vane for maintenance.	Requires reinforced concrete to be specified by design engineer and be no steeper than 1(V):6(H).
Outlet or discharge area	Prevent erosion or scour from stormwater draining out of the collection area.	Requires erosion protect to be specified by design engineer.
Truck access point	Allow removal of waste collection area without double handling or excessive plant movements.	4 m wide reinforced concrete access point suitable for 40 tonne truck.
Hard base	Allow machinery to scrape sediment off the base.	Refer to the manufacturer's specification for base of the storage area and surrounding the diversion vane (3 m upstream and downstream).

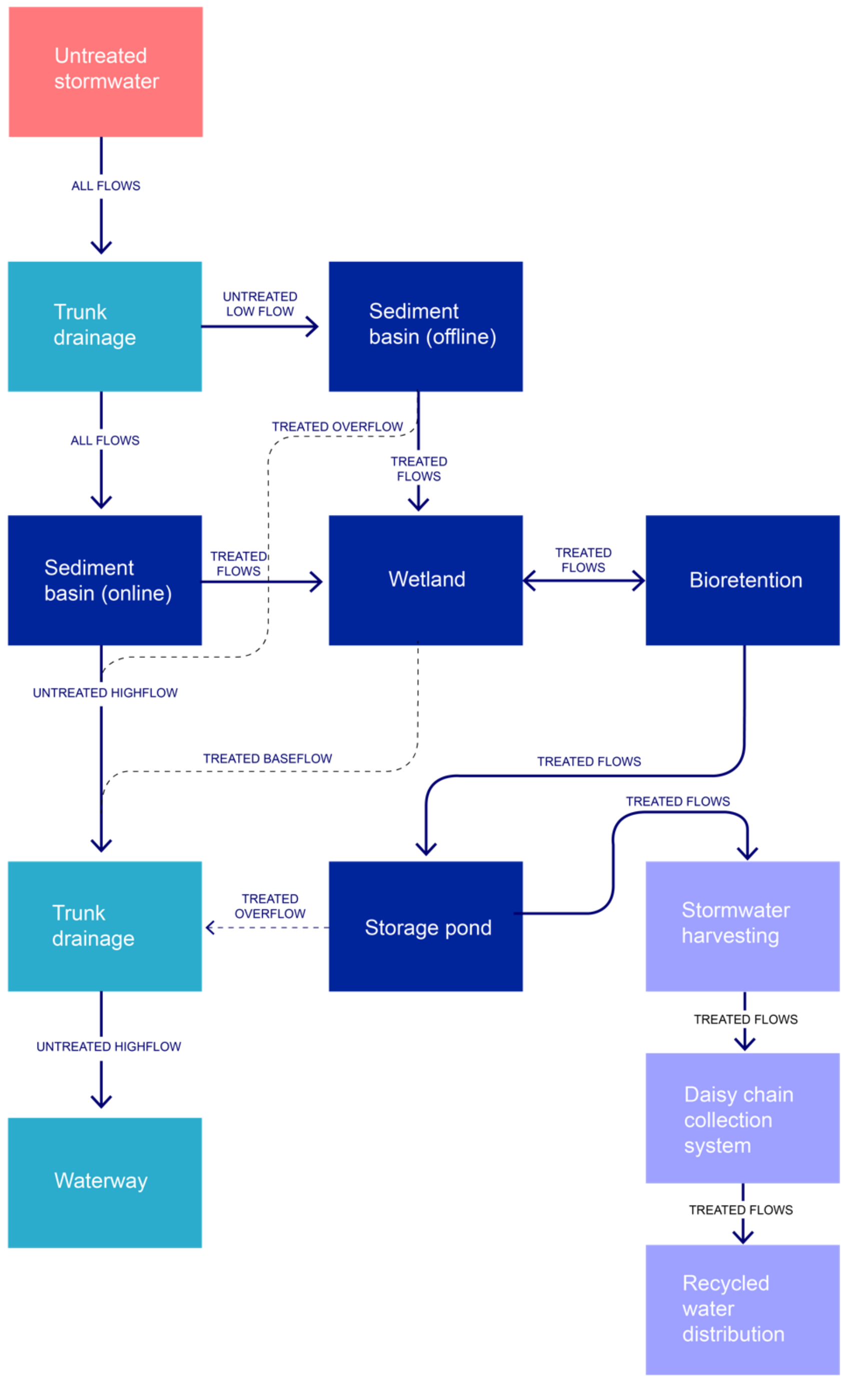
Table 12: Offline GPT's Components and Design Consideration

Component	Purpose	Requirements/considerations
Upstream diversion weir	Push treatable flows into GPT and into the sediment basin.	Generally, a concrete structure within a pit that has access for maintenance.
GPT structure and screen	Filter stormwater to capture gross pollution.	Designed as per manufacturer's recommendations.
GPT sump (collection area)	Store gross pollutants so that they can be safely and easily.	Designed as per manufacturer's recommendations.
Access track	Allow plant to remove the waste easily and safely from the GPT sump and clean behind the screen.	4 m wide reinforced concrete access point suitable for 40 tonne truck.
Inlet and Outlet pipes	Allow flows through the device without impacting its performance.	Designed as per manufacturer's recommendations to achieve the desired flow rates.
Hydraulic grade line (HGL)	Ensuring the HGL upstream of the GPT does not rise above the diversion weir for the design event.	An initial k_u Value of 1.2 may be used but must be verified by the manufacturer.

7. Regional Stormwater Scheme

The regional stormwater scheme is the end-of-line WSUD measures adopted by Sydney Water to achieve the Wianamatta-South Creek stormwater targets set by the NSW Government. It consists of either an online or offline sediment basin, a wetland, a bioretention system and a storage pond, as shown in Figure 7.

Figure 7: Regional Stormwater Scheme



7.1.1 Design Flow and Diversion

Controlled stormwater flows through the regional WSUD system are crucial for achieving the desired water quality and quantity targets. High flow bypass systems need to be incorporated upstream to divert excess flows and ensure WSUD assets perform effectively at specific flow rates. Excessive stormwater can cause damage or increase the maintenance demands, impact operating cost. Therefore, having proper controls at each inlet and outlet is vital for the scheme to function as intended.

The preliminary sizing for the design high flow bypass aims to capture the peak flow of the 4EY from the catchment resulting from the first 12mm of rainfall over the full range of ‘frequent’ temporal pattern ensembles from ARR2019. This 12mm depth should be the equivalent sum of the extended detention depth volumes of the sediment pond, wetland, biofiltration and pond.

It is important to verify this depth when the basin is oversized or undersized for its catchment. Early consultation with Sydney Water is recommended for further guidance on high flow modelling.

7.1.2 Recycled water demand MUSIC modelling

Sydney Water’s demand assumptions differ from the DPHI guideline and significantly affect stormwater infrastructure. Sydney Water demand assumptions balance acceptable risk to the Stormwater Scheme’s compliance with the Waterway Health Targets and Capex. See Table 13 for adopted reuse rates.

Table 13: MUSIC Modelling Reuse Rates

Land-use (zoning or description)	Music node	Recycled water usage rate	Application on land
Industrial development (IN1)	Lot roof and road impervious	3.8 kl/ha/day	100%
Content goes here	Lot perviousness, Road perviousness	600 mm/year	50%
RE1 - Public open space and RE2 – private open space	Landscape	600 mm/year	50%
Floodplain	Revegetation	600 mm/year	100%
Regional stormwater basin batters	Revegetation	600 mm/year	100%

The monthly recycled water demands for outdoor and open spaces are provide in Table 14.

Table 14: Non-potable water demands for outdoor & open space

Mon	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Tot
%	13	6	6	4	2	0	4	7	12	14	13	19	100

7.1.3 Inter-Asset WSUD Connections

Each regional WSUD system will encounter unique site constraints, such as topography, which influence their design and implementation. These variations affect how stormwater flows through the system to achieve the desired stormwater quality and quantity targets. Despite the differences among basins, a standard scheme has been proposed to ensure consistent water flow across different catchment locations.

7.1.4 Stormwater Scheme Pit and Pipe

7.1.4.1 Step Irons

Step irons shall be provided to all access points at 300mm centres to allow for comfortable access.

7.1.4.2 Pipe Size and Type

General requirements include:

- Pipes shall have a minimum diameter of 375mm.
- Pipes should minimise deflection angles and pit losses (45° desirable maximum).
- Flow velocities should exceed 0.7m/s for self-cleansing purposes.
- The inlet and outlet drain to pipelines shall be carefully designed to avoid either scouring or silting velocities during storm flows, and adequate scour protection.
- Pipe Material include Reinforced Concrete, Fibre Reinforce Concrete and UPVC pipes.

7.1.5 Wildlife Management

Refer to Sydney Waters Wildlife management policy for further details.

7.1.6 Locating WSUD Within the Floodplain

Sydney Water will support WSUD located within the 1% AEP flood extents subject to compliance with the LGA LEP requirements and Aerotropolis / Mamre Road Precinct DCP. Sydney Water advises the proponent that Sydney Water is not the consent authority for the floodplain. The following information is taken from the “Technical guidance for achieving stormwater management targets” (DPE 2022) and are adopted as part of the requirements.

When locating WSUD measures on the floodplain, two important factors need to be considered:

- WSUD measures should not adversely impact on flood behaviour, the community locally and at a strategic catchment scale.
- WSUD measures are not washed away or destroyed up to a defined flood event.

In accordance with these factors, WSUD measures may be located within the 1% AEP flood extent provided the following criteria are met:

- No adverse impact on regional flood behaviour or the community, in accordance with a Flood Impact and Risk Assessment (FIRA) undertaken by a qualified professional engineer.
- Considering the following areas as identified in Wianamatta South Creek Catchment Flood Study – Existing Conditions (Advisian 2022):
  - WSUD measures are allowed within the 1% AEP flood fringe areas provided the first bullet point above is demonstrated.

- WSUD measures are allowed within the 1% AEP non-critical flood storage areas provided the first bullet point above is demonstrated.
- WSUD measures are avoided in flood conveyance areas (i.e. 1% AEP floodway and high floodway) and 1% AEP critical flood storage areas, other than waterway rehabilitation, waterway diversion works, dam rehabilitation works or works to support significant stormwater harvesting infrastructure. Any works must demonstrate the first bullet point above.
- WSUD measures are to achieve the levels of protection suggested in Table 8.

- Generally, WSUD measures should be located offline from external waterways for drainage areas greater than 25 ha to provide a level of protection from flood related damage.
- Appropriate hydraulic modelling should confirm the relevant flood levels, velocities, and inundation periods. Where a WSUD measure is potentially prone to high velocity, a geomorphic assessment may be required to confirm the WSUD measure, and associated embankments will be stable and will not cause erosion in an adjacent waterway.

Table 15: WSUD Requirements on Floodplain

Component	Sediment Basin	Wetland	Bioretention	Pond
Top of embankment	Must be located above the 63% AEP water level + 200 mm freeboard for regional flooding	Must be located above the 63% AEP water level in the adjacent receiving waterway with 200mm freeboard for regional flooding. (Discuss with Sydney Water for Aerotropolis Precinct)	Must be located above the 50% AEP water level + 200mm freeboard for regional flooding. (Discuss with Sydney Water for Aerotropolis Precinct)	Must be located above the 63% AEP (local flooding) or 50% (regional flooding) AEP water level + 200mm freeboard.
Embankment (internal and external) Velocity Threshold	Designed to withstand flood velocities for all events up the 1% AEP. Allowance to be made for appropriately sized rock armour for flows above 1 m/s.	Designed to withstand flood velocities for all events up the 1% AEP. Allowance to be made for appropriately sized rock armour for flows above 1 m/s.	Designed to withstand flood velocities for all events up the 1% AEP. Allowance to be made for appropriately sized rock armour for flows above 1 m/s.	Designed to withstand flood velocities for all events up the 1% AEP. Allowance to be made for appropriately sized rock armour for flows above 1 m/s.
Velocity over surface	-	Velocity over the surface must be less than 0.5 m/s in the 20% AEP and 1 m/s in the 1% AEP.	Velocity over the surface must be less than 1 m/s in the 1% AEP.	-
Inundation Period	-	Inundation period must be less than 3 days (local flooding) and 5 days (regional flooding) for events up to the 63% AEP.	Inundation period must be less than 12 hours (local flooding) and 24 hours (regional flooding) for events up to the 63% AEP.	-

NRAR Requirements	The design must adhere to the “Guidelines for controlled activities on waterfront land: Riparian corridors” (DPI–NRAR 2018)

7.1.7 Stormwater Scheme Space Reservation

Sydney Water has conducted an extensive design of the stormwater scheme and provides the following guidance for reserving space for stormwater infrastructure. The space reservation is based on the total contributing catchment and serves as an initial guideline for the proponent. However, it does not replace values derived from detailed engineering modelling.

Table 16: Stormwater Scheme Space reservation

Stormwater Asset	% of Contributing Catchment
Sediment Basin	0.14
Wetland	1.4
Bioretention Pond	0.6
Pond	3.3
Total (including Access Tracks and Batter)	7% - 8%

7.2 Sediment Basin

The design guidelines from December 2022 required sediment basins to be offline, receiving treatable flows from a diversion structure with pre-treatment via a gross pollution trap. This requirement has been updated to allow sediment basins to be either online or offline.

- Online sediment basins are recommended for open drainage channels with sufficient space and access, as they reduce land use and simplify system maintenance.
- Offline sediment basins should be used when piped drainage or site constraints make online basins impractical. Early consultation with Sydney Water is advised for optimal configuration.

7.2.1 Purpose And Role in Scheme

Sediment basins are a widely recognised stormwater management system, playing a crucial role in protecting natural waterways. They achieve this by:

- Enhancing evapotranspiration to reduce Mean Annual Runoff Volume (MARV) and meet flow-based stormwater targets.
- Collecting and retaining sediment, floating debris and litter specifically where there is no upstream GPT.
- Controlling and allowing treatable flows as outlined above to enter a wetland while bypassing higher flows.

7.2.2 Performance Outcomes

Sediment basins are required to achieve the following performance outcomes:

1. Removing coarse sediment (125 µm or larger) through settlement for 4EY flow events.

2. Capture coarse sediments before stormwater flows into the downstream wetland and improving water quality.

7.2.3 MUSIC Modelling Requirements

Refer to Section 7.3.3 for sediment basin MUSIC modelling parameters. The calculated volume is the volume to be used for designing the physical dimensions of the online or offline sediment basin.

7.2.4 Components And Design Requirements

Table 17: Sediment Basins Components

Component	Purpose	Details / considerations
Inlet and outlet system	Control stormwater entry and prevent scour and lifting of sediments.	Refer to AERO-RSI-GA-SK01 online sediment basin and AERO-RSI-GA-SK02 for offline sediment basin configuration. The designer is to ensure sufficient erosion and scour protection for all inlets.
Water level control pit to Wetland	Ensure stormwater pretreatment entering wetlands.	This control pit must include: • A 900 mm x 900 mm x min. 900 mm deep pit with the top set at the NWL and litter screen cage to prevent debris blockage. • A DN300 uPVC pipe connection to the outlet control pit which houses a drop board to isolate the sediment basin. • An outlet pipe (size determined by designer) connected to wetland. For more detail see AERO-RSI-SB-SK04.
Edge treatment	Minimise the likelihood of attracting birds to the "mud flats".	Use of sandstone logs as per AERO-RSI-SB-SK03.
Liner	Prevent stormwater infiltration and groundwater entry.	Refer to liner specifications for further details.
Safety Bench	Ensure safe entry and exit from sediment basin.	All batters around the edge of the sediment are to be 1V:8H for the initial 2.4 m. Refer to AERO-RSI-SB-SK03.
Internal Batters (Sediment Storage Zone)	Ensure safe entry and exit from sediment basin during maintenance.	Sediment storage zone batters are to be a maximum 1V:3H. Refer to AERO-RSI-SB-SK03.

7.2.5 Design Requirements

7.2.5.1 Sediment Basin Size

Sediment basins are to be sized to target 95% removal of particles greater than 125µm for all storm up to the 4EY storm events. Preliminary sizing for an online sediment basin, when combined with a wetland, should be 0.14% of the contributing catchment but may be optimised on reasonable grounds. This initial estimate does not replace the necessity for modelling. Offline sediment basin volume is to be determined by design.

7.2.5.2 Shape

The shape of the sediment basin must ensure it is integrated into the trunk drainage channel (online) or wetland (offline) and is required to:

- Maximise the length to width ratio with a minimum of 4L:1W to promote sediment settling without short circuiting.
- Minimise longitudinal bends to facilitate ease of maintenance.
- Maximise travelling distance for sediment settling.

If space for a combined offline sediment basin and wetland is limited, do not reduce the size of the sediment basin, reduce the size of the macrophyte zone instead.

7.2.5.3 Depth and Storage Volume

The sediment basin must provide sufficient storage volume for sediment cleanout every 5 years. The design must meet the following storage criteria:

$$V_s > V_{s:5yrs}$$

Where:

V_s is the storage volume in the bottom half of the permanent pool depth, V_s calculated as the product of the sedimentation basin area (A_b) and half the permanent pool depth ($0.5 \times d_p$), with consideration of the internal batters.

$V_{s:5yr}$ is the volume of accumulated sediment over 5 years, determined by assessing sediment loads entering the basin and the fraction of target sediment removed (R).

7.2.5.4 Inlet Dissipation and Scour Protection

When the longitudinal grade of the incoming trunk drainage channel exceeds 0.8% for an online sediment basin, a drop structure with a rock apron or scour protection structure is required. The vertical placement of the apron will be dependent on incoming trunk drainage levels. Maintain the channel grade between the drop structure and the upstream batter slope of the sediment basin below 0.8%.

If this is not feasible, consult with Sydney Water as additional scour protection may be needed for the upstream batter slope of the sediment basin.

7.2.5.5 Maintenance Access Requirements

The following design components are required:

- Access from public road to sediment basin:
  - Suitable wide driveway and layback that can withstand 40-tonne vehicle that is 12.5 m in length, use the Austroads single unit truck 12.5 m as a guide.
  - Include a lockable gate to exclude un-authorised vehicle access.
  - Be signposted “authorised access only”.
  - Ensure there is suitable visibility to ensure pedestrians/bike riders can be seen (no tall hedges).
  - Ability to close the main access path at both ends to exclude the public (small barricade/gate or similar), especially when excavation works are occurring. 4 m wide track, reinforced concrete, with a parking area access track capable of supporting large vehicles.
- Dedicated concrete access point to allow maintenance vehicles to access the sediment storage zone without excessive civil works. Maintenance vehicles include:

  - For small systems that can be maintained from the side, a 4 m wide ramp to the bench within the sediment pond, allowing the excavator to sit 1 m above the top sediment level. The maximum grade from the maintenance track to the bench is 1V:6H (recommended 1V:10H).
  - For large systems, the above access for a long reach excavator with suitable access for a Spider excavator to enter the base and move sediment to a location for removal by a long reach excavator.
  - Truck of suitable size to transport wet material to dewatering area.
- A dewatering area that is approximately 25% of the basin area (at NWL) and drain towards the basin for sediments drying, incorporating the following:
  - Be accessible from the access ramp and parking area.
  - A minimum length to width ratio of 10:1 (consult with Sydney Water when unachievable).
    - Contain all sediment removed, spread out at a maximum depth of 500 mm and once dry be accessible for a Bobcat or small excavator to load dry material into truck for removal.
    - Be located to drain back into the sediment basin and away from access tracks
    - Be located at least 50 m from residential or public open space areas for potential odour and visual issues to residents.
    - Address public safety and impacts on public access to open space areas.

Note, the dewatering area can be part of the maintenance access track itself in systems where there is no space to include a dedicated dewatering area. However, if this is to occur the following needs to apply:

  - the needs for alternative access to the rest of the system for maintenance vehicles (the sediment can't block all access to the system).
  - The access track can be isolated to prevent public access (barrier or gates).
  - Will need to be wider than the normal path (min. 5 m wide)
- Other considerations include:
  - Suitable access to hydraulic structures (e.g. inlet and outlet pipes, bypass weir, pits, etc.). Ideally all these assets should be accessible by foot (preferably dry but can be wet) or within 5 m from utility or light truck with a Hiab.

Image 1 – Melbourne Water (https://www.melbournewater.com.au/media/602/download)

7.3 Constructed Wetlands

7.3.1 Purpose and Role in Scheme

Constructed wetlands are a widely recognised stormwater management system, playing a crucial role in meeting the Wianamatta-South Creek stormwater targets. They achieve this by:

1. Treating urban stormwater to make it is suitable for non-potable reuse. This is achieved by adhering to the multiple barriers approach required by the National Water Quality Management Strategy as detailed in the “Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (phase 2) Stormwater harvesting and reuse” (July 2009).
2. Enhancing evapotranspiration losses, which aid in the reduction of Mean Annual Runoff Volume (MARV) to meet flow-based stormwater targets.
3. Slowing and detaining flows within the EDD above the normal water level, helping to meet specific flow percentile targets such as the 90th percentile flow target.

7.3.2 Performance Outcomes

Constructed wetlands are to achieve the following performance outcomes:

1. Facilitate evapotranspiration of stormwater to meet the MARV requirements.
2. Enhance the aesthetics and cooling of the surrounding area, creating a comfortable and attractive environment.
3. Act as a combined extended detention storage and capture fine sediments before stormwater flows into the downstream bioretention system.

7.3.3 MUSIC Modelling Requirements

Table 18: MUSIC Modelling Parameters

Component	Acceptable parameter
Inlet/sediment pond volume	Sized to target 95% removal of 125µm particles for 4EY flow events
Low flow bypass (m^3/sec)	0
High flow bypass	As outlined in Section 7.1.1
Extended detention depth	Maximum of 350mm
Permanent pool volume	0.3 – 0.4 m x wetland surface area
Exfiltration rate (mm/hr)	0 or <1 x 10^{-8} m/s
Evaporation loss as % of PET	125%
Outlet pipe properties	Adjust to ensure notional detention time is within range
Notional detention time	48 to 72 hours for detention depths of 100 to 350mm
K & C values	Use default values

7.3.3.1 Combined Wetland and Bioretention System

When the wetland is combined with a bioretention system and the levels of both systems are the same, they can share the extended detention. In this case, the MUSIC modelling method changes such that:

- EDD between 0 - 50 mm above NWL must use the wetland surface area. This treat flow is directed back into the trunk drainage channels, bypassing the rest of the WSUD system to maintain base and environmental flow to the waterways.
- EDD between 50 – 350 mm above NWL use the combined bioretention and wetland surface area. Stormwater flows are directed into the bioretention systems for further treatment before being discharged into a storage pond (described in Section 7.5).

7.3.4 Components and Design Requirements

Table 19: Wetland Components

Component	Purpose	Details / considerations
Inlet system	Control stormwater entry and prevent damage to macrophytes.	The main inlet pipe, from the maintenance pit (AERO-RSI-SB-SK04), is to discharge into a deep-water inlet zone within the wetland. Alternative inlets, from the high flow system (AERO-RSI-SB-SK05) is to discharge at the wetland NWL. The designer is to ensure sufficient erosion and scour protection for all inlets.
Water Level Control Pit to	Ensure the baseflow from the system is not harvested and allowed to continue downstream.	This outlet consisting of:

Trunk drainage		• A 900 mm x 900 mm pit with the top set 500mm below NWL with a litter screen cage on top. Utilise a ballast cage such as TfNSW drawing CV0400998 or equivalent. • A DN300 uPVC pipe connecting the inlet pit to the outlet control pit which houses a valve to isolate the wetland and riser with holes drilled at NWL to the suitable flow rate (determined in conjunction with Sydney Water). • This outlet control pit is 1800mm x 900mm x varies height to the access path. • A water level control pit to collect flows up to 50mm above the NWL. • An outlet pipe (size determined by designer) connected to drainage channel or waterway. For more detail see AERO-RSI-WET-SK02.
Macrophyte Zone	Remove nutrients from stormwater and improve aesthetics.	The macrophyte zone is to be planted as per Appendix B. The planting should be done in a matrix with similar aquatic species (2 to 3) and not in monoculture bands. The zone is to be a maximum 300mm deep (NWL to wetland media).
Edge Treatment	Minimise the likelihood of attracting birds to the “mud flats”.	Use of sandstone logs as per AERO-RSI-WET-SK01.
Liner	Prevent stormwater infiltration and groundwater entry.	Refer to liner specifications for further details.
Safety Bench	Ensure safe entry and exit from wetland.	All batters around the edge of the wetland are to be 1V:8H for the initial 2.4 m.
Internal Batters	Maximise deep water volume	Deep water inlet zone batters are to be a maximum 1V:3H.
Outlet to Bioretention	Allow stormwater to flow into the bioretention for treatment before entering the pond.	A 300mm high (min) culvert will be used to control flows into the bioretention system, with the width and length being determined by the specific site requirements. Multiple culverts may be needed for wider bioretention areas to maintain suitable flow rates. Refer to AERO-RSI-BIO-SK01 for more details. A trash screen will be required to prevent floating debris from entering the bioretention system. Designer to provide site specific design.
High Flow Outlet Pit	Allow high flows to bypass the bioretention system to protect it from overloading.	The outlet is to be positioned at the furthest point from the inlet in wetland to maximise treatment distance. The pit needs to be a minimum 900mm x 900mm with Weldlock surcharge grate. The top of the pit wall must align with the wetlands EDD water level, while the pit depth is to be determined by designer. The pit includes an outlet pipe connected to the bioretention outlet pit, allowing for drainage into the storage pond. Refer to AERO-RSI-BIO-WET03 for more details. Note that if the bioretention outlet pit is not close to the wetland high flow outlet, the outlet pipe can discharge directly into the storage pond.

7.3.4.1 Contributing Catchment Size

Wetlands are to be sized to treat runoff from their upstream catchment. The post development catchment area must be within a range of ±10% of the natural catchment area. The preliminary sizing of wetlands should be based on a notional area of 1.4% of contributing catchment. However, this initial estimate does not eliminate the necessity for detailed modelling.

Each wetland system should only have one sediment basin unless no other option is feasible. This limitation aims to minimise complexity and maintenance costs.

7.3.4.2 Shape

The shape of the wetland is required to integrate into the landscape and adopt an organic shape. This can be achieved by:

- Ensuring the length of the macrophyte zone is at least three times the average width and maintain a consistent width throughout to create a uniform and effective flow path.
- Using curved edges that enhance water flow and avoid stagnation, while avoiding islands in the macrophyte zone to maintain a continuous flow path.
- Creating a sinuous flow path within the wetland to increase residence time, i.e., maximise the number of continuously stirred tank reactor (CSTR) cells.
- Implementing dense vegetation bands and flat bathymetry orientated perpendicular to the flow path to ensure even flow distribution and reduce short-circuiting through the macrophyte zone.

7.3.4.3 Deep Water Zones

Deep water zones will be limited to two areas, as follows:

1. The inlet:
    a. A deep-water zone that is no greater than 10%, including the sediment basin area within the open water zone calculation, of the total wetland area, serves two purposes of:
        i. Evenly disperses flows across the wetland width.
        ii. Allowing sediment to settle before water enters the macrophyte zone.
2. The outlet:
    a. A deep-water zone is only necessary when the wetland length is greater than 100 m, which would create issues in draining the wetland effectively.

7.3.4.4 Depth (bathymetry)

Bathymetry impacts flow distribution and treatment of pollutants within the wetland. To minimise depth variation, different marsh zones and maintain a level longitudinal profile across the wetland, the longitudinal grade should be limited to 1:150 in a saw tooth configuration. Depth variations should be limited to 50 mm.

7.3.4.5 Macrophyte zone

The bathymetry of the macrophyte zone should be designed to:

- Ensure a minimum 80% coverage of macrophytes.
- A depth of 300mm in the macrophyte zone (80% of wetland size) but allow for 100mm accretion (rise in the bed level) to reduce maintenance frequency.
- Connect to an open water zone that is deep enough to retain sufficient water throughout the dry season to allow mosquito predators to seek refuge.

- Reduce the potential habitat that will attract a wide variety of birds that will increase the risk of bird strike with the nearby airport. Refer to Planting Palette Appendix B.

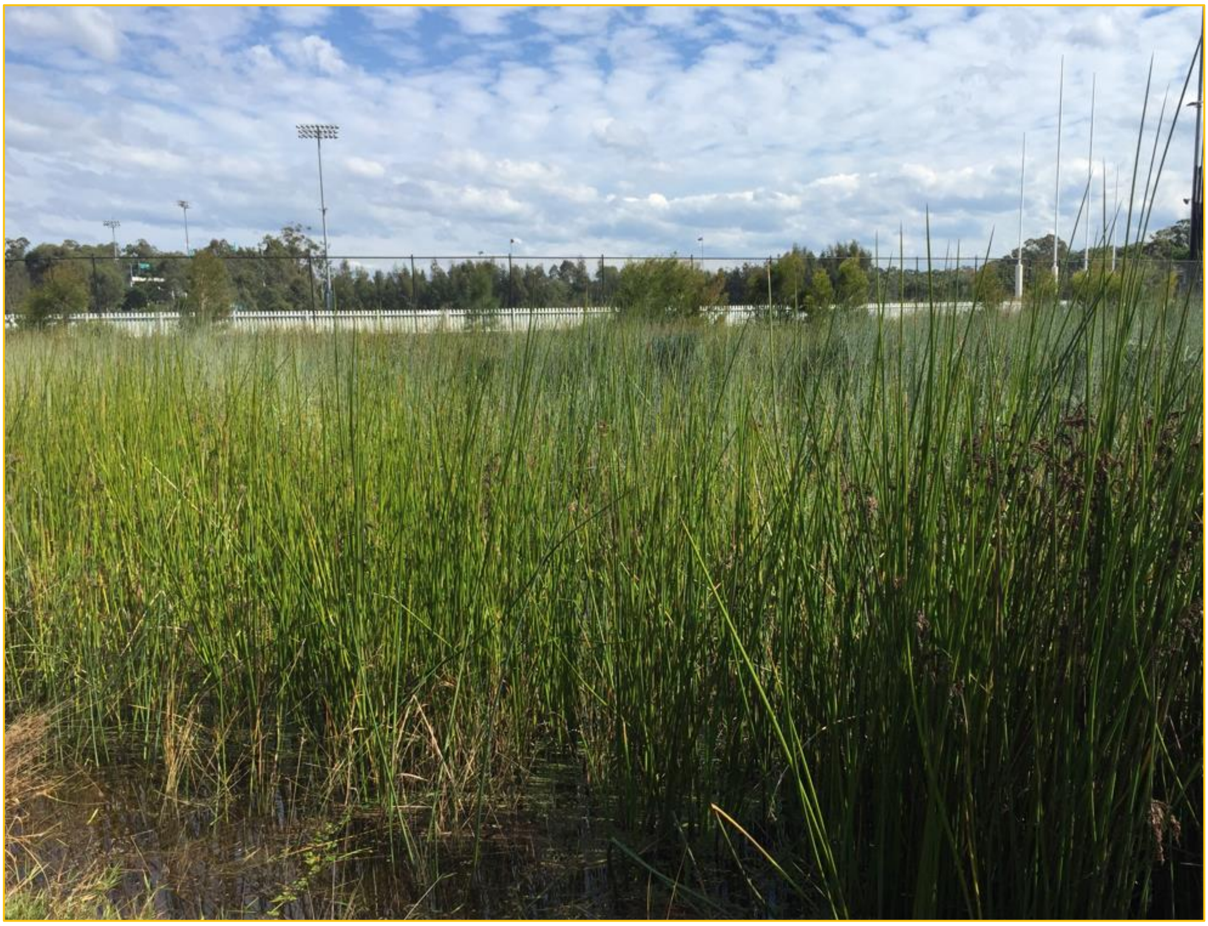


Image 2 Macrophyte Zone in Stormwater Harvesting Wetland (Blacktown International Sports Park)

7.3.4.6 Residence Time

In general, the residence time should be maximised, however a minimum of 48 hours should be achieved.

When the outlet control for a wetland is a complex structure which consists of a riser with standard size drilled holes, assessing the residence time requires a different approach. In such cases, using a hydraulic model such as DRAINS will be required.

To model the wetland in DRAINS, input the appropriate parameters such as basin geometry, rainfall data and outlet characteristics. Run simulations for different storm events to observes how water levels and flow rates change over time. This will help determine the residence time of water in the wetland, providing a detailed understanding of its performance.

7.3.4.7 Flow Velocities

The following parameters are required to be achieved within the macrophyte zone regarding flow velocity:

- Peak velocity of 0.05 m/s in the 4EY event.
- Peak velocity of ≤ 1 m/s in the 1% AEP event.

Velocity can be measure by:

$$V = \frac{Q_{in}}{Cross\ Sectional\ Area}$$

The cross-sectional area is the maximum water level multiplied by the narrowest width of the macrophyte zone.

7.3.4.8 Maintenance Access Requirements

The wetland deep water inlet zone is to be designed to have the sediment removed every 10 to 20 years. Therefore, is not critical to provide dedicated access points into the deep-water zone/s, however it is important that machinery, such as a spider excavator, can access the deep-water zone without excessive civil works. The main components and their design requirements include:

- 1 informal machinery access point that is:
  - Graded at 1 (V):6 (H) to from the general maintenance access path to the base of deep-water zone.
  - Has no trees/shrubs planted or other infrastructure that would block access.
- Suitable access to all pits and other structures by foot.

7.3.4.9 Sediment dewatering area

This should be the same as the sediment basin as it is unlikely the sediment basin and wetland will need to be maintained at the same time. If the sediment basin dewatering area is over 250 m from the area to be de-silted consultation with Sydney Water is required.

7.3.4.10 Solid base

A solid/hard base of 50 mm to 100 mm rock spalls is required to aid with maintenance of the deep-water zone of the wetland. The requirements are to be the same as the sediment pond.

7.4 Bioretention systems

The previous design guidelines (December 2022) did not include bioretention systems as part of the regional stormwater system. They have been added due to their efficient stormwater pollution removal properties and ability to fit into the landscape. They are to be used in combination with wetland systems and not in isolation.

7.4.1 Purpose and Role in Scheme

Bioretention systems are a widely recognised stormwater management system, playing a crucial role in meeting the Wianamatta-South Creek stormwater targets. They achieve this by:

1. Providing effective stormwater quality treatment by removing key nutrients, nitrogen, and phosphorus, from stormwater.
2. Enhancing evapotranspiration losses which aid in the reduction of Mean Annual Runoff Volume (MARV) to meet flow-based stormwater targets.
3. Increasing stormwater attenuation by allowing stormwater to temporarily pool on the surface and percolate through the filter media.

7.4.2 MUSIC Modelling Requirements

The following requirements shall be adopted:

Table 20: MUSIC Modelling Parameters

Component	Acceptable parameter
Low flow bypass (m^3/sec)	0

High flow bypass (m^3/sec)	100 (controlled by wetland upstream)
Extended detention depth	Maximum of 300mm
Surface area (m2)	Combination of bioretention and wetland surface area due to the shared extended detention.
Filter media (m^2)	As required to meet water quality targets
Unlined filter media perimeter	0.01m
Saturated hydraulic conductivity (mm/hr)	100, 200 (sensitivity testing)
Filter depth (m)	0.5
TN content of filter media (mg/kg)	400
Orthophosphate content of filter media (mg/kg)	40
Exfiltration rate (mm/hr)	0
Base lined	yes
Vegetation properties	Vegetated with effective nutrient removal plants
Outlet properties	Adjust overflow weir width to size of outlet pit

7.4.2.1 Saturated Zone Modelling

Saturated zones are to be incorporate in the bioretention construction and design without added carbon. The saturated zone should not be included in the MUSIC model as it does not contribute to pollutant reduction.

7.4.3 Components and design requirement

Table 21: Bioretention System Components

Name	Purpose	Design/considerations
Inlet	Control stormwater flows on the filter media surface.	Use either one or multiple concrete culverts from the wetland (refer to AERO-RSI-BIO-SK01 for details).
Outlet pit (including overflow)	Drain both the treated from underdrains and untreated stormwater from overflow device into the storage pond.	The pit is to be sized by the designer and ensure sufficient surface area for drainage. Ensure all joins are properly sealed to ensure watertightness. Refer to AERO-RSI-BIO-SK02 for details
Batters	Allow the EDD to be contained within system	The outer edge of the bioretention system should feature a single row of sandstone logs to prevent bird attraction.
Plants	The plants remove nutrients, provide roots that allow water to flow down through the filter media, provide visual amenity and habitat for fauna.	A mix of terrestrial and semi-aquatic plants that can tolerate being periodically wet or underwater. Plant appropriate species with suitable densities on the batters above the logs and use mulch to suppress weeds. Use the planting palette specified in appendix B.

Filter media (500 mm min)	Filter stormwater to capture sediment, particulate nutrients, and heavy metals, provide plant-growing media, and control vertical flow rate into the system.	Use an engineered sand/gravel mix with some organic content to support plant growth. Confirm filter media specifications with Sydney Water before finalizing construction. Refer to AERO-RSI-BIO-SK01 for more detail.
Transition layer (200 mm)	Provides a bridging layer to stop filter media being lost in the drainage layer.	Designer to confirm transition layer specification with Sydney Water prior to construction. Refer to AERO-RSI-BIO-SK01 for more detail.
Drainage layer (Saturated Zone)	Collects the treated stormwater and conveys it to the outlet via slotted pipe.	The depth of drainage layer is dependent on the size of the underdrain used with a minimum 50mm cover over top of pipe. Refer to AERO-RSI-BIO-SK01 for submerged zone configuration.
Underdrains	Collect and direct flow to the outlet pit.	Refer to AERO-RSI-BIO-SK02 for underdrain configuration.
Flushing points	These points provide access to the underdrain for inspection and cleaning	The flushing point must use a watertight seal to prevent water from draining into the underdrain and bypassing treatment. It should be located no more than 3m from the outer edge of the filter surface and sit 100mm above the filter surface for visibility.
Outlet pipe	Discharge both treated and un-treated stormwater into the storage pond	A concrete pipe is to be sized by the designer to convey bioretention outflows and have a minimum slope of 0.5%.
Liner	Prevent stormwater infiltration and groundwater entry.	Refer to liner specifications for further details.

7.4.3.1 Size and Shape

A bioretention systems can have multiple cells, with a maximum cell size of 3,000 m². Each cell should not exceed 55 m in width, to ensure the maximum distance from any edge or maintenance track is 30 m. Preliminary sizing for bioretention systems when combined with a wetland, should be based on a minimum area of 0.6% contributing catchment. However, this initial estimate does not replace the necessity for modelling.

7.4.3.2 Solar Access

Solar access must be considered to ensure adequate light penetration for vegetation during winter. Sydney Water requires a minimum of 1 hour of sunlight in mid-winter over the bioretention system. Any height above 2m on the north-eastern, northern, and north-western sides should be set to a maximum slope of 1V:1.5H. This can be accomplished using stepped level planting areas (minimum width of 1500 mm).

These solar access requirements can be challenging for bioretention systems located on the southern side of high retaining walls or large industrial buildings that cast significant shadows. To evaluate this impact, shadow diagrams may be necessary for assessment.

7.4.3.3 Filter Media

The filter media shall be designed in accordance with the properties listed Table 22. Alternative media may be approved by Sydney Water, but detailed material testing and demonstrated performance will be required. If recycled material is used it must be demonstrated at the contractor's expense that the material is both inert and free of contaminants.

Table 22: Filter Media Requirements

Property	Description
Depth	Minimum 500 mm
Material	Either an engineered material - a washed, well graded sand - or naturally occurring sand, a mixture is permitted. It should be free of rubbish and weeds and not be hydrophobic.
Hydraulic Conductivity	Saturated hydraulic conductivity rate of the filter media shall match the designed value.
pH	5.5 - 7 As specified for "natural soils and blends" (pH: in water)
Electrical Conductivity	<1.2 DS/M as specified for natural soils and blends.
Nutrient Content	Low nutrient content Total nitrogen (TN) < 1000 mg/kg Nitrogen drawdown > 0.5 (NDI) Available phosphate (COLWELL) < 80 mg/kg Orthophosphate < 40 mg/kg
Grading of particles	Smooth grading of all particle size classes should be represented across sieves sizes from the 0.05mm to the 3.4mm sieve as per ASTM F 1632-03 (2010).

To avoid migration of the filter media into the transition layer the particle size distribution should be assessed to meet bridging criteria. The smallest 15% (d_{15}) of the transition layer particles must be no greater than 5 times the size of the largest 15% (d_{85}) of the filter media particles. That is:

$$D_{15}(\text{Transition}) \leq 5 \times D_{85}(\text{Filter})$$

7.4.3.4 Particle Size Distribution

Particle size distribution is provided in the table below:

Table 23: Particle Size Distribution

ACCEPTABLE RANGE	(%W/W)	RETAINED
Clay & silt	< 3%	(< 0.05 mm)
Very fine sand	5-30%	(0.05 - 0.15 mm)
Fine sand	10-30%	(0.15 – 0.25 mm)
Medium sand	40-60%	(0.25 - 0.5 mm)
Coarse sand	< 25%	(0.5 – 1.0 mm)
Very coarse sand	0-10%	(1.0 - 2.0 mm)
Fine gravel)	< 3%	(2.0 - 3.4 mm)
Organic content	< 5%	-

7.4.3.5 Transition Layer

The transition layer is required to prevent the migration of the filter media into the drainage layer. It creates a layer between the filter media and the drainage layer. The material must be clean, well graded sand/course material containing little or no fines. Use of well washed recycled glass is acceptable. The bridgeing criteria is

$$D_{15} \text{ (Transition} \geq D_{15} \text{ (Filter) x 5}$$

This criteria ensures greater hydraulic conductiviy of the transition later than the media.

7.4.3.6 Underdrains

The following specifications are required to be achieved for underdrain sizing:

- Maximum spacing at 3 m intervals.
- Minimum sn8 strength with maximum slot widths of 4 mm.
- Joints to be rubber ring, bends should be 45° to ensure that the pipe can be flushed.
- Corrugated twin wall pipe (i.e.draincoil) is acceptable.
- Pipes > 60 m long need intermediate flushing points and risers.
- Designed to convey a minimum flow rate of 4.4 l/s/100m^2 of filter area. This was calculated using Darcy's Equation and assumed an EDD of 0.3 m, filter media depth of 0.5 m and KSAT of 100 mm/hr.
- For smaller systems up to 100 m^2, the minimum pipe diameter is to be DN100 mm pipes subject to confirmation the HGL remains below the filter media (at maximum design flow).
- For large systems greater than 100 m^2, the minimum pipe diameter is to be DN150 mm.

Alternative sizing may be justified when sizing the underdrains in the bioretention system. Sydney Water require calculations be provided demonstrating assumptions of head, friction losses and results.

7.4.3.7 Maintenance Access

All designs shall ensure that maintenance crews can easily and safely perform tasks such as removing litter, debris, sediment, replanting, weeding and replacement of the filter media. The following requirements are to be met:

- The inlet point must be within 5 m of a location accessible by an educator truck or small excavator.
- An educator truck access to the outlet pit must be provided to remove debris from the underdrains while flush them with a high-pressure hose.
- Pedestrian access must be available around the cell perimeter to allow for wheelbarrow access for vegetation maintenance and other tasks.

7.5 Storage Ponds

Storage ponds are the final downstream treatment element of the regional WSUD system. Any excess stormwater flows back into the trunk drainage channel or directly into the waterway.

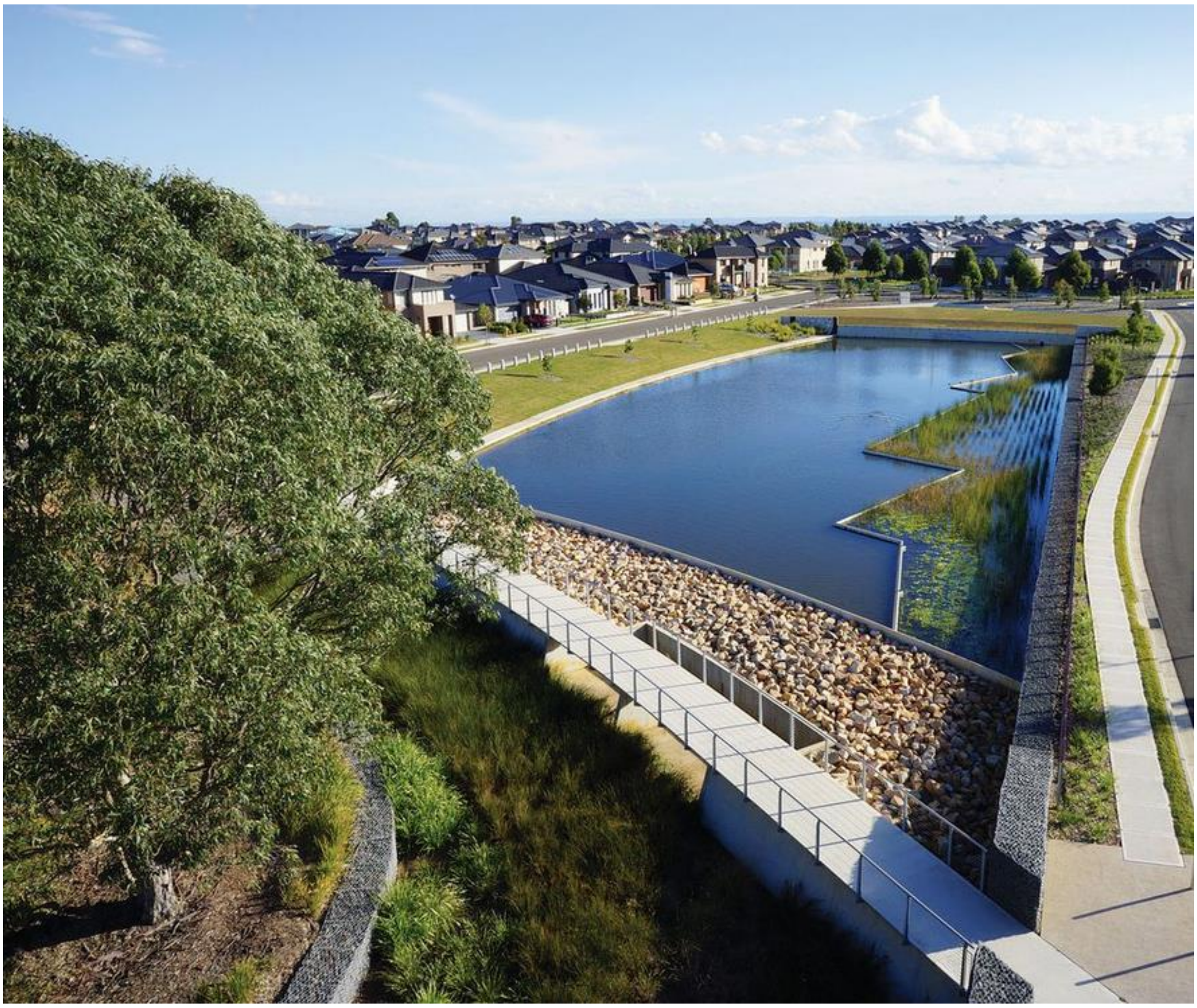


Image 3 Julluck Pond at The Ponds, image courtesy Urban Growth NSW

7.5.1 Purpose and Role in Scheme

Storage ponds play a crucial role in achieve the water quality and quantity targets by targeting the Mean Annual Runoff Volume (MARV) target of less than 2 ML/ha/yr. They achieve this by:

1. Retaining excess stormwater over an extended period to supply the regional non-potable reuse scheme. As the water is used, the pond's water level decreases, creating additional storage capacity for runoff from subsequent storm events.
2. Providing extended detention above the low flow outlet which attenuates very frequent storm events and assists in achieving the 90th percentile flow targets.
3. Polishing water quality prior to regional reuse through additional hydraulic retention times which assist in further decay of contaminants and exposure to UV light to assist in sterilisation of pathogens.

7.5.2 MUSIC Modelling Requirements

Table 24: MUSIC Modelling Parameters

Component	Acceptable parameter
Low flow bypass (m^3/sec)	0
High flow bypass (m^3/sec)	100. (controlled by upstream wetland)
Surface area	subject to modelling
Extended detention depth	100 mm – 350 mm
Permanent pool volume	Based on volume requirements
Exfiltration rate (mm/hr)	0
Evaporation loss as % of PET	125%
Outlet pipe properties	Adjust to ensure notional detention time is within range
Notional detention time	10 hours for detention depths of 100 to 350mm
K & C values	Use default values

7.5.3 Components and design requirements

Table 25: Storage Pond Components

Component	Purpose	Design/considerations
Inlet system/s	Control stormwater entry and minimise scour/erosion.	The pipe from the bioretention outlet pit is to discharge into the storage pond via a head wall and the designer is to specify appropriate rock scour protection. Due to fluctuating water levels from harvesting, scour protection is likely needed to run to the base. Refer to AERO-RSI-BIO-SK01 for more detail.
Pond Outlet to Stormwater Harvesting and Reticulation Pit	Provide water into the harvesting and reticulation pit.	The system includes a headwall at the base of the pond to maximize stormwater harvesting volume, with a minimum 375mm pipe sloping at 0.5% towards the pond. The pipe should have a minimum cover of 450mm and cut-off collars. The headwall will require a trash screen to prevent large objects entering the pump. Refer to AERO-RSI-PON-SK02 for more details.
Stormwater Harvesting and Reticulation Pit	Pump treated stormwater into the daisy chain system for recycled water. Prevent stagnant water within the system to reduce algal growth and pond turnover risk.	The pit is divided into two halves: one for the inlet where water from the pond enters, and the other for the pumps. A large physical screen between them prevents debris from entering the pumps. The screen is required to be removable, come in multiple parts for lighter weight, and has lifting points with a maximum aperture size of 5mm. The designer must provide pit size and screen details for approval by Sydney Water. Refer to AERO-RSI-PON-SK03 for more details.

	Drain the pond via pumping for maintenance.	
Water Level Control Pit	Ensure the EDD residence time is achieved in the storage pond	The outlet includes a 600mm x 600mm x minimum 600mm deep pit, with the top set 500mm below NWL. It has a litter screen cage to prevent debris from blocking the outlet hole. A DN300 uPVC pipe PN12 connects the inlet pit to the outlet control pit, which houses a riser with holes drilled at NWL to the suitable flow rate (determined with Sydney Water). See AERO-RSI-PON-SK04 for details.
Pond Overflow Pit	To allow high flows to drain out of the system to protect it from overloading.	Locate the outlet close to the drainage channel to minimize pipe lengths. The pit must be at least 900 mm x 900 mm with a Weldlock surcharge grate, set at the pond EDD water level. The pit size and depth will be determined by the designer. Refer to AERO-RSI-PON-SK04 for more details.
Safety Bench	To allow for safe passage out of the basin.	The safety bench is to be consistent with wetland specifications. Refer to AERO-RSI-PON-SK01 for more detail.
Storage Zone Internal Batters	To maximise water storage.	Maximum pond batters slope of 1V: 3H and are not to be planted. Refer to AERO-RSI-PON-SK01 for more detail.
Liner	To prevent stormwater infiltration and groundwater entry.	Refer to liner specifications for further details.
Irrigation system	To ensure plant survival and clay liner integrity.	The irrigation system must have sufficient throw to reach the base to keep batters wet and prevent cracking.

7.5.4 Design Requirements

7.5.4.1 Pond Size/Volume

The volume of each pond must be determined using MUSIC modelling and in consultation with Sydney Water. Preliminary sizing for storage ponds should be based on a minimum area of 3.3% of contributing catchment. However, this initial estimate does not replace the necessity for modelling.

Due to shared water supply within the recycled water network, volume requirements will vary for each pond. The pond volume will be impacted by the landform constraint and the surrounding infrastructure.

7.5.4.2 Shape and Form

The shape and form of the storage pond is to be designed in a way that is compatible with the landscape:

- Reducing cut by using the topography of the surrounding landscape.
- Considering the proximity to the inlets (bioretention system) and different outlets (treatable flow to stormwater harvesting and overflows to trunk drainage or waterway).
- Maximising evaporation potential.

7.5.4.3 Depth

This guideline has been revised to remove the maximum 1.5 m depth condition for storage ponds. This change ensures pond depth is determined by local soil, groundwater conditions and the depth to the nearest water way. Designers are required to:

- Maximise the storage pond depth to avoid excessive footprint.
- Ensure the storage pond depth ranges between 1.5 m and 4 m subject to local soil, groundwater conditions and depth to the nearest water way.
- Consult with Sydney Water early to determine allowable pond depths.

7.5.4.4 Reuse Rate

Refer to Section 7.1.2 for the appropriate reuse rate to be adopted onsite.

7.5.4.5 Residence Time

A minimum residence time of 10 hours is critical to meet the performance outcomes of the storage pond.

7.5.4.6 Overflow Weir

A high flow overflow weir is required within the storage pond to control flows exceeding the calculated flow rate as nominated in Section 7.1.1. The width is to be determined through hydraulic calculation and must provide a 150 mm freeboard to the embankment of the pond. Preliminary sizing can be undertaken using the weir equation.

$$Q = CLH^{1.5}$$

Acceptable values for C are 2.15 (Ogee Weir), 2.00 (Broad Crested Weir, sloping approach), 1.74 (Sharp crested, vertical upstream face), 1.45 (Broad crested, vertical upstream face).

7.5.4.7 Reducing Thermal Stratification

Ponds deeper than 1.5 m can experience thermal stratification, leading to pond turnover during summer. This occurs when warm, oxygen rich surface water mixes with the cold, oxygen depleted bottom water, potentially causing nutrient spikes and fish death. These events significantly impact stormwater harvesting capabilities and the ability to meet both the stormwater quality and quantity targets. The effects of thermal stratification are to be mitigated as follows:

- Regular water harvesting from the base of the pond to allowing the layers to mix.
- Reticulation of the system will pump water to the wetland and ensure water is moving through the system. This process will yield additional benefit through continuous treatment of harvested water to remove nutrients and other pollutants.
- Exposure to winds which contribute to mixing the top and bottom water.

7.5.4.8 Reticulation System

The storage ponds require a reticulation system to maintain high oxygen levels and prevent excessive algal growth (up to 15,000 cells) and pond turnover. The reticulation system will pump water back into the wetland, ensuring water movement to reduce algae and prevent issues with stagnant water. The reticulation system must include the following components:

- Water quality monitoring equipment.
- A footing with a recessed socket for a lifting Davit.
- Step irons at 300 mm intervals for pit depths greater than 1200 mm for access.
- Two (2) pumps (duty and standby) sized to circulate the full pond volume over a 14-day period with water level sensors for pump controls.

- A discharge point into either the sediment basin or wetland deep water inlet zone.
- An additional discharge pipe, controlled by a manual value, connecting to the trunk drainage channel to allow the pond to be fully drained for maintenance.
- Integration with the stormwater harvesting scheme SCADA system for communications and electrical supply.

7.5.5 Dam Safety Requirements

TBC

7.5.6 Construction, operation, and maintenance considerations

Construction staging

TBC

During maintenance

TBC

Establishment operation and maintenance

TBC

7.6 Stormwater Harvesting System

TBC

7.7 Generic Requirements for the Regional WSUD System

The following provides design advice for the regional system that relates to all WSUD assets and the overall design.

7.7.1 WSUD Batters

The following is required for all WSUD batters:

- Topsoil is to be used in areas above the normal water level, filter media or wetland soil media is not permitted.
- The batters:
  - below the top water level are to jute matted with 150mm pins at 1 m centres and every 0.5m along edges.
  - Above the top water level are to be mulched with 100 to 150mm of Eucalyptus/native mulch (free of weed seeds and soil)

7.7.2 Topsoil Requirements

The top 300mm of in-situ topsoil is to be removed and replaced with imported topsoil compliant with AS4419. Alternatively, the existing soil can be ameliorated in accordance with AS4419 requirements, signed off by suitable qualified soil specialist, and ensuring it is weed free.

7.7.3 Water level control devices

- The type, size, and brand of any water level control device is to be approved by Sydney Water prior at the concept design stage of the system.
- Stop board structures are to be installed as per the manufacturers requirements and be watertight (tested and signed off) before being handed over to Sydney Water.
- The method of low flow diversion/bypass (holes drilled into stop board or riser etc.) is to be included in design with clear instructions as to what and how it is to be constructed.

Image 4 holes drilled into stop boards.

7.7.4 Safety in Design

Refer to Sydney Water's Specification D0000653 for further information.

7.7.5 Fencing

Table 26: Fencing Components

Application	Purpose	Type of fencing and details	Asset Ownership / Responsibility	Australian Standard
Falls Risk	Vertical fall > 900 mm	• Height: ≥ 1.2 m. • Top and bottom square sections. • Tubular rail with infill bars. • Corrosion-resistant materials. • Optional: Powder coated finish for sensitive areas. • Avoid within 1% AEP flow path.	Funded and maintained by Sydney Water within stormwater infrastructure easement or lands	AS 1926 – Fences and Gates for Private Swimming Pools Powder coated paint finishes in accordance with AS 1163 – Structural Steel Hollow Sections.

Vehicle barrier (road verge)	Stop vehicles entering channel	• Recycled plastic bollard (min. 125 mm thick, 1000 mm high) or sandstone log (1 m high, 1 m deep, > 2 m long). • Gaps ≤ 2 m.	Funded and maintained by Sydney Water between public/private road stormwater infrastructure when: There is no major (>500 mm) drop of levels (retaining walls or similar) There is no thick vegetation that could be used as a barrier.	AS5100. 1-2004 – Bridge Design Part 1: Scope and general principles
Full exclusion	Stop public access to assets	• Minimum 1.8 m height security-type fence. • Palisade fencing required.	Funded and maintained by Sydney Water within stormwater infrastructure easement or lands	Powder coated paint finishes in accordance with AS 1163 – Structural Steel Hollow Sections.
Between Private land and stormwater land	Prevent public access to private land	**Scenario 1:** On private property above a retaining wall: • Fencing determined and funded by the industrial landowner. • Recommended: Palisade fencing. **Scenario 2:** On the boundary with no retaining wall: • Fencing to be discussed with Sydney Water at final design stage. • If required, generally palisade fencing for full exclusion.	Scenario 1: Funded by private landowner. Scenario 2: Cost shared between Sydney Water and landowner	-
Vehicle gates/removable bollard	Control maintenance access	• Type (hinged gate or removable bollard) to be discussed with Sydney Water during detailed design. • Removable bollards next to vehicle entry point. • Hinged gate for other types of fencing; local Council requirement applies. • All gates or bollards will have keyed access and locked with “daisy chain” arrangement.	Funded and maintained by Sydney Water within stormwater infrastructure easement or lands	-

7.8 Maintenance Access Requirements

Considering maintenance requirements during the design of these assets is essential to ensure safe and effective upkeep. This includes:

- Maintenance access
  - Safe access to components requiring high frequency maintenance (< once every 5 years)
  - Access to components requiring infrequent maintenance (> once in 10 years)
- Isolation of assets
  - Designing systems so maintenance on one asset does not impact the performance of others, allowing the system to function without temporary closure.
- Confined space access is required to conform to Sydney Waters WHSMS0068 procedures.

Suitable access to open water storages

The regional WSUD system has several assets that have open water storages, each with varying maintenance frequencies. The below table highlights each asset, its main maintenance activity, frequency, and the required infrastructure to ensure safe and effective maintenance.

Table 27: Asset Maintenance Requirements

Asset	Maintenance activity and frequency	Access requirement
Sediment basin	Floating litter and debris removal (every 3 months)	1 in 8 batters on the edge to allow for scoping of rubbish from bank
	Sediment removal from base (every 5 years)	• Dedicated access from trunk drainage or road. • Dedicated concrete access ramp (1 in 6 grades to base) Hard base of sediment basin for machinery. • Ability to drain water to operational level (1000 mm off base)
	Weed removal from batters and upper banks (submerged) (every month)	1 in 4 batters on edge with a maintenance track (pedestrian or vehicle within 5 meters)
Wetland	Floating litter and debris removal (every 3 months)	1 in 8 batters on the edge to allow for scoping of rubbish from bank
	Sediment removal from base (every 10 to 20 years)	• A 3m wide section of the batter that will allow access to the deep-water zone at a 1 in 6 grade to base. This can be vegetated with groundcovers only. • Hard base of deep-water zone for machinery. • Ability to drain deep-water zone (500mm off base)
	Weed removal from batters and macrophyte zone (submerged) (every month)	1 in 8 batters on edge with a maintenance track (pedestrian or vehicle within 5 meters from wetland edge)

Bioretention	Sediment removal from inlet point (once every 5 to 10 years)	Access track to suit heavy vehicle (educator truck) within 5 meters of inlet
	Inspection of under drainage lines (once every 5 years)	Access track to suit heavy vehicle (educator truck) within 30 meters of flushing points to allow CCTV/high pressure hose and 5 meters from outlet pit to remove debris coming out of under drains from flushing.
	Weed removal from batters and filter media surface (every month)	1 in 8 batters on edge with a maintenance track (pedestrian or vehicle within 5 meters from bioretention edge). Bioretention system no wider than 30 meters from any edge.
Storage pond	Floating litter and debris removal (every 3 months)	• 1 in 8 batters on the edge to allow for scoping of rubbish from bank. • Boat/canoe access that includes an area with batter no steeper than 1 in 8 from top to bed of pond.
	Sediment removal from base (every 25 years)	A 3m wide section of the batter that will allow access to the base at a 1 in 6 grade. This can be vegetated with groundcovers only.
	Weed removal from batters and upper banks (submerged) (every month)	1 in 8 batters on edge with a maintenance track (pedestrian or vehicle within 5 meters)

Maintenance track requirements

The regional WSUD system and trunk drainage lines require dedicated maintenance tracks to allow for safe and effective access. The maintenance track hierarchy and requirements are included in the table below.

Table 28: Maintenance Track Requirements

Type	Main use	Requirements
Shared user path	Used by both maintenance crews and the public.	TfNSW/council requirements
Heavy vehicle	To allow heavy maintenance vehicles into the area without damaging services or other critical infrastructure	Sydney Water Civil specification
Light vehicle	To allow most vehicles used for maintenance into an area including cars, utilities, and light trucks (<4 tonne GMV)	• Minimum width - 3m • Inner and outer radius – 7m and 11m MIN • Cross fall – 1% MIN • Flat tracks - 150 mm compacted sandstone on compacted sub grade comprising 100mm MIN layer of free draining material. Use Edge Treatment along both sides. • Graded tracks or areas of frequent surface flow - 150mm of 20MPA concrete with SL82 Mech joints on 100mm compacted DGB20 over compacted sub grade
Pedestrian	To allow maintenance crew to walk around an asset with a wheelbarrow or similar device.	• Pedestrian only path width– 1.5m MIN • 100mm compacted sandstone on compacted sub grade comprising of 75mm MIN layer of free draining material. Use Edge Treatment along both sides.

		• Shared path width - to 2.5m MIN • 150mm of 20MPA concrete with SL82 Mech joints on 100mm compacted DGB20 over compacted sub grade
Edge Treatment	Keep loose material in place and prevent migration of material	Use a concrete edge beam or sandstone log or other appropriate barrier edge to keep compacted sandstone and sub grade material in place. Concrete and sandstone edge should be 150mm wide MIN and full depth of material.
Dedicated access ramp	To be used to access the base of the sediment basin	Sydney Water Civil specification at a max grade of 1 in 6.

Dedicated storage/drying area

The design of the regional WSUD system should include an open space area within that can be used for:

- Temporarily store new filter media or other landscape material for maintenance of the bioretention system.
- Sediments and other material removed from any WSUD asset (sediment basin, wetland, bioretention or pond) is required to be dried before taken offsite for disposal or reuse. The area should ideally drain back into the sediment basin to reduce contamination of any other WSUD asset.

This area should have:

- A minimum of 250m² or 25% of the NWL area that can be used to store this material.
- Be located next to an access point to dump the material (heavy vehicle access).
- Be compatible with landscaping to ensure that it does not prevent heavy vehicle access.
- Be easily isolated to stop public access (during construction and maintenance works).
- Be flat (0.5% to 1%) and sloping towards a water body to allow water to drain away.
- Be grass or another material that is easy to maintain and cheap to replace/repair, when required.

References

The following documents were referred to in the development of this guideline (TBC)

Title
Brisbane City Council (2003) *Natural Channel Design – Guidelines*. Brisbane City Council, Queensland.
DPIE, 2021. Performance criteria for protecting and improving the blue grid in the Wianamatta – South Creek catchment, NSW Department of Planning, Industry and Environment, Parramatta
Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions
Recognise Country: Guidelines for Development in the Aerotropolis
Mamre Road Precinct Development Control Plan 2021
Western Sydney Aerotropolis Development Control Plan 2022
State Environmental Planning Policy (Precincts—Western Parkland City) Amendment (Miscellaneous) 2022
Technical guidance for achieving Wianamatta South Creek stormwater management targets (Department of Planning and Environment, 2022)
Stormwater connections to natural waterways (Sydney Water, 31 July 2014)
Constructed Waterways Design Manual, Melbourne Water, 2019
NRAR, 2018. Guidelines for controlled activities on waterfront land - Riparian corridors (NRAR, 2018)
Good practices in riparian rehabilitation - Benchmarks for Environmental Trust funded projects (Department of Planning, Industry & Environment and Natural Resources Commission, 2020)
Wianamatta South Creek Catchment Flood Study Existing Conditions (Advisian, 2022)
The Constructed Wetlands Manual (DLWC, 1998) - Department of Land and Water Conservation (DLWC, NSW) (1998)
Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (phase 2) Stormwater harvesting and reuse (July 2009)
Wetland Design Manual A1: Design, Construction and Establishment of Wetlands Manual (Melbourne Water, December 2020)
Australian Runoff Quality – A guide to Water Sensitive Urban Design (2006)
Safety in Design Procedure (Sydney Water 2017)
Work Health and Safety Act
MUSIC Modelling Toolkit – Wianamatta NSW Department of Environment and Heritage - https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Water/Water-quality/Wianamatta-South-Creek-documents/technical-guidance-for-achieving-wianamatta-south-creek-stormwater-management-targets-220503.pdf

Appendix A – Typical Concept Sketches

Appendix B – Planting Palette

B1 Planting Requirements

Vegetation cover is an essential functional component of the trunk drainage lines, wetland, pond, and bioretention system. Significant care and consideration should be taken for the design, supply, installation, and maintenance of vegetation within these systems. The below provides the main details to be considered at each asset and stage.

B2 Landscape Design

1. Plants are to be 50mm hiko tube stock or forestry tubes. Special mature trees (45L to 200L) can be used to provide immediate benefits but require approval from Sydney Water due to the additional cost involved.
2. The final planting list must be included in the landscape plan and receive endorsement by Sydney Water before plant supply is organised.
3. For each WSUD asset, and components from each asset (I.e., zone and water depth for wetland/pond), only plants from the approved planting palette should be used.

B3 Plant Supply and Installation

Table 29: Planting Process

Requirement	Description
Plant Source and Conditions	Source plants from a local (Sydney basin) nursery. Ensure they are weed-free, healthy, and hardened. Sydney Water to inspect prior to installation.
Long Lead Time Plants	Some plants may need to be grown from seed, taking up to 12 months. Plan accordingly.
Optimal Planting Season	Ideally plant from March to October. Approval required for planting outside this period.
Timing of Planting	Plant within 14 days after preparing the area (e.g., filter media installation).
Planting matrix	Plant as a matrix within the designated zone ensuring diverse coverage.
Plant Selection	Prefer plants from the preferred list. Use alternative list plants only with Sydney Water endorsement if preferred plants are unavailable.
Post Planting Soil Reinstatement	Re-instate soil to a flat surface after planting. Dispose of or return all pots and rubbish to the nursery.
Watering and plant survival	Water plants appropriately before and after installation. Contractor responsible for plant survival until handover to Sydney Water. Replace losses over 10% at contractor's cost, excluding vandalism or extreme weather events.
Fertiliser and Water Crystals	Use slow-release fertilisers and water crystals with prior endorsement from Sydney Water for type and application rate.
Planting Sign off	Contractor to sign off planting in accordance with the approved landscape plan. Variations need Sydney Water endorsement.

B4 Plant Maintenance:

The following maintenance is required from practical completion to handover.

1. The maintenance period, extending from practical completion to final completion, must last a minimum of 24 months from the date the system is fully planted before handover. During the first 12 months, plant establishment requires higher maintenance frequency and regular watering.
2. Each system must achieve the minimum density of plants per m^2 specified in Appendix B within 24 months. Plants should be vigorous, healthy, and free of weeds. The contractor must inform Sydney Water if the required density is not achieved by 12 months and undertake replanting to ensure all plants meet the specified density and have been growing for at least 12 months by handover.

Appendix C – Engineering Requirements Checklist

Appendix D – Indigenous Design Considerations

Appendix E – Safety in Design Workshop