



Wetland Design Manual Part A3: Design Considerations for Wetlands Manual

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1. Purpose

The purpose of this manual is to provide guidance for the design of constructed stormwater quality treatment assets resulting in robust, maintainable assets that effectively deliver stormwater treatment in line with BPEM guidelines, as well as contributing to benefits such as the provision of alternative water supplies, improved landscape amenity and enhancing liveability for local communities.

2. Scope

The scope of this manual is limited to component assets of constructed wetlands considered to provide a stormwater quality treatment function i.e. sediment ponds and wetland cells, along with associated control structures (e.g. inlet/outlet structures, bypasses, balance pipes), maintenance infrastructure (e.g. access tracks) and associated landscaping features.

3. Design Considerations

3.1 Innovation in Design

Melbourne Water supports opportunities for designers to push the boundaries of their designs and to come up with innovative design solutions that are particularly tailored to their site and project; however all designs must still achieve the core outcomes outlined in **Part A1** of this manual. Innovation is an important part of progression and we encourage designers to look for better ways to deliver creative design solutions. Innovation invariably involves higher costs and longer timeframes and ultimately the risk of failure but these risks can be offset by the potential savings and benefits that the innovative design can generate. Developers and designers need to consider these potential upfront costs and risks before the innovative design approach is adopted.

Designers may submit their proposals and innovative design solutions to Melbourne Water through the **alternative design approach** for consideration and acceptance.

3.2 Open Water, Landscape Design and Amenity

Wetlands are a valued asset to urban communities, providing open space areas with formal and informal recreational benefits. Well-designed wetlands incorporated into new urban environments are often highly valued natural assets.

The amenity associated with wetlands is a commonly expressed reason for community visitation to wetland areas and is therefore an important value that needs to be managed and protected. The use of feature open water zones (lakes) associated with a wetland are often of high value to a developer and the community, however they have limited stormwater treatment benefits. A developer can propose to incorporate feature open water zones with their wetland design, however this may not be a component that is ultimately funded by Melbourne Water or considered to contribute to the overall stormwater quality targets.

The landscape values associated with wetlands delivered by Melbourne Water are generally provided via the wetland vegetation, and facilitating and/or carefully managing public interactions with the wetland area in the form of paths, boardwalks and pedestrian bridges. Please note that whilst these landscape features are highly valued and supported by Melbourne Water, Melbourne Water does not fund, own or maintain boardwalks, footpaths and pedestrian bridges associated with wetlands.

Landscape values are also delivered through the interface between Melbourne Water’s interests and any Council requirements for adjacent public open spaces where physical infrastructure may be provided (e.g. open mown grassed areas, seating, playgrounds and barbecues). With all these elements being closely related, amenity values can be created through the landscape design process.

Wetland amenity values are diminished by the presence of unpleasant or intrusive development, odour, colour, litter, noise, mosquitoes and other pests.

The design of wetlands and the surrounding urban environment requires an integrated approach where the requirements of Melbourne Water and Council influence each other to support a common vision. This integrated approach between various authorities highlights the importance of the conceptual design stage in the design acceptance process, where the design intent is clearly outlined and general acceptance from Melbourne Water and Council is obtained before time and money is spent on the functional and detailed design requirements. See **Part B** of this manual for more details.

A clear demarcation between the roles and responsibilities of Melbourne Water and Council is essential to effectively deliver amenity in wetlands. Responsibility for different parts of the wetland system and surrounding open spaces must be clearly defined within a [maintenance agreement](#) to enable effective asset ownership and maintenance, especially at the interface between these two areas. See Melbourne Water’s [Building and Works website](#) for details on the management of wetlands and **Part A1** for amenity aspirational outcomes.

Important note: If larger areas of open water area are desired, then these should be created as a separate system and located downstream of the wetland. This includes open water bodies required for stormwater harvesting storage.

3.3 Hydrodynamic Design Considerations

The hydrodynamic design of wetlands is crucial to the successful establishment of emergent and submerged vegetation, and the ongoing performance of the wetland. Poorly designed wetlands often result in ongoing operational and management problems and do not provide the intended level of water quality treatment.

A summary of the major hydrodynamic requirements which must be considered during wetland design are provided in the table below:

Table 1: Hydrodynamic design considerations

	Design Consideration
Flow distribution	<ul style="list-style-type: none"> The wetland shape, bathymetry and placement of the inlet and outlets must facilitate uniform flow across the wetland. This will help avoid short circuiting of flows and poorly mixed zones.
Permanent pool depth	<ul style="list-style-type: none"> The wetland bathymetry must facilitate establishment of emergent and submerged macrophytes throughout the wetland. Macrophyte species are sensitive to permanent pool depth, and the depth ranges provided within each marsh zone should be suitable for the types of macrophytes to be planted.

	Design Consideration
	<ul style="list-style-type: none"> • A uniform depth across the wetland width minimises the area of fringing vegetation, which negatively influence water treatment by enhancing dead zones. • The permanent pool depth for the shallow marsh zones are: ≤ 150 mm below normal water level (NWL) (+EDD = 500 mm) • The permanent pool depth for the deep marsh zones are: $\leq 150-350$ mm below NWL (+EDD = 500-700 mm) • A minimum 80% of the macrophyte zone at NWL must be ≤ 350 mm (i.e. shallow and deep marsh) • The permanent pool depth for the submerged marsh zones are: 350-700 mm below NWL (+EDD = 700-1050 mm)
Hydrologic regime	<ul style="list-style-type: none"> • The wetland's extended detention hydrologic regime (inundation depth, duration and frequency) has a major influence on the establishment and persistence of macrophytes within the wetland. The hydrological characteristics of the wetland's extended detention (depth, inlet and outlet properties) therefore play a major role in the sustainability of vegetation cover within the wetland and the ongoing water quality treatment performance of the wetland system. Note: Melbourne Water will be installing hydraulic level sensors and data loggers on all Development Services Scheme wetlands to ensure the wetland is meeting the required hydraulic performance targets. • Wetlands must be designed to enable the permanent pool to be occasionally drawn down, as this replicates the hydrological regime of natural wetlands through regular wetting and drying of the wetland sediments (important to nutrient uptake) and the long term sustainability of the wetland vegetation (macrophyte regeneration and growth).
Extended detention depth (EDD)	<ul style="list-style-type: none"> • The extended detention depth in the macrophyte zone must be ≤ 350 mm. See Part A2 for design criteria. • If an extended detention depth greater than 350mm is proposed then an inundation frequency analysis will be required to ensure the effective water depth (permanent pool depth plus engagement of extended detention) does not exceed half the design plant height for more than 20% of the time (see Part A2 and Part D for more information). However, a wetland with extended detention depths greater than 350mm still has the risk of not being accepted by Melbourne Water.
Open water	<ul style="list-style-type: none"> • Inclusion of a limited proportion of open water is supported in the wetland design; however open water still plays a significant role in the diversity of a wetland system. • Deep zones in the wetland help to break short-circuits when placed as intermediate pools and provide some degree of treatment via

	Design Consideration
	<p>sedimentation, microbial processing in the substrate and via algal oxygenation and nutrient uptake in the water column.</p> <ul style="list-style-type: none"> • Placement of deep zones at the inlet will accumulate heavy sediment particles, which will likely reduce sediment accumulation in the shallow zones. Placement of deep zones at the inlet and outlet may also reduce the likelihood of blockages.

The sensitivity of vegetation to inundation depth is well established in the scientific literature. Plant growth is severely restricted in excessively deep water and plants will inevitably die, even if they persist for the first one or two years. The resulting low plant cover, biomass and productivity are detrimental to the overall wetland function.

Growth difficulties for many emergent macrophytes are reported to occur for water depths > 300 mm. On this basis, most of the shallow and deep marsh falls within a sufficiently shallow range when at normal water level. However, an extended detention depth of 350 mm increases the shallow marsh inundation depth range to 350-500 mm water depth, and up to 700 mm water depth in the deep marsh, which predominantly lie outside the maximum depth typical of healthy and dense vegetation. The ability of the macrophytes to cope with increased inundation (such as occurs when the EDD of the wetland is engaged) depends upon the inundation frequency, duration and depth. Repeated rainfall events can lead to prolonged inundation within wetlands, and even a single flood event may cause significant loss of vegetation if the wetland vegetation is fully inundated for more than one week.

The potential impact of inundation upon the wetland vegetation has been addressed by the requirement of an inundation frequency analysis during the design, and further criteria relating to suitable plant types and planting. Refer to the following websites for access to the online [inundation frequency analysis tool & wet spells analysis](#).

Important note: the extended detention depth should not be iteratively determined based upon an inundation frequency analysis.

In Australia, natural wetlands have evolved in an environment of cyclic wet and dry periods and it is not unusual for them to completely dry out. It is important to design a wetland so that it has the ability to dry out so that access to the wetland can be achieved for maintenance, remove unwanted plants, clean out sediment and rubbish, and renew the vegetation if necessary. This periodic wetting and drying should be incorporated into the [Maintenance Agreement](#) and [Operational Plan](#) for the wetland system.

Consideration must be given to how inflows are controlled during a deliberate drying out phase, and provision should be made to allow flows to bypass the wetland or specific cells and elements of the wetland. Please note, exposing the vegetation to excessive dry periods can be detrimental to the health of vegetation and specific advice should be sought from an experienced aquatic plant specialist to determine the risks to the plants during extended wet and dry periods.

Important note: water level manipulation with the ability to fully drain the wetland is essential for wetland maintenance plus long-term sustainability and asset life.

Important note: often too much is expected of a wetland and many wetlands in the past have been undersized or constructed online without consideration of the impact that larger and frequent flows will have on the aquatic vegetation and/or the likelihood of re-suspension of the stored pollutants.

The design and construction of these wetland systems is not a task for amateurs and requires the involvement of professional wetland specialists experienced in the long-term management of these systems.

A pond fringed with emergent aquatic vegetation will have little impact on nutrient control and will provide an ideal habitat for water birds, which could result in an increase in faecal contaminants as well as elevated nutrient levels within the water column and excessive damage to the emergent macrophytes.

3.4 Locating Wetlands within a Drainage Channel or Waterway

Although it is possible to design a wetland within a drainage channel or waterway it is not Melbourne Water's first preference. Online wetlands are considered undesirable due to hydrological impacts on wetland function and vegetation survival. Excessive flows through wetlands may lead to increased inundation frequency, scouring of the vegetation, accumulated sediments (including metals) and topsoil loss. This compromises the integrity of the wetland system and functional performance, both in the short and long term, resulting in higher ongoing operational and lifecycle costs.

The primary objective when seeking to locate wetlands within or adjacent to waterways should be the protection of the waterway; including connectivity of upstream and downstream aquatic ecosystems (including ephemeral and constructed waterways). Most urban waterways have highly beneficial ecosystem values, and the construction of online wetlands is generally deemed inappropriate. Refer to Melbourne Water's [Healthy Waterways Strategy](#) and *Constructed Waterways in New Urban Developments: Design Manual* for further information.

Connectivity is a vital component of stream ecology. Connectivity, maintains baseflow conditions, provides passage for fish, invertebrates and other biota within the waterway, and facilitates the movement of water borne plant propagules within the waterway. The location of wetlands within a waterway channel can significantly impact biodiversity processes and influence the natural sediment transport processes that may be required for downstream habitat formation and stability. Wetland systems that are within a waterway channel are also at risk of intercepting large volumes of water, debris and sediment that increases the need for and costs associated with maintenance.

Maintenance of a wetland system within a waterway is costly, especially when you consider the full asset lifecycle. It is desirable for a wetland to be able to be taken offline, drawn down and dried out, as this replicates the hydrological regime of a natural wetland through regular wetting and drying of wetland sediments (important to nutrient uptake) and the long term sustainability of the wetland vegetation (macrophyte regeneration and growth).

The Deemed to Comply design criteria outlined in **Part A2** states that 'sediment ponds must be located offline of waterways but online to the pipe or lined channel they are treating water from'.

3.4.1 Definition: Offline vs Online Wetlands

All wetlands are required to be online to the catchment they are treating runoff from but offline from waterways (Figures 1 & 2). A waterway is defined as either a natural or constructed

waterway, and includes reaches of a waterway that are required to be fully or partially constructed to service new development.

The general configuration of a wetland system offline to a waterway is shown in Figure 1. The sediment pond is located online to the pipe or channel conveying stormwater from Catchment A but offline to the waterway receiving stormwater from Catchment B. The macrophyte zone is located offline of the pipe or channel and the waterway. A bypass route (pipe or channel) enables flows to be diverted around the macrophyte zone and discharged to the waterway when the water level in the macrophyte zone is at TED. In some circumstances, the wetland may be located within the base of a retarding basin. Under this scenario, the wetland configuration will be the same including provision of a bypass route (Figure 1).

A wetland may be located within the floodplain adjacent to a waterway (Figure 2). Under this scenario, the sediment pond is located online to the pipe or channel conveying stormwater from Catchment A but must not be located online to the waterway receiving stormwater from Catchment B. The macrophyte zone is located offline of the pipe or channel and within the floodplain adjacent to the waterway. Treated stormwater may be discharged directly to the waterway, whereas a bypass route (pipe or channel) is still required to divert flows around the macrophyte zone and to the waterway when the water level in the macrophyte zone is at TED. It is important that the potential impacts of flooding within the waterway corridor are considered when undertaking the inundation frequency analysis for the wetland.

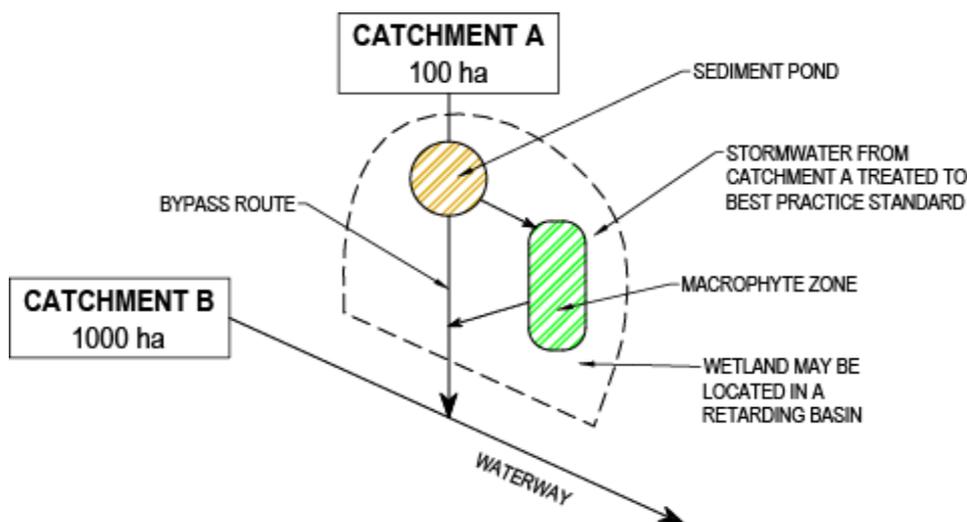


Figure 1: Wetland is online to Catchment A and offline to Catchment B.

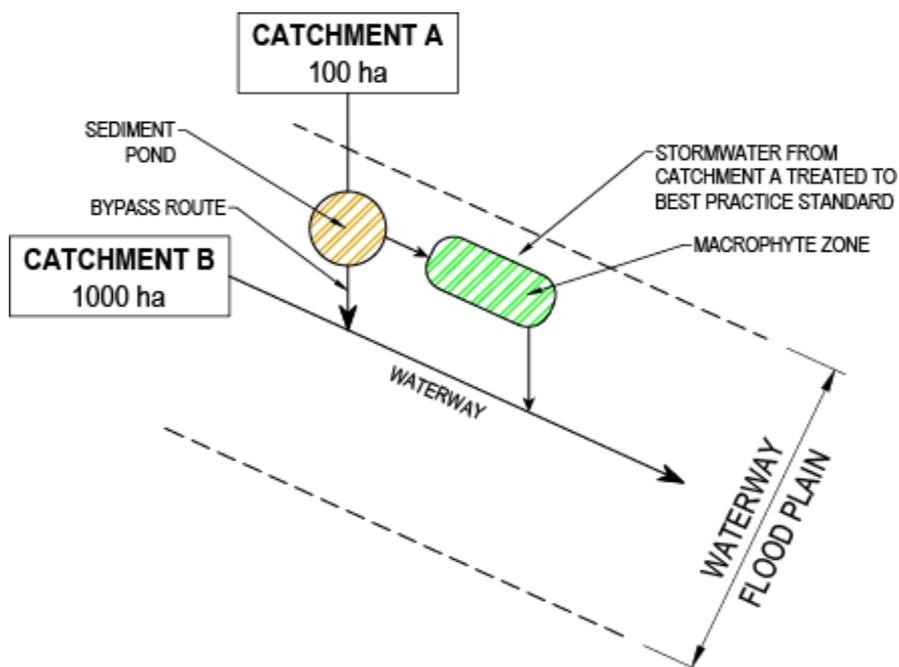


Figure 2: Wetland located within the waterway floodplain – online to Catchment A and offline to Catchment B.

In some instances where there is no alternative, the design of a wetland may need to be located within a drainage channel or waterway. Designers may submit proposals to Melbourne Water through the alternative design approach for consideration and acceptance. Table 2 is a summary of the requirements that should be considered for wetland designs that are located within a waterway:

Table 2: Requirements that should be considered for wetland designs that are located within a waterway

Primary Objective	
1. Waterway health and connectivity of aquatic ecosystems	Waterway form and function should be protected and the connectivity of upstream and downstream ecosystems should be considered (including ephemeral and constructed waterways). Connectivity is a vital component of stream ecology, as maintaining baseflow conditions provides passage for fish and invertebrates within the stream and facilitates the movement of water borne plant propagules within the stream system.
2. Overall maintenance of wetland system	The wetland must be designed so that it is able to be drawdown and dried out for future maintenance considerations
Secondary Objectives	
3. Sizing and maintenance frequency of the sediment pond	Capture 95% of >125 µm particles for the peak three month ARI.
	The size of the sediment pond must result in clean out frequencies of less than five years

Primary Objective	
4. Protection of the sediment pond and macrophyte zones from scouring	Velocities within the sediment pond must not exceed 0.5 m/s during a 100 year ARI event.
	Velocities within the macrophyte zone must not exceed 0.05 m/s during 3 month ARI inflow events or 0.5 m/s during the 100 year ARI flow event (if located in a floodplain).

Important note: the primary objectives must be satisfied to Melbourne Water’s acceptance before the secondary objectives will be considered.

Important note: Low velocities through the wetland are critical to prevent scouring, erosion and vegetation loss – hence they are critical to the long term performance of the wetland. The design of the high flow bypass, wetland size, configuration and outlet properties are the key influences on velocities. Once scouring of the sediments has started, vegetation growth may be compromised, which promotes further scouring in a negative feedback cycle. Hence it is vital to protect the wetland from high velocities associated with large runoff events.

3.5 Locating Wetlands Within Retarding Basins

Wetlands are often located in the base of a retarding basin to reduce the overall area of land required for both stormwater treatment and flood mitigation. Wetlands located within retarding basins are prone to greater inundation depths when retarding basins are engaged during intense rainfall events. Whilst the drawdown of water levels in a retarding basin is normally short (less than 12 hours), it will take at least another three days for water levels in the wetland to return to normal water level, meaning that the wetland vegetation may be inundated for extended periods of time.

It is important that the hydraulic and hydrologic conditions within retarding basins are checked during the design process to ensure that the wetland vegetation is protected from high inflow velocities and that the expected inundation depth, frequency and duration will not be detrimental to the long term health of the wetland vegetation.

Important note: If a wetland must be located in a retarding basin, the design must ensure a relatively rapid drainage of the basin. The inundation frequency analysis must include consideration of water levels controlled by the retarding basin outlet to assess the potential impacts of extended inundation when the retarding basin is fully engaged.

Important note: A requirement for longer establishment periods for vegetation and for asset handover to Melbourne Water may be necessary for wetlands located within retarding basins.

Important note: A bypass route for flows up to the 1 year ARI is still required for a wetland located within a retarding basin.

3.6 Designing for Maintenance Access

Wetlands must be designed to facilitate safe maintenance access to all areas of the wetland. Maintenance requirements should be considered through all phases of wetland design, as it may be too late to modify a wetland design to accommodate maintenance access during detailed design. The maintenance and machinery access requirements, including sediment dewatering areas, will also help to determine the size, configuration, and design of the wetland.

A summary of the major wetland maintenance access requirements that should be considered during wetland design are provided in Table 3 below:

Table 3: Maintenance access requirement

Sediment pond	<ul style="list-style-type: none"> • A 4 m wide access track between external site access and sediment pond, capable of supporting large vehicles.
	<ul style="list-style-type: none"> • A 4 m wide ramp to the base of the sediment pond to enable heavy machinery to enter sediment pond for clean out operations (except for small ponds that may be edge cleaned).
	<ul style="list-style-type: none"> • A track between the sediment pond and dewatering area capable of supporting large vehicles.
	<ul style="list-style-type: none"> • Access to hydraulic structures, e.g. inlet and outlet pipes, bypass weir, pits, etc.
	<ul style="list-style-type: none"> • Gentle batter slopes to enable maintenance access to the perimeter of the sediment pond.
Macrophyte zone	<ul style="list-style-type: none"> • A 4 m wide access track around parts of the perimeter of the wetland for maintenance access. Perimeter access tracks are often integrated with the landscape design, e.g. pedestrian pathway networks can also be used for maintenance vehicle access; however they must be reinforced to a suitable strength to cope with heavy machinery. Note: Melbourne Water may also accept subdivisional roads acting as maintenance tracks where a formal access track isn't possible.
	<ul style="list-style-type: none"> • Access to wetland outlet structures (pits) and water level gauge.
	<ul style="list-style-type: none"> • Gentle batter slopes to enable the macrophyte zone to be readily accessed from all locations.

3.7 Sediment Pond Design Considerations

Sediment ponds must be designed to capture at least 95 % of the coarse suspended solids (≥ 125 μm diameter) for the peak three month flow and have sufficient storage capacity to enable a minimum cleanout frequency of 5 years. In some cases, the size of the sediment pond may need to be increased to provide sufficient storage volume required for a 5 year cleanout frequency.

Sediment ponds that are oversized (i.e. more than 120% of the size needed to capture coarse sediments or provide a 5 year cleanout frequency) are prone to capturing a higher proportion of the fine suspended solids (<125 μm diameter), which are normally captured and retained within the macrophyte zone. Fine suspended solids captured in the sediment pond are highly prone to scour, and may ultimately be removed from the sediment pond and transported to the downstream waterway during large rainfall events.

The number of sediment ponds used within a wetland system must be minimised to one or in some instances no more than two. Multiple sediment ponds associated with a wetland are significantly more complex and expensive to maintain. Desilting sediment ponds requires areas

to be fenced off and having multiple sediment ponds requires a significant land area to be fenced off, which reduces customer satisfaction and increases land disturbance to the surrounding open space area. To undertake maintenance work safely, entire sections of the open space area surrounding the wetland may need to be fenced off to public access or the implementation of very intensive traffic management programs may be required, which are costly. There may be instances where the topography of a site makes it difficult to achieve one sediment pond however all options to reduce the number of sediment ponds must be considered before submitting a design proposal with multiple sediment ponds.

The sediment pond will need to be drained for maintenance and clean out. The sediment pond must be designed to ensure that the water level in the macrophyte zone must not be lowered during sediment pond draw down. This is achieved by pumping excess water within the sediment pond into the transfer pit. Refer [Standard Drawing 7251/12/001](#) and Melbourne Waters [Resetting Sediment Ponds Best Practice Guide](#) for additional information.

Sediment ponds must be designed with a vegetated safety bench below normal water level. The vegetated safety bench helps to minimise unrestricted access to the water and also provides a visual screen around the margins of the sediment pond.

A maintenance access ramp to the base of the sediment pond must be provided to enable heavy machinery such as excavators to enter the sediment pond for cleanout. A small sediment pond may not require a maintenance access ramp if the sediment storage can be accessed (by an excavator) from the margins. The base of the sediment pond should comprise of either reinforced concrete or rock work (Refer Standard Drawing [7251/12/012](#)). This is to enable the base of the sediment pond to be detected during cleanout, and to protect the clay liner.

The primary advantage of placing the high flow bypass within the sediment pond is that it enables sediments to be captured within the sediment pond rather than silting up the instream diversion, and potentially enabling more sediments to be transported to the downstream waterway. The diversion of high flows prior to the water entering a sediment pond also means that there is no feedback mechanism operating on inflows to the macrophyte zone. This means, depending upon the diversion properties, that either too little or excessive flows may be entering the macrophyte zone.

Important note: When the available space for a wetland is constrained, it is important to ensure that the size of the sediment pond is not reduced. This ensures the larger sediments are effectively trapped and prevented from smothering the macrophyte zone. When the site constrains the size of the wetland it is the macrophyte zone of the wetland that should be reduced accordingly.

A summary of requirements which should be considered during sediment pond design and construction are provided in Table 4 below:

Table 4: Requirements which should be considered during sediment pond design and construction

	Considerations
Building phase damage	It is important to have protection from upstream flows during construction of the sediment pond. A mechanism to divert flows around a construction site and to provide protection from litter and debris is required. Refer to Melbourne Waters Building and Works website for additional information.

	Considerations
High flow contingencies	Contingencies to manage risks associated with flood events during construction are required. All machinery should be stored above acceptable flood levels and the site stabilised as best as possible at the end of each day as well as plans for de-watering following storms made.
Maintenance access	An important component of a sediment pond is accessibility for maintenance. Should excavators be capable of reaching all parts of the sediment pond an access track may not be required to the base of the sediment pond; however an access track around the perimeter of the sediment pond would be required. If sediment collection is required by using earthmoving equipment, then a stable ramp will be required into the base of the sediment pond (See Standard Drawing 7251/12/013).
Solid base	To aid with maintenance the sediment pond must be constructed with a hard base (i.e. rock or concrete). This serves an important role for determining the levels that excavation should extend to during sediment removal (i.e. how deep to excavate). Hard bases are also important if maintenance is required by driving directly into the sediment pond. (see Standard Drawing 7251/12/012)
Dry out area	An area should be constructed that allows for de-watering of removed sediments from a sediment pond. This allows the removed sediments to be transported as 'dry' material and can greatly reduce disposal costs compared to liquid wastes. This area should be located such that water from the material drains back into the sediment pond (see Resetting Sediment Ponds Best Practice Guide for additional information.)
Inlet checks	It is good practice to check the operation of inlet erosion protection measures following the first few rainfall events. It is important to check for these early in the systems life, to avoid continuing problems. Should problems occur in these events the erosion protection should be enhanced.

The connection of the sediment pond to the macrophyte zone should be via a transfer pipe and pit arrangement. It is important to have an initial open water section in the macrophyte zone to help disperse flows across the width of the wetland. See relevant design criteria in **Part A2** for more information (plus [Standard Drawing 7251/12/001](#)).

The Transfer Pit within the sediment pond should be designed with the following considerations in mind:

- Ensure that the crest of the pit is set 100mm above the NWL of the wetland inlet pool
- Ensure that the dimension of the pit provides discharge capacity that is greater than or equal to the discharge capacity of the inlet structure
- Discharge capacity does not exceed that of the downstream infrastructure
- Protection is provided against blockage by flood debris

- Maintenance is simple to undertake and suitable provisions are made for access

3.7.1 Quick Reference and Standards for Sediment Pond Design and Construction

- Sediment pond to operate as a flow regulator into the macrophyte zone during normal operation
- Sediment pond to operate for by-pass of the macrophyte zone during above design conditions
- The connection between the sediment pond and the macrophyte zone must have an appropriate design of the inlet conditions to provide for energy dissipation and distribution of inflow into the macrophyte zone
- Provision for sediment and debris removal must be allowed with appropriate maintenance access and provisions provided
- Adequate area must be allocated for dewatering and short term storage of removed sediments
- Sediment ponds must have a mechanism to be drained without impacting on the macrophyte zone water levels. This is achieved by pumping excess water within the sediment pond into the transfer pit. Refer [Standard Drawing 7251/12/001](#) and Melbourne Waters [Resetting Sediment Ponds Best Practice Guide](#) for additional information.

3.8 Designing the Connection Between the Sediment Pond and Macrophyte Zone

The connection between the sediment pond and macrophyte zone must be configured to enable the peak three month ARI to be transferred to the macrophyte zone when the macrophyte zone is at normal water level.

The connection of the sediment pond to the macrophyte zone is achieved using a pipe and pit arrangement. A piped connection will generally comprise of an overflow pit located in the sediment pond with a pipe connection to the macrophyte zone inlet pool. Piped connections are often used in wetland systems where the water level in the sediment pond is higher than the water level in the macrophyte zone (tiered arrangement). In such cases, the opening of the overflow pit or the diameter of the connecting pipe may be used to limit (provide inlet control) the flow rate to the macrophyte zone. Where pipe connections are used, it is important to have an initial open water section in the macrophyte zone to help disperse flows across the width of the wetland.

3.9 Macrophyte Outlet Design Considerations

The water level in a wetland is controlled via a twin chamber outfall pit (Refer Standard Drawing [7251/12/005](#)).

The twin chamber outfall pit has two purposes:

1. Hydrologic control of the water level and flows in the macrophyte zone to achieve the design detention time; and
2. To allow the wetland to be drained or drowned for maintenance.

Twin chamber outfall pits should be designed and located so that they can be easily accessed for maintenance. Any twin chamber outfall pit located within the outlet pool of the macrophyte zone should be accessible from the edge of the wetland (Refer [Conceptual Standard Drawings](#)

[7251/12/4001-4019](#)). This means that the edge of the pit closest to the wetland margin should be located in no more than 350 mm depth.

In addition to being easily accessible, the twin chamber outfall pit should have a hinged grate or gridded lid to enable visual inspection of the sidewinding penstock and open the gate valve from the surface. The submerged offtake pit connecting into the twin chamber outfall pit should be set 300mm off the invert of the deepest part of the outlet pool and be fitted with a water level gauge (see Standard Drawings [7251/12/035](#) and [7251/12/011](#)).

The side winding penstock valve allows the water levels to be adjusted easily. Riser or siphon outlets have been used in past but the maintenance and longevity of these outlets is now considered inappropriate and Melbourne Water will not accept wetland designs with these outlet configurations. A riser cannot be altered should the sizing and catchment change in the future. The PVC material used with the riser is also prone to damage by vandals or the weather. Siphons are permanently inundated; cannot be maintained; and are prone to unacceptable sediment accumulation and blockage.

Spillways or weirs as controlled outlet structures are simple to construct but are not adjustable and incorrect water levels can lead to wetland failure and the rectification works on the spillway height can be difficult and costly. Therefore, Melbourne Water will only accept weirs or spillways as an outlet control in wetland designs when they operate in conjunction with a twin chamber outfall pit ([Refer Concept Drawings 7251/12/4001-4019](#)). The twin chamber outfall pit working in tandem with a weir or spillway also assists with bypassing the EDD for the first 12 months of the planting establishment period, enhancing plant growth in this time.

The outlet in large wetlands may comprise of a twin chamber outfall pit being located adjacent to the wetland and a dedicated high flow bypass structure (pit or weir) located within the outlet pool (Refer Concept Drawing [7251/12/4003](#) and [7251/12/4004](#)) Under this scenario, treated stormwater passes through the twin chamber outfall pit. When the water level in the macrophyte zone is at TEDD, all further inflows to the macrophyte zone will discharge via the overflow structure (pit or weir). Outflows from the twin chamber outfall pit and the overflow from the high flow bypass structure, combine into a single pipe or waterway and are then conveyed to the downstream receiving waterway.

The use of a twin chamber outfall pit maintains an adequate hydraulic gradient across the wetland, and also has significant benefits in the operation and maintenance of the wetland. The twin chamber outfall pit includes: the control of the wetland design detention depth (EDD) (Refer Standard Drawing [7251/12/005](#)) incorporation of a resilient seated gate valve (not a high pressure valve) to allow full or partial draw down of the system (no other valve types are acceptable)) and provides the outlet of flows from the wetland. This provides outlet conditions with a more dynamic hydraulic regime which allows the establishment of shallow marsh vegetation and ephemeral and deep marsh species.

Regardless of the controlled outlet type, the controlled outlet must be configured to provide a 90th percentile residence time of a maximum of 72 hours (refer to **Part D** for guidance on calculating the wetland residence time) and should also include measures to trap debris to prevent clogging and blockage of the outlet structure.

Outlet structures should be designed and located so that they are easily identifiable and maintainable. This requires easy and safe access for maintenance and operational personnel. The ability to have total visibility inside the weir pit through a grate structure is essential so that the pit lid does not always need to be lifted to see the controlled outlet in operation, which improves operational staff health and safety and reduces confined space entry requirements.

3.10 Vegetation and Establishment Considerations

The treatment performance of a wetland is highly dependent upon flows passing through dense vegetation. The distribution of wetland vegetation is typically determined by inundation depth, frequency and duration. In wetlands these factors are determined by the permanent pool depth of the various macrophyte zones (shallow marsh, deep marsh, submerged marsh) and the amount of time that inflows engage the extended detention depth. Vegetation in the wetland has a direct relationship to the treatment performance. If the vegetation does not meet the design criteria, then it is unlikely that the wetland is achieving the required treatment standard.

Important note: Approximately equal amounts of shallow marsh (100-150 mm deep) and deep marsh (150-350 mm deep) in the macrophyte zone is required, and supported by science literature, for effective wetland function.

At least 80% of the wetland area below normal water level should comprise of shallow and deep marsh vegetation.

Dense vegetation bands and flat bathymetry orientated perpendicular to the flow path are required for even flow distribution and reduced short-circuiting through the macrophyte zone.

Macrophyte species planted within the wetland must be in accordance with the species lists and guidance provided in **Part A2**. Whilst the majority (90%) of the species planted within the wetland must conform to the species lists provided in Part B2, an allowance of up to 10% has been made for the use of alternative species (20% for the ephemeral batter). Refer to the species lists provided in Appendix A, [WSUD Engineering Procedures: Stormwater](#) for information on alternative species that may be planted in the wetland.

The expected wetland inundation regime must be analysed to determine whether there is a potential risk to the long term health of the emergent macrophytes. The effective water depth (permanent pool depth plus EDD) must not exceed half the average plant height for more than 20% of the time. This must be demonstrated during design using an inundation frequency analysis. Refer to the Melbourne Water online [inundation frequency analysis tool & wet spells analysis tool](#), and **Part D** for guidance on undertaking an inundation frequency analysis.

Submerged marsh planting (350-700mm) is to occur around the margins of all open water zones within the macrophyte zone, but are not to be included in the calculation of the 80% emergent vegetation cover and the inundation frequency analysis.

The minimum pot size to be specified for macrophyte seedlings is $\geq 550\text{cm}^3$. Macrophyte seedlings grown in smaller pots (90cm^3 hiko cell or 200cm^3 forestry tubes) are generally too small and do not have sufficient energy reserves to withstand inundation and grazing pressure.

The larger pot size for macrophyte seedlings of $\geq 550\text{cm}^3$ are likely to be more resilient against inundation and waterbird grazing. Seedlings sourced from bare-root divisions from tub/tray grown stock or stock harvested from existing wetlands will not be accepted.

The adoption of larger pot sizes ($\geq 550\text{cm}^3$ pots) has resulted in a reduction in minimum planting densities for this seedling size (refer to **Part A2** for minimum planting densities).

The minimum acceptable pot or tray size for seedlings planted in the ephemeral batters is 90cm^3 (V93 Hiko equivalent) with 200cm^3 forestry tubes the preferred option.

The quality of topsoil used in a wetland may have a major influence on vegetation establishment and growth characteristics. The requirement to meet the Australian Standard AS 4419 'Soils for landscaping and garden use' will ensure that the basic agronomic requirements (salinity, pH, soil structure) are considered prior to lining the wetland with topsoil (Refer [Melbourne Waters topsoil specification](#)).

3.11 Designing to Avoid Mosquitos

Mosquitos are a natural component of wetland fauna. The construction of any water body will create a habitat suitable for mosquito breeding and growth. Healthy, well vegetated wetlands function as balanced ecosystems and have predators that control mosquito populations. The risk of mosquito breeding can be addressed through:

- Ensuring all parts of the wetland are well connected to provide access for mosquito predators to all inundated areas of the wetland;
- Providing areas of permanent open water that provide refuges for mosquito predators (even during long dry periods);
- Ensuring wetland water quality is adequate to support of mosquito predators such as macroinvertebrates and fish (this is normally the case for wetlands where stormwater is the dominant inflow);
- Providing a bathymetry that ensures that regular wetting and drying is achieved and water draws down evenly so isolated pools are avoided;
- Ensuring wetland configuration does not provide dead spots or open areas away from normal direction of flow;
- Maintaining water level fluctuations that disturb the breeding cycle of some mosquito species;
- Providing gross pollutant control upstream of the wetland so that gross pollutants do not accumulate and provide mosquito breeding habitat within the wetland; and
- Ensuring that maintenance procedures do not result in wheel ruts or other localised depressions that create isolated pools when wetland water levels fall.

3.12 Climate Change

An assessment of the potential impacts of climate change on stormwater treatment wetlands was undertaken by Melbourne Water (EDAW, 2010)¹.

Predicted long term changes in climate for Melbourne include:

- Long term increase in temperatures and evapotranspiration, particularly during summer;
- Reduced mean annual rainfall, particularly during winter and spring; and
- Infrequent but more intense storms and longer dry spells with heavy rainfall events, particularly during summer.

¹ EDAW (2010) Discussion paper: Potential impacts of climate change on wetland performance. Report prepared for Melbourne Water.

Three climate scenarios were investigated for predicted changes in rainfall and evapotranspiration for 2030, 2070A and 2070B (CSIRO and Bureau of Meteorology, 2007)².

The modelling indicated that climate change would result in a slight increase in treatment performance of stormwater wetlands as a result of decreased mean annual rainfall and increased evapotranspiration, which provides greater drawdown between events and therefore increased treatment performance for subsequent events.

The study concluded that no design response is required to protect stormwater treatment wetlands from the potential impacts of climate change, and that potential issues associated with water level drawdown could be managed by slightly increasing the normal water level of a wetland.

3.13 Safety in Design

Melbourne Water advises that the construction of any water body must include the following design considerations to minimise risk associated with the system:

1. The edge of any deep open water should not be hidden or obscured by embankment or terrestrial planting unless measures are taken to preclude access (this could be barrier planting in the long term with short term safety fencing or farm fencing).
2. All boardwalks, piers, bridges and/or structurally treated edges installed and maintained by others are to have heights and or railings in accordance with relevant design codes and satisfy inundation and safety criteria.
3. Details and safety requirements for batter slopes are outlined as design criteria in **Part A2**.
4. Please refer to Melbourne Water's [Constructed Shallow Lake Systems - Design Guidelines for Developers](#), when large areas of open water are included in the design in addition to a wetland. Open water or shallow lakes are generally considered to have a higher probability of algal blooms than wetlands due to the longer residence times of stormwater, lower abundance of rooted macrophytes and an increased likelihood of thermal stratification. The likelihood of algal blooms can however be minimised by appropriate design and management of the waterbody.
5. Interim fencing will be required until vegetation establishment has occurred and where any component of the wetland is deeper than 350 mm and not provided with default minimum safety slopes to the water's edge. Please refer to Melbourne Water's [risk assessment for safety and security fencing on construction sites](#).
6. Permanent fencing and/or combined fencing and dense impenetrable plantings should be used alongside deep water zones that do not have safety batters, or that are adjacent to potentially unsafe structures.
7. Maintenance access areas must be fenced, gated or contain bollards to discourage unauthorised access.
8. Public access to structures, the top of weirs, pits and outlet structures must be restricted by appropriate safety fences and other barriers.

² CSIRO and Bureau of Meteorology (2007) Climate change in Australia. Technical Report, 140 pp.

9. No public access is permitted into the wetland site during the construction phase. Appropriate fencing and signage must be provided and maintained by the developers contractor during this phase. Please refer to Melbourne Water's [risk assessment for safety and security fencing on construction sites](#).
10. A minimum offset of 15 metres from the edge of the water to any allotment boundary or Melbourne Water asset (not including a shared pathway).

As part of Melbourne Water's 'Zero Harm' culture, 'Safety in Design' is a paramount consideration. The **Deemed to Comply** design conditions have been prepared to ensure that designs are safe for the contractors to build, safe for people to use, and safe for people to maintain in the future. Our management of risks and hazards include eliminating, through design, as many risks as possible that may be encountered during construction, maintenance or demolition.

Wetland designs must comply with the Melbourne Water Safety in Design Audit to ensure that projects are undertaken in accordance with the Melbourne Water Safety in Design Management Procedure. For more information, please contact Melbourne Water's Developer Project Works team or visit [Melbourne Water's website](#).

4. References

Document title
Building and Works website
Concept Drawing 7251/12/4003
Concept Drawing 7251/12/4004
Conceptual Standard Drawings 7251/12/4001-4019
Healthy Waterways Strategy
Maintenance Agreement
Melbourne Water's Topsoil Specification
Melbourne Water's Constructed Shallow Lake Systems - Design Guidelines for Developers
Melbourne Water's Resetting Sediment Ponds Best Practice Guide
Melbourne Water's Risk Assessment For Safety And Security Fencing On Construction Sites.
Operational Plan
Resetting Sediment Ponds Best Practice Guide
Standard Drawing 251/12/011
Standard Drawing 7251/12/001
Standard Drawing 7251/12/001
Standard Drawing 7251/12/005
Standard Drawing 7251/12/012
Standard Drawing 7251/12/013
Standard Drawing 7251/12/035
WSUD Engineering Procedures: Stormwater

5. Document History

Date	Reviewed/ Actioned By	Version	Action
December 2020	Senior Asset Practitioner – Water Quality	1	Updated template and links