Biofiltration systems in Development Services Schemes

Guideline

September 2020

Melbourne Water makes a vital contribution to the famous Melbourne lifestyle through the supply of high-quality water, reliable sewerage services, integrated drainage and flood management services and by enhancing our waterways and land for greater community use.

Melbourne Water
Enhancing Life and Liveability

Table of contents

Acknowledgements

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Acronyms and Abbreviations

Term	Definition
AEP	Annual Exceedance Probability
ARI	Annual Recurrence Interval
EDD	Extended Detention Depth
EY	Exceedances per Year
NWL	Normal Water Level
TED	Top of Extended Detention
WSUD	Water Sensitive Urban Design

1. Purpose

This guideline is intended for use by members of the land development industry who design, construct and establish biofiltration systems in Melbourne Water Development Services Schemes. It may also be a useful resource for other professionals working within the stormwater management and land development industry.

The aim of the guideline is to facilitate the consistent delivery of best practice biofiltration system assets.

The guideline applies where no Council specific requirements exist for these systems. Where Council requirements exist, these requirements will be applicable unless otherwise directed by Council. Where Council requirements are applied, the relevant Council is responsible for the design, construction, construction supervision, maintenance, renewal and performance of the asset.

2. Scope

The guideline articulates Melbourne Water's expectations and requirements for biofiltration systems and provides design acceptance pathways for consultants submitting biofiltration system design and construction applications to Melbourne Water.

It covers standard, gravity-fed, non-proprietary biofiltration systems for treating stormwater runoff from an urban catchment. It does not cover biofiltration swales, biofiltration tree pits, proprietary systems, systems required to treat major road runoff or systems designed for stormwater harvesting.

3. PART A: General considerations

Key messages

- Biofiltration systems are defined as terrestrial stormwater treatment systems. This differs from constructed stormwater treatment wetlands, which function as aquatic systems.
- Biofiltration systems proposed in Melbourne Water Development Services Schemes must meet a number of *Deemed to Comply Criteria or specified core outcomes* where no Council specific criteria exist.
- This document covers standard biofiltration systems, not including bioretention swales, bioretention tree pits, proprietary systems or systems designed for stormwater harvesting.
- Melbourne Water does not support the use of biofiltration systems at risk of being exposed beyond their intended inundation and wetting regime, (that is flows >3 month ARI, fully connected to >10 hectare catchments) unless it can be proven that this risk can be removed through an alternative design approach.

What is a biofiltration system?

Biofiltration systems, also known as biofilters, bioretention systems, bio-infiltration systems and raingardens are one component of a range of accepted Water Sensitive Urban Design (WSUD) elements (Wong 2006). They are a low energy treatment technology with the potential to provide both water quality and minor quantity benefits. They are generally quite small, typically only two per cent of the impervious urban catchment area and are best located close to the source.

Biofiltration systems are designed to treat the minor yet frequent storm events, that is, up to the 3 month Annual Recurrence Interval (ARI). Their primary use is to improve stormwater quality through removal of nutrients and sediments from stormwater. They are effective at removing fine sediment, phosphorus, nitrogen, metals and hydrocarbons from stormwater. They may also provide minor flood mitigation benefits through temporary shallow ponding above the filter media, and can be designed to provide stream flow benefits through a slow release of the ponded stormwater via percolation through the filter media. A typical system consists of a vegetated basin overlying layers of porous media as illustrated in Figure 1. Stormwater enters the system via an inflow pipe or other form of distribution onto the surface of the system. Stormwater ponds on the surface of the system, then percolates vertically through the filter media. As stormwater moves through the filter media, pollutants are captured or transformed by a range of physical, chemical and biological processes associated with the media, plants and soil microbial community. Depending on the design, treated water may be discharged into surrounding soils, or collect in an underground drainage system for conveyance to downstream waterways or storages for subsequent re-use (Water by Design 2014; Payne, Hatt et al. 2015).

Biofiltration systems are fundamentally different to constructed stormwater treatment wetlands in a number of ways. Biofiltration systems are essentially terrestrial systems as ponding of water is only temporary following a storm event, and they are designed to dry out between inflows. Water in a biofiltration system is processed in a vertical flow direction. Constructed stormwater wetlands are aquatic systems, which differ in their treatment processes and have permanent pools of water. Water is processed in a horizontal flow direction and retained for longer periods. Wetlands have a lesser depth requirement for drainage outfall than biofiltration systems, however usually require a larger site footprint.

1. Outlet
2. Overflow weir
3. Outlet pipe
4. Overflow pit
5. Filter media
6. Transition layer
7. Liner
8. Cleanout riser pipe
9. Drainage layer with underdrainage
10. Extended detention
11. Coarse sediment removal system
12. Vegetation
13. Inflow pipe
14. Maintenance access
15. Insitu soils
16. Bund / embankment

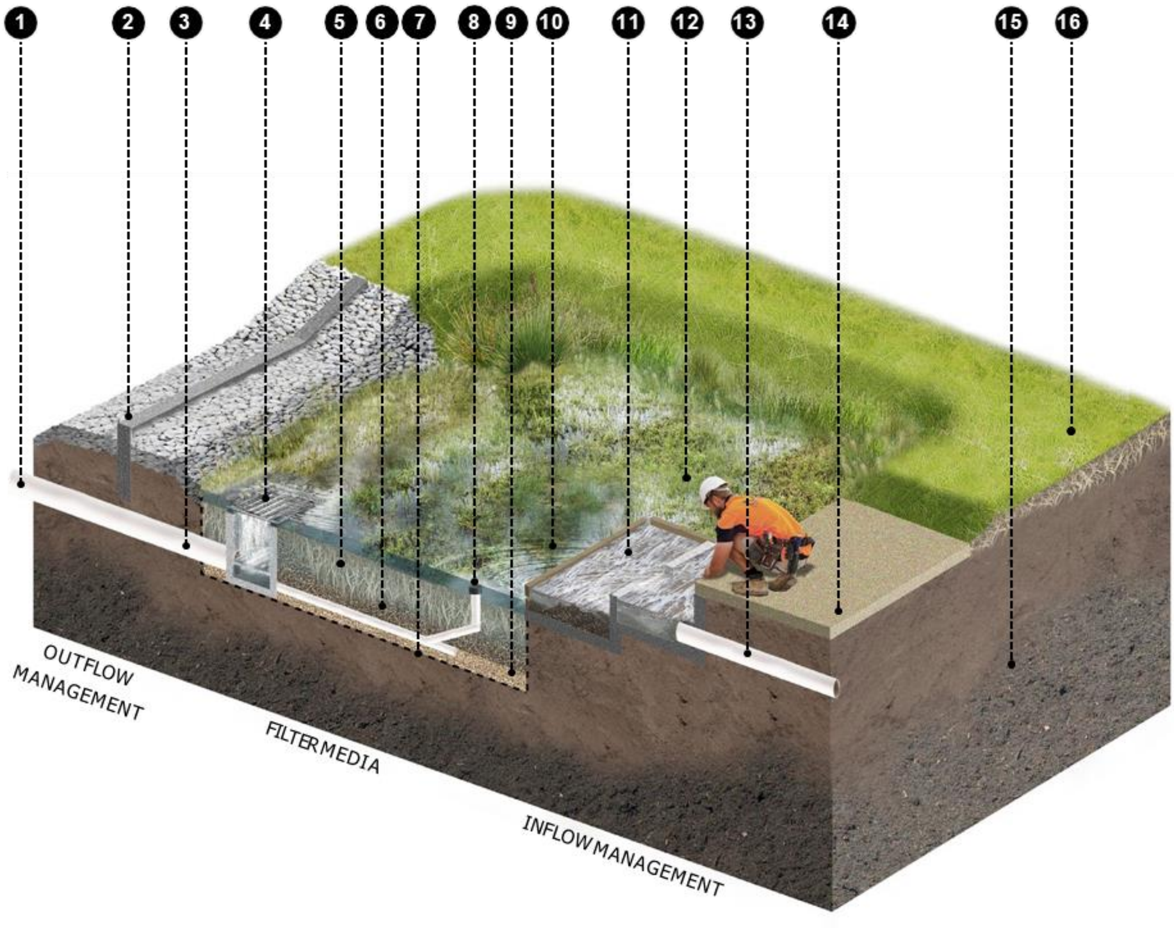


Figure 1 Components of a typical biofiltration system

Biofiltration systems form part of a stormwater treatment train. A treatment train is a term to describe a set of treatment measures arranged in series. In this way the outflow from one treatment measure flows into the next until the discharge to the receiving waters meets the treatment requirements for a location. A treatment train is required in most cases as a single measure is rarely capable of treating all of the stormwater pollutants. In a stormwater treatment train, biofiltration systems form the secondary or tertiary treatment stage as illustrated in Figure 2.

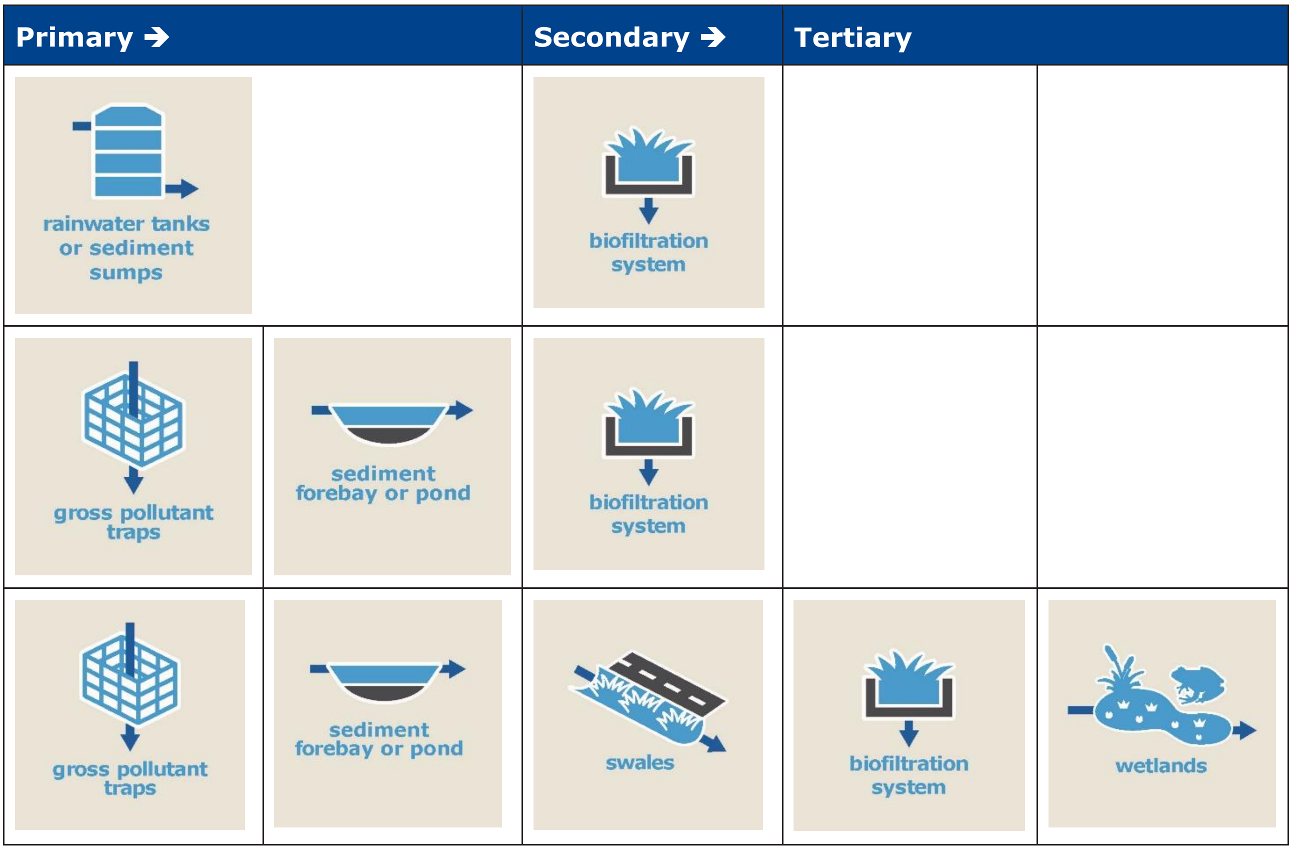
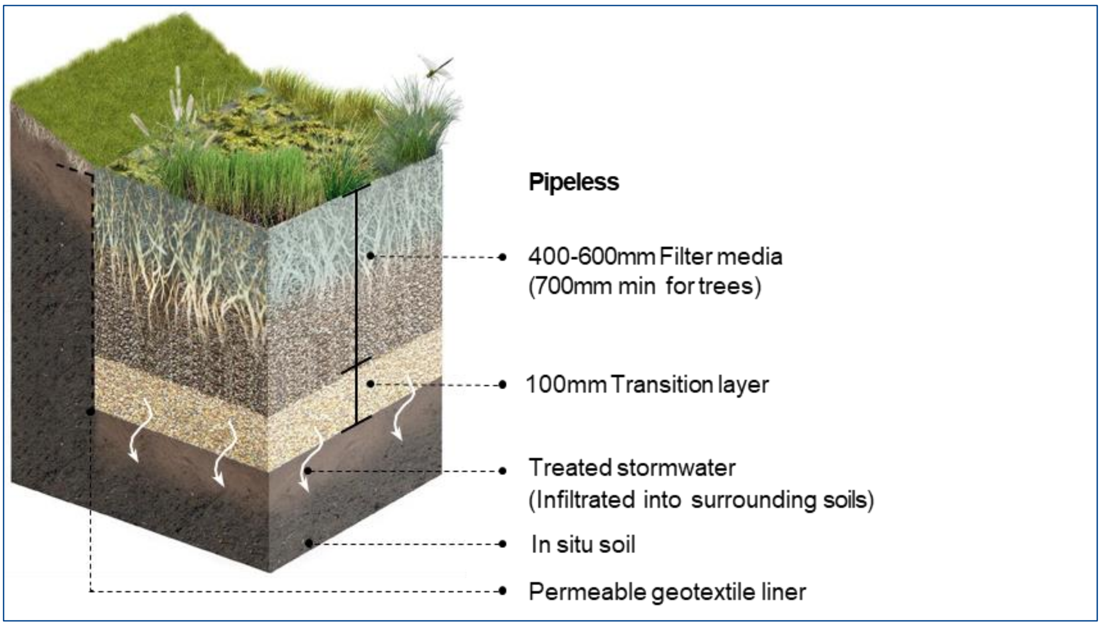


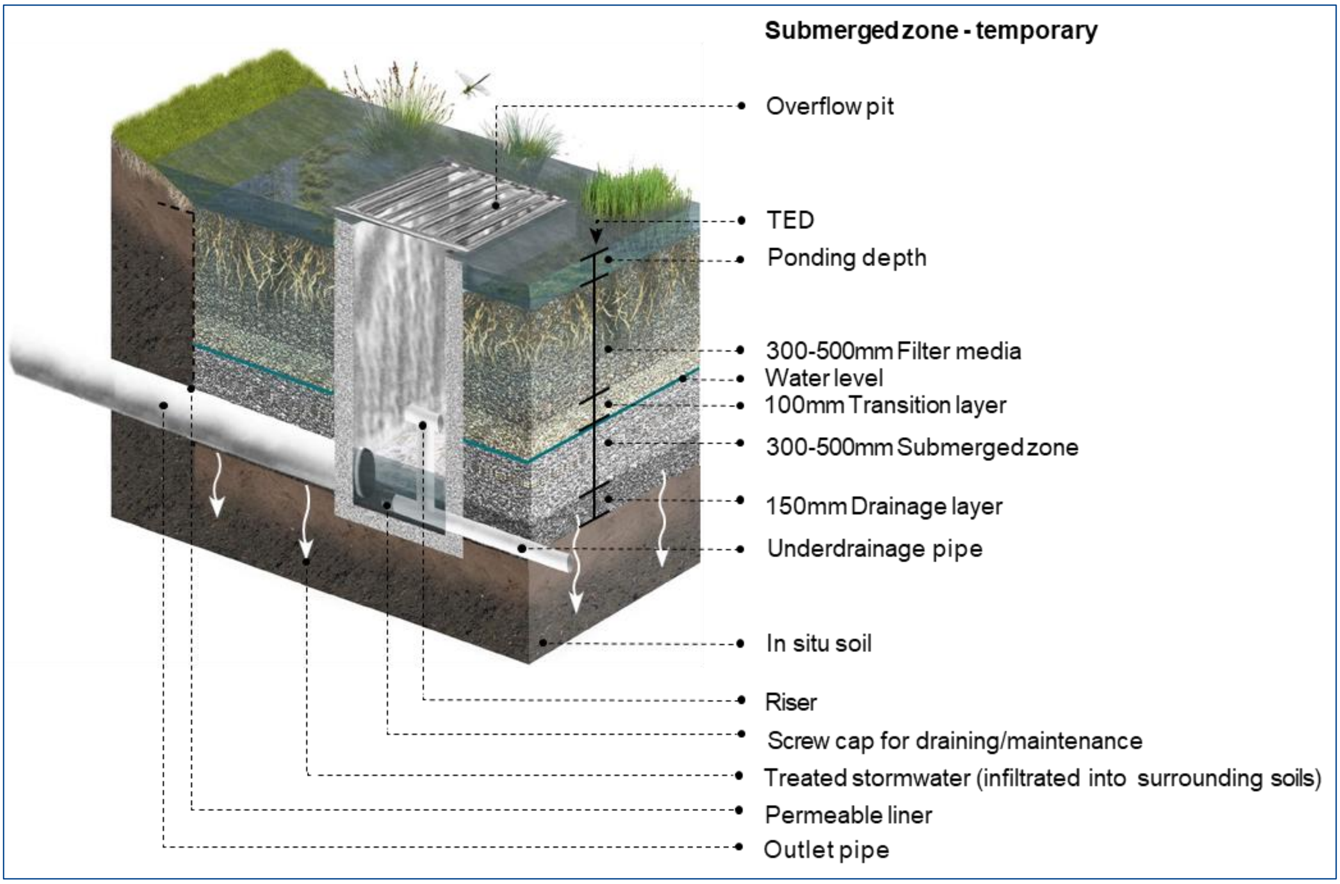
Figure 2 Examples of biofiltration system sequencing in a treatment train

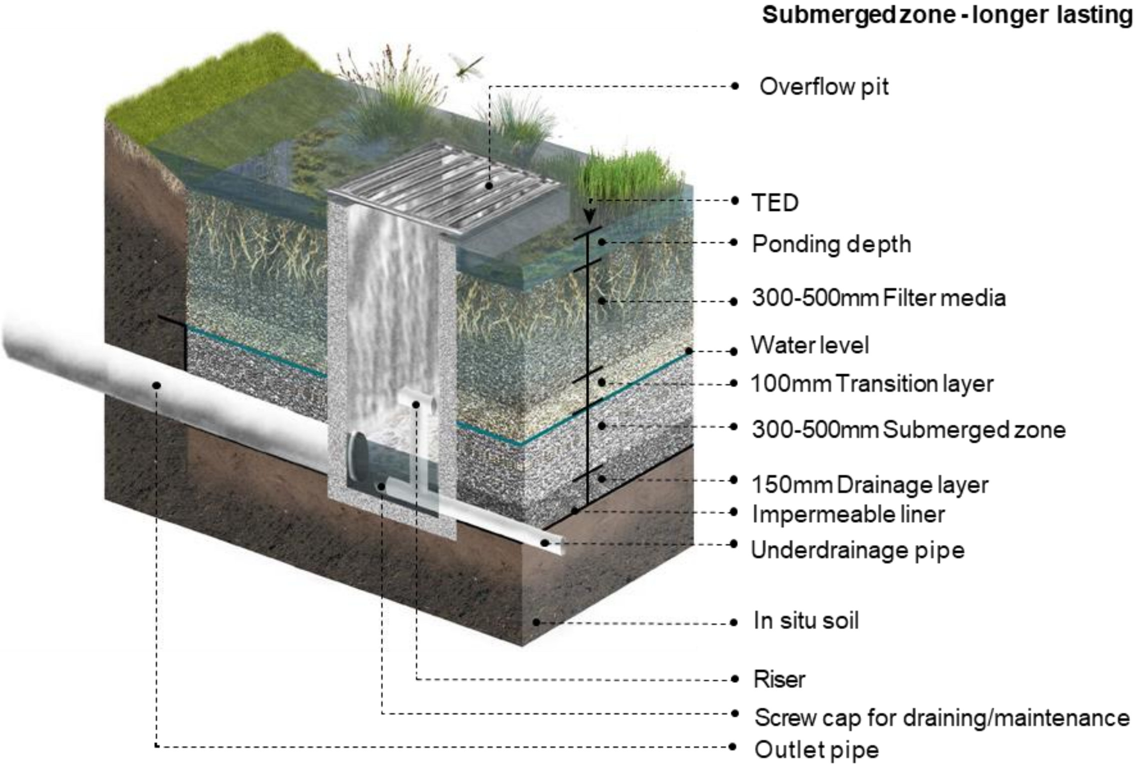
Biofiltration system treatment elements can be combined in various ways to create different system types. Examples of these combinations are illustrated in Figure 3. Designs must be chosen based on the purpose they are required to achieve. Submerged systems are recommended wherever possible as they provide a reliable moisture source for the planted vegetation. To keep cost and complexity at a minimum, design solutions must be as simple as possible.

System type	Elements	Application and purpose
Pipeless	Underdrains: absent Raised outlet: absent Side liner: present/permeable type Base liner: absent	The omission of underdrains and base liner enable exfiltration to manage frequent urban stormwater flows where infiltration capacity of the surrounding soil is equal to or greater than the system's exfiltration capacity. The permeable geotextile liner* prevents surrounding soil migration into the biofiltration layers. * A geotechnical report must be provided confirming the permeable liner can be eliminated, where such an option is proposed.

System type	Elements	Application and purpose
Submerged zone – temporary	Underdrains: absent Raised outlet: present Side liner: present/permeable type Base liner: absent	The raised outlet holds water at the top of the submerged zone layer to provide an internal water storage for vegetation and microbes to draw from. This storage is temporary due to the omission of the base liner, which enables exfiltration. The internal water storage is drawn down through plant uptake, exfiltration and evaporative losses.
Submerged zone – longer lasting	Underdrains: absent Raised outlet: present Side liner: present/impermeable type Base liner: present/ impermeable type	The impermeable liner and raised outlet (riser or weir for large systems) hold water at the top of the submerged zone layer, which provides a longer lasting internal water storage (wet sump) for vegetation and microbes to draw from during dry periods. This facilitates plant and soil biological health and helps maintain ongoing treatment performance. It benefits nitrogen removal by providing anaerobic conditions for denitrification. The internal water storage is drawn down through plant uptake and evaporative losses.
Basic	Underdrains: present Raised outlet: absent Side liner: present/permeable type Base liner: absent	The permeable geotextile liner prevents surrounding soil migration into the biofiltration layers. The absence of a base liner enables exfiltration. Underdrains provide drainage when the soil infiltration capacity and uptake of moisture through the planted vegetation is exceeded.
Contained	Underdrains present Raised outlet: absent Side liner present/impermeable type Base liner: present/ impermeable type	The impermeable liner provides structural separation where water needs to be prevented from being exchanged between the biofiltration system and the surrounding soil. These are situations where exfiltration is not desirable, such as where systems are designed to store harvested water, where surrounding soils need to be prevented from contaminating the filter or treated water in the system, or where surrounding soils are at risk of eroding when exposed to water.


Pipeless
400-600mm Filter media
(700mm min for trees)
100mm Transition layer
Treated stormwater
(Infiltrated into surrounding soils)
In situ soil
Permeable geotextile liner


Submerged zone - temporary
Overflow pit
TED
Ponding depth
300-500mm Filter media
Water level
100mm Transition layer
300-500mm Submerged zone
150mm Drainage layer
Underdrainage pipe
In situ soil
Riser
Screw cap for draining/maintenance
Treated stormwater (infiltrated into surrounding soils)
Permeable liner
Outlet pipe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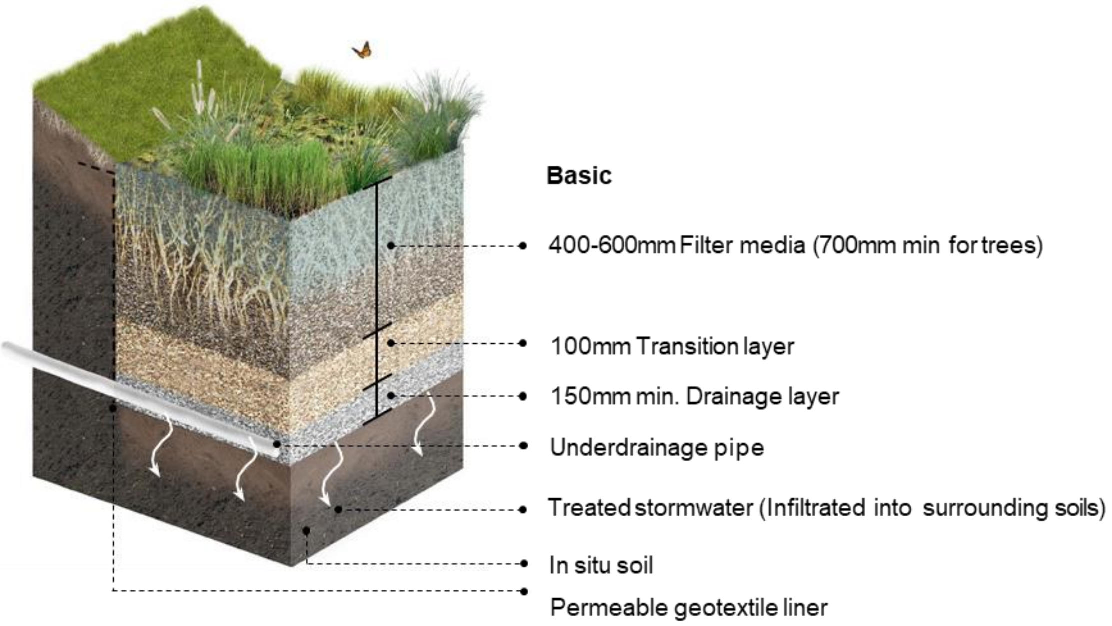
Basic
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100mm Transition layer
150mm min. Drainage layer
Underdrainage pipe
Treated stormwater (Infiltrated into surrounding soils)
In situ soil
Permeable geotextile liner

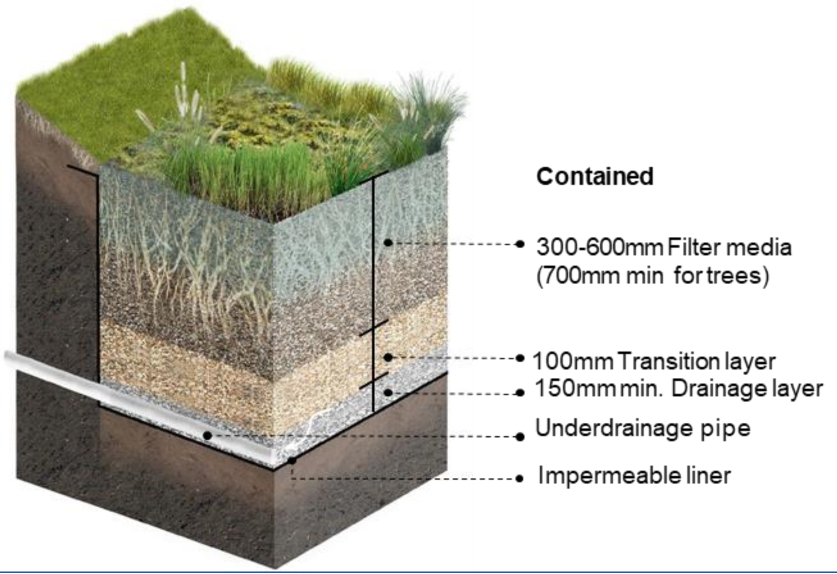

Figure 3 Biofiltration system types

Core and aspirational outcomes

All biofiltration systems in Development Services Schemes must achieve the following core outcomes:

1. Deliver effective pollutant removal and flow regime management.
2. Offer a safe environment for the community to interact with.
3. Provide safe assets for operational and maintenance personnel.
4. Enable cost effective, long-term asset management over a life span of at least 25 years.

It is encouraged that biofiltration systems contribute to the following aspirational outcomes:

- material sustainability
- cooling
- wellbeing, liveability and amenity
- alternative water supply
- recreation
- landscape and cultural objectives
- accessibility
- local habitat improvements
- conservation.

Detailed descriptions of these core outcomes and aspirational outcomes can be obtained from the *Wetland Design Manual* (Melbourne Water, 2016) and Appendix B in this document.

When is a biofiltration system not appropriate?

The below checklist is to be used as a first decision making step when assessing whether a biofiltration system is the appropriate treatment solution for a site.

Not appropriate	Why	Potential mitigating design response
Too Wet Sites that are too frequently wet or for too prolonged a time, for example sites that are: • in retarding basins, floodplains, flow paths • downstream of regional wetlands • fully shaded • inundated by shallow or seasonal ground water tables, • fully connected to catchments >10 hectares • with oversized catchments or with undersized systems.	Algae can form thick surface biofilms in continuously wetted systems, which reduce the rate of infiltration into the filter media and cause clogging. Similarly moss can form on the filter surface where excessively wet conditions, coupled with optimal light exposure, support growth. Systems fully connected to larger catchments are at risk of excessive wetting due exposure to continuous trickle flows. Full shading can prevent periodic drying and inhibit plant establishment. Periodic drying out of a biofiltration system is required and damp conditions inhibit this.	Low flow diversions may help solve problems caused by continuous inflow but won't address capture and treatment of the flows containing the highest concentration of pollutants, hence are not effective. The selection of fully shaded sites must be verified through evaporation calculations that take into account climatological records such as sunshine, temperature, humidity and wind speed at the subject site and vegetation specific parameters such as conductance of the plant surface. Options for treating catchments > 10 hectares may include using more than one biofiltration system, a wetland or a combination of biofiltration systems and other WSUD measures.
Too dry Downstream of oversized sediment ponds, high demand rainwater tanks, high exfiltration or without saturated zones during dry conditions	Upstream sediment ponds must not be oversized for their catchment (particularly in drier regions) as, through water losses, there may be insufficient moisture supply for biofiltration system vegetation. High demands connected to upstream rainwater tanks may result in a lack of overflows and hence insufficient moisture supply for the biofiltration system vegetation.	Submerged systems are recommended wherever possible to provide a reliable moisture source for the planted vegetation. Modelling and analysis to track soil moisture patterns (durations, spells) are required to verify design in uncertain circumstances. Carefully specified media and selecting resilient vegetation in these circumstances will increase certainty.

Not appropriate	Why	Potential mitigating design response
	High exfiltration may result in insufficient moisture supply for biofiltration system vegetation. The lack of a submerged zone removes the opportunity to provide a reliable water source for biofiltration system vegetation during dry conditions.	
Sites exposed to high flows, for example within retarding basins, floodplains, flow paths	If systems are exposed to high flows there is the risk that sediment trapped in pre-treatment measures remobilises and settles over the filter media causing clogging. The added risk of floating debris settling over the biofiltration system poses unnecessary additional maintenance risks.	
Site without appropriately sized pre-treatment measures including gross pollutant and sediment traps	Correct sequencing of the treatment train is important. Gross pollutant traps (GPTs) are required to ensure that litter and debris does not smother vegetation or increase the difficulty and cost of litter removal. Coarse sediment removal systems are required to ensure coarse sediment does not smother vegetation.	The selection and sizing of pre-treatment measures must respond to each site's specific catchment characteristics, for example consider variations in litter, debris and sediment generated by local land uses.
Where the cost for land acquisition, construction and maintenance is greater than that required for a wetland	This is to ensure that the infrastructure to service development is optimal in terms of cost and performance in accordance with Development Services Scheme principles and the ultimate asset owner is not burdened with unnecessary maintenance costs.	
Sites with inappropriate flow paths, insufficient drainage outfall depth, or no option to provide an	Undersized or inappropriately positioned flow paths can cause unacceptable flooding. A frequently inundated drainage layer will not support drainage of the filter media – which may adversely impact vegetation health; and may	Flow paths must be designed to safely convey the maximum flow rate a biofiltration system will be exposed to. Refer to *Deemed to Comply Criteria* GN5 for guidance.

Not appropriate	Why	Potential mitigating design response
overflow weir and high flow bypass	cause blockages in the pipes within the drainage layer.	Designs for potentially vulnerable sites need to be informed by an understanding of downstream water level pattern (for example dry weather flows for all seasons, frequent event water levels and associated dry and wet spells). A design for a submerged zone is compatible with a shallower drainage outfall.
Sites with tidal influence, shallow saline groundwater or at risk of being impacted by sea level rise	Saline water compromises the biological function of the system.	Designs for potentially vulnerable sites need to be informed by an understanding of observed tidal patterns, groundwater levels and sea level rise predictions. As above, submerged zones enable raising of the outlet pipe above the tidal influence and so protect biological function.
Sites subject to toxic runoff, for example sites receiving stormwater from industrial catchments that have insufficient control measures in place	When the system is at risk of being exposed to toxic substances, such as herbicides, solvents or industrial contaminants, its biological function will be compromised.	Structural separation (refer to *Deemed to Comply Criteria* BR1) must be used to mitigate the impact of industrial activity (and associated harmful toxicants) on the stormwater system.
Sites inaccessible for maintenance	Regular maintenance is vital to ensure optimal function of the system and asset longevity.	
Sites with acid sulphate soils (ASS) or potential acid sulphate soils (PASS)	Acid sulphate soils are harmful when exposed to air, such as through drainage or excavation.	Activities with the potential to disturb acid sulphate soils must be managed carefully to avoid serious environmental harm.
Sites with exfiltration into dispersive soils	Dispersive soils are structurally unstable and disperse into their constituent particles (clay, silt and sand) when in contact with water. They are highly erodible when	Contained systems using an impermeable liner must be used.

Not appropriate	Why	Potential mitigating design response
	mechanically disturbed. An exchange of water between the biofiltration system and surrounding dispersive soil will cause erosion of this soil and clogging of the filter media through intrusion of its fine particles.	
The quality of inflow is impacted by upstream construction phase activities	High sediment loads running off developing catchments clog the filter media requiring it to be reset. Refer to *Deemed to Comply Criteria* CN2. Biofiltration systems need to be protected from construction sediment at all times, including during the building phase.	The biofiltration system may be constructed without planting and covered with a protective surface that will be removed (together with accumulated sediment) once the high risk development activity period has passed. Refer to *Deemed to Comply Criteria CN2* for further guidance.

Design acceptance approaches

In order to stream-line standard design applications and provide a pathway for innovative design solutions, Melbourne Water has adopted two design review and acceptance approaches:

1. The Deemed to Comply approach

   The *Deemed to Comply* approach requires the design documentation to demonstrate compliance with the prescriptive set of design criteria as outlined in this document. *Deemed to Comply* designs have an estimated review (not acceptance) timeframe of 4 weeks maximum. Design documentation that demonstrates full compliance with the criteria provides a high level of confidence of achieving acceptance by Melbourne Water.

2. The Alternative approach

   The Alternative approach provides the option of submitting design solutions that differ from the *Deemed to Comply* prescriptive approach, but still delivers the required core outcomes as outlined on page 12 of this document. Designs are considered to be an alternative approach where the full set of *Deemed to Comply Criteria* cannot be achieved. Alternative designs that do not meet the required core outcomes will not be accepted. *Alternative* designs have an estimated review (not acceptance) timeframe of 4 weeks minimum.

Design acceptance process

The design acceptance process must follow the pathway described in the *Wetland Design Manual, Part B* (Melbourne Water, 2016). The checklist provided in Appendix A in this document must be completed and provided as part of the design submission.

4. PART B: Deemed to Comply Criteria

The following design, construction and maintenance criteria apply where no specific Council requirements exist.

Design

<table>
<tr><th colspan="2">General</th></tr>
<tr><td>GN1</td><td>The treatment and flow regime performance of the biofiltration system must be modelled in MUSIC (Model for Urban Stormwater Improvement Conceptualisation).</td></tr>
<tr><td>GN2</td><td>The meteorological data used in the MUSIC model must be in accordance with Melbourne Water's latest MUSIC Guidelines. The MUSIC guidelines specify a rainfall template for the relevant region. If an alternate rainfall file is used it must be:

• based on at least 10 years of historical records with an annual average that is representative of the long term average of the region
• recorded at six minutes intervals
• sourced from a pluviographic station nominated for the relevant rainfall region.</td></tr>
<tr><td>GN3</td><td>Peak design flows must be estimated in accordance with methods in the latest version of Australian Rainfall and Runoff.</td></tr>
<tr><td>GN4</td><td>The system configuration shown on the design plans must be consistent with the conceptual modelling parameters (for example MUSIC) and sediment pond calculator/calculations.</td></tr>
<tr><td>GN5</td><td>Hydraulic structures must be designed in accordance with the following requirements:

<table>
<tr><th>Structure</th><th>Design criteria</th></tr>
<tr><td>Inlet capacity</td><td>Convey all flows up to and including the 3 month ARI flow.</td></tr>
<tr><td>Overflow weir and flow path capacity</td><td>Maximum flow that can enter the biofiltration system during the peak major storm event, that is driven by the head of water during the peak 100 year ARI event. Ensuring acceptable freeboard is provided during the peak 100 year ARI event.</td></tr>
<tr><td>Overflow pit orifice capacity</td><td>Maximum flow that can enter the biofiltration system during the peak minor storm event, that is driven by the head of water during the peak 5 year ARI.</td></tr>
<tr><td>High flow bypass weir and flow path capacity</td><td>Convey maximum overflow from the sediment pond during the peak 100 year ARI event.</td></tr>
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Overflow pit crest level	Top of extended detention (TED)
Overflow weir crest level	300mm above the overflow pit crest level
Embankment crest level	Maximum head of water above the overflow weir and pit during the major storm event (that is 100 year ARI) plus minimum freeboard (refer to *Deemed to Comply Criteria* ET2).
Outlet pipe capacity	Maximum flow that can enter the biofiltration system during the peak minor storm event, that is 5 year ARI, taking into account tailwater conditions (refer to *Deemed to Comply Criteria* IO5).

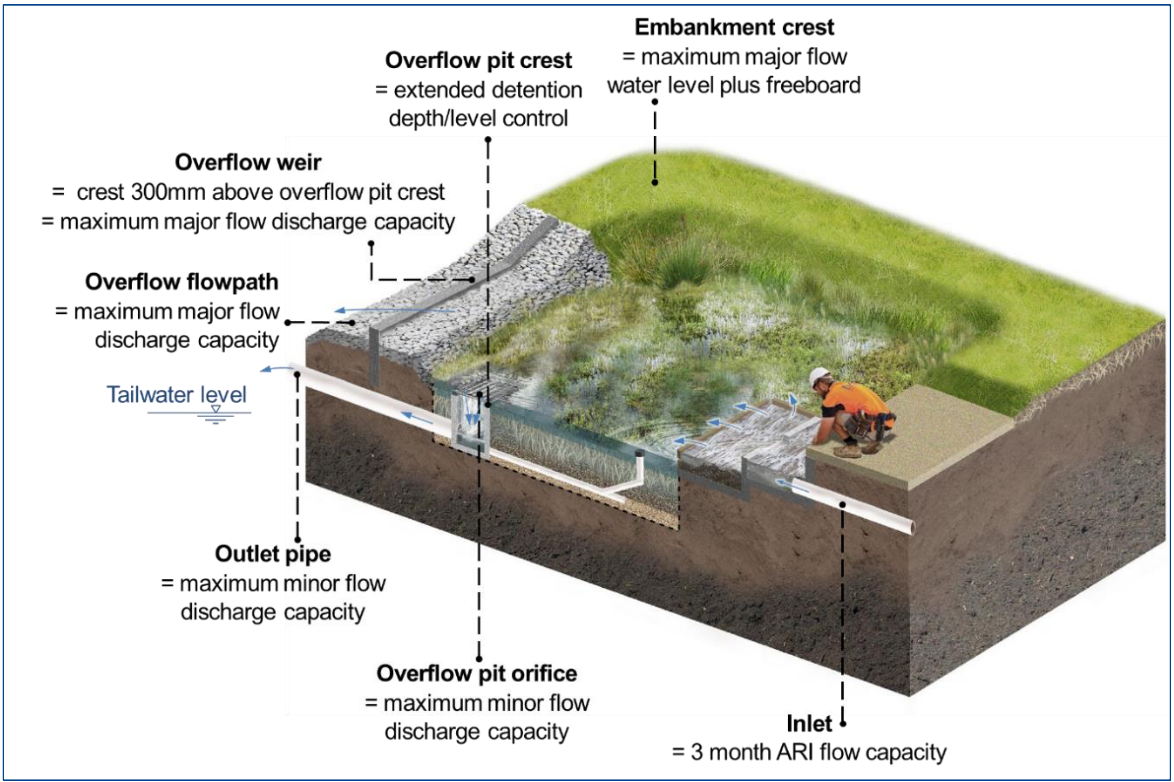

Figure 4 Hydraulic structures

For a conversion between ARI, Annual Exceedance Probability (AEP) and number of exceedances per year (EY) refer to the Glossary.

For guidance on the sizing of hydraulic structures refer to Bioretention Technical Design Guidelines (Water by Design, 2014) and *WSUD Engineering Procedures: Stormwater* (Melbourne Water, 2005).

GN6	The coarse sediment removal system and biofiltration system must not be over or undersized.

GN7	An operations and maintenance plan, as-constructed information and asset recording information must be provided as part of the handover documents. For an example operations and maintenance plan refer to Appendix B, *WSUD Maintenance Guidelines* (Melbourne Water, 2017).
GN8	Before commencement of the design, existing and future services must be located and identified on the design drawings.
GN9	Design, construction and establishment checklists provided in this document must be completed and signed off before handover.
GN10	Submerged zone – longer lasting systems must be used in dry climates where >3 weeks without rain is common (for example Little River and Melbourne Airport rainfall regions).
GN11	Contained systems must be used where the biofiltration system is located close to sensitive structures, where infiltration is a concern, where in-situ soils are unconsolidated, sodic, contaminated, saline or dispersive or where there is shallow groundwater.
Safety provisions	
SF1	The biofiltration design must consider all aspects of safety, including pedestrians, vehicles and maintenance personnel likely to be present near the biofiltration system. Important safety components which must be considered include: • Clear sightlines for traffic and pedestrians – the size and form of plant species planted within the biofiltration system must reflect the site context, that is it may be prudent to use low-growing vegetation within streetscape systems to ensure that pedestrian and vehicle sightlines are maintained. • Reduced ponding depths – lower extended detention depths (EDD) must be adopted for biofiltration systems located adjacent to areas frequented by children, such as play grounds and public parks. • Edge design – unsafe vertical drops along the edges of biofiltration systems must be avoided to prevent accidental falls. Gentle batter slopes, the planting of dense vegetation or placement of architectural features, such as walkways with rails, seating etc. along vertical edges must be used to provide safe edges. These treatments must be agreed upon by the future asset owner. • Streetscape biofiltration systems located adjacent to vehicle parking areas – a flat extension of the kerb (minimum width - 400 mm) must be provided between the kerb and edge of the biofiltration system to provide a safe area for vehicle occupants to alight or provide a refuge for pedestrians. • Pedestrian refuges – the placement of pedestrian refuges must be considered along the edges of biofiltration systems in locations where pedestrians may be stranded, for example biofiltration systems located in median strips. This may be achieved by breaking the edge vegetation using stepping stones or kerb extensions. • Trip hazards – all components of a biofiltration system must be evaluated for potential trip hazards. The selection of plant species to be established along the edges of biofiltration systems should consider whether the foliage will protrude onto pedestrian pathways when mature and constitute a tripping hazard.

<table>
<tr><th colspan="2">Coarse sediment removal systems</th></tr>
<tr><td>CS1</td><td>Coarse sediment removal systems must be provided before discharging flows into biofiltration systems in the following scenarios:
<table>
<tr><th>Scenario</th><th>Coarse sediment removal method</th></tr>
<tr><td>Roof runoff only</td><td>None</td></tr>
<tr><td>Catchment area ≤2ha and biofiltration systems ≤100m^2</td><td>Vegetated swale, sediment sump or sediment forebay (as shown in Figure 5)</td></tr>
<tr><td>Catchment area >2ha to ≤5ha, or biofiltration systems >100m^2, whichever applies first</td><td>Vegetated swale, sediment forebay or sediment pond</td></tr>
<tr><td>Catchment area >5ha to ≤10ha
Inlet pipes >600mm diameter
Multiple biofiltration cells (where required in accordance with Deemed to Comply Criteria BR5)</td><td>Sediment pond</td></tr>
</table></td></tr>
<tr><td>CS2</td><td>Forebays must be sized to:
capture 95% of coarse particles ≥125μm diameter from the peak 3 month ARI flow
be ≤300mm deep
provide adequate sediment storage volume to store 1 year of sediment
provide energy dissipation of incoming flows (refer to Deemed to Comply Criteria IO1)
be free draining.</td></tr>
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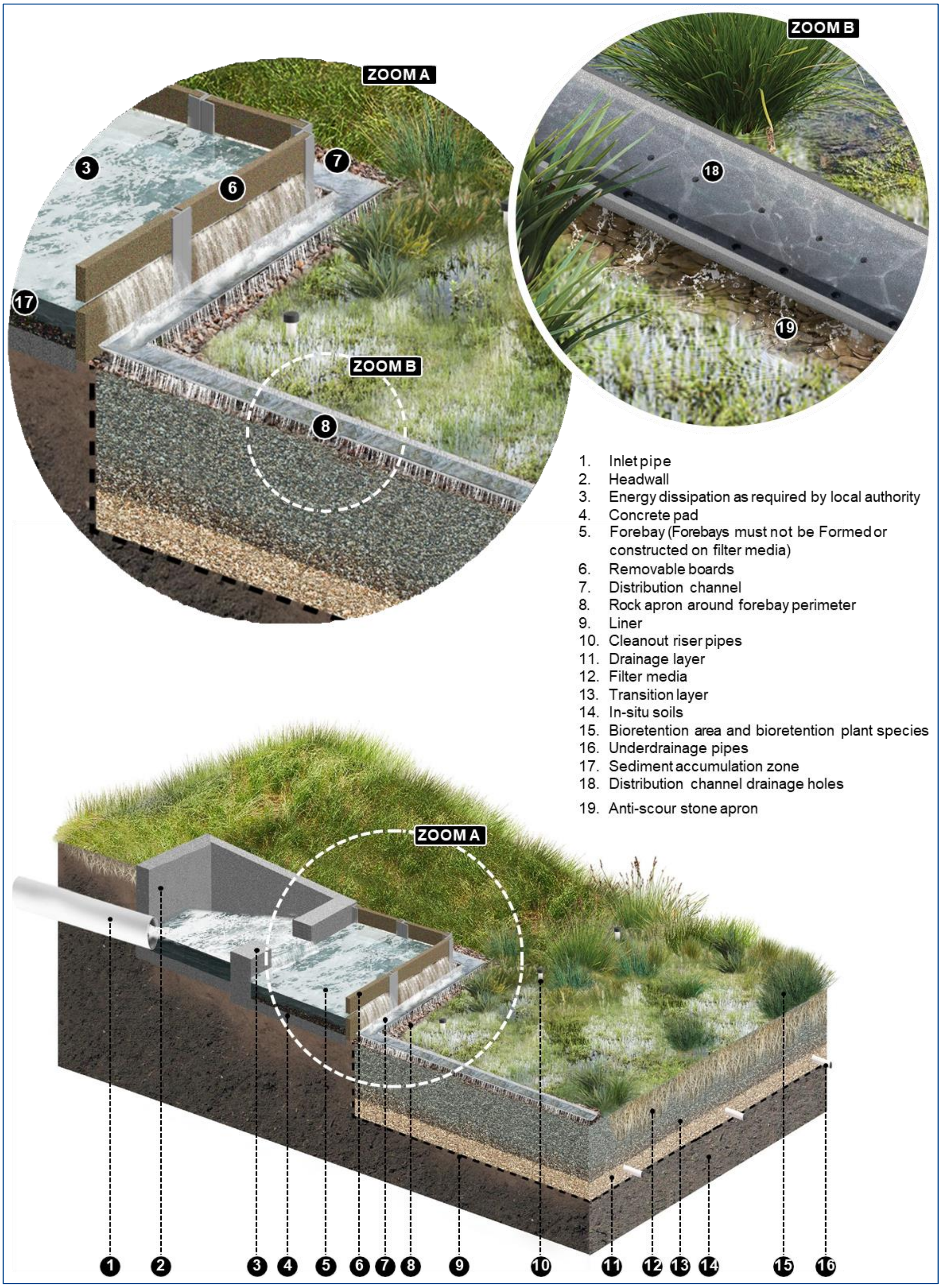

Figure 5 Example of elements suitable for a sediment forebay configuration

Refer to Deemed to Comply Criteria BR6 for photos of the distribution system indicated in Figure 5.

CS3	Sediment forebays and sediment ponds must be located at each point where stormwater enters the biofiltration system, unless the catchment of the incoming stormwater is <5% of the total biofiltration system catchment.
CS4	Sediment ponds must be located offline of waterways, but online to the pipe or lined channel from which they are treating water.
CS5	Sediment ponds must allow for high flows to bypass the biofiltration system. For guidance on sizing the bypass route refer to *Deemed to Comply Criteria* GN5. The high flow Top Water Level (TWL) must be contained within the sediment pond and not overflow into the biofiltration system.
CS6	Sediment ponds must be sized to: • capture 95% of coarse particles ≥125µm diameter from the peak 3 month ARI flow • be ≤ 1.6m deep • provide adequate sediment storage volume to store 5 years of sediment. The top of the sediment accumulation zone must be assumed to be 500mm below Normal Water Level (NWL) (refer to Figure 6) • provide energy dissipation of incoming flows (refer to *Deemed to Comply Criteria* IO1) • provide an EDD≤350mm • ensure that velocity through the sediment pond up to the peak 100 year ARI event is ≤0.5m/s. (The flow area must be assumed to be the EDD multiplied by the narrowest width of the sediment pond, at NWL, between the inlet and overflow outlet). Sediment ponds must be ≤120% of the size needed to meet the limits of the above criteria. Compliance with the above criteria must be demonstrated using the calculation methods described in *WSUD Engineering Procedures: Stormwater* (Melbourne Water, 2005). Alternatively, the velocity criteria can be checked using a hydraulic model such as HEC-RAS. Refer to Melbourne Water Standard Drawings for constructed wetlands for more details relevant to the sediment pond.

Figure 6 Sediment pond configuration

Biofiltration cells

BR1	Biofiltration systems must not be exposed to toxic substances (for example herbicides, solvents or industrial contaminants). Where these risks exist, structural separation must be used to exclude harmful toxicants from the stormwater system. Structural separation is achieved by physically separating materials and practices involving toxic substances such that runoff containing these does not enter the stormwater or sewerage system. Structural separation examples can be obtained from *Industrial Stormwater Code of Practice* (Hume City Council, 2008).

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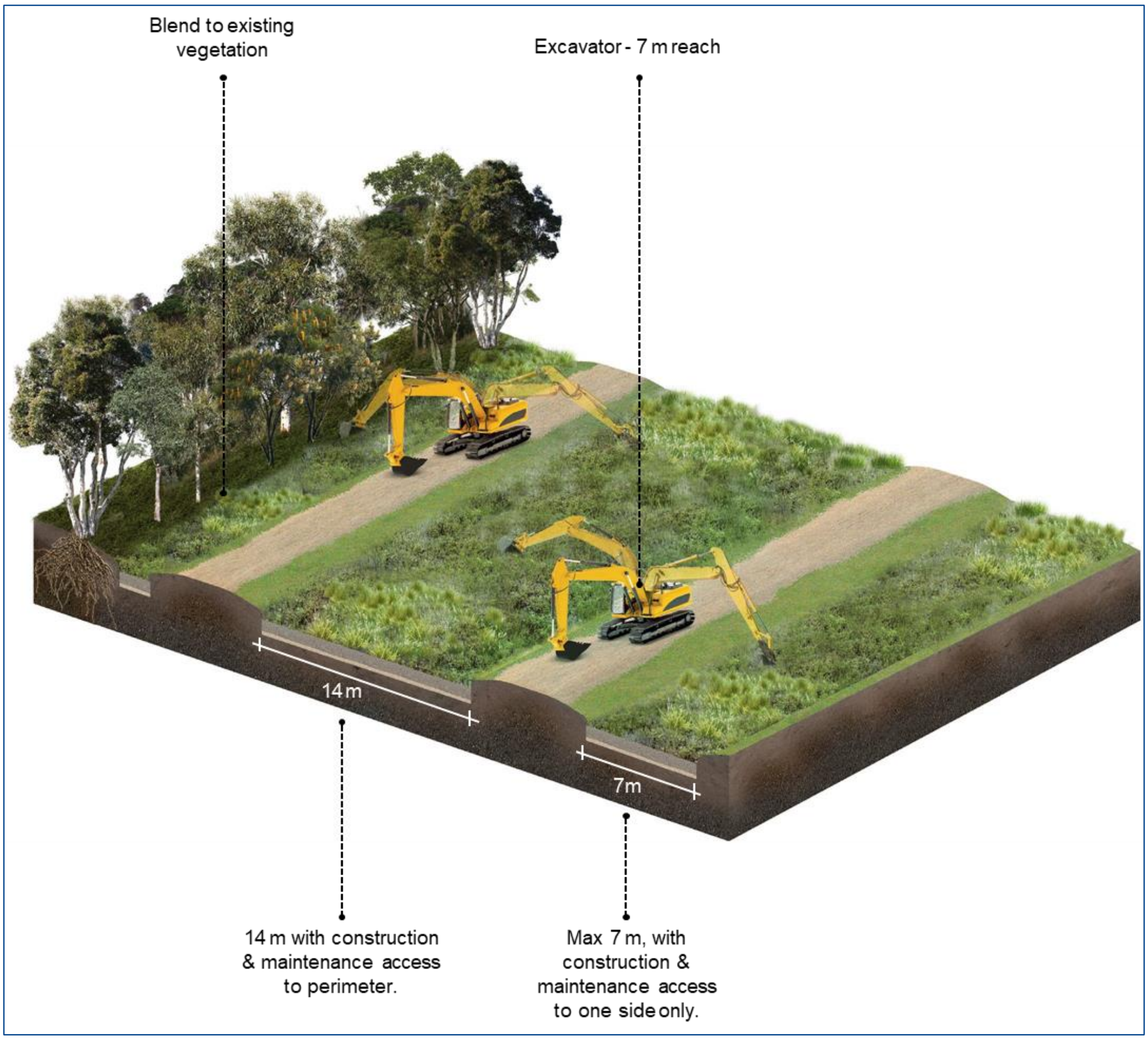
Hierarchy of controls to be applied when planning industrial or commercial developments:
<table>
<tr><th>Control Type</th><th>Example</th></tr>
<tr><td>Elimination</td><td>Removing need to discharge</td></tr>
<tr><td>Substitution</td><td>Replacing poor quality discharge with high quality discharge</td></tr>
<tr><td>Engineering Controls</td><td>Solutions as agreed with the responsible authority</td></tr>
<tr><td>Administrative Controls</td><td>Change the way businesses assess the effect of their practices on stormwater and sewage</td></tr>
</table>
</td>
</tr>
<tr>
<td>BR2</td>
<td>Biofiltration systems must be located offline from all waterways and drains, that is, only up to the peak 3 month ARI treatment flow must be diverted into the cell and there must be a high flow bypass route around the cell.
Alternatively the system may be designed with a 'feedback control' to achieve high flow bypass at the inlet after the EDD is filled.</td>
</tr>
<tr>
<td>BR3</td>
<td>The elevation difference between filter media and surrounding surface must not exceed the following depths:
<table>
<tr><th>Application</th><th>Elevation difference</th></tr>
<tr><td>Streetscape</td><td>≤300mm below kerb invert at biofiltration inlets where adjacent to unrestricted pedestrian access</td></tr>
<tr><td>Civic space</td><td>≤500mm</td></tr>
<tr><td>Parkland (larger systems)</td><td rowspan="2">no specific limit as long as batter slope and vertical drop criteria are met (refer to Deemed to Comply Criteria ET4, ET8 and ET9)</td></tr>
<tr><td>Adjacent to natural areas (larger systems)</td></tr>
</table>
</td>
</tr>
<tr>
<td>BR4</td>
<td>The extended detention depth must be as per the table below, depending on the local safety, maintenance and construction requirements.
<table>
<tr><th>Rainfall region</th><th>Extended detention depth (mm)</th></tr>
<tr><td>• Melbourne City
• Koo Wee Rup
• Narre Warren North
• Mt St Leonard</td><td>100-300[1]</td></tr>
</table>
</td>
</tr>
</table>

[1] Based on Adoption Guidelines for Biofiltration Systems (CRC for Water Sensitive Cities, 2015).

	• Little River • Melbourne Airport	100-500[2]
BR5	The following filter media surface dimensions must be adhered to ensure construction and maintenance of the biofiltration system is feasible (refer to Figure 7): • minimum width 600mm • maximum width 14m where construction access is available from opposite sides • maximum width 7m where construction access is available from only one side • maximum length 40m. Where a filter surface area with greater than these dimensions is required, this area must be achieved using multiple cells that are within the width and length limits specified above.  Figure 7 Biofiltration system width limitations	

[2] Based on Bioretention in the West – Phase 1, Design for Sustained Health of Plants through Consideration of Soil Moisture Behaviour (E2DesignLab, 2013).

<table>
<tr>
<td>BR6</td>
<td>
Biofiltration cells must include:

a distribution system that directs low flows from the coarse sediment removal system to the cells and distributes these flows evenly across the surface of each cell.
construction and maintenance access between and around the full perimeter of each cell (refer to maintenance provisions criteria).

The distribution system layout must ensure that low flows are supplied to surface areas of about equal width and length (refer to

Figure 8). That is to ensure the surface is evenly supplied and that there are no areas more distant from the distribution system than others.

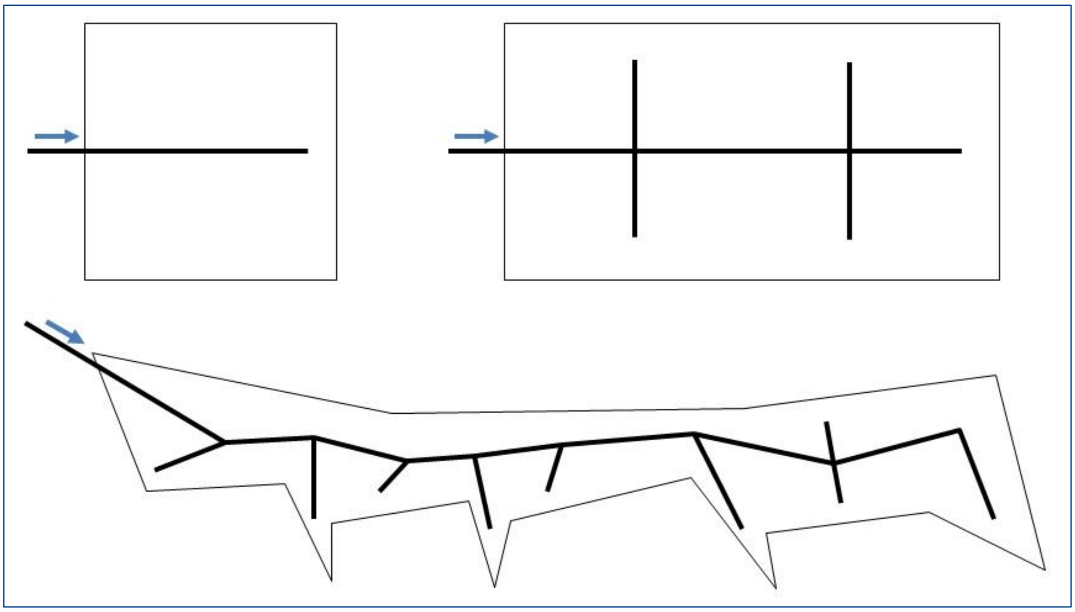



Figure 8 Schematics of distribution system layouts across different biofiltration cell surface shapes

Figure 9 Example of elements suitable for surface distribution systems as installed in Dawson Street, Brunswick (images: Birgit Jordan, 2019)
</td>
</tr>
</table>

BR7	Biofiltration system layers must be installed to the following specifications, which are further detailed in the *Adoption Guidelines for Biofiltration Systems* (CRC for Water Sensitive Cities, 2015):

Layer	Depth (mm)			Material description[3]
	Basic Contained	Pipeless	Submerged zone	
Filter	Min. 400; Min. 700 for trees		Min. 300	Washed well graded sand, particle size diameter 0.05-3.4mm with hydraulic conductivity of 100-300mm/hr and low nutrient content Total Nitrogen <1,000mg/kg and available phosphate (Colwell) <80mg/kg
Transition[4]	Min. 100			Well graded coarse sand containing <2% fines, for example A2 filter sand
Drainage[4]	Dia of underdrain pipe + 50 cover above pipe	n/a	Min. 150	Fine gravel, for example 2-7mm washed screenings (not scoria)
Submerged zone	n/a	n/a	Min. 300-	Sand or fine aggregate mixed with 5% by volume low nutrient carbon source, for example 6-10mm hard wood chips, pine chips without bark, sugar cane mulch, pine saw dust

[3]For detailed specifications and testing requirements refer to Appendix C, *Adoption Guidelines for Biofiltration Systems* (CRC for Water Sensitive Cities, 2015).
[4]It is important to apply the particle size distribution bridging criteria to the transition layer and the drainage layer to avoid the migration of filter media downwards into the transition layer and the migration of the transition layer into the drainage layer.

BR8	Distances to infiltration systems, that is systems without impermeable liner, near structures in consideration of the soil type present must be provided as outlined below. For detailed information refer to *Australian Runoff Quality: Guide to Water Sensitive Urban Design* (Engineers Australia, 2006). The soil types present must be confirmed by providing a geotechnical report.

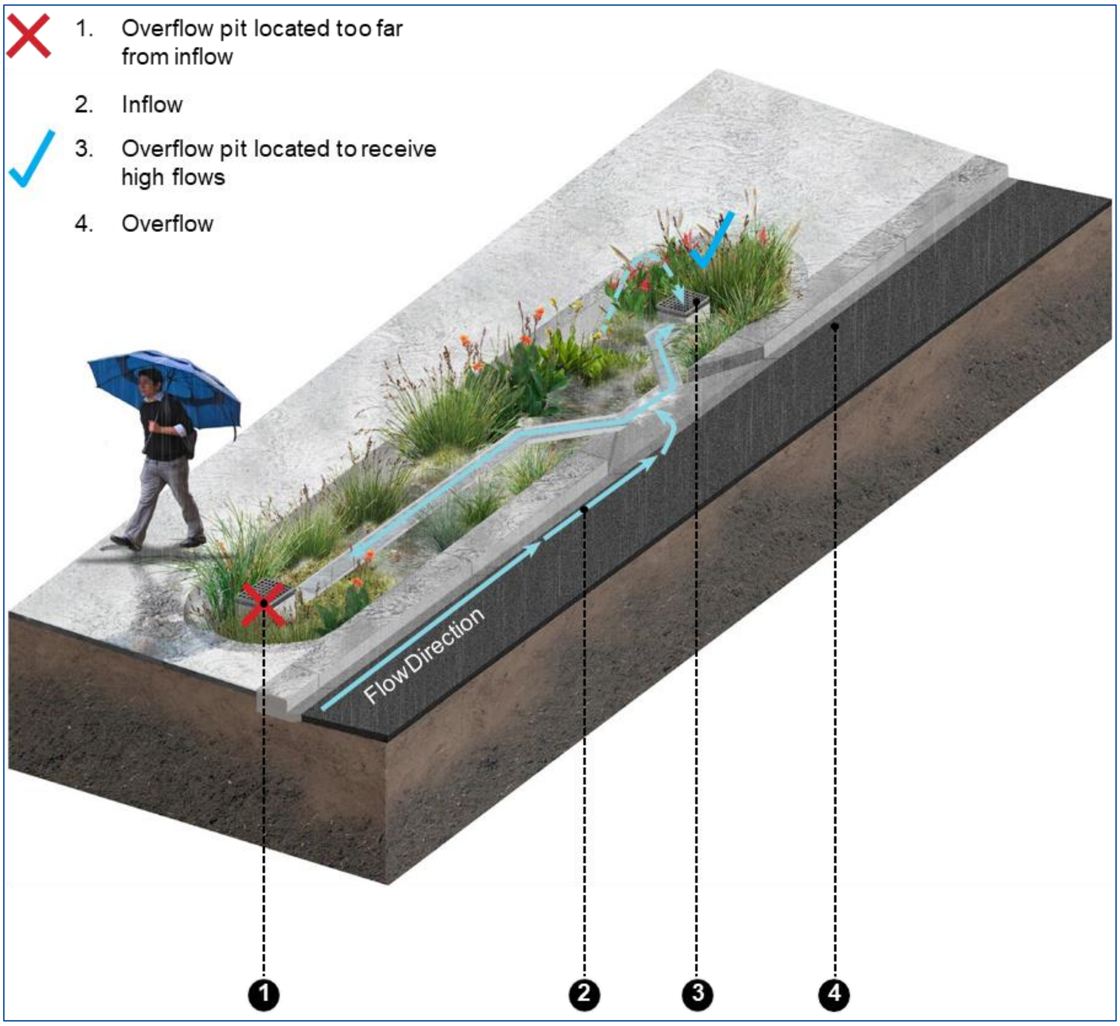
Soil type	Soil type hydraulic conductivity (mm/h)	Minimum offset distance
Deep, confined or unconfined sands (homogenous)	≥180	2m where sand is associated with a mantle of sandy clay, otherwise 1m
Sandy clays (homogenous)	36 to 180	2m
Medium clays (homogenous)	3.6 to 36	4m
Heavy clays (homogenous)	0.036 to 3.6	5m
Constructed clay soils (homogenous)	0.0004 to 0.036	5m
Sites with rock or shallow soil over rock	3.6 to 36	2m

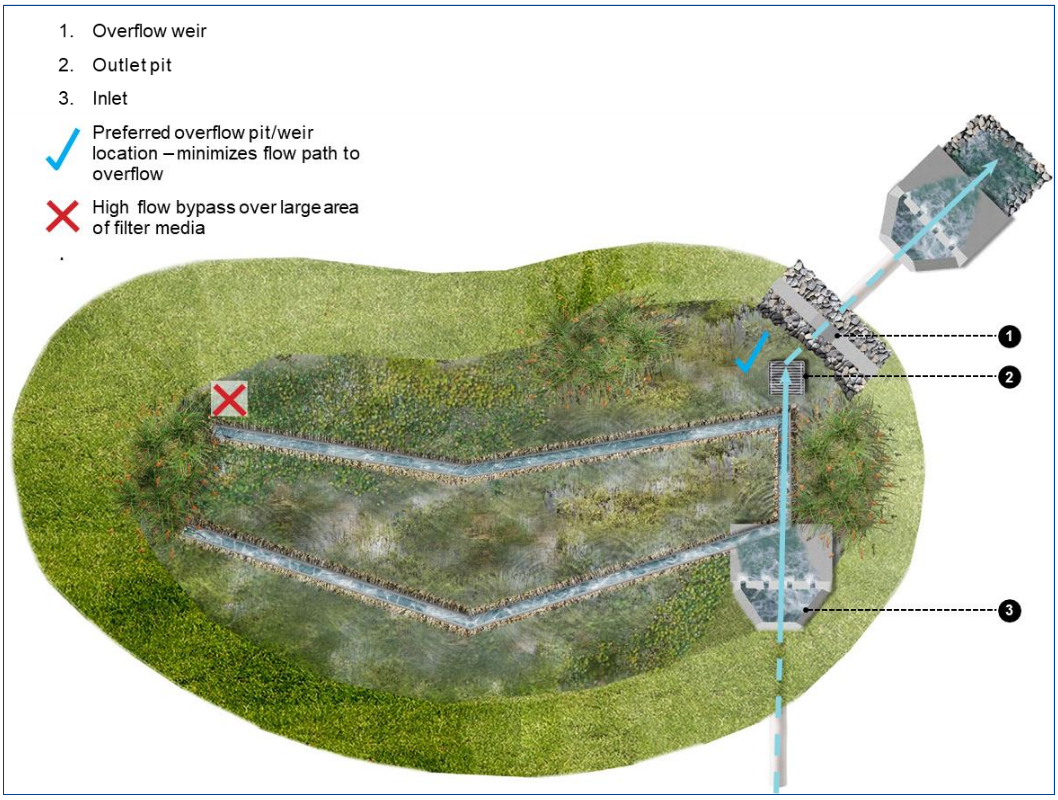
BR9	Biofiltration systems will not be accepted with a mulch layer as organic mulches pose a high risk to blocking outlets and gravel mulches limit plants from spreading, can kill tube stock due to overheating during hot weather and make desilting more difficult. Correct plant selection, placement, irrigation and weeding regimes during establishment should remove the need for mulching.
BR10	Underground services must not be within the filter media area, but may be incorporated into biofiltration system batters where appropriate cover and offsets to plant roots can be provided in accordance with the service provider's requirements.
BR11	The top surface of the filter layer, transition layer and drainage layer must be designed to be level.
BR12	The base of the biofiltration system must be above the maximum normal or seasonal groundwater level.
Inlets and outlets	
IO1	All inlets require energy dissipation and scour protection using appropriately sized and designed pipes, pits and rock aprons to manage and slow velocities to ≤0.5m/s within the sediment pond and ≤1m/s within the biofiltration cell. Energy dissipation solutions must be designed for the site specific flow directions, velocities and volumes to be managed. Options include, but are not limited to: • rock beaching aprons • drops from the inlet onto concrete aprons • drop structures before the inlet • semi submerged inlets • pits or sumps with weirs before the inlet.

<table>
<tr><td>IO2</td><td>All outlets including pipes and weirs require energy dissipation (refer to Deemed to Comply Criteria IO1) and scour protection.

Refer to Melbourne Water Standard Drawings 7251/08/103 and 7251/08/104 for more details.</td></tr>
<tr><td>IO3</td><td>Invert levels of inflow pipes or channel inverts must be positioned as follows:
<table><tr><th>Inflow point</th><th>Required level</th></tr><tr><td>Directly into biofiltration system</td><td>At or a maximum of 200mm above the surface of the biofiltration system</td></tr><tr><td>Sediment forebay</td><td>At the top of the sediment accumulation depth (refer to Figure 5)</td></tr><tr><td>Sediment pond</td><td>100mm below NWL</td></tr></table></td></tr>
<tr><td>IO4</td><td>Inlet and outlet locations must be located as close as possible (refer to Figure 10) to each other to prevent scouring of vegetation and filter media and enable isolation of the system.

</td></tr>
</table>


1. Overflow pit located too far from inflow
2. Inflow
3. Overflow pit located to receive high flows
4. Overflow
Flow Direction
1
2
3
4



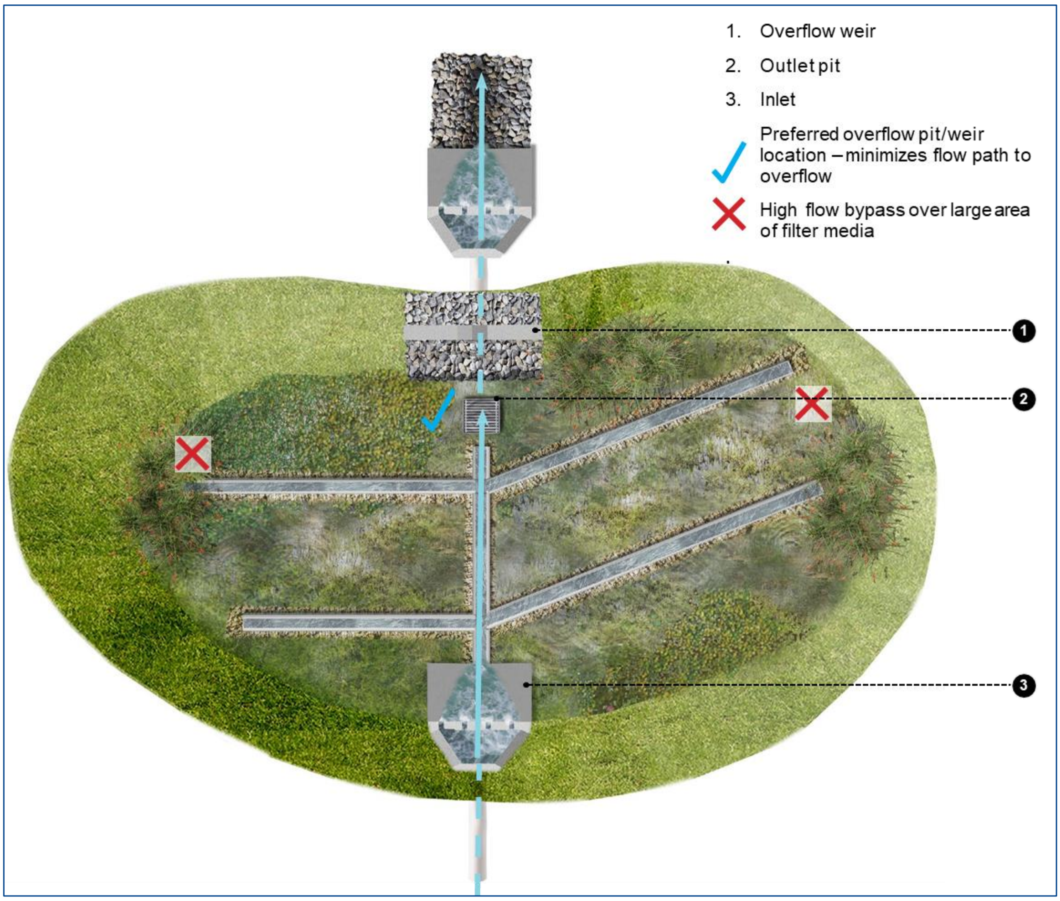
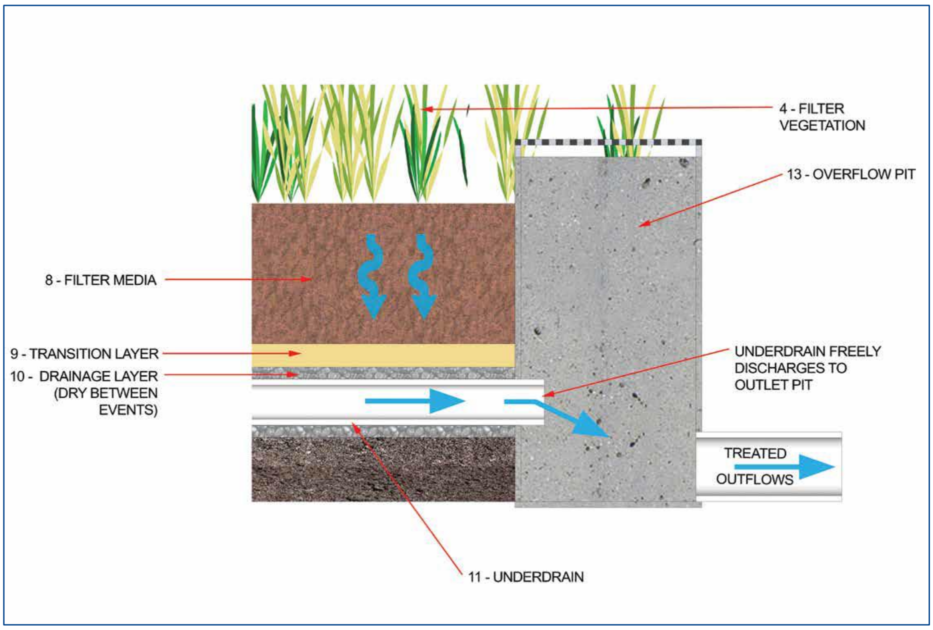
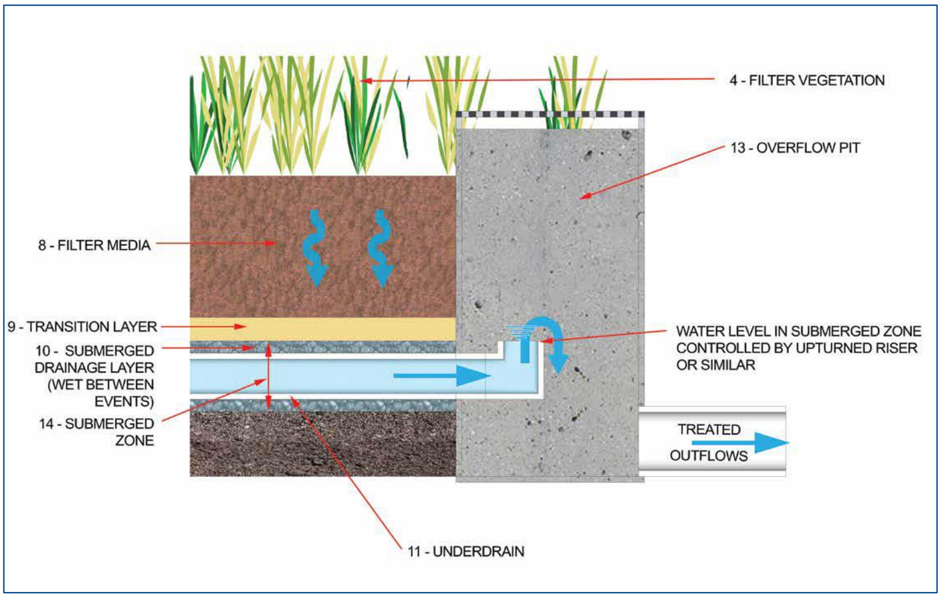


Figure 10 Correct positioning of biofiltration system inflow and outflow locations

IO5	The biofiltration system outlet must be configured to enable free drainage and not cause back-watering to allow for drying of the filter layers in between events.  Figure 11 Basic system outlet control (image: WSUD Maintenance Guidelines, Melbourne Water 2017)  Figure 12 Submerged zone system outlet control (image: WSUD Maintenance Guidelines, Melbourne Water 2017)
IO6	The biofiltration system outlet pit must be at a minimum 900x900mm to enable maintenance access.

<table>
<tr><td>IO7</td><td>The connection between the sediment pond and biofiltration system must be sized such that, assuming the water level is at TED:

all flows ≤ the peak 3 month ARI event are transferred to the biofiltration system via the transfer pipe
at least 60% of the peak 1 year ARI flow overflows from the sediment pond into the bypass channel/pipe when the water level in the biofiltration system is at TED (and not enter the biofiltration system) and ≤40% of the peak 1 year ARI flow is transferred to the biofiltration system via the transfer pipe when the water level in the biofiltration system is at TED
the velocity across the filter media surface is ≤1m/s during the peak 100 year ARI event.

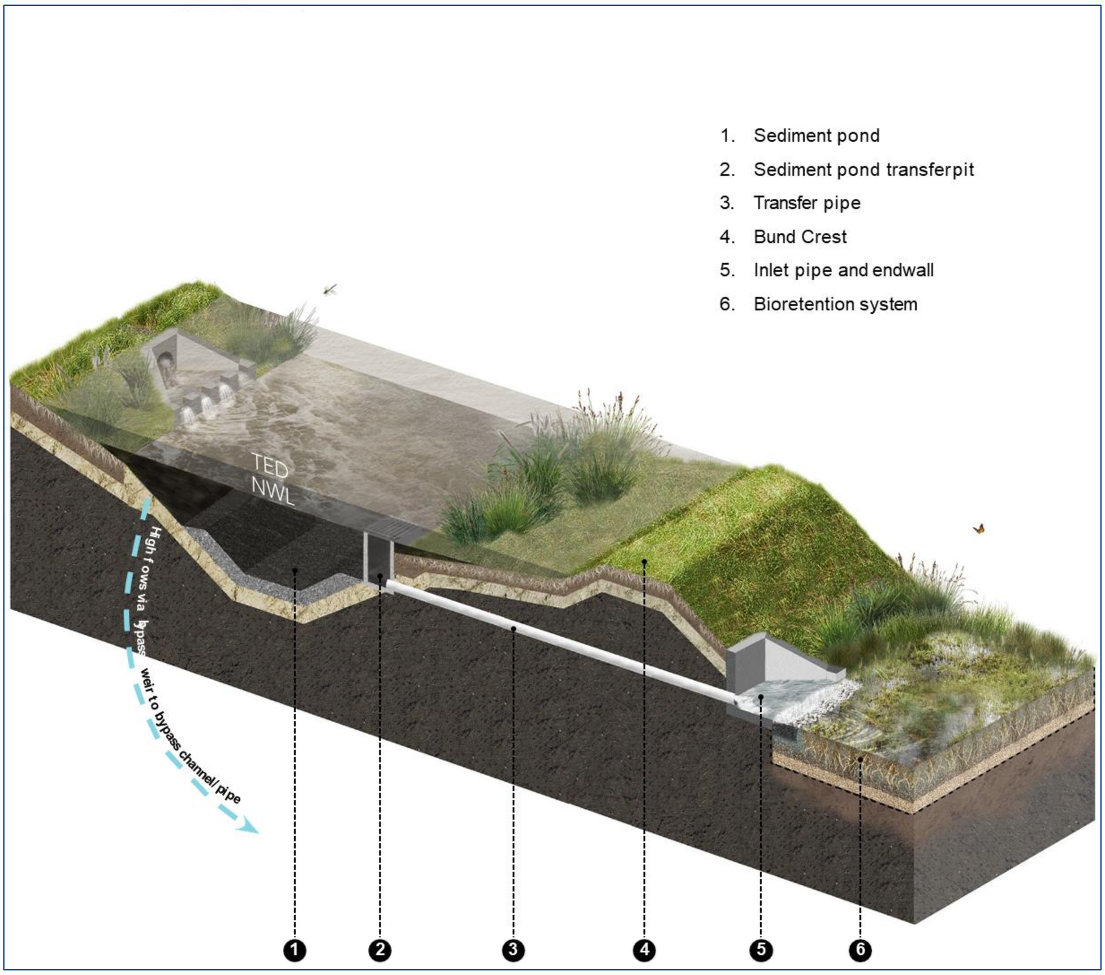
Refer to Melbourne Water Standard Drawings for constructed wetlands for more details relevant to the sediment pond.


Figure 13 Connection between sediment pond and biofiltration system</td></tr>
<tr><td>IO8</td><td>The filter media must be bolstered against the overflow pit in its immediate surrounds to prevent scour around the pit.</td></tr>
<tr><td>IO9</td><td>Any stormwater connection to Melbourne Water assets must be formally approved by Melbourne Water.
For information refer to Melbourne Water's Planning and building webpage.</td></tr>
</table>

Pipe selection	
PS1	Slotted rigid PVC pipes must be used for the underdrainage. Underdrainage pipes must not be wrapped in a filter sock and slots must be small enough to prevent drainage layer material from falling into the pipe. For guidance on the sizing of underdrainage pipes refer to *Bioretention Technical Design Guidelines* (Water by Design, 2014).
PS2	Underdrainage pipes must be sized to convey the maximum flow rate and drain the filter media freely at its hydraulic conductivity or greater. Underdrain pipe diameters must not be less than 100mm. Collector and outlet pipes must be sized to convey all connected inflows. Refer to *Deemed to Comply Criteria* GN5 for outlet pipe capacity requirements.
PS3	Pipe bends must be 45° (not 90°) to facilitate inspection and clearance of blockages.
PS4	The spacing of underdrainage pipes must be as follows: Filter surface area (m^2) — Maximum spacing from centre to centre (m) <100m^2 — 1.5 >100m^2 — 2
PS5	Underdrains must grade at a minimum 0.5% towards the overflow pit, except for submerged zone systems.
PS6	Vertical solid PVC pipe sections with screw caps extending at least 150mm above the biofiltration system surface with the same diameter as the underdrains must be provided at the ends of all underdrainage pipes, and at least every 20m for pipes longer than 20m, to provide inspection and clean-out points. Caps must be secured with screws to manage vandalism.
PS7	All pipe junctions and joints must be sealed.
PS8	Pipe classes must be selected based on the loads each pipe will be exposed to.
Vegetation and landscape	
VG1	Biofiltration system earthworks must avoid the critical root zone of existing surrounding vegetation, particularly trees. The area to be avoided is calculated as: Tree Protection Zone = Diameter at Breast Height (DBH) x 12. Where DBH = trunk diameter measured at 1.4 m above ground. Further guidance is provided in AS 4970-2009 Protection of trees on development sites (Standards Australia, 2009).
VG2	The following minimum numbers of plant species must be used. Species tolerant of wet conditions must be planted near inlets and species tolerant of dry conditions away from inlets and on batters. Semi-aquatic plants must not be used as they are unable to tolerate extended dry conditions.

<table>
<tr><td></td><td>
<table>
<tr><th>Situation</th><th>Minimum number of species</th></tr>
<tr><td>Small scale urban
(filter area ≤100m^2)</td><td>2</td></tr>
<tr><td>Medium scale urban
(filter area 100 to 400m^2)</td><td>4</td></tr>
<tr><td>Large scale urban
(filter area ≥400m^2)</td><td>6</td></tr>
<tr><td>Riparian and bushland landscapes</td><td>10</td></tr>
</table>
</td></tr>
<tr><td>VG3</td><td>Planting densities must be provided as follows:
<table>
<tr><th>Vegetation type</th><th>Filter surface (plants/m^2)</th><th>Batters (plants/m^2)</th></tr>
<tr><td>Groundcovers, grasses, sedges and rushes</td><td>8-10</td><td>6-8</td></tr>
<tr><td>Shrubs</td><td><1</td><td><1</td></tr>
<tr><td>Trees</td><td><1</td><td>n/a</td></tr>
</table>
</td></tr>
<tr><td>VG4</td><td>The entire biofiltration system surface must be covered by vegetation at planting.</td></tr>
<tr><td>VG5</td><td>Plant stock must be healthy, mature, sun hardened and contain a fully established fibrous root system (as opposed to just a tap root system) that does not crumble when removed from its container. Plants with a mixture of different root types must be chosen to ensure that the filter media is occupied by a matrix of root systems that are effective at maintaining the porosity of the filter media.

Plants with dense spreading foliage must be chosen to slow velocities and protect the filter surface from scouring.

The plants must be 300-500mm high at planting.

Tubestock containers must be at least the size of forestry tubes (200cm^3), except pot sizes for trees must be 150mm diameter minimum.

Plant stock must be free of pest, disease and weeds, show no signs of nutrient deficiency, show signs of new growth and general vigour and be clearly labelled.

Refer to Melbourne Water's *Vegetation Standards* for further guidance.</td></tr>
<tr><td>VG6</td><td>At least 50% of species with effective stormwater treatment characteristics must be incorporated and these must be distributed evenly across the filter surface. All species listed in Deemed to Comply Criteria VG7 are considered effective.</td></tr>
<tr><td>VG7</td><td>The selection of plants must consider:
• sun and shade exposure
• wet and dry conditions
• maintenance requirements</td></tr>
</table>

- public safety/barrier requirements
- landscape amenity/aesthetic
- potential microclimate benefits
- enhanced biodiversity
- Council specified biofiltration planting palettes.

These selection criteria must be agreed upon by the future asset owner. Where a Council specified biofiltration planting palette is adopted and the asset is located near or connected to natural areas such as bushland or waterways, Melbourne Water reserves the right to reject species recorded as a weed of the environment and agriculture in Australia. Mixed plant communities including groundcovers, shrubs and trees are encouraged as this minimises weed maintenance once established and provides biodiversity and habitat benefits. Sites that provide periodic shading are recommended over sites that are exposed to full shade or full sun as this may cause suboptimal plant health and moisture conditions. The following plant species must be chosen from, based on the system's treatment objectives and asset owner's requirements:

Objective	Suitable for wet and dry conditions	Suitable for wet or dry conditions
Nitrogen removal	· Baumea rubiginosa (sedge) · Carex appressa (sedge) · Goodenia ovata (ground cover) · Juncus amabilis (rush) · Juncus flavidus (rush) · Juncus pallidus (rush) · Juncus subsecundus (rush) · Melaleuca ericifolia (shrub/tree) · Melaleuca incana (tree) · Melaleuca lateritia (shrub)	Wet · Allocasurina littoralis (tree) · Juncus kraussii (rush) · Leptospermum continentale (tree) Dry · Poa poiformis (grass)
Pathogen removal	· Carex appressa (sedge) · Leptospermum continentale (tree) · Melaleuca incana (tree)	
Infiltration capacity	· Melaleuca incana (tree) · Melaleuca ericifolia (shrub/tree	
Iron removal	· Carex appressa (sedge)	

VG8

Any grassed areas that Melbourne Water has to maintain are to meet one of the below options to ensure safety and maintainability. Requirements for grassed areas maintained by Councils must be confirmed individually.

1) Batter slopes: To be 1 : 5 or flatter with a 3m run out area no steeper than 1 : 12 at the toe. The run out area is to be clear of holes, rocks, trees, fences and other obstructions.

	2) All other areas: No steeper than 1 : 12 and clear of holes, rocks, trees, fences and other obstructions. A run out area is not required. 3) Grassed areas containing vegetation to be retained: Where mowing around such vegetation is required, 3m minimum width mowable buffers around the vegetation must be provided to provide machinery clearance.
VG9	Slopes steeper than 1 : 5 must be densely vegetated.
Edge treatment	
ET1	The design of the interface between biofiltration system and surrounding landscape must consider public safety, maintenance and visual amenity to the future asset owner's satisfaction.
ET2	Batters and embankments around the biofiltration system must be designed to contain the maximum water level above the overflow weir during the peak major flow event plus a minimum freeboard and prevent the system from being damaged by high flows or flows from external catchments. Freeboard provisions must be at least 20% of the elevation difference between the biofiltration system surface and maximum water level or 100mm, whichever is greater.
ET3	Batters and embankments must be densely vegetated to provide 100% coverage at planting (about 6 plants per m^2), 90% coverage at handover.
ET4	Batter slopes must be 1 : 5 or flatter for drops ≥1m and no steeper than 1 : 3 for drops ≤1m (refer to Figure 14).

<table>
<tr><td></td><td>

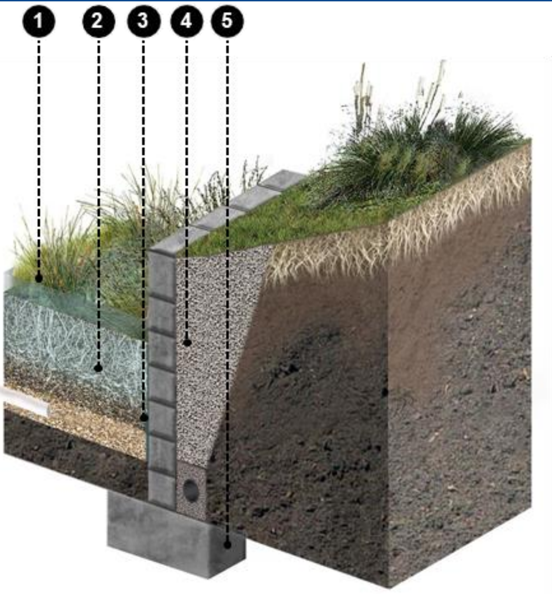
Figure 14 Batter safety</td></tr>
<tr><td>ET5</td><td>Lateral flows down batters must be avoided and managed by creating designated inflow points with adequate erosion protection in accordance with Melbourne Water's <u>Principles of Erosion Management</u> and <u>Specification for temporary erosion and weed control matting</u>.</td></tr>
<tr><td>ET6</td><td>Retaining walls must be designed based on specialist engineering and geotechnical advice.</td></tr>
<tr><td>ET7</td><td>Public safety associated with vertical drops into streetscape biofiltration systems must be managed by providing a barrier forming edge treatment such as seating or other form of barrier as agreed upon by the future asset owner.</td></tr>
<tr><td>ET8</td><td>The extent of vertical retaining walls must comply as follows:
<table>
<tr><th>Vertical drop</th><th>Extent of retaining wall</th></tr>
<tr><td>≤150mm</td><td>≤100% of perimeter</td></tr>
<tr><td>150 to 300mm</td><td>≤75% of perimeter</td></tr>
<tr><td>300 to 800mm</td><td>≤50% of perimeter</td></tr>
</table></td></tr>
</table>

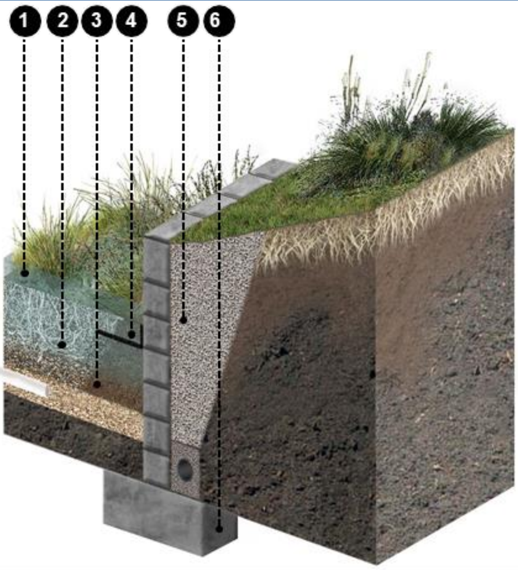
<table>
<tr><td>ET9</td><td>Vertical drops ≥800mm must be designed to Council satisfaction. A suggested option is terracing using a combination of batters and walls of heights ≤800mm. Where it is unavoidable to position retaining walls in parallel it is suggested they are separated by a vegetated bench ≥3m wide.</td></tr>
<tr><td>ET10</td><td>

Where a retaining wall forms the edge of the filter media, it must have a flat surface and the filter media must be compacted against the retaining wall.

Where uneven rock retaining walls are adopted, the retaining wall should be set back from the filter media, retaining at least 1m of in-situ soil. The separation must be wide enough to ensure the base of the rock retaining wall is well founded, at a 45 degree angle from the base of the filter media.

For guidance refer to Figure 15.





</td></tr>
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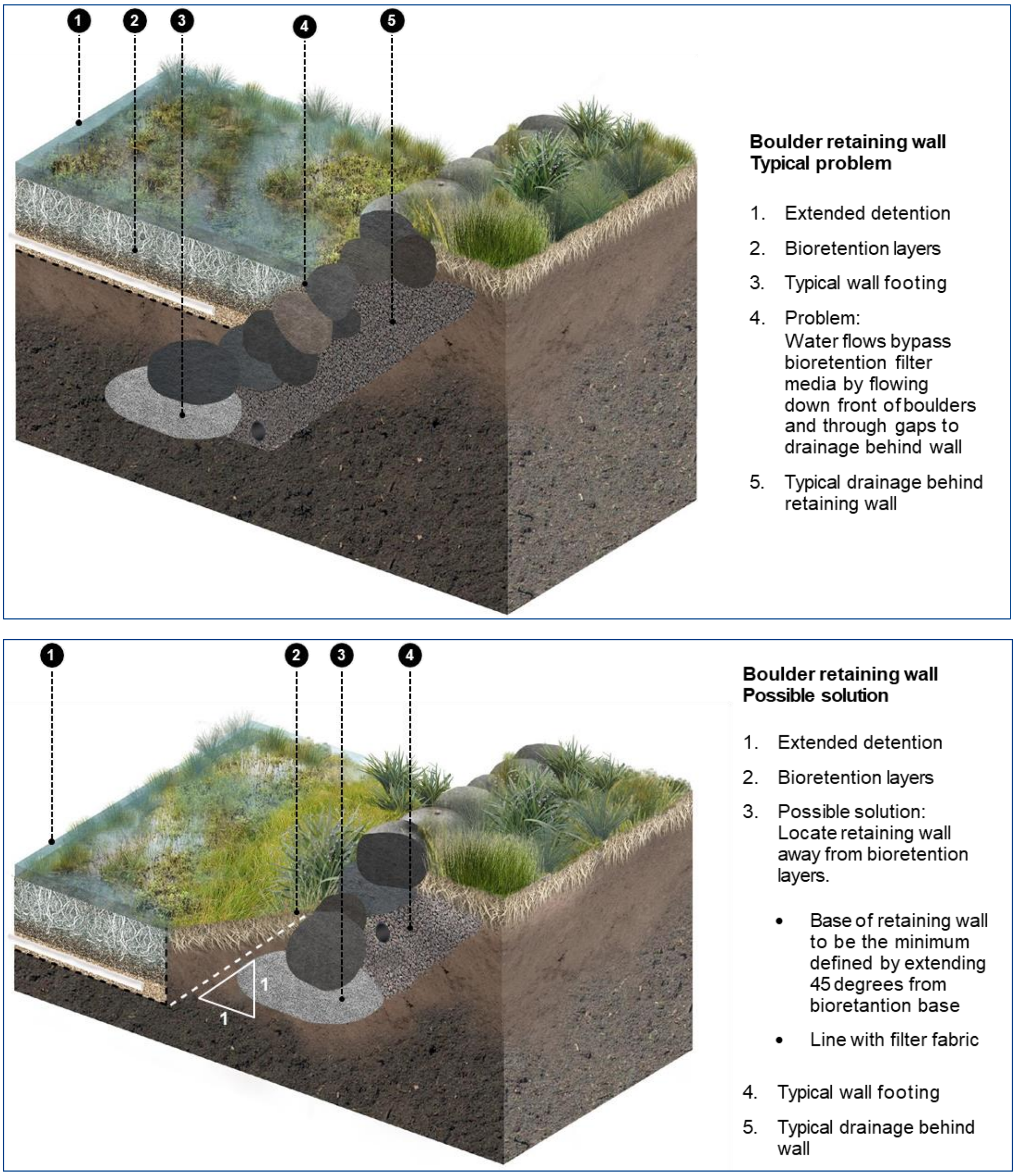
<table>
<tr><td></td><td>


Figure 15 Retaining walls in and adjacent to biofiltration systems – typical problems and possible solutions
</td></tr>
<tr><td>ET11</td><td>At least 200mm of topsoil must be provided on all batters and embankments in accordance with Melbourne Water’s <u>Topsoil Specification</u>, which is a sub-set of AS 4419 Soils for landscaping and garden use. Testing must be carried out by a NATA accredited laboratory. If required, amelioration to the topsoil must be undertaken to achieve compliance with Melbourne Water’s Topsoil Specification.</td></tr>
<tr><td>ET12</td><td>Pipes through embankments must be backfilled, compacted, and have an anti-seepage collar, cut-off walls, or filter collars.</td></tr>
</table>

Liners	
LN1	Impermeable liners must be provided around longer lasting submerged zones and systems where exfiltration is not desired.
LN2	Impermeable liners must ensure water cannot be exchanged between the biofiltration system and the surrounding soil. They must be made from 300mm compacted non-dispersive clay or manufactured material. Robust seals must be provided around pipe and structure perforations. The liner must have a hydraulic conductivity of less than $1x10^{-9}$m/s. If the in-situ soil meets these requirements, it can be compacted for form a natural liner. A geotechnical report must be provided confirming the impermeable liner meets these requirements.
LN3	Permeable liners (for example geotextile) must be provided where in-situ soils need to be prevented from contaminating or migrating into filter media or the underdrainage network. The chosen material's suitability for this application must be confirmed by providing a geotechnical report.
LN4	When used, permeable liners must extend at least 300mm onto the biofiltration base and be pinned down or held by the lowest biofiltration layer.
LN5	When used, manufactured liners must be keyed into the biofiltration batters by extending them at least 500mm beyond the edge of the filter media (that is up the batter) then pinned to the in-situ soil and covered with at least 200mm of topsoil. Where an embankment bounds the system, the manufactured liner must extend over the embankment.

Maintenance provisions

Sediment forebay	
MN1	Sediment forebays must be designed so that the responsible Council can maintain it. Requirements must be confirmed with Council. The base of the forebay must be accessible allowing equipment to easily move from the access track to it.
MN2	Sediment forebay access tracks or ramps must be at a minimum 4m wide (unless otherwise specified by Council), no steeper than 1 : 5 and be made of fine crushed rock (FCR) unless otherwise specified by Council.
Sediment pond	
MN3	All parts of the base of a sediment pond must be accessible: • within seven metres of a designated hard stand area for excavation vehicles ("edge cleaned") OR • via a maintenance access ramp into the base of the sediment pond. Refer to *Melbourne Water Standard Drawing* 7251/12/005.

MN4	The sediment pond base material must extend vertically up the batter by 300mm and comprise of: • concrete – steel reinforced, minimum 150mm thick; OR • 400mm compacted rock. About 50% 300mm in size. The remaining 50% made up of 0-100mm graded rock, premixed with 300mm diameter rocks and spread and tracked so as to form a compacted base. Refer to Melbourne Water Standard Drawing 7251/12/004.
MN5	'Edge cleaned' sediment ponds must have hardstand areas (for example crushed rock) for excavation vehicles. A maintenance track must be provided around the full perimeter of the sediment pond. Refer to Melbourne Water Standard Drawing 7251/12/005.
MN6	Maintenance access ramps are required on all sediment ponds that cannot be 'edge cleaned'. The maintenance access ramp into a sediment pond must: • extend from the base of the sediment pond to at least 0.5m above TED • be at least 4m wide • be no steeper than 1:5 below NWL and 1:8 above NWL (1:12 cross fall or flatter) • be capable of supporting a 20 tonne excavator • constructed of compacted 200mm deep layer of rock – Bottom layer is 100mm depth of 0-100mm FCR – Top layer is 100mm depth of 0-40mm non-descript crushed rock (NDCR) (6% cement stabilised below NWL) • have a barrier to prevent unauthorised vehicle access (for example gate, bollard and/or fence). Refer to Melbourne Water Standard Drawing 7251/12/013.
MN7	A maintenance access track must be provided to the sediment pond maintenance access ramp and to enable maintenance vehicles to safely access and exit the site. The maintenance access track must: • be at least 4m wide • comprise of compacted 200mm deep layer of rock – Bottom layer is 100mm depth of 0-100mm FCR – Top layer is 100mm depth of 0-40mm NDCR • be reinforced to take a 20 tonne vehicle • at the road edge, have an industrial crossover to Council standard and rolled kerb adjoining it • have a barrier to prevent unauthorised vehicle access (for example gate, bollard and/or fence). Refer to Melbourne Water Standard Drawing 7251/12/013.

MN8	A hardstand area with a minimum turning circle appropriate to the types of maintenance vehicles to be used must be provided adjacent to the sediment pond maintenance access ramp to enable maintenance vehicles to safely reverse and exit the sediment loading area. Designers should seek advice from the future asset owner on the types of maintenance vehicles that will be used. The turning circle must be in accordance with the *Austroads Design Vehicles and Turning Path Templates*.
MN9	Intersections between pedestrian pathways and site maintenance access tracks should be reinforced to take a 20 tonne vehicle.
MN10	Where sediment dewatering areas are required, a dedicated space must be provided and: • be accessible from the maintenance ramp/track • have a length to width ratio no narrower than 10:1 • have a 1:12 cross fall or flatter • be able to contain all sediment removed from the sediment accumulation volume spread out at a maximum of 500mm depth • be located above the peak 10 year ARI water level and within 25m of each sediment pond • be located at least 15m from residential areas, public access spaces (playgrounds, sports fields etc), and consider potential odour and visual issues for local residents • address public safety and potential impacts on public access to open space areas • be free from above ground obstructions (for example light poles) and be an area that the future asset owner has legal or approved access to for the purpose of dewatering sediment. Refer to *Resetting sediment ponds best practice guide* (Melbourne Water, 2016) for additional information.
Biofiltration system	
MN11	Maintenance edges must be provided around the full perimeter of biofiltration system planting except for those located next to bushland or riparian planting. This is to minimise the risk of turf and weed encroachment into the system, provide for easy maintenance and delineate the system from surrounding land uses. Depending on the asset owner's requirements, edges must consist of: • pedestrian pathways or un-vegetated maintenance access tracks • concrete landscape maintenance edge or • larger broad leaf grasses.

<table>
<tr><td>MN12</td><td>Biofiltration system perimeter access must be provided as follows:
<table>
<tr><th>Filter area</th><th>Perimeter access</th></tr>
<tr><td>$<500\text{m}^2$</td><td>Grassed foot access ≥1m wide along one side of the biofiltration system ≥40% of the perimeter</td></tr>
<tr><td>$>500\text{m}^2$</td><td>Concrete path ≥2.5m wide for small utilities or tractors along ≥40% of the perimeter of each cell
Grassed foot access ≥1m wide around the remaining perimeter</td></tr>
</table>
Where tops of embankments form part of the access, they must be ≥4m wide.</td></tr>
<tr><td>MN13</td><td>Where underground services are located near the biofiltration system, the design of the system must ensure:
• Services do not traverse the system.
• The operation of the biofiltration system does not compromise the function of the service and vice versa.
• Common maintenance and checking activities undertaken on the underground service do not compromise any component or function of the biofiltration system and vice versa.</td></tr>
<tr><td>MN14</td><td>Inlet and outlet locations must be configured such that they can be maintained without damaging the biofiltration system or surrounding areas.</td></tr>
</table>

Construction

<table>
<tr><td>CN1</td><td>Wherever reasonable and practicable the disturbance of sodic and dispersive soils must be avoided. Dispersive soils must be managed in accordance with Best Practice Erosion and Sediment Control (IECA, 2008 and 2016 Addendum).</td></tr>
<tr><td>CN2</td><td>Biofiltration systems must be protected from construction sediment at all times, including during the building phase, and not be handed over before the upstream catchment has reached the 90% developed (Statement of Compliance) stage. This handover requirement applies where the catchment being treated by the biofiltration system is being developed by the same developer.
Sediment management up to this stage must be provided by installing sediment fencing around the full perimeter of the biofiltration system (including filter area and batters) and using one of these options:
<table>
<tr><th>Option</th><th>Description</th></tr>
<tr><td>Protective surface layer</td><td>Must be applied until 90% of the catchment is developed, then it can be removed and the system planted out.
The layer must consist of:
• 25mm coarse sand covered with 25mm topsoil and turf or
• filter cloth, topsoil and turf.</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td>
<table>
<tr><td></td><td>The top level of this layer must be below the inlet level and at least 100mm below the crest of the overflow pit.</td></tr>
<tr><td>Sediment ponds combined with protective surface layer</td><td>Must be sized to either capture all coarse sediment up to 125µm or as determined by local soils (Refer to Best Practice Erosion and Sediment Control, IECA 2008 and 2016 Addendum).
This option must be combined with the protective surface layer to manage fine sediment.
Before handover the pond must be cleaned and reinstated, or decommissioned where it is temporary, and the protective layer removed and planting established.</td></tr>
</table>
</td></tr>
<tr><td>CN3</td><td>Before begin of construction, soil within the site area must be stabilised and appropriate erosion and sediment control must be present in the catchment in accordance with Melbourne Water's Principles of Erosion Management, Specification for temporary erosion and weed control matting and Best Practice Erosion and Sediment Control (IECA, 2008 and 2016 Addendum).</td></tr>
<tr><td>CN4</td><td>The site must comply with erosion control standards in accordance with Melbourne Water's Principles of Erosion Management, Specification for temporary erosion and weed control matting and Best Practice Erosion and Sediment Control (IECA, 2008 and 2016 Addendum) when construction phase sediment ponds are decommissioned or transformed into other stormwater management devices.</td></tr>
<tr><td>CN5</td><td>Timing of the civil works must be planned to protect the filter media from any stormwater inflows during construction. A suitably dry period (that is a time of year when it is not expected to rain for the duration of the construction period) must be chosen for the construction period or a diversion system be put in place to isolate the works area.</td></tr>
<tr><td>CN6</td><td>All materials must be ordered and delivered to the site and protective measures installed before construction starts.</td></tr>
<tr><td>CN7</td><td>Before installing the filter media, it must be tested in accordance with Appendix C, Adoption Guidelines for Biofiltration Systems (CRC for Water Sensitive Cities, 2015) to confirm it has a suitable hydraulic conductivity, can support plant growth and can hold adequate moisture. Testing must be carried out by a NATA accredited laboratory. If the media does not meet these requirements it must not be installed.
The number of samples for the filter media must be as follows:
<table>
<tr><th>Biofiltration surface area (m^2)</th><th>Number of samples per m^3 of filter media</th></tr>
<tr><td><500</td><td>1 per 500m^3</td></tr>
<tr><td>>500</td><td>1 per 2,000m^3 PLUS
1 per 500m^3 for the hydraulic conductivity test (for example one full CRC Guideline test PLUS three hydraulic conductivity tests per 2,000m^3)</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td>CN8</td><td>Hold points must be adhered to in accordance with Bio Retention System Hold Points Training Manual (Melbourne Water, 2017).</td></tr>
<tr><td>CN9</td><td>The following certification and chain of custody must be adhered to for the filter media:
1. The supplier and contractor are responsible for ensuring the filter media meets the requirements described in Deemed to Comply Criteria BR7 and that the correct material is delivered to site. The supplier must arrange for testing of the filter media by a certified soil laboratory in accordance with the saturated hydraulic conductivity and all other requirements described in Deemed to Comply Criteria BR7. On the basis of the testing, the soil laboratory and supplier must certify the material meets these specifications. The supplier must provide the certification and laboratory test results to the contractor with the supply docket.
2. The contractor provides a copy of the supplier’s certification, test results and supply docket to the site superintendent or biofiltration designer for review.
3. Following review of the certification, test results and the supply docket, the site superintendent or biofiltration designer approves installation of the biofiltration media.
4. The relevant sections of the Biofiltration Media Sign-Off Form provided in Appendix A in this document must be completed and signed. This Sign-Off Form is provided as part of the construction certification by the site superintendent or biofiltration designer.</td></tr>
<tr><td>CN10</td><td>Construction tolerances must not exceed the following parameters:
<table>
<tr><th>Biofiltration system element</th><th>Permissible tolerance</th><th>Survey method to be used</th></tr>
<tr><td>Hydraulic structures</td><td>+/-25mm</td><td rowspan="3">Survey</td></tr>
<tr><td>Filter media surface</td><td>Area <300m^2: +/-25mm
Area >300m^2: +/-40mm</td></tr>
<tr><td>Base</td><td>+/-50mm</td></tr>
<tr><td>Drainage and transition layer</td><td>+/-25mm</td><td>Dumpy level, laser or measuring tape</td></tr>
<tr><td>Underdrainage</td><td>+/-25mm</td><td>Dumpy level or laser</td></tr>
</table></td></tr>
<tr><td>CN11</td><td>Filter media must be installed in two lifts for depths >500mm and lightly compacted between lifts, for example for 800mm overall depth installation must be in two lifts of 400mm.</td></tr>
<tr><td>CN12</td><td>The top surface of the filter layer, transition layer and drainage layer must be constructed to be level.</td></tr>
</table>

CN13	The filter media must be lightly compacted during installation with a single pass of a light roller (for example drum roller) or a vibrating plate for smaller systems or 'positracks' bobcat for larger systems.
CN14	Planter holes must be twice the size of the tubestock or plant pot size. Plant stems must not be broken from the root ball when planted. The top of the plant root ball must be slightly lower than the finished surface level after the media is placed in the planter hole around the plant. Refer to Melbourne Water's *Vegetation Standards* for further guidance.
CN15	Existing vegetation, particularly trees must be protected from construction activity. The area to be avoided is calculated as: Tree Protection Zone = DBH x 12. Where DBH = trunk diameter measured at 1.4 m above ground. Further guidance is provided in *AS 4970-2009 Protection of trees on development sites* (Standards Australia, 2009).

Establishment

<table>
<tr><td>EB1</td><td>During establishment regular watering must be provided with consideration of season, climate and rainfall events.
The following guideline must be adjusted to suit conditions:
<table>
<tr><th>Time frame</th><th>Frequency of watering per week</th></tr>
<tr><td>Week 1-6</td><td>5</td></tr>
<tr><td>Week 6-10</td><td>3</td></tr>
<tr><td>Week 11-15</td><td>2</td></tr>
</table>
In the absence of rain, each plant must receive 2.5-5 litres of water per week during the first 6 weeks (40mm of watering per week).</td></tr>
<tr><td>EB2</td><td>Before handover, the following establishment criteria must be demonstrated:

Greater than 90% of plants surviving
More than 1 species per wet zone and per dry zone
At least 50% increase in plant height where planting height of a species is 50% or less than its maximum height
Propagation occurring with more than 2-3 stems and seeding
No weeds
</td></tr>
</table>

5. Glossary

Term	Conversion
3 month ARI	= 98.17 AEP or 4 EY
1 year ARI	= 63.21% AEP = 1 EY
5 year ARI	= 20% AEP or 0.05 EY
10 year ARI	= 10% AEP = 0.11EY
100 year ARI	= 1% AEP or 0.01 EY

6. References

Clearwater (2018). Clearwater Tool for WSUD Guidelines

CRC for Water Sensitive Cities (2015). Adoption Guidelines for Biofiltration Systems

E2DesignLab (2013). Bioretention in the West – Phase 1, Design for Sustained Health of Plants through Consideration of Soil Moisture Behaviour

Engineers Australia (2006). Australian Runoff Quality: Guide to Water Sensitive Urban Design

Geoscience Australia (2019). Australian Rainfall and Runoff

Hume City Council (2008). Industrial Stormwater Code of Practice

International Erosion Control Association (2008 and 2016 Addendum). Best Practice Erosion and Sediment Control

Melbourne Water (2017). Bio Retention System Hold Points Training Manual

Melbourne Water (2016). Resetting sediment ponds best practice guide

Melbourne Water (2009). Shared Pathways Guidelines

Melbourne Water, Stormwater Victoria (2017). WSUD Audit Guidelines

Melbourne Water (2005). WSUD Engineering Procedures: Stormwater

Melbourne Water (2016). Wetland Design Manual

Melbourne Water (2017). WSUD Maintenance Guidelines

Melbourne Water (2017). Living Rivers WSUD Asset Audit

Standards Australia (2009). AS 4970-2009 Protection of trees on development sites

Tony Ladson (2017). Converting between EY, AEP and ARI

Townsville City Council (2011). Water sensitive urban design for the Coastal Dry Tropics (Townsville): technical design guidelines for stormwater management

Water by Design (2014). Bioretention Technical Design Guidelines

Water by Design (2009). Construction and Establishment Guidelines

Water by Design (2014). Water Sensitive Designs

Wyndham City Council (2018). WSUD Asset Selection and Design Standards Guideline

7. Appendices

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Appendix A: Checklists and forms

Deemed to Comply Criteria Checklist

THIS CHECKLIST MUST BE USED BY THE BIORETENTION SYSTEM DESIGNER TO CLEARLY COMMUNICATE WHICH DEEMED TO COMPLY CRITERIA THE PROPOSED DESIGN MEETS. FOR ANY DEEMED TO COMPLY CRITERIA THAT IS NOT MET, THE DESIGNER MUST DEMONSTRATE HOW THE ALTERNATIVE APPROACH ACHIEVES THE REQUIRED CORE OUTCOMES.

THIS FORM MUST BE SUBMITTED TO MELBOURNE WATER AT THE FUNCTIONAL AND DETAILED DESIGN STAGE OF THE DESIGN ACCEPTANCE PROCESS.

ADDRESS:

PROJECT TITLE AND JOB DESCRIPTION:

DEVELOPER:

CONSULTANT:

CONSULTANT REF:

MELBOURNE WATER REF (EPMS #, LD #):

Declaration

I declare and acknowledge that I have submitted the attached application in its entirety and accuracy in accordance with Part B of the Melbourne Water Biofiltration Guideline. I further acknowledge that if the application is incomplete it will be returned and will not be considered lodged with Melbourne Water.

Signature: Date:

Print name: Position:

Design

Criterion	Met (yes/no)	Comments and/or alternative approach justification
General		
GN1 Performance modelling		
GN2 Rainfall data		
GN3 Flow estimation		
GN4 Design plans		
GN5 Hydraulic structures		
GN6 System sizing		
GN7 Handover documents		
GN8 Service identification		
GN9 Checklists		
GN10 Dry climates		
GN11 Use of contained systems		

Safety provisions		
SF1 Public safety		
Coarse sediment removal systems		
CS1 Coarse sediment removal methods		
CS2 Forebay sizing		
CS3 System location		
CS4 System connection		
CS5 High flow bypass		
CS6 Sediment pond sizing		
Biofiltration cells		
BR1 Toxic substances		
BR2 System connection		
BR3 Elevation difference		
BR4 Extended detention depth		

BR5 Surface dimensions		
BR6 Distribution system		
BR7 Layer specifications		
BR8 Infiltration near structures		
BR9 Mulching		
BR10 Underground services		
BR11 Filter layer surface design		
BR12 Groundwater level		
Inlets and outlets		
IO1 Inlet scour protection		
IO2 Outlet scour protection		
IO3 Invert levels		
IO4 Locations		
IO5 Drainage		

IO6 Outlet pit		
IO7 Connection sizing		
IO8 Overflow pit		
IO9 Connection to Melbourne Water assets		
Pipe selection		
PS1 Material		
PS2 Sizing		
PS3 Bends		
PS4 Spacing		
PS5 Drainage		
PS6 Inspection, clean-out		
PS7 Joints		
PS8 Pipe class		
Vegetation and landscape		
VG1 Existing vegetation		
VG2 Numbers of species		

VG3 Densities		
VG4 Surface cover		
VG5 Plant stock		
VG6 Effective species		
VG7 Selection criteria		
VG8 Grassed areas		
VG9 Slope treatment		
Edge treatment		
ET1 Surrounding landscape		
ET2 Batter, embankment height		
ET3 Batter, embankment vegetation		
ET4 Batter slopes		
ET5 Lateral flows		
ET6 Retaining wall design		
ET7 Vertical drop safety		

ET8 Extent of walls		
ET9 Vertical drops ≥800mm		
ET10 Retaining wall solutions		
ET11 Topsoil		
ET12 Pipes through embankments		
Liners		
LN1 Impermeable liner use		
LN2 Impermeable liner properties and installation		
LN3 Permeable liner use		
LN4 Permeable liner installation		
LN5 Manufactured liner installation		

Maintenance provisions

Criterion	Met (yes/no)	Comments and/or alternative approach justification
Sediment forebay		
MN1 Access to base		
MN2 Access track/ramp		
Sediment pond		
MN3 Access to base		
MN4 Base design		
MN5 Edge cleaning requirements		
MN6 Access ramps		
MN7 Access track		
MN8 Turning circles		
MN9 Track crossings		
MN10 Sediment dewatering areas		
Biofiltration system		
MN11 Maintenance edges		

MN12 Perimeter access		
MN13 Underground services interface		
MN14 Inlet and outlet locations		

Construction

Criterion	Met (yes/no)	Comments and/or alternative approach justification
CN1 Sodic and dispersive soils		
CN2 Protection during construction		
CN3 Erosion and sediment control		
CN4 Construction phase sediment ponds		
CN5 Timing		
CN6 Prior to construction		
CN7 Filter media testing		

CN8 Hold points		
CN9 Certification and chain of custody		
CN10 Construction tolerances		
CN11 Filter media installation		
CN12 Filter layer surface construction		
CN13 Filter media compaction		
CN14 Planting technique		
CN15 Protection of existing vegetation		

Establishment

Criterion	Met (yes/no)	Comments and/or alternative approach justification
EB1 Watering		
EB2 Prior to handover		

Biofiltration media sign-off form

To be undertaken in accordance with *Deemed to Comply Criteria* BR7, CN7 and Appendix C, Adoption Guidelines for Biofiltration Systems (CRC for Water Sensitive Cities, 2015).

Check point requirement	Checked	Satisfactory	Action (if unsatisfactory)	Initial
Drainage layer				
Material meets the specifications				
Material meets the required hydraulic conductivity				
Delivery supply docket certifies that the material delivered is the material tested (delivery docket attached)				
Transition layer				
Material meets the specifications				
Supplier certification provided (certification attached)				
Delivery supply docket certifies that the material delivered is the material tested (delivery docket attached)				
Filter media				
Material meets the specifications				
Material meets the required hydraulic conductivity				
Frequency of laboratory testing completed in accordance with specifications (results of testing attached)				

Delivery supply docket certifies that the material delivered is the material tested (delivery docket attached)				

HOLD POINT: Superintendent or biofiltration designer inspection and review of test results and certifications before proceeding. Comments:

Appendix B: Material Sustainability

The sourcing of locally available construction materials and plant species and the conservation of resources such as water, soil, rock and energy is encouraged to reduce the environmental impact of a new asset.

Consideration should be given to:

- Low impact
  - Low energy/carbon
  - Local source
  - Extraction damage minimise
  - Non-renewables avoided
- Durability – appropriate length of life cycle
- Reasonable costs, functionality and maintenance requirements

Material sustainability decision making should be guided the EPA Victoria waste management hierarchy principles.

Figure 16 EPA Victoria waste management hierarchy

8. Document History

Date	Reviewed/ Actioned By	Version	Action
September 2020	Senior Stormwater Quality Technical Advisor	3	Version for website approval Acknowledgements updated
August 2020	Senior Stormwater Quality Technical Advisor	2	Version for controlled document workflow approval
July 2020	Senior Stormwater Quality Technical Advisor	1	Final version ready for publication

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