Water Sensitive Urban Design Guidelines

South Eastern Councils

State Government Victoria

Melbourne Water

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Executive Summary

Water Sensitive Urban Design (WSUD) forms an important part of integrated water management. Innovative stormwater management, such as WSUD, can contribute greatly to sustainability and liveability, particularly when considered as part of an overall urban strategy. Councils recognise the importance of stormwater management and are striving for more widespread implementation of WSUD in their municipalities. As such, these WSUD Guidelines were created to promote the implementation of WSUD and to create consistency across the councils in the southern and eastern regions of Melbourne.

These WSUD Guidelines set out councils' expectations for WSUD projects within their respective municipalities. They include the main guidelines document covering information relevant to all councils, and an addendum document for each council outlining council specific requirements. The WSUD Guidelines can be used as a reference for external stakeholders, such as developers and consultants, as well as council.

The guidelines outline the key processes and requirements for WSUD in three main sections:

1. **Introduction** – Background information and regulatory considerations
2. **Planning and design**
3. **Construction and maintenance**

These three sections cover the overall processes, major hold points, approvals, handovers and key considerations for each phase of a WSUD project. The WSUD Guidelines also outline council specific requirements through the addendum document.

1. Introduction

1.1 Background

The importance of sustainable water management, including Water Sensitive Urban Design (WSUD), is becoming more widely recognised by councils and communities. As such, a number of councils are striving for more widespread implementation of WSUD within their municipalities.

In 2011, Melbourne Water's Living Rivers Stormwater Program provided funding to progress and finalise the second round of Water Sensitive Urban Design (WSUD) Guidelines for councils on the southern and eastern fringe of Melbourne. To assist Melbourne Water, Parsons Brinckerhoff was commissioned to develop the guidelines and the council specific addenda for Bass Coast Shire, Baw Baw Shire, Cardinia, Casey, Greater Dandenong, Maroondah, Mornington Peninsula, South Gippsland Shire and Yarra Ranges Shire Councils.

1.2 Purpose of the Guidelines

These guidelines outline councils' expectations for WSUD projects within their respective municipalities. They are for use within council and to inform developers, consultants and Owners Corporations for external projects. The document provides information on the planning, design, construction and maintenance of WSUD systems. The information includes WSUD targets and objectives, processes, approvals, and handovers for the various phases of a WSUD project. Each Addendum document also provides council specific information that should be considered for WSUD projects within that particular council.

The WSUD Guidelines do not seek to recreate the technical guidance provided in other published documents (see the References section), but rather to tie these documents together and act as a first reference point for WSUD projects. The guidelines also seek to provide greater consistency in WSUD requirements between councils.

A council working group for WSUD can also act as a first reference point and assist with the implementation and promotion of the WSUD Guidelines within council. A working group can offer value to the development and implementation of WSUD through guiding others in the relevant processes and requirements. It can also function as a learning tool to discuss lessons learnt and to share knowledge both within and between councils.

1.3 How to use the Guidelines

These guidelines aim to provide clarity on WSUD processes and greater consistency across councils in the southern and eastern regions of Melbourne. The WSUD Guideline document should be used as a first point of reference for all WSUD projects across Bass Coast Shire, Baw Baw Shire, Cardinia, Casey, Greater Dandenong, Maroondah, Mornington Peninsula, South Gippsland Shire and Yarra Ranges Shire Councils. The WSUD Guidelines consist of a main document, common to all councils, and a council specific addendum for each council.

The WSUD Guideline main document is broken down into three main sections: Introduction (Section 1), Planning and Design (Section 2), and Construction and Maintenance (Section 3). The diagrams shown at the beginning of Sections 2 and 3 provide an overview of the key steps involved for each phase of the project. The remainder of the section provides further detail on each of these key steps and the processes and requirements involved. Appendices A and B outline the functionality, applicability and main considerations for the different WSUD asset types. The main document and Appendices A and B provide information consistent across the region and should therefore remain the same for all councils.

The council addendum is referenced throughout the main guideline document and should be referred to for all council specific WSUD requirements.

1.4 What is Water Sensitive Urban Design?

Water Sensitive Urban Design (WSUD) integrates urban water cycle management with urban planning and design, with the aim of mimicking natural systems to minimise negative impacts on the natural water cycle and receiving waterways and bays. It offers an alternative to the traditional conveyance approach to stormwater management by acting at the development scale (at the source), and thereby reducing the required size of the structural stormwater system. It seeks to minimise impervious surfaces, reuse water on site, incorporate retention basins to reduce peak flows, and incorporate treatment systems to remove pollutants. WSUD also provides the opportunity to achieve multiple benefits though sustainable urban water management.

The key principles of WSUD as stated in the Urban Stormwater: Best Practice Environmental Management Guidelines (BPEMG) (Victorian Stormwater Committee, 1999) are:

a. Protect and enhance natural water systems within urban environments.

b. Integrate stormwater treatment into the landscape, maximising the visual and recreational amenity of developments.

c. Improve the quality of water draining from urban developments into receiving environments.

d. Reduce runoff and peak flows from urban developments by increasing local detention times and minimising impervious areas.

e. Minimise drainage infrastructure costs of development due to reduced runoff and peak flows.

1.5 Why use Water Sensitive Urban Design?

Stormwater is the water that runs off our urban surfaces following rainfall events. It has been identified as a key cause of pollution and declining health of our waterways.

With increased urban development, the proportion of impervious surfaces in our catchments increases. This increases the velocity and amount of water running into our waterways, creating problems of erosion and flooding and changing natural flow regimes, with associated ecological damage. It also washes more pollutants into our streams, further impacting river health.

WSUD has been identified as a means to control flows and filter stormwater to remove pollutants. It offers the potential to reduce the costs, infrastructure sizing and occupied land area associated with conventional drainage approaches whilst treating runoff closer to its source. This more effectively mimics a natural system and, as treatment can be located further upstream than for conventional approaches, is efficient by providing flow-on effects that benefit the entire catchment.

WSUD is also an important component of integrated water management, and can contribute to multiple benefits such as enhancing liveability.

The benefits of WSUD are such that the approach is now supported – and in some cases mandated – by various regulations and policies applied across Victoria. These are briefly outlined in the following section.

1.6 Regulatory considerations for stormwater management

There are a number of regulatory considerations for stormwater management. They include water policy, such as the State Environment Protection Policy – Waters of Victoria (see Section 1.6.1), as well as planning provisions (see Section 1.6.2). More recently the Ministry Advisory Council for the Living Melbourne, Living Victoria Plan for Water (2011) developed a Roadmap, which emphasises the importance of integrated water management. The Roadmap outlines strategic priorities to deliver 'smart, secure water for a liveable, sustainable and productive Melbourne'. These general principles of sustainability, liveability and productivity can be incorporated into council strategies to promote the multiple benefits that can be achieved through innovative stormwater management.

The following sections outline in further detail some of the regulatory considerations for stormwater management.

1.6.1 State Environment Protection Policy (Waters of Victoria)

The State Environment Protection Policy (SEPP) (Waters of Victoria) (EPA Victoria, 2003) is a state wide policy requiring that runoff from urban and rural areas must not compromise the beneficial uses of receiving waterways. This policy specifically refers to stormwater pollution and requires the implementation of measures to control its environmental impact. WSUD is a tool used to comply with this Policy.

1.6.2 Victoria Planning Provisions

The Victoria Planning Provisions (VPP) contains a number of clauses that support the sustainable management of stormwater runoff from development, including the use of WSUD. These include the State Planning Policy Framework Clauses 10, 11, 12, 14, 15 and 19, which pertain to all types of development within the state. Councils are responsible for administering planning policies, and these clauses provide a solid basis in the planning scheme for councils to apply WSUD requirements to all developments, including residential, industrial and commercial uses.

Furthermore, Clauses 56.07 and 56.08 of the VPP were introduced on 9 October 2006, and have provided a significant driver for the development of these guidelines. Clause 56.07 relates to integrated water management in residential subdivisions, and Clause 56.07-4 and Standard 25 mandate best practice targets for pollutant load reductions and flow discharges to be met in such developments. In most cases, this will necessitate the incorporation of WSUD into the subdivision design. Clause 56.08 establishes requirements for site management during residential subdivision works and includes many issues pertinent to the protection of WSUD systems, such as site sediment control.

This document is designed to guide the integration of WSUD into all types of developments, including residential, industrial and commercial. It does, in particular, also aim to set out and simplify the process and requirements involved in satisfying Clause 56.07-4.

All of the abovementioned planning policies relating to stormwater management apply state wide. Further information on these policies is provided below.

Clause 10 – Operation of the State Planning Policy Framework

This Clause, and the following Clauses, establishes the link between the planning system and the state requirements for environmental protection and provides guidance for developers from a planning perspective.

Clause 11 – Settlement

Clause 11 aims to ensure a sufficient amount of land is available for residential, commercial, industrial, recreational, institutional and other public uses within urban areas. It aims to contribute towards:

– "A high standard of urban design and amenity.

– Prevention of pollution to land, water and air.

– Protection of environmentally sensitive areas and natural resources."

Clause 12 – Environmental and Landscape Values

Clause 12 aims to "protect the health of ecological systems and the biodiversity they support" and to "conserve areas with identified environmental and landscape values". It states that "Planning must implement environmental principles for ecologically sustainable development that have been established by international and national agreements" and references a number of the agreements and strategies.

Clause 14 – Natural Resource Management

Clause 14 aims to "assist in the conservation and wise use of natural resources including energy, water, land, stone and minerals to support both environmental quality and sustainable development".

Clause 14.02, Water, outlines objectives, strategies and policy guidelines for catchment planning and management, water quality and water conservation. This clause includes protecting and restoring waterways, catchments and other water bodies, protecting water quality, and encouraging the use of alternative water sources.

Clause 15 – Built Environment and Heritage

Clause 15 aims to protect "sites with significant heritage, architectural, aesthetic, scientific and cultural value". It aims to achieve high quality urban design to contribute positively to communities, enhance liveability, reflect cultural identity, and promote attractive and high amenity communities.

Clause 19 – Infrastructure

Clause 19 aims to ensure social and physical infrastructure is provided in an "efficient, equitable, accessible and timely" way.

Clause 19.03-2, Water supply, sewerage and drainage, requires that planning and responsible authorities should ensure that:

a. "Water quality in water supply catchments is protected from possible contamination by urban, industrial and agricultural land uses."

b. Urban stormwater drainage systems take into account the catchment context, and "include measures to reduce peak flows and assist screening, filtering and treatment of stormwater, to enhance flood protection and minimise impacts on water quality in receiving waters" and prevent intrusion of litter.

Clause 19.03-3, Stormwater, has a key objective to "reduce the impact of stormwater on bays and catchments" with strategies to:

a. "Support integrated planning of stormwater quality through a mix of on-site measures and developer contributions.

b. Mitigate stormwater pollution from construction sites.

c. Ensure stormwater and groundwater entering wetlands do not have a detrimental effect on wetlands and estuaries.

d. Incorporate water-sensitive urban design techniques into developments to:
   – Protect and enhance natural water systems.
   – Integrate stormwater treatment into the landscape.
   – Protect quality of water.
   – Reduce run-off and peak flows.
   – Minimise drainage and infrastructure costs."

Clause 56.07-4 and Standard C25

Under Clause 56.07-4 local councils are responsible for requiring that urban runoff from new residential subdivisions of 2 lots or more meet best practice water quality and flow requirements. The objectives of Clause 56.07-4, which must be met, are:

a. "To minimise damage to properties and inconvenience to residents from urban run-off.

b. To ensure that the street operates adequately during major storm events and provides for public safety.

c. To minimise increases in stormwater run-off and protect the environmental values and physical characteristics of receiving waters from degradation by urban run-off."

Standard C25 sets out the normal way of meeting the Clause 56.07-4 objectives. Among other requirements, Standard C25 requires that urban stormwater management systems 'must' be:

a. Designed to meet current best practice performance objectives for stormwater quality, as outlined in the Urban Stormwater: Best Practice Environmental Management Guidelines (Victorian Stormwater Committee, 1999) as amended. Refer to Section 1.7 for more information.

b. Designed to ensure that flows downstream of the subdivision site are restricted to predevelopment levels unless increased flows are approved by the relevant drainage authority and there are no detrimental downstream impacts.

Standard C25 requires that urban stormwater management systems must be designed and managed to the requirements of the relevant drainage authority. This is typically Council, with the exception of catchments of 60ha or more within the Melbourne Water drainage boundary, when it is Melbourne Water.

Clause 56 Tool

Clearwater has developed the C56 Tool to support Victorian councils, developers, consultants and applicants when carrying out residential subdivisions. The C56 Tool is designed to raise awareness and build understanding of when Clause 56.07-4 applies. The Tool is made up of several elements including an interactive decision tree, fact sheets, practice notes and checklists to assist in the interpretation and associated processes with applying the Clause. The C56 Tool can be accessed on Clearwater's website – www.clearwater.asn.au. The Tool is supported by Melbourne Water, the Municipal Association of Victoria and the Department of Sustainability and Environment.

1.7 Urban Stormwater Best Practice Environmental Management Guidelines for stormwater treatment

The objectives for on-site treatment relating to urban stormwater quality, as outlined by the Urban Stormwater: Best Practice Environmental Management Guidelines (Victorian Stormwater Committee, 1999), are:

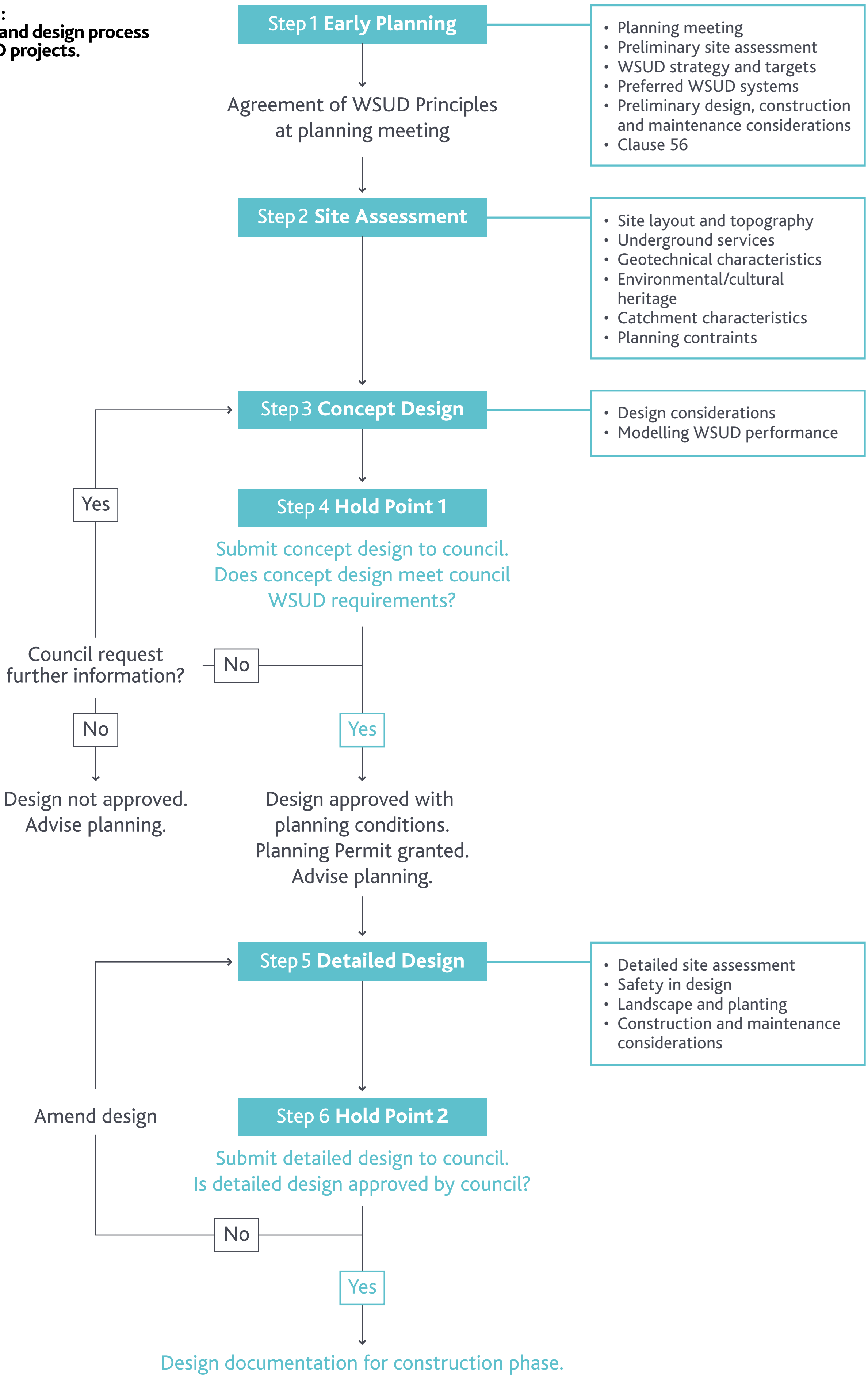
- 80% retention of the typical urban annual load for Total Suspended Solids (TSS)
- 45% retention of the typical urban annual load for Total Phosphorus (TP)
- 45% retention of the typical urban annual load for Total Nitrogen (TN)
- 70% retention of the typical urban annual load for gross pollutants (litter).

The guidelines prescribe that discharges for 1.5yr ARI (Average Recurrence Interval) be maintained at pre-development levels for stormwater treatments. Retarding regular low flow events reduces in-stream erosion that often results from urban development.

These stormwater quality objectives reflect the level of stormwater management necessary to meet the SEPP (Waters of Victoria) (EPA Victoria, 2003) requirements and are the target design criteria for WSUD treatments.

2. Planning and design

Figure 2.1: Planning and design process for WSUD projects.



2.1 Step 1: Early planning

The early planning phase is important to establish site characteristics, WSUD targets and preferred WSUD assets types for a particular project. The WSUD targets should align with overall council strategies. Many councils have adopted or are developing strategies with specific WSUD targets, which need to be considered during this phase. Further information on the development of WSUD strategies can be found in "Developing a strategic approach to WSUD implementation" on the Clearwater website (www.clearwater.asn.au).

The early planning phase should also be used to consider any constraints that may arise through the design, construction and maintenance phases. Melbourne Water and council expectations for each project should also be clearly established during the early planning phase.

The following sections outline the key stages and actions in the early planning phase.

2.1.1 Planning meeting

A planning meeting should be held early in the planning phase for both council and non-council projects. The aim of the planning meeting is to establish agreed project strategies and targets, including a strategy to address potential issues and constraints, and to clarify any project requirements. The planning meeting should cover the following information:

- Site characteristics (see Section 2.1.2)
- Drainage characteristics (see Section 2.1.2)
- WSUD strategies and targets (see Section 2.1.3)
- Preferred WSUD distribution (e.g. distributed or end of line systems) (see Section 2.1.4)
- Preferred WSUD asset types (see Section 2.1.4)
- Clause 56 implications (see Section 2.1.5)
- Design considerations (see Section 2.1.5)
- Preliminary construction, operation or maintenance considerations (see Section 2.1.6)
- Council and Melbourne Water expectations
- Precinct Structure Plan for growth areas
- Funding opportunities – from within council or external support (e.g. private sector, government grants or Melbourne Water programs)

It is important to have the right representatives at the planning meeting, and this may vary for council and external projects:

- **Council projects** (e.g. capital works) – the planning meeting should include representatives from the relevant teams within council, for example; project manager, planning, engineering, drainage, environment and landscaping, infrastructure, and maintenance. For major or sensitive projects, or projects as part of a Melbourne Water program, the planning meeting may also include representatives from Melbourne Water.
- **External projects** (e.g. developments) – the planning meeting will form part of the pre application process and should include representatives from council, Melbourne Water or Catchment Management Authority (particularly for larger or more complex projects), as well as the developers, consultants or contractors.

The following sections outline in further detail some of the topics that should be discussed at the planning meeting.

2.1.2 Preliminary site assessment

A preliminary site assessment should be undertaken to determine the site and drainage characteristics. This site assessment can be a high level assessment, but should cover the following information:

a. Location

b. Type of development (e.g. residential, industrial, etc.)

c. Area and number of lots

d. Development density

e. Proposed outfall / legal point of discharge (LPOD)

g. Proposed extent of WSUD (indicative only)

f. Potential site constraints

g. Environmental considerations (habitat identified biodiversity significance)

h. Cultural heritage considerations (e.g. waterway corridors)

2.1.3 WSUD strategy and targets

The WSUD strategy and targets should be established in the early planning phase. These strategies and targets should be agreed on by all parties at the planning meeting, and may include:

- Reducing runoff and inundation
- Reducing Directly Connected Imperviousness (refer to Developing a Strategic Approach to WSUD, on the Clearwater website www.clearwater.asn.au)
- Stormwater treatment targets (refer to Section 1.7 for treatment requirements)
- Water conservation
- Maintaining environmental flows (refer to Section 1.7 for flow discharge requirements)
- Improving the local environment and landscape
- Community benefits (such as high quality recreation areas)
- Other council specific targets or strategies (refer to Addendum)

Precinct Structure Plans and Development Services Schemes should also be considered, where applicable, when establishing these targets.

The WSUD strategies and targets will likely vary for different projects and may be influenced by factors such as; site location, receiving waterway (e.g. drainage pipe, constructed waterway, or existing waterway or bay), project size, development type, and community requirements.

Consideration of where higher standards (e.g. above best practice standards or Clause 56 requirements) are required, for example where the receiving waterways are identified as high value catchments or where threatened species have been identified.

2.1.4 Preferred WSUD systems

The preferred WSUD asset types and distribution of systems should be discussed in the planning meeting, and based on the agreed strategies and targets as outlined in Section 2.1.3. The WSUD system/s may consist of one treatment type or a treatment train of multiple assets to meet these targets. Note that council may not support the use of all WSUD asset types, due to their unsuitability for local topography, maintenance or safety requirements. Refer to the Addendum for the council approved list of WSUD treatment types. For an overview of the different WSUD asset types and functionality refer to Appendix A and B.

Selection of WSUD asset type may depend on:

- Development type
- Treatment requirements (or other WSUD targets)
- Catchment size
- Topography
- Land availability

The preference for a particular distribution of WSUD assets (e.g. distributed throughout the catchment or end of pipe systems), may also vary for different projects. Examples of each of system are listed below:

- Distributed – raingardens located within smaller lots throughout a development area, or swales located through multiple streets within a catchment
- End of pipe – a wetland located at the outlet of a larger development site

Factors impacting the distribution of WSUD systems may include:

- Development type and size
- Multiple site outlets
- Existing or constructed waterways dividing the site
- Achieving multiple benefits (e.g. wetlands designed in the base of detention basins)
- Construction and maintenance requirements (including access and on-going responsibilities)
- Minimising damage or disruption to existing environment or assets

The use of a distributed or end of line systems should be discussed with Melbourne Water and council in the planning meeting. It may also be useful to discuss indicative locations for the WSUD asset.

2.1.5 Design considerations

Discussing design requirements in the early planning phase can be important to identify the general design strategy and potential design consideration, assisting the later design phase. The design considerations should be discussed in the planning meeting and may include; site constraints, integrating WSUD with existing drainage systems, requirements for smaller development sites, and requirements for sites already within a Melbourne Water Development Services Scheme. These design considerations are outlined below.

Site constraints

Any major site constraints should be reviewed in the planning phase and discussed at the planning meeting. Information on any site constraints should also be handed over to the design team.

Integrating WSUD with drainage systems

The integration of WSUD systems with existing or proposed drainage systems should be thought about during planning. The integration of WSUD with the drainage system will likely influence the preferred type of WSUD asset or location within site.

Clause 56 and subdivisions within Melbourne Water Development Services Schemes

Clause 56 promotes the implementation of integrated water management in urban developments. It also aims to ensure that urban runoff from new residential subdivisions meets best practice for stormwater quality and flow requirements. Clause 56 is included as part of the Victorian Planning Provisions. Section 1.6.2 of this document and the Clearwater website outlines Clause 56 in more detail.

The Development Services Schemes apply the key objectives of Clause 56 to an overall stormwater strategy. Development Services Schemes have been developed for a number of locations within Greater Melbourne. If a development occurs within the Development Services Scheme area, reference should be made to this document and the associated plans for the overall stormwater strategy for the catchment. Refer to the Melbourne Water website and the Council Addendum for local Development Services Schemes.

Refer to the Clearwater website (www.clearwater.asn.au) for further information on Clause 56 and the Melbourne Water website (www.melbournewater.com.au) for further information on Development Services Schemes.

Sites of less than 1ha

The Clause 56.07 Planning Practice Note (DSE, 2006) makes an exception for residential subdivisions of less than 1ha. Where best practice stormwater quality requirements are not achieved and all reasonable actions within the subdivision have been taken, the relevant drainage authority may offer other options, as outlined in the Practice Notes.

Alternative options to meet stormwater quality requirements may include treating stormwater downstream as part of a larger scheme. Refer to the addendum for council options.

Precinct Structure Plans

Precinct Structure Plans (PSPs) set the future structure for whole communities within Victoria's growth areas. The development of these master plans is overseen by the Growth Area Authority. The Growth Area Authority (GAA) defines PSPs as follows:

Precinct Structure Plans "provide more detail on the land uses defined by the Growth Area Framework Plan. The Precinct Structure Plan shows how the objectives of Clause 56 of the local planning scheme will be achieved within the precinct. A permit application under a Precinct Structure Plan must meet particular Objectives set out in Clause 56 and should meet the Standards set out in Clause 56, as appropriate. The Precinct Structure Plan is incorporated into the local planning scheme to guide the use and development of land in the precinct over the long term."

Refer to Engineering Design and Construction manual for Subdivisions in Growth Areas (GAA, 2011) for more information on PSPs, or the GAA website for information on the status of PSPs.

2.1.6 Preliminary construction, operations and maintenance considerations

Preliminary construction, operations and maintenance requirements or principles should be considered in the planning phase. It is important to consider these factors in the planning phase to ensure council requirements can be met and to assist with the later project phases. The following sections of these guidelines provide further information on construction, operations and maintenance requirements:

a. Section 2.5.3 and Section 3.4 for construction phase requirements.

b. Section 3.7 for defect liability requirements.

c. Section 2.5.4, 3.8 and 3.9 for maintenance and handover requirements.

d. Section 3.1 for developing budgets for on-going operations and maintenance

e. Addendum for any council specific requirements.

f. Appendix A for relative performance, site suitability, approaches to site constraints and on-going maintenance considerations.

g. Appendix B for WSUD treatment descriptions, and design and maintenance considerations.

2.2 Step 2: Site assessment

A site assessment should be completed prior to commencing design. This assessment will typically involve a desktop study and site visit for the concept design phase. Further assessment may be required at the detailed design phase for particular site characteristics or identified issues. The assessment for the detailed design may be through a more detailed desktop analysis or through assessments on site (e.g. geotechnical site assessment). The type of information that should be collected as part of the site assessment may include:

- Site layout and potential extent and locations available for WSUD
- Topographic information including contours
- Underground services
- Geotechnical characteristics
- Environmental and cultural heritage features
- Planning constraints
- Climatic conditions
- Upstream catchments
- Catchment hydrology
- Integration of WSUD with existing or proposed drainage systems
- Ecological condition of vulnerable or threatened receiving waterways

The information collected as part of the site assessment should be documented and used for the concept and detailed design, and included in the design reports.

2.3 Step 3: Concept design

A concept design is to be developed based on the required WSUD targets (see Section 2.1.3), the appropriate WSUD assets (see Section 2.1.4), and the results of the site assessment. The concept design should also take into account other design considerations, such as:

- **Multiple WSUD benefits** – design WSUD systems to achieve multiple stormwater benefits, such as stormwater treatment, stormwater retention as well as water conservation and demand management. Consider if other benefits can also be achieved through the stormwater design, such as high quality open space for communities.
- **Flooding** – develop designs to minimise local inundation.
- **Environment** – consider if WSUD can protect and enhance the environment.
- **Cultural heritage** – determine if a cultural heritage assessment is required (refer to the Planning Scheme overlays, or the Heritage Victoria, Heritage Council of Victoria or Aboriginal Affairs Victoria website for further information, or the Addendum for specific council requirements).
- **Climate change** – consider the impacts that climate change may have on a system, and if these need to be accounted for in the design.
- **Community** – consider opportunities for community engagement and education, such as signage, designing WSUD systems to be a community feature, or information sessions and community meetings.
- **Preliminary construction and maintenance considerations** – refer to Section 2.1.6.

Concept design options should be modelled to check if the proposed concept meets the required WSUD targets. Designs are typically modelled using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC), as outlined in Section 2.3.1.

2.3.1 Modelling WSUD performance

Stormwater treatment

The stormwater treatment performance of each WSUD system should be modelled using MUSIC. The treatment system can include individual WSUD assets or a treatment train including multiple assets. There are a number of input parameters for MUSIC, and these should be based on the Council Addendum and Melbourne Water MUSIC Guidelines (2010).

- **Rainfall data** – refer to the Council Addendum. The appropriate rainfall station has been selected to best represent the region. Representative years of rainfall data have been selected to best match long-term meteorological records in terms of mean annual rainfall and the 90th percentile of rainfall. Rainfall data sets for stormwater treatment systems should include a minimum of 1 year of rainfall data with a 6 minute time step.
- **Other input parameters** – refer to the Melbourne Water MUSIC Guidelines (2010).

Note that STORM can also be used to model stormwater treatment performance. STORM is a simplified model for rating stormwater quality performance for use on smaller catchments or sites, typically less than 1ha. Refer to Melbourne Water for guidance on using STORM: http://wsud.melbournewater.com.au/content/storm/storm.asp

Stormwater harvesting

A basic water balance model should be developed for the concept design of stormwater harvesting schemes and rainwater tanks, to check the water demand requirements are met. A basic water balance model can be created using MUSIC, or calculations such as in a spreadsheet.

The water balance model should include the demand profile for the particular site and use the rainfall data outlined in the Council Addendum. Note that a longer rainfall data series (e.g. over 10 years) is preferred, to create a more accurate water balance model. It is recommended that a 1 hour time step is used for stormwater harvesting models in MUSIC.

Refer to the MUSIC Guidelines (Melbourne Water, 2010) for details on input parameters and losses that may be included, if using MUSIC.

The water balance model should also consider the relevant stormwater diversion licence and the volume of water that can be diverted to the system.

2.4 Step 4: Submission of Concept Design

Concept design submissions are to include the following:

- Design report – on the WSUD design intent meeting the requirements detailed in Section 2.3
- Concept design drawings
- Maps or plans showing drainage, contour and catchment information

Concept designs must also satisfy the following WSUD requirements:

a. The concept design must consider future maintenance requirements. Where council believes that the treatment may not be able to be adequately maintained, council may request additional information.

b. Use council approved WSUD treatment types (refer to the Addendum).

c. Meet the stormwater quality requirements for the development (see Section 1.7 and Section 2.1.3).

d. Restrict discharges of 1.5 year ARI to pre-development levels for stormwater quality treatment systems and 1 in 5 year ARI for the entire drainage system. For more information on calculating peak flows refer to the Australian Rainfall and Runoff guide.

e. Meet any council specific design, construction, maintenance and handover requirements in the Addendum.

f. The overall development plan must also address the relevant drainage, flood management, open space and public safety requirements for the development.

g. For developments within growth areas, concept designs should also meet the drainage provision requirements as outlined in Section 4.9 of the Engineering Design and Construction Manual for Subdivisions in Growth Areas (Growth Area Authority, 2011).

2.4.1 Report on WSUD design intent

Council approval will be subject to the WSUD treatment performance meeting the stormwater requirements, as per Section 1.7 and Section 2.1.3, and as set out pre-application discussions. The concept design should include a report outlining the WSUD design intent and an electronic copy of the MUSIC (or STORM) model. Where STORM is used, a print-out of the input parameters and relevant performance of the system should be submitted. The concept design submission should also include a map or plan showing drainage, contour and catchment information.

Report Contents

The report on the WSUD design intent should include a summary of the treatment performance in terms of:

a. Mean annual load (kg) from development area for Total Suspended Solids (TSS), Total Phosphorus (TP), Total Nitrogen (TN) and gross pollutants.
b. % reduction for TSS, TP, TN and gross pollutants for the total treatment train
c. % reduction for TSS, TP, TN and gross pollutants for each treatment system in the treatment train

Where rainwater tanks or stormwater harvesting systems are proposed a continual water balance model should be provided. It is preferred that a longer series of rainfall data (e.g. over 10 years) is used, with minimum missing data, to provide a more accurate result in the model. The design report should include the demand profiles, rainfall station and years of rainfall data adopted.

The report should also include a description of the function and intent of the WSUD systems, including:
- WSUD asset types
- WSUD asset sizes

The following information about the catchment and MUSIC configuration should be included:

a. Rainfall data used (refer to the Council Addendum)
b. MUSIC input parameters for the WSUD treatment systems or a printout of the input parameters and relevant performance if using STORM
c. Land use zones and the fraction impervious used
d. Land use zones and the pollution concentration data used if different to the default parameters used in MUSIC (not recommended unless justified by scientifically sound, peer-reviewed studies)
e. Description of any deviation from the design process.

The concept design report should also address construction, maintenance and handover considerations as outlined in Section 2.1.6.

Electronic data to be provided to Council

An electronic copy of the following MUSIC model information should be provided to council with the WSUD design intent report:

- Sqn or Sqz model of the catchment with WSUD measures
- Map showing drainage and contour information for the catchment and sub-catchments in MapInfo or other approved format. If an electronic copy is not available then a hard copy may be acceptable.

The free MUSIC Auditor Tool may be used to identify and address any inappropriate input parameters prior to submission. The tool is available at: http://music.melbournewater.com.au

2.5 Step 5: Detailed Design

The detailed design is to be developed based on the approved concept design. The detailed design will include the development of detailed design drawings, a design report as well as other design documentation. Refer to the WSUD Engineering Procedures: Stormwater (Melbourne Water, 2005) for more information, including examples, on the design of each WSUD asset type. Refer also to Appendix B for design considerations for the different WSUD assets.

A detailed site assessment should be completed based on the items outlined in Section 2.2. There are a number of other factors that also need to be considered for each WSUD design. The sections below outline in further detail some of these considerations. Refer also to the Addendum for council specific requirements.

2.5.1 Safety in Design

Safety in design must be addressed for all WSUD designs. Safety considerations may include:

- Site access (for construction and maintenance) – for staff and machinery/vehicles
- Safety considerations during construction
- Public access
- Appropriate signage to identify risks (for example deep water, use of recycled water, confined spaces etc.)
- Batters and requirements for open water (refer to Melbourne Water Constructed Wetlands Guidelines, and the Royal Life Saving guidelines)
- Batters for maintenance – steepest 1 in 5
- Risks of using recycled water, refer to NWQMS Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) – Stormwater Harvesting and Reuse (2009)
- Flood depths and velocities – refer to the Guidelines for Development in Flood-prone areas (Melbourne Water, 2007)
- Locations of existing services

2.5.2 Landscape and planting

Landscape and planting plans are to be included with the detailed design. Vegetation type should be chosen based on:

- WSUD asset type and treatment requirements (refer to WSUD Engineering Procedures: Stormwater Appendix A (Melbourne Water, 2005), Constructed Wetlands Guidelines Appendix 4 (Melbourne Water, 2010), Stormwater Biofiltration Systems Adoption Guidelines Section 3.5.12 (FAWB, 2009)
- Council requirements (refer to Addendum)
- Local environment and native vegetation
- Requirements for erosion control
- Vegetation that can be easily maintained.

2.5.3 Construction phase requirements

Appendices A and B provide detailed information about the specific construction considerations for the different WSUD asset types. Some particular requirements that should be considered for all WSUD projects, and documented as part of the design documentation, are listed here:

- Planting – best conducted during autumn months. However the timing of planting also depends on adequate water availability, adequate by-pass of high winter flows, and the schedule for the development.
- A detailed Site Environmental Management Plan (SEMP) should be submitted with the design documentation. Refer to Section 3.2 for further detail.
- Preferred site access (for staff and machinery/vehicles)
- Asset protection measures (refer to Section 3.4.1)
- Areas for stockpiling cut and fill
- Defect liability periods (refer to Section 3.7)

2.5.4 Maintenance phase requirements

The following items should be considered during the design phase. Documentation indicating how these items have been addressed will be required as part of the Detailed Design documentation.

- preliminary maintenance plans: responsibilities, requirements, clearly locating assets to be maintained and indicative costs
- asset handover arrangements, where appropriate, including defect liability and timeframes
- maintenance access for staff and vehicles/machinery: considering required maintenance frequency, if 'all weather' access is required, safety requirements, environmental impacts of access tracks, and aesthetics of the overall system

Designs should also consider any council specific maintenance and handover requirements as detailed in the Addendum, and the on-going maintenance activities for specific treatment types as discussed in Appendices A and B.

2.6 Step 6: Submission of Detailed Design

Detailed design submissions are to include the following:

- Design report – to address all stormwater drainage, quality and conservation issues
- Detailed design drawings
- Site management plan – which meets the construction phase requirements
- Digital data for the asset management systems (refer to Council Addendums for specific data requirements)
- Indicative management arrangements or plans for maintenance and handover of WSUD assets, that meet the defect liability requirements (refer to Section 3.7)
- Preliminary life cycle costing estimates – based on previous experience, guidelines and the Melbourne Water WSUD Life Cycle Costing analysis (currently being developed – refer to the Clearwater and Melbourne Water websites). Refer to Section 3.1 for further information

The detailed design submissions must also satisfy the following WSUD requirements:

a. Be consistent with the concept design (Section 2.3), i.e. be consistent with the submitted MUSIC model, including parameters used therein (if these change, a new MUSIC model should be submitted to reflect the changes).

b. Use council approved WSUD treatment types (see Council Addendum).

c. Meet the stormwater quality requirements for the development (see Section 1.7 and 2.1.3).

d. Restrict discharges of 1.5 year ARI to pre-development levels for stormwater quality treatment systems and 1 in 5 year ARI for the entire drainage system.

e. Meet any council specific design or maintenance requirements as per the Addendum.

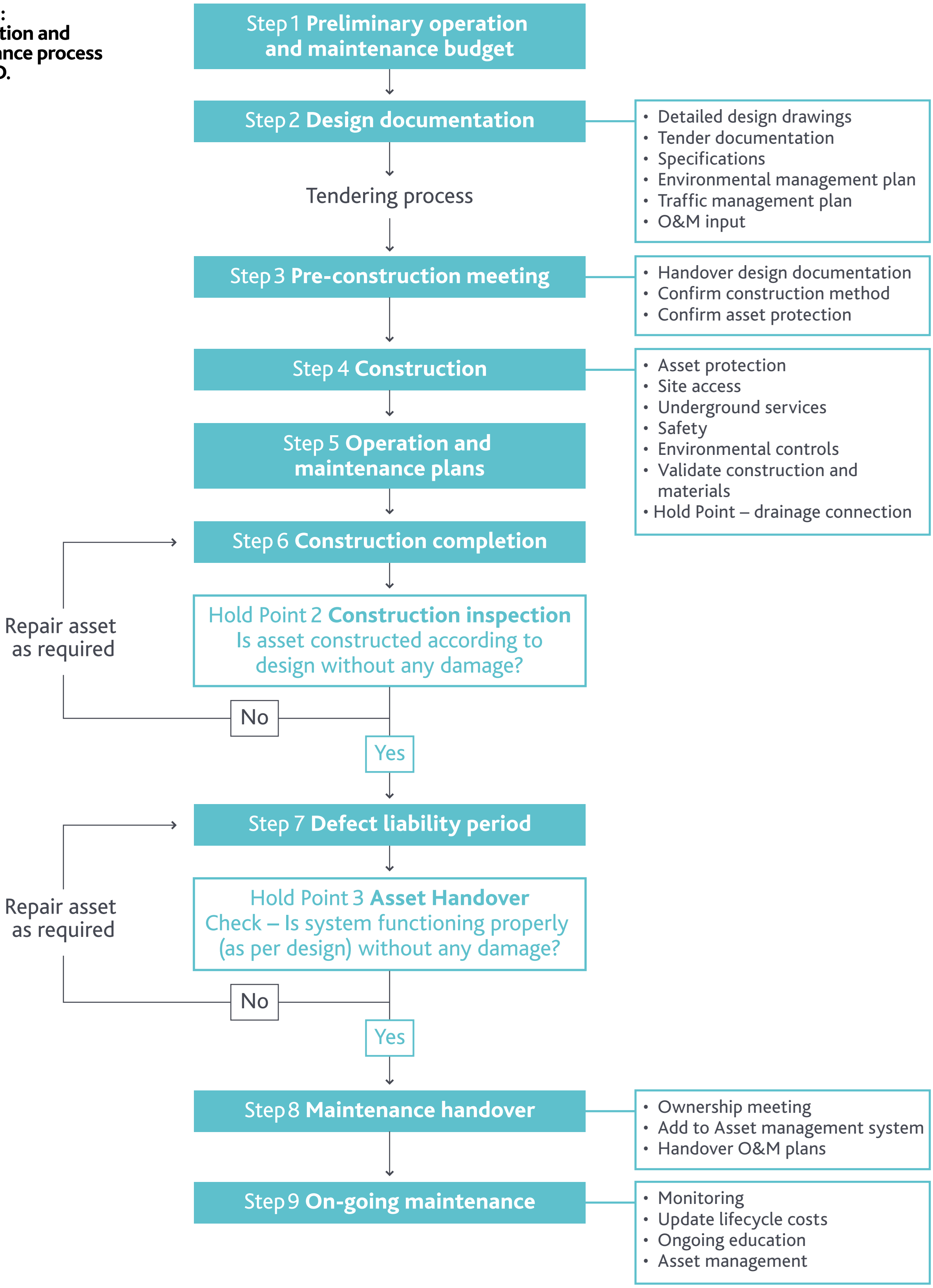
f. The overall development plan must also address the relevant drainage, flood mitigation, space and public safety requirements for the development.

g. For developments within growth areas, detailed designs should also meet the design submission content requirements as outlined in Section 6.2 of the Engineering Design and Construction Manual for Subdivisions in Growth Areas (Growth Area Authority, 2011).

3. Construction and maintenance

The construction, operation and maintenance requirements will vary for different WSUD assets. However, there are a number of processes common to all WSUD systems that should be adopted to ensure WSUD assets are constructed and maintained to function properly. Figure 3.1 below shows the typical process for the construction and operation and maintenance phases, with more detail outlined in the sections below.

Figure 3.1: Construction and maintenance process for WSUD.



3.1 Step 1: Preliminary operation and maintenance budget

A preliminary estimate of the operation and maintenance costs should be developed. The preliminary estimate should be used to inform council maintenance budgets. This estimate may be based on:

- previous experience
- case studies
- maintenance team knowledge or data
- information from developers
- information from neighbouring councils
- guidelines (e.g. Maintaining WSUD Elements (EPA, 2008))
- cost estimates developed as part of the Melbourne Water WSUD Life Cycle Costing assessment (scheduled completion 2012)

The preliminary cost estimate should be updated during the construction and design phases as more information (including actual costs) becomes available, and the council maintenance budgets updated accordingly.

3.2 Step 2: Design documentation

Design documentation is to be provided for the construction phase, following approval by council. Design documentation needs to be clear with sufficient information to complete construction. In some cases an iterative process may be required between the construction and design team, for example to clarify any design issues or uncertainties, or if further information is required. Design documentation may include:

- detailed design drawings –to include sufficient information for construction to be completed and easy to understand. Detail design drawings need to consider construction and maintenance issues, such as site access, locations of underground services and safety considerations.
- tender documents and specifications – to be developed for both the civil works and the landscape works prior to the tendering process. Documents should consider timing of works, hold points for the remaining phases, material supply and material availability. Specifications may include both technical specifications (e.g. filter media), or general site establishment specifications.
- Site Environmental Management Plan (SEMP) – to be completed by the construction company and submitted prior to construction. Refer to the Clause 56.08 Planning Practice Note (DSE, 2006) for further guidance on the contents of an SEMP. The SEMP should at least:
  - identify areas of stockpiling
  - specify how creeks, drains, pits, adjoining properties, streets and WSUD treatment systems will be protected during construction from inappropriately located stockpiled material, sediment laden runoff, tracking of soil from the site and damage from vehicles. Refer to Section 3.4.1.

For temporary asset protection measures refer to Section 3.4.1 and the EPA publications Doing it Right on Subdivisions, Temporary Environmental Protection Measures for Subdivision Construction Sites (2004) and Keeping our Stormwater Clean – A builders guide (2007).

- Traffic Management Plan (if required) – may be required where works will impact traffic, or the site is located within or near a road reserve. Requirements for a Traffic Management Plan for a particular project will be determined by council.

Following the development of the design documentation there is a hold point. At this stage the design documentation must be submitted to council for approval prior to construction (as part of the design phase – see Section 2.6). If the documents are not approved, discuss any issues with council.

3.3 Step 3: Pre-construction meeting

A pre-construction meeting is to be held prior to commencing construction. The purpose of this meeting is to handover design documentation (refer to Section 3.2) and to confirm the construction method.
The pre-construction meeting should also be used to discuss any site specific issues, such as:

- Safety considerations
- Measures to limit public access
- Locations of underground services
- Asset protection measures – refer to Section 3.4.1
- Construction hold points, materials validation and required signoffs – refer to Section 3.4.2
- Environmental controls – in accordance with Site Environmental Management Plan (refer to Section 3.2)
- Traffic controls (if applicable) – in accordance with Traffic Management Plan (refer to Section 3.2)

The pre-construction meeting should include representatives from the design and construction teams. This meeting can save considerable time during the construction phase and can help prevent issues arising through construction.

For subdivision developments within the growth areas, the pre-construction or pre-commencement meeting should also comply with Chapter 18 of the Engineering Design and Construction Manual for Subdivisions in Growth Areas (Growth Area Authority, 2011).

3.4 Step 4: Construction

Construction of WSUD assets is to be undertaken in accordance with the detailed design drawings and other design documentation. All design documentation needs to be approved by council and handed over prior to this stage (refer to Sections 3.2 and 3.3 for more information).

The construction should occur in accordance with the construction method, and other site specific requirements (e.g. asset protection, safety measures, limiting public access, environmental controls, hold points etc.) agreed in the pre-construction meeting (refer to Section 3.3).

This section describes options for asset protection, and outlines required hold points and validation measures throughout the construction phase. For further information on the construction considerations for the specific WSUD asset types refer to Appendix A and B and the WSUD Engineering Procedures (Melbourne Water, 2005). For construction inspection checklists during construction refer to Table 3.1.

Table 3.1 Construction inspection checklists for WSUD assets

WSUD asset	Reference
Sedimentation basin	Construction Inspection Checklist – During Construction, Section 4.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
Bioretention swale	Construction Inspection Checklist – During Construction, Section 5.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
Bioretention basin	Construction Inspection Checklist – During Construction, Section 6.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
Sand filters	Construction Inspection Checklist – During Construction, Section 7.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
Wetlands	Construction Inspection Checklist – During Construction, Section 8.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
Constructed wetlands	Construction Inspection Checklist – During Construction, Section 9.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
Ponds and lakes	Construction Inspection Checklist – During Construction, Section 10.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
Infiltration measures	Construction Inspection Checklist – During Construction, Section 11.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
GPTs	Construction Inspection Checklist – During Construction, Refer to manufacturer specifications

3.4.1 Asset protection

The existing environment (including vegetation, waterways, existing infrastructure etc.) and the WSUD assets need to be protected during construction. Asset protection measures are to be confirmed at the pre-construction meeting (refer to Section 3.3).

The primary form of asset protection should be through building controls, for example to prevent sediment from washing off site in stormwater runoff. At source building controls may include:

- wheel washes
- gravel crossover from the construction area to site boundary
- rubbish bins on site to contain litter
- reduce waste
- maintain existing vegetation
- silt fences or straw bales to contain stockpiles
- locating stockpiles away from low point on site
- catch drains

For more information on building controls refer to Keeping Our Stormwater Clean – A Builder's Guide (EPA and Melbourne Water, 2007), which is available on the Clearwater website (www.clearwater.asn.au).

Asset protection measures may also be required to protect the surrounding environment, drainage infrastructure or WSUD assets during the construction phase. These measures may include:

- silt fences
- straw bales
- fences/bollards around WSUD treatment systems
- sacrificial layers in treatment systems
- temporary planting during construction for sediment control (e.g. with turf), which can then be removed and the area planted out with long term vegetation
- temporary sedimentation basins
- temporary diversions of stormwater around WSUD asset during construction

In some cases a multi-phase approach may be required for the construction of WSUD assets. For example, in a development that is being constructed over a number of years the design and construction of WSUD assets may also need to be staged to match the overall development. Consideration of asset protection and ensuring the design requirements are achieved with each construction phase (e.g. enough runoff is provided for raingardens), is important in multi-phase developments.

3.4.2 Validate construction and materials

There are several hold points through the construction phase when validation of the construction and/or the materials being used should occur. For general checklists during the construction phase refer to Table 3.1. Some of the construction phase checks will be common to all WSUD assets, for example:

- Maintenance access provided
- Vegetation – it may be useful to record the type, extent and densities of vegetation planted during the construction phase (e.g. by photograph) to compare to at the end of the Defects Liability Period.
- Provision for high flows during the construction phase (e.g. high flow by-pass, erosion control measures, etc.) – these should be checked at the beginning of the construction phase and after high rainfall events throughout construction.
- Drainage connection – ensure correct connection to existing drainage lines.

Other hold points will vary for the different WSUD asset types, as outlined in Table 3.2. Photographs of the asset or signoff by council may be required at the various hold points, and the council requirements for this should be discussed at the pre-construction meeting.

Table 3.2 Construction hold points and materials validation

WSUD asset type	Hold point & validation	Reference information
Bioretention basin and bioretention swales (raingardens)	1. **Liner** – check liner is installed properly (if clay liner – check compaction, if geotextile – ensure liner is installed properly without any damage).	1. Refer to design drawings
	2. **Perforated/slotted pipes** – check perforated pipes are installed as per design plans, and check inspection openings (if applicable).	2. Refer to design drawings Section 6.4.2 WSUD Engineering Procedures (Melbourne Water, 2005)
	3. **Filter media** – check the hydraulic conductivity meets design requirements (certified by the supplier otherwise in-situ testing should be conducted). Note avoid traffic access on filter media. Check level of filter media and ensure extended detention depth is as specified in the design drawings.	3. Appendix E (In situ monitoring of hydraulic conductivity), Adoption Guidelines for Stormwater Biofiltration Systems (FAWB, 2009) Section 5.4.2 WSUD Engineering Procedures (Melbourne Water, 2005)
	4. **Inlet & outlet structures** – check construction of structures in accordance with design plans. Check for erosion or scour after major rainfall events. If road side inlet, check width of flow in the gutter to ensure traffic is not impacted.	4. Section 5.4.2 and 6.3.2 WSUD Engineering Procedures (Melbourne Water, 2005)
Constructed wetlands	1. **Base layer** – ensure smooth transitions between different depth zones, or benches, and batter slopes. Check liner (if applicable) in accordance with design plans.	1. Section 9.4.2 WSUD Engineering Procedures (Melbourne Water, 2005) Design drawings
	2. **Batter slopes** – as per design plans and in accordance with safety requirements	2. Section 10.3.2.3 WSUD Engineering Procedures (Melbourne Water, 2005) Figure 4 and Section 6 Constructed Wetlands Guidelines
	3. **Inlet & outlet structures** – check construction of structures, including invert levels and erosion protection measures, and access.	3. Section 10.3.3 and 10.4.2 WSUD Engineering Procedures (Melbourne Water, 2005)
GPTs	1. **GPT installation** – as per manufacturers specifications (note manufacturer guarantee for system should also be obtained)	1. Manufacturers specifications
	2. **Back fill** – as per design drawings and to match finished surface level	2. Design drawings
	3. **Hardstand** – as per design drawings and manufacturer requirements	3. Design drawings
Infiltration measures	1. **Infiltration media** – as per design. Note avoid traffic access on media.	1. Design drawings Section 11.4.2 WSUD Engineering Procedures (Melbourne Water, 2005)
	2. **Inspection wells** – as per design	2. Design drawings Section 11.4.2 WSUD Engineering Procedures (Melbourne Water, 2005)
	3. **Pre-treatment measures and/or detention storage** – as per design	3. Design drawings Section 11.4.2 WSUD Engineering Procedures (Melbourne Water, 2005)
Ponds and lakes	1. **Depths** – as per design plans	1. Design drawings
	2. **Batter slopes** – as per design plans and in accordance with safety requirements	2. Section 4.3.3 WSUD Engineering Procedures (Melbourne Water, 2005)
	3. **Inlet & outlet structures** – check construction of structures, including invert levels and erosion protection measures	3. Section 4.4.2 WSUD Engineering Procedures (Melbourne Water, 2005)
Sand filters	1. **Impervious liner** – check installation as per design plans	1. Section 7.3.2.2 WSUD Engineering Procedures (Melbourne Water, 2005)
	2. **Slotted collection pipes** – check slotted pipes are installed as per design plans, and check inspection openings (if applicable).	2. Refer to design drawings Section 7.3.3 and 7.4.2 WSUD Engineering Procedures (Melbourne Water, 2005)
	3. **Sand media** – check against sand media specifications. Note avoid traffic access on sand media.	3. Section 7.3.2.2 and 7.4.3 WSUD Engineering Procedures (Melbourne Water, 2005)
Sedimentation basin	1. **Base layer** – check maintenance base layer (e.g. rock or sand layer) has been installed as per design.	1. Section 4.4.2 WSUD Engineering Procedures (Melbourne Water, 2005)
	2. **Batter slopes** – as per design plans and in accordance with safety requirements	2. Section 4.3.3 WSUD Engineering Procedures (Melbourne Water, 2005)
	3. **Inlet & outlet structures** – check construction of structures, including invert levels and erosion protection measures	3. Section 4.4.2 WSUD Engineering Procedures (Melbourne Water, 2005)
Swale & buffer strips	1. **Inlet structure** – check construction of structure, including invert levels and erosion protection measures	1. Section 8.4.2 WSUD Engineering Procedures (Melbourne Water, 2005)

3.5 Step 5: Operation and maintenance plans

Operation and maintenance plans should be developed during the construction phase, and approved by council prior to handover of WSUD assets. The plans should take into account the maintenance considerations from the earlier stages, such as those noted in the design phase. The plans should also consider any issues or changes required as a result of the construction phase.

The operation and maintenance plans may be a generic council plan for a particular WSUD asset type, or one specific to the project. The plans should clearly outline the roles and responsibilities for the WSUD asset. Further detail on the operation and maintenance plans is outlined below. For examples of operations and maintenance plans refer to the Clearwater website (www.clearwater.asn.au).

3.5.1 Operation plans

The requirement for an operation plan should be determined on a case by case basis, but is typically required for WSUD systems that are difficult to operate (e.g. stormwater harvesting schemes with complex control systems or wetlands that include penstocks to control water level). Operation plans include the details and requirements for the operational components of a WSUD asset, and may include the following type of information:

- photographs and locations of relevant components (including clearly marking components e.g. with a bollard or sign)
- make and manufacturer
- purpose of each component
- operational requirements
- expected frequency of operation.

For an example operation plan refer to Appendix 6 of the Constructed Wetland Guidelines (Melbourne Water, 2010).

3.5.2 Maintenance plans

Maintenance plans should be developed for all WSUD assets. The plans need to clearly identify the maintenance requirements and state who is responsible for the on-going maintenance. All maintenance plans should be approved by council prior to commencement of the maintenance period.

Maintenance plans should include:

- a description or plan showing the location of assets that require maintenance. Marker locations may also be required for pits or other infrastructure that cannot be easily found (e.g. once vegetation is established), but requires maintenance
- required inspections and frequencies
- the required maintenance tasks, for example:
  - cleaning the asset, removal and safe legal disposal (in accordance with EPA standards) of litter, debris, silt and sediment
  - removal and replacement of the filter media
  - edge control and erosion management
  - vegetation management, including: weed removal, mowing, tree pruning and replacement of plants and mulch
  - maintaining pumps, controls and wiring
  - on-going monitoring and reporting.
- maintenance procedure and any specific equipment that may be required
- materials list and supplier details
- manufacturers documents, warranties and schedules
- plant lists
- monitoring method
- maintenance access (note: frequency of access, timing (e.g. if all weather access is required), safety requirements, environmental impacts and aesthetics should all be considered in regards to maintenance access)
- any site specific requirements (e.g. locks on systems to prevent vandalism)
- an estimate of the on-going maintenance costs to be included in budgets.

For further information on required maintenance activities and maintenance plans refer to Appendix A and the WSUD Engineering Procedures (Melbourne Water, 2005). For further information on vegetation management refer to Maintaining Water Sensitive Urban Design Elements (EPA, 2008) and WSUD Engineering Procedures (Melbourne Water, 2005).

3.6 Step 6: Construction completion

Following the construction completion (in accordance with the design plans) a construction inspection should occur (see Section 3.3.1). After approval by council at the construction inspection meeting the Defect Liability Period begins (refer to Section 3.7), and following that the maintenance handover occurs (refer to Section 3.8). This section of the document outlines the requirements for the construction inspection.

3.6.1 Construction inspection

A construction inspection is required at the end of construction. The construction inspection should involve representatives from the construction team as well as from council (e.g. the Superintendent). Inspections and sign-offs will be required at this stage, to confirm approval by council prior to the starting Defects Liability Period.

The Construction Inspection Checklists (Final Inspection) in the WSUD Engineering Procedures (Melbourne Water, 2005), can be used as a guide for typical inspection requirements for the various WSUD asset types (see Table 3.3.). Note that additional items, above those listed in the checklists, may also need to be checked as per the design drawings.

Table 3.3 Construction inspection checklists for WSUD assets

WSUD asset	Reference
Sedimentation basin	Construction Inspection Checklist – Final Inspection, Section 4.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
Bioretention swale	Construction Inspection Checklist – Final Inspection, Section 5.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
Bioretention basin	Construction Inspection Checklist – Final Inspection, Section 6.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
Sand filters	Construction Inspection Checklist – Final Inspection, Section 7.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
Wetlands	Construction Inspection Checklist – Final Inspection, Section 8.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
Constructed wetlands	Construction Inspection Checklist – Final Inspection, Section 9.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
Ponds and lakes	Construction Inspection Checklist – Final Inspection, Section 10.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
Infiltration measures	Construction Inspection Checklist – Final Inspection, Section 11.4.3 of WSUD Engineering Procedures (Melbourne Water, 2005)
GPTs	Refer to manufacturer specifications

3.7 Step 7: Defect liability period

The defect liability period begins after construction completion and approval by council at the final construction inspection (refer to Section 3.3.1).

Agreement between council and the developer should be made for the following defects liability periods (to commence after the final construction inspections of the WSUD treatments – refer to Section 3.3.1):

- Civil assets (e.g. pipes and concrete structures) – 12 months
- Landscape vegetation/plantings and filter media – 24 months

The defect liability period should also be used to validate the operation and maintenance plans and budgets. If it is found during the defects liability period that changes to the operation and maintenance plans or budgets are required, these should be reported back to council.

3.8 Step 8: Maintenance handover

The handover process from the construction phase to the maintenance phase typically involves an ownership meeting, handover of the operation and maintenance plans, and inspection and handover of the WSUD asset. It is important that all relevant parties, including council representatives and external stakeholders, are involved in this process, so everyone has a clear understanding of the roles and responsibilities for the on-going maintenance of the WSUD asset.

3.8.1 Ownership meeting

A meeting should be held prior to handover of the WSUD asset to clearly define the ownership and roles and responsibilities for the WSUD system. This meeting should involve the relevant representatives from within council (e.g. project manager, design or engineering team, maintenance team, parks and gardens team etc.) as well as the relevant external stakeholders (e.g. maintenance contractors, Owners Corporation). This meeting should be used to:

- define the ownership of the asset
- determine who is responsible for maintaining the WSUD asset, or if there will be multiple groups involved (note if multiple groups are involved clearly define who is responsible for each component of the WSUD asset)
- determine if training is required for the maintenance team (internal or external).

The ownership meeting can help save time in the later stages of handover and on-going maintenance, and can help to ensure that the roles and responsibilities are clearly defined prior to handover.

3.8.2 Asset management

Asset management systems are used by council to register, track and manage assets, including WSUD assets. They typically combine geographic information and asset management information. Asset management databases can be used to inform capital works programs, forecast life cycle and maintenance budgets and for maintenance contracts and programs. Council therefore require all relevant WSUD information to be provided in the appropriate format for the inclusion in the asset management system during the handover process. Information required may include:

- 'as constructed' drawings and information (showing details of all WSUD assets such as invert levels, locations etc.)
- operation and maintenance plans (including roles & responsibilities)
- estimated life cycle and maintenance costs
- actual maintenance tasks completed and costs

Refer to the Melbourne Water Asset Inventory project (currently being developed), for information on WSUD asset management systems. Refer to the Council Addendum for further information on the specific asset management database requirements for each council, and the information and format required during the handover process.

3.8.3 Asset handover

Handover of the WSUD assets should occur following the defect liability period (refer to Section 3.7) and the development of the operation and maintenance plans (refer to section 3.5). A final site inspection should occur prior to handover, and the relevant WSUD asset handover checklist completed at this time (refer to Table 3.4 below). The handover inspection is to ensure that the WSUD asset has been constructed as per the design and that the system has been functioning correctly through the defects liability period. The handover inspection should also be used to ensure the maintenance team (internal or external) has received all the relevant maintenance information and documentation. The asset handover inspection meeting should therefore involve all relevant council and external stakeholders (e.g. maintenance team, project manager, developer, construction team representative, Owners Corporation, council representative).

Table 3.4 Asset handover checklists for WSUD assets

WSUD asset	Asset Handover Checklist (Melbourne Water, 2005)
Sedimentation basin	Section 4.4.4 of WSUD Engineering Procedures
Bioretention swale	Section 5.4.4 of WSUD Engineering Procedures
Bioretention basin	Section 6.4.4 of WSUD Engineering Procedures
Sand filters	Section 7.4.4 of WSUD Engineering Procedures
Swale & buffer strips	Section 8.4.4 of WSUD Engineering Procedures
Constructed wetlands	Section 9.4.4 of WSUD Engineering Procedures
Ponds and lakes	Section 10.4.4 of WSUD Engineering Procedures
Infiltration measures	Section 11.4.4 of WSUD Engineering Procedures
GPTs	Refer to manufacturer specifications

3.9 Step 9: On-going maintenance

The on-going maintenance tasks will vary for the different WSUD systems, but should be based on the operations and maintenance plans developed, as outlined in Section 3.5 above. The WSUD Engineering Procedures (Melbourne Water, 2005), Maintaining Water Sensitive Urban Design Elements (EPA, 2008), and Appendix A provide further information on typical maintenance tasks for the various WSUD asset types. Table 3.5 below also provides reference checklists for indicative maintenance activities. Refer also to the maintenance guidelines currently being developed by Melbourne Water.

Table 3.5 Maintenance checklists for WSUD assets

WSUD asset	Maintenance Checklist (Melbourne Water, 2005)
Sedimentation basin	Section 4.5 of WSUD Engineering Procedures
Bioretention swale	Section 5.5 of WSUD Engineering Procedures Section 4.3 and Appendix D of Stormwater Biofiltration Systems Adoption Guidelines (FAWB, 2009)
Bioretention basin	Section 6.5 of WSUD Engineering Procedures Section 4.3 and Appendix D of Stormwater Biofiltration Systems Adoption Guidelines (FAWB, 2009)
Sand filters	Section 7.5 of WSUD Engineering Procedures
Swale & buffer strips	Section 8.5 of WSUD Engineering Procedures
Constructed wetlands	Section 9.5 of WSUD Engineering Procedures
Ponds and lakes	Section 10.5 of WSUD Engineering Procedures
Infiltration measures	Section 11.5 of WSUD Engineering Procedures
GPTs	Refer to manufacturer specifications

The following sections outline other activities, including monitoring, updating lifecycle costs and education, which should occur as part of the on-going maintenance phase.

3.9.1 Monitoring

On-going monitoring of WSUD systems is recommended to check the functionality of WSUD assets. A monitoring regime needs to be developed to effectively monitor the system, to ensure monitoring results accurately represent the functionality of the system. Regimes should include regular monitoring of the WSUD systems, rather than irregular spot samples that won't always accurately represent the system functionality.

The monitoring method should be outlined in the maintenance plan and should clearly state the required monitoring frequency. Monitoring results should be reported back to council. These results should be considered in future WSUD design and for determining on-going maintenance activities, and can also be used to inform future maintenance budgets.

3.9.2 Lifecycle costs

Lifecycle and maintenance costs should be determined for each WSUD system and included in the maintenance budgets. Replacement and renewal costs should also be included in the lifecycle estimates. Costs can be estimated based on past experience, case studies, maintenance team knowledge or data, information from private developers, or information from neighbouring councils. Guidelines can also be used for an initial estimate, for example the costs outlined in Maintaining WSUD Elements (EPA, 2008), or those that will be documented as part of the Melbourne Water WSUD Lifecycle Costing assessment.

Lifecycle and maintenance costing should be an iterative process and actual costs should be fed back into the initial estimates, to more accurately assess costs and to inform future budgets.

3.9.3 Education

Education is a crucial element for the on-going success of WSUD projects. Education can include both learning and training for those involved in the different phases of WSUD projects (e.g. council, developers, maintenance contractors), as well as community education. Education for those involved in WSUD projects is important to ensure WSUD systems are planned, designed, constructed and maintained properly. Education opportunities may include:

- WSUD working groups across departments within council – to discuss ideas, issues and lessons learnt, and to offer guidance on WSUD projects within council
- Informal discussions, meetings or working groups between neighbouring councils
- Clearwater's education programs – refer to section below

Community education is important to raise awareness and promote the benefits of WSUD systems. Community education opportunities may include:

- signage
- community meetings
- newsletters
- 'friends of' groups
- opening events or education events for key WSUD projects

Refer to the Council Addendum for any council specific requirements for community education.

Clearwater education programs

Clearwater is a leading capacity building program in sustainable water management that plays a critical role in shaping a water sensitive future. They offer a number of capacity building initiatives to help build the knowledge and skills of practitioners who plan, design and manage WSUD.

Clearwater's education program offers:

- technical training
- guided technical tours
- knowledge sharing and tailored events
- online information and resource library
- online C56 Tool
- guidance and support

For more information on training and education opportunities refer to the Clearwater website: www.clearwater.asn.au

Living Rivers program

The Living Rivers Stormwater Program provides support to enable council to set and achieve its objectives for sustainable water management. Living Rivers works in partnership with 38 local governments across Melbourne Water's operating area with key aims to:

- improve stormwater quality runoff for improved waterway and bay health
- create green open spaces and enhance urban landscapes
- mitigate urban heat island impacts
- influence site scale flood mitigation
- contribute to potable water substitution

Through funding contributions, expertise and guidance, Living Rivers provides councils with the support they need to:

- Build understanding, skills and organisational commitment for sustainable stormwater quality management.
- Develop relationships across local government by supporting Water Sensitive Urban Design (WSUD) networks.
- Develop strategies and targets which enhance a council's direction and commitment to sustainable stormwater management.
- Design and implement on-ground works that provide opportunities for innovation and learning across local government.
- Train staff to address knowledge gaps in council

Refer to the Melbourne Water website for further information on the Living Rivers Program.

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5. Acknowledgements

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Yarra Ranges Shire Council – Vjeko Matic

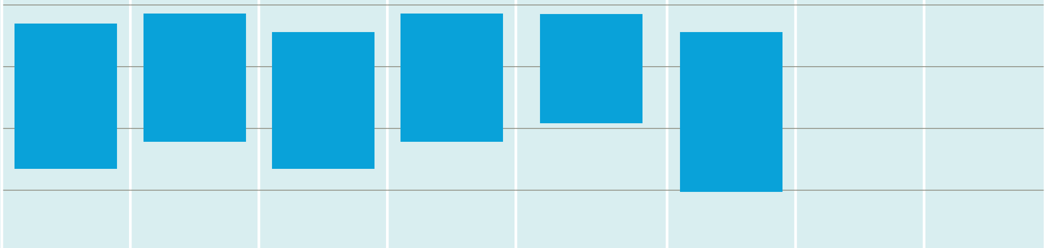
Appendix A

WSUD Treatment Function, Applicability and Maintenance Considerations

The functionality, applicability and maintenance requirements of each WSUD treatment type should be carefully considered when preparing and approving designs. The following tables outline the functionality, applicability and maintenance considerations for various WSUD treatment systems. Indicative costs for the different treatment systems have also been included. These are intended to be a comparative guide only. These tables are intended to be used in conjunction with the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005).

Table A-1: Summary of treatment function, applicability and cost:
Adapted from: Victorian Stormwater Committee (1999); Wong (2006); EPA (2008)

✓ High applicability ✓ Medium applicability ✓ Low applicability	Bioretention swales	Bioretention basins /raingardens	Vegetated swales/ buffer strips	Sand filters	Sedimentation basins	Constructed wetlands	Ponds and shallow lakes	Rainwater tanks
FUNCTION:								
Water quality treatment	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓
Flow attenuation	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓
Stormwater conveyance	✓✓✓	✓	✓✓✓	✓	✓	✓	✓	✓
Particle size removal								
Coarse-Medium particles 5000 µm-125 µm								
Fine particulates 125 µm-10 µm								
Very fine/Colloidal particulates 10 µm-0.45 µm								
Dissolved particles <0.45 µm								
Additional function		Landscape value	Aesthetic appeal Habitat values		Landscape value	Habitat, visual & recreation amenity	Habitat, visual & recreation amenity	Stormwater re-use
APPLICABILITY:	Median strip/ verge	Streets	Median strip/ verge/parks	Streets/many	Pre-treatment to wetland	Parks/vacant land	Aesthetic/ post wetland	On-property
Area requirement	Larger areas (with limited public access)	Limited space	Larger areas (with limited public access)	Limited space	Large areas	Large areas	Large areas	Limited space
Slope considerations and approach to site constraints	Gentle slopes (< 5%). Where slopes exceed 5%, flow spreaders or check dams may be required.	Flat land. Where land is sloped terraces can be used.	Gentle slopes (< 5%). Where slopes exceed 5%, flow spreaders or check dams may be required.	Suitable for steeper slopes	Flat land	Flat land	Suitable for steep land	Suitable on most sites
Level of flow control	Conveyance	Discharge	Conveyance	Discharge	Discharge	Discharge	Discharge	Source
INDICATIVE COSTS:								
Installation costs	Moderate	Moderate	Low	Low/ Moderate	High	High	High	Low
Maintenance costs	Moderate	Moderate	Moderate/ High	Moderate	Moderate/High	Moderate	Moderate	Low



Indicative costs: Indicative costs for comparison purposes only

Installation costs: Based on the treatment's total installed cost per hectare of catchment. Broad approximations are as follows:
- High: Greater than $1500 per hectare of catchment;
- Moderate: Between $500 and $1500 per hectare of catchment; and
- Low: Less than $500 per hectare of catchment

Maintenance costs: Based on the cost per hectare per annum for each treatment type. Broad estimates are as follows:
- High: Greater than $250 per hectare of catchment per annum;
- Moderate: Between $100 and $250 per hectare of catchment per annum; and
- Low: Less than $100 per hectare of catchment per annum.

Table A-2: Indicative ongoing maintenance considerations:
Adapted from: Melbourne Water 2005, WSUD Engineering Procedures; EPA 2008, Maintaining WSUD Elements

	Bioretention swales	Bioretention basins /raingardens	Vegetated swales/ buffer strips	Sand filters	Sedimentation basins	Constructed wetlands	Ponds and shallow lakes	Rainwater tanks
Debris removal	On-going/ as required	On-going/ as required	On-going/ as required	On-going/ as required	On-going/ as required	On-going/ as required	On-going/ as required	
Check inlet erosion protection	Routine inspections following significant storm events*	Routine inspections following significant storm events*	Routine inspections following significant storm events*		After significant rainfall events immediately following installation.	After significant rainfall events immediately following installation.	After significant rainfall events immediately following installation.	
Removal of accumulated sediments	Monitor & remove accumulation near bioretention inlet particularly during construction activities.	Monitor & remove accumulation near inlet particularly during construction activities. Monitor long term for filter media effectiveness.	On-going/ as required*	After significant rainfall events immediately following installation. 6 monthly after this*.	When basin is more than half full of accumulated sediment (typically every 5 years).	As required during first two years if poor site erosion management during construction, but sedimentation basin should prevent.	As required during first two years if poor site erosion management during construction, but sedimentation basin should prevent.	
Vegetation maintenance – Removal of noxious plants – Replacement of dead plants – Fertilising plants	Intensive during plant establishment (2 years) then as needed. Can be coordinated with other garden maintenance carried out by Council.	Intensive during plant establishment (2 years) then as needed. Can be coordinated with other garden maintenance carried out by Council.	Intensive during plant establishment (2 years) then as needed. Can be coordinated with other garden maintenance carried out by Council.			Intensive during plant establishment (2 years) then as needed. Can be coordinated with other garden maintenance carried out by Council.	Suitable for steep land.	
Inspection of sedimentation chamber and filter/sand media	Every year check filter media composition/ infiltration rate.	Every year check filter media composition/ infiltration rate.		Every 3-6 months check sed chamber & sand surface.				
Maintenance of artificial turnover system (if installed)							Specific to design	
Roof/gutter maintenance								6 months
First flush device								3-6 months
Inlet/overflow screens								6 months
Sludge accumulation								2-3 years
Pump system								As required

* Note that the frequency of many of these activities will depend on the nature of the catchment, ie. more often during construction phase.

Appendix B

WSUD Treatment Measures – Design and Maintenance Considerations

WSUD Treatment Measures

This section provides information on some of the design and maintenance considerations. However, this section in no way replaces the existing WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005) and other documents referred to in the respective sections, which provide detailed design and maintenance guidance for WSUD treatment measures.

This section provides a summary of key WSUD treatment measures that are currently used for best practice urban stormwater management around Melbourne and surrounding Shire Councils. A combination of measures is often used as a 'treatment train', to effectively manage stormwater and achieve desired pollutant reductions. Table A-1 provides a guide to the function, applicability and cost of each of the treatment types.

It is recommended that developers refer to the Addendum for a list of Council-approved treatment types before proceeding.

Primary treatment WSUD measures such as litter and gross pollutant traps have not been included here, as there are numerous manufactured devices and technical design manuals available. Ponds and lakes are included, because they are considered to provide a stormwater management function when installed as part of a treatment train, although they are not considered as a stand-alone WSUD treatment measure.

The hydraulic conductivity of filter media is critical to the effectiveness of bioretention basins and rain gardens. Note that in the first year compaction and silting can result in reduced hydraulic conductivity of the filter media. Research suggests that it can be reduced by up to half in the first year (FAWB, 2009). It is recommended that the size or ponding depth of rain gardens and bioretention basins should be maximised to compensate for this variability by sizing the system with an ultimate hydraulic conductivity of 50% of the prescribed hydraulic conductivity. Where this is not possible, filter media should be used with a higher hydraulic conductivity (approximately twice) than that used for modelling the system in MUSIC. Refer to FAWB (2009) for more detail.

Bioretention Swales

Bioretention swales (or bioretention trenches) are bioretention systems that are located within the base of a swale. They provide both a conveyance function for stormwater and treatment through filtration, extended detention and some biological uptake. The swale facilitates the removal of coarse to medium sized sediments, while the bioretention system is particularly efficient at removing nitrogen and other soluble or fine particulate contaminants.

Bioretention swales are often well suited to highly urbanised areas such as commercial precincts or car parks as they can be easily incorporated into landscaped areas without impacting on development opportunities. They can provide attractive landscape features in an urban development and are commonly located in the median strip of divided roads. Swales can often be used as an alternative to a conventional pipe system, resulting in construction cost reductions.

The design of bioretention swales should be in accordance with guidelines set out in Chapter 5 (Section 5.3) of the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005).

Design and Maintenance Considerations

- Bioretention swales are sensitive to materials that may clog the filter medium and may suffer vegetation damage through traffic and washdown wastes which should be controlled. Protection during construction phase is critical.
- Filter media should be hydraulic conductivity tested before construction and before handover.

Refer to the WSUD Engineering Procedures: Stormwater Guide (2005) for the filter media specification.

- Typically bioretention swales are best suited to slopes of 1 to 4% or where velocities during major flood events do not exceed 2 m/s. Where excessive grades are identified as a constraint, check dams may be required to reduce flow velocities.
- Water ponding at entry points to the swale should not occur for longer than 1 hour after the cessation of rainfall as prescribed in Clause 56.07-4 of the VPP.
- The gradient of swale batter slopes are dependant on Council regulations and will relate to traffic access and driveway crossings. For maintenance requirements, grassed swales requiring mowing must not have side slopes exceeding 1 in 4.
- A velocity-depth check should be undertaken to ensure public safety (refer to Section 5.3.4.1 of the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005)).
- Consultation with landscape architects is recommended when specifying vegetation to ensure the treatment of the system compliments the landscape of the area. Refer to the plant species list in the Addendum or the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005) for suitable vegetation options.

Bioretention basins/Rain gardens

Bioretention basins and rain gardens treat stormwater by passing runoff through prescribed filter media (commonly vegetated) that provides treatment through fine filtration, extended detention and some biological uptake.

A wide range of vegetation can be used within a bioretention basin allowing them to be readily integrated into the landscape of an area.

Bioretention basins are suitable at a range of scales and shapes and, hence, provide a flexible treatment measure. They can be positioned at regular intervals along streets to treat runoff prior to entry into an underground drainage system or be located at drainage system outfalls to provide treatment for larger areas. Bioretention systems are often more effective in removing Nitrogen than conventional wetlands and can therefore be a practical alternative where land for a treatment system is limited.

Design considerations for bioretention basins are detailed in Section 6.3 of the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005) and should be consulted.

Design and Maintenance Considerations

- Bioretention basins are sensitive to materials that may clog the filter medium and may suffer vegetation damage through traffic and washdown wastes which should be controlled. Protection during construction phase is critical.
- Filter media should be hydraulic conductivity tested before construction and before handover. Refer to the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005) for the filter media specification.
- The width of water ponding at entry points to the basin should not occur for longer than 1 hour after the cessation of rainfall as prescribed in Clause 56.07-4 of the VPP.
- Soil testing to determine the expected hydraulic conductivity should be undertaken where bioretention systems are installed near to significant structures, to minimise any leakage from the system. If surrounding soils are sensitive to seepage from the bioretention basin, such as in sandy soils, or where the filter is located near a permanent structure, an impervious liner, such as geofabrics, can be used to contain all water within the basin. Lining measures should not create subsurface barriers to shallow groundwater movements.
- Consultation with landscape architects when selecting vegetation is recommended. Refer to the plant species list in the Addendum or the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005) for suitable vegetation options.
- The use of biofilters should be avoided where there is a permanent base flow, which prevents the filter medium from drying out in between storm events.

Vegetated swales/Buffer strips

Vegetated swales convey stormwater and provide removal of coarse and medium sediment.

They are commonly used in conjunction with areas of vegetation through which runoff passes, known as buffer strips. Vegetated swales are similar to bioretention swales, but are less effective in removing nitrogen from the stormwater, as they do not feature the filtering component and convey water on the surface only.

Vegetated swales can provide an aesthetically pleasing landscape feature and are relatively inexpensive to construct and maintain. They can be used median strips, verges, car park runoff areas, parks and recreation areas.

The design specifications for swales and buffer strips can be found in Chapter 8 (Section 8.3) of the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005). Design techniques to ensure swales are sized appropriately should be consulted (refer to Appendix C of BPEMG (Victorian Stormwater Committee, 1999)).

Design and Maintenance Considerations

- The longitudinal slope of a swale is the most important consideration. Swales are most efficient with slopes of 1% to 4%. Lower than this, swales can become waterlogged and/or have stagnant pooling, while steeper slopes may have high flow velocities (with potential erosion and vegetation damage risks). Check banks (small porous rock walls) may be constructed to distribute flows evenly across the swale if they are identified as the most suitable treatment option in such areas.
- Where swales are publicly accessible, flow depths and velocities must be acceptable from a public risk perspective. Refer to Section 8.3.5.1 of the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005) for standards.
- Traffic and deliveries should be kept off swales as they may damage vegetation and create preferential flow paths that do not offer filtration. Appropriate mitigation measures should be implemented.
- Swale side slopes depend on Council regulations, traffic access and the provision of crossings. Typically 1 in 9 side slopes are suitable. For maintenance requirements, grassed swales requiring mowing must not have side slopes exceeding 1 in 4.

Sand Filters

Sand filters comprise a bed of sand or other media through which runoff is passed. Gross pollutants and coarse to medium sized sediment (125 μm or larger) are retained in a sedimentation chamber before stormwater percolates through the filtration media. The filtrate is then collected by an underdrain system. These systems lack surface vegetation either because they are installed underground or because the filter media does not retain sufficient moisture to support plant growth.

Sand filters can be retrofitted and may therefore also be a suitable WSUD measure in existing developments.

The design of sand filters should follow Section 7.3 of the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005). Construction advice can be obtained from Section 7.4.2 and maintenance requirements from Section 7.5 of this document.

Design and Maintenance Considerations

- Sand filters are particularly useful in areas of limited space where treatment is best achieved underground. They are suited to upstream areas where constructed wetlands are unfeasible.
- Regular maintenance is required to ensure the sand filter media does not become clogged with accumulated sediments.
- Water lost from the sand filter to the surrounding soil may be an issue if they are installed near to significant structures. The surrounding soils should be tested (particularly to determine their hydraulic conductivity). An impervious liner can be used to contain all water in the form of a flexible membrane or concrete casing.
- Large sand filters lacking vegetation may be unattractive.
- Unsuitable for highly disturbed catchments or those with high sediment yields (unless pre-treatment is proposed to protect the system).

Sedimentation Basins

Sedimentation basins serve to remove coarse to medium-sized sediments (typical target size of particles is 125 μm or larger) and are often the first element in a stormwater treatment train. They facilitate the settling of particles through temporary detention and the reduction of flow velocities. A sedimentation basin should always be constructed upstream of a wetland.

Determining the critical size of a sedimentation basin is crucial to:

- Prevent smothering of downstream treatment measures (if the basin is too small)
- Avoid the accumulation of smaller particles of higher contaminant concentrations (in the case of over-sized basins), and
- Prevent the need for frequent desilting.

Details on verifying the required basin size can be found in the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005) sections 4.2 and 4.3.2.

Key design parameters include a consideration of design flows, sediment storage volume, target sediment size, hydraulic structures and vegetation specification. For details refer to Section 4.3 of the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005).

Design and Maintenance Considerations

- The design operation discharge for the basin should be a minimum of 1 year ARI peak discharge.
- A bypass structure should provide for flow bypass of downstream macrophyte zones and wetlands for events up to 100-year ARI event. Weirs are often a suitable method of controlling surface flows so that large events can bypass a treatment, while allowing the required flow to pass through the system.
- Sedimentation basins are often large structures requiring substantial area and are important assets

when constructed upstream of wetlands. When available space is constrained, the sediment basin size should not be compromised if forming part of a treatment train. If the site constrains the total size of the treatment system, the macrophyte zone in the wetland should be reduced accordingly.

- The sedimentation basin should be designed to remove 95% of the particles less than 125 µm in a 1 in 1 year storm event.
- Approach batter slopes should be no steeper than 1:5 Vertical to Horizontal (V:H). All edges should have safety benches of at least 1.5m to 3.0m wide from the edge of the normal top water level.
- Safety benches should have a maximum grade of 1:8 (V:H) for the first 1.5m – 3.0m before changing to a 1:5 (V:H) grade for at least the next 0.5m. Beyond this the grade may be to a maximum of 1:3 (V:H).

It is recommended that an independent safety audit be conducted for each design.

- Refer to the Constructed Wetland Systems: Design Guidelines for Developers (Melbourne Water, 2005) for guidance on hard stand areas, which should be provided adjacent to the inlet zone to allow for the maintenance and cleanout of this zone. The hard stand should be at least 3m wide and designed to be capable of supporting a 20 tonne excavation plant. Multiple areas should be considered where the pond is greater than 7m wide. Adequate space for dewatering must be provided. Access ramps and tracks into ponds cells and to all hard stand areas are required and must be capable of supporting a 20 tonne excavation plant for maintenance.
- Where sedimentation basins double as a landscape element, a weir is recommended as an appropriate discharge control structure. Refer to Section 4.3.4.2 of the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005).
- Accumulated sediment requires regular removal to prevent scouring during storm events. A desirable frequency of basin desilting for permanent facilities is once every five years (or when sediment accumulates to half the basin depth).
- Install a rock layer in base above clay liner to indicate limit of sediment (this reduces the risk of damage to the clay liner during future maintenance activities).
- For sediment basins less than 14m wide, access is to be provided along both edges for maintenance vehicle.
- For sediment basins greater than 14m wide, drawdown of the basin is required with vehicular access available into the base of the facility.

Constructed Wetlands

Constructed wetland systems are shallow, extensively vegetated water bodies that remove pollutants through enhanced sedimentation, fine filtration and pollutant uptake processes. Stormwater runoff is passed slowly through the vegetated areas, which filter sediments and pollutants, and biofilms establish on the plants, which absorb nutrients and other contaminants.Wetlands are well suited to treat large volumes of stormwater runoff and have the advantage of improving local amenity and providing habitat diversity. Key design issues to consider include: verifying the size and configuration for treatment; determining design flows; designing the inlet zone (see sedimentation basins); layout of the macrophyte zone; hydraulic structures; selecting plant species and planting densities and providing maintenance.

Refer to the following documents for detail:

- Section 9.3 of the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005);
- Section 7.9.2 and Appendix G of the Urban Stormwater: Best Practice Environmental Management Guidelines (Victorian Stormwater Committee, 1999); and
- Constructed Wetland Systems: Design Guidelines for Developers (Melbourne Water, 2005).

Design and Maintenance Considerations

- The constructed wetland should treat at least 90% of Mean Annual Runoff (MAR) through the use of a stored event volume above the normal standing water level of the wetland.
- A high flow bypass should be capable of taking flows in excess of design flows (typically a 1 in 1 year event).
- The wetland design must meet safety requirements and implement reasonable safety measures. This includes fencing, safety batters, signage and benching. Refer to Section 5 of the Constructed Wetland Systems: Design Guidelines for Developers (Melbourne Water, 2005) for detail. Health and Safety considerations for maintenance staff should also be addressed. It is recommended that an independent safety audit be conducted for each design.

- Approach batter slopes should be no steeper than 1:5 Vertical to Horizontal (V:H). All edges should have safety benches of at least 1.5m to 3.0m wide from the edge of the normal top water level.
- Safety benches should have a maximum grade of 1:8 (V:H) for the first 1.5m – 3.0m before changing to a 1:5 (V:H) grade for at least the next 0.5m. Beyond this, may be up to a maximum of 1:3 (V:H). The safety bench should be densely planted with emergent macrophytes such that casual entry will be difficult.
- Refer to the Constructed Wetland Systems: Design Guidelines for Developers (Melbourne Water, 2005) for guidance on hard stand areas, which should be provided adjacent to the inlet zone to allow for the maintenance and cleanout of this zone.
- The following measures may be taken to reduce the prevalence of mosquitoes: Provide access for mosquito predators such as fish and predatory insects; Maintain natural water level fluctuations to disturb the breeding cycle of some mosquito species; and provide sufficient gross pollutant control at the inlet such that litter does not accumulate and provide breeding habitat.
- Ensure that the required detention time is achieved by using outlet risers to control flows.
- The riser outlet pipe should be sized to act as an emergency overflow equivalent to the one year ARI peak discharge.
- A minimum of a 0.3m freeboard for the embankment is required.
- Where possible, wetlands should be constructed in the base of retarding basins to reduce land requirement.
- When considering macrophyte zone layout, it is important to optimise hydraulicefficiency (i.e. reduce dead zones and short circuiting of water). The optimal hydraulic efficiency value for constructed wetlands should be not less than 0.5 and greater than 0.7 where possible. Refer to Section 9.3.3 and Figure 9.6 in the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005).
- The wetland should be divided into four macrophyte zones, an open water zone and a littoral zone. The percentage allocation of each zone is outlined in Table 9.2, Section 9.6.3 of the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005) and should be followed. Refer to the plant species list in the Addendum or the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005) for suitable vegetation options.
- Wetlands require large areas of land for construction and are unsuited to steeply sloping land.
- A geotechnical investigation is required prior to design to determine soil profiles and infiltration rates. Hydrogeological investigations may also be required in areas where there is a likelihood of groundwater discharge or high seasonal water tables.

Ponds and shallow lake systems

It is not recommended that shallow lakes and ponds be used as a stand alone measure to meet BPEMG targets.

They may however function as a useful element when implemented as part of a treatment train.

Ponds promote particle sedimentation, adsorption of nutrients by phytoplankton and UV disinfection. They can also double as storage facilities for reuse schemes, recreation features and wildlife habitats. Often wetlands will flow into ponds although they can exist independently in areas where wetlands are unfeasible for example in steep terrain.

Details of design procedures for ponds and lakes can be found in Section 10.3 of the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005). Refer also to the Constructed Shallow Lake Systems: Design Guidelines for Developers (Melbourne Water, 2005), which should be read in conjunction with the Constructed Wetland Guidelines (Melbourne Water, 2010) for guidance on hard stand areas. These documents should be referred to for detailed design guidance.

Design and Maintenance Considerations

- Algal blooms are the main risk with ponds and lake systems and reducing the risk of blooms is an integral component of design (refer to Section 10.3.2 of the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005)).
- When considering macrophyte zone layout, it is important to optimise hydraulic efficiency (i.e. reduce dead zones and short circuiting of water). The optimal hydraulic efficiency value for ponds and lakes should be not less than 0.5 and greater than 0.7 where possible. Refer to Section 10.3.2 and Figure 10.7 in the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005).

- Gentle slopes, safety benching, handrails and vegetation planting are methods that may be employed to account for public safety. It is recommended that an independent safety audit of each design be conducted.
- Fringing vegetation is important for bank stability and aesthetics but contributes little to improving stormwater quality. Refer to the plant species list in the Addendum or the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005) for suitable vegetation options.
- Ponds are well suited to steep, confined valleys where storage volumes can be maximised.

Rainwater tanks

Rainwater tanks collect roof runoff for subsequent reuse, conserving potable mains supplies and reducing stormwater runoff volumes and pollutants from reaching downstream waterways.

Rainwater tanks are applicable to areas of high roof area to occupancy ratio, while they are less applicable in regions of low roof area to occupancy ratio, such as medium and high density residential dwellings.

The use of rainwater tanks should follow considerations stated in Section 12.2 and design procedures in Section 12.4 of the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005).

Design and Maintenance Considerations

- Rainwater tanks should be installed in accordance with the Plumbing and Drainage Standards (AS/NZS 3500 2003).
- Rainwater tanks may not provide the optimal strategy for stormwater runoff from a sustainability perspective compared to a centralised stormwater harvesting scheme. This issue should be investigated thoroughly during the concept design stage of a project.
- Continual water balance assessments using MUSIC should be performed to determine how much runoff rain tanks are removing from the catchment in terms of runoff volumes and associated pollutant loads.
- Rainwater tanks should be sized using the appropriate reference curves for the region (refer to Section 12.4.2 of the WSUD Engineering Procedures: Stormwater Manual (Melbourne Water, 2005)).

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