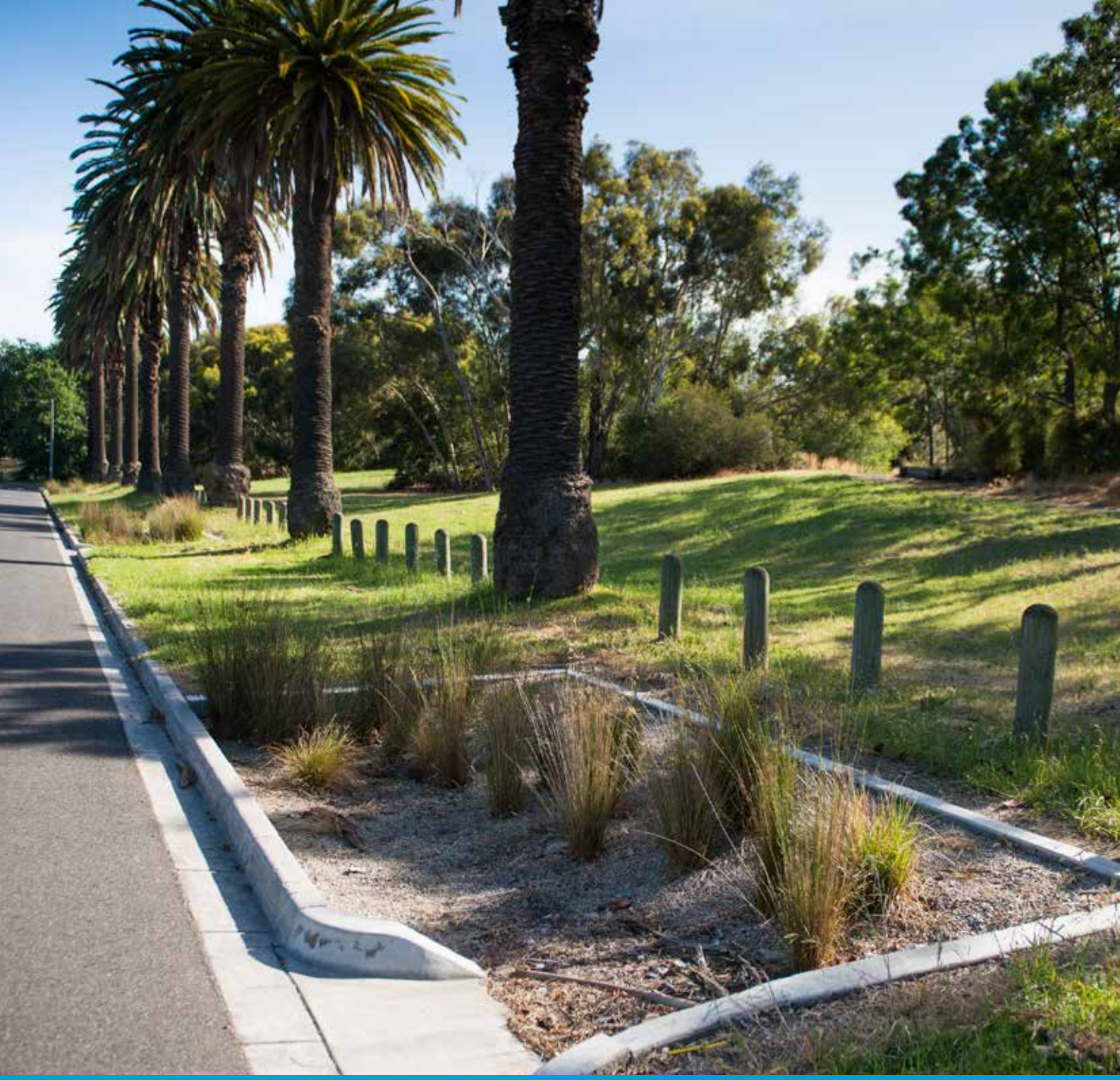

WSUD Audit Guidelines

STORMWATER VICTORIA

Melbourne Water
Enhancing Life and Liveability

WSUD Audit Guidelines (Version 1.0)

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This guideline represents an evolution and a step change in thinking with respect to the auditing and management of water sensitive urban design (WSUD) assets. However it builds on years of good work and effort by many within the industry to promote the need to effectively manage WSUD as well as develop checklists and guidelines to effectively audit and manage these assets.

An extensive consultation process was undertaken for the development of the guideline including workshops with Council, Melbourne Water staff and other interested parties. The tools were also peer reviewed and trialled by other consultants to ensure they would be broadly useful. A great deal of feedback was generously provided and while it was challenging to balance some of the varying perspectives and needs this has greatly improved the quality and usefulness of the guidelines and associated tools.

We would like to thank the following people:

- The project control group including Michael Godfrey, Sam Innes and Ralf Pfleiderer
- Georgie Wettenhall and Jason Sonneman, Harry Virahsawmy, Darren Bos and Jarrod Gaut for their time and generous feedback.
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- The many participants from Councils and the broader industry who shared ideas and feedback at the consultation workshops and training.

Photo credits: E2Designlab, Melbourne Water, Alluvium
Fact sheet diagram credits: DesignFlow

Contents

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1. Introduction

1.1 Guideline overview

1.1.1 Guideline purpose

This guideline describes how to undertake audits of WSUD assets to determine their condition and identify maintenance and renewal requirements. It also sets out the context within which audits occur.

The purpose of auditing WSUD assets is to help councils understand their condition and maintenance requirements to inform future planning and budgeting to ensure the WSUD assets meet the desired levels of service.

The guideline describes the following:

- Why WSUD asset management and audits are important
- How to undertaken a WSUD asset audit
- Templates and items to be audited
- Guidance on interpreting audit outcomes, identifying and prioritising maintenance activities
- Common maintenance activities
- Guidance on developing an asset management framework for WSUD assets
- Guidance for budgeting of maintenance and renewal works

1.1.2 Guideline audience

The WSUD audit guidelines are intended for councils seeking to develop their own internal WSUD management frameworks and undertake audits. The guidelines will be used by:

- *Asset owners and managers* to plan WSUD asset audits, prioritise, plan and budget for maintenance and renewal works.
- *Asset auditors and maintenance staff* responsible for inspecting WSUD assets to assess condition and identify maintenance and renewal needs and action maintenance works.

1.1.3 How to use the Guidelines

The guidelines have been developed as a number of separate sections focussing on different aspects of WSUD asset management. These are colour coded for ease of use.

The structure of the guidelines and intended audience for each section is shown in Figure 1.

Document chapter	Section content	Audience
Introduction	- purpose of the guidelines - audience - how to use guidelines (structure) - relationship with other documents - what is WSUD - WSUD assets covered by the Guidelines - WSUD audits and maintenance works defined	- All users
WSUD asset management	- why WSUD asset maintenance is important - asset lifecycle - roles and responsibilities - relationship to other asset management	- Asset managers
WSUD asset audits	- target performance for each asset type - inspection and audit frequency - audit sheets - typical audit items	- Asset managers - Asset inspectors
Identification and prioritisation of maintenance and rectification actions	- maintenance and rectification identification - maintenance and rectification prioritisation - scoring - budget allocations	- Asset managers - Asset inspectors
Maintenance and rectification works	- undertaking maintenance and rectification works - maintenance and rectification works guidance	- Asset managers - Asset maintainers
Glossary	- glossary of common terms	
Resources	- list of additional relevant resources	
Attachments	- WSUD asset factsheets - Asset data management	- Asset managers - Asset maintainers

Figure 1 - Guidelines structure and intended audience

1.1.4 Relationship with other documents

This document should be used in the context of planning requirements for WSUD set out in:

- State Environmental Protection Policy (Waters of Victoria), Best Practice Environmental Management Guidelines (Victoria Stormwater Committee, 1999); and
- Clause 56.07 of the Victorian Planning Provisions (DTPLI, 2015).

These guidelines focus on the operational phase of WSUD maintenance and renewal. Other documents provide guidance for the planning, design, construction and handover of WSUD assets or provide higher level guidance on maintenance and inspections, see Figure 2.

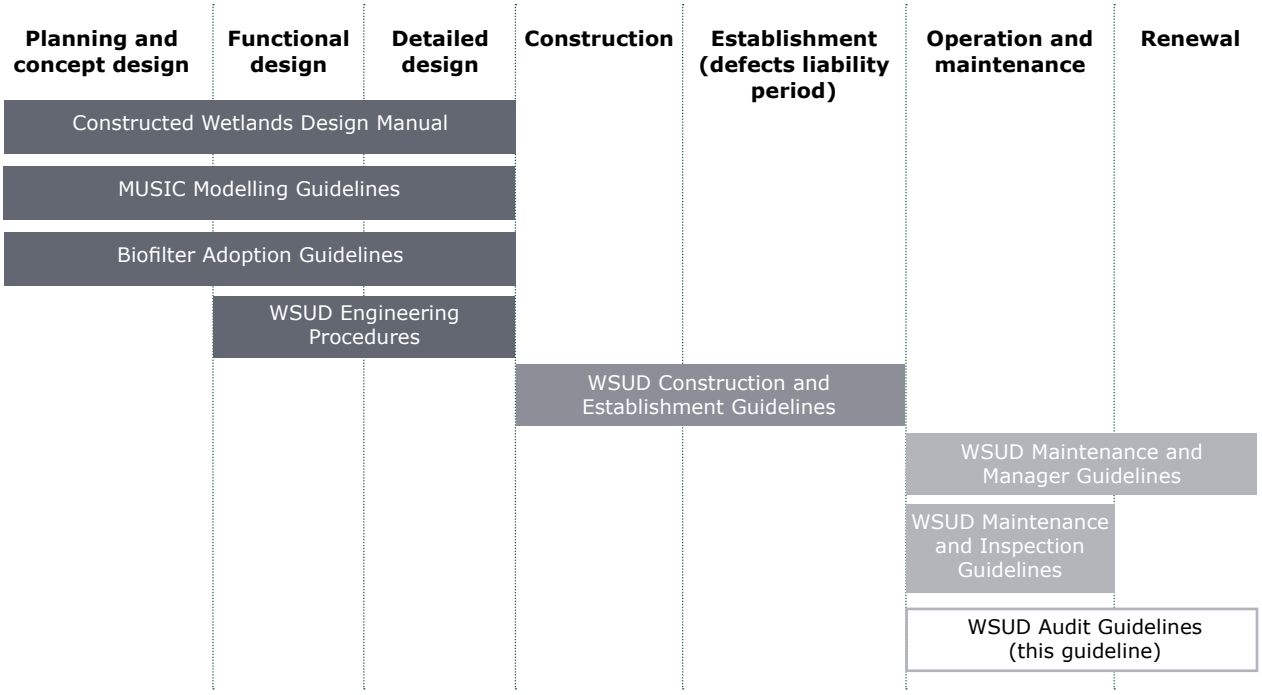


Figure 2 - WSUD asset life cycle and guideline documents

Design processes, methods and requirements for WSUD assets are described in a range of documents:

Design

- Constructed Wetlands Design Manual (Melbourne Water, 2016) – Comprehensive reference for design of wetlands to Melbourne Water expectations
- MUSIC Modelling Guidelines (Melbourne Water, 2016) – Reference for modelling all WSUD assets to understand potential performance
- Biofilter Adoption Guidelines (Payne, 2015) – Research basis and resulting design guidance for biofilters and raingardens
- WSUD Engineering Procedures (Melbourne Water, 2005) – a dated but useful technical guideline with sound technical procedures and calculations for sizing elements such as inlets and outlets.

Construction and establishment

There is currently no comprehensive construction and establishment guideline for Victoria. It will potentially be developed in the future.

Construction, establishment and handover processes are broadly outlined for wetlands in the Constructed Wetlands Design Manual (Melbourne Water, 2016). The Water by Design Construction and Establishment Guidelines (Water by Design, 2010) can be used as a reference.

Checklists for handover can be found in a number of guideline documents.

- The Biofilter Adoption Guidelines (Payne, 2015) provide checklists for bioretention asset handover
- Design and handover checklists for a range of WSUD assets can also be found in the WSUD Engineering Procedures (Melbourne Water, 2005).

Operation and maintenance

- This WSUD Audit Guideline (this Guideline) - Provides a comprehensive manual for structured WSUD asset audits and maintenance including:
  - WSUD asset management
  - Planning and undertaking WSUD asset audits
  - Structured templates for recording audit outcomes
  - Identifying and prioritising maintenance and rectification responses
  - Setting up an electronic asset database for managing audit data
  - Budgeting for maintenance and renewal/rectification

These guidelines build on the extensive body of work that exists in the field of WSUD asset management and maintenance and are intended primarily for councils who are responsible for multiple WSUD assets and require a consistent and semi-automated framework to support numerous asset audits over a period of time.

- The WSUD Maintenance Guidelines - A guide for asset managers (Melbourne Water, 2013) describes the broader asset management framework and provides a description and hard copy forms for the maintenance of raingardens, tree pits, permeable pavements, swales and bio-swales. This provides a useful resource to anyone wanting to understand how to maintain one or a small number of assets.
- The WSUD Maintenance Guidelines - Inspection and maintenance activities (Melbourne Water, 2013) - provides a simple overview and list of common inspection and maintenance tasks for selected WSUD assets for use by field staff seeking to familiarise themselves with WSUD assets and common tasks.

Checklists

Checklists for design, construction and handover can be found on Melbourne Water's Stormwater Management (WSUD) website under 'Case studies and checklists'.

- The Constructed Wetlands Design Manual (Melbourne Water, 2016) provides a useful checklist for wetland design review.

1.2 What is WSUD?

Urban development affects the natural water cycle (see Figure 3). It increases the proportion of hard surfaces, called impervious areas, within a catchment while reducing the extent of soil and vegetation. This greatly reduces the volume of water that is evaporated and transpired by plants into the atmosphere (called evapotranspiration) and infiltrates into groundwater (called infiltration). Conversely, stormwater runoff increases, resulting in more frequent and severe flooding, altered stream hydrology and an increase in pollutant transportation and deposition. Urban surfaces generate more stormwater pollutants including sediment, nutrients, heavy metals and hydrocarbons which impact upon water quality in downstream waterways and bays and can kill aquatic life such as fish and bugs.

Water Sensitive Urban Design (WSUD) seeks to manage water in urban landscapes to improve environmental outcomes and contribute to liveable cities. Typically, WSUD uses constructed systems (Table 1) to provide treatment and flow management of stormwater (Figure 3). Other benefits include: reduced potable water use, temperature control, passive irrigation, flood mitigation, litter removal and increased amenity.

All WSUD asset types require ongoing maintenance to ensure they are operating as designed, that is, continuing to meet high treatment performance and aesthetic standards.

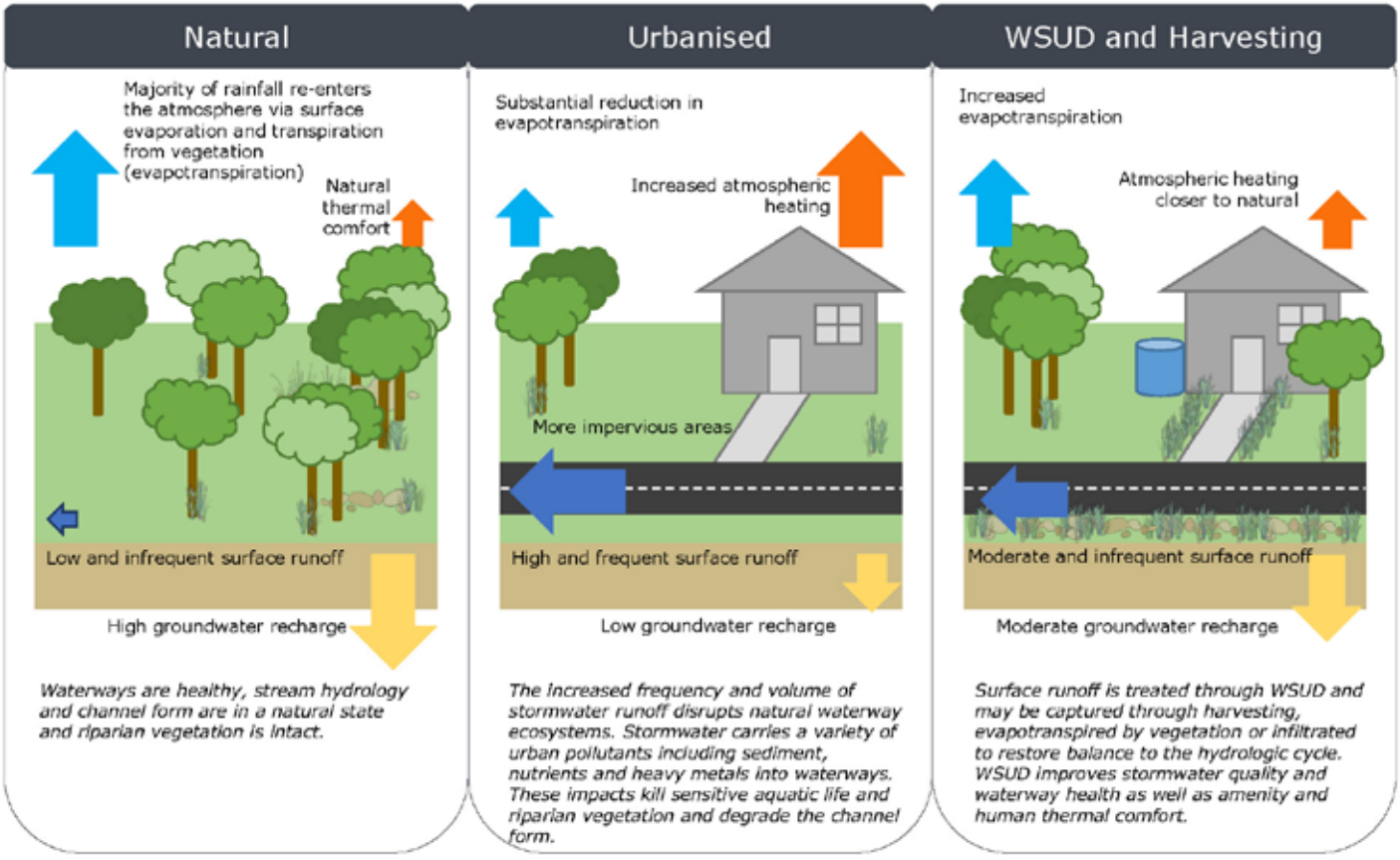


Figure 3 - The impacts of urbanisation on landscape, atmosphere and hydrology and potential benefits of WSUD and stormwater harvesting (Wong T. H. F., 2013)

1.3 WSUD assets covered by the guidelines

These guidelines focus on the following types of WSUD assets most commonly used by councils in the treatment of stormwater (Table 1). However, the principles provided could be applied to any asset that contributes to stormwater treatment.

Table 1 - WSUD assets

	Asset	Description	Example images
Vegetated	Swales	Swales are long channels or depressions that collect and convey stormwater. They are planted with grass or landscaped using denser plants such as shrubs and native grasses. They are generally formed into existing soils and allow some infiltration and evapotranspiration to occur.	
	Bioretention systems (basins, swales)	A system with vegetation and filter media. They capture, retain and treat stormwater before slowly releasing it to receiving waterways. These systems may be referred to as bioretention, biofilters or raingardens with these terms now used interchangeably. Bioretention systems may have different forms such as a basin or swale. The latter can be called a bioswale and differs from a swale as it has an underlying filter media while a swale does not. This document uses raingarden as the current preferred terminology. Stormwater may infiltrate to the underlying soil (unlined), discharge via a drainage layer to the stormwater drainage (lined) or a combination. Unlined systems help to restore natural hydrology by allowing infiltration and reducing surface runoff while lined systems focus solely on providing water quality treatment. Some bioretention systems also have a 'submerged zone' which provides enhanced treatment and water for plants during dry periods.	Bioretention basin  Bioretention swale  Raingarden 
	Tree pits	A tree pit designed to receive stormwater and filter it through the root zone to provide both treatment and passive irrigation. A WSUD tree pit is essentially a small bioretention system. It usually has deeper filter media and is preferably unlined to best support tree root growth. Treated water may discharge via a drainage layer and/or infiltrate to the underlying soil.	
	Wetlands	A vegetated waterbody that is specifically designed for stormwater treatment (i.e. reduce inflow velocities, settle sediments and remove pollutants). Wetlands have large areas of shallow water with plants called a macrophyte zone.	

	Asset	Description	Example images
	Sediment ponds	An open water body which is used to settled coarse to medium sized sediments from stormwater. They are typically used as pre-treatment of stormwater flows to protect downstream wetlands and bioretention systems from being smothered with sediment.	
Non-vegetated	Infiltration systems	While infiltration can occur from a range of WSUD assets, the term 'infiltration system' refers specifically to a non-vegetated basin or trench designed to infiltrate water to the surrounding soils. They are typically a basin, or trench filled with a porous material such as gravel, designed to collect stormwater runoff and infiltrate to the surrounding soils.	
	Porous pavements	Porous and permeable pavements allow stormwater to penetrate the hard surface and infiltrate into the underlying soils	
	Gross pollutant traps	Gross pollutant traps capture litter and coarse organic matter (i.e. leaves and debris). They are typically located downstream of areas with high litter loads or upstream of other WSUD assets such as sediment ponds and wetlands to protect the asset from litter.	

More detail on each of these assets is provided in Chapter 8: WSUD Asset Fact Sheets.

1.4 WSUD audits, inspections and reviews

Routine inspections, audits, ongoing maintenance and timely renewals are essential to support the ongoing function of WSUD assets. The following are recommended:

- Audit
- Regular inspection
- Comprehensive handover audit and design and construction review

WSUD asset audit

'Audit' refers to an independent assessment of asset condition, function and works requirements at a specific point in time.

An audit seeks to define the condition of the asset relative to a set of performance targets and determine whether the asset is functioning as intended to meet its objectives including both stormwater management as well as amenity, safety and other expectations.

The outcomes of an audit can be used to:

- Score and rank assets based on their condition; and
- Identify and prioritise maintenance and renewal/rectification works
- Identify where decommissioning may be recommended

Within a well-structured asset management program, ***audits of WSUD assets would typically be undertaken at least once a year and ideally also following large rainfall events.*** This is considered sufficient for assets observed to be well-established and stable.

Typically the first external asset audit for a municipality will assess all or most assets. Once the condition of assets are known, auditing can be refined to target either a representative sample of assets or those most likely to have issues requiring attention with internal auditing of other assets.

A WSUD asset audit should use the guidance and templates within this document.

Regular inspection

A regular inspection can be:

1. a quick visual check of an asset to identify any obvious issues or areas requiring maintenance attention
2. a more thorough inspection that uses a simplified version of the audit templates or a summary of observations noted during scheduled maintenance.

Inspections may be scheduled or ad-hoc and the outcomes may be recorded as a maintenance task in the asset management system or as a simplified audit record focussing on any issues.

For most WSUD assets, it is recommended routine inspections are undertaken every 3-6 months. This should be varied to suit the available resources and needs of council as well as the profile and behaviour of the assets.

For high profile sites (i.e. where aesthetics is a critical driver) or where individual site conditions necessitate (i.e. unusually heavy rubbish or leaf litter loads), a more frequent inspection regime of *every 1-2 months* and following heavy rainfall could be adopted.

A WSUD asset inspection may use the WSUD maintenance guidelines – inspection and maintenance activities and/or these guidelines as a reference.

Comprehensive handover audit and design and construction review

When an asset is handed over to council it is particularly important that the asset is carefully assessed to ensure that:

1. its design and construction was undertaken to appropriate standards
2. all construction phase reconfiguration and sediment clean-out has occurred, and
3. the asset is functioning as expected.

While these guidelines do not set out to provide direction on handover audits and the review of the design and construction of a WSUD asset, the templates can be used as a preliminary reference checklist of issues to look for.

It is strongly recommended that handover inspections are undertaken by qualified internal or external personnel with strong working knowledge and experience in WSUD assets and their function.

1.5 WSUD maintenance, renewal and rectification

WSUD assets require ongoing maintenance as well as rectification activities where required to ensure their ongoing sustainable operation.

Works required may be either simple maintenance works or major rectification or renewal works, each of which will have their own requirements in terms of equipment and skills. The nature of works and their required frequency will also vary according to the type of WSUD asset. Maintenance is considered to describe relatively simple and repetitive tasks while rectification and renewal refer to more substantial, one-off and specialised works.

Most maintenance activities are manual and can be undertaken using basic landscaping tools such as rakes, spades, shovels and hoes. Boats may also be required occasionally for maintenance in open pool areas. Maintenance works may be undertaken as:

- proactive or planned maintenance; or
- reactive maintenance

Proactive maintenance

Regular scheduled maintenance tasks planned based on regular inspections, audits and/or anticipated frequency of tasks.

Proactive maintenance in the first two years following establishment is the most intensive and important.

Reactive maintenance

Reactive unscheduled maintenance tasks are typically undertaken in response to identified issues or community complaints. They may require a swift response to address a problem or safety concern.

Rectification and renewal

Rectification works are required to address major issues which cannot be resolved successfully with typical maintenance activities. These works will vary depending on the issues and may require specialist investigations and skills to identify and undertake the appropriate actions to return the asset to its target condition.

Renewal is the replacement of one or more main elements of an asset when it reaches the end of its useful life expectancy and has deteriorated to a level where renewal is warranted. Civil elements and trees have a limited life and will eventually need replacement while some systems accumulating sediment and other pollutants will need clean-outs, usually at regular intervals. Renewal of civil assets can be planned based on median life expectancy while recognising that actual renewals will vary depending on the quality of initial construction and conditions during the life of the asset. Vegetated assets that can self-propagate may last indefinitely.

Typical maintenance and rectification works are listed in Table 2.

Chapter 5 provides further information on maintenance and rectification activities to address typical issues associated with WSUD assets.

Table 2 - Typical maintenance and rectification works

Maintenance works	Rectification works
Removal of litter and debris.	*Major sediment removal*
Removal of sediment.	*Water level management and drainage review*
Removal and management of invasive weeds and pests.	*Extensive vegetation replacement*
Pruning of plants	*Removal of major weed infestation and replanting*
Replacement of plants that have died (or areas where weeds have been removed)	*Major scour or erosion repair*
Watering of vegetation during extended dry periods (and establishment period).	*Preferential flow path repair*
Repair asset profile to prevent the formation of isolated pools.	*Filter media reinstatement or asset reset*
Removal of blockages from inlet and outlet structures.	*Repair of damaged structures*
Repair of minor vehicle or pedestrian damage	*Addressing significant water quality issues*

2

2. The role of WSUD asset management

2.1 Why WSUD asset management is important

WSUD assets need to be managed, including audits, planned maintenance and rectification, for the following reasons:

- Regulatory compliance
- Environmental protection
- Amenity
- Cost benefit efficiency
- Safety and risk management

2.1.1 Regulatory compliance

The State Environment Protection Policy - Waters of Victoria (Government of Victoria, 2003), referred to as the 'SEPP', sets out objectives for protection of waterways and waterbodies. All new development must comply with these objectives. Local council is the planning authority with responsibility to ensure this occurs.

Authorities including councils and Melbourne Water have obligations to ensure WSUD assets constructed to meet State Environment Protection Policy and planning requirements continue to deliver the expected levels of service for treatment, meet community expectations for amenity and protect public safety.

There are various guidelines and planning requirements for WSUD supporting the SEPP. These include the Best Practice Environmental Management Guidelines (Victoria Stormwater Committee, 1999) and Clause 56.07 of the Victorian Planning Provisions (VPPs) (DTPLI, 2015) which applies to residential subdivisions (see Figure 4). These set out practical objectives, measures and approaches to meet SEPP requirements. Current objectives include:

- 80% reduction in the mean annual suspended solids load
- 45% reduction in the mean annual phosphorus load
- 45% reduction in the mean annual nitrogen load
- 70% reduction in the mean annual litter load
- No increase in the 1.5 year annual recurrence interval (ARI) flow from pre-development conditions.

Developers usually comply with the SEPP by designing and constructing WSUD assets that achieve the specified levels of stormwater treatment. Councils typically inherit these WSUD assets from developers as part of the urban development process (in the same way that they receive roads, drainage and other infrastructure). Some WSUD assets are handed over to Melbourne Water (when the upstream catchment of the asset is greater than 60 ha in area) within the Port Phillip Bay and Westernport Region.

In addition, councils are required to have a plan in place to meet SEPP requirements to protect the beneficial uses of receiving waters. Usually this is a stormwater management or integrated water cycle management plan formulated to ensure that urban development does not impact upon beneficial uses of receiving waters. Through these plans, councils invest in WSUD assets to provide stormwater treatment for existing urban areas, protect waterways and water bodies as well as improve amenity. Increasingly, stormwater harvesting schemes may also be constructed to supply non potable uses like irrigation of sports fields to reduce reliance on potable water supplies.

It is implied (though not stated in the SEPP) that WSUD assets constructed during the development process or by councils are maintained to protect downstream waterways and waterbodies. Where assets are not maintained, the responsible owner and relevant authorities including council and Melbourne Water may be failing to comply with their legal obligations under the SEPP.

Planning and Legislation

There are many federal, state and local regulations that influence the management of stormwater

- The National Water Initiative commits all states and territories to innovation and capacity building to create Water Sensitive Cities.
- The State Environment Protection Policies (Water of Victoria) states that runoff from urban and rural areas must not compromise the identified beneficial uses of the receiving waters.
- Clause 56:07 of the Victoria Planning Provisions mandates Integrated Water Management and requires compliance with best practice stormwater quality treatment objectives for residential subdivisions.

Key agencies and organisations involved in the management of stormwater include Melbourne Water, local councils, catchment management authorities, water retailers and the EPA.

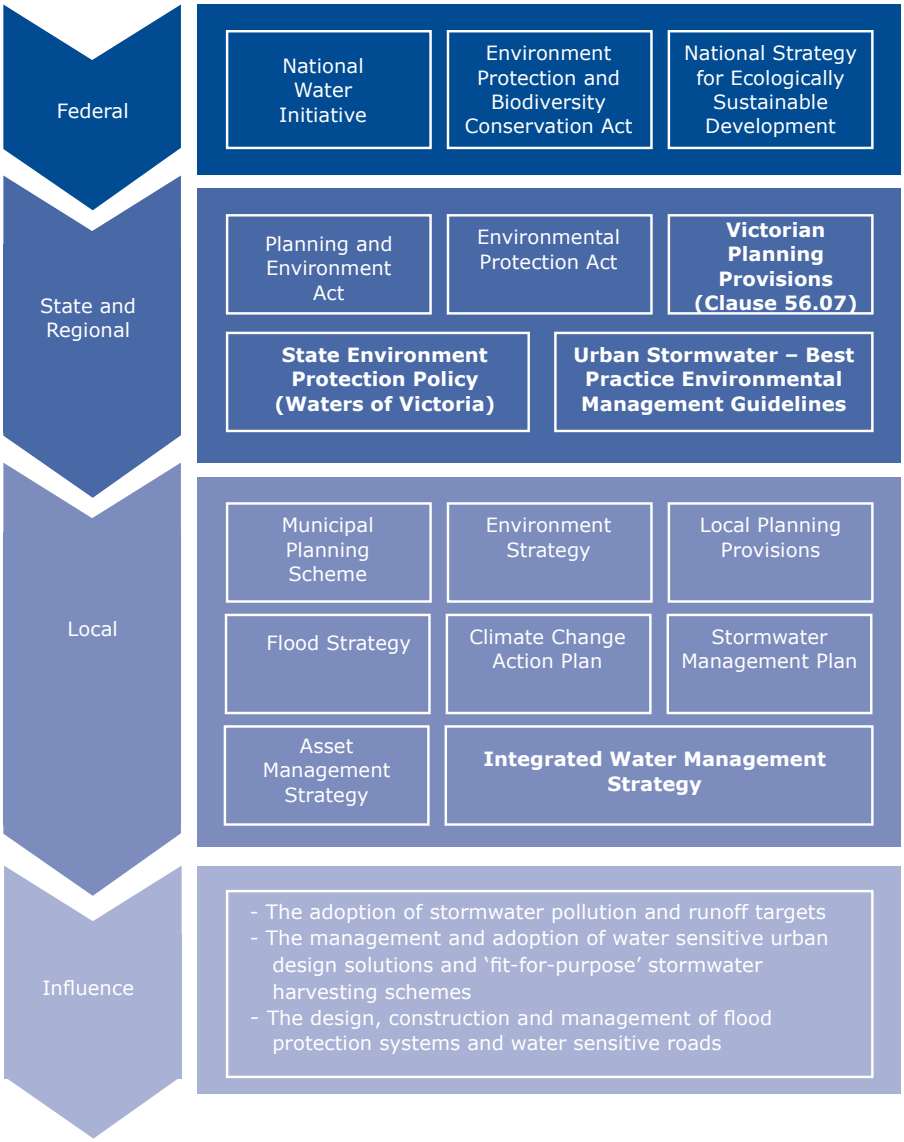


Figure 4 - A summary of key documents that set out stormwater management obligations

2.1.2 Environmental protection

WSUD assets need to function effectively to protect the beneficial uses of downstream receiving waters and comply with the intent of the SEPP (Waters of Victoria). When WSUD assets are not maintained, they risk complete failure or reduced performance, limiting their environmental protection.

2.1.3 Amenity

WSUD assets contribute to the amenity of an area by creating an attractive landscape (see Figure 5). Passive irrigation of WSUD means vegetation health is improved compared to a standard garden bed.

Figure 5 - An attractive raingarden improves the amenity of its surrounds (City of Greater Geelong, 2015)

The local community may value the WSUD asset because it is seen as part of a scenic landscape (e.g. neat, well managed landscape) or an ecological landscape (e.g. natural system providing habitat) (see Figure 6).

Figure 6 - Importance of context for public amenity success of WSUD assets. The right-hand option with abundant flowering exotic plants does not relate well to the immediate setting or the nearby gardens. Photos supplied by M. Dobbie, Monash University; photo manipulation by H. Smillie, Seddon (Payne, 2015).

The maintenance of the WSUD asset can influence the community's perception, as a poorly maintained asset can detract from amenity values. This might include the accumulation of litter, loss of plants or presence of weeds (see Figure 7). Furthermore, poorly maintained systems are at risk of interference by the community, as local residents may actively change vegetation or fill in WSUD assets if they don't like the aesthetics or don't understand it's purpose.

Figure 7 - A raingarden and tree pit in need of attention to clear litter, impacting the aesthetic appeal of the WSUD asset (E2Designlab, 2014b)

High profile assets located in high traffic areas or near entrances of major buildings, schools or fast food outlets may need more frequent attention to manage litter, sediment and planting to protect amenity values, see Figure 8.

Figure 8 - Example of a high profile site

2.1.4 Achieving cost-benefit efficiencies in WSUD asset management

A maintenance program may focus primarily on pro-active maintenance based on regular inspections and planned maintenance activities or on reactive maintenance in response to identified issues. In practice, a combination of pro-active or planned maintenance and reactive response to any complaints or issues is needed along with a timely and appropriately resourced renewal program. Regular audits of WSUD assets are essential to inform a pro-active maintenance program.

A comparison of the costs and benefits of broadly proactive and reactive approaches to maintenance (E2Designlab, 2014a and E2Designlab, 2015b), has shown that a focus on proactive maintenance

- realises greater benefits (e.g. nutrient reduction)
- reduces long term costs of asset management (see Figure 9).

In practice, a combined approach is needed with pro-active planning of regular maintenance and asset renewals and reactive responses to community complaints or event-triggered maintenance needs.

Figure 9 reflects the fact that where proactive maintenance is not undertaken, reactive maintenance and rectification works are more likely to be required. WSUD assets that are not regularly inspected and maintained are at risk of failure or under-performance. For example, if an initially minor problem such as a blocked outlet or emergence of invasive weed species is not addressed quickly it can lead to major issues such as plant loss due to over inundation or weeds out-competing the chosen plant species. This can result in costly extensive weed removal and replanting. If severe, the issue can also lead to the early re-setting of WSUD systems, for example the clogging of bioretention filter media due to algal growth.

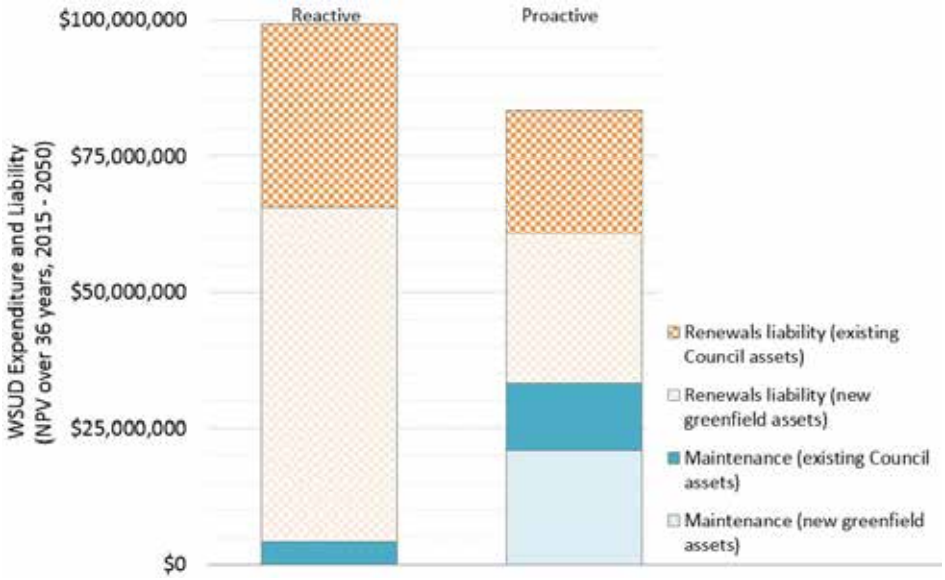


Figure 9 - A comparison of reactive and pro-active approaches to maintenance showing changes in the long term net present value of costs and liabilities, adapted from City of Greater Geelong Stormwater Quality Strategy (E2Designlab, 2015b).

The potential life span of WSUD assets is estimated to be 15-20 years for swales and bioretention systems, 20-25 years or longer for wetlands and infiltration systems and at least 25 years for permeable pavements and gross pollutant traps. With good design, construction and maintenance lifespans of vegetated systems could be longer. At the end of this lifespan, major renewal works may be needed to clean out sediment and accumulated organic matter.

Figure 10 - Short-circuiting flows erode a channel around a blocked porous rock wall (E2Designlab, 2015a)

Regular maintenance can increase the likelihood of WSUD assets to function effectively beyond these time-frames, deferring the timing and costs of these major works.

When assets are not maintained regularly and rigorously inspected, there is an increased likelihood they may require rectification works prior to reaching the end of their expected life. This results in a reduced average lifespan for WSUD asset base and increased renewal costs. The effects of this on annual renewal liabilities is illustrated in Figure 9.

An important first step for councils to manage rectification and renewal liabilities is *to include these within their accounts based on typical lifespans and taking into account the general maintenance approach* (proactive or reactive).

2.1.5 Safety and risk management

Regular audits, maintenance and rectification reduce the likelihood of safety issues developing in WSUD assets and ensure any issues are quickly recognised and rectified. For example blocked outlets or clogging can result in unintended ponding within an asset or high velocity flows in constrained areas. Also, damage to protective fencing, boardwalks and loss of planting restricting access can create hazards for the community. Where a potential safety risk is identified this will usually be a high priority for maintenance or rectification works.

Figure 11 - Example of identified hazards assessed as high risk

2.2 WSUD asset management lifecycle

An ideal WSUD management lifecycle includes appropriate handover processes followed by a regular cycle of inspections and audits, prioritisation and maintenance then renewal once assets reach their expected end of life, see Figure 12.

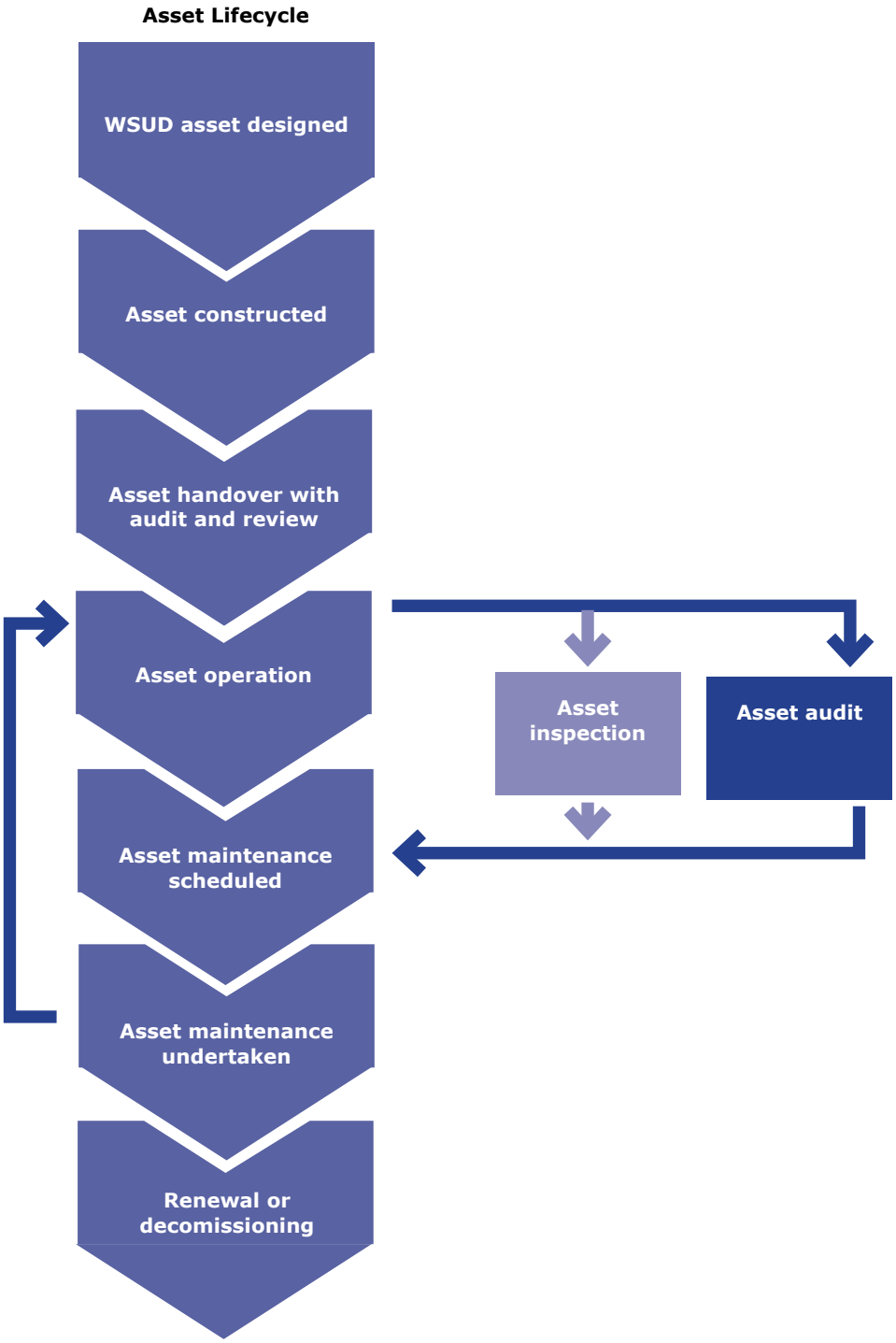


Figure 12 - WSUD asset management lifecycle

2

This guideline provides advice on how to assess the asset condition and identify, prioritise, plan and undertake WSUD maintenance. The preceding asset handover process is an important step for ongoing asset management as the initial condition and function of the asset at handover will impact ongoing performance and maintenance requirements. Assets handed over to council that have not been designed, constructed or maintained to best practice standards are likely to have ongoing issues.

Key steps during design and at the initial handover stage to reduce future maintenance risks for council include:

- **Design review** – to ensure that the asset can operate effectively in accordance with its design intent. Many asset management issues can be avoided with good design choices. Some guidance on design review can be found in the Water Sensitive Urban Design Guidelines – South Eastern Councils (Melbourne Water, 2013)
- **Handover assessment** – to ensure that the asset has been constructed and established as per the design and that it is operating effectively as the nominated asset type. Good construction and establishment typically leads to assets with minimal maintenance and rectification needs while issues at this stage are likely to impact asset life and result in early rectification works.

2.3 Roles and responsibilities

There are a number of different roles and skill sets (see Table 3) required throughout the WSUD asset management lifecycle.

It is important that each council department and staff member understands their role and responsibilities in the management of WSUD assets.

Table 2 provides a summary of the typical roles and responsibilities required for WSUD asset management and provides recommendations on the council department which might be best placed to fulfil these roles. It is important that each department communicates effectively to support the WSUD asset management process.

Table 3 - Typical roles and responsibilities

Role	Responsibilities	Typical Council Department
Council	• Compliance with regulatory requirements in accordance with SEPP and Local Government Act • Council commitment to responsible management of existing assets • Safety and risk	Mayor and Councillors
Council management	• Compliance with regulatory requirements in accordance with SEPP and Local Government Act • Effective and cost efficient management of existing assets • Establish targets and performance indicators • Safety and risk	Executive and management team
Asset manager or owner	• Comply with regulatory, environmental, risk management and safety obligations • Asset management plan • Update and maintain WSUD asset database • Prioritise and schedule maintenance works • Allocate budgets • Understand field issues and needs • Understand and maintain systems and databases • Determine appropriate responses for major issues / rectification works	Infrastructure or engineering
Asset audit and maintenance crews	• Undertake audit and maintenance • Understand and maintain systems and databases • Identify items which present a safety risk	Engineering and drainage, parks and landscape (including natural areas)
Consultants and contractors	• General or specialist asset audits and investigations • Delegated audit and maintenance tasks • Major renewals and specialist works	

The successful delivery and ongoing management of WSUD assets can be greatly influenced by effective cross-organisational communication to ensure all the stakeholders involved fulfil their respective roles, pass on information in a timely manner and collaborate effectively.

2.4 Relationship to management of other assets

Asset management is a core council function and usually a focus of the council or city plan. The plan may set targets or key performance indicators for the level of service to be provided. It is important that clear performance targets are put in place for WSUD assets. The *ratio of actual to required maintenance and renewal expenditure* to maintain target performance condition can provide an indicator of council commitment and action.

Supporting the city plan are a range of asset management plans for different classes of assets. WSUD assets may have their own asset management plan or be included within plans for drainage and public open space assets.

The management of WSUD assets should be linked to council policies, strategies and plans where appropriate to highlight their importance in achieving a range of council objectives.

3. WSUD Asset Audits

This chapter describes the process for undertaking a WSUD asset audit and use of the audit template sheets.

Assets within the WSUD asset database need to be regularly audited. An audit involves inspecting a number of elements, or items, associated with the asset. A current condition rating should be assigned for each item to identify issues affecting asset performance and actions required to improve performance. The type and severity of issues identified supports the prioritisation process to allocate maintenance and rectification actions and budgets.

Condition assessments should consider the following:

- Asset attributes (Section 3.1).
- Timing and regularity of audits (Section 3.2).
- Condition assessment of elements against performance targets (Section 3.4).

The following information should be taken on site to conduct an asset condition assessment:

- Audit sheet (paper or electronic), see Section 3.3 and Attachment 3.
- Layout drawing and/or maintenance drawing for asset indicating the location of key elements such as inlet and outlet structures, deep pool, macrophyte zone, filter media, batters, etc.

The following preparation and equipment is recommended for audits:

- An industry recognised risk assessment such as a Task Risk Assessment (TRA) or Job Safety Assessment (JSA) (refer Figure 13) should be prepared prior to an inspection or audit detailing risk assessment and safety considerations.
- Appropriate Personal Protective Equipment (PPE) safety clothing and equipment.
- Camera with GPS, tablet or phone for recording condition and any issues (a backup device, charger and/or batteries are advisable).
- A shovel (for addressing minor sediment accumulation, inspecting soils and filter media, etc).
- Bags for taking samples of filter media and sediment accumulations
- Gloves, tongs and garbage bags (for addressing minor litter and leaf litter accumulation).
- Hand soap and clean water for washing hands after contact with soil or stormwater
- Water for checking raingarden infiltration.

Job Safety Analysis Worksheet

Company name:	Stormwater Victoria	Date: 15/02/2017	JSA No. 1001
Site name:	Beronia Rd Retarding Basin, Wicks Reserve and Sheffield Road raingarden	Permit to work requirement: Yes	No X
Contractor:	N/A	Approved by:	
Activity:	WSUD audit		

Activity List the tasks required to perform the activity in the sequence they are carried out	Hazards Against each task list the hazards that could cause injury when the task is performed	Risk control measures List the control measures required to eliminate or minimise the risk of injury arising from the identified hazard	Who is responsible? Write the name of the person responsible (supervisor or above) to implement the control measure identified
Drive to and from site	Car accident	Comply with road rules and drive in a manner that ensures all occupants are safe; Wear seatbelts whenever the vehicle is in motion; Don't distract driver; Drive to conditions, slow down in poor visibility, rough surface etc Specific mitigating circumstances: All driving will be within metropolitan Melbourne.	
	Car breakdown	Ensure vehicle is suitable for use (i.e. roadworthy and reliable); Undertake daily vehicle inspection (including tyre pressure and spare tyre); Vehicles to carry appropriate means of communication.	
	Hazardous Road Conditions	Ensure the vehicle is suitable for the conditions As far as possible, minimise the need to drive at high risk times for animal activity on roads (night, sunrise, sunset); If animals are sighted, slow vehicle – don't swerve; Safe driving techniques for poor road conditions.	
Site work	Snake Bite	Wear long trousers, solid shoes and long sleeve shirt while in the field; Tramp and make noise while walking; Be aware of potential threat;	
	Fire	Check ahead of time for weather information and fire warnings; Be aware of surroundings and potential for bushfires to occur; Regularly monitor wind direction and signs of fire; Carry communication equipment;	
	Dehydration / Sun Exposure	Carry and use sunscreen, hats, sunglasses and long sleeved shirts; Drink water and take breaks regularly; Work in shade where possible; Specific mitigating circumstances: Middle of day, ensure all staff have hat and sunscreen.	
	Drowning / water related illnesses	2 or more people present for site inspection; Identify any people that are unable to swim; Avoid where possible walking on steep, slippery and unstable banks; Stay out of water; Avoid contact with water and use gloves, wash hands thoroughly if contact occurs; Carry communication equipment;	
	Slips, trips and falls	Avoid areas without delineated tracks where possible; Wear footwear with adequate support; Take precautions in adverse ground conditions (e.g. wet, obscured, vegetation etc) and act accordingly; Work at a slow pace;	
	Public interaction	Where possible avoid contact with public, any potentially confrontational circumstances or any activity that may put the team at risk.	
	Flying objects and debris	Wear sunglasses, stay clear of roadways where possible.	
	Vehicle collision with pedestrian	Stay clear of roadway as much as possible; Always face oncoming traffic where in proximity of road; Minimise travel along roadways; Wear safety vests;	

Remember: Each JSA must be site specific.
Include all workers in the development of this JSA.

WorkSafe

Figure 13 - Example JSA Form

3.1 Asset attributes

It is important to understand the asset attributes before condition assessments are undertaken. The type of information that should be available for each asset may include:

- Site details – including location, address and layout plan
- Asset details – asset type, identification number and links to design plans and records
- Asset dimensions – including surface area
- Asset maintenance – including information to support maintenance; and
- Asset performance – including expected performance.

This information can be used to get an understanding of the importance of the asset in terms of its location and treatment performance.

More details on the recommended information to be collected in an asset management database are provided in Attachment 2.

3.2 Inspection and audit frequency

Regular audits, informal inspections, ongoing maintenance and timely renewals are essential to support the ongoing function of WSUD assets.

Asset audits would typically be undertaken once a year. This may be varied to suit the available resources and needs of council as well as the profile and behaviour of the assets.

For high profile or priority sites (e.g. stormwater harvesting) more frequent audits may be undertaken for example, every 6 months. A reduced frequency of once every two years or even less may be quite sufficient for assets known to be well established and stable provided these are supplemented with regular inspections or simplified audits.

For most WSUD assets, it is recommended that audits are supplemented with informal inspections or simplified audits (e.g. only inlets and outlets or only observed issues flagged) *every 3-6 months.* This may be varied to suit the available resources and needs of council as well as the profile and behaviour of the assets.

For high profile sites (i.e. where aesthetics is a critical driver) or where individual site conditions necessitate (i.e. unusual heavy rubbish or leaf litter loads), a more frequent inspection regime of *every 1-2 months* or following heavy rainfall could be adopted.

3.3 Audit sheets

This section describes the template sheets that can be used for undertaking audits. It provides additional details on the audit task, condition assessment and triggers for maintenance and rectification works.

For each asset type, an audit template sheet is provided within a spreadsheet accompanying this document (refer to Attachment 3). An example is shown in Figure 14. They may be printed and filled in by hand with later transfer to a spreadsheet or other database or filled in directly in the spreadsheet using a laptop or ipad.

Each audit sheet is tailored for a particular asset type and provides a series of audit elements and inspection items.

Each asset comprises several of the following elements:

- Surrounds and other infrastructure
- Inlet (s)
- Batters
- Open Water Zone (s)
- Vegetated base and batters (swales)
- Permeable vegetated base (bioretention or tree pit filter media)
- Unvegetated permeable base or infiltration base (infiltration trench or basin, porous paving)
- Aquatic macrophyte zone
- Outlet, overflow and inspection pipes
- Litter and sediment sump

A series of inspection items (e.g. erosion, blockage) associated with each element of the asset are listed. Audits should generally be undertaken for all of the key elements within the WSUD asset. For example, when inspecting a stormwater treatment wetland, this will involve checking the sediment pond (inlet zone), inlet and outlets, batters and the macrophyte zone.

An audit item (e.g. erosion) has the same description and assessment criteria regardless of the element or asset type. This provides consistency across assessments and reduces the amount of information to be remembered by assessors. It should be recognised though, that the effect and response to issues may vary depending on asset type.

A simple guide for rating items as 'Good', 'Moderate' or 'Poor' is provided in the audit sheets. Further detail and images are provided in Section 3.5 to assist assessors in assigning a rating.

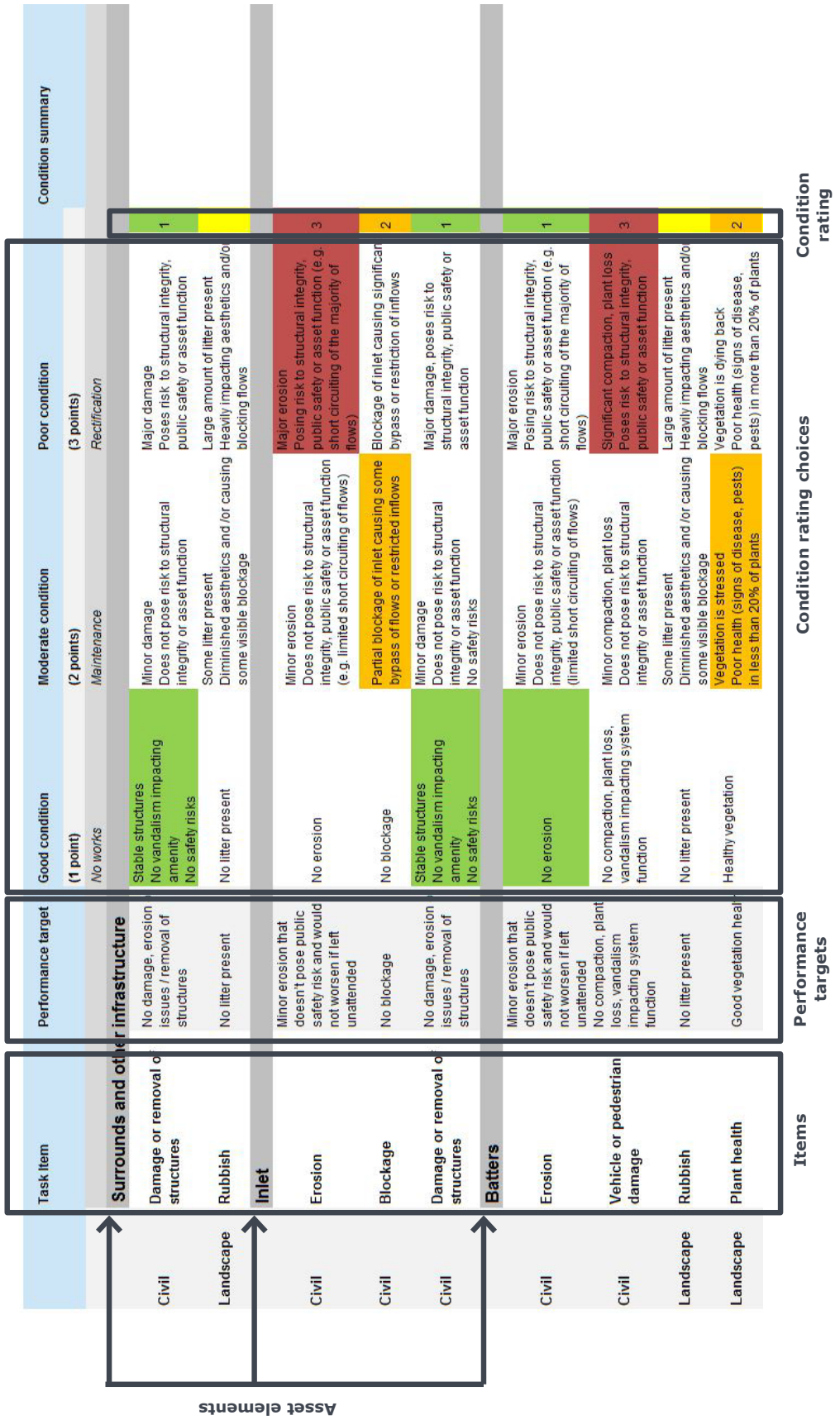


Figure 14 - Audit sheet

3.4 Audit items

Audit items to be assessed for the various WSUD asset elements typically include civil and landscape components. These can be assessed by two people with relevant civil/ environmental engineering and landscape/horticulture expertise respectively or a single auditor trained in assessing all aspects of WSUD assets.

In some cases where an asset may not have an element (for example many streetscape bioretention systems have no batters), the corresponding audit items can be marked N/A or left blank.

The relevant audit items for elements within each asset type are summarised in the following tables.

Table 4 - **Swale assets**: Relevant items and elements

	Inlet	Vegetated base and batters	Outlet, overflow and inspection pipes
Blockage	x		x
Damage or removal of structures	x		x
Erosion	x	x	x
Extended detention depth			
Floating plants			
Leaf litter		x	
Mosquitos			
Nuisance fauna		x	
Permeability and clogging			
Plant cover		x	
Plant health		x	
Rubbish		x	
Sediment accumulation		x	
Standing water or boggy conditions		x	
Surface levels		x	
Vehicle or pedestrian damage		x	
Water levels			
Water quality (oil slicks, odour, algae)			
Weeds		x	

Table 5 - **Bioretention assets:** Relevant items and elements

	Surrounds and other infrastructure	Inlet	Batters	Permeable vegetated base	Outlet, overflow and inspection pipes
Blockage		x			x
Damage or removal of structures	x	x			x
Erosion		x	x	x	x
Extended detention depth				x	
Floating plants					
Leaf litter				x	
Mosquitos					
Nuisance fauna			x	x	
Permeability and clogging				x	
Plant cover			x	x	
Plant health			x	x	
Rubbish	x		x	x	
Sediment accumulation				x	
Standing water or boggy conditions					
Surface levels				x	
Vehicle or pedestrian damage			x	x	
Water levels					
Water quality (oil slicks, odour, algae)					
Weeds			x	x	

Table 6 - **Tree pit assets:** Relevant items and elements

	Inlet	Permeable vegetated base	Outlet, overflow and inspection pipes
Blockage	x		x
Damage or removal of structures	x		x
Erosion	x	x	x
Extended detention depth		x	
Floating plants			
Leaf litter		x	
Mosquitos			
Nuisance fauna		x	
Permeability and clogging		x	
Plant cover		x	
Plant health		x	
Rubbish		x	
Sediment accumulation		x	
Standing water or boggy conditions			
Surface levels		x	
Vehicle or pedestrian damage		x	
Water levels			
Water quality (oil slicks, odour, algae)			
Weeds		x	

Table 7 - **Wetland assets:** Relevant items and elements

	Surrounds and other infrastructure	Inlet	Batters	Aquatic macrophyte zone	Outlet, overflow and inspection pipes
Blockage		x			x
Damage or removal of structures	x	x			x
Erosion		x	x	x	x
Extended detention depth					
Floating plants				x	
Leaf litter				x	
Mosquitos				x	
Nuisance fauna			x	x	
Permeability and clogging					
Plant cover			x	x	
Plant health			x	x	
Rubbish	x		x	x	
Sediment accumulation				x	
Standing water or boggy conditions					
Surface levels					
Vehicle or pedestrian damage			x	x	
Water levels				x	
Water quality (oil slicks, odour, algae)				x	
Weeds			x	x	

Table 8 - **Sediment pond assets:** Relevant items and elements

	Surrounds and other infrastructure	Inlet	Batters	Open water zone	Outlet, overflow and inspection pipes
Blockage		x			x
Damage or removal of structures	x	x			x
Erosion		x	x		x
Extended detention depth					
Floating plants				x	
Leaf litter					
Mosquitos				x	
Nuisance fauna			x	x	
Permeability and clogging					
Plant cover			x		
Plant health			x		
Rubbish	x		x	x	
Sediment accumulation				x	
Standing water or boggy conditions					
Surface levels					
Vehicle or pedestrian damage			x		
Water levels					
Water quality (oil slicks, odour, algae)				x	
Weeds			x	x	

Table 9 - **Infiltration assets:** Relevant items and elements

	Inlet	Batters	Unvegetated permeable or infiltration base	Outlet, overflow and inspection pipes
Blockage	x			x
Damage or removal of structures	x			x
Erosion	x	x	x	x
Extended detention depth				
Floating plants				
Leaf litter			x	
Mosquitos				
Nuisance fauna		x		
Permeability and clogging			x	
Plant cover		x		
Plant health		x		
Rubbish		x	x	
Sediment accumulation			x	
Standing water or boggy conditions				
Surface levels			x	
Vehicle or pedestrian damage		x	x	
Water levels				
Water quality (oil slicks, odour, algae)				
Weeds		x	x	

Table 10 - **Porous pavement assets:** Relevant items and elements

	Unvegetated permeable or infiltration base	Outlet, overflow and inspection pipes
Blockage		x
Damage or removal of structures		x
Erosion	x	x
Extended detention depth		
Floating plants		
Leaf litter	x	
Mosquitos		
Nuisance fauna		
Permeability and clogging	x	
Plant cover		
Plant health		
Rubbish	x	
Sediment accumulation	x	
Standing water or boggy conditions		
Surface levels	x	
Vehicle or pedestrian damage	x	
Water levels		
Water quality (oil slicks, odour, algae)		
Weeds	x	

Table 11 - **GPT assets:** Relevant items and elements

	Inlet	Outlet, overflow and inspection pipes	Litter and sediment sump
Blockage	x	x	
Damage or removal of structures	x	x	
Erosion	x	x	
Extended detention depth			
Floating plants			
Leaf litter			
Mosquitos			
Nuisance fauna			
Permeability and clogging			
Plant cover			
Plant health			
Rubbish			x
Sediment accumulation			x
Standing water or boggy conditions			
Surface levels			
Vehicle or pedestrian damage			
Water levels			
Water quality (oil slicks, odour, algae)			
Weeds			

3.5 Condition audit factsheets

Blockage - inlet

Blockage of inlets generally consists of sediment accumulation, leaf litter and rubbish. Any blockage impeding flow into an asset must be removed as it may prevent water entering assets resulting in partial or complete bypass. Besides reducing treatment effectiveness, this can prevent water reaching plants resulting in plant loss, rapid asset failure and loss of environmental benefits. Inlet blockages may also result in nuisance flooding during larger event flows.

Blockage may occur due to inlet design issues such as the size and number of inlets or lack of grade into the asset. Where such issues are recognised, these should be identified in the notes for rectification works.

Where inlet blockage has moderate or poor condition, further assessment should consider the overall inlet design and the following:

- Is inlet appropriately sized?
- Is there a drop in level?
- Are there a sufficient number of inlets?

Audit Criteria

Condition rating	Criteria	Works
Performance target	• No blockage	
Good condition	• No blockage	None
Moderate condition	• Partial blockage of inlet causing some bypass of flows or restricted inflows	Maintenance
Poor condition	• Blockage of inlet causing significant bypass or restriction of inflows	Rectification

Example Images

Condition rating	Example images
Moderate condition	 *Partial blockage of inlet from leaf litter accumulation*
Poor condition	  *Completely blocked inlets*

Blockage - outlet

Blockage of outlets generally consists of sediment accumulation, leaf litter and rubbish. Any blockage impeding flow out of an asset must be removed as it can prevent water flowing out of the asset and result in ponding, prolonged elevated water levels and water-logging. This can result in drowning of plants and consequent plant losses and lead to rapid asset failure. Blockage may also may result in nuisance flooding during larger event flows.

Blockage of outlets could be considered the most important audit item for wetlands due to the potential for costly plant losses.

Where an outlet is substantially or completely blocked, further investigation should be undertaken to evaluate the likely causes. Considerations may include the period of time since the last audit, any large recent storm events and any obvious catchment or asset issues likely to have caused the blockage. Where a reoccurrence is likely, rectification works to mitigate this may be needed.

Audit Criteria

Condition rating	Criteria	Works
Performance target	• No blockage	
Good condition	• No blockage	None
Moderate condition	• Partial blockage of outlet causing some obstruction of outflows or requiring removal	Maintenance
Poor condition	• Blockage of outlet preventing or significantly obstructing outflows	Rectification

Example Images

Condition rating	Example images
Moderate condition	 *Partial blockage of outlet caused by minor sediment accumulation*
Poor condition	  *Major blockage of outlets obstructing and preventing outflows*

Damage or removal of structures

It is important to ensure structures within and adjacent to WSUD assets (such as bollards, seating, pathways, pits, kerbs etc.) are in good working condition and not posing a risk to the public. Structures can be impacted by age, impact from vehicles, vandalism, storm event and debris damage.

Audit Criteria

Condition rating	Criteria	Works
Performance target	• No damage, erosion or issues, removal of structures or safety risks due to infrastructure damage	
Good condition	• Stable structures • No vandalism impacting amenity • No safety risks	None
Moderate condition	• Minor damage • Does not pose risk to structural integrity or asset function • No safety risks	Maintenance
Poor condition	• Major damage • Poses risk to structural integrity, public safety or asset function	Rectification

Example Images

Condition rating	Example images
Moderate condition	   *Minor damage to structures not causing major risk to public or structural integrity of asset*
Poor condition	 *Unstable batter causing risk to structure*

Erosion or scour

Erosion is typically caused by high velocity flows, poor vegetation cover, poor soil conditions or a combination. It is important to identify the cause of the erosion before undertaking maintenance works. Erosion on the batters, surface or around inlets and outlets can create issues for public health and safety and also impact the function of the WSUD asset (e.g. erosion can result in the short circuiting of flows through a system and reduce treatment performance). Particular attention should be given to areas around inlets and outlets.

Audit Criteria

Condition rating	Criteria	Works
Performance target	• Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	
Good condition	• No erosion	None
Moderate condition	• Minor erosion • Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Maintenance
Poor condition	• Major erosion • Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	Rectification

Example Images

Condition rating	Example images
Moderate condition	 *Minor erosion not causing risk to public or asset function*
Poor condition	  *Major erosion putting public and structures at risk*

Extended detention depth

The extended detention depth is the difference between the asset surface level and the outlet level for assets such as bioretention, swales, infiltration trenches and basins

For wetlands and sediment pond the extended detention depth is the difference between the normal water level and the overflow weir or pipe. The normal water level is the level below which water cannot drain through an outlet but infiltration, evaporation and transpiration can occur).

When a storm event occurs, the extended detention depth is filed an then draws down as water infiltrates through the filter media or flows through the outlet pipe or weir in a controlled manner. It is important that the extended detention depth is not compromised through over-filling of filter media or mulch or sediment accumulation. This reduces the storage volume of the asset and the treatment effectiveness and can also result in bypass.

To check this item it is necessary to refer to the extended detention depth identified in the design of the asset and confirm this has been retained. It is very common for extended detention depth to be compromised in bioretention systems through over-filling during construction or maintenance.

Audit Criteria

Condition rating	Criteria	Works
Performance target	• Extended detention depth complies with design	
Good condition	• Design extended detention depth provided	None
Moderate condition	• At least 50% of design extended detention provided	Maintenance
Poor condition	• Less than 50% of design extended detention depth provided	Rectification

Example Images

Condition rating	Example images
Moderate condition	 *Reduced extended detention depth due to elevated surface levels* 
Poor condition	 *No extended detention provided due to outlet sitting at the same level as the base of the asset* 

Floating plants

Floating plants can be problematic in WSUD assets which permanently hold water for a number of reasons including:

- Decomposition of floating plants creates a readily available carbon source in water bodies which can lead to poor water quality
- Coverage of a system with floating plants hides the visibility of the open water which can reduce the amenity of the system and also cause a public health and safety issue as people can think they can walk into the system without understanding there is water below the vegetation.
- Coverage of floating plants limits light penetration and results in loss of other vegetation and aquatic species

Audit Criteria

Condition rating	Criteria	Works
Performance target	• No nuisance floating plants present	
Good condition	• No or minimal nuisance floating plants present (<10%)	None
Moderate condition	• Low/Moderate cover (10-50%) • Mechanical removal of nuisance floating plants is effective in managing blooms	Maintenance
Poor condition	• Nuisance floating plant blooms are problematic (>50% cover), impacting on wetland performance and too extensive to remove mechanically	Rectification

Example Images

Condition rating	Example images
Moderate condition	 *Low nuisance floating plant cover*
Poor condition	 *>50% cover of nuisance floating plants*

Leaf litter

Leaf litter can accumulate and become saturated within a WSUD asset. Breakdown of the leaves in saturated conditions can produce fine organic matter that can leach nutrients into the asset and downstream waterways and in the long term can also cause clogging of the filter media surfaces. A heavy leaf litter load can block inlets and outlets and also impede flows and vegetation growth in the asset.

Audit Criteria

Condition rating	Criteria	Works
Performance target	• No accumulated leaf litter causing blockages or impeding flows or vegetation growth	
Good condition	• Minimal leaf litter present or covers less than 20% of surface	None
Moderate condition	• Some wet and decaying leaf matter present (covering 20-50% of surface) • Aesthetic issue • Some obstruction of flow paths	Maintenance
Poor condition	• Large amount wet and decaying leaf matter present (covering >50% of the surface) • Impacting vegetation growth • Obstructing flow paths and blocking inlets or outlets	Rectification

Example Images

Condition rating	Example images
Moderate condition	  *Leaf litter not causing damage to plant health or obstructing flows*
Poor condition	 *Leaf litter accumulating and becoming a blockage in outlet*

Mosquitoes

Mosquitoes can be problematic in WSUD assets if they retain water in isolated pools. Systems which are designed to hold water usually have a low mosquito risk as these assets are designed to have a permanent water body that supports mosquito predators. Issues typically arise for mosquitos where there are isolated depressions which fill with water after rain, or rafting vegetation which create and hold isolated pockets of water.

Audit Criteria

Condition rating	Criteria	Works
Performance target	• No nuisance populations of mosquitoes or suitable mosquito breeding sites	
Good condition	• No isolated depressions which can become breeding sites when water levels recede • Deep pools provide refugia for predators • No dead or rafting vegetation	None
Moderate condition	• Potential mosquito habitats observed (e.g. isolated pools, rafting vegetation)	Maintenance
Poor condition	• Nuisance populations of mosquitoes observed and/or reported by local community • Numerous potential mosquito habitats observed (e.g. isolated pools, rafting vegetation)	Rectification

Example Images

Condition rating	Example images
Moderate condition	 *Rafting edge vegetation can create pockets in which mosquitos can breed*  *Isolated pools of water provide mosquito habitats*

Nuisance fauna

Nuisance fauna, which may include birds, mammals or aquatic species or declared pest species (e.g. Carp) can be problematic for WSUD assets as they can cause vegetation damage (e.g. by trampling or removing vegetation), can cause water quality issues (e.g. defecation into the system) or impact the native biodiversity of the system.

Audit Criteria

Condition rating	Criteria	Works
Performance target	• No nuisance fauna	
Good condition	• No nuisance fauna	None
Moderate condition	• Some nuisance fauna but limited impact on aesthetics, water quality and/or vegetation growth	Maintenance
Poor condition	• Significant nuisance fauna issues • Heavily impacting aesthetics, vegetation growth and/ or water quality	Rectification

Example Images

Condition rating	Example images
Moderate condition	  *Some damage caused by digging on surface (left) and carp in wetland (right)*
Poor condition	 *Bank erosion caused by nuisance water birds*

Permeability and clogging

There are a number of WSUD assets which require permeable media to perform their intended stormwater management function including bioretention basins, bioretention swales, raingardens, tree pits as well as porous pavements and infiltration systems. Maintenance is required to ensure the permeability of these assets is preserved, allowing stormwater flows to freely drain through them.

Audit Criteria

Condition rating	Criteria	Works
Performance target	• Infiltration / hydraulic capacity of the system is preserved	
Good condition	• Dry Conditions: Water poured on surface infiltrates almost immediately , minimal fine sediment accumulation. • Wet Conditions: Surface ponding (100 - 300mm) for bioretention systems is drawn down over 1 - 3 hrs after inflow to the system has stopped following rainfall.	None
Moderate condition	• Dry Conditions: Water infiltrates surface slowly but ponding clears within minutes, some fine sediment accumulation. • Wet Conditions: Surface ponding observed for longer than normal (more than 3 hours).	Maintenance
Poor condition	• Dry Conditions: Water ponds with minimal infiltration, significant fine sediment accumulation. • Wet Conditions: Surface ponding (100 - 300mm) remains more than 12 hrs after inflow to the system has stopped following rainfall. Presence of algae or moss may indicate persistent wetting (e.g. baseflows) or clogging requiring further investigation.	Rectification

Example Images

Condition rating	Example images
Moderate condition	  *Some clogging of filter media (slow infiltration of flows) caused by silt+clay content and sediment accumulation*
Poor condition	 *Ponding water in bioretention system*  *Very high silt + clay content restricts infiltration rates (>50%)*  *Ponding water in infiltration trench*

Plant cover

Vegetation is critical to the treatment performance in most WSUD assets and therefore maintenance is required to ensure the plant cover meets the design requirements.

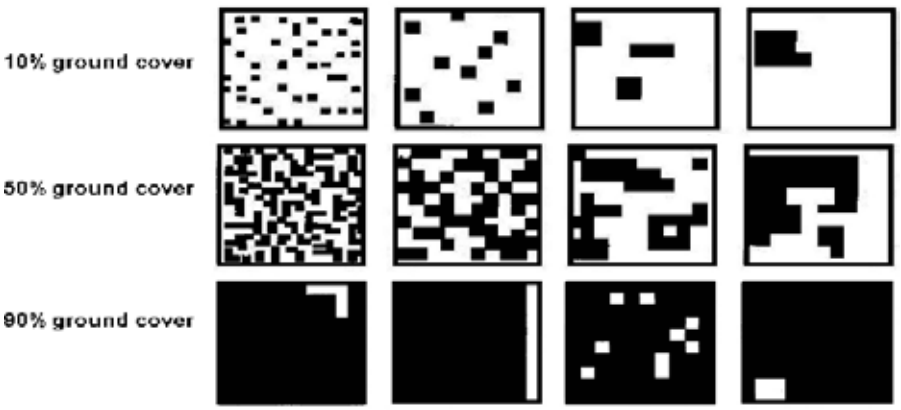
Audit Criteria

Condition rating	Criteria	Criteria (Tree pits)	Works
Performance target	• Good vegetation cover over >80% of the planted surfaces	• Tree present	
Good condition	• Good vegetation cover in planted areas (>80% cover / >6 plants per m^2)	• Tree present	None
Moderate condition	• Moderate vegetation cover in planted areas (50-80% cover)	• Tree not present, replacement only required	Maintenance
Poor condition	• Poor vegetation cover in planted areas (<50% cover)	• Tree not present and other functional issues	Rectification

Example Images

Condition rating	Example images
Moderate condition	 *Some bare patches in vegetation cover in bioretention (left) and wetland macrophyte zones (right)*
Poor condition	 *Complete lack of vegetation cover in bioretention (left) and wetland macrophyte zone (right)*

Stylised guide to help estimate vegetated cover proportions (Eyre et al, 2011)



Plant health

Poor plant health can impact WSUD asset performance and be caused by poor growth, inappropriate species selection for the hydrology of the zone, excessive inundation, weed competition, smothering by sediment and leaf litter and lack of water due to inlet blockage or flow distribution problems.

Audit Criteria

Condition rating	Criteria	Works
Performance target	• Good vegetation health	
Good condition	• Healthy vegetation	None
Moderate condition	• Vegetation is stressed • Poor health (signs of disease, pests) in less than 20% of plants	Maintenance
Poor condition	• Vegetation is dying back • Poor health (signs of disease, pests) in more than 20% of plants	Rectification

Example Images

Condition rating	Example images
Moderate condition	  *Plants still alive but showing signs of stress (e.g. lack of water)*
Poor condition	  *Plants dead or dying*

Rubbish

The type and size of litter in WSUD assets can range from cigarette butts and plastic bags to furniture and shopping trolleys. Maintenance is critical to ensure rubbish does not result in blockages, impede flows across the surface of the asset and to preserve aesthetics (especially in highly visible locations).

Audit Criteria

Condition rating	Criteria	Criteria (GPT)	Works
Performance target	• No rubbish present	• No potential loss of litter from sump	
Good condition	• No rubbish present	• Some litter present (<80% of capacity)	None
Moderate condition	• Some rubbish present • Diminished aesthetics and /or causing some visible blockage	• Large amount of litter present (>80% of capacity)	Maintenance
Poor condition	• Large amount of rubbish present • Heavily impacting aesthetics and/or blocking flows	• Frequency of cleanout much less than design or cleanout difficult due to access issues.	Rectification

Example Images

Condition rating	Example images
Moderate condition	  *Some rubbish present which can be easily removed by hand*
Poor condition	 *Large items of rubbish which require equipment to remove*

Sediment accumulation

Sediment accumulation in WSUD assets can change the profile of the asset, cause bypass, redirection and short-circuiting of flows, smother vegetation and clog filter media.

Audit Criteria

Condition rating	Criteria	Criteria (sediment pond)	Criteria (GPT)	Works
Performance target	• No accumulated sediment impeding flows or vegetation growth	• No accumulated sediment or minimal sediment with no obvious impacts	• No excessive accumulation of sediment with potential loss of material from sump	
Good condition	• No accumulated sediment or minimal sediment with no obvious impacts	• No accumulated sediment or minimal sediment with no obvious impacts	• Some accumulated sediment present (<80% capacity)	None
Moderate condition	• Some accumulated sediment (covering less than 50% of surface) • Causing some redirection of flows through the system	• Water depth above sediment surface is less than 0.5 m	• Large amount of sediment present (>80% of capacity)	Maintenance
Poor condition	• Accumulated sediment covering more than 50% of the surface • Impeding or significantly redirecting flows • Smothering vegetation	• Frequency of cleanout much less than design or at least once a year. Sediment cleanout difficult due to access issues.	• Frequency of cleanout much less than design or cleanout difficult due to fine sediment compaction	Rectification

Example Images

Condition rating	Example images
Moderate condition	 *Sediment accumulation causing some redirection of flows*
Poor condition	 *Sediment smothering vegetation*

Standing water or boggy conditions

WSUD assets such as swales, are typically designed with a slope to freely convey stormwater along their length. They will naturally infiltrate stormwater and will be wet following rainfall. However, they may retain water and become boggy when the surface slopes are too flat or the outlets are set too high.

Audit Criteria

Condition rating	Criteria	Works
Performance target	• Well drained with no surface ponding or boggy areas	
Good condition	• Well drained with no surface ponding or boggy areas	None
Moderate condition	• Partially impacted drainage, with boggy conditions only occurring after rain and drying out within 24 hours	Maintenance
Poor condition	• Standing water present and/or continued boggy conditions which is making maintenance difficult	Rectification

Example Images

Condition rating	Example images
Moderate condition	 *Boggy invert in swale, slow to drain after rain events but can still be mown*
Poor condition	 *Standing water at base of swale making maintenance difficult*

Surface levels

An evenly graded surface allows stormwater to flow through the WSUD assets as designed without the creation of preferential flowpaths or creation of isolated pools which can become mosquito breeding habitats. It also ensures that the whole surface is engaged with water flowing over or infiltrating through the surface to provide treatment. Common causes of uneven surface levels are lack of levelling during construction, erosion and slippage of batters.

Audit Criteria

Condition rating	Criteria	Works
Performance target	• Even surface with no depressions or mounds. Base is flat with flows evenly distributed across asset surface.	
Good condition	• Even surface with no depressions or mounds. Base is flat with flows evenly distributed across asset surface	None
Moderate condition	• Some small depressions or mounds present or preferential flow paths. Base is mostly flat with flows evenly distributed across most of asset.	Maintenance
Poor condition	• Significant depressions or mounds present or defined preferential flow paths. Surface levels are impacting flows through the asset (e.g. short circuiting flows, blocking flows, limited flow distribution).	Rectification

Example Images

Condition rating	Example images
Moderate condition	 *Small depressions on surface not impacting flows or drainage*
Poor condition	 *Stormwater flows unable to enter asset due to elevated surface levels*

Vehicle or Pedestrian Damage

WSUD assets located within streetscape, carparks or other areas which have high levels of vehicular and pedestrian movement can be damaged when these enter the asset. Damage includes compaction or erosion of the surface or damage to structure and vegetation.

Audit Criteria

Condition rating	Criteria	Works
Performance target	• No compaction, plant loss, vandalism impacting system function	
Good condition	• No compaction, plant loss, vandalism impacting system function	None
Moderate condition	• Minor compaction, plant loss • Does not pose risk to structural integrity or asset function	Maintenance
Poor condition	• Significant compaction, plant loss • Poses risk to structural integrity, public safety or asset function	Rectification

Example Images

Condition rating	Example images
Moderate condition	 *Minor tracks caused by vehicle damage*
Poor condition	 *Major impact (plant loss) caused by ongoing vehicle damage requiring bollards to stop vehicles*

Water levels

There are a number of WSUD assets which are designed to retain water (i.e. wetlands and sediment ponds). These systems require dense vegetation to operate as designed and therefore it is critical the water level depths and variation in the depths can support healthy vegetation. Water level issues can be associated with low catchment inflows, incorrect surface levels or incorrect water levels set by outlets. Of particular concern are water levels in wetlands remaining elevated well above the normal water level due to higher than expected inflows or baseflows that may drown plants.

Audit Criteria

Condition rating	Criteria	Works
Performance target	• Water level depths and drawdown suitable to support healthy plant growth	
Good condition	• Water level height and variation as designed • Diverse vegetation confirms confidence in appropriate water level variation	None
Moderate condition	• Some concerns about water levels and variation but impact on vegetation health and treatment performance is small	Maintenance
Poor condition	• Significant concerns about water level variation and effects on vegetation. • Impact on treatment performance is expected to be significant.	Rectification

Example Images

Condition rating	Example images	
Moderate condition		*Low water levels in wetland causing some dieback of vegetation in the macrophyte zone*
Poor condition		*Elevated water levels in wetland resulting in complete dieback of macrophyte zone vegetation*

Water quality

WSUD assets are designed to treat stormwater and therefore typically stormwater of poor quality. However, water quality issues such as oil slicks, excessive algae growth and odours can be problematic for assets in terms of aesthetics and function. The presence of these issues may also be an indication that something is wrong with the asset.

Audit Criteria

Condition rating	Criteria	Works
Performance target	• No water quality issues (oil slicks, odours, algae)	
Good condition	• No water quality issues (oil slicks, odours, algae)	None
Moderate condition	• Some minor water quality issues visible (oil slicks, odours, algae) but no major impact on aesthetics or water quality	Maintenance
Poor condition	• Significant water quality issues (oil slicks, odours, algae) • Heavily impacting aesthetics and/or water quality	Rectification

Example Images

Condition rating	Example images
Moderate condition	 *Some algal growth on vegetation*
Poor condition	  *Significant algal growth*

Weeds

Weeds and nuisance plants species can impact the aesthetics and function of WSUD assets and ideally, these plants should be removed as soon as they appear.

A list of declared noxious weeds can be found on the Agriculture Victoria website at: http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/protecting-victoria-from-pest-animals-and-weeds/legislation-policy-and-permits/declared-noxious-weeds-and-pest-animals-in-victoria

Further details and advise on timing for treatment can be found at: http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/weeds/a-z-of-weeds

Audit Criteria

Condition rating	Criteria	Works
Performance target	• Limited weed cover with no declared noxious weed species	
Good condition	• Limited weed cover (<10%) and no declared noxious weed species	None
Moderate condition	• Low/Moderate weed cover (10-50%) and no declared noxious weed species	Maintenance
Poor condition	• High weed cover (>50%) • Declared noxious weed species present	Rectification

Example Images

Condition rating	Example images
Moderate condition	 *Low weed cover*
Poor condition	 *>50% weed cover*

4. Identification and prioritisation of maintenance and rectification actions

Once the condition of an asset has been assessed, maintenance and rectification works can be identified (Section 4.1) and then prioritised (Section 4.2), to develop a transparent and robust maintenance plan and budget.

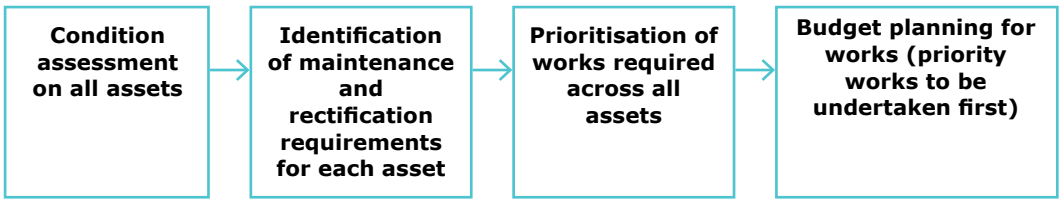


Figure 15 - Diagram representing how audit outcomes can be used to inform budgets and planning

4.1 Identification of maintenance and rectification actions

The condition ratings for audit items will provide an indication of the level of works required for each asset:

- Items rated "Good" (1) will require no action
- Items rated "Moderate" (2) will typically require a 'Maintenance works' response
- Items rated "Poor" (3) will usually require a 'Rectification works' response

  It is recognised that many Councils will have separate programs for planned maintenance (operating) and rectification works (capital) and thus require maintenance and rectification works to be prioritised separately.
- **Maintenance works** – are works that typically require minimal resources and can be completed at the time of audit or scheduled as actions for a Council maintenance team. They primarily involve actions such as removal of debris and litter, minor maintenance of the filter media to ensure good drainage (levels and infiltration rate), weeding, pruning and minor replanting. These tasks can be undertaken during audits or planned as future maintenance works.
- **Rectification works** – are corrective works where a more comprehensive effort is required to address an issue. If an asset is in poor condition and requires rectification works these should be referred to the asset manager because the works are likely to be more time consuming and expensive than other maintenance actions. Detailed investigations may be needed to determine the cause of the issue and to select an appropriate response. Responses may involve re-design or resetting of the asset. While some works may be undertaken by Council's maintenance team, they are likely to require a contractor or specialist skillset or equipment. These activities need to be planned with allocated budget.

An asset can be reviewed using the flow chart in Figure 16 to help identify the appropriate response for each asset based on the condition assessment outcomes. This considers the condition ratings of audit items to identify what type of actions need to be undertaken.

The highest condition rating assigned to an asset will determine whether it is classified as 'No works', 'maintenance' or 'rectification. If any items receive a condition rating of 3, it will be assigned for rectification, if any are 2 but none 3 it will be assigned for maintenance or if all condition ratings are 1 it will be assigned for No works.

It would be common to split the assets into two lists, one for maintenance and one for rectification and then rank these from lowest to highest to obtain initial priority listings for the maintenance and rectification programs (typically operating and capital programs and expenditure respectively).

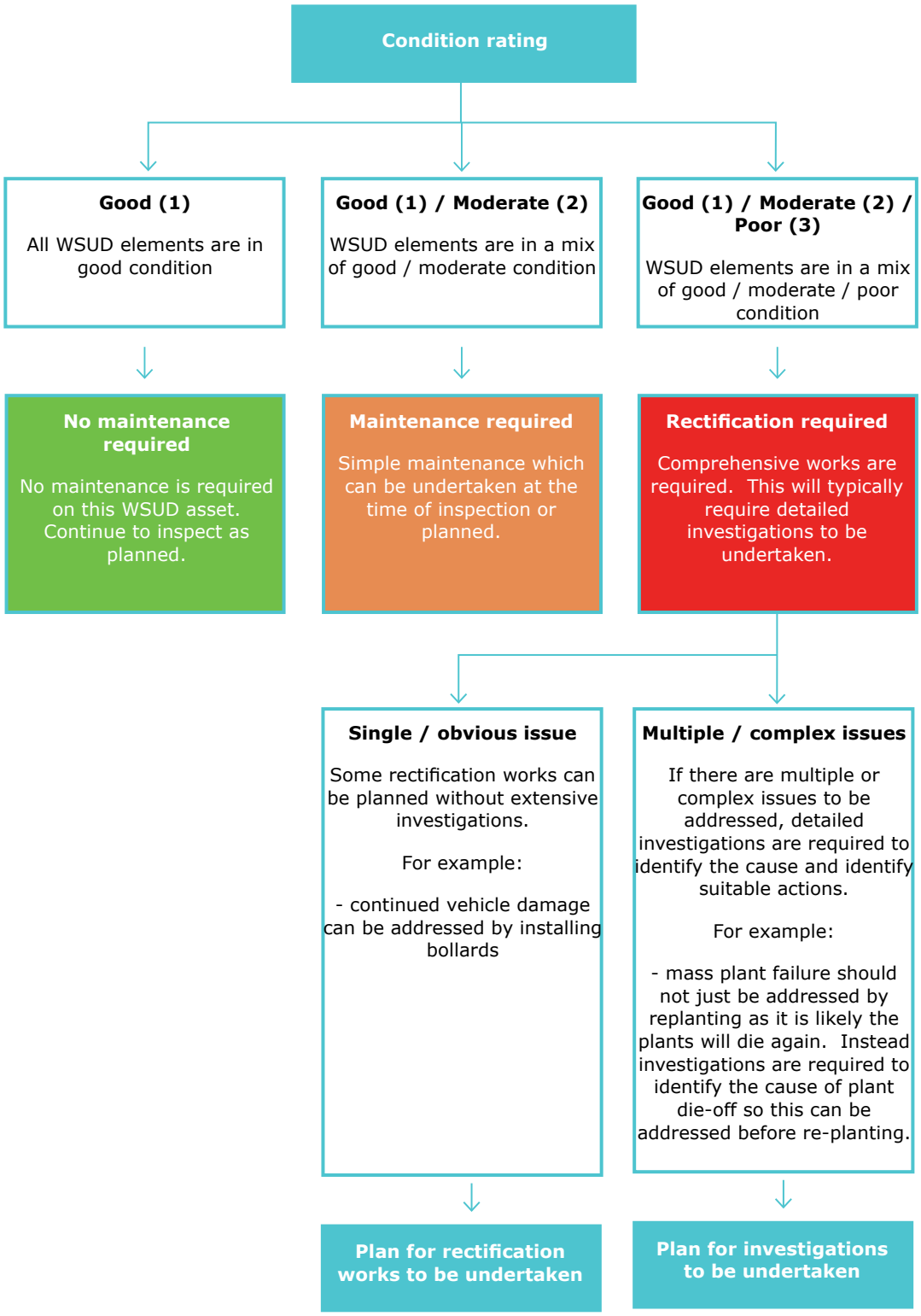


Figure 16 - Diagram showing how condition assessment outcomes can be used to identify appropriate maintenance requirements

4.2 Prioritising maintenance and rectification works

Once the maintenance and rectification works for each WSUD asset have been determined, these need to be actioned though planning, budgeting and prioritisation. Maintenance and rectification works are usually undertaken in an environment where resources are limited and hence the works and assets must be prioritised. Some fundamental questions are:

- Which assets should we prioritise?
- What actions will give the greatest functional improvements?
- What will improve amenity where it counts most?
- What actions are prudent to undertake now?
- What can we afford to do?

Works can be prioritised by consideration of the whole asset, by individual actions or both. The framework proposed below prioritises works based on an asset. It takes into account the condition of the asset with respect to its impact on three condition factors:

1. Function and stormwater quality treatment
2. Risk
3. Amenity

It also takes into account the relative value and importance of the asset based on three asset factors:

1. Significance of asset
2. Catchment risk and sensitivity of downstream receiving environment
3. Visibility

These condition and asset factors are described in the following sections.

4.2.1 Condition

The condition of an asset is the fundamental consideration and the main purpose of maintenance and rectification works is to ensure assets are functioning as intended.

While common sense suggests assets in poorer condition will require more attention and works, it is typically more cost effective to keep an asset in good condition than repair an asset already degraded. This approach is commonly used for waterways where greater effort is directed towards preserving healthier waterways in better condition than expending effort on heavily degraded waterways. On this basis it is recommended effort should generally be directed as follows:

- Firstly towards assets mostly in good or moderate condition with only one or two maintenance issues affecting functional performance.
- Subsequent efforts should then shift to rectifying those assets that are in poor condition for one or two reasons that can be identified and rectified with confidence.

- Lastly, assets that are in very poor condition and require major works or where works will only result in limited improvements. A portion of maintenance budget should be directed, on an ongoing basis, to keeping assets in good condition to prevent degradation and costly rectification works.

The following condition factors should be taken into account:

- **Function and stormwater quality treatment**
  - The primary purpose of WSUD assets is to improve stormwater quality therefore maintaining this function is a priority for maintenance efforts.
- **Risk**
  - Public health and safety - Issues such as blue green algae, trip hazards, compromised structural integrity of banks or structures may present a risk to public health and safety.
  - Continued damage - Some maintenance issues can be safely left for some time while others require prompt action to prevent the issue developing into a problem requiring a more costly response. For example , the blockage of an inlet or outlet may be easily cleared but if left unattended can quickly result in drying out or inundation of plants resulting in extensive plant loss. These issues should be given higher priority than addressing aesthetic or functional issues.
  - Local environmental impact - The presence of weeds or nuisance fauna (particularly declared noxious weeds or pests) in a WSUD asset may present a risk to native flora or fauna and these may need urgent management action even if functional implications are minimal.
  - Flooding - WSUD assets may provide a level of flood protection or present an increased risk of local nuisance flooding if they are not functioning properly. If an asset is bypassing flows or not draining as designed due to blockage or clogging than action may be needed to minimise local or upstream flood risks.

Figure 17 - Flooding upstream of a raingarden with compromised extended detention depth

- **Amenity**
  - The amenity of an asset should be maintained to meet community expectations. Assets in high profile locations such as popular parks, shopping strips or other highly trafficked areas may be maintained to a higher standard than less visible assets. While focussing on treatment function, improving and not detracting from amenity value and presenting an appealing example of WSUD is also important. Assets that are well maintained for amenity build community support for WSUD programs while poorly presented ones can create opposition.

    An example of why amenity can be important: In one council, a concept design for a new streetscape raingarden was prepared. During community consultation the proposed raingarden was opposed on the grounds that other assets located a few streets away were quite unappealing due to design issues and a lack of effort to restore lost plant cover.

The condition factors above can be given a score based on the outcomes of the audit (see Table 12).

Table 12 - Prioritisation categories and relevant audit items for condition factors

Condition factor	Audit items
Function and stormwater quality treatment	- Water levels - Blockage - Permeability and clogging - Plant cover - Water quality (oil slicks, odour, algae)
Risk - Public health and safety – poor water quality, blue green algae, trip hazards, structural integrity issues - Continued damage – blockage or inundation patterns - Flooding – Increased flood risk due to blockage or clogging - Local environmental impacts – Weeds or nuisance fauna that may spread	- Blockage - Erosion - Damage or removal of structures - Water quality (oil slicks, odour, algae) - Weeds - Nuisance fauna - Mosquitos
Amenity – Appearance of asset and effect on surrounding area given its context	- Plant cover - Rubbish - Damage or removal of structures

4.2.2 Asset Class Factors

Besides condition, it is also useful to consider the priority of different assets. This can be determined by establishing different 'classes' of assets with varying priority, e.g. high, low, medium. The Asset Class Factor considers the context of the asset, where it is located, its significance and the catchment in which it is located. The following asset class factors should be taken into account based on the asset characteristics:

- **Significance of asset** - The benefits of WSUD assets extend beyond stormwater treatment and may also include enhanced amenity, improved recreational areas, water features, cooling the urban environment, reduced flood risk, or provision of habitat, etc. The significance of an asset is determined by the catchment size, asset size and pollutant load reduction capacity relative to other assets within the catchment and municipality.
- **Catchment risk and sensitivity of downstream receiving environment** - Most urban catchments contain a mix of land uses with most presenting similar levels of risk. Those with commercial or industrial activities, roads or high risk uses such as materials recycling or extensive construction can present increased risk to receiving waters through increased litter, sediment and heavy metals discharges. These catchments can be identified through an assessment of catchment risks.

  A prior assessment of catchment and downstream receiving water values can support prioritisation of effort towards catchments with significant values requiring protection. For example, WSUD assets located upstream in catchments with sensitive waterways, RAMSAR sites, natural wetlands and high profile public destinations like lakes or beaches will be a higher priority for maintenance.
- **Visibility** - The visibility of an asset is determined by the number of people passing or visiting an asset and the frequency and duration of this contact. Highly visible assets such as a rain garden in a shopping strip or wetland in a highly used park will usually be maintained to higher aesthetic standards than assets hidden from view where aesthetic impacts such as litter and sediment accumulation, not affecting function, are less critical.

The asset class factors relate to the asset as a whole and are calculated based on information collected when an asset is entered into the database. A template for capturing new asset information is provided in Chapter 8 - Asset Data Management.

The asset class factors account for external factors that influence the relative importance of the asset. The asset factors are summarised in Table 13. A score of '1' is assigned for high and '3' for low so the most significant, sensitive or visible assets will receive the lowest scores.

Table 13 - Prioritisation categories and audit items for Asset factors

Asset Class Factor	High	Medium	Low
Score	1	2	3
Significance of asset	• Asset is a major regional WSUD asset • Asset is the main WSUD asset within the catchment	• Asset is one of a number of assets with the catchment or is of moderate size	• Asset is a small asset providing limited pollutant load reductions
Catchment risk and sensitivity of downstream environment	• High risk land use activities exist within the catchment such as materials recycling, extensive construction • Catchment contains extensive commercial or industrial areas or very high proportion of major roads. • Highly sensitive downstream environment (e.g. RAMSAR site, waterway in moderate or better condition or high profile public destination)	• No high risk land use activities in catchment • Moderately sensitive (e.g. degraded urban waterways in poor or very poor conditions)	• No high risk land use activities in catchment • Catchment is predominantly residential, open space, conservation area with minimal commercial or industrial activity • No sensitive downstream environment (e.g. concrete drain)
Visibility	• Visible to the broader community providing recreation/ amenity values (i.e located in district, metropolitan parks and main streets)	• Visible to the local community providing recreation/amenity values (i.e located in local, neighbourhood parks and streets)	• Not visible or accessible to the general public and provides no recreation or amenity values (i.e located in conservation park)

4.3 Prioritisation scoring

For transparent prioritisation, an overall score for each WSUD asset can be calculated. The following is a proposed methodology for calculating an asset score based on the above factors. Two interim scores for condition factor and asset factor are calculated and used to determine a single overall asset score as follows:

A *condition factor score* is calculated by multiplying the scores for each of the underlying factors by a weighting and averaging these. In recognition that stormwater treatment function is a higher priority while amenity is typically lower, the following weightings are assigned but can be adjusted depending on the priorities of the asset manager:

- Function: 1
- Risk: 0.8
- Amenity: 0.5

An *asset factor score* is calculated by multiplying the scores for each of the underlying factors by a weighting and averaging these. The following weightings are assigned but can be adjusted depending on the priorities of the asset manager:

- Significance of asset: 1
- Catchment risk and sensitivity of downstream receiving environment: 1
- Visibility: 0.5

The *final asset score* is calculated by multiplying the condition factor score by the asset factor score as shown in Figure 18. The final asset score can be used to rank and prioritize each asset to develop a maintenance and budget plan.

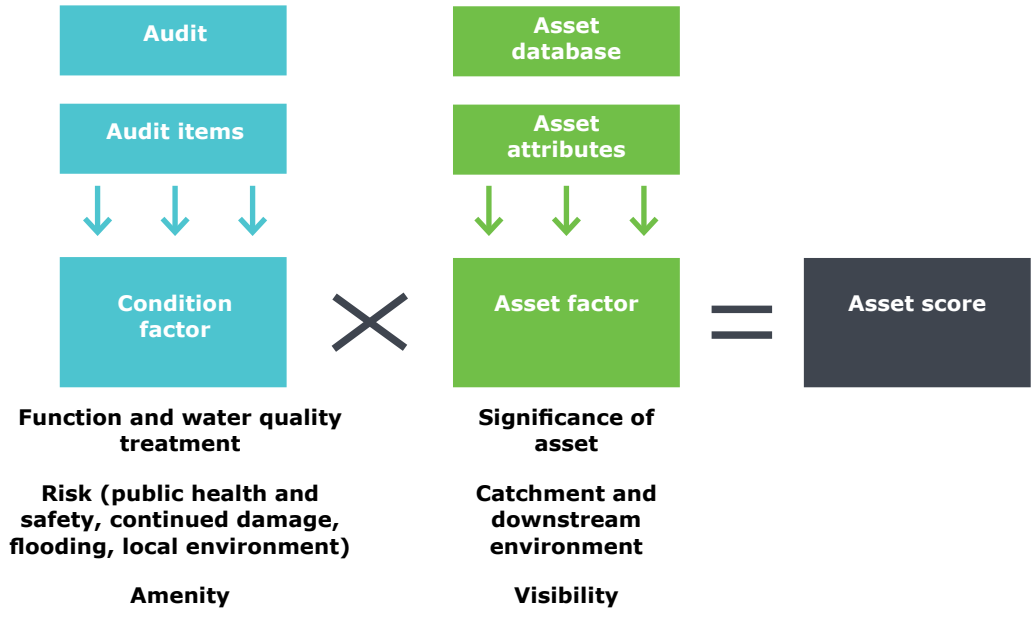


Figure 18 - Calculation of asset score based on condition and asset factors

Note: The asset score, as well as rankings for maintenance and rectification can be found at the far right end of the InspectionOutcomesDatabase sheet in the templates spreadsheet provided.

It is important to recognise the asset score provides an initial potential prioritisation to inform a broader decision making process by the asset manager that should take into account the following:

- Asset score
- What was the determining factor for the score?
  - Condition factors
  - Asset factors
- Potential to improve outcomes (function, risk, amenity)
- Estimated costs and resources available
- Legislated requirements - public health and safety, declared noxious weeds
- Risks and consequences of not addressing condition issues
- Other Council drivers

These considerations should be used to re-rank the assets to ensure that any particular assets or issues (especially health and safety or critical preventative works) are addressed and Council is able to meet its broader objectives.

Alternate prioritisation approaches

Another way to think about priority is for higher priority to be given to works that significantly improve or protect function of the assets and address safety risks while amenity and 'house-keeping' works that have less effect on functionality are a lower priority. The priority given to amenity and risk considerations will depend upon the asset managers priorities. To use this approach, an understanding of the potential (unimpaired) as well as impaired performance is needed. The relative potential for improving function by undertaking different works also needs to be estimated.

Using this approach, the asset manager would select either the assets with the greatest difference between actual and potential performance (see Figure 19) or the individual works or collections of works that will make the greatest difference in asset performance relative to cost.

At present, there is limited science and understanding on the performance of 'impaired' assets and the effectiveness of different rectification works to support this approach.

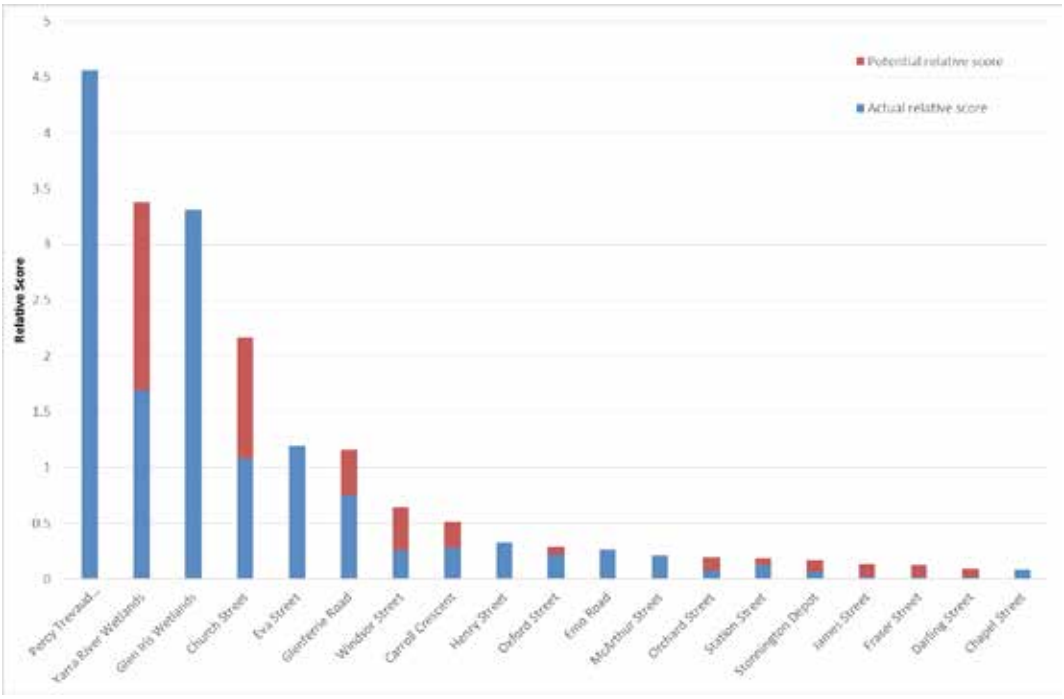


Figure 19 - Ranking of assets by potential and actual relative asset scores. The assets with the largest scores have the greatest effect on overall treatment performance and those with the largest gap (shown in red) have the greatest potential for improvement

4.4 Budget allocations

Resources for maintenance are often limited and budgets must be allocated to support cost effective works and maximise benefits derived. Councils often have separate budgets for operational maintenance and capital renewal works (including major rectification works).

WSUD assets may need to be periodically renewed once they reach the end of their useful life. In the absence of more detailed information on life expectancy typical predicted lifespans can be used. However, it is recognised that well established assets such as wetlands may continue to function effectively well beyond this time and not require renewal so long as they are maintained effectively. Conversely, audits suggest many assets have either failed from the outset due to design, construction and establishment issues or prematurely failed due to a lack of audits and maintenance to mitigate problems leading to failure and require rectification works.

As an initial means of approximating life expectancy for budgeting purposes, it is recommended typical lifespans are adopted for assets with a regular maintenance program and these are approximately halved for assets receiving no maintenance. A set of suggested lifespans are provided is Table 14. These may be further revised following completion of condition assessments.

Table 14 - Lifespan or life expectancy of WSUD assets

Treatment type	Renewal cost as % of construction	Average years to refurbishment
Raingarden or bioretention	80%	20
Swale	80%	20
Wetland	120%	25
Tree pit	80%	20
Pond	120%	25
Sediment pond*	60%	25
Infiltration system	80%	20
Gross pollutant trap	100%	25

*Sediment ponds will typically require sediment clean-out every 5 years.

4.4.1 Annual WSUD management budget based on assets

Prior to obtaining audit data, a Council can estimate its potential annual costs for maintenance and renewal based on unit rates provided by Melbourne Water (Melbourne Water, 2013) (adjusted for inflation to 2016) and the data from its asset database summarising the type, area and age of its WSUD assets.

A spreadsheet for estimating a budget for maintenance and renewal taking into account the above asset lifespans is available as part of the WSUD Audit Guidelines. The spreadsheet is configured to provide an economic estimate of net present costs including application of a discount rate for future costs.

4.4.2 Annual WSUD management budget based on works

Once an asset is in the asset database and audits are undertaken, the data from these audits can be collated and the identification, prioritisation and planning of maintenance and renewal/rectification tasks can be generated.

The costs for each of these can be estimated in terms of personnel hours and quantities of materials (area, volume or plants as appropriate) to develop a schedule of associated costs. These can be aggregated for each asset and for all assets. It is likely that each Council will have their own preferences for how the cost calculations are structured, depending on how they undertake and cost their maintenance. A typical budget for rectification tasks is illustrated in Figure 20.

The next step is to compare the available budget and resources with the priority list of assets and works and determine which works can be undertaken within the available budget and available resources within Council.

This enables a provisional budget to be assigned for WSUD works. Where the budget assigned for WSUD works is less than the provisional estimate or calculated costs of works based on audits, appropriate provisions for liabilities should be entered into Councils accounts to recognise the unfunded future liabilities that are accumulating.

Figure 20 - A typical budget for rectification tasks

Asset No.	Asset Name	Asset Type	Condition score	Priority of works (1-3)	Corrective Actions Required	Time Req. / Task	Staff	Rate	Area	Volume	Rate	Labour cost	Materials cost	Cost Estimate / Task	Timing of works	Total Costs
9	Sediment pond A	Sediment ponds			Stablise steep slope near outlet between footpath and culvert with concrete.	16	2	$ 200		1	$ 300	$ 6,400		$ 6,400		$ 6,400
4	Bioretention C	Bioretention			Scrape surface 50 mm to remove accumulated sediment including site setup.	32	2	$ 200	500	25	$ 400	$ 12,800	$ 10,000	$ 22,800	Works to occur only after construction is near complete	$ 50,200
					Replace filter media as needed.	16	2	$ 200	500	50	$ 100	$ 6,400	$ 5,000	$ 11,400		
					Replant with recommended species at density of 8 plants/m^2.				500		$ 4	$ -	$ 16,000	$ 16,000		
					Construct gate to restrict access to maintenance track								$ -	TBC		
					Rectification works to batter to provide effective maintenance access								$ -	TBC		
7	Wetland A	Wetland and sediment pond			Install an outlet pit, pipe and headwall to replace the porous rock weir while retaining the existing structure as an overflow weir, see Melbourne Water's Constructed Wetlands Design Manual, Part A2, 2015 for details on the design of this type of connection. The decision to recommend a submerged pipe connection rather than a submerged weir is based on consideration of minimising litter flow through to the wetland and lake.	80	2	$ 200				$ 32,000		$ 32,000	Long term	$ 32,000

5 - Maintenance and rectification works

A forward plan should be developed to allow budgeting and resourcing of works, especially rectification works which will typically require additional resources.

5.1 Undertaking maintenance and rectification works

Required information:

The following information should be taken on site when conducting maintenance:

- Summary of issues identified and works required
- Maintenance form
- Layout drawing or images showing the damage to be addressed
- Other drawings as desired

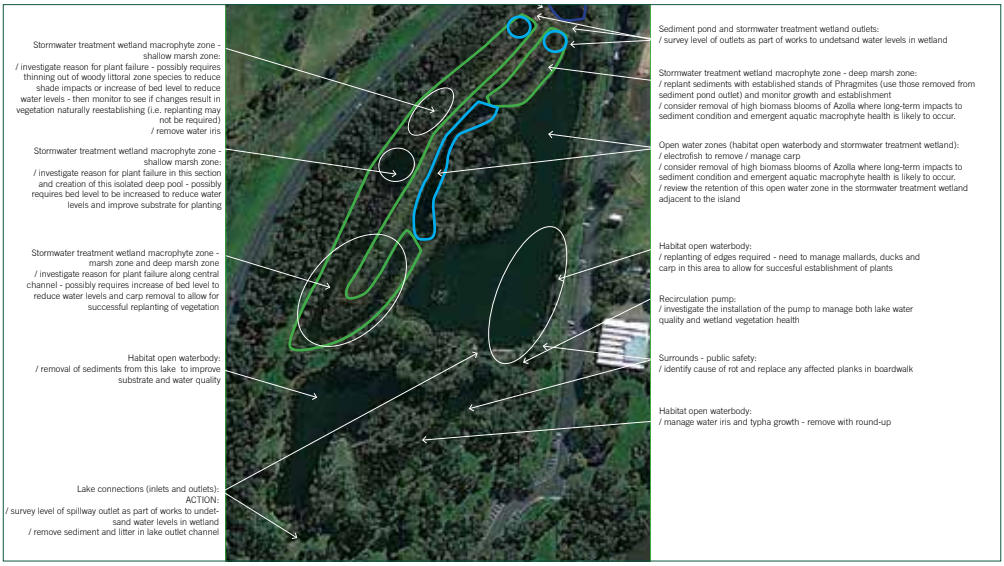


Figure 21 Example of information to be take on site for asset maintenance –plan of asset identifying location of issues to be addressed

Protection of receiving environment

Care should be taken to ensure activities don't negatively impact on receiving environments such as waterways or natural waterbodies.

For example, de-silting operations have the potential to release sediments to the receiving environment. Maintenance staff need to be aware of these considerations when excavating accumulated sediments. This would normally be done in the dry season when the risk of discharge to the receiving environments is lower.

Weeds need to be managed and disposed of carefully to reduce risk of weed propagation in the downstream environment.

Record keeping and reporting

Template audit and maintenance forms have been prepared and are provided in Attachment 8. These can be used to record any maintenance activities required and undertaken on WSUD assets. These forms should be kept in an appropriate maintenance record file for future reference.

These records will identify when WSUD assets are not meeting their performance targets. Ongoing records can allow identification of repetitive non-conformances which should be thoroughly reviewed to understand the root causes and appropriate action taken.

Workplace health and safety

All maintenance activities should be undertaken in a manner that eliminates or minimises the workplace health and safety risks to maintenance personnel as well as public health and safety risks.

For example, working near water can be a dangerous activity and personnel should be appropriately trained before undertaking maintenance work. Weather forecasts should always be reviewed before undertaking maintenance activities and maintenance staff should be wearing PPE equipment appropriate to their task or activity and consistent with Council Guidelines.

Up-to-date "Dial Before You Dig" records should also be sought and maintenance staff should be aware of the location of existing services (i.e. sewer mains, power, communications). These services need to be appropriately protected before maintenance commences.

When undertaking maintenance activities, maintenance staff should:

- Comply with their employer's work health and safety policy and risk management processes.
- Have a thorough knowledge of the potential workplace health and safety risks associated with maintenance activities and how these risks will be managed.
- Be equipped with and wear personal protective equipment (PPE) appropriate to their task or activity.
- Be aware of and actively manage public health and safety risks associated with maintenance activities.

Public safety

If an activity is likely to pose a risk public safety then access to the work area should be appropriately screened to restrict public access.

Use of earthmoving equipment for de-silting operations will require a Traffic Management Plan to ensure pedestrian and traffic safety prior to works.

Maintenance access

Maintenance access should be provided for all WSUD assets to allow for periodic maintenance activities, including sediment and gross pollutant removal. The location of this maintenance access should be identified prior to undertaking maintenance.

5.2 Maintenance and rectification works

The following is a summary of typical maintenance and rectification activities for WSUD assets.

Rectification is a complex subject and the following does not seek to cover all possible types of rectification works. Rather, it provides examples of the more common and typical works that may be undertaken.

Removal of blockages

Works type	Maintenance activities
Maintenance	• Inlets and outlets that are partially blocked with litter or debris can be removed by hand or with hand tools such as tongs and shovels. • Collected debris should be placed into bags or similar and transported to appropriate waste disposal facilities.
Rectification	• INVESTIGATION: If the structures are getting blocked consistently, the cause of the persistent blockage should be investigated to identify appropriate management actions • Potential corrective actions may include: installation of an upstream trash rack or GPT, increase the frequency of maintenance of litter control assets within the treatment train, place appropriate bins in parklands and education of the public to reduce the amount of litter entering the drainage system.

Address damaged / removal of structures

Works type	Maintenance activities
Maintenance	• Monitor condition of structure and identify likely cause of damage.
Rectification	• INVESTIGATION: Identify likely cause of damage and opportunities to reduce re-occurrence. • Repair damage / replace structure

Erosion rectification

Works type	Maintenance activities
Maintenance	• Minor erosion or scour can be re-profiled with hand tools, limiting the damage to adjacent vegetation. Short circuit pathways must also be re-profiled. • Affected areas should then be replanted with the design vegetation (if required). • If fill material is required use the appropriate media for the WSUD asset.
Rectification	• Large areas of erosion may require machinery and new fill material and plant stock to be imported. • INVESTIGATION: If erosion is continually occurring, the cause needs to be investigated (typically caused by high velocity flows, poor vegetation cover or poor soil conditions). It is important to identify the cause of the erosion before undertaking major stabilisation works to ensure that the appropriate actions are being taken. For example, high velocity flows may need to be managed before they enter the asset using devices to slow velocities or disperse flows, and only once these velocities are controlled stabilisation works should be undertaken. • Potential corrective actions may include: installation of flow distribution channels or energy dissipation devices.

Extended detention depth

Works type	Maintenance activities
Maintenance	• In bioretention assets, scrape surface level to provide designed extended detention depth • Minor depressions or mounds can be re-profiled with hand tools, limiting the damage to adjacent vegetation. • Replant with design vegetation as required to fill affected locations.
Rectification	• INVESTIGATION: The following issues with extended detention depth will require corrective maintenance to be undertaken: - Elevated surface levels blocking inflows or not allowing detention to occur at the design depths - Large isolated pools, creating potential mosquito habitat The following provides some recommendations on potential corrective actions: • Elevated surface levels: - Remove plants as needed and set aside. - Remove sediment and re-set surface levels as designed. - Replace plants (if required) at 6-12 plants/m2. - If elevated surface levels were a result of sediment accumulation over time, and not a design, or construction error, consider installing a sediment capture zone (sediment forebay or sediment pond) to collect sediment deposition in a designated location. - If the elevated surface level was a design, or construction error, the appropriate extended detention level can be achieved by either lowering the surface levels (but need to make sure there is at least 500 mm of filter media in bioretention systems) or elevating the level of the inlet and/or drainage outlets. • Large isolated pools: - Large isolated pools may be a result of the WSUD surface (either the base or batters) not being graded correctly (e.g. ensuring water retreats to designated deep pool zones in wetlands) and therefore may be require specific machinery and fill material to create the desired bathymetry.

Removal of floating plants

Works type	Maintenance activities
Maintenance	• Mechanical removal is generally practical for small WSUD assets or small amounts of floating plants. The floating plants can be removed by hand using rakes and floating booms.
Rectification	• If the asset is regularly affected by floating plant outbreaks floating booms or nets can be used to capture and remove this vegetation. • Ongoing control is best achieved by ensuring the edges and macrophyte zones are densely planted, ensuring good cover of emergent aquatic macrophytes to create shade and control the growth rate of floating plants. • INVESTIGATION: If the floating plants are entering the system regularly from upstream systems, a heavily vegetated system upstream of the WSUD asset may be required to capture and shade out the floating plants (such as azolla) to stop them entering the WSUD asset.

Leaf litter removal

Works type	Maintenance activities
Maintenance	• Remove excessive leaf litter from the surface of the asset (including around inlet and outlet areas and smothering plants) using rakes or other appropriate hand tools. • Leaf litter must be removed from the site and composted or disposed of appropriately.
Rectification	• If vegetation or the surface permeability has been damaged, replanting of the design vegetation and scraping away of the top surface of the permeable media may be required. • INVESTIGATION: If large volumes of leaf litter are impacting plant growth and/or permeability and being removed regularly, investigations should be undertaken to identify the source and identify potential management actions • Possible corrective actions may include: replacement of deciduous trees with evergreen trees or inclusion of litter traps at inlet.

Mosquito management

Works type	Maintenance activities
Maintenance	• Remove any potential mosquito habitats: - Fill in isolated depressions which could fill with water after rain - Removal of dead or rafting edge vegetation around deep water zones which can create isolated pockets of water protected from predators • Maintain water in deep pools designed to provide ongoing refugia to support mosquito predators such as small native freshwater fish and macroinvertebrates • Ensure that vegetation with thin vertical upright stems is maintained within the littoral zone around deep water zones as these maximise predation of mosquito larvae by allowing for the passage of small fish and macroinvertebrate predators.
Rectification	• INVESTIGATION: If there is an ongoing issue and nuisance population of mosquitoes are identified in the WSUD asset a site specific investigation should be undertaken to understand the cause and identify suitable actions. For example, regular water quality incidents (such as sewer overflows) can regularly wipe out mosquito predators and need to be addressed.

Nuisance fauna removal

Works type	Maintenance activities
Maintenance	• If the fauna is not causing any issues to the aesthetic or function of the WSUD asset, monitor the situation and if damage is caused by the fauna, look to undertake corrective action
Rectification	• Birds and carp are some examples of nuisance fauna typically known to cause damage to WSUD assets (especially those which hold permanent water). • Birds: - Large populations of some birds (e.g. ibis, ducks and various water hens) can be problematic to WSUD assets, causing damage to vegetation and batters and increasing nutrient loads through defecation. - Nuisance bird populations can be managed by removing their preferred habitat (islands and roosts etc.) and using signage to encourage the public not to feed the birds. - Introduced species such as mallards and hybrids should be trapped and removed. • Carp: - Carp can cause considerable damage to banks, vegetation and water quality. Electrofishing can be used to remove Carp from waterbodies, but is really only practical in predominantly open water systems. This is a highly effective technique if the bathymetry of the system is flat. Drawing water levels down can also make the collection and treatment more effective. By-catch can be easily return to the system. - In heavily vegetated waterbodies, such as stormwater treatment systems, the effective collection of stunned fish can be difficult and good capture rate may not be possible, although open water sections could be electro-fished. Carp would generally occupy these areas, but because of dense surrounding vegetation repeated treatment may be required to significantly reduce populations. - Water level draw-down to create a drying episode can also be an effective control and elimination method for carp. However the drying period needs to be carefully managed in that it needs to be long enough to dry the bed sediments to ensure fish kill but not long enough to have a detrimental impact on perennial emergent aquatic vegetation. In stormwater wetlands which are primarily for water improvement purposes it is may also be possible to use a fish poison such as rotenone. Rotenone is safe for other aquatic vertebrates such as birds, but toxic to frogs and particularly tadpoles. The use of rotenone would require approvals from Department of Conservation.

Permeability

Works type	Maintenance activities
Maintenance	• If the surface crust is fine, use hand tools to remove/scrape clay and fine sediment from around the plants. Remove sediment from site and dispose of appropriately. • Test that the exposed filter media retains the design infiltration rates. • Monitor sediment accumulation to identify any ongoing high sediment loads.
Rectification	• INVESTIGATION: If standing water is present in permeable WSUD assets for more than 12 hours after a rainfall event, there could be 2 causes: - Thick layer of accumulated fine sediment or clay clogging the surface - System is unable to drain The following provides some recommendations on potential corrective actions: • Thick layer of accumulated fine sediment / clay: - Remove existing plants and store appropriately. - Use hand tools or appropriate machinery to scrape off the top 100mm of filter media. - Undertake in-situ hydraulic conductivity testing. If underlying filter media retains design infiltration rate (or similar, hydraulic conductivity tests typically have an accuracy of ± 50%), replace top 100mm with appropriate filter media material. If drainage rate not adequate, determine whether complete reset is required (replacement of entire depth of filter media). - Remove sediment from site and dispose of appropriately. - Replant existing plants and provide infill planting to ensure at least 6-12 plants/m2 (depending on species) coverage once established. • System unable to drain: The following could be causing the system to retain water: - Outlet structure is backwatering – review downstream conditions to identify if there is a constraint to levels that should be removed. Consider the inclusion of a backflow prevention device or modify outlet design or asset type. Wetlands and saturated zone bioretention devices require less depth to drain than typical bioretention systems and a saturated zone can sometimes be retro-fitted to an existing bioretention system - Underdrains or outlet is blocked – remove blockage - High local water table – consider re-setting the system with an impermeable liner or changing the asset type to cope with high groundwater levels

Plant cover

Works type	Maintenance activities
Maintenance	• Replanting small areas can be achieved in a simple and cost effective manner by dividing and relocating existing mature vegetation with rhizomatous root systems. • Choose vegetation from high density stands in a similar inundation zone. • Simply remove and divide the mature plant by splitting it through the base into multiple sections. • Directly plant these new sections into the area which requires replanting.
Rectification	• INVESTIGATION: Review species selection and replant with plants species more suitable for the inundation conditions. This could include using plants which are doing well in similar conditions elsewhere in the asset, or looking at the design drawings or natural templates for that region to identify suitable species. Consider if plant health issues are a factor and address as required (see 'Plant Health'). Increasing the species diversity will provide more resilience to the vegetation in the WSUD asset. • When vegetation is replanted, provide an establishment phase program including monitoring, weeding, infill planting and irrigation is required • If new juvenile plants are required for wetlands where water levels cannot be maintained at a low level during plant establishment, or where grazing waterbirds are present, replant using larger, more mature plants. If these are not issues, tube stock can be used for replanting (this is more cost effective). • Care should be taken by maintenance staff to ensure that the immature plants are not confused with weed species. Juvenile plants can look quite similar and it is important that maintenance of newly replaced plants be carried out by staff that can confidently differentiate weed species from replacement wetland plants.

Plant health

Works type	Maintenance activities
Maintenance	• INVESTIGATION: Poor plant health can be caused by the following: - Lack of water (dry season) - Shade from adjacent vegetation - Disease and pests - Too much water (over inundation) The following provides some recommendations on potential corrective actions: • Lack of water (dry season): - If the vegetation is stressed due to lack of water as a result of an extended dry period, irrigation is required. • Shade from adjacent vegetation: - If the vegetation health is being impacted by shading from other vegetation, look to trim back adjacent vegetation or plant shade tolerant species. • Disease and pests: - Prune affected plant matter (or remove entire plant where necessary), treat if appropriate and replant any plants that have been lost or removed. • Adjust water levels in the wetland (see Water Level Management)
Rectification	• INVESTIGATION: Continued and extensive poor plant health can be caused by the following: - Unsuitable planting media - Unsuitable plants for inundation conditions The following provides some recommendations on potential corrective actions: • Unsuitable planting media: - Bioretention filter media can difficult to establish vegetation in if it has poor water holding capacity. Amendments can be made to increase water holding capacity where soil moisture is identified as being deficient. - Unconsolidated sediments (like sludge) caused by organic matter decomposition can also make it difficult for vegetation to establish. This material needs to be removed and replaced with suitable planting media. • Unsuitable plants for inundation conditions: - Review species selection and replant with plants species more suitable for the inundation conditions • When vegetation is replanted, provide an establishment phase program including monitoring, weeding, infill planting and irrigation if required

Rubbish removal

Works type	Maintenance activities
Maintenance	• Litter can be removed by hand or with hand tools such as rakes, tongs and shovels. Waders or a boat may be required to remove litter from areas with standing water. • Collected litter should be placed into bags or similar and transported to an appropriate waste disposal facility.
Rectification	• INVESTIGATION: If large volumes of litter are being removed regularly, investigations should be undertaken to identify the source and appropriate litter management actions should be undertaken. • Possible corrective actions may include: retrofitting the catchment with litter control devices, GPTs or trash racks, appropriate bins in parklands and education of the public to reduce the amount of litter entering the drainage system.

Sediment accumulation removal

Works type	Maintenance activities
Maintenance	• For minor sediment removal, or cleaning of sediment fore-bays, use hand tools to remove/scrape sediment away. • Remove sediment from site and dispose of appropriately. • Monitor sediment accumulation to identify any ongoing high sediment loads.
Rectification	• If excessive sediment is covering more than 50% of the surface, remove plants as needed and set aside. Remove sediment and re-set surface levels as designed. Replace plants (if required) at 6-12 plants/m2. • Sediment may also need to be removed if it has become unconsolidated (like sludge) due to organic matter decomposition which in turn makes it difficult for vegetation to establish and it can become a nutrient source and cause odour or algal issues. • Sediment will also need to be removed from sediment ponds periodically (typically once every 5 years). This will need to occur when there is less than 1m of water above the accumulated sediment, thereby reducing the capacity of these systems to capture coarse to medium sediments. • Major sediment removal should occur in dry weather, ideally mid/late summer – early autumn when long dry spells can be expected. • When removing sediment, the following considerations need to be made: - If the sediments are contaminated, a licensed waste removal contractor is required to remove waste as per state regulations - Approval for works (e.g. dewatering and draining the asset) may be required • The following steps are typically required to remove sediment from WSUD assets which hold water (e.g. wetlands and sediment ponds): - Where possible ensure asset is off-line (i.e. divert flows around asset by blocking inlets etc) - Lower water level with a maintenance valve or dewatering with a pump, in accordance with approval requirements and ensuring no adverse environmental impacts downstream - Remove and store plants which may be impacted to allow them to be replanted once sediment is removed (e.g. edge zone communities for sediment ponds). - Remove sediment using appropriate machinery, such as a long arm excavator or heavy vacuum loader if sediment needs to be removed from the edge, or a backhoe or excavator if there is reinforced access into the asset. Sediment should only be removed to the design base level of the asset (as identified on the design drawings). - If dewatering area is available, place sediment in this area until it is suitable to move. Ensure there is appropriate sediment control around this area to reduce risk of downstream environmental impacts. Test dry sediment to identify if it is suitable for re-use in landscaping etc. If it is not suitable for re-use on-site, organise transport to an approved recycling or disposal facility. - If dewatering areas are not available, organise sealed truck for transport to an approved disposal facility. • Once sediment is removed and base levels are checked, replant vegetation into disturbed areas to achieve design densities. • INVESTIGATION: Continual, increased or unexplained large sediment loads should be investigated to identify the source of the sediment and to identify potential actions. • Potential corrective actions may include: Enforcing sediment and erosion control on construction sites within the catchment, installing a sediment capture zone (sediment forebay or sediment pond) to collect sediment deposition in a designated location.

Standing water / boggy conditions

Works type	Maintenance activities
Maintenance	• Monitor condition to ensure that boggy conditions don't persist and impact maintenance activities
Rectification	• INVESTIGATION: If standing water is present in the swale for more than 1 day after a rainfall event, or causing persistent boggy conditions that are impacting maintenance, there could be 2 causes: - The surface slope is too flat - System outlet is too high or blocked The following provides some recommendations on potential corrective actions: • Flat surface: - Either regrade the system, install a shallow layer of sandy soil and replant or install underdrainage • Outlet issues: - Lower or modify outlet to allow the system to freely drain - Unblock outlet

Surface level re-profiling

Works type	Maintenance activities
Maintenance	• Re-profile to achieve level surface across the WSUD asset to remove isolated depressions and ensure flows through the asset are not impacted. • Minor depressions or mounds can be re-profiled with hand tools, limiting the damage to adjacent vegetation. • If fill material is require, use the appropriate media. • Replant with design vegetation as required to fill affected locations
Rectification	• INVESTIGATION: The following issues with surface levels will require corrective maintenance to be undertaken: - Elevated surface levels blocking inflows or not allowing detention to occur at the design depths - Large isolated pools, creating potential mosquito habitat The following provides some recommendations on potential corrective actions: • Elevated surface levels: - Remove plants as needed and set aside. - Remove sediment and re-set surface levels as designed. - Replace plants (if required) at 6-12 plants/m2. - If elevated surface levels were a result of sediment accumulation over time, and not a design, or construction error, consider installing a sediment capture zone (sediment forebay or sediment pond) to collect sediment deposition in a designated location. - If the elevated surface level was a design, or construction error, the appropriate extended detention level can be achieved by either lowering the surface levels (but need to make sure there is at least 500 mm of filter media in bioretention systems) or elevating the level of the inlet and/or drainage outlets. • Large isolated pools: - Large isolated pools may be a result of the WSUD surface (either the base or batters) not being grading correctly (e.g. ensuring water retreats to designated deep pool zones in wetlands) and therefore may be require specific machinery and fill material to create the desired bathymetry.

Address vehicle / pedestrian damage

Works type	Maintenance activities
Maintenance	• Vehicle or pedestrian damage often involves compaction or erosion of surface media, vegetation damage or damage to other infrastructure like bollards. • If the damage is related to surfaces and vegetation and is minor, use hand tools to loosen/till top 100mm of soil. Replant with plants likely to deter access (tall, robust with dense foliage) at densities >6 plants/m2 and protect during establishment phase. • If the damage relates to other infrastructure, repair or replace damaged items as needed.
Rectification	• If the damage continues to occur or poses a risk to the structural integrity or performance of the asset, install bollards or fences to stop access into the asset.

Water level management

Works type	Maintenance activities
Maintenance	• During a prolonged dry season vegetation may start to look stressed (especially if there has been 70 days or more of dry weather). • If this occurs, irrigation may be required and/or the water level may need to be topped up.
Rectification	• INVESTIGATION: If water levels are persistently low, the following could be the cause: - A blockage or obstruction may be preventing stormwater from reaching the asset - The asset might be leaking or excessive water infiltrating - The asset outlets or surface may be at the wrong level - The WSUD asset may be too large for the catchment and therefore not getting enough inflows • If water levels are persistently high, the following could be the cause: - The asset outlets or surface are at the wrong level - The WSUD asset may be too small for the catchment and therefore getting too much inflows, too regularly - Persistent baseflows exceeding design expectations may be occurring The following provides some recommendations on potential corrective actions: • Leaking asset: - The outlet should be investigated to see if this is the cause of the leak. If so, it needs to be repaired or replaced. - If the outlet is not leaking, it may be the base or batters of the system, which may require a re-set of the system to install an impermeable liner. • Incorrect surface or structure levels: - Assess the as-constructed levels of the macrophyte zone base and the hydraulic structures (e.g. riser / orifice plate). - Modifications may need to be made to the hydraulic structures (inlet or outlets structures) to create optimal water levels in the wetland. • Asset wrong size for catchment: - The asset may need to be reset and re-sized, or the vegetation design needs to be altered to reflect the actual inundation depths (inundation frequency curves can help this design process). • Asset receiving too much water or regular baseflows: - The outlet may need to be modified to allow water to discharge more freely or for base flows to be diverted to reduce the frequency of elevated water levels

Water quality management (oil slick, algae or odour management)

Works type	Maintenance activities
Maintenance	• Oil spills: - Minor slicks can be left alone if they are not impacting the vegetation or function of a WSUD asset (e.g. wetlands are good at processing low to moderate concentrations of hydrocarbons) • Algae: - Filamentous algae can be removed by hand using rakes and hand tools. if causing amenity issues. Alternatively it can be left (note: filamentous algae is common in recently constructed wetlands and will typically disappear over time.
Rectification	• Oil spills: - The impact of moderate or major oil slicks should be minimised immediately through the use of barriers such as floating booms. - The outlet of the asset should also be closed to avoid the risk of the oil spill entering downstream environments. - For major spills it will be necessary to remove the bulk of the spill with an adductor truck. Medium to small spills in stormwater treatment systems could be manage in-situ by the application surfactants to break up the oil. • Algae: - If there is presence of blue-green algae or if there are other public health and safety concerns, signage should be placed around the WSUD asset and public access should be restricted through temporary fencing etc. Specialist advice should be sought before actions are undertaken. - Filamentous algae can form visible chains which can appear as algal mats in both open and shallow water areas. Excessive biomass of these algae can impact asset function by blocking inlets and outlets and smothering vegetation. If the algae are impacting aesthetics or function of the wetland system, it can be removed by hand using rakes or with specialist machinery. - If significant algae growth is observed on consecutive audits, investigations should be undertaken to identify cause of algal growth. - In WSUD assets designed to hold water, the best protection against nuisance algal growths is dense even emergent aquatic macrophyte cover. - In assets which are not designed to hold water, the best protection is to ensure the asset is able to drain effectively to reduce the liklehood of standing water. • Odour: - Odours are typically caused by decomposing organic matter, blue green algae, anoxic sediments, resident bird populations or poor water quality. Investigations should be undertaken to identify cause of odour and appropriate management actions identified, such as removal or floating plants, blue green algae management, removal of sediment, management of oil slicks / spills and nuisance bird management.

Removal of weeds

Works type	Maintenance activities
Maintenance	• Non-design plant species can impact the aesthetics and function of WSUD assets. Ideally, these plants should be removed as soon as they appear, as weed management becomes harder and more expensive once nuisance species start to dominate. These plants can be removed using 2 methods: - Option 1 (preferred) – Hand pull weeds / nuisance plants (dispose of appropriately) and provide infill planting for any bare areas (if necessary) with design plants. Weeding should take place before the plants flower to reduce the likelihood of seed dispersal and further regeneration. - Option 2 – Herbicide application using spot spray, or similar targeted approach, only. Herbicide must be approved for use in proximity to waterways. This will minimise the potential impact on desirable species and reduce the likelihood of chemical residuals within the soil profile, or local waterways.
Rectification	• If the nuisance plants are dominating the WSUD system, but are not impacting the function of the asset, it may be more cost effective to leave these species in the system until full re-setting is required in the future. If there are declared noxious weeds in the system, these should be removed immediately. • Replanting and sustaining dense and healthy species will help to control the ingress of weeds into the WSUD assets, but regular weeding may still be required. • A list of declared noxious weeds can be found on the Agriculture Victoria website at http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/protecting-victoria-from-pest-animals-and-weeds/legislation-policy-and-permits/declared-noxious-weeds-and-pest-animals-in-victoria. Further details and advice on timing for treatment can be found at http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/weeds/a-z-of-weeds • INVESTIGATION: If the weeds are entering the system regularly from upstream systems, a heavily vegetated system upstream of the WSUD asset may be required to capture and shade out the weeds to stop them entering the WSUD asset. Alternatively, a catchment wide program is required.

6 - Glossary

Asset condition: the physical state of the asset, which may or may not affect its performance (IPWEA, undated).

Asset performance: the ability to provide the required level of service. Generally this can be measured in terms of reliability, availability, capacity, and meeting customer demands and needs (IPWEA, undated).

Target performance: This is met when a WSUD asset is functioning effectively to meet best practice design standards.

Bioretention system (Bioretention basin, bioretention swale, raingarden): A system with vegetation and layered filter media that captures, retains and treats stormwater before slowly releasing it to receiving waterways. A bioretention swale combines an overlying swale with underlying bioretention media to provide conveyance with underlying filter media for effective treatment. A raingarden is usually a small bioretention system used at a household or streetscape scale.

Gross pollutant trap: Structures that use physical processes to trap solid waste such as litter and coarse sediment. They are commonly used as a pre-treatment because they mostly remove non-biodegradable large pollutants.

Infiltration: The process of water entering and passing through a filter media or soil below and surrounding a WSUD asset. Most WSUD assets allow some infiltration to occur while bioretention, infiltration trenches and basins and porous pavements depend on it for treatment.

Infiltration systems including trenches, basins and porous pavements: 'Infiltration system' in this document refers exclusively to non-vegetated infiltration assets.

An infiltration trench is an underground trench filled with a porous material such as gravel, designed to collect stormwater runoff, infiltrate it into the soil and recharge groundwater.

An infiltration basin is an open and unlined basin, typically overlying sand or gravel that allows ponded water to infiltrate into the soil and recharge groundwater.

Only 'cleansed' stormwater from roofs or with sediment pre-treatment should be allowed to flow into an infiltration system to avoid clogging and premature failure.

Lakes, ponds and dams: Natural or man-made structures used to store water while also providing some treatment function (e.g. sedimentation) and potentially some habitat value.

Litter traps: Used to capture litter in stormwater runoff, these traps use physical processes similar to gross pollutant traps but are typically simpler and smaller.

Maintenance: Regular, predictable and planned activities undertaken to preserve or improve the condition of an asset.

Non-potable water: Water that is not fit for drinking purposes but may be fit for other end uses (e.g. garden watering, toilet flushing, dust suppression).

Potable water: Water that is fit for drinking purposes.

Porous and permeable pavements: Porous and permeable pavements allow stormwater to penetrate and infiltrate into the underlying soils. This reduces the effective impervious area and resulting stormwater flow volumes.

Porous and permeable pavements should generally be extensive across all or most of the catchment they are treating.

Rectification: Corrective actions required to bring a WSUD asset back to its target performance.

Stormwater treatment wetland: A well vegetated waterbody that is specifically designed for stormwater treatment (i.e. reduce inflow velocities, settle sediments and remove pollutants).

Stormwater: Surface water runoff from all surfaces within a catchment (e.g. roofs, driveways, roads, footpaths and vegetated areas) that occurs as a result of rainfall.

Water Sensitive Urban Design (WSUD): A holistic approach to water management that integrates urban design and planning with social and physical sciences in order to deliver water services and protect aquatic environments in an urban setting. Assets intended to provide stormwater treatment are often referred to as 'WSUD assets'.

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8

8 - Attachments

Attachment 1 - WSUD Factsheets

Attachment 2 - Asset Data Management

Attachment 3 - Audit and Maintenance Templates

Swales

Swales are stormwater conveyance and treatment measures that primarily treat runoff through filtering and deposition of sediments. Swales have the following characteristics:

- Typically shallow vegetated channels with a trapezoidal cross section
- Vegetated with grass, turf or sedges
- Primarily convey stormwater but also allow infiltration
- Can accept flows either as piped flows or distributed sheet flows such as from flush kerbs along roads
- Planted with grass, turf or sedges. Treatment performance is best in swales with dense vertical plantings
- System drains and dries out quickly after rain events and does not hold water
- Flows are distributed evenly across and throughout the swale

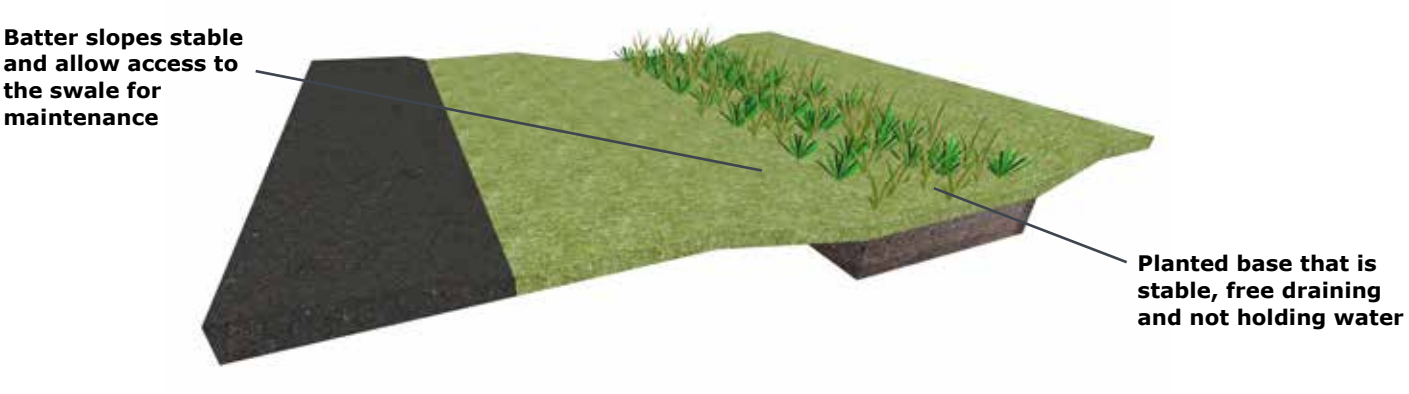


Figure 21 Typical swale features (based on Melbourne Water, 2013)

Typical design parameters

Swales typically have the following characteristics:

- No high flow bypass as they are designed to contain and convey flows up to a design event
- Slope between 1 and 5% (flat slopes (<1%) can be difficult to drain and can become boggy and steep slopes (>5%) can create high velocity flows which may cause erosion). Note that design adaptations can help to overcome these issues (e.g. underdrainage on flat swales and check dams in steep swales)
- Batter slopes are stable and allow access for maintenance (e.g. 1:3 batters for densely vegetated systems and 1:5 batters for turf systems)

Key maintenance considerations

- Clear any large accumulations of sediment that may impede conveyance
- A continuous cover of vegetation is required for treatment and protection from erosion. Inspect to identify gaps in vegetation or any evidence of erosion. Swales should be weeded as needed and any gaps in planting replaced.

Bioretention systems

Bioretention systems (sometimes referred to as raingardens, biofilters or bioswales) are specially designed garden beds that filter stormwater runoff from surrounding areas or stormwater pipes through a vegetated filter media. Treatment of the stormwater occurs both on the surface of the bioretention system and within the filter media.

Stormwater enters the bioretention system and temporarily ponds on the surface within the 'extended detention depth', where some pollutants settle on the garden bed surface. The vegetation assists in maintaining porosity so stormwater drains down through the filter media. The soil, plant roots and microbes work together to naturally filter the water and remove other pollutants (such as nutrients) which are caught in the soil and may be used by the plants. Treated water may infiltrate to the underlying soil (unlined) or discharge via a drainage layer (lined) to the stormwater drainage or both (unlined with drainage) depending on the design.

Bioretention systems also slowly release treated water to receiving waterways in a way that is more like natural flow conditions

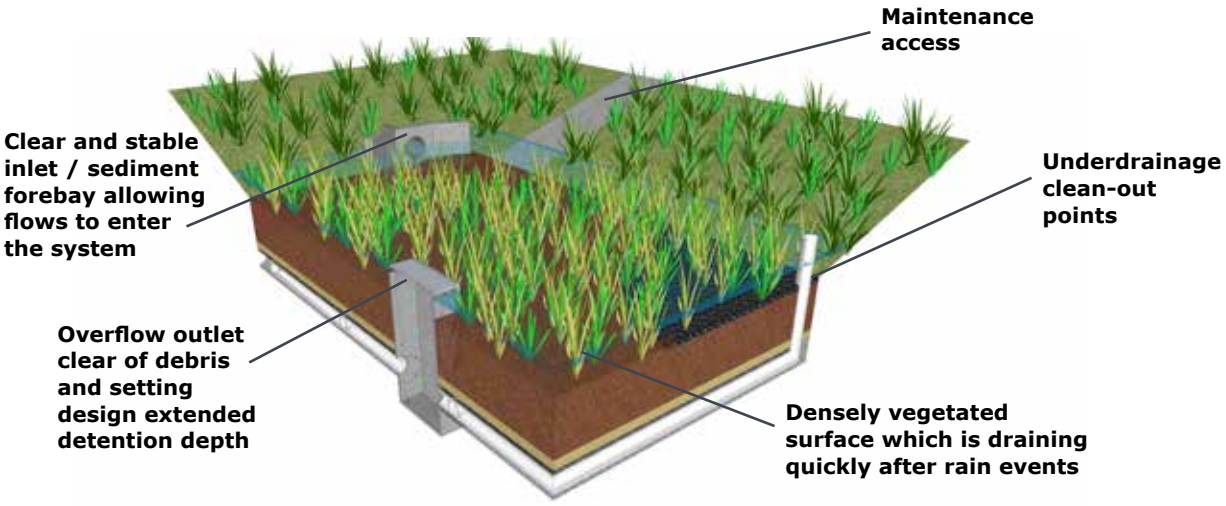


Figure 22 Typical bioretention features (based on Melbourne Water, 2013)

Bioretention systems (Cont.)

Typical design parameters

Bioretention systems typically have the following characteristics:

- Extended detention depth created by the height of an overflow outlet
- Densely vegetated surface
- Flat surface with no depressions
- Filter media which meets design specifications with additional transition and underdrainage layers if required
- If underdrainage is included in the design, inspection and clean out point risers should be included
- Stormwater should enter the system and cover the entire surface of the bioretention and drain within a couple of hours
- Sediment pre-treatment such as a sediment forebay at the inlet, sediment pond or swale is recommended. Sediment pre-treatment is essential for bioretention systems greater than 100 m^2

Key maintenance considerations

- Any blockage of the inlet can prevent water reaching plants and is a critical failure risk
- Clear any significant accumulations of sediment, particularly around the inlet
- Remove any weeds promptly to prevent spread
- A continuous cover of vegetation is required for treatment and to maintain porosity. Minor plant losses should be infilled promptly while larger losses should be investigated to determine causes and an appropriate response before replanting.
- Investigate any surface ponding more than 12 hours after rainfall

Tree pits

A WSUD tree pit is designed to receive stormwater runoff and filter it through the root zone to provide both treatment and passive irrigation. WSUD tree pits are essentially small-scale bioretention systems with a single tree.

Water enters the tree pit at the surface of the soil media, temporarily ponds in the surface pond up to the extended detention depth and drains through the soil. Treated water may infiltrate to the underlying soil or discharge via a drainage layer depending on the design.

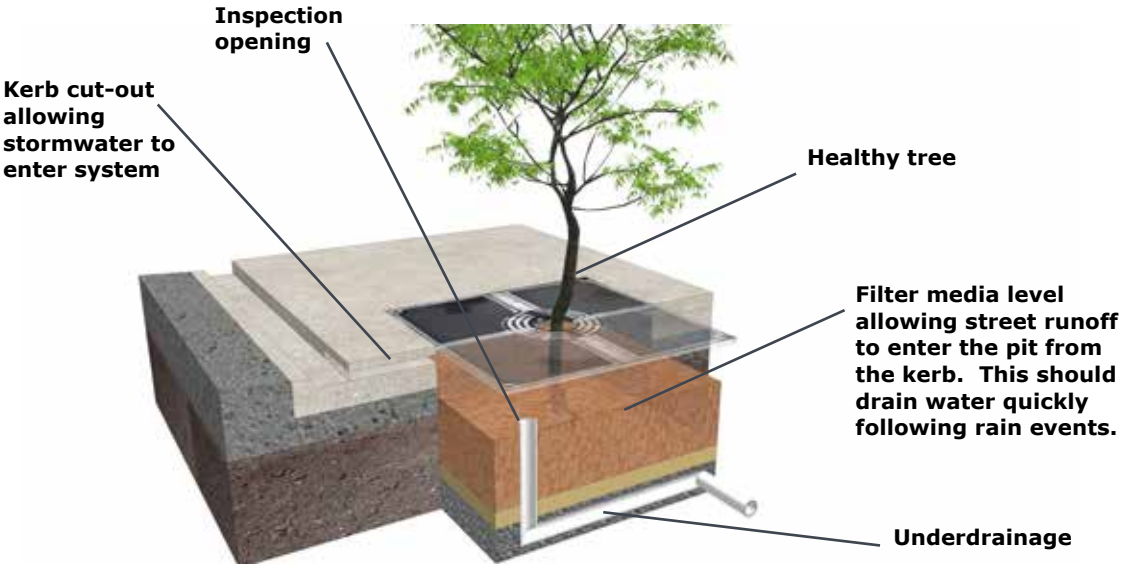


Figure 23 Typical tree pit features (based on Melbourne Water, 2013)

Typical design parameters

Tree pits typically have the following characteristics:

- Tree planted into filter media or soil
- Cut out in the kerb to allow street runoff to enter the tree pit
- Soil profile sitting lower than the road or surrounding surface to allow flows to pond
- Stormwater should drain within a couple of hours

Key maintenance considerations

- Any blockage of the inlet can prevent water reaching plants and is a critical failure risk
- Clear any significant accumulations of sediment, particularly around the inlet
- Investigate any surface ponding more than 12 hours after rainfall

Wetlands

Well designed and constructed wetlands are densely vegetated water bodies that treat stormwater through filtration, sedimentation and biological uptake to remove pollutants.

Water typically enters a sediment pond which removes coarse to medium sized sediments and bypasses high flows around the wetland. Water enters the wetland from the sediment pond, filling the wetland up to the extended detention depth and draining slowly via the outlet over up to 3 days. It is during this time pollutants are removed from the stormwater.

The surface of the wetland will be predominately densely vegetated with emergent macrophytes and this is typically designed to cover 80% of the wetland surface. There will be some deep pools covering up to 20% of the surface area which retain permanent water in the wetland to support mosquito predators. Many older wetlands have larger open water areas.

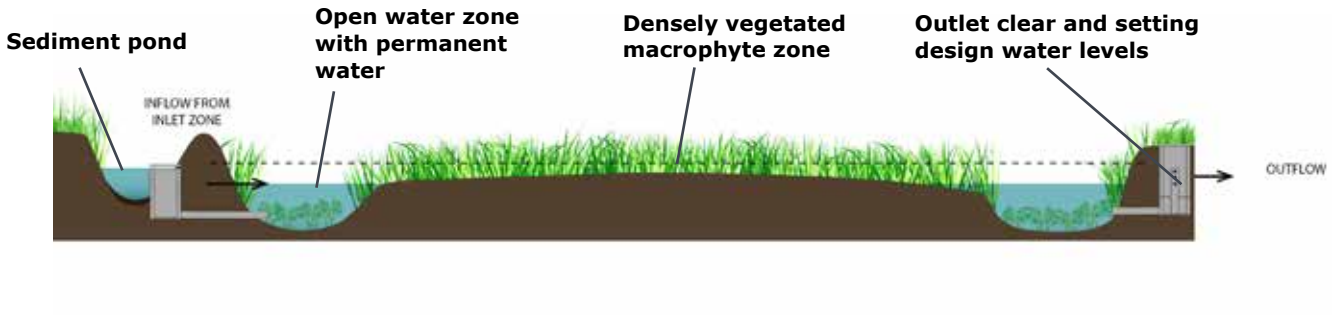


Figure 24 Typical wetland features

Typical design parameters

Constructed stormwater treatment wetlands typically have the following characteristics:

- Extended detention depth
- Upstream sediment pond to remove coarse to medium sized sediments
- High flow bypass
- Deep pools to retain permanent water
- Densely vegetated macrophyte zone (which covers 80% of the wetland area)
- Outlet structure

Key maintenance considerations

- Any blockage of the outlet can result in drowning of plants and is a critical failure risk
- Prompt removal of invasive weeds prevents spread and minimises future costs.
- Extensive vegetation cover is essential for effective treatment and gaps should be replaced at an appropriate time

Sediment ponds

Sedimentation basins provide primary treatment of stormwater by promoting settling of sediments through the reduction of flow velocities and temporary detention. They are typically used as pre-treatment of stormwater flows to protect downstream wetlands and bioretention systems from sediment.

Sediment ponds should be sized to mostly only capture coarse to medium sized sediments and to require sediment clean-out once every 3 to 5 years. Maintenance access and de-watering areas should be provided for sediment ponds.

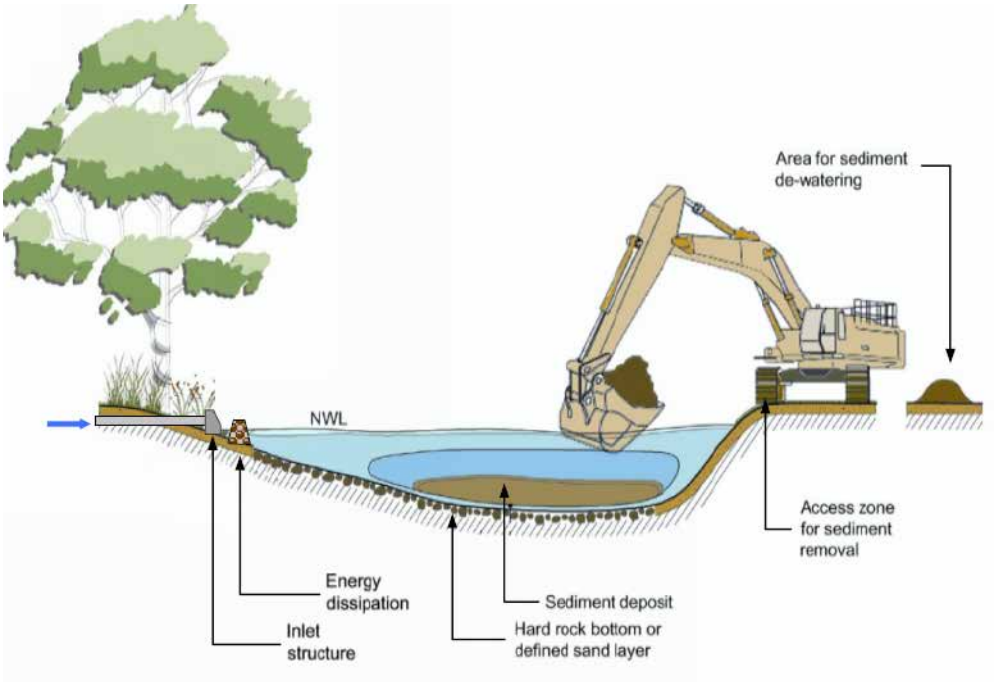


Figure 25 Typical sediment pond features (MBWCP, 2006)

Typical design parameters

Sediment ponds typically have the following characteristics:

- Inlet and outlet structures
- Vegetated batters
- Settling pond area
- Overflow structure
- Maintenance access and de-watering zone

Key maintenance considerations

- Regular removal of sediment once the sediment pond reaches its design accumulation level or before is important to protect downstream treatments from high volumes of sediments and reduce the risk of heavy metals accumulating to levels where the sediment is classified as prescribed waste.

Infiltration systems

Dedicated infiltration systems can be designed as trenches, wells or basins. They contain porous material such as gravel, designed to collect stormwater runoff and encourage it to infiltrate through the walls and base into the surrounding soil. They are very effective for restoring natural hydrology by increasing infiltration and groundwater recharge and simultaneously reducing the frequency and volume of surface runoff.

Infiltration trenches are generally a secondary treatment asset because they need pre-treatment to remove other pollutants such as sediment, nutrients and heavy metals to protect groundwater from contamination.

It is noted that other assets such as bioretention may be designed to include an infiltration storage component that functions as an infiltration system and is protected by the overlying biofilter media. These are considered a variant of bioretention systems.

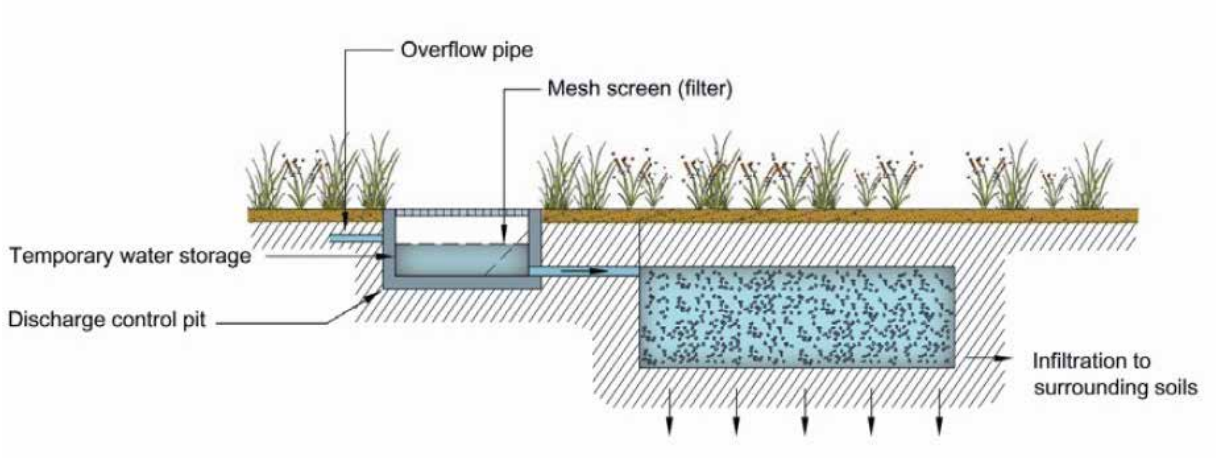


Figure 26 Typical infiltration system features (MBWCP, 2006)

Typical design parameters

Infiltration systems typically have the following characteristics:

- Only 'clean' flows from roofs or pre-treated flows are allowed to enter
- Basin area or trench filled with gravel or other porous materials
- Temporary storage of water which drains away quickly and doesn't leave boggy surfaces or ponding water

Key maintenance considerations

- Any accumulation of sediment at the inlet should be removed before it can reach infiltration surfaces if possible
- Ponding more than 24 hours after rainfall may be an indication of clogging failure and requires further investigation

Porous and permeable paving

Porous and permeable pavements are pavements that allow stormwater to penetrate and infiltrate into the underlying soils, reducing the effective impervious area and surface runoff volumes.

Typically porous or permeable paving will consist of either:

- A permeable asphalt, concrete or other paver that allows water to pass directly through it; or
- Non-permeable inter-locking masonry or engineered pavers with permeable gaps (includes strengthening materials combined with grass) that allow water to infiltrate into subsurface layers

A base of sand or gravel typically sits under the porous pavers to improve drainage. In areas where soils have poor drainage (e.g. heavy clays) an underdrain may be needed in the drainage layer to prevent water-logging.

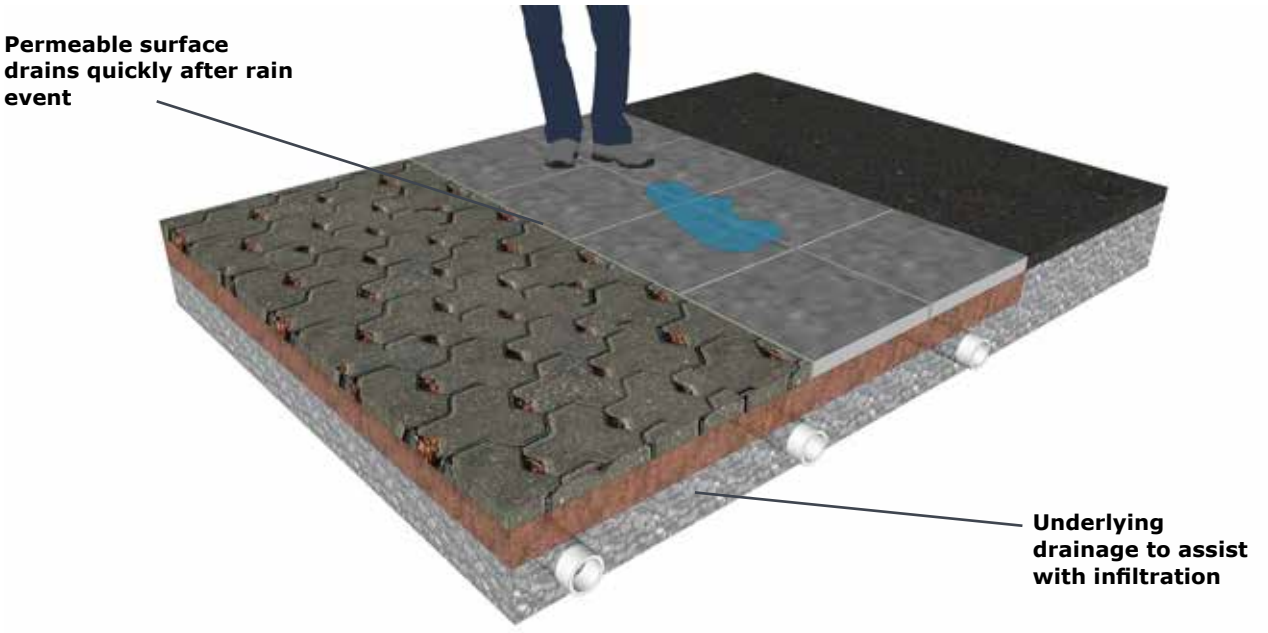


Figure 27 Typical permeable paving features (based on Melbourne Water, 2013)

Porous and permeable paving (Cont.)

Typical design parameters

Porous pavements typically have the following characteristics:

- Porous pavement or pavers or interlocking pavers with gaps to allow water to infiltrate through the pavement
- An underlying drainage layer (sand / gravel) that provides temporary detention of water to allow opportunity for infiltration and some filtration
- Water drains away quickly with no standing water or boggy conditions. Underdrainage may be required on sites with low subsurface infiltration rates
- Sites with steep slopes and potential for downslope resurfacing of infiltrated flows should be avoided
- Porous pavements generally effectively manage the rainfall falling directly on them. Any upstream impervious catchments draining onto porous pavement areas should generally be small relative to the area of porous pavement

Key maintenance considerations

- Any accumulation of sediment or significant organic matter such as leaf litter should be removed
- Ponding more than 12 hours after rainfall may be an indication of clogging failure and requires further investigation

Gross pollutant traps

There are many different types of Gross Pollutant Traps (GPTs) ranging from trash racks to underground proprietary devices. The type of GPT should reflect the gross pollutant types generated from the catchment (i.e. trash racks will only be effective at removing large anthropogenic litter while modern centrifugal GPT's can effectively remove litter, coarse sediment, floating litter and hydrocarbons as well as some finer particles and pollutants.

GPTs are typically used to provide pre-treatment to protect other devices such as wetlands and bioretention basins or water bodies such as lakes or waterways from litter, coarse sediment and other larger particles (>5mm). They are often targeted for treatment of priority catchments likely to generate high litter loads.

A GPT will usually consist of:

- A diversion chamber containing a weir to control inflows and allow bypass of high flows
- Screen
- Sediment storage sump or basket

Depending on the design of the GPT, sediment may be removed by either:

- Removable basket
- Material grab
- Suction from an eductor truck

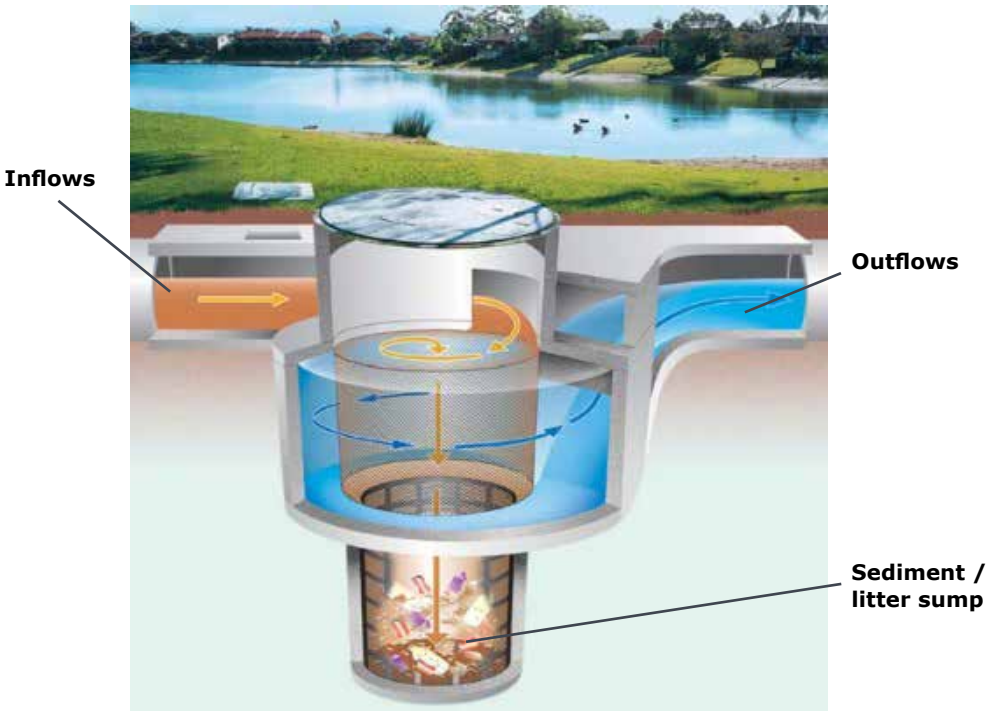


Figure 28 A typical gross pollutant trap (Rocla, 2016) illustrating diversion, screen and sediment sump

Gross pollutant traps (Cont.)

Typical design parameters

GPTs typically have the following characteristics:

- A 'treatable flow rate' that can be diverted through the GPT
- A gross pollutant and sediment storage with a limited capacity that must be periodically cleaned out
- Minimum operating head requirement

Key maintenance considerations

- GPT's should be cleaned out when or before they are full where possible, particularly where they are protecting a downstream treatment system as a full GPT will bypass flows without treatment
- Reference should be made to manufacturers specifications for maintenance requirements and procedures

Asset Data Management

An ideal WSUD asset management system would have the following elements:

- **Asset database** that contains all information needed by maintenance and management teams to understand the system (location information, critical design features and dimensions, drawings).
- **Audits** are undertaken to check on system function and identify issues that require maintenance (audits and record of observations / function / issues / identified maintenance actions).
- **Prioritisation** and scheduling of required works occurs as part of adequately resourced and coordinated maintenance and rectification programs.
- **Planned maintenance** works are undertaken with appropriate record keeping to gather useful information (e.g. sediment loads, issues).
- **Rectification works** (and investigations) are undertaken with record keeping and *feedback* to design and construction inspection teams where appropriate to improve the design and construction of future assets.
- A **reliable and innovative platform** provides inspection forms, databases, prioritisation framework and reporting in electronic formats that are easy to use, efficient and provide information back to managers / community.

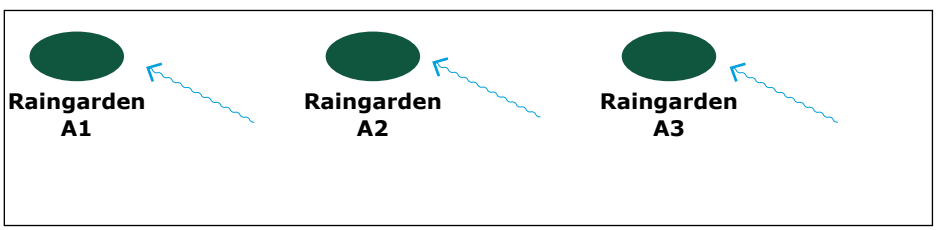
Effective asset management requires accurate asset data, managed via systematic processes that allow for capture, retention, interpretation and communication of that data. This is best achieved by a well-structured and regularly maintained asset database. The database should include records and reporting for different levels of information and meet the needs of a range of users including simple access for inspectors recording information, useful prioritisation data for asset managers and clear actions for staff and contractors maintaining assets.

Database structure and information requirements

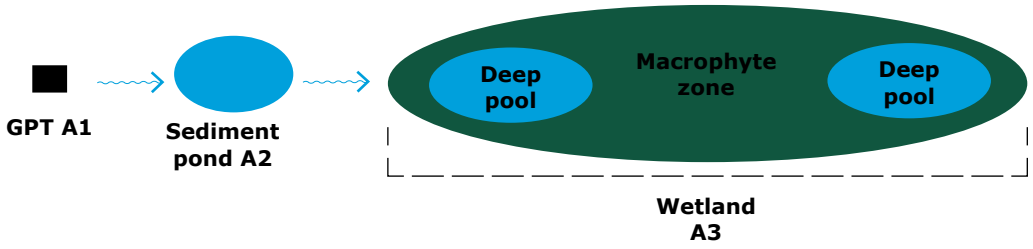
Defining WSUD Assets

Many WSUD treatment trains involve a combination of different asset types. For example, a gross pollutant traps or sediment pond upstream of a wetland or raingarden. Since each asset type can have unique or particular maintenance issues it is beneficial to recognise them as individual assets so audits and maintenance can be tailored accordingly. This also makes it much easier to clearly identify and later locate an issue requiring maintenance. On this basis it is recommended each 'asset' should be entirely in one location and consist of a single treatment type. For example:

- Three raingardens along a street would be recorded as three unique assets.



- A wetland with a sediment pond and a gross pollutant trap would be recorded as three unique assets with corresponding asset types.
- A wetland with several macrophyte zones and deep pools would be recorded as one unique asset.



Each asset should be allocated a unique identification code. See Figure 29 for an example of asset definition.

Asset types

For consistency across Councils, it is recommended each asset is described as one of the WSUD asset types in Table 1 of these Guidelines. A sub-type may be used to differentiate within assets where required, for example for bioretention:

- Bioretention basin
- Bioswale
- Raingarden

Asset collections

A collection of assets oftern has common data. This may be recorded at a 'site', 'parent asset' or 'complex' level that sits above the asset table. This means information common to these assets only needs to be entered once and can be assigned to all relevant assets. This is particularly useful where a series of similar assets are constructed in a street or a development contains multiple assets described on common plans (e.g. 10 tree pits on one street).

Attachment 2 - Asset Data Management

Information collected for each asset

Once each asset has been identified, information should be collected and regularly updated on each asset's attributes, condition and maintenance.

Asset attributes

Asset attributes include design features, location and the asset type, It is recommended this information is collected via an asset input form, see Table 9, to ensure consistency of data. The type of information collected can be broadly grouped into the following categories:

- Site details – including location, address and layout plan
- Asset details – asset type, identification number and links to design plans and records
- Asset dimensions – including dimensions
- Asset maintenance – including information to support maintenance; and
- Asset performance – including expected performance.

The type of information collected at this stage will range from spatial data, links to design drawings and manually inputted data. A list of the typical information that should be collected at the identification or handover stage for each asset type is provided in Table 15.

Table 15 Asset table with required fields for each asset type Asset Condition

		Parameter	Swale	Bioretention	Tree pit	Wetland	Sediment basin	Infiltration basin or trench	Porous pavement	Gross pollutant trap
Asset details	COUNCIL TO FILL IN	Asset name	•	•	•	•	•	•	•	•
		Asset class	•	•	•	•	•	•	•	•
		Asset owner	•	•	•	•	•	•	•	•
		Asset Service Manager	•	•	•	•	•	•	•	•
		Asset Maintainer	•	•	•	•	•	•	•	•
		WSUD Type	•	•	•	•	•	•	•	•
		WSUD Sub-type		•					•	•
		Manufacturer							•	•
		Catchment No.	•	•	•	•	•	•	•	•
		Upstream asset ID number	•	•	•	•	•	•	•	•
		Downstream asset ID number	•	•	•	•	•	•	•	•
		Downstream receiving environment condition (e.g. RAMSAR vs concrete drain)	•	•	•	•	•	•	•	•
		Construction date	•	•	•	•	•	•	•	•
		Constructed by	•	•	•	•	•	•	•	•
		Designed by	•	•	•	•	•	•	•	•
		Design files - Database reference design drawing final	•	•	•	•	•	•	•	•
		As constructed survey	•	•	•	•	•	•	•	•
		Images - Database reference image	•	•	•	•	•	•	•	•
		MUSIC files - Database reference MUSIC file final	•	•	•	•	•	•	•	•
Asset Dimensions	CONSULTANT TO FILL IN	Length (m)	•	•	•	•	•	•	•	•
		Width (m)	•	•	•	•	•	•	•	•
		Surface area (m^2)	•	•	•	•	•	•	•	•
		Perimeter (m)	•	•	•		•	•	•	•
		Volume (m^3)				•	•			
		Extended detention depth (mm)	•	•	•	•	•	•		•
		Permanent pool depth (mm)		•	•	•	•	•		•
		Filter media depth (mm)		•	•				•	
		Submerged zone depth (mm)		•	•					
		Saturated hydraulic conductivity (mm/hour)		•	•				•	
		Exfiltration rate (mm/hour)	•	•	•	•	•	•	•	
Maintenance		Maintenance access plan	•	•	•	•	•	•	•	•
		Maintenance equipment requirements	•	•	•	•	•	•	•	•
		Mown area (m^2)	•	•		•	•	•		
		Landscaped area (m^2)	•	•	•	•	•	•	•	
		Planted treatment area (includes wetland planted, biofilter filter, swale or buffer strip) (m^2)	•	•	•	•	•			
		Plant species	•	•	•	•	•			
		Open water area (m^2)				•	•			
		Finished surface level (m AHD)	•	•	•	•	•	•	•	
		Outlet crest level (m AHD)	•	•		•	•	•		•
Performance data		Unique catchment area (m^2)	•	•	•	•	•	•	•	•
		Unique catchment impervious fraction	•	•	•	•	•	•	•	•
		TSS load reduction (kg/yr)	•	•	•	•	•	•	•	•
		TP load reduction (kg/yr)	•	•	•	•	•	•	•	
		TN load reduction (kg/yr)	•	•	•	•	•	•	•	
		Gross pollutants load reduction (kg/yr)	•	•	•	•	•	•	•	•
		TSS % reduction	•	•	•	•	•	•	•	•
		TP % reduction	•	•	•	•	•	•	•	
		TN % reduction	•	•	•	•	•	•	•	
		Gross pollutants % reduction	•	•	•	•	•	•	•	•

Asset condition

Assessment of an asset's condition allows required maintenance activities to be identified and prioritised. By recording this data in an asset database, a history of issues and actions can be reviewed, allowing patterns and common problems to be identified.

Information to be collected during a condition audit will vary by each asset type but should be recorded on a condition audit sheet. In addition, it is recommended to take photos, to provide a visual record of the state of the asset.

	Task item	Performance target	Good condition	Moderate condition	Poor condition		Condition summary
			(1 point)	(2 points)	(3 points)		
			No works	Maintenance	Rectification		
	Surrounds and other infrastructure						
Civil	Damage or removal of structures	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function	Major damage Poses risk to structural integrity, public safety or asset function	2	Repair two damaged bluestone kerb stones
Landscape	Rubbish	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	1	
	Inlet						
Civil	Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	1	
Civil	Blockage	No blockage	No blockage	Partial blockage of inlet causing some bypass of flows or restricted inflows	Blockage of inlet causing significant bypass or restriction of inflows	2	Clear minor sediment from sediment forebay and clean out sediment sump

Figure 29 Example inspection form and photo damage to kerb and minor sediment accumulation

Asset maintenance and rectification

Asset audits typically lead to a set of outstanding maintenance and rectification actions that need to be undertaken.

Outcomes of maintenance activities in response to these actions items needs to be recorded. This provides an updated list of outstanding works and record of works that have been completed.

Identified actions and works undertaken over time can be reviewed to identify patterns of repeated behaviour for individual assets and across the asset base. This will help to identify where further intervention may be needed to manage recurring problems or modify design approaches.

The types of information collected and stored for each maintenance visit includes:

- Record of maintenance and rectification actions taken.
- Notes of further work or monitoring required.
- Photos.

WSUD asset database structure

WSUD asset data may be stored within Council's existing asset management systems with adaptations to support WSUD assets or a separate database if greater flexibility is required than existing systems allow.

It is recommended the asset database used to store WSUD asset data is structured to allow the asset information, audit information and maintenance information collected to be linked into useful summary databases. The database should be able to store, sort and filter large volumes of information which can then be linked to summary pages for each asset. Asset database structure including input forms, database sheets to store and sort information and summary sheets to present key information for each asset or site as illustrated in Figure 30.

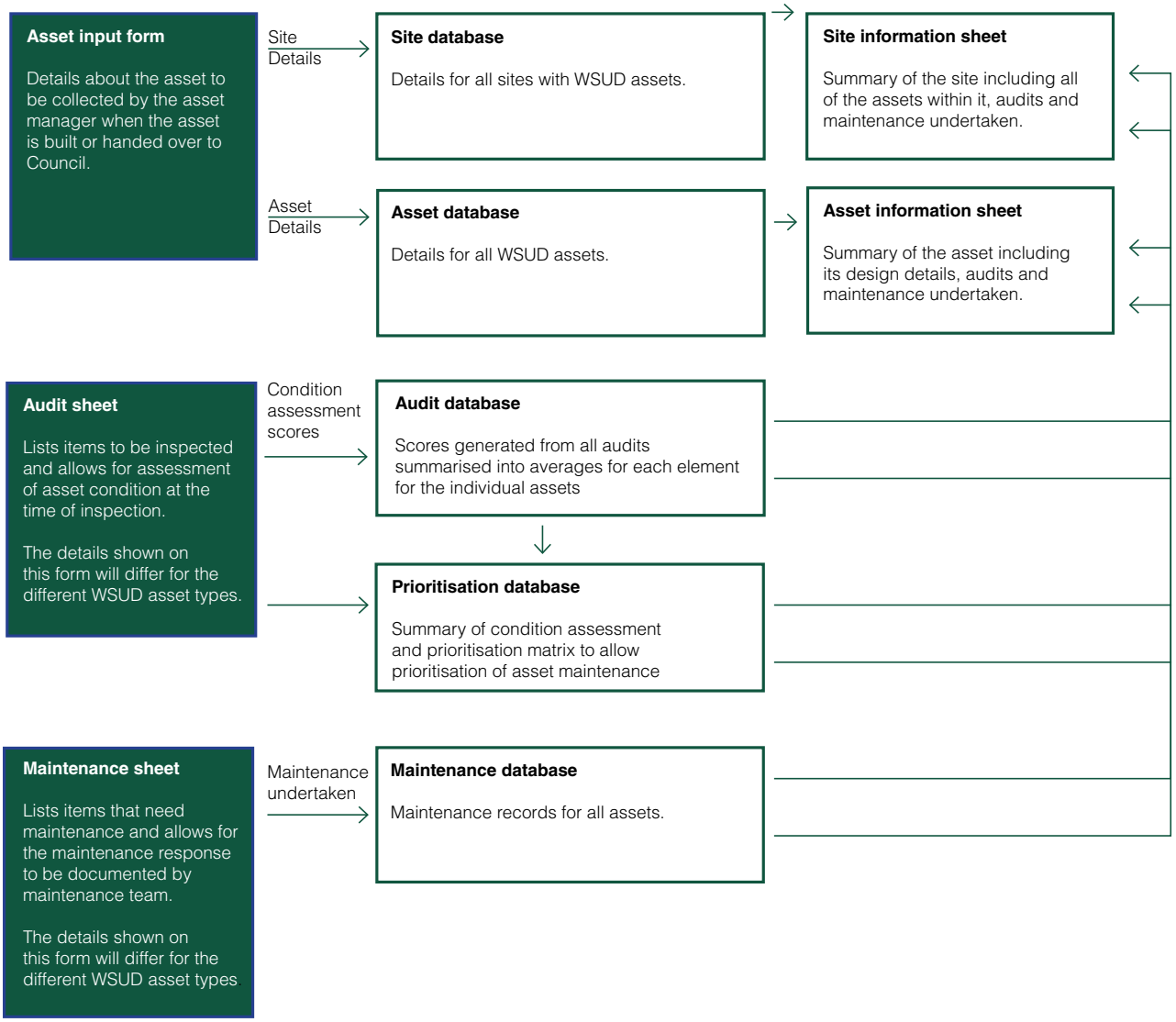


Figure 30 Key tables and relationships of a typical WSUD asset database

Asset database reports and views

The asset management system should support reporting at a range of levels to support different purposes. For example, the database should allow a user to view a single site or asset and easily print out key information. Reporting should support the following levels:

- Individual assets.
- A user selection of assets such as assets with identified maintenance actions.
- All assets for reporting of asset condition or performance.

Common reports required by various teams include:

- A summary of identified maintenance actions for prioritisation.
- A list of maintenance actions for a series of sites for attention by a maintenance crew.
- A summary of an asset including details and maintenance works required for a maintenance crew.
- A summary of all assets and performance to report Council compliance with SEPP requirements or annual reporting.

An example asset summary report below provides a summary of the key features of an asset, design and dimension details as well as when it was last inspected and maintained, see Figure 31.

STREETSCAPE WSUD ASSET DESCRIPTION

Site ID	3
Site Location:	Dow Street
Suburb:	Port Melbourne
Melway Reference:	57 B4
Number of WSUD systems:	5
Design files – TRIM reference design drawing	
MUSIC files – TRIM reference MUSIC file final	
Images – TRIM reference images	
Asset ID	10305
Easting	
Northing	
Asset name	Infiltration Raingarden 3 (F) Dow St & Raingarden
WSUD Type	
Designed by	
Council Design Project Manager	
Construction Date	
Constructed by	
Council Construction Project Manager	
Last inspection date	15/07/2013
Last maintenance date	
Design Information	
Catchment area (m^2)	67
Surface area (m^2)	4
Finished surface level	
Extended detention depth (mm)	100
Filter media depth (mm)	350
Submerged zone depth (mm)	
Saturated hydraulic conductivity (mm/hour)	50-100
Exfiltration rate (mm/hour)	
Plant species	
Modelled Treatment Performance	

Location Plan / Design Schematic:

0

Print Asset Information Worksheet

Figure 31 An example asset summary report

A summary of audit outcomes and recommended maintenance tasks will assist a maintenance crew or contractor in identifying what works need to be done for a given asset, Figure 33.

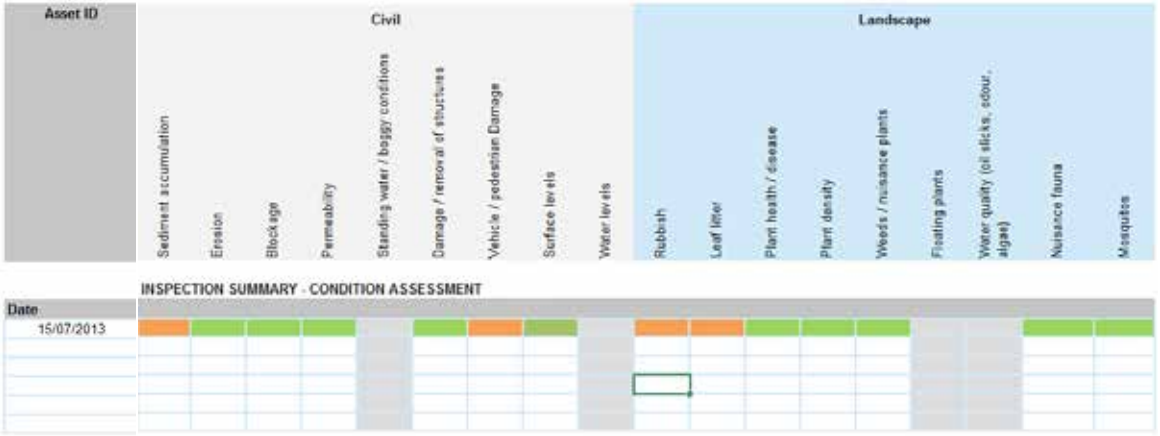


Figure 33 An asset audit summary report identifying maintenance works to be undertaken

The work undertaken can then be reviewed by a manager, see Figure 34. Tailored reports for use by asset managers and field crews can ensure information is accessible and useful.

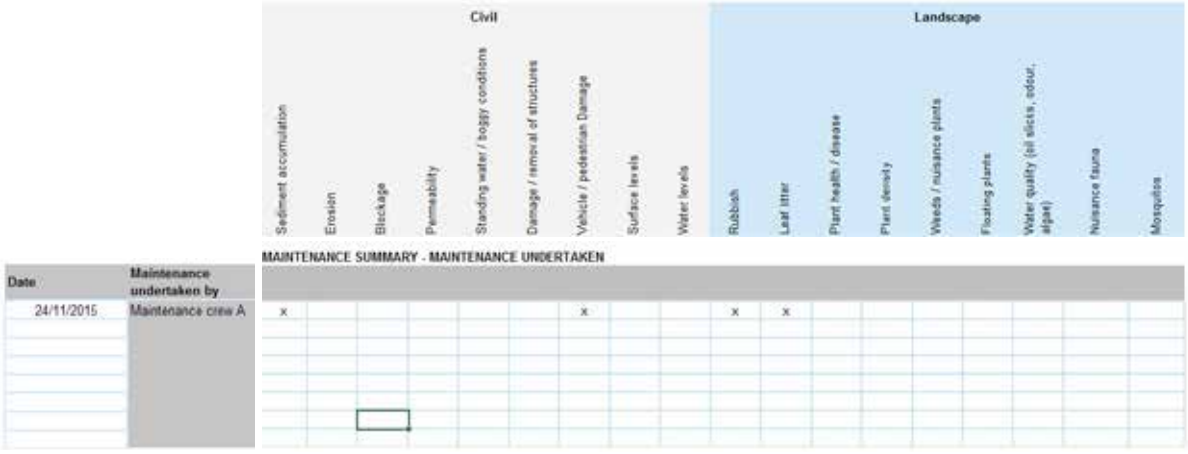


Figure 34 Database report of what maintenance was undertaken and when

The database should allow summary reports listing all assets with identified planned maintenance or rectification actions arising from audits or of actions undertaken. An example summary report for audit outcomes illustrating the prioritisation of maintenance actions for several assets is shown in Figure 35, illustrating the prioritisation of maintenance actions for several assets.

Figure 35 Database report of prioritization of works for a number of assets

Spatial data

It is helpful to map WSUD assets spatially as a layer within a GIS system and link this to the database so relevant data is kept up to date. This can:

- Facilitate route mapping and scheduling of maintenance and rectification activities to minimise travel time.
- Help determine upstream catchment areas and identify complementary WSUD assets providing upstream and downstream treatment to support other assets.
- Allow recognition of 'gaps' where failing assets may put high value waterways at risk

A map of WSUD asset catchments can help with assessments of opportunities for future WSUD treatment and minimise duplication of effort. A better understanding of the catchment area can also help identify causal factors within a catchment that contribute to issues with an asset, such as recent construction activity leading to excessive sedimentation.

Initial mapping should include map points or polygons identifying the extents of each WSUD asset (a polygon is more useful since it allows areas to be checked), see Figure 36.

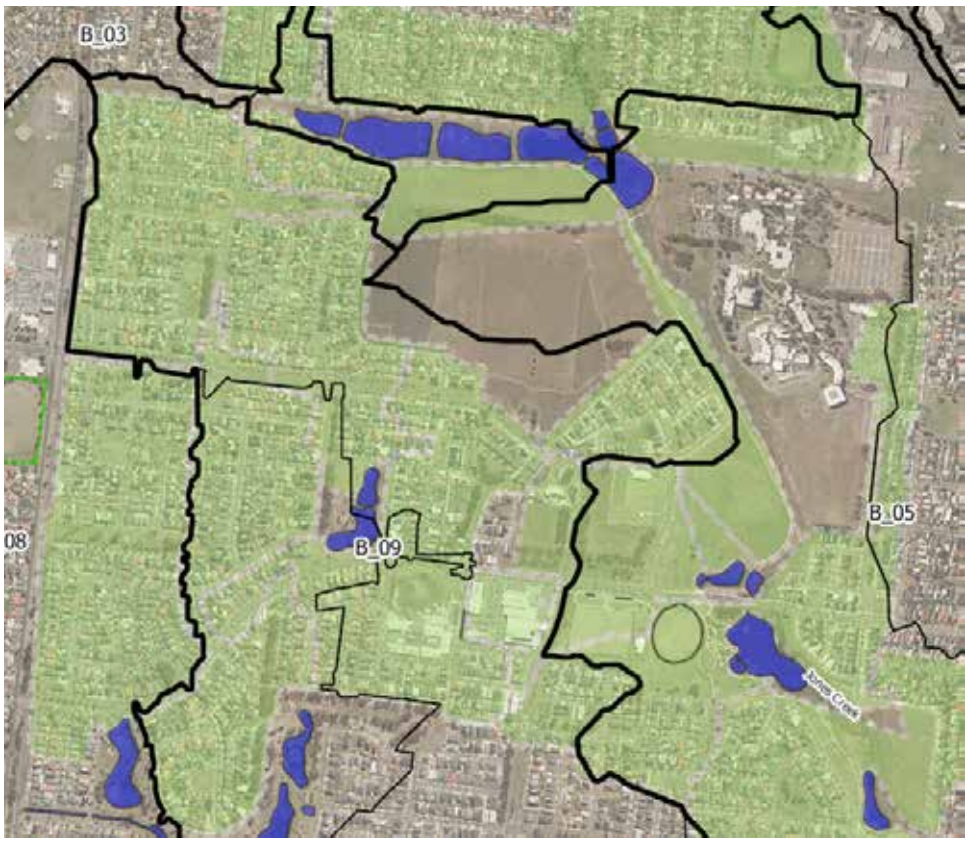


Figure 36 Mapping of WSUD assets and catchments (E2Designlab, 2016)

More detailed mapping should map specific features within a WSUD asset so they can be readily identified or marked up on a diagram to facilitate maintenance, see Figure 37.

Figure 37 Detailed mapping of WSUD asset features (Source: City of Geelong, 2015)

8

Attachment 3 - Audit and maintenance templates

Swale audit checklist

Date				Add inspection data
Weather		Site address		
Date of last rainfall		Site ID		
WSUD Type		Asset name		
Inspected by		Asset ID		

	Task Item	Performance target	Good condition	Moderate condition	Poor condition	Condition summary
			(1 point)	(2 points)	(3 points)	
			No works	*Maintenance*	*Rectification*	
	Inlet					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function	Major damage Poses risk to structural integrity, public safety or asset function	
Civil	**Blockage**	No blockage	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function No safety risks	Major damage, poses risk to structural integrity, public safety or asset function	
	Vegetated base and batters					
Civil	**Sediment accumulation**	No accumulated sediment impeding flows or vegetation growth	No accumulated sediment or minimal sediment with no obvious impacts	Some accumulated sediment (covering <50% of surface) Causing some redirection of flows through the system	Accumulated sediment covering >50% of the surface Impeding flows Smothering vegetation	
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Standing water or boggy conditions**	No surface ponding or boggy areas	Well drained with no surface ponding or boggy areas	Partially impacted drainage, with boggy conditions only occuring after rain and drying out within 24 hours	Standing water present an/or conitnued boggy conditions which is making maintenance difficult	
Civil	**Vehicle or pedestrian damage**	No compaction, plant loss, vandalism impacting system function	No compaction, plant loss, vandalism impacting system function	Minor compaction, plant loss Does not pose risk to structural integrity or asset function	Significant compaction, plant loss Poses risk to structural integrity, public safety or asset function	
Civil	**Surface levels**	Even surface with no depressions or mounds	Even surface with no depressions or mounds	Some small depressions or mounds present Limited impact on flows through the asset	Level of surface is impacting flows through the asset (e.g. short circuiting flows, blocking flows and / or reduced extented detention depth) Isolated pools created in the surface	
Landscape	**Rubbish**	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
Landscape	**Leaf litter**	No accumulated leaf litter causing blockages or impeding flows or vegetation growth	Minimal leaf litter present or covers less than 20% of surface	Some wet and decaying leaf matter present (covering 20-50% of surface) Aesthetic issue Some obstruction of flow paths	Large amount wet and decaying leaf matter present (covering >50% of the surface) Impacting vegetation growth Obstructing flow paths and blocking inlets or outlets	
Landscape	**Plant health**	Good vegetation health	Healthy vegetation	Vegetation is stressed Poor health (signs of disease, pests) in less than 20% of plants	Vegetation is dying back Poor health (signs of disease, pests) in more than 20% of plants	
Landscape	**Plant cover**	Good vegetation densities covering >80% of the planted surfaces	Good vegetation cover in planted areas (>80% cover / >6 plants per m2)	Moderate vegetation cover in planted areas (50-80% cover)	Poor vegetation cover in planted areas (<50% cover)	
Landscape	**Weeds**	Limited weed cover with no declared noxious weed species	Limited weed cover (<10%) and no declared noxious weed species	Low/Moderate weed cover (10-50%) and no declared noxious weed species	High weed cover (>50%) and/or declared noxious weed species present	
Landscape	**Nuisance fauna**	No nuisance fauna	No nuisance fauna	Some nuisance fauna but limited impact on aesthetics, water quality and/or vegetation growth	Significant nuisance fauna issues Heavily impacting aesthetics, vegetation growth and/or water quality	
	Outlet, overflow and inspection pipes					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Blockage**	No blockage	No blockage	Partial blockage of outlet or overflow causing some obstruction of outflows or requiring removal	Blockage of outlet or overflow preventing or significantly obstructing outflows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function	Major erosion Poses risk to structural integrity, public safety or asset function	

Raingarden audit checklist

Date
Weather
Date of last rainfall
WSUD Type
Inspected by

Site address
Site ID
Asset name
Asset ID

Add inspection data

	Task Item	Performance target	Good condition	Moderate condition	Poor condition	Condition summary
			(1 point)	(2 points)	(3 points)	
			No works	*Maintenance*	*Rectification*	
	Surrounds and other infrastructure					
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function	Major damage Poses risk to structural integrity, public safety or asset function	
Landscape	**Rubbish**	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
	Inlet					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Blockage**	No blockage	No blockage	Partial blockage of inlet causing some bypass of flows or restricted inflows	Blockage of inlet causing significant bypass or restriction of inflows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function No safety risks	Major damage, poses risk to structural integrity, public safety or asset function	
	Batters					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Vehicle or pedestrian damage**	No compaction, plant loss, vandalism impacting system function	No compaction, plant loss, vandalism impacting system function	Minor compaction, plant loss Does not pose risk to structural integrity or asset function	Significant compaction, plant loss Poses risk to structural integrity, public safety or asset function	
Landscape	**Rubbish**	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
Landscape	**Plant health**	Good vegetation health	Healthy vegetation	Vegetation is stressed Poor health (signs of disease, pests) in less than 20% of plants	Vegetation is dying back Poor health (signs of disease, pests) in more than 20% of plants	
Landscape	**Plant cover**	Good vegetation densities covering >80% of the planted surfaces	Good vegetation cover in planted areas (>80% cover / >6 plants per m2)	Moderate vegetation cover in planted areas (50-80% cover)	Poor vegetation cover in planted areas (<50% cover)	
Landscape	**Weeds**	Limited weed cover with no delcared weed species	Limited weed cover (<10%) and no declared noxious weed species	Low/Moderate weed cover (10-50%) and no declared noxious weed species	High weed cover (>50%) and/or declared noxious weed species present	
Landscape	**Nuisance fauna**	No nuisance fauna	No nuisance fauna	Some nuisance fauna but limited impact on aesthetics, water quality and/or vegetation growth	Significant nuisance fauna issues Heavily impacting aesthetics, vegetation growth and/or water quality	
	Permeable vegetated base					
Civil	**Sediment accumulation**	• No accumulated sediment	No accumulated sediment or minimal sediment with no obvious impacts	Some accumulated sediment (covering <50% of surface) Causing some redirection of flows through the system	Accumulated sediment covering >50% of the surface Impeding flows Smothering vegetation	
Civil	**Erosion**	• No erosion	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Permeability and clogging**	Infiltration / hydraulic capacity of the system is preserved	Dry Conditions: Water poured on surface infiltrates almost immediately , minimal fine sediment accumulation or visible surface crust. Wet Conditions: Surface ponding (100 - 300mm) for bioretention systems is drawn down over 1 - 3 hrs after inflow to the system has stopped following rainfall.	Dry Conditions: Water infiltrates surface slowly but ponding clears within minutes, some fine sediment accumulation or surface crust evident. Wet Conditions: Surface ponding observed for longer than normal (more than 3 hours).	Dry Conditions: Water ponds with minimal infiltration, significant fine sediment accumulation or extensive surface crust. Wet Conditions: Surface ponding (100 - 300mm) remains more than 12 hrs after inflow to the system has stopped following rainfall. Presence of algae or moss may indicate persistent wetting (e.g. baseflows) or clogging requiring further investigation.	
Civil	**Vehicle or pedestrian damage**	No compaction, plant loss, vandalism impacting system function	No compaction, plant loss, vandalism impacting system function	Minor compaction, plant loss Does not pose risk to structural integrity or asset function	Significant compaction, plant loss Poses risk to structural integrity, public safety or asset function	
Civil	**Surface levels**	Even surface with no depressions or mounds	Even surface with no depressions or mounds. Base is flat with flows evenly distributed across asset surface.	Some small depressions or mounds present or preferential flow paths. Base is mostly flat with flows evenly distributed across most of asset.	Significant depressions or mounds present or defined preferential flow paths. Surface levels are impacting flows through the asset (e.g. short circuiting flows, blocking flows, limited flow distribution).	
Civil	**Extended detention depth**	Designed extended detention depth provided	Design extended detention depth provided	At least 50% of design extended detention provided	Less than 50% of design extended detention depth provided	
Landscape	**Rubbish**	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
Landscape	**Leaf litter**	No accumulated leaf litter causing blockages or impeding flows or vegetation growth	Minimal leaf litter present or covers less than 20% of surface	Some wet and decaying leaf matter present (covering 20-50% of surface) Aesthetic issue Some obstruction of flow paths	Large amount wet and decaying leaf matter present (covering >50% of the surface) Impacting vegetation growth Obstructing flow paths and blocking inlets or outlets	
Landscape	**Plant health**	Good vegetation health	Healthy vegetation	Vegetation is stressed Poor health (signs of disease, pests) in less than 20% of plants	Vegetation is dying back Poor health (signs of disease, pests) in more than 20% of plants	
Landscape	**Plant cover**	Good vegetation densities covering >80% of the planted surfaces	Good vegetation cover in planted areas (>80% cover / >6 plants per m2)	Moderate vegetation cover in planted areas (50-80% cover)	Poor vegetation cover in planted areas (<50% cover)	
Landscape	**Weeds**	Limited weed cover with no declared noxious weed species	Limited weed cover (<10%) and no declared noxious weed species	Low/Moderate weed cover (10-50%) and no declared noxious weed species	High weed cover (>50%) and/or declared noxious weed species present	
Landscape	**Nuisance fauna**	No nuisance fauna	No nuisance fauna	Some nuisance fauna but limited impact on aesthetics, water quality and/or vegetation growth	Significant nuisance fauna issues Heavily impacting aesthetics, vegetation growth and/or water quality	
	Outlet, overflow and inspection pipes					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Blockage**	No blockage	No blockage	Partial blockage of outlet or overflow causing some obstruction of outflows or requiring removal	Blockage of outlet or overflow preventing or significantly obstructing outflows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function	Major erosion Poses risk to structural integrity, public safety or asset function	

Tree pit audit checklist

Date
Weather
Date of last rainfall
WSUD Type
Inspected by

Site address
Site ID
Asset name
Asset ID

Add inspection data

	Task Item	Performance target	Good condition	Moderate condition	Poor condition	Condition summary
			(1 point)	(2 points)	(3 points)	
			No works	*Maintenance*	*Rectification*	
	Inlet					
Civil	**Erosion**	No damage, erosion or issues / removal of structures	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Blockage**	No blockage	No blockage	Partial blockage of inlet causing some bypass of flows or restricted inflows	Blockage of inlet causing significant bypass or restriction of inflows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function No safety risks	Major damage, poses risk to structural integrity, public safety or asset function	
	Permeable vegetated base					
Civil	**Sediment accumulation**	No accumulated sediment	No accumulated sediment or minimal sediment with no obvious impacts	Some accumulated sediment (covering <50% of surface) Causing some redirection of flows through the system	Accumulated sediment covering >50% of the surface Impeding flows Smothering vegetation	
Civil	**Erosion**	No erosion	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Permeability and clogging**	Infiltration / hydraulic capacity of the system is preserved	Dry Conditions: Water poured on surface infiltrates almost immediately , minimal fine sediment accumulation or visible surface crust. Wet Conditions: Surface ponding (100 - 300mm) for bioretention systems is drawn down over 1 - 3 hrs after inflow to the system has stopped following rainfall.	Dry Conditions: Water infiltrates surface slowly but ponding clears within minutes, some fine sediment accumulation or surface crust evident. Wet Conditions: Surface ponding observed for longer than normal (more than 3 hours).	Dry Conditions: Water ponds with minimal infiltration, significant fine sediment accumulation or extensive surface crust. Wet Conditions: Surface ponding (100 - 300mm) remains more than 12 hrs after inflow to the system has stopped following rainfall. Presence of algae or moss may indicate persistent wetting (e.g. baseflows) or clogging requiring further investigation.	
Civil	**Vehicle or pedestrian damage**	No compaction, plant loss, vandalism impacting system function	No compaction, plant loss, vandalism impacting system function	Minor compaction, plant loss Does not pose risk to structural integrity or asset function	Significant compaction, plant loss Poses risk to structural integrity, public safety or asset function	
Civil	**Surface levels**	Even surface with no depressions or mounds	Even surface with no depressions or mounds. Base is flat with flows evenly distributed across asset surface.	Some small depressions or mounds present or preferential flow paths. Base is mostly flat with flows evenly distributed across most of asset.	Significant depressions or mounds present or defined preferential flow paths. Surface levels are impacting flows through the asset (e.g. short circuiting flows, blocking flows, limited flow distribution).	
	Extended detention depth	Designed extended detention depth provided	Design extended detention depth provided	At least 50% of design extended detention provided	Less than 50% of design extended detention depth provided	
Landscape	**Rubbish**	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
Landscape	**Leaf litter**	No accumulated leaf litter causing blockages or impeding flows or vegetation growth	Minimal leaf litter present or covers less than 20% of surface	Some wet and decaying leaf matter present (covering 20-50% of surface) Aesthetic issue Some obstruction of flow paths	Large amount wet and decaying leaf matter present (covering >50% of the surface) Impacting vegetation growth Obstructing flow paths and blocking inlets or outlets	
Landscape	**Plant health**	Good vegetation health	Healthy vegetation	Vegetation is stressed Poor health (signs of disease, pests) in less than 20% of plants	Vegetation is dying back Poor health (signs of disease, pests) in more than 20% of plants	
Landscape	**Plant cover**	Tree present	Tree present	Tree not present, replacement only required	Tree not present and other functional issues	
Landscape	**Weeds**	Limited weed cover with no declared noxious weed species	Limited weed cover (<10%) and no declared noxious weed species	Low/Moderate weed cover (10-50%) and no declared noxious weed species	High weed cover (>50%) and/or declared noxious weed species present	
Landscape	**Nuisance fauna**	No nuisance fauna	No nuisance fauna	Some nuisance fauna but limited impact on aesthetics, water quality and/or vegetation growth	Significant nuisance fauna issues Heavily impacting aesthetics, vegetation growth and/or water quality	
	Outlet, overflow and inspection pipes					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Blockage**	No blockage	No blockage	Partial blockage of outlet or overflow causing some obstruction of outflows or requiring removal	Blockage of outlet or overflow preventing or significantly obstructing outflows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function	Major erosion Poses risk to structural integrity, public safety or asset function	

Wetland audit checklist

Date					
Weather		Site address		Add inspection data to	
Date of last rainfall		Site ID			
WSUD Type		Asset name			
Inspected by		Asset ID			

	Task Item	Performance target	Good condition	Moderate condition	Poor condition	Condition summary
			(1 point)	(2 points)	(3 points)	
			No works	*Maintenance*	*Rectification*	
	Surrounds and other infrastructure					
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function	Major damage Poses risk to structural integrity, public safety or asset function	
Landscape	**Rubbish**	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
	Inlet					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Blockage**	No blockage	No blockage	Partial blockage of inlet causing some bypass of flows or restricted inflows	Blockage of inlet causing significant bypass or restriction of inflows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function No safety risks	Major damage, poses risk to structural integrity, public safety or asset function	
	Batters					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Vehicle or pedestrian damage**	No compaction, plant loss, vandalism impacting system function	No compaction, plant loss, vandalism impacting system function	Minor compaction, plant loss Does not pose risk to structural integrity or asset function	Significant compaction, plant loss Poses risk to structural integrity, public safety or asset function	
Landscape	**Rubbish**	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
Landscape	**Plant health**	Good vegetation health	Healthy vegetation	Vegetation is stressed Poor health (signs of disease, pests) in less than 20% of plants	Vegetation is dying back Poor health (signs of disease, pests) in more than 20% of plants	
Landscape	**Plant cover**	Good vegetation densities covering >80% of the planted surfaces	Good vegetation cover in planted areas (>80% cover / >6 plants per m2)	Moderate vegetation cover in planted areas (50-80% cover)	Poor vegetation cover in planted areas (<50% cover)	
Landscape	**Weeds**	Limited weed cover with no declared noxious weed species	Limited weed cover (<10%) and no declared noxious weed species	Low/Moderate weed cover (10-50%) and no declared noxious weed species	High weed cover (>50%) and/or declared noxious weed species present	
Landscape	**Nuisance fauna**	No nuisance fauna	No nuisance fauna	Some nuisance fauna but limited impact on aesthetics, water quality and/or vegetation growth	Significant nuisance fauna issues Heavily impacting aesthetics, vegetation growth and/or water quality	
	Aquatic macrophyte zone					
Civil	**Sediment accumulation**	No accumulated sediment impeding flows or vegetation growth	No accumulated sediment	Some accumulated sediment (covering <50% of surface) Causing some redirection of flows through the system	Accumulated sediment covering >50% of the surface Impeding flows Smothering vegetation	
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Vehicle or pedestrian damage**	No compaction, plant loss, vandalism impacting system function	No compaction, plant loss, vandalism impacting system function	Minor compaction, plant loss Does not pose risk to structural integrity or asset function	Significant compaction, plant loss Poses risk to structural integrity, public safety or asset function	
Civil	**Water levels**	Water level depths and drawdown suitable to support healthy plant growth	Water level variation as designed (with appropriate drawdown of attenuated flow following rainfall, dry periods are not extensive (<70 days/year)) Diverse vegetation confirms confidence in appropriate water level variation.	Some concerns about water level variation but impact on treatment performance is expected to be small.	Significant concerns about water level variation. Impact on treatment performance is expected to be significant.	
Landscape	**Rubbish**	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
Landscape	**Leaf litter**	No accumulated leaf litter causing blockages or impeding flows or vegetation growth	Minimal leaf litter present or covers less than 20% of surface	Some wet and decaying leaf matter present (covering 20-50% of surface) Aesthetic issue Some obstruction of flow paths	Large amount wet and decaying leaf matter present (covering >50% of the surface) Impacting vegetation growth Obstructing flow paths and blocking inlets or outlets	
Landscape	**Plant health**	Good vegetation health	Healthy vegetation	Vegetation is stressed Poor health (signs of disease, pests) in less than 20% of plants	Vegetation is dying back Poor health (signs of disease, pests) in more than 20% of plants	
Landscape	**Plant cover**	Good vegetation densities covering >80% of the planted surfaces	Good vegetation cover in planted areas (>80% cover / >6 plants per m2)	Moderate vegetation cover in planted areas (50-80% cover)	Poor vegetation cover in planted areas (<50% cover)	
Landscape	**Weeds**	Limited weed cover with no delcared weed species	Limited weed cover (<10%) and no declared noxious weed species	Low/Moderate weed cover (10-50%) and no declared noxious weed species	High weed cover (>50%) and/or declared noxious weed species present	
Landscape	**Floating plants**	• No nuisance floating plants present	No or minimal nuisance floating plants present (<10%)	Low/Moderate cover (10-50%) Mechanical removal of nuisance floating plants is effective in managing blooms	Nuisance floating plant blooms with high cover (>50%) or are problematic, impacting on wetland performance and too extensive to remove mechanically	
Landscape	**Water quality (oil slicks, odour, algae)**	• No water quality issues (oil slicks, odours, algae)	No water quality issues (oil slicks, odours, algae)	Some minor water quality issues visible (oil slicks, odours, algae) but no major impact on aesthetics or water quality	Significant water quality issues (oil slicks, odours, algae) Heavily impacting aesthetics and/or water quality	
Landscape	**Nuisance fauna**	No nuisance fauna	No nuisance fauna	Some nuisance fauna but limited impact on aesthetics, water quality and/or vegetation growth	Significant nuisance fauna issues Heavily impacting aesthetics, vegetation growth and/or water quality	
Landscape	**Mosquitos**	No nuisance populations of mosquitoes	No isolated depressions which can become breeding sites when water levels recede Deep pools provide refugia for predators No dead or rafting vegetation	Potential mosquito habitats observed (e.g. isolated pools, rafting vegetation)	Nuisance populations of mosquitoes observed and/or reported by local community. Numerous potential mosquito habitats observed (e.g. isolated pools, rafting vegetation)	
	Outlet, overflow and inspection pipes					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Blockage**	No blockage	No blockage	Partial blockage of outlet or overflow causing some obstruction of outflows or requiring removal	Blockage of outlet or overflow preventing or significantly obstructing outflows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function	Major erosion Poses risk to structural integrity, public safety or asset function	

Sediment pond audit checklist

Date
Weather
Date of last rainfall
WSUD Type
Inspected by

Site address
Site ID
Asset name
Asset ID

Add inspection data

	Task Item	Performance target	Good condition	Moderate condition	Poor condition	Condition summary
			(1 point)	(2 points)	(3 points)	
			No works	*Maintenance*	*Rectification*	
	Surrounds and other infrastructure					
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function	Major damage Poses risk to structural integrity, public safety or asset function	
Landscape	**Rubbish**	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
	Inlet					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Blockage**	No blockage	No blockage	Partial blockage of inlet causing some bypass of flows or restricted inflows	Blockage of inlet causing significant bypass or restriction of inflows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function No safety risks	Major damage, poses risk to structural integrity, public safety or asset function	
	Batters					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Vehicle or pedestrian damage**	No compaction, plant loss, vandalism impacting system function	No compaction, plant loss, vandalism impacting system function	Minor compaction, plant loss Does not pose risk to structural integrity or asset function	Significant compaction, plant loss Poses risk to structural integrity, public safety or asset function	
Landscape	**Rubbish**	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
Landscape	**Plant health**	Good vegetation health	Healthy vegetation	Vegetation is stressed Poor health (signs of disease, pests) in less than 20% of plants	Vegetation is dying back Poor health (signs of disease, pests) in more than 20% of plants	
Landscape	**Plant cover**	Good vegetation densities covering >80% of the planted surfaces	Good vegetation cover in planted areas (>80% cover / >6 plants per m2)	Moderate vegetation cover in planted areas (50-80% cover)	Poor vegetation cover in planted areas (<50% cover)	
Landscape	**Weeds**	Limited weed cover with no delcared weed species	Limited weed cover (<10%) and no declared noxious weed species	Low/Moderate weed cover (10-50%) and no declared noxious weed species	High weed cover (>50%) and/or declared noxious weed species present	
Landscape	**Nuisance fauna**	No nuisance fauna	No nuisance fauna	Some nuisance fauna but limited impact on aesthetics, water quality and/or vegetation growth	Significant nuisance fauna issues Heavily impacting aesthetics, vegetation growth and/or water quality	
	Open water zone					
Civil	**Sediment accumulation**	No accumulated sediment impeding flows or vegetation growth	No accumulated sediment or minimal sediment with no obvious impacts	Water depth above sediment surface is less than 0.5 m	Frequency of cleanout much less than design or at least once a year. Sediment cleanout difficult due to access issues.	
Landscape	**Rubbish**	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
Landscape	**Weeds**	Limited weed cover with no declared noxious weed species	Limited weed cover (<10%) and no declared noxious weed species	Low/Moderate weed cover (10-50%) and no declared noxious weed species	High weed cover (>50%) and/or declared noxious weed species present	
Landscape	**Floating plants**	No nuisance floating plants present	No or minimal nuisance floating plants present (<10%)	Low/Moderate cover (10-50%) Mechanical removal of nuisance floating plants is effective in managing blooms	Nuisance floating plant blooms with high cover (>50%) or are problematic, impacting on wetland performance and too extensive to remove mechanically	
Landscape	**Water quality (oil slicks, odour, algae)**	No water quality issues (oil slicks, odours, algae)	No water quality issues (oil slicks, odours, algae)	Some minor water quality issues visible (oil slicks, odours, algae) but no major impact on aesthetics or water quality	Significant water quality issues (oil slicks, odours, algae) Heavily impacting aesthetics and/or water quality	
Landscape	**Nuisance fauna**	No nuisance fauna	No nuisance fauna	Some nuisance fauna but limited impact on aesthetics, water quality and/or vegetation growth	Significant nuisance fauna issues Heavily impacting aesthetics, vegetation growth and/or water quality	
Landscape	**Mosquitos**	No nuisance populations of mosquitoes	No isolated depressions which can become breeding sites when water levels recede Deep pools provide refugia for predators No dead or rafting vegetation	Potential mosquito habitats observed (e.g. isolated pools, rafting vegetation)	Nuisance populations of mosquitoes observed and/or reported by local community	
	Outlet, overflow and inspection pipes					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Blockage**	No blockage	No blockage	Partial blockage of outlet or overflow causing some obstruction of outflows or requiring removal	Blockage of outlet or overflow preventing or significantly obstructing outflows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function	Major erosion Poses risk to structural integrity, public safety or asset function	

Infiltration basin or trench audit checklist

Date		Site address	
Weather		Site ID	
Date of last rainfall		Asset name	
WSUD Type		Asset ID	
Inspected by			

Add inspection data

	Task Item	Performance target	Good condition	Moderate condition	Poor condition	Condition summary
			(1 point)	(2 points)	(3 points)	
			No works	*Maintenance*	*Rectification*	
	Inlet					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Blockage**	No blockage	No blockage	Partial blockage of inlet causing some bypass of flows or restricted inflows	Blockage of inlet causing significant bypass or restriction of inflows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function No safety risks	Major damage, poses risk to structural integrity, public safety or asset function	
	Batters					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Vehicle or pedestrian damage**	No compaction, plant loss, vandalism impacting system function	No compaction, plant loss, vandalism impacting system function	Minor compaction, plant loss Does not pose risk to structural integrity or asset function	Significant compaction, plant loss Poses risk to structural integrity, public safety or asset function	
Landscape	**Rubbish**	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
Landscape	**Plant health**	Good vegetation health	Healthy vegetation	Vegetation is stressed Poor health (signs of disease, pests) in less than 20% of plants	Vegetation is dying back Poor health (signs of disease, pests) in more than 20% of plants	
Landscape	**Plant cover**	Good vegetation densities covering >80% of the planted surfaces	Good vegetation cover in planted areas (>80% cover / >6 plants per m2)	Moderate vegetation cover in planted areas (50-80% cover)	Poor vegetation cover in planted areas (<50% cover)	
Landscape	**Weeds**	Limited weed cover with no delcared weed species	Limited weed cover (<10%) and no declared noxious weed species	Low/Moderate weed cover (10-50%) and no declared noxious weed species	High weed cover (>50%) and/or declared noxious weed species present	
Landscape	**Nuisance fauna**	No nuisance fauna	No nuisance fauna	Some nuisance fauna but limited impact on aesthetics, water quality and/or vegetation growth	Significant nuisance fauna issues Heavily impacting aesthetics, vegetation growth and/or water quality	
	Unvegetated permeable or infiltration base					
Civil	**Sediment accumulation**	No accumulated sediment impeding flows or vegetation growth	No accumulated sediment or minimal sediment with no obvious impacts	Some accumulated sediment (covering <50% of surface) Causing some redirection of flows through the system	Accumulated sediment covering >50% of the surface Impeding flows Smothering vegetation	
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Permeability and clogging**	Infiltration / hydraulic capacity of the system is preserved	Dry Conditions: Water poured on surface infiltrates almost immediately , minimal fine sediment accumulation or visible surface crust. Wet Conditions: Surface ponding (100 - 300mm) for bioretention systems is drawn down over 1 - 3 hrs after inflow to the system has stopped following rainfall.	Dry Conditions: Water infiltrates surface slowly but ponding clears within minutes, some fine sediment accumulation or surface crust evident. Wet Conditions: Surface ponding observed for longer than normal (more than 3 hours).	Dry Conditions: Water ponds with minimal infiltration, significant fine sediment accumulation or extensive surface crust. Wet Conditions: Surface ponding (100 - 300mm) remains more than 12 hrs after inflow to the system has stopped following rainfall. Presence of algae or moss may indicate persistent wetting (e.g. baseflows) or clogging requiring further investigation.	
Civil	**Vehicle or pedestrian damage**	No compaction, plant loss, vandalism impacting system function	No compaction, plant loss, vandalism impacting system function	Minor compaction, plant loss Does not pose risk to structural integrity or asset function	Significant compaction, plant loss Poses risk to structural integrity, public safety or asset function	
Civil	**Surface levels**	Even surface with no depressions or mounds	Even surface with no depressions or mounds	Some small depressions or mounds present Limited impact on flows through the asset	Level of surface is impacting flows through the asset (e.g. short circuiting flows, blocking flows and / or reduced extented detention depth) Isolated pools created in the surface	
Landscape	**Rubbish**	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
Landscape	**Leaf litter**	No accumulated leaf litter causing blockages or impeding flows or vegetation growth	Minimal leaf litter present or covers less than 20% of surface	Some wet and decaying leaf matter present (covering 20-50% of surface) Aesthetic issue Some obstruction of flow paths	Large amount wet and decaying leaf matter present (covering >50% of the surface) Impacting vegetation growth Obstructing flow paths and blocking inlets or outlets	
Landscape	**Weeds**	Limited weed cover with no declared weed species	Limited weed cover (<10%) and no declared noxious weed species	Low/Moderate weed cover (10-50%) and no declared noxious weed species	High weed cover (>50%) and/or declared noxious weed species present	
	Outlet, overflow and inspection pipes					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Blockage**	No blockage	No blockage	Partial blockage of outlet or overflow causing some obstruction of outflows or requiring removal	Blockage of outlet or overflow preventing or significantly obstructing outflows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function	Major erosion Poses risk to structural integrity, public safety or asset function	

Permeable paving audit checklist

Date		Site address	
Weather		Site ID	
Date of last rainfall		Asset name	
WSUD Type		Asset ID	
Inspected by			

Add inspection data

	Task Item	Performance target	Good condition	Moderate condition	Poor condition	Condition summary
			(1 point)	(2 points)	(3 points)	
			No works	*Maintenance*	*Rectification*	
	Unvegetated permeable or infiltration base					
Civil	**Sediment accumulation**	No accumulated sediment impeding flows or vegetation growth	No accumulated sediment or minimal sediment with no obvious impacts	Some accumulated sediment (covering <50% of surface) Causing some redirection of flows through the system	Accumulated sediment covering >50% of the surface Impeding flows Smothering vegetation	
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Permeability and clogging**	Infiltration / hydraulic capacity of the system is preserved	Dry Conditions: Water poured on surface infiltrates almost immediately , minimal fine sediment accumulation or visible surface crust. Wet Conditions: Surface ponding (100 - 300mm) for bioretention systems is drawn down over 1 - 3 hrs after inflow to the system has stopped following rainfall.	Dry Conditions: Water infiltrates surface slowly but ponding clears within minutes, some fine sediment accumulation or surface crust evident. Wet Conditions: Surface ponding observed for longer than normal (more than 3 hours).	Dry Conditions: Water ponds with minimal infiltration, significant fine sediment accumulation or extensive surface crust. Wet Conditions: Surface ponding (100 - 300mm) remains more than 12 hrs after inflow to the system has stopped following rainfall. Presence of algae or moss may indicate persistent wetting (e.g. baseflows) or clogging requiring further investigation.	
Civil	**Vehicle or pedestrian damage**	No compaction, plant loss, vandalism impacting system function	No compaction, plant loss, vandalism impacting system function	Minor compaction, plant loss Does not pose risk to structural integrity or asset function	Significant compaction, plant loss Poses risk to structural integrity, public safety or asset function	
Civil	**Surface levels**	Even surface with no depressions or mounds	Even surface with no depressions or mounds	Some small depressions or mounds present Limited impact on flows through the asset	Level of surface is impacting flows through the asset (e.g. short circuiting flows, blocking flows and / or reduced extented detention depth) Isolated pools created in the surface	
Landscape	**Rubbish**	No litter present	No litter present	Some litter present Diminished aesthetics and /or causing some visible blockage	Large amount of litter present Heavily impacting aesthetics and/or blocking flows	
Landscape	**Leaf litter**	No accumulated leaf litter causing blockages or impeding flows or vegetation growth	Minimal leaf litter present or covers less than 20% of surface	Some wet and decaying leaf matter present (covering 20-50% of surface) Aesthetic issue Some obstruction of flow paths	Large amount wet and decaying leaf matter present (covering >50% of the surface) Impacting vegetation growth Obstructing flow paths and blocking inlets or outlets	
Landscape	**Weeds**	Limited weed cover with no delcared weed species	Limited weed cover (<10%) and no declared noxious weed species	Low/Moderate weed cover (10-50%) and no declared noxious weed species	High weed cover (>50%) and/or declared noxious weed species present	
	Outlet, overflow and inspection pipes					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Blockage**	No blockage	No blockage	Partial blockage of outlet or overflow causing some obstruction of outflows or requiring removal	Blockage of outlet or overflow preventing or significantly obstructing outflows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function	Major erosion Poses risk to structural integrity, public safety or asset function	

Gross pollutant trap audit checklist

Date				
Weather		Site address		Add inspection data
Date of last rainfall		Site ID		
WSUD Type		Asset name		
Inspected by		Asset ID		

	Task Item	Performance target	Good condition	Moderate condition	Poor condition	Condition summary
			(1 point)	(2 points)	(3 points)	
			No works	*Maintenance*	*Rectification*	
	Inlet					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Blockage**	No blockage	No blockage	Partial blockage of inlet causing some bypass of flows or restricted inflows	Blockage of inlet causing significant bypass or restriction of inflows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function No safety risks	Major damage, poses risk to structural integrity, public safety or asset function	
	Litter and sediment sump					
Civil	**Rubbish**	No potential loss of litter from sump	Some litter present (<80% of capacity)	Large amount of litter present (>80% of capacity)	Frequency of cleanout much less than design or cleanout difficult due to access issues.	
Civil	**Sediment accumulation**	No excessive accumulation of sediment with potential loss of material from sump	Some accumulated sediment present (<80% capacity)	Large amount of sediment present (>80% of capacity)	Frequency of cleanout much less than design or cleanout difficult due to fine sediment compaction	
	Outlet, overflow and inspection pipes					
Civil	**Erosion**	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended	No erosion	Minor erosion Does not pose risk to structural integrity, public safety or asset function (e.g. limited short circuiting of flows)	Major erosion Posing risk to structural integrity, public safety or asset function (e.g. short circuiting of the majority of flows)	
Civil	**Blockage**	No blockage	No blockage	Partial blockage of outlet or overflow causing some obstruction of outflows or requiring removal	Blockage of outlet or overflow preventing or significantly obstructing outflows	
Civil	**Damage or removal of structures**	No damage, erosion or issues / removal of structures	Stable structures No vandalism impacting amenity No safety risks	Minor damage Does not pose risk to structural integrity or asset function	Major erosion Poses risk to structural integrity, public safety or asset function	

Swale works checklist

Date	
Weather	
Date of last rainfall	
WSUD Type	
Works by	
Site address	
Site ID	
Asset name	
Asset ID	

Add works data to database

Task Item	Performance target	Works M - Maintenance R - Rectification	Condition summary
Inlet			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		
Vegetated base and batters			
Sediment accumulation	No accumulated sediment impeding flows or vegetation growth		
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Standing water or boggy conditions	No surface ponding or boggy areas		
Vehicle or pedestrian damage	No compaction, plant loss, vandalism impacting system function		
Surface levels	Even surface with no depressions or mounds		
Rubbish	No litter present		
Leaf litter	No accumulated leaf litter causing blockages or impeding flows or vegetation growth		
Plant health	Good vegetation health		
Plant cover	Good vegetation densities covering >80% of the planted surfaces		
Weeds	Limited weed cover with no declared noxious weed species		
Nuisance fauna	No nuisance fauna		
Outlet, overflow and inspection pipes			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		

Raingarden works checklist

Date	
Weather	
Date of last rainfall	
WSUD Type	
Works By	
Site address	
Site ID	
Asset name	
Asset ID	

Add works data to database

Task Item	Performance target	Works M - Maintenance R - Rectification	Condition summary
Surrounds and other infrastructure			
Damage or removal of structures	No damage, erosion or issues / removal of structures		
Rubbish	No litter present		
Inlet			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		
Batters			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Vehicle or pedestrian damage	No compaction, plant loss, vandalism impacting system function		
Rubbish	No litter present		
Plant health	Good vegetation health		
Plant cover	Good vegetation densities covering >80% of the planted surfaces		
Weeds	Limited weed cover with no delcared weed species		
Nuisance fauna	No nuisance fauna		
Permeable vegetated base			
Sediment accumulation	No accumulated sediment		
Erosion	No erosion		
Permeability and clogging	Infiltration / hydraulic capacity of the system is preserved		
Vehicle or pedestrian damage	No compaction, plant loss, vandalism impacting system function		
Surface levels	Even surface with no depressions or mounds		
Extended detention depth	Designed extended detention depth provided		
Rubbish	No litter present		
Leaf litter	No accumulated leaf litter causing blockages or impeding flows or vegetation growth		
Plant health	Good vegetation health		
Plant cover	Good vegetation densities covering >80% of the planted surfaces		
Weeds	Limited weed cover with no declared noxious weed species		
Nuisance fauna	No nuisance fauna		
Outlet, overflow and inspection pipes			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		

Tree pit a works checklist

Date	
Weather	
Date of last rainfall	
WSUD Type	
Inspected by	
Site address	
Site ID	
Asset name	
Asset ID	

Add works data to database

Task Item	Performance target	Works M - Maintenance R - Rectification	Condition summary
Inlet			
Erosion	No damage, erosion or issues / removal of structures		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		
Permeable vegetated base			
Sediment accumulation	No accumulated sediment		
Erosion	No erosion		
Permeability and clogging	Infiltration / hydraulic capacity of the system is preserved		
Vehicle or pedestrian damage	No compaction, plant loss, vandalism impacting system function		
Surface levels	Even surface with no depressions or mounds		
Extended detention depth	Designed extended detention depth provided		
Rubbish	No litter present		
Leaf litter	No accumulated leaf litter causing blockages or impeding flows or vegetation growth		
Plant health	Good vegetation health		
Plant cover	Tree present		
Weeds	Limited weed cover with no declared noxious weed species		
Nuisance fauna	No nuisance fauna		
Outlet, overflow and inspection pipes			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		

Wetland works checklist

Date	
Weather	
Date of last rainfall	
WSUD Type	
Inspected by	
Site address	
Site ID	
Asset name	
Asset ID	

Add works data to database

Task Item	Performance target	Works M - Maintenance R - Rectification	Condition summary
Surrounds and other infrastructure			
Damage or removal of structures	No damage, erosion or issues / removal of structures		
Rubbish	No litter present		
Inlet			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		
Batters			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Vehicle or pedestrian damage	No compaction, plant loss, vandalism impacting system function		
Rubbish	No litter present		
Plant health	Good vegetation health		
Plant cover	Good vegetation densities covering >80% of the planted surfaces		
Weeds	Limited weed cover with no declared noxious weed species		
Nuisance fauna	No nuisance fauna		
Aquatic macrophyte zone			
Sediment accumulation	No accumulated sediment impeding flows or vegetation growth		
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Vehicle or pedestrian damage	No compaction, plant loss, vandalism impacting system function		
Water levels	Water level depths and drawdown suitable to support healthy plant growth		
Rubbish	No litter present		
Leaf litter	No accumulated leaf litter causing blockages or impeding flows or vegetation growth		
Plant health	Good vegetation health		
Plant cover	Good vegetation densities covering >80% of the planted surfaces		
Weeds	Limited weed cover with no delcared weed species		
Floating plants	• No nuisance floating plants present		
Water quality (oil slicks, odour, algae)	• No water quality issues (oil slicks, odours, algae)		
Nuisance fauna	No nuisance fauna		
Mosquitos	No nuisance populations of mosquitoes		
Outlet, overflow and inspection pipes			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		

Sediment pond works checklist

Date	
Weather	
Date of last rainfall	
WSUD Type	
Inspected by	
Site address	
Site ID	
Asset name	
Asset ID	

Add works data to database

Task Item	Performance target	Works M - Maintenance R - Rectification	Condition summary
Surrounds and other infrastructure			
Damage or removal of structures	No damage, erosion or issues / removal of structures		
Rubbish	No litter present		
Inlet			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		
Batters			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Vehicle or pedestrian damage	No compaction, plant loss, vandalism impacting system function		
Rubbish	No litter present		
Plant health	Good vegetation health		
Plant cover	Good vegetation densities covering >80% of the planted surfaces		
Weeds	Limited weed cover with no delcared weed species		
Nuisance fauna	No nuisance fauna		
Open water zone			
Sediment accumulation	No accumulated sediment impeding flows or vegetation growth		
Rubbish	No litter present		
Weeds	Limited weed cover with no declared noxious weed species		
Floating plants	No nuisance floating plants present		
Water quality (oil slicks, odour, algae)	No water quality issues (oil slicks, odours, algae)		
Nuisance fauna	No nuisance fauna		
Mosquitos	No nuisance populations of mosquitoes		
Outlet, overflow and inspection pipes			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		

Infiltration basin or trench works checklist

Date	4/04/2016
Weather	
Date of last rainfall	
WSUD Type	
Inspected by	
Site address	
Site ID	
Asset name	
Asset ID	

Add work data to database

Task Item	Performance target	Works M - Maintenance R - Rectification	Condition summary
Inlet			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		
Batters			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Vehicle or pedestrian damage	No compaction, plant loss, vandalism impacting system function		
Rubbish	No litter present		
Plant health	Good vegetation health		
Plant cover	Good vegetation densities covering >80% of the planted surfaces		
Weeds	Limited weed cover with no delcared weed species		
Nuisance fauna	No nuisance fauna		
Unvegetated permeable or infiltration base			
Sediment accumulation	No accumulated sediment impeding flows or vegetation growth		
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Permeability and clogging	Infiltration / hydraulic capacity of the system is preserved		
Vehicle or pedestrian damage	No compaction, plant loss, vandalism impacting system function		
Surface levels	Even surface with no depressions or mounds		
Rubbish	No litter present		
Leaf litter	No accumulated leaf litter causing blockages or impeding flows or vegetation growth		
Weeds	Limited weed cover with no declared weed species		
Outlet, overflow and inspection pipes			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		

Permeable paving works checklist

Date	
Weather	
Date of last rainfall	
WSUD Type	
Inspected by	
Site address	
Site ID	
Asset name	
Asset ID	

Add works data to database

Task Item	Performance target	Works M - Maintenance R - Rectification	Condition summary
Unvegetated permeable or infiltration base			
Sediment accumulation	No accumulated sediment impeding flows or vegetation growth		
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Permeability and clogging	Infiltration / hydraulic capacity of the system is preserved		
Vehicle or pedestrian damage	No compaction, plant loss, vandalism impacting system function		
Surface levels	Even surface with no depressions or mounds		
Rubbish	No litter present		
Leaf litter	No accumulated leaf litter causing blockages or impeding flows or vegetation growth		
Weeds	Limited weed cover with no delcared weed species		
Outlet, overflow and inspection pipes			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		

Gross pollutant trap works checklist

Date	
Weather	
Date of last rainfall	
WSUD Type	
Inspected by	
Site address	
Site ID	
Asset name	
Asset ID	

Add works data to

Task Item	Performance target	Works M - Maintenance R - Rectification	Condition summary
Inlet			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		
Litter and sediment sump			
Rubbish	No potential loss of litter from sump		
Sediment accumulation	No excessive accumulation of sediment with potential loss of material from sump		
Outlet, overflow and inspection pipes			
Erosion	Minor erosion that doesn't pose public safety risk and would not worsen if left unattended		
Blockage	No blockage		
Damage or removal of structures	No damage, erosion or issues / removal of structures		