

WATER SENSITIVE URBAN DESIGN OPERATION AND MAINTENANCE GUIDELINES

Prepared for the Northern Territory Department of Planning and Infrastructure

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1 INTRODUCTION

As part of preparing a WSUD Strategy for Darwin Harbour, an operation and maintenance guideline has been prepared to assist WSUD practitioners in the ongoing management of WSUD treatment elements such as wetlands, bioretention systems and swales.

Through a series of interviews with key stakeholders in the Darwin region, operation and maintenance was identified as one of the key barriers to the successful implementation of WSUD in the wet-dry tropics. While WSUD systems are designed to be low maintenance, regular ongoing operation and maintenance is essential to preserve the long term functional elements of the WSUD systems. Failure to undertake regular ongoing inspection and maintenance can result in reduced performance of the treatment system, public health and safety risks, decreased aesthetic amenity, and decreased habitat diversity (and dominance of exotic weeds).

These guidelines provide assistance to asset managers to by providing a number of tools to maintain WSUD assets including a sample maintenance plan, inspection checklists, and maintenance schedules.

1.1 Purpose of this Document

This document has been developed as part of the WSUD Strategy for Darwin Harbour. It is primarily intended to inform asset managers, particularly local councils and developers, about the maintenance that will be required after construction. This document is part of a set of guidelines and tools on implementing WSUD as part of the development process. The framework of guideline documents is shown in Figure 1.

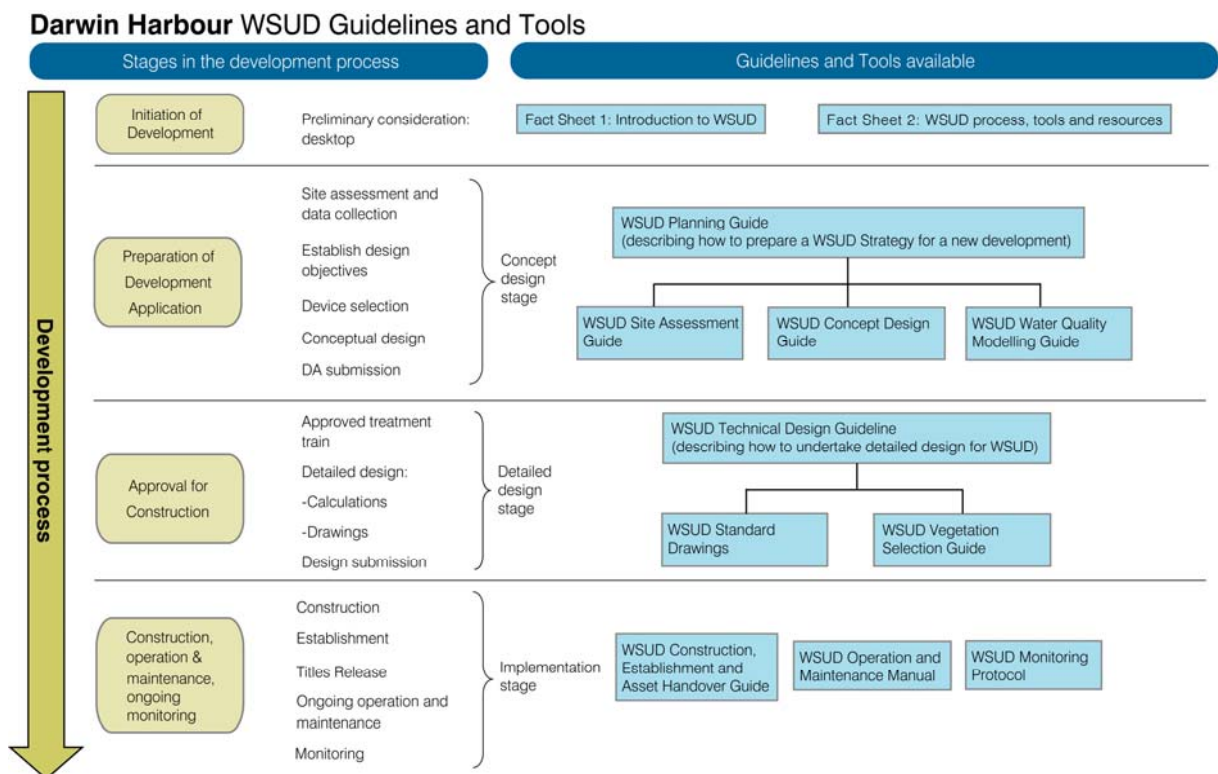


Figure 1: Relationship of this “Operation and Maintenance Guideline” to other guidelines and tools

This guideline should be used in conjunction with the other guidelines and tools developed as part of the WSUD Strategy for Darwin Harbour. In particular the operation and maintenance guidelines are used to complement the technical design guidelines and construction and asset handover guidelines.

1.2 Outline of this Document

This document is organised into the following sections:

- Section 2 provides an overview of the operation and maintenance process
- Section 3 provides information on operating and maintaining specific WSUD elements
- Section 4 includes templates for maintenance checklists
- Section 5 includes an example maintenance plan

2 PLANNING FOR OPERATION AND MAINTENANCE

Operation and maintenance needs to be considered at the beginning of the design phase. A well designed treatment system can minimise maintenance needs and simplify maintenance tasks. This requires an understanding of the requirements of operation and maintenance including access, maintenance methods, tools and equipment required to undertake maintenance, occupational health and safety requirements, timing and frequency of maintenance.

Maintenance activities are required throughout the lifetime of WSUD elements. It is important that WSUD elements are constructed with an ongoing commitment and capability for the WSUD element to be regularly maintained. It is unlikely that WSUD will achieve its design intent if they are not maintained.

At a broad level, implementation of WSUD elements involves the following tasks:

- Planning and design
- Construction and handover
- Routine maintenance activities
- Inspections and reporting
- Corrective maintenance

The broad relation between these tasks is shown in Figure 2. Operation and maintenance begins immediately after asset construction. Initially, maintenance is undertaken by the developer, then after asset handover it will become the responsibility of the local council. Each task is discussed in further in the following sections.

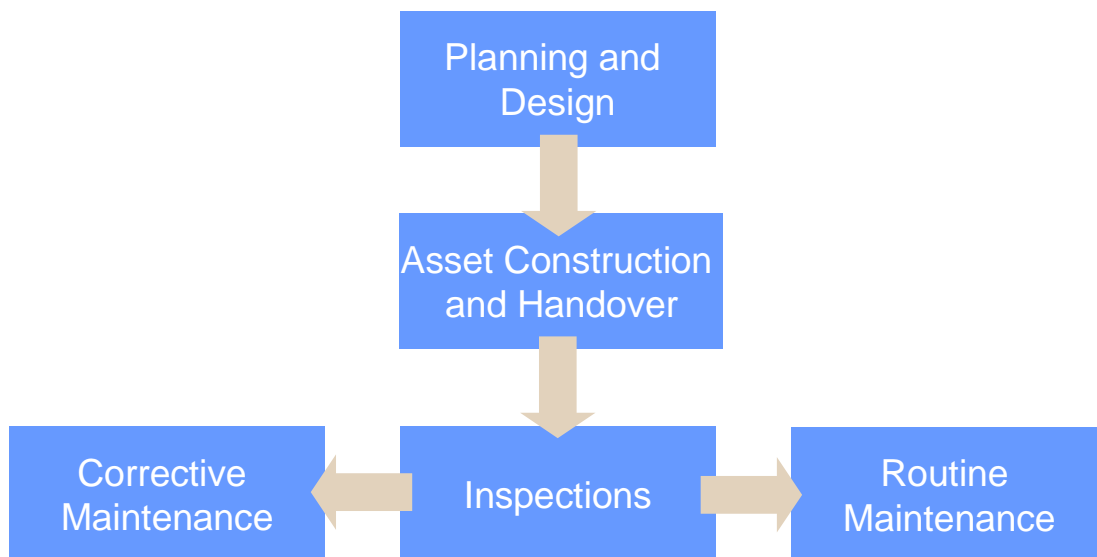


Figure 2: Operation and Maintenance Process

2.1 Planning and Designing for Maintenance

Planning for operation and maintenance requires systems that have been designed with reference to future maintenance activities. Design needs to be undertaken with maintenance in mind at the inception of any project. Key maintenance considerations for the design phase include:

- Viable and legal site access is available

- Access track is suitable for maintenance vehicles with full loads
- Turning bays
- Horizontal and vertical clearance (from overhead infrastructure etc)
- Slopes are suitable
- Availability of maintenance equipment and personnel
 - Are any external resources required by council? (e.g. eductor trucks)
 - Are specialist skills and training required and if so are sufficiently qualified personnel available? (e.g. confined spaces)
 - If contractors are to be used to undertake maintenance has this been factored in to life cycle cost analysis?
- Frequency of cleaning requirements
 - in the wet dry tropics it is difficult to undertake maintenance during the wet season and most maintenance are therefore likely to be undertaken annually during the dry season
 - considering the maintenance frequency, are systems designed adequately to withstand potentially high loads and compacted waste?
 - during the design phase, estimated pollutant loads should be used to calculate the desired cleaning frequency and treatment systems should be sized to ensure that sufficient storage is available
- A maintenance plan should be prepared during the project planning and design phase, including the following information:
 - Outline of the location and type of WSUD element
 - A description of the system's function
 - Frequency of required inspection and maintenance tasks
 - Simple checklists of tasks to be undertaken
 - Detailed maintenance procedures, including equipment needs, maintenance techniques, occupational health and safety, public safety, environmental management considerations, disposal requirements for material removed, access issues, stakeholder notification requirements, data collection requirements
 - Any specifications or drawings should be included in the plan
- Assessment of whole of lifecycle costs
 - The lifecycle cost includes the costs to plan, design, construct, maintain, manage and decommission the asset
 - Operation and maintenance costs include both routine and corrective maintenance costs
 - Currently little cost information exists for WSUD in the wet/dry tropics. To assist in the process of better cost estimates it is recommended that good cost records are kept at each stage of the WSUD life cycle

- Designs should incorporate features to simplify maintenance
 - For example water level controllers allow water levels to be manipulated for maintenance purposes in permanent or semi-permanent water bodies
 - Isolation valves or diversions to enable the system to be taken offline if required
 - Where possible partial or full road closures should not be required to undertake maintenance and access to the site should not be restricted by parked vehicles

During the development process the following key tasks should be undertaken between the WSUD designer and the identified future asset owner:

Design Phase	Requirements
Concept Design	<ul style="list-style-type: none"> • Asset owner’s maintenance and operation staff are consulted regarding maintenance issues • Discuss Asset owner’s requirements for transfer of asset ownership • Concept designs are reviewed by the asset owner’s maintenance officer
Detailed Design	<ul style="list-style-type: none"> • Asset owner’s maintenance and operation staff are consulted regarding maintenance issues • A maintenance plan is submitted with the detailed designs • Detailed designs are reviewed by the asset owner’s maintenance officer • Agreements between the developer and the asset owner on minimum and maximum periods of establishment and security bonds required before handover occurs • Designs consider the impact of dry weather low flows especially on the impact of mosquito breeding sites
Construction and Asset Handover	<ul style="list-style-type: none"> • Developer keeps maintenance records, maintenance manual and schedules which are transferred after practical completion • At the end of practical completion the asset is certified by the asset owner or approved certifying authority and inspection is undertaken by asset owner • On-site meeting occurs between asset owner and developer for maintenance induction • Asset owner updates asset management system • Where required, easement and public covenants are registered with the land titles office

Planning for operation and maintenance also involves the asset owner preparing for the management of the WSUD asset. Key documentation and information required is:

- Understanding the tasks and machinery required to undertake regular operations and maintenance
- Identify who will be responsible for supervising and undertaking maintenance including an understanding of the tasks to be performed by internal staff and by external contractors (through a contractor service agreement detailing the scope of works that are required)
- Identifying and undertaking any staff training that needs to occur to perform any specialist maintenance tasks (e.g. weed identification, cleaning of proprietary GPTs)
- Ensuring that the asset owner has a long term sustainable financial source to undertake the operation and maintenance of the WSUD elements

- Ensuring that an appropriate asset management system is in place which has a record of the maintenance plan, work as executed drawings, locations of the treatment systems and records of maintenance and inspections undertaken.
- Ensuring that an appropriate maintenance recording procedure is in place including recording of financial and operational information and records and that personnel responsible for maintenance are aware of the procedure
- Process for reviewing the maintenance plan and funding of maintenance activities such as an annual report

2.2 Construction, Establishment and Asset Handover

Maintenance should commence immediately following construction. During establishment until asset handover, maintenance will be the responsibility of the developer. During the establishment phase, maintenance needs are generally greater, as vegetation is establishing. Weed control is particularly important during this phase, and in wetlands water level manipulation is required to help the vegetation establish. There may be a need for corrective maintenance if any unexpected issues are identified in this phase.

While the frequency of maintenance activities will generally be higher during establishment, the routine inspection and maintenance requirements are generally the same as in later stages. Key activities include:

- Inspection for scour, erosion, traffic and other damage, and repairing damage where required
- Inspection for excessive sediment deposition, build up of debris and blockage, and clearing where required
- Inspection to identify issues which may increase the risk of mosquito breeding, such as isolated pools, and corrective action where required
- Inspection and testing of irrigation systems (where installed)
- Weed removal
- Mowing, slashing or pruning to remove unwanted vegetation and stimulate new growth
- Occasional replanting when vegetation dies
- Pest monitoring and control

More information on construction, establishment and asset handover is available in the “Construction, Establishment and Asset Handover Guide”.

2.3 Inspections

A clear and regular inspection regime should be developed for the WSUD element. Inspections of above ground elements can be conducted by simple visual assessments without machinery while inspections of underground structures such as GPTs will require the use of tools to lift access lids. In general it is recommended to undertake the follow inspections as a minimum:

- Twice during the wet season to observe the performance of the WSUD element during rain events
- At the end of the wet season to determine what maintenance is required during the dry season.

- At the end of the dry season to determine if the WSUD element is likely to be functional during the upcoming wet season

It should be noted that in many cases inspections can occur at the same time that routine maintenance is undertaken.

Inspection of the system is required to ensure that the system is functioning as designed (including proper operation of the hydraulic structures including the inlets and outlets) and also to observe water quality, evidence of scour, erosion and deposition, damage to structures or embankments, blockage and build up of debris, evidence of mosquito breeding sites or odours. Inspections will also identify any routine maintenance that needs to occur including:

- Minor maintenance to repair any scouring or other damage
- Removal of sediment build up within treatment system
- Weed removal and vegetation management
- Removal of debris from inlet and outlet to prevent blockage or impedance of their function

2.4 Routine maintenance activities

Routine maintenance activities are required in all WSUD elements. While WSUD elements, when appropriately designed, are low maintenance systems, they are not maintenance free. Routine maintenance tasks are outlined in the following sections.

2.4.1 Cleaning

Cleaning involves the removal and appropriate disposal of waste that has been captured by WSUD elements. Waste typically includes gross pollutants including litter and organic debris such as leaf and bark litter as well as sediment. It may be possible in some circumstances, after screening for anthropogenic litter, to reuse sediment and organic debris for landscaping.

Cleaning of WSUD elements is typically required at a particular point within the treatment system, such as a sediment basin, sediment forebay or a gross pollutant trap. The main vegetated area of a swale, wetland or bioretention system is less likely to require routine cleaning. Periodic cleaning may be required particularly at the end of the dry season if inspections identify areas where sediment or litter removal is required. Depending on the design of the treatment system, cleaning may require dewatering (for example the dewatering of a sediment basin before it the sediment can be removed).

In the wet dry tropics cleaning will be required annually at the end of the wet season. Where possible cleaning should also be considered during a dry period in the early wet season, particularly for gross pollutant traps. It is difficult to undertake cleaning during the wet season and designs should take this into consideration when considering waste storage volumes.

2.4.2 Landscape and vegetation management

Landscape and vegetation management requires routine maintenance. Many WSUD elements utilise vegetation as an integral part of the treatment process. Proper functioning of the treatment system requires that the vegetation is healthy and provides dense coverage. Vegetation management in treatment systems involves tasks such as:

- Pruning to encourage new growth
- Weed removal, particularly of aggressive weed species such as *Cabomba*, *Salvinia* or *Mimosa*. Weed removal methods can include removal by hand, or spot spraying using herbicides
- Maintenance of grass including mowing and irrigation

- Treatment or replacement of plants due to pest or disease
- Plant replacement to maintain original planting densities
- Rectification works due to vandalism or other damage
- Removal of unwanted debris
- Maintenance to prevent mosquito breeding sites (for more detail refer to the Guidelines to the Prevention of Mosquito Breeding Sites in Constructed Wetlands)

2.4.3 Hydraulic and structural maintenance

Periodic and routine maintenance is required to ensure that key hydraulic and structural components are functioning according to their design. Maintenance tasks for key structures includes:

- Removal of any sediment or debris that is clogging any inlet or outlet pits or pipes
- Removal of sediment buildup immediately downstream of entry sites to a WSUD element (such as a scour pad)
- Routine maintenance to any bunds or embankments
- Routine maintenance to areas which are designed to prevent scour and erosion including baffles, scour pads and overflow spillways
- Routine maintenance to any water level controllers or other flow control devices particularly in wetlands and ponds
- Routine maintenance to fences or other access devices

2.5 Corrective Maintenance

Infrequent corrective maintenance is likely to be required over the lifetime of a WSUD element. Corrective maintenance includes tasks which are required to restore the integrity of a component of a WSUD element to its design intent due to a component failure or due to particular climactic conditions (e.g. unusually high rainfall, extended dry season).

Corrective maintenance should be addressed promptly as failure to address an issue may cause an escalation in corrective maintenance costs later or pose a risk to public safety. Corrective maintenance tasks include

- Repairs to broken structural or hydraulic elements (broken pipes, pit lids, embankments, headwalls etc)
- Maintenance to prevent erosion particularly important in areas where slope stability is likely to be an issue
- In swales and bioretention systems, raking or aerating the surface can overcome clogging
- Maintenance of access paths
- High pressure jetting of stormwater pipes due to the deposition of fine sediment
- Regrading of surfaces to prevent localised ponding

In order to undertake corrective maintenance activities in wetlands and lakes, water level manipulation may be required.

2.6 Reporting

The asset management system should keep a record of all reports on work undertaken for the treatment system. Data capture is key to management and maintenance of a WSUD element. Reporting ensures that information is accessible within the organisation.

Basic reporting should include the filing of reports for all:

- Inspections
- Routine maintenance tasks
- Corrective maintenance tasks
- Records of any monitoring undertaken such as monitoring of waste removed or any water quality sampling

These reports are typically standard template reports, such as checklists and other standardised formats to record tasks undertaken. The reports should include basic information including

- Basic details of inspection/maintenance including personnel involved, dates, purpose of visit
- Details of any work undertaken
- Details of any additional work that needs to be undertaken
- Observations
- Difficulties encountered

Examples of these checklists are included in Section 4

3 OPERATION AND MAINTENANCE OF WSUD SYSTEMS

Specific operation and maintenance guidance for individual treatment systems is discussed in the following sections.

3.1 Gross pollutant traps

There are a wide variety of gross pollutant traps whose primary role is to remove anthropogenic waste as well as organic debris and sediment. The major operation and maintenance task for gross pollutant traps is the removal of this waste through various cleaning methods.

Gross pollutant traps include the following types:

- pit basket inserts
- trash racks
- angled vane traps
- floating booms and traps
- nets
- wet vault proprietary traps (e.g. CDS, Ecosol, Humeceptor, Rocla)

3.1.1 Inspections

Inspection tasks for gross pollutant traps include:

- observations of waste and volumes of waste including floating materials and oils
- the hydraulic inlets and outlets should be checked for blockages
- the gross pollutant screen/basket/insert should be checked for any blockages
- the structural components should be checked for damage (walls, access covers, base, etc)
- any moving parts including any bypass measures should be checked that they are operational
- detection of standing water and/or odours

3.1.2 Maintenance

Cleaning of gross pollutant traps can use a variety of methods including:

- Manual cleaning predominantly used for smaller devices where manual lifting is possible and waste loads are low
- Truck mounted crane arms which are used for devices which contain large heavy baskets, sumps or nets. In many cases the entire filtration device (net/basket) is removed and waste removed from the device externally. Waste can either be stored in the same truck or within a tipping truck
- Clamshell grab which uses a special clamshell bucket are often used for floating material or material in a sump
- Eductor trucks which suck material out of the device being cleaned into a storage tank

- Loaders (such as bobcats) can be used to clean devices such as trash racks using a bucket to remove waste to a tipping truck

In many cases there may be the need for a combination of manual methods and mechanical methods. For example the use of eductor trucks may need to be supplemented with manual removal of larger objects which may not be able to be removed by the eductor due to the restrictions on the inlet size of the suction hose.

Maintenance tasks for gross pollutant traps involve

- Removing and recording the volume/mass of waste trapped
- Clearing inlets and outlets of any blockages
- Clearing the screen/basket/insert of any blockages
- Repairing any damage to structural components (repairing walls, access covers, base, etc)
- Removal of any standing water and/or odours

While in most cases the removal of waste can be performed mechanically, the removal of blockages will normally need to be undertaken manually.

3.1.3 Frequency

The frequency of maintenance is strongly limited by the ability to safely remove waste during the wet season. As a minimum, waste removal and cleaning should be undertaken annually at the end of the wet season. At this time a complete waste removal and dewatering (in wet sump devices) should be undertaken.

Often in the early wet season after a number of smaller initial rain events there may not be rain for a week. During this time and if weather forecasts predict fine weather, it is recommended to undertake cleaning of gross pollutant traps. This is particularly important in helping to remove the potential higher pollutant loads caused by any build-up of pollutants during the dry season.

Inspections for blockages should occur on a frequent basis during the wet season. Monthly inspections should be undertaken to ensure that the inlets, outlets and filter mechanisms are not blocked. Maintenance to remove blockages should be undertaken on an as needed basis during the wet season.

3.2 Sediment basins

The primary function of sediment basins is to remove coarse sediment from stormwater. Sediment basins work by settling out coarse sediments in a permanent pool. Sediment basins should be installed with a maintenance drain to allow for manual emptying of the sediment basin. Sediment basins also need a suitable access ramp and access path into their base, which is capable of withstanding the loads of any maintenance vehicles.

3.2.1 Inspections

Inspection tasks for sediment basins include:

- observations of sediment build up
- observation of the inlet to check for any scouring or erosion
- the hydraulic inlets and outlets should be checked for blockages
- detection of standing water during the dry season

- observations of weeds and other vegetation

3.2.2 Maintenance

Removal of sediment from a sediment basin (“desilting”) is typically undertaken by first draining the sediment basin using the maintenance drain and then using a loader or similar excavator with an attached bucket. The loader is used to collect the sediment which is deposited into a tipping truck for reuse or disposal.

Manual activities for sediment basins include removal of any blockages, dewatering, erosion control, scour protection, weeding and other tasks to maintain the integrity of the basin.

3.2.3 Frequency

The frequency of desilting is limited by the ability to safely remove waste during the wet season. In most cases desilting will be undertaken annually at the end of the wet season. In some cases where there is sufficient storage available and it is acceptable to leave collected sediment in situ over the dry season, it may be possible to undertake desilting on a less frequent basis.

During the dry season the sediment basin should be left dry to prevent any opportunity for mosquito breeding.

Inspections for blockages should occur on a frequent basis during the wet season. Monthly inspections should be undertaken to ensure that the inlets, outlets and filter mechanisms are not blocked. Inspection frequency can be reduced with a well established and well functioning sediment basin. Maintenance to remove blockages should be undertaken on an as needed basis during the wet season.

3.3 Swales

The primary stormwater quality function of a swale is to filter sediment through a vegetated surface of grass or native vegetation. Swales are also conveyance systems which provide for conveyance of design flows safely within urban areas. Maintenance of swales is focussed on the maintenance of a well vegetated surface to provide effective filtration and the ability of the swale to convey the required flows.

3.3.1 Inspections

Inspection tasks for swales include:

- observation of deposition of sediment, litter or other debris on the surface of the swale
- observations of vegetation and weeds
- observation of any check dams or other hydraulic control devices
- observation of the entire length of the swale to check for any scouring or erosion
- the hydraulic inlets and outlets should be checked for blockages
- inspection for damage to the swale from vehicular or pedestrian traffic
- detection of permanent water during the dry season
- inspection of vegetation for pests and disease
- where swales are irrigated inspections of the proper functioning of the irrigation system should also be undertaken

- where swales are installed with subsoil drains the drains should be inspected

3.3.2 Maintenance

Maintenance of swales is typically manual and is undertaken with basic landscaping tools such as rakes, spades, shovels and hoes. Maintenance includes tasks such as removal of any litter or sediment from the swale, removal of any blockages, erosion control, re-establishing vegetation where required, weeding by hand or by spot application of herbicides and other tasks to maintain the integrity of the swale.

For grass swales maintenance will also involve mowing of the surface of the swale. If mowing occurs during the wet season the clippings should be collected to prevent mobilisation by subsequent rain events. Care should be taken to prevent rutting when mowing the swale if it is wet.

3.3.3 Frequency

Inspections to ensure that the swale is functioning according to design should occur on a frequent basis during the wet season. Monthly inspections should be undertaken to ensure that the inlets, outlets and the swale itself are not blocked and that the swale is free from erosion and scouring. Inspection frequency can be reduced with a well established and well functioning swale. Maintenance to remove blockages should be undertaken on an as needed basis during the wet season.

Inspections during the early wet season are required to ensure that the treatment device transitions from the dry season to the wet season satisfactorily. There is a higher risk of destabilisation of the swale at the beginning of the wet season.

More significant works, such as surface regrading or major weeding will be undertaken annually at the end of the wet season.

Inspections during the dry season should also be undertaken periodically, particularly to ensure that there is no ponding on the surface of the swale.

3.4 Wetlands and ponds

Wetlands retain water for relatively long periods at a time and typically have a permanent pool within the wetland footprint. Wetlands are typically vegetated with both emergent and submerged aquatic vegetation. Many wetlands will be designed with an inlet pond or sediment basin to remove coarse sediment. For maintenance of the inlet pond refer to section 3.2.

3.4.1 Inspections

Inspection tasks for wetlands include:

- observations of dense and diverse vegetation coverage and to check for presence of weeds
- damage to wetland vegetation due to high flows
- evidence of smothering of vegetation by sediment
- checking hydraulic inlets and outlets for evidence of blockage
- inspection of any high flow spillways and bypass channels for stability
- checking slopes and embankments for slope stability and erosion
- inspection for proper functioning of the maintenance drain

- detection of potential mosquito breeding sites, particularly during the dry season and the early wet season
- evidence of mosquito breeding
- inspection of visible water quality indicators including odours, oils and algal blooms
- inspection of landscaping elements such as pathways, decking, walls and terrestrial vegetation
- Inspection of aeration devices (if present)

3.4.2 Maintenance

Maintenance of well functioning wetlands is predominantly manual and is undertaken with basic landscaping tools such as rakes, spades, shovels and hoes. While designers should minimise the need for the use of boats, boats may be useful to undertake maintenance in the centre of deep pools. Maintenance includes tasks such as

- removal of any litter or floating debris from the wetland,
- removal of any blockages from hydraulic structures such as pits, risers and water level controllers
- stabilisation of batters,
- regrading and other works to prevent the creation of mosquito breeding sites
- re-establishing vegetation where required,
- weeding by hand or by spot application of herbicides
- pest and disease control
- maintenance to any landscaping structures and surrounding terrestrial vegetation
- maintaining water levels of wetlands during the dry season
- restocking mosquito predator populations
- routine maintenance of any aeration devices
- repairs to the structural integrity of the pond liner

3.4.3 Frequency

Wetlands require inspections during the early wet season to ensure that the wetland transitions from the dry season to the wet season satisfactorily. In particular inspections should be undertaken to ensure that the wetland vegetation is not negatively affected by

- rapid water level increase
- high sediment loads in the early part of the wet season, which could smother vegetation

If necessary water levels may need to be artificially manipulated.

Routine inspections should also be undertaken during the wet season to ensure that the wetland is functioning according to its design. Monthly inspections should be undertaken to ensure that the inlets, outlets and vegetation is functioning appropriately. Inspection frequency can be reduced with a well

established and well functioning wetland. Maintenance to remove blockages should be undertaken on an as needed basis during the wet season.

More significant works such as surface regrading or major weeding will be undertaken annually at the end of the wet season.

Occasional inspections during the dry season should also be undertaken, to ensure that if poor quality low flows are being delivered to the wetland that these flows are not having an adverse impact on the system. An inspection of the wetland and pond system should also be conducted at the end of the dry season. Permanent pools at the end of the dry season are at higher risk of poor water quality, including low levels of dissolved oxygen, remobilisation of pollutants due to anaerobic conditions and changes in water quality due to high evaporation losses. In extended dry seasons it may be necessary to top up permanent pools manually, to protect aquatic flora and fauna and maintain a healthy, functioning wetland system.

3.5 Bioretention systems

Bioretention systems temporarily pond stormwater on their surface, then water slowly filters through the soil media. The main treatment mechanism in a bioretention system is through media filtration. Maintenance of bioretention systems is focussed predominantly on the maintenance of a well vegetated surface to prevent clogging of the filter media.

3.5.1 Inspections

Inspection tasks for bioretention systems include:

- observations to ensure that ponded water is draining freely through the filter media and is not permanently ponding
- observations to ensure consistent vegetation cover and for evidence of weeds
- observations for any signs of clogging of the surface
- observations of hydraulic devices to convey water within the bioretention system
- the hydraulic inlets and outlets should be checked for blockages
- observations for damage to the bioretention system from vandalism or traffic
- subsoil drains should be inspected at collection pits and flush points to ensure integrity of the drainage collection system
- detection of permanent water ponding during the dry season due to persistent low flows
- where bioretention systems are irrigated inspections of the proper functioning of the irrigation system should also be undertaken

3.5.2 Maintenance

Maintenance of bioretention systems is typically manual and is undertaken with basic landscaping tools. The majority of the maintenance tasks for a bioretention system are similar to the tasks undertaken on a garden bed including

- weeding by hand or by spot application of herbicides,
- plant replacement,
- pest and disease control

- surface regrading when required,
- irrigation during the dry season
- removal of debris or litter.

Maintenance also includes tasks caused by the movement of water through the system including

- removal of any blockages to hydraulic structures,
- erosion control,
- maintenance to remove any clogging at the surface of the bioretention system by raking the surface or similar methods
- removal of sediment deposited, particularly at inlets, scour pads and any conveyance structures
- maintenance to batter slopes or hydraulic structures such as bunds

3.5.3 Frequency

Inspections to ensure that the bioretention system is functioning according to design should occur on a frequent basis during the wet season. Monthly inspections should be undertaken to ensure that the bioretention system is draining freely and the surface is not clogged, to ensure that inlets and outlets are not blocked and that the bioretention system is not affected by scour. Inspection frequency can be reduced with a well established and well functioning system. Maintenance to remove blockages should be undertaken on an as needed basis during the wet season.

Inspections during the early wet season are required to ensure that the treatment device transitions from the dry season to the wet season satisfactorily. In particular there is a higher risk of impacts on the vegetation in the early wet season from sediment, rapid water level build up or other destabilising impacts on the bioretention system.

More significant works such as surface regrading or major weeding will be undertaken annually at the end of the wet season.

Inspections during the dry season should also be undertaken periodically, particularly to ensure that there are no impacts from any persistent dry weather flows.

3.6 Sand filters

Sand filters are similar to bioretention systems without a vegetated surface. Sand filters are typically located underground. Maintenance of sand filters is focussed predominantly on the maintenance of sediment to prevent clogging of the filter media. Due to their high susceptibility to clogging, sand filters should be designed with a pre-treatment facility consisting of either a sediment basin/chamber or a gross pollutant trap.

3.6.1 Inspections

Inspection tasks for sand filters include:

- observations to ensure that water is draining freely through the filter media and is not being detained on the surface for long periods of time
- observations for any signs of clogging of the surface especially from sediment, oil and grease or other pollutants
- observations of hydraulic devices to convey water within the sand filter

- the hydraulic inlets and outlets should be checked for blockages
- subsoil drains should be inspected at collection pits and flush points to ensure integrity of the drainage collection system
- inspection of the structural components of the filter including the walls, base cover and access chambers
- observations of impacts of persistent low flows during the dry season

3.6.2 Maintenance

Maintenance of sand filters is typically manual and is undertaken with basic tools. The majority of the maintenance tasks for a sand filter include

- Routine raking or tilling of the surface to prevent clogging
- Filter surface regrading when required,
- removal of sediment or debris from the surface of the filter layer
- replacement of part or all of the filter media on an as needed basis.
- removal of any blockages to hydraulic structures,
- jetting or flushing of the collection drains as required

3.6.3 Frequency

Inspections to ensure that the sand filter is functioning according to design should occur on a regular basis during the wet season. Regular inspections should be undertaken to ensure that the sand filter system is not clogged and is draining well and to ensure that inlets and outlets are not blocked. Inspection frequency can be reduced with a well established and well functioning sand filter. Maintenance to remove clogging or to remove blockages should be undertaken on an as needed basis during the wet season.

Sand filters should be designed so that they can easily be taken off line for major maintenance activities, so that these can be undertaken in the wet season if required.

4 Checklist templates

4.1 Gross pollutant trap

GROSS POLLUTANT TRAP INSPECTION CHECKLIST			
Date of Visit:	/ /	Weather:	
Location:			
Purpose of Inspection:	Routine inspection/Post maintenance inspection/ Response to complaint/Other (specify):		
Asset I.D.			
Site Visit by:			
INSPECTION ITEMS:	Y	N	Comments/Suggested Action
Odours detected?			
Vandalism Present?			
Litter evident downstream of the device?			
Water ponding was present?			
Surrounding site condition ok?			
Access to device was available?			
Inlet was blocked?			
Outlet was blocked?			
High flow bypass was blocked?			
Clogging of screen or filter visible?			
Captured waste in GPT?			Volume: 25% / 50% / 75% / 100%
Condition of the access cover, walls, etc is sound?			
Condition of the screen/filter/net is sound?			
COMMENTS			

4.2 Sediment Basin

SEDIMENT BASIN INSPECTION CHECKLIST			
Date of Visit:	/ /	Weather:	
Location:			
Purpose of Inspection:	Routine inspection/Post maintenance inspection/ Response to complaint/ Other (specify):		
Asset I.D.			
Site Visit by:			
INSPECTION ITEMS:	Y	N	Comments/Suggested Action
Odours detected?			
Vandalism Present?			
Litter evident within basin?			
Significant water ponding was present in basin?			
Minor isolated water ponding was present?			
Surrounding site condition ok?			
Access to device was available?			
Inlet was blocked?			
Outlet was blocked?			
High flow bypass was blocked?			
Sediment in basin?			Sediment Level: 25% / 50% / 75% / 100%
Condition of the slopes, base, etc is sound?			
Condition of pits/pipes is sounds?			
Site vegetation is satisfactory?			
Maintenance drain is operational?			
COMMENTS			

SEDIMENT BASIN MAINTENANCE CHECKLIST			
Date of Visit:		Weather:	
Location:			
Purpose of Inspection:	Routine maintenance/Corrective maintenance/ Response to complaint Other (specify):		
Asset I.D.			
Site Visit by:			
INSPECTION ITEMS:	Y	N	Comments/Suggested Action
Drain sediment basin?			
Remove and dispose sediment?			
Remove blockage from inlet?			
Remove blockage from outlet?			
Remove blockage from high flow bypass?			
Repairs due to vandalism?			
Repairs to surrounding site or access?			
Repairs to banks/base/pit?			
Repairs to pits/pipes/etc?			
Maintenance of vegetation (weeding, irrigating)?			
Replanting of vegetation?			
COMMENTS			

4.3 Swales

SWALE INSPECTION CHECKLIST			
Date of Visit:	/ /		Weather:
Location:			
Purpose of Inspection:	Routine inspection/Post maintenance inspection/ Response to complaint/ Other (specify):		
Asset I.D.			
Site Visit by:			
INSPECTION ITEMS:	Y	N	Comments/Suggested Action
Odours detected?			
Vandalism or traffic damage present?			
Litter evident in swale?			
Sediment/debris present in swale?			
Flowing water was present on surface?			
Water ponding was present on surface?			
Erosion or scouring of swale present?			
Mowing required?			
Replanting required?			
Removal of dead/diseased vegetation required?			
Inlet was blocked?			
Outlet was blocked?			
Condition of the slopes, base, etc is sound?			
Condition of pits/pipes is sounds?			
Access to device was available?			
Irrigation system (if installed) is working?			
COMMENTS			

SWALE MAINTENANCE CHECKLIST			
Date of Visit:		Weather:	
Location:			
Purpose of Inspection:	Routine maintenance/Corrective maintenance/ Response to complaint Other (specify):		
Asset I.D.			
Site Visit by:			
INSPECTION ITEMS:	Y	N	Comments/Suggested Action
Remove litter, sediment, debris from swale?			
Remove blockage from inlet?			
Remove blockage from outlet?			
Repairs due to vandalism?			
Repair swale due to erosion or scouring?			
Mowing?			
Replanting			
Weeding?			
Pruning, removal of dead vegetation?			
Irrigation?			
COMMENTS			

4.4 Wetlands and ponds

WETLAND AND POND INSPECTION CHECKLIST			
Date of Visit:	/ /	Weather:	
Location:			
Purpose of Inspection:	Routine inspection/Post maintenance inspection/ Response to complaint/Other (specify):		
Asset I.D.			
Site Visit by:			
INSPECTION ITEMS:	Y	N	Comments/Suggested Action
Odours detected?			
Vandalism or traffic damage present?			
Litter evident in wetland/pond?			
Significant water ponding present?			
Minor isolated water ponding present?			
Erosion or scouring present?			
Vegetation density satisfactory?			
Significant dead/diseased vegetation present?			
Inlet was blocked?			
Outlet was blocked?			
Condition of the slopes, bunds, etc is sound?			
Condition of pits/pipes is sounds?			
Access to device was available?			
Maintenance drain is working?			
COMMENTS			

4.5 Bioretention system

BIORETENTION SYSTEM INSPECTION CHECKLIST			
Date of Visit:	/ /	Weather:	
Location:			
Purpose of Inspection:	Routine inspection/Post maintenance inspection/ Response to complaint Other (specify):		
Asset I.D.			
Site Visit by:			
INSPECTION ITEMS:	Y	N	Comments/Suggested Action
Odours detected?			
Vandalism or traffic damage present?			
Litter evident within basin?			
Sediment/debris present at inlet?			
Water ponding was present on surface?			
Erosion or scouring present?			
Vegetation density satisfactory?			
Significant dead/diseased vegetation present?			
Clogging of surface present?			
Inlet was blocked?			
Outlet was blocked?			
Condition of the slopes, bunds, etc is sound?			
Condition of pits/pipes is sounds?			
Access to device was available?			
Collection drain is draining satisfactorily?			
Irrigation (if installed) is working?			
COMMENTS			

BIORETENTION SYSTEM MAINTENANCE CHECKLIST			
Date of Visit:		Weather:	
Location:			
Purpose of Inspection:	Routine maintenance/Corrective maintenance/ Response to complaint Other (specify):		
Asset I.D.			
Site Visit by:			
INSPECTION ITEMS:	Y	N	Comments/Suggested Action
Remove litter, sediment, debris from swale?			
Remove blockage from inlet?			
Remove blockage from outlet?			
Repairs due to vandalism?			
Repair due to erosion or scouring?			
Replanting?			
Weeding?			
Irrigation?			
Pruning, removal of dead vegetation?			
Jetting or rodding of collection drain?			
COMMENTS			

4.6 Sand Filters

SAND FILTER INSPECTION CHECKLIST			
Date of Visit:	/ /		Weather:
Location:			
Purpose of Inspection:	Routine inspection/Post maintenance inspection/ Response to complaint Other (specify):		
Asset I.D.			
Site Visit by:			
INSPECTION ITEMS:	Y	N	Comments/Suggested Action
Odours detected?			
Vandalism detected?			
Litter evident?			
Water ponding was present on surface?			
Erosion or scouring present?			
Surface clogging was evident?			
Inlet was blocked?			
Outlet was blocked?			
Condition of the walls, base, etc is sound?			
Condition of pits/pipes is sounds?			
Access to device was available?			
Drainage system is working?			
COMMENTS			

5 MAINTENANCE PLAN OUTLINE

An outline of a maintenance plan is included here showing the sections that should be covered by the plan. Every maintenance plan should be tailored to the individual treatment system. While treatment systems are similar it is likely that every treatment system will have a number of site specific requirements. The following sections outline the basic sections of a maintenance plan.

5.1 Introduction

This section should include an introduction to the treatment system including:

- A brief history of the design and construction of the system
- A broad overview of the treatment system maintenance plan
- Key features of the treatment system
- key features of the maintenance plan
- Key logistic considerations such as asset owner, asset id number, right of access, etc

5.2 Treatment System Operation

This section should include an overview of the treatment system operation including:

- A map clearly identifying access routes, location and all key features of the system
- An overview of the key sizes of all key elements in the system pits and pipes
- A brief description of how the system is designed to function including water movement into, through, around and out of the system

5.3 Inspections

This section should succinctly describe all the inspections that are likely to be required. Where appropriate, visual information should be provided. This can take the form of images or photos (e.g. to help identify weeds).

A site-specific inspection checklist should be created and for easy reference included in a single page as an Appendix. All the inspection tasks on the checklist should be described in this section.

This section of the report should clearly outline the frequency at which inspections are required.

5.4 Maintenance Tasks

This section should clearly describe:

- the method of all the routine maintenance tasks that are required to operate the WSUD element. The tasks should be described in sufficient detail to undertake the work.
- the frequency at which maintenance tasks are required.
- the preparation tasks that are required before undertaking maintenance
- tools and machinery that are required
- skills (such as confined spaces, vegetation identification skills, pest and disease identification),

- environmental management consideration (such as disposal, discharge of water in sumps etc)
- any important access information
- stakeholder or resident notification requirements
- data collection requirements

A maintenance task checklist should be created and for easy reference included in a single page as an Appendix. All the tasks on the checklist should be described in this section.

5.5 Identification of Occupational Health and Safety and Public Safety Issues

This section should clearly identify all the specific safety risks for the site and how the safety risks should be reduced including measures to avoid the risk or reduce the likelihood of it occurring.

Risks that need to be considered are:

- Trips and slips
- Risks due to standing water or moving water including drowning
- Heavy lifting and manual handling
- Contact with sharps such as syringes
- Contact with pathogens
- Traffic hazards and the requirement for any traffic barriers
- Personal protective equipment required
- Risks due to extreme weather events (heat, wet weather)
- Bites and stings from insects and animals
- Chemical materials (herbicides and pesticides)

5.6 Reporting

The maintenance plan should outline the proper reporting process that is required by council including the requirement for recording inspections and maintenance undertaken as well as the procedure for record keeping. An asset register should be kept, preferably in both hard copy and electronic format, which contains:

- A record of all inspection checklists/reports
- A record of all maintenance checklists/reports
- A record of any major corrective maintenance
- A copy of the maintenance plan including all appendices

5.7 Long term maintenance requirements

Longer term maintenance requirements are those that occur on a frequency greater than 5 to 10 years. It is expected that in the longer term a number of components of WSUD elements will require

“resetting”, such as soil filter media in a bioretention system or replacement of physical elements such as screens or scour protection devices.

As a minimum this section of the document should outline the:

- potential long term maintenance tasks that are required
- the processes required to undertake the task
- the likely or potential timeframe that it will be required.

5.8 Appendix A Inspection Checklist

An inspection checklist, specific to the treatment system, is required.

5.9 Appendix B Maintenance Checklist

A maintenance checklist, specific to the treatment system, is required.

5.10 Appendix C Manuals of specific proprietary devices

Any manuals of proprietary devices such as GPTs, or mechanical devices (such as aerators or pumps) need to be included in this Appendix.

5.11 Appendix D Construction and Work as Executed Drawings

A record of both the Work As Executed (WAE) and construction drawings need to be included in this Appendix.

5.12 Appendix E Construction Photo Database

It is strongly recommended that a visual record in the form of photographs or videos of the construction of the treatment system is kept and recorded in this appendix.

6 REFERENCES

CSIRO (2006), WSUD Engineering Procedures, Melbourne

EPA Victoria (2008), Maintaining water sensitive urban design elements, Melbourne.

FAWB (2008), Raingardens and bioretention tree pits Maintenance Plan Example, Melbourne

Healthy Waterways Partnership (2006), WSUD Technical Design Guidelines for South East Queensland, Brisbane.

Institute of Engineers (2006), Australian Runoff Quality, Canberra.

NSW Water Directorate (2006), Draft Maintenance Guidelines for Stormwater Treatment Measures, Sydney.