Bellingen Shire COUNCIL

Water Sensitive Urban Design Guidelines

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Water Sensitive Urban Design Guidelines

Prepared For:	Bellingen Shire Council
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1 INTRODUCTION

1.1 Purpose of the WSUD Guidelines

This document outlines Council's requirements for the implementation of Water Sensitive Urban Design (WSUD) as a component of future development within the Bellingen Shire Council LGA.

1.2 Background

Urban development often results in significant modification to soils, topography, catchment imperviousness and vegetation. Surface runoff volumes and pollutant concentrations from urbanised catchments are typically elevated above natural conditions and without mitigation have the potential to convey elevated pollutant loads to receiving waters. Urban development also has the potential to significantly increase surface runoff flow rates leading to impacts on stream stability, receiving water ecology and flooding.

WSUD is a philosophy that incorporates urban water management into the urban design process. WSUD considers options to integrate urban water management infrastructure within the natural environment. WSUD aims to protect the health of aquatic ecosystems and minimise negative impacts on the natural water cycle. Achieving the full benefits of WSUD requires combined consideration of water supply, wastewater, stormwater, groundwater, flooding and riparian zones when planning a development. Stormwater quality and quantity management are particularly important for protecting aquatic ecosystems.

Implementation of WSUD within a development to detain, retain, harvest, filter, infiltrate and biologically treat stormwater runoff will assist to reduce the concentrations and loads of pollutants discharged to the receiving waters. In addition, harvesting and infiltrating runoff can reduce the volume of runoff which has the potential to generate additional pollutants through erosion and sedimentation in the receiving watercourses. As the urban population increases, more efficient use of water also becomes increasingly important. New development, redevelopment and alterations to existing buildings can contribute to more efficient use of water resources by incorporating water efficient measures.

A development incorporating consideration of WSUD principles provides a range of community and environmental benefits when compared to conventional development including:

- Reduced nutrients, sediment load and exotic/weed seeds discharging to aquatic habitats resulting in lowered nuisance plant growth, lowered turbidity, less smothering of aquatic plants and animals, and improved photosynthesis;
- Reduced litter, organic debris and other coarse matter discharging into waterways used by residents and tourists for swimming, surfing, boating, and other recreational activities;
- Reduced suspended solids, heavy metals, oils and greases , and other contaminants discharging into waterways that are used for fishing and aquaculture;
- Reduced impacts on surface and groundwater flow regimes;
- Improved protection of watercourses, wetlands, groundwater and riparian corridors;

- Increased conservation of potable water leading to more efficient use of natural water resources;
- Reduced impacts on drinking water supply catchments;
- Reduced sewage discharges to the natural environment;
- Maintenance of stream stability through reduced erosion and sedimentation;
- Integration of stormwater, water supply, wastewater and flooding management improving efficiency and reducing long term costs to the community;
- Increased system reliability and reduced nuisance flooding through integration of stormwater quality and drainage management systems;
- Integration of water into the landscape to enhance visual, cultural and ecological values; and
- Sustainable water resources management education opportunities for the community.

1.3 Requirement for WSUD

Bellingen Shire Council (Council) requires that all developments are designed incorporating consideration of WSUD to minimise impacts on the natural and built environment. Council's primary focus is currently on the stormwater component of WSUD and specifically on mitigating the impacts of increased stormwater volumes and pollutant loads on receiving environments. The main WSUD objectives for Council are:

- To maintain the high ecological, recreational and agricultural values of Bellingen's waterways;
- To ensure stormwater systems are carefully planned, designed and located to prevent the disturbance, redirection, reshaping or modification of watercourses and associated vegetation and to protect the quality of receiving waters;
- To ensure that stormwater harvesting (source controls) SQIDs are implemented to maximise stormwater reuse and prevent increases in the quantity of stormwater discharge from the development site which can impact on downstream environments; and
- To ensure that any stormwater facilities installed on Council property are appropriate having regard to Council's ongoing ability to manage and maintain those facilities.

1.4 WSUD Guidelines Structure

These WSUD guidelines support the Bellingen Shire Development Control Plan 2010 (DCP) by outlining guidance to development proponents on acceptable approaches to demonstrate how the DCP objectives can be addressed and targets achieved within their development. These WSUD guidelines should be considered along with Chapter 12 of the DCP which provides:

- Key objectives for new stormwater systems in Bellingen Shire;
- Stormwater quality management objectives and targets;
- Stormwater quantity management objectives and targets;
- Development types and scales that the stormwater management targets apply to; and
- Stormwater Management Plan requirements.

The WSUD guidelines are structured in the following way:

Section 2 outlines the scope of these WSUD Guidelines and provides a summary of WSUD considerations at different development stages.

Section 3 outlines some of the key physical constraints that should be considered when developing a Stormwater Management Plan (SMP) for a development site.

Section 4 provides advice on selection of Stormwater Quality Improvement Devices (SQIDs) considering the constraints of a particular site. This section also includes practice notes for preferred SQIDs within the Bellingen Shire Council LGA.

Section 5 provides advice on arranging selected SQIDs in a treatment series.

Section 6 provides guidance on local parameters to be adopted when preparing MUSIC models within the Bellingen Shire Council LGA.

Section 7 outlines key consideration for developing concept designs.

Section 8 provides guidance on preparing a draft operation and maintenance plan to support an SMP.

Section 9 provides a list of elements to be addressed with an SMP report that is required to be provided with a Development Application.

Section 10 describes the handover procedure that Council applies for transfer of WSUD assets to Council following completion of construction.

2 WSUD GUIDELINES SCOPE

2.1 Overview

The scope of these WSUD guidelines in relation to other key Council policies and guidelines is summarised in Figure 2-1. The WSUD objective and targets, and relevant development scales that these criteria apply to, are provided in the Bellingen Shire Council DCP 2010. The DCP should be reviewed to confirm the WSUD objectives and targets that apply to specific developments.

2.2 Development Application

These WSUD guidelines focus on key considerations for the preparation of a Stormwater Management Plan (SMP) at the Development Application stage. Although, to ensure that only minor changes are required to the SMP at the following Construction Certificate stage, sufficient investigations shall be completed to confirm the type, size and location of Stormwater Quality Improvement Devices (SQIDs) required to achieve Council's objectives and targets. The size of the SQIDs shall be estimated by MUSIC modelling (or similar approved modelling acceptable to Council) and the development footprint for each SQID confirmed by considering the physical constraints of each individual site. Concept sketches/drawings shall be prepared showing the plan arrangement and a typical cross section to outline the proposed configuration of the SQIDs. An important consideration at this stage will be the preparation of a draft operation and maintenance plan that addresses how the SQIDs will be maintained efficiently into the future.

2.3 Construction Certificate

Detailed design of the SQIDs would be completed during preparation of documentation required to support the Construction Certificate application. The initial task would be to review the SMP prepared as a component of the Development Application to confirm that the development layout and configuration of the proposed SQIDs is unchanged.

If modifications to the development layout or proposed SQIDs are required, revised MUSIC modelling (or similar approved modelling acceptable to Council) shall be completed and the results provided with an application to modify the development consent. The operation and maintenance plan should also be updated to reflect any changes.

The detailed design will involve reviewing the concept sketches/drawings. Detailed engineering drawings will be required to document the SQIDs. Drawings will typically include a detail plan, typical sections, cross sections and details (e.g. diversion structures, low level outlets, weirs, energy dissipation structures). A landscaping plan would also be required for vegetated SQIDs. Additional engineering calculations will be required to size the inlet and outlet structures. Technical specifications shall also be prepared for all works required to complete the SQIDs

These WSUD guidelines do not provide specific guidance on preparing detailed designs and technical specifications for SQIDs, although links are included to resources that can assist with these tasks. Council's technical specifications and engineering standards shall be considered when preparing the designs.

2.4 Subdivision Certificate

For developments that involve subdivision of land and associated works that include the construction of SQIDs, Council may require the lodgement of maintenance bonds to cover the cost of works required to ensure establishment of vegetation within vegetated SQIDs. Where Council deems this to be necessary, maintenance bonds shall be lodged with Council when the Subdivision Certificate application is lodged.

2.5 Asset Handover

Council will typically assume responsibility for future maintenance of SQIDs installed in public lands following completion of construction and fulfilment by the developer of the requirements for issuing of a Subdivision Certificate.

Prior to accepting ownership of constructed SQIDs, Council will require documented evidence that the SQID has been constructed in accordance with the consent and that maintenance has regularly occurred up until the date of asset handover. A final operation and maintenance plan shall be provided to Council and a maintenance induction completed for Council staff prior to handover.

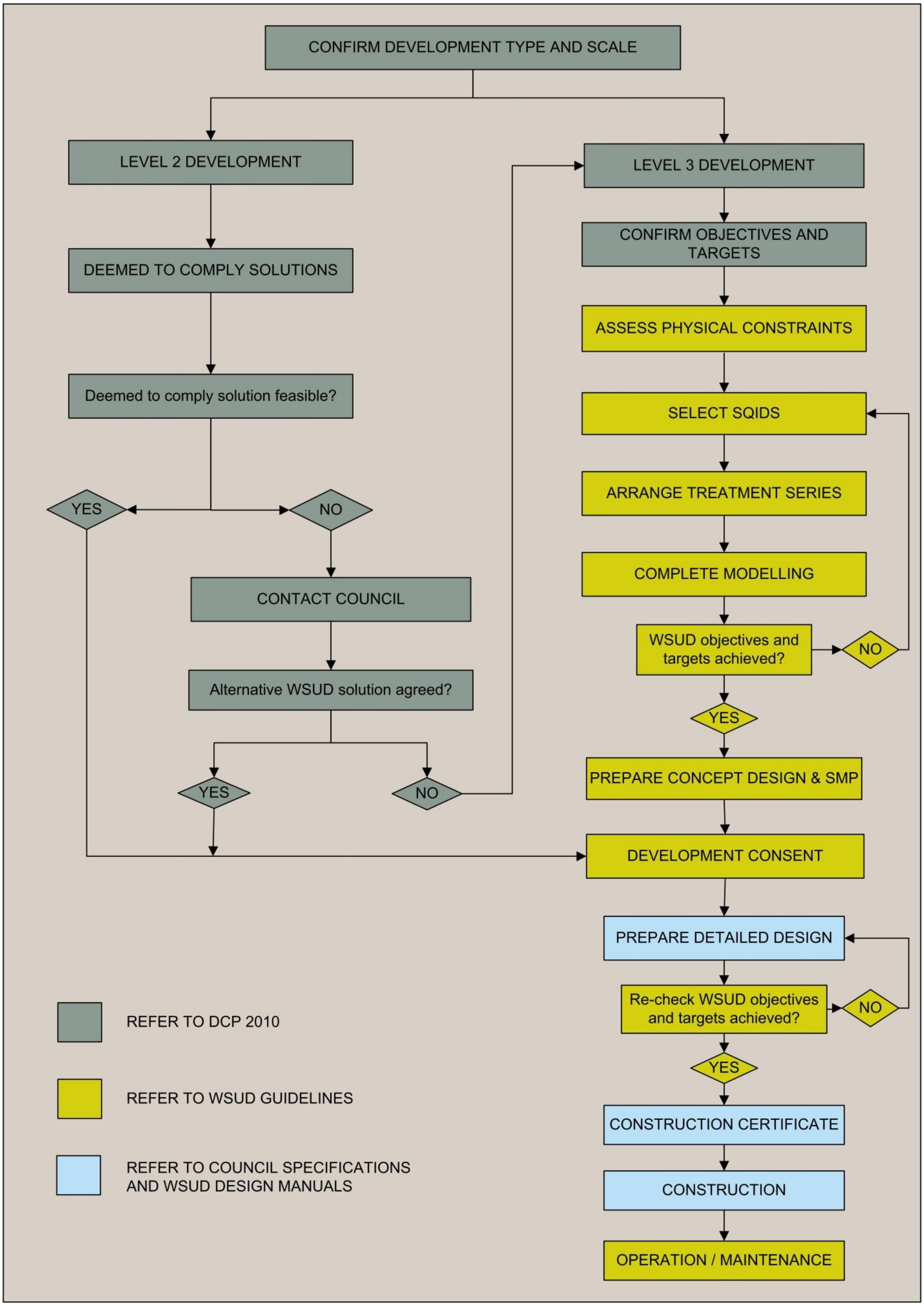


Figure 2-1 WSUD Guidelines Context

3 ASSESS PHYSICAL CONSTRAINTS

3.1 Terrain

The terrain of a site and adjacent land is typically one of the key constraints for WSUD. The site terrain is typically analysed to confirm sub-catchments for a particular development and includes consideration of both internal and external parts of the site. The terrain analysis also assists with confirming surface drainage pathways within the site. A slope analysis may also be undertaken to interpret surface gradients across the site and confirm appropriate locations for particular SQIDs.

In addition to the terrain, the location of existing stormwater drainage systems and roads should be considered when determining sub-catchments as this infrastructure can modify catchments from that indicated by the general topography. The sub-catchments should also be defined considering land uses and the future development configuration.

The terrain of the site is commonly assessed utilising geographical information systems (GIS) and/or digital terrain models (DTM) that enable catchments to be delineated and the spatial distribution of site gradients to be interpreted. The terrain can also be interpreted from topographic maps or contour surveys where GIS data is unavailable.

To analyse the terrain, the site can be divided into gradient bands (e.g. <1%, 1-4% >4%) that relate to particular WSUD constraints using GIS and the site DTM. This analysis will identify the gradients perpendicular to the contours. Alternatively, hard copy plans showing contours could be reviewed to evaluate slopes within the site. By aligning infrastructure along the contours it may also be possible to modify the slopes to provide more amenable gradients for particular SQIDs.

In addition to assessing the gradients across the site, other terrain features should also be identified that potentially will impact on the location of SQIDs including areas of slope instability and rock outcrops.

3.2 Soils and Groundwater

A key objective of WSUD is to minimise changes in the stormwater runoff volumes and flow duration following development. Typically this can be achieved through rainwater/stormwater harvesting and/or maximising infiltration/evapotranspiration within the remaining pervious areas.

In order to assess the suitability of a particular site for infiltration it is important that soil investigations are undertaken. Whilst infiltration will assist with reducing the volume of stormwater it is also important to consider the potential impacts of increased infiltration on factors including groundwater levels/flow/quality, downslope seepage, downslope built infrastructure, soil salinity and the function of SQIDs.

Preliminary desktop investigations may be undertaken using published soil landscape mapping/data and previous geotechnical investigations in the area and these can be used for preliminary planning and scoping geotechnical field investigations.

Geotechnical field investigations typically will be required on larger sites to confirm appropriate locations and types of SQIDs. The geotechnical investigations may also assist with defining parameters for modelling. The extent of investigations required will depend on the individual characteristics of the site and the proposed SQIDs. Investigations may include:

- Description, classification and mapping of the soil types within the site;
- Depth of individual soil layers in the profile and the depth to bedrock;
- Location of the groundwater table and assessment of the groundwater response to rainfall/seasonal influences;
- Groundwater monitoring/sampling and assessment for salinity, water quality, seasonal movement and flow direction/velocity;
- Soil pH and assessment of the presence of potential and/or actual acid sulfate soils;
- Presence or evidence of any soil contamination;
- Soil salinity classification;
- Saturated hydraulic conductivity testing and assessment of the permeability of surface and sub-surface soil layers (hydrophobic, hard setting soils); and
- Soil dispersion and erosion potential.

3.3 Riparian Corridors

The protection of riparian areas is important for maintaining or improving the geomorphic form and ecological functions of watercourses through a range of hydrologic conditions. Advice is provided by the NSW Office of Water (NoW) on acceptable arrangements for managing riparian corridors. Minimum riparian corridors widths are defined within the *Guidelines for Riparian Corridors on Waterfront Land* (NoW, 2012). The development applicant shall ensure that those guidelines (or updated guidelines) are sourced and reviewed from the relevant regulatory authority (currently NoW) when preparing an SMP.

Minimum riparian corridors widths are defined within the *Guidelines for Riparian Corridors on Waterfront Land* (NoW, 2012). The riparian corridor (RC) includes the watercourse channel and adjacent vegetated riparian zone (VRZ) as shown in Figure 3-1.

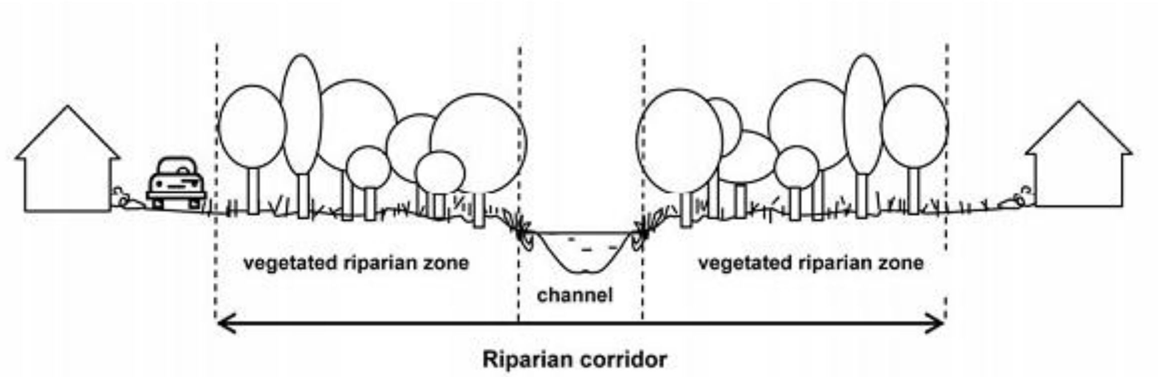


Figure 3-1 Riparian Corridor Structure (NoW, 2012)

NoW recommends that RC and VRZ widths are based on the watercourse order classified under the Strahler System using current 1:25,000 topographic maps. The recommended RC and VRZ widths for watercourses are summarised in Table 3-1.

The channel comprises the bed and banks of the watercourse to its highest banks. The VRZ adjoins the channel. NoW typically seeks to ensure that the VRZ remains, or becomes vegetated, with fully structured native vegetation (including groundcovers, shrubs and trees). The VRZ also functions to protect the environmental integrity of the watercourse from weed invasion, micro-climate changes, litter, trampling and pollution.

Table 3-1 RC and VRZ widths (NoW, 2012)

Watercourse type	VRZ width (each side of watercourse)	Total RC width
1st order	10 metres	20 m + channel width
2nd order	20 metres	40 m + channel width
3rd order	30 metres	60 m + channel width
4th order and greater (includes estuaries, wetlands and any parts of rivers influenced by tidal waters)	40 metres	80 m + channel width

Under some circumstances NoW allows the positioning of certain infrastructure within riparian corridors. Infrastructure that is allowable in riparian corridors is outlined in the *Guidelines for Riparian Corridors on Waterfront Land* (NoW, 2012). SQIDs required for stormwater quality management are not allowed to be positioned within the RC.

3.4 Bushfire Setbacks

Asset Protection Zones (APZ) are a requirement of the NSW Rural Fire Service and are designed to protect assets (house, buildings etc.) from potential bushfire damage. SQIDs can typically be located within the APZ provided the NSW Rural Fire Service requirements outlined in the guideline document *Planning for Bushfire Protection, 2006* are met.

3.5 Services and Infrastructure

Existing services and infrastructure can often constrain the location of SQIDs. The site analysis should also include investigations for any planned infrastructure and services that need to be accommodated in the future site design.

A services search should be undertaken through Dial-Before-You-Dig to identify the location of existing above and below ground infrastructure. Liaison with Council may be required to identify the location of stormwater drainage, sewerage and water supply infrastructure.

The location of services including water supply, sewerage, gas, electricity, telecommunications, oil pipelines and drainage etc should be confirmed by field survey. A plan should be prepared showing the location and typical depth (or actual depth if known) of existing infrastructure that would potentially conflict with the location of proposed SQIDs.

4 SELECT SQIDS

4.1 SQIDs Accepted by Council

The types of SQIDs that will be accepted by Council are influenced by their local experience in using various SQIDs and their ability to maintain SQIDs in the long term. Bellingen Shire Council generally accepts the following SQIDs within the Bellingen Shire Local Government Area:

- Rainwater tanks – On private lots only.
- Swales - Within overland flow paths only, although generally not permissible in road reserves.
- Biofiltration measures - Raingardens and biofiltration basins.
- Gross Pollutant Traps – Acceptable types are subject to Council approval.
- Retention basins.
- Constructed wetlands.
- Formed void or gravel filled infiltration systems.
- Filter strips – Only allowable in areas not trafficable by vehicles.

Council generally does not support pit inserts due to high maintenance requirements and potential stormwater flooding risks. However, they may be allowable in some circumstances if specifically approved by Council.

Guidance on selection of the following SQIDs accepted by Council is provided in the following sections:

- Rainwater tanks;
- Filter strips;
- Biofiltration measures (raingardens and biofiltration basins); and
- Retention basins.

4.2 Physical Characteristics

Particular physical characteristics can often limit the potential for SQIDs to be incorporated into a development. A range of physical characteristics and how they broadly apply to SQIDs are summarised in Table 4-1. The physical characteristics have been assessed into three broad categories, low (✓), medium (?) and high (x) for each of the SQIDs. Low constraint physical characteristics typically will not impact on the feasibility of a particular SQID for most sites. Medium constraints provide some restriction for a SQID, but can often be overcome through good design or increasing the development footprint of the SQID. High constraints may preclude use of a SQID except in exceptional circumstances where a unique design solution can be developed.

Table 4-1 Terrain, Soils and Groundwater Constraints for SQIDs

SQID	Steep slopes (>4%)	Moderate slopes (1-4%)	Gentle slopes (<1%)	Shallow bedrock	Low permeability soil	High permeability soil	High water table	High sediment load
Rainwater tanks	?	✓	✓	✓	✓	✓	✓	✓
Vegetated filter strips	x	✓	?	x	✓	✓	✓	✓
Raingardens	x	✓	✓	x	✓	?	x	?
Retention basins	?	✓	✓	x	✓	?	x	✓
Biofiltration basins	?	✓	✓	x	✓	?	x	?

Table key: Low constraint (✓), Medium constraint (?), High constraint (x)

4.3 Stormwater Quality Considerations

The stormwater pollutants targeted for removal by the SQIDs can cover a wide range of different sizes. The treatment series proposed should initially focus on capturing gross pollutants (litter, organic debris etc.) and coarse particulates (sediment), followed by fine sediments, colloidal and dissolved pollutants. Configuring the treatment series in this manner will achieve pre-treatment for downstream treatment SQIDs that could potentially be damaged, require excessive maintenance or be impaired by excessive loads of gross pollutants and coarse sediment. For example, a biofiltration basin may become clogged with coarse sediment very quickly if no upstream retention basin is provided.

Individual SQIDs function most effectively across particular hydraulic loading rates and pollutant size ranges. As the size of the targeted pollutants reduces, the hydraulic loading rate similarly reduces to ensure that effective treatment is achieved.

SQIDs that are appropriate for particular targeted pollutants are shaded in Table 4-2. From Table 4-2 it can be seen that to capture certain pollutants, one SQID may not be sufficient. For example, whilst a rainwater tank can remove some particulate nutrients, it will be ineffective for the colloidal and dissolved nutrients for which a raingarden or biofiltration basin will provide more effective treatment.

Table 4-2 SQIDs for Stormwater Quality Management

SQID	Litter	Organic debris	Coarse sediment (>150µm)	Fine sediment (<150µm)	Metals (particulate)	Nutrients (particulate)	Nutrients (dissolved)
Rainwater tanks	x	✓	✓	✓	✓	✓	x
Vegetated filter strips	✓	✓	✓	x	x	x	x
Raingardens	?	?	?	✓	✓	✓	✓
Retention basins	✓	✓	✓	?	?	x	x
Biofiltration basins	?	?	?	✓	✓	✓	✓

Table key: Target pollutant (✓), Potential target pollutant with modification to typical arrangement (?), Pollutant not targeted (x)

4.4 Stormwater Quantity Considerations

The majority of SQIDs will typically have some influence on reducing the stormwater runoff rates and volumes from future development. The potential for a SQID to impact on stormwater flow rates and volumes from development sites depends on the size of the stormwater retention and/or detention volume available within the SQID. SQIDs that retain and slowly release or divert stormwater volumes will typically have an influence on stormwater retention and stream forming flows. During storm events exceeding the 1 year ARI flow, the availability of a dedicated stormwater detention storage will become more influential on reducing outflows. The potential for individual SQIDs to assist with achieving particular flow objectives is summarised in Table 4-3.

Table 4-3 SQIDs for Stormwater Quantity Management

SQID	Stormwater drainage	Water conservation	Stormwater retention	Stream forming flows	Stormwater detention
Rainwater tanks	x	✓	✓	✓	?
Vegetated filter strips	x	x	x	x	x
Raingardens	x	x	✓	✓	x
Retention basins	x	x	✓	✓	?
Biofiltration basins	x	x	✓	✓	?

Table key: Target objective (✓), Potential flow target with modification to typical arrangement (?), Flow range not targeted (x)

4.5 Practice Notes

The following sections provide descriptions of selected SQIDs that are currently accepted by Council for use within the Bellingen Shire Council LGA. Alternative SQIDs may be considered by Council, based on their merits provided ongoing consultation is held with Council during development of the SMP for a particular development.

The primary objective of these practice notes is to provide sufficient guidance to developers to ensure that appropriate SQIDs are selected at the Development Application stage. The aim of these practice notes is to provide sufficient information that will assist with avoiding significant changes to the SMP during the detailed design, construction and operational phases of the development lifecycle. The practice notes should be read alongside the concept design considerations outlined in Section 7. Resources that may assist with the detailed design of the SQIDs are provided in Section 11. Practice notes are provided in the following sections for:

- Rainwater tanks;
- Filter strips;
- Biofiltration measures (raingardens and biofiltration basins); and
- Retention basins.

The practice notes include:

- A sketch of each SQID;
- A summary of the function of each SQID;
- A description of the typical configuration of each SQID;
- A summary of typical inspection and maintenance requirements; and
- Examples of typical installations that highlight some of the key considerations.

RAINWATER TANKS

Sketch

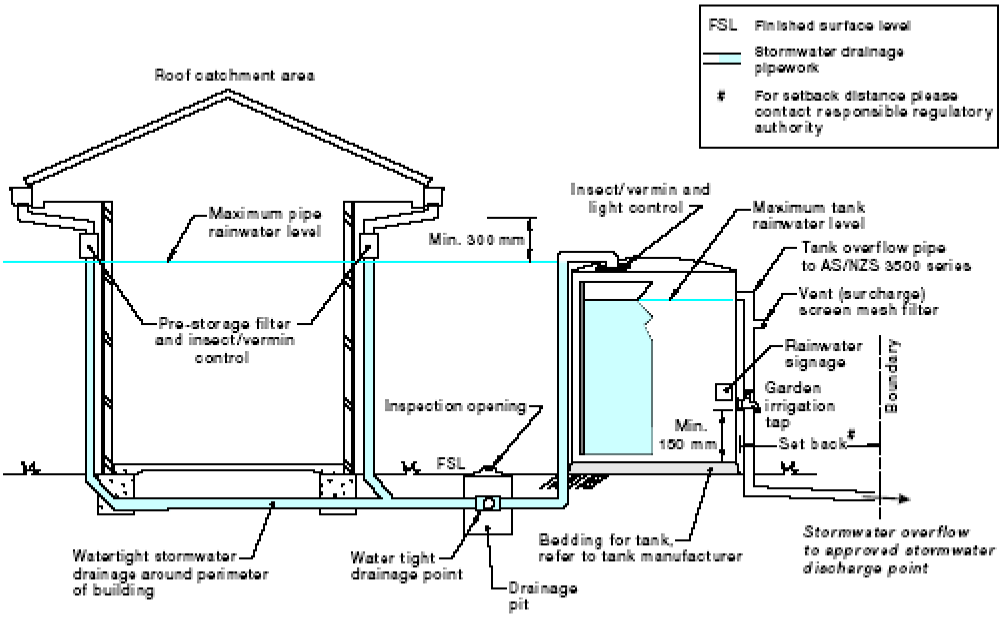


Figure 4-1 Typical Above-ground Rainwater Tank Installation (charged system) (National Water Commission, 2008)

Function

Rainwater tanks are typically installed within private lots in urban areas to capture roof runoff for internal and external uses. Indirect benefits of using roof runoff include potable water conservation, stormwater detention and water quality improvement. Retaining and using rainwater reduces reliance on potable water supply systems in urban areas and as such can assist with deferring potable water system upgrades. The retention of roof runoff can also contribute to reducing the duration of elevated stream flows from urban catchments. Rainwater tanks will typically have limited influence on water quality concentrations, although retention and diversion of stormwater to the sewer and garden areas reduces the volume of stormwater pollutants discharging to watercourses in the catchment of the development.

Rainwater tanks are more efficient when the retained water is used to supply multiple water demands within a development. Within urban residential areas, rainwater can typically contribute to supplying up to 90% of water demands including toilet flushing, garden watering, laundry, hot water and pool filling. The NSW Department of Health does not expressly prohibit rainwater tanks being used as a source of drinking water, however, the guidelines recommend avoiding drinking rainwater where a reticulated potable supply is available. Typically a potable water service connection is still required for situations where the rainwater tank is empty and water is unable to be accessed from another source. Rainwater tanks are typically required for many residential developments to achieve BASIX criteria. In these circumstances, rainwater tanks will also form a part of the treatment series.

Although rainwater tanks can potentially provide a high security of supply to a site, available space may limit the size of tank that can be installed. Rainwater tanks can be relatively simple and efficient to maintain provided the tanks are initially configured appropriately and on-going attention is given to maintaining electrical equipment and tank inlets/outlets.

This practice note applies only to rainwater tanks to be positioned above-ground as this is Council's preferred arrangement. Other below-ground, under floor, in-slab or membrane rainwater tanks may require specialist consideration and design by a qualified consulting engineer.

Configuration

Roof runoff is directed to a rainwater tank either by direct connection of downpipes or in-direct connection via a charged pipe system. Filtering devices are often installed across roof gutters and downpipe inlets to minimise the potential for leaves and other organic debris to be conveyed by roof runoff into the tanks. First flush devices are typically installed to capture the first proportion of runoff from roofs which may contain elevated levels of sediment and other pollutants. Typically a first flush diversion pipe with a floating ball valve is installed just prior to the rainwater tank inlet.

In order to drain a high proportion of roof area to a tank, a below ground piped system is typically constructed to collect multiple downpipes and discharge the combined runoff via a single inlet into the rainwater tank. At the conclusion of a rainfall event, the pipes remain charged (i.e. filled with water). Typically a drainage valve or slow seepage device is provided at the low point of the charged system to allow the pipes to be drained between events. The roof water discharged into the tank is filtered through a mosquito proof mesh screen to remove any coarse material that bypasses the gutter filters and first flush diverter.

Most residential rainwater tanks are configured to pump water from a tank through a water controller/switch that alternates between mains water and rainwater tank supply depending on the level of stored water in the tank. When the tank storage level is high, a valve on the potable water service line closes and supply to the fixtures within the building will be from rainwater. As the rainwater tank level drops, the pressure on the valve reduces and the valve opens to enable mains water to flow to the fixtures. When the tank refills following rainfall, the supply source reverts to the rainwater tank. Other arrangements using internal float switches with mains water topping up of tanks are also occasionally used.

Inspections and Maintenance

The following inspection tasks typically apply to rainwater tanks:

- Regularly check rainwater tanks during flushing of toilets, washing machine operation, garden watering, etc. to ensure that the tank and pumps continue to function as designed.
- Any accesses to rainwater tanks should be checked frequently to ensure they are secure to prevent risk of entry by children.
- Check inlets and mosquito/insect prevention screens frequently to ensure they are intact and clear of debris.
- Inspect the rainwater tank internally (if possible) annually for evidence of access by animals or insects.

- Inspect pipe work and fittings annually during a storm event to ensure that connections are not leaking.
- Measure sediment level in the tank annually.

The following maintenance tasks typically apply to rainwater tanks:

- Prune trees overhanging roof areas annually.
- Clear gutters and filter screens of organic debris and sediment annually unless inspections identify additional needs.
- Flush out charged roof drainage systems (if relevant) during extended dry periods.
- First flush diverter should be checked and cleaned quarterly.
- Rainwater tank structure should be checked annually for leaks and any repairs undertaken.
- Clean pumps on an annual basis.
- Clean/replace/backwash pre and post rainwater tank storage filtration devices annually.
- Dewater the rainwater tank where inspections identify the potential for accumulated sediment to block the outlets.

Examples

	Rainwater tank installed away from dwelling enables access to the entire tank perimeter. Roof runoff enters the tank through a charged roof water drainage system that relies on the difference in height between the roof gutter and tank inlet to convey roof runoff into the tank.
Roof runoff filter to remove leaf matter and sediment prior to draining to below ground rainwater tank.	

Provision of mesh over roof gutters will assist with reducing the quantity of organic debris and sediment discharged to a rainwater tank.

(photo source www.gumleafgutterguard.com)

Careful consideration of plumbing arrangement should reduce the complexity of the inlet and outlet configuration for a rainwater tank.

Rainwater tanks can be provided with appropriate controls to switch the water supply to a building from rainwater tank supply when the storage is low to backup potable water supply. This avoids the need to top rainwater tanks up from the potable water supply and optimises the capture of rainwater.

Filter canisters are often installed to provide further treatment of the rainwater prior to supplying to a building.

Rainwater tank installed with first flush diverter. First flush fills up small length of pipe that terminates at a screw cap incorporating a drip line that slowly discharges the first flush water onto the adjacent ground. The screw cap needs to be checked and cleaned frequently to remove fine sediment and avoid the drip line becoming blocked.

FILTER STRIPS

Sketch

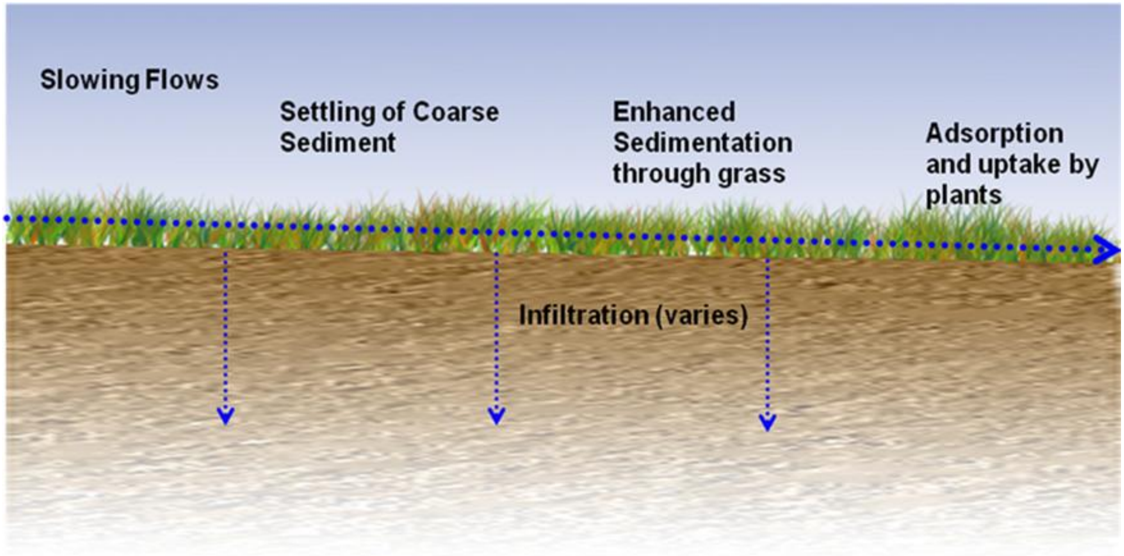


Figure 4-2 Typical Filter Strip

Function

Filter strips are vegetated strips which are effective at removing litter, organic debris, coarse to medium sized sediment particles and attached pollutants. Filter strips are typically provided directly adjacent to road pavement or carparking areas for filtering of sheet flow runoff from these impervious surfaces.

Filter strips are SQIDs that typically perform a primary treatment function and also assist shallow infiltration of stormwater runoff. Filter strips typically provide pre-treatment for flows draining to a secondary or tertiary treatment measure to remove the bulk of coarse matter to reduce the loadings on these SQIDs and subsequently the blockage potential.

Filter strips are relatively simple to maintain with similar mowing requirements as grassed footpaths, although the grass must be maintained at a reasonable height to be effective. The vegetation is typically maintained at a reasonable height (150mm) to improve the effectiveness of the filter. Additional maintenance may be required to remove gross pollutants and sediment, repair scouring and clear drainage inlets.

Configuration

Filter strips typically comprise a grassed or otherwise vegetated strip of land directly adjacent to a paved area. Runoff from the paved area is typically able to sheet flow onto the filter strip. The sheet flow is distributed across the filter strip and treatment occurs through friction with the grasses which slows the flow and enables sedimentation to occur. Where concentrated flows enter the filter strip, scour protection measures are typically provided to reduce flow velocities and distribute the flow to minimise the potential for scouring.

The raised concrete edge strips typically provide a 50mm vertical step between the road pavement edge and filter strip to reduce edge trimming requirements and minimise sediment accumulation on the road. Bollards or other similar traffic control devices are usually provided to restrict vehicular access the filter strip.

Filter strips are typically provided adjacent to grassed swales, raingardens or biofiltration swales to provide pre-treatment of flows draining to these SQIDs.

Inspections and Maintenance

The maintenance frequency will depend on a number of factors including seasonal influences, catchment area, catchment development, recent rainfall, pollutant loads/characteristics, maintenance equipment, receiving water sensitivity etc. An appropriate inspection and maintenance frequency can usually be determined after 2 years of operation when the catchment and filter strip have become more stabilised.

Typically during spring and summer grass cutting and weeding should occur at least on a monthly basis. During autumn and winter this frequency may be extended to a 2-3 month interval. For some sites, higher loading rates and aesthetics may require more frequent maintenance. To prevent rutting within the filter strips, maintenance should only be undertaken following dry weather.

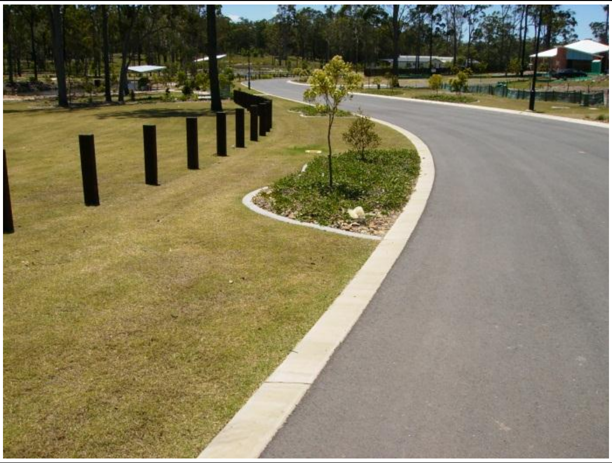
The following inspection tasks typically apply to filter strips:

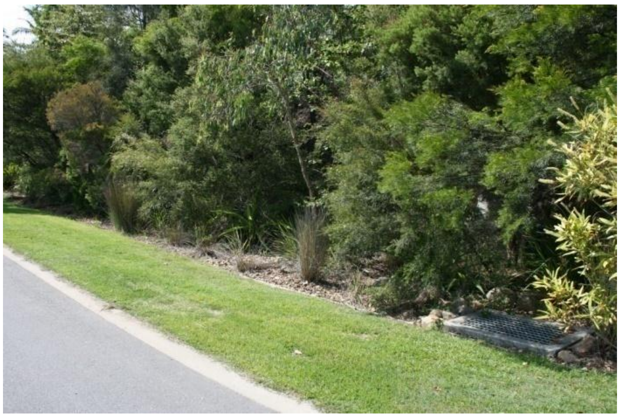
- Check for bare patches and/or areas where weed growth exceeds 10% of the filter strip area.
- Check for accumulated deposits of sediment, litter, rocks and/or organic debris.
- Check for erosion around inlets or concentrated flow rills formed within the filter strip.
- Observe for concentrated flows within the filter strip during wet weather.
- Check for vehicle wheel ruts or other evidence of vehicle access.

The following maintenance tasks typically apply to filter strips:

- Manually remove weeds, sediment, litter and organic debris using rakes, shovels and/or hoes.
- Cut grass to the minimum design height using mowers with catchers, line trimmers and edge trimmers.
- Regrade and replant bare areas.
- Remove cut grass, weeds, litter, debris and other matter and dispose off-site.

Examples

	Grassed filter strip adjacent to road pavement. Road has been constructed with concrete edge strip allowing runoff to sheet flow onto adjacent open space area. For aesthetics, grass is maintained low. Improved water quality outcome would be achieved by maintaining grass higher.
Combined filter strip/swale. Area of grass adjacent to the road pavement performs a filter function prior to concentrated flows in the grass swale being conveyed to a downslope drainage inlet. Vehicular access to the filter strip/swale is restricted by decorative timber bollards.	
	Grassed and mulched filter strip blended in with the driveway edges. A small vertical drop of less than 50mm is provided on each side of the driveway to assist with reducing trapping of sediment on the driveway.
Filter strips can be incorporated as pre-treatment for biofiltration swales.	

	Mulched filter strip constructed on sandy soils on high slope resulting in scouring and erosion of mulch and sand during runoff events.
Mulched filter strip constructed on sandy soils on moderate slope less prone to scouring and erosion of mulch and sand during runoff events.	
	Grassed filter strips can be combined with vegetated and mulched buffers. Drainage inlets provided within the filter strips can manage drainage flows.
Filter strips are an effective control for filtering organic debris and coarse sediment from runoff. Filter strips constructed on a slight gradient would function similarly to a swale	

BIOFILTRATION MEASURES

Sketch

A typical arrangement of a biofiltration measure (raingarden or biofiltration basin) is shown in Figure 4-3. Biofiltration measures may also be constructed with a submerged zone which includes an additional depth of storage below the invert of the collection pipe. Biofiltration measures may also be unlined when the saturated hydraulic conductivity of the surrounding soils are an order of magnitude less than the filter media and groundwater inflow is not a concern.

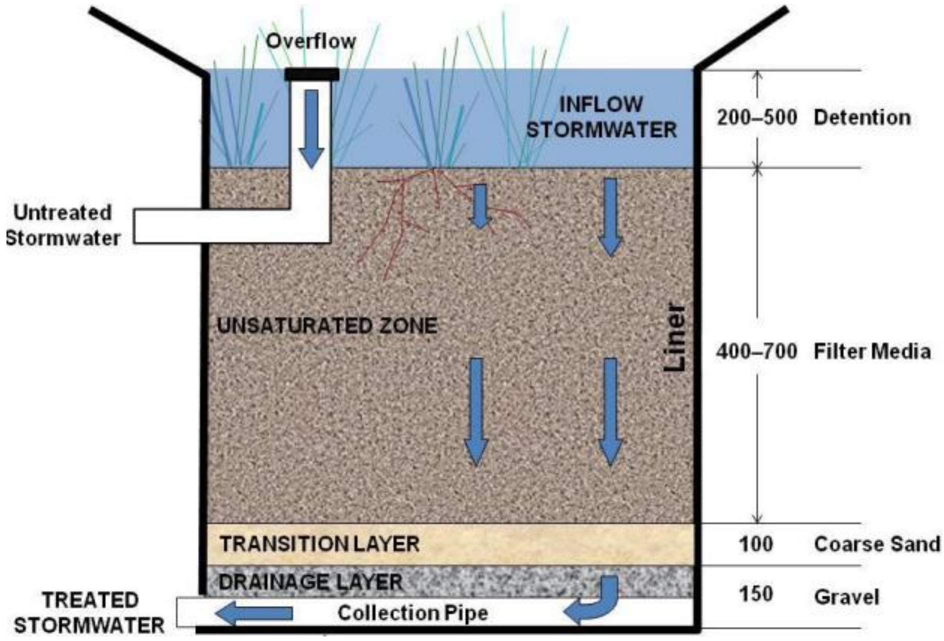


Figure 4-3 Typical Biofiltration Arrangement (FAWB, 2009)

Function

Biofiltration measures including raingardens and biofiltration basins assist with achieving stormwater quality and stormwater retention objectives. Biofiltration measures comprise an above ground retention/detention storage and below ground filter media. The above ground storage enables settling of sediment and other particles which is a function of the hydraulic residence time. The below ground filter intercept finer particles including heavy metals. Nutrients are removed through uptake by appropriate vegetation planted within the SQID. Biofiltration measures assist with disconnecting impervious areas from urban streams by retaining stormwater for an extended period.

Biofiltration measures include raingardens, biofiltration swales and biofiltration basins. These measures all perform a similar function, although at different scales. Raingardens are often provided close to a runoff source and are typically small retention cells/basins constructed at strategic points within a development or within the streetscape. Biofiltration swales are typically provided in conjunction with grassed swales to function as a combined flow and water quality management measure. Biofiltration swales are commonly provided within public road reserves (footpath or central median), public open spaces and carparks. Biofiltration basins are typically provided as large end-of-line SQIDs that may be combined with other community functions (e.g. detention basins, sporting fields). Smaller biofiltration basins may also be distributed throughout a development precinct.

Configuration

Biofiltration measures typically comprise above-ground extended detention and below-ground media filter components. The extended detention is typically trapezoidal shaped with a slightly grading base and 1(v):4 to 6(h) side slopes for access. In situations where space is limited, and safety and maintenance access can be managed appropriately, near vertical sides formed from concrete or rocks may be considered. The extended detention temporarily stores runoff prior to filtration through the media filter. During events that exceed the available volume in the extended detention storage, excess runoff typically overflows into a minor drainage system through structures positioned within the SQID.

The media filter typically consists of a biofilter layer and drainage layer. The biofilter layer is the upper layer and incorporates soil that has a reasonable water holding capacity that is required to sustain vegetation growth. The biofilter layer must also have a reasonable saturated hydraulic conductivity to enable steady percolation of runoff when the water holding capacity is exceeded. The lower layer comprises fine gravel that typically surrounds slotted agricultural drainage pipe and captures the filtered stormwater before directing it to a constructed drainage system. A transitional layer of coarse sand is often provided between the upper and lower layers to intercept fine to medium size soil particles that may otherwise be conveyed into the drainage layer and potentially block the underdrains.

Geotextiles should not be used to perform the transitional layer function for their potential to block. In situations where the surrounding soil has a saturated hydraulic conductivity exceeding the biofilter, vertical lining of the sides of the media filter layers with an impermeable membrane may be warranted to prevent ex-filtration of untreated stormwater.

A key component of the SQID is vegetation which is planted into the biofilter layer. Appropriate species should be selected considering the biofilter soil characteristics and climatic conditions. Species should be capable of withstanding dry periods in addition to periods of frequent wetting.

Inspections and Maintenance

Biofiltration measures should be inspected regularly until the vegetation is established and then typically on a monthly basis or following significant storm events. A bi-monthly inspection frequency following stabilisation of vegetation is typical.

Maintenance will be more regular during the initial one to two year establishment period. During this period regular watering, mulching, weeding, soil treatment, removal and replacement of dead/diseased vegetation may be required. An appropriate long-term maintenance frequency can usually be determined after 2 years of operation when the catchment and biofiltration measure have become more stabilised.

The typical long-term maintenance frequency varies with aesthetics and seasonal influences. Grass cutting and weeding are typically required either fortnightly or monthly (depending on the species) during spring and summer. Less frequent grass cutting and weeding (typically every 2 to 3 months) typically occurs during autumn and winter where other factors (e.g. aesthetics, litter removal, erosion, vegetation damage) may control the maintenance frequency.

The following inspection tasks typically apply to biofiltration measures:

- Check any pre-treatment SQIDs for areas of accumulated sediment or erosion.
- Check inlets and areas of concentrated flow into the SQIDs for erosion.
- Check for bare patches and/or areas where weed growth exceeds 10% of the biofilter area.
- Check for accumulated deposits of sediment, litter, rocks and/or organic debris.
- Check for withering, dead or otherwise unhealthy plants. If concentrated areas of dead or unhealthy plants are identified, undertake soil sampling to determine if soil improvement is required.
- Check the SQIDs during wet weather to confirm that flow is evenly distributed and not concentrated along one flow path.
- Check that the biofilter media has a good coverage of mulch with limited gaps.
- Check for saturated areas or concentrated deposits of silt where water may be ponding excessively.
- Check underdrains through inspection covers to confirm that excessive silting of the drains has not occurred.
- Check driveway crossings and other interfaces with impervious surfaces for erosion or sediment accumulation.
- Check for vehicle wheel ruts or other evidence of vehicle access.

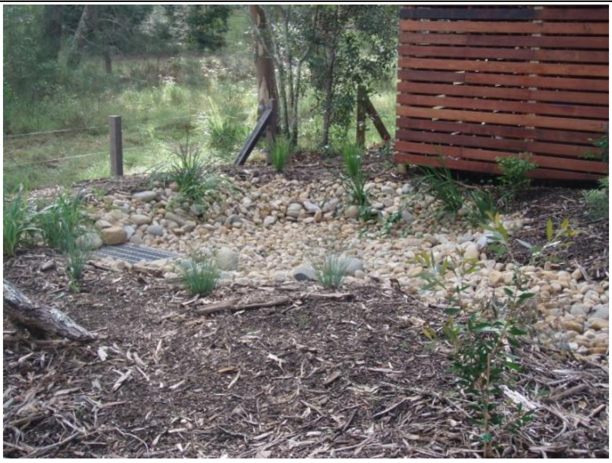
The following maintenance tasks typically apply to biofiltration measures:

- Check weather forecast to confirm that maintenance is scheduled during dry weather.
- Pre-treatment filter strips or retention basins should be maintained in accordance with the guidelines for those SQIDs.
- Prune and/or remove dead branches from trees and shrubs.
- If the biofiltration measure surface has become clogged from the input of elevated loads of sediment, tilling should be undertaken to break these areas up to improve permeability of the surface layer. Reasons for the elevated input of sediment should be investigated.
- Manually remove sediment, litter and organic debris using rakes, shovels and/or hoes.
- Manually remove weeds if the weed coverage is localised. If the weed coverage is more widespread, options including spot spraying of herbicides approved for use within an aquatic environments or hot water based treatments may be considered.
- Cut grass adjacent to biofilter using mowers with catchers.
- Use line trimmers to trim biofilter vegetation and cut grass in areas inaccessible by mower.
- Regrade and replant bare areas.

- Spread appropriate low nutrient mulch annually prior to summer and replace mulch every 2 to 3 years during dry periods. Mulching should also be undertaken periodically to fill in gaps observed during inspections.
- Clear drainage structures of any blockages.
- Flush underdrain system using high-pressure jets or hoses.
- Repair damage due to vandalism as required.
- If pests are present, implement appropriate non-toxic measures to control.

Examples

Raised grate and drainage inlet within raingarden enables water to pond temporarily prior to filtration through the biofilter media. During high rainfall intensity events ponding depth would exceed the level of the pit inlet enabling stormwater to bypass the biofilter media and overflow into the drainage system. Sub-soil drains at the base of the biofilter connected filtered stormwater to the base of the stormwater pit.	
	Provision of raingardens within private lots requires careful consideration of how the long term performance will be maintained throughout the lifecycle of the SQID.

Raingarden installed within front garden of private residential lot.	
	Kerb slot inlet to street scale raingarden.
Kerb return inlet to street scale raingarden. Cutoff timber bollards and raised half island provided to restrict vehicular access. Turfed filter strip and horizontal timber boards provided between road pavement and the biofilter to enable temporary ponding of water prior to overflowing into the biofilter.	
	Vertical inspection pipes can be provided within raingardens to assist inspections and enable flushing of the underdrain system. Vertical edgings around the raingarden can assist with restricting the intrusion of adjacent exotic grass species into the SQID.

Street scale raingarden provided with river pebble mulch. Creates instant cover for the biofilter media to limit intrusion of weeds during vegetation establishment phase.

Cascading series of raingardens formed on steep gradients can lead to scouring of the highly erodible biofilter media prior to vegetation establishing. Provision of rock check dams/weirs can reduce the flow gradient, but sufficient bed protection is required at drops to prevent scour pools forming just downstream of the check dams.

Street scale raingarden provided with lintel inlet to manage flows in excess of the capacity of the system. When the water depth exceeds the inlet level stormwater overflows into an adjacent below ground piped drainage system.

Street scale raingarden provided with raised grate inlet to manage flows in excess of the capacity of the system. When the water depth exceeds the inlet level stormwater overflows into an adjacent below ground piped drainage system.

Raingardens provided between road pavement and footpath. Slots provided between kerb sections to enable flow to passively enter the raingarden. Footpath side of the raingardens is framed by a low concrete wall that also functions as seating for users of the adjacent passive recreational space.	
	Ineffective gross pollutant trapping can result in large quantities of gross pollutants being distributed throughout a biofiltration basin. Requires time consuming manual collection to remove these pollutants and may also result in high quantities of sediment smothering the biofilter,
Inadequate erosion and sediment control during construction may lead to biofilter media being smothered with fine sediments prior to vegetation establishment. In addition to blocking the biofilter surface, fine sediments may also clog the biofilter substantially reducing the hydraulic conductivity and therefore future performance of the SQID. In some cases, the entire biofilter media layer may need to be removed and replaced.	
	Pre-treatment SQIDs provided upstream of biofiltration basins need to also consider the function of the drainage system during design events where the performance of the drainage system can be detrimentally impacted by blockages that can be avoided. Grates over the culverts and stormwater drainage system outlets would not be acceptable to Council due to safety concerns.

Access and ease of debris removal should be primary considerations when planning pre-treatment of flows discharging into a biofiltration basin.	
	Energy dissipation structures can assist with reducing flow energy at the inlet to biofiltration basins providing conditions for gross pollutants to settle or be separated from the flow.
Trash racks with easy access for vehicles can be relatively quick and efficient to maintain.	
	Trash racks combined with sediment trapping bays at inlets to biofiltration basins can be effective at stopping the bulk of gross pollutants entering the SQID. Combined with a sufficiently wide concrete access ramp, these pre-treatment SQIDs can be efficiently cleaned using skid steer loaders.

Rock protection can protect the biofiltration basin bed and assist to dissipate flow energy prior to runoff draining to the vegetated biofilter.

Clear bordering and delineation of biofiltration basin extents can assist maintenance. Provision of bypass swales around SQIDs limits the magnitude of flows discharging into the basin.

Clear delineation and structural protection of high flow weirs is good design practice. High flow weirs can also be provided with a sacrificial turf covering to improve aesthetics.

All weather unsealed access can be formed by placing rock aggregate in appropriate locations. Gradients need to be lower than a sealed access but can be appropriate for many applications where only light vehicle access is required.

Excavation to biofilter base

Placement of underdrains and impermeable liner

Biofilter media placed

Biofilter media consolidated

Biofilter planting completed

Biofilter vegetation established

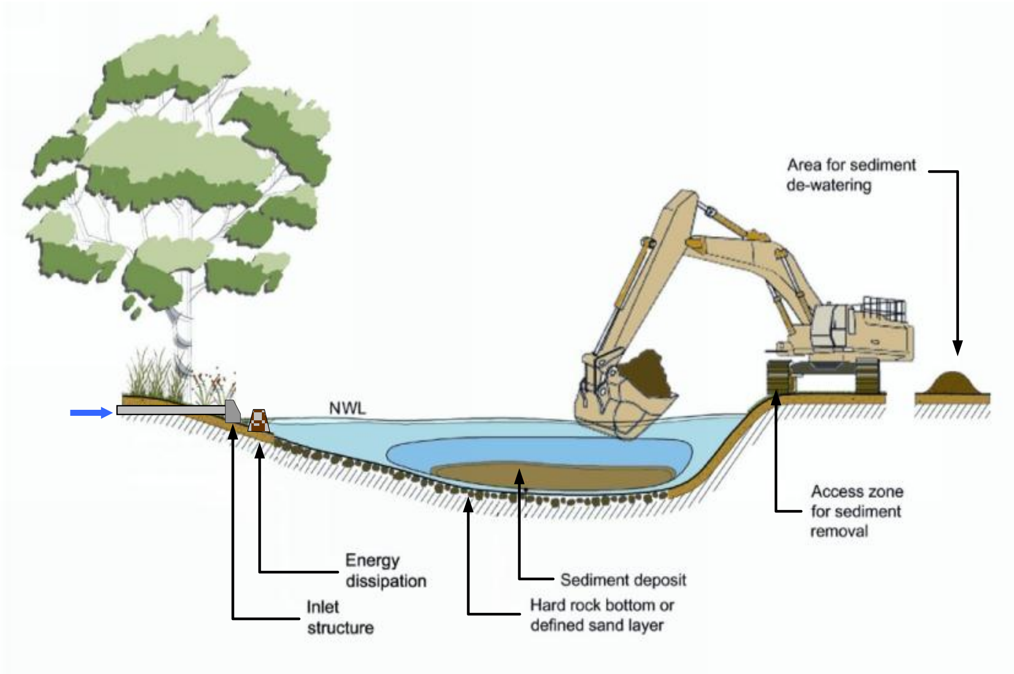
Biofilter basin vegetation growing

Biofilter basin vegetation several years after construction

	Fencing provided to exclude pedestrians and cyclists from steep fringing batters.
For a biofiltration basin to function it is important that the filter media is of an appropriate size and grading to filter the stormwater. Planting out the biofilter is also a key element of the SQID and without planting only limited treatment would be possible.	
	Biofiltration basins can be a component of multi-purpose open space areas that incorporate a range of active and passive recreation areas.
The potential to trap aquatic fauna should be considered when planning pre-treatment SQIDs for capturing gross pollutants. In addition to gross pollutants from the catchment, many of these traps will also capture freshwater turtles, snakes, lizards, eels, cats, dogs and other animals found in areas where urban development interacts with the natural environment.	

RETENTION BASINS

Sketch



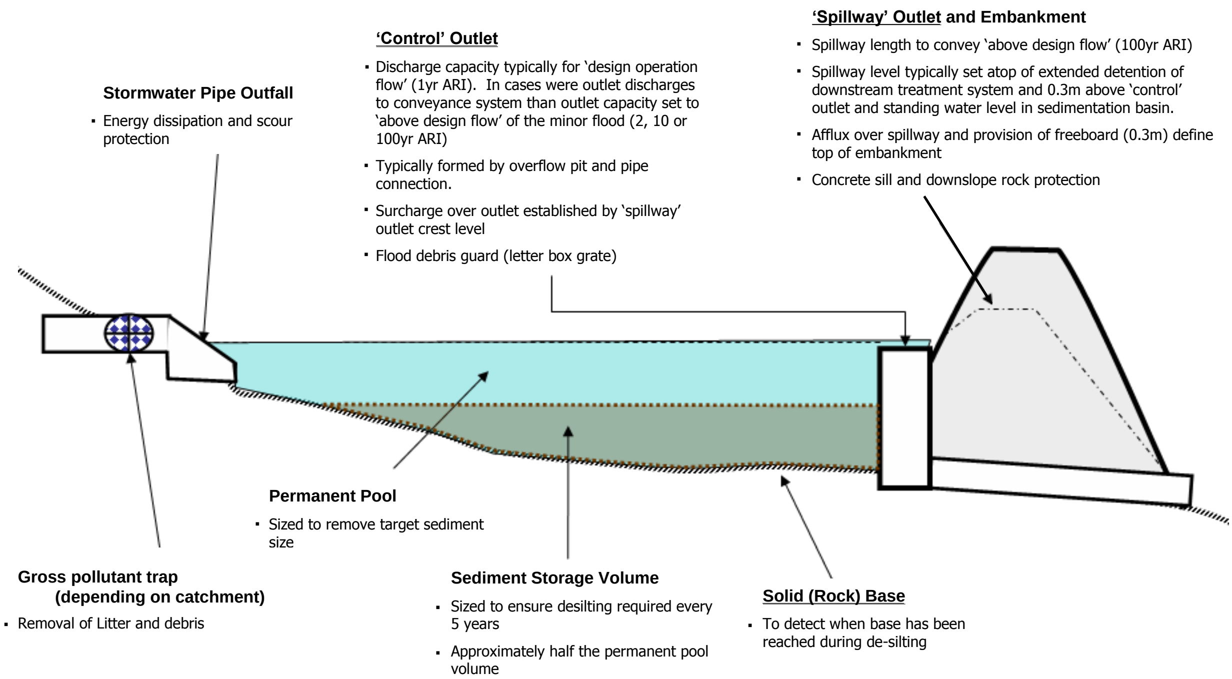


Figure 4-4 Typical Retention Basin Configuration and Maintenance Method (GCCC, 2005).

Function

Retention basins assist with achieving stormwater quality and quantity management objectives. Retention basins often function during the construction and post development phases. During construction, a temporary retention basin may be formed to manage sediment washed from exposed soil areas during construction. After construction, temporary retention basins are often modified to form a permanent retention basin which provides pre-treatment for other SQIDs designed to remove finer and dissolved pollutants during the post development phase. Guidance on the application of retention basins for sediment control during construction is provided in the Managing Urban Stormwater: Soils and Construction handbook (the 'Blue Book') (Landcom, 2004). These guidelines focus on the role of permanent retention basins in the post development stormwater quality management series.

Retention basins typically target the removal of litter, organic debris and coarse sediment during the post development phase. Retention basins function by capturing and storing stormwater runoff which is typically discharged into the basin from a piped stormwater drainage system outlet. The stormwater runoff is retained within the retention basin for an extended period to promote settling of sediment and other pollutants. Retention basins can be either dry or wet storage SQIDs. Wet retention basins may also have an additional storage above the permanent storage that functions as a temporary storage for the detention of stormwater during flooding events. Dry retention basins only have a temporary retention storage that fills during an event and drains during the period immediately following the event.

The performance of the retention basin is related to the residence time of the stormwater captured within the SQID. Retention basins are typically designed to capture coarser particles. As the residence time increases, the size of particles able to settle becomes smaller. As the size of particles captured reduces, a higher proportion of nutrients attached to fine sediment particles can also be captured. Whilst this initially would seem beneficial, if the retention pond does not incorporate significant areas of aquatic vegetation, there is a potential that eutrophication and algal blooms can occur regularly in the wet basin when climatic conditions are suitable.

Configuration

Retention basins typically include inlet and outlet structures, and a settling basin. Retention basins may also incorporate a high flow weir where high flows are not initially controlled at the inlet. The settling basin includes a temporary/permanent pool settling zone and a sediment storage zone.

The inlet structure to a retention basin may comprise a diversion structure that controls the maximum flow rate that discharges into the basin with higher flows diverted around the basin. The inlet structure may also include a trash rack or other form of screening mechanism to filter out litter and organic debris before it discharges into the main settling basin to assist with efficient maintenance. Flow would then pass into the main settling basin.

Wet retention basins will typically comprise a trapezoidal shaped storage with slightly grading benches (typically 1(v):10(h)) planted out to limit access leading into a base and 1(v):4 to 6(h) side slopes to suit access/egress requirements. In situations where space is limited, and safety and maintenance access can be managed appropriately, near vertical sides formed from concrete or rocks could be considered. During events that exceed the available volume in the extended detention storage, excess runoff typically overflows into a minor drainage system through structures positioned within the SQID.

A key component of the SQID is vegetation which is planted into the biofilter layer. Appropriate species should be selected considering the biofilter soil characteristics and climatic conditions. Species should be capable of withstanding dry periods in addition to periods of frequent wetting.

Inspections and Maintenance

Retention basins should be inspected regularly during the first year after construction of a pond and more regular maintenance should be expected during this period to ensure that the retention basin functions effectively and vegetation establishes. Following the initial year of operation, bi-annual maintenance may be appropriate. Although, the maintenance frequency should be adjusted in response to observations made during inspections.

Following construction of a retention basin, inspections during the first several significant storm events should be undertaken to confirm that the drainage system functions effectively and that bank stability and vegetation cover is sufficient. Retention basins should be inspected within 48 hours of a significant storm event.

The following inspection tasks typically apply to retention basins:

- Check any pre-treatment SQIDs/forebays and inlet structures for accumulations of litter and organic debris. Inspect inlet and outlet structures to ensure they are not blocked by debris. Any debris should be removed at the time of inspection if practical.
- Check inlets and outlets for areas of concentrated flow into the SQIDs for erosion.
- Check for accumulated deposits of sediment, litter, rocks and/or organic debris.
- Check that the weed coverage and algal growth (wet storage) within retention basins is low.
- Check the depth and/or area of sediment annually to confirm the volume of sediment within the pond. When sediment storage exceeds 25% of the storage volume, the retention basins should be dewatered (if required) and sediment removed.
- Check embankments and high flow spillway for erosion, cracks, seepage or other signs of instability.
- Check the health of aquatic and landscaping vegetation.
- Check for offensive odours during inspections as these can often indicate low oxygen conditions within the retention basins.
- Check the SQIDs during wet weather to confirm that flow is evenly distributed and not concentrated along one flow path.

The following maintenance tasks typically apply to retention basins:

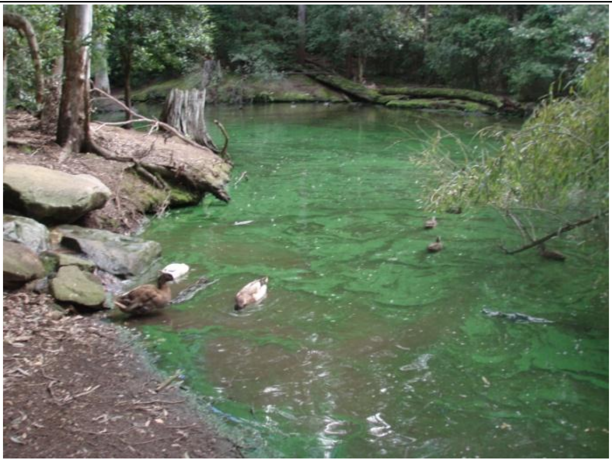
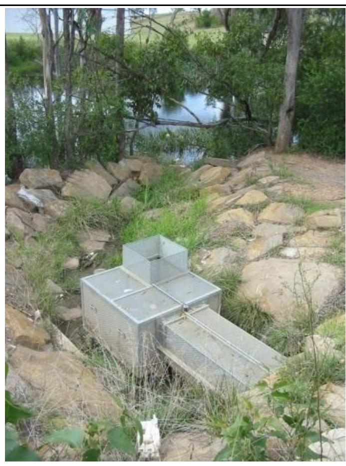
- Check weather forecast to confirm that maintenance is scheduled during dry weather.
- Check site prior to locating maintenance equipment on site. Retention basins should not be mown if the soil is wet to prevent rutting and subsequent erosion.

- Remove accumulated litter and debris from the pre-treatment zone of the retention basin and the inlet/outlet structures.
- Clear inlet/outlet structures of any debris causing blockage.
- Remove accumulated sediment from the retention basin. An excavator (e.g. skid-steer loader, backhoe etc) would be required to remove accumulated sediment from wet retention basins. The retention basin may need to be drained to enable access. A dewatering system should be provided for wet retention basins to enable the water level to be manually adjusted.
- Remove invasive plants species, weeds or any other unwanted vegetation from retention basin and surrounding landscaped surfaces. A flat-bottomed boat may assist with removing floating and fixed aquatic weeds. If weeds are more widespread, options including spot spraying of herbicides approved for use within an aquatic environment may be required along with de-watering or removal of weeds by an excavator.
- Prune and/or remove dead branches from trees and shrubs.
- Place sediment, litter and organic debris in a designated secure area for drying (if required) prior to transport and disposal.
- Cut grass using mowers with catchers.
- Use line trimmers to trim landscaping vegetation in areas inaccessible by mower.
- Regrade and replant bare areas.
- Repair damage due to vandalism as required.
- If pests are present, implement appropriate non-toxic measures to control.
- Repair destabilised banks and areas showing signs of erosion. Identified structural bank instability may require reconstruction of the embankments.
- Repair inlet and outlet structures as necessary.

Examples

Gross pollutant trapping SQIDs upstream of retention basins can be relatively simple structures where space and drainage system hydraulics allow. Gross pollutants should be trapped at one targeted location in the treatment series.

Systems incorporating retention/stilling basins with permeable walls can provide effective litter, debris and some sediment removal during most events and provide good access and a platform for storage of captured debris.

Small retention basins can provide effective treatment in advance of larger treatment SQIDs.	
	Provision of wet retention basins that capture fine-grained soil particles and contain limited aquatic vegetation and poor circulation are susceptible to algal blooms which can be potentially toxic.
Easy access to pre-treatment gross pollutant traps is an important consideration when planning retention basins. Gradients to the SQIDs should be appropriate for the required maintenance methods to minimise risks to maintenance personnel and ensure devices can be cleaned efficiently.	
	Wet retention basins constructed with steep batters are a hazard for the community and are difficult to access for maintenance.

Retention basins should be provided with fringing aquatic vegetation to control access and shallow gradients around the basin perimeter to reduce risks to the community.	
	Planting of appropriate trees around the fringes of retention basin can provide shade and reduce light penetration which can assist with reducing the potential for algae and aquatic weed growth.
Wet retention basins typically vary from constructed wetlands due to the extent of aquatic vegetation provided. Wet retention basins will typically have nominal fringing vegetation to assist with stablising the banks, resticting access and improving aesthetics.	
	Providing a multi-purpose sealed path assists with providing access to a SQID for maintenance. Paths need to have sufficient strength to manage the vehicular load including consideration of the mass of materials removed from the retention basin.

5 ARRANGE TREATMENT SERIES

Appropriate individual SQIDs for a particular development can be identified considering Council's preferences, the physical site constraints, available treatment scale options, maintenance considerations, stormwater quality management targets and stormwater quality management targets. To develop a SMP for a particular development, the SQIDs then need to be arranged in an appropriate series to optimise treatment performance.

Currently no one particular SQID has the ability to intercept the complete range of stormwater pollutants from large debris to dissolved pollutants without requiring a high degree of maintenance. Therefore, a number of SQIDs are typically arranged in a treatment series to efficiently capture the full range of targeted stormwater pollutants. The initial SQIDs in the series will often be maintained more regularly to remove larger pollutants, whilst the following measures capturing increasingly finer pollutants can often be maintained less frequently. As the range of pollutants is separated by different measures, opportunities may exist for more economical removal and disposal of captured pollutants.

SQIDs function in different ways to remove stormwater pollutants. Essentially treatment processes can be divided into screening, retention, filtration, detention, biochemical transformation and infiltration processes. The treatment series should be configured to achieve the treatment processes in this order. A development applicant shall identify a treatment series that will collectively perform all of these functions.

Guidance on suitable SQIDs for particular treatment processes is summarised in Table 5-1.

Table 5-1 Stormwater Treatment Processes

WSUD Measure	Screening	Filtration	Retention	Detention	Biochemical	Infiltration
Rainwater tank	✓	**x**	✓	**?**	**x**	**x**
Vegetated filter strip	**?**	✓	**x**	**x**	**x**	**?**
Raingardens	**x**	✓	✓	**x**	✓	**?**
Sediment basin	**?**	**x**	✓	**?**	**x**	**x**
Biofiltration basin	**x**	✓	✓	**?**	✓	**?**

Table key: Key treatment process (✓), Potential treatment process with modification to typical arrangement (?), Treatment process not applicable (x).

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6 MUSIC MODELLING

6.1 Introduction

Stormwater quantity and quality modelling shall be undertaken using the Model for Urban Stormwater Improvement and Conceptualisation (MUSIC) (or an equivalent stormwater pollutant modelling method approved by Council) to estimate runoff volumes and loads of common stormwater pollutants including Total Suspended Solids (TSS), Total Phosphorus (TP) and Total Nitrogen (TN). The modelling shall be completed to inform development of a concept plan and SMP for a development site.

MUSIC includes algorithms to evaluate the hydrology and concentrations / loads of common stormwater pollutants (i.e. TSS, TP and TN) from urban catchments and estimate the performance of SQIDs at capturing these pollutants.

MUSIC was designed to continuously simulate urban stormwater systems over a range of temporal and spatial scales utilising historically representative rainfall data. MUSIC is considered within the industry to be an appropriate conceptual design model for the assessment and sizing of SQIDs.

The hydrologic algorithm in MUSIC is based on the model developed by Chiew & McMahon (1997). The model simplifies the rainfall-runoff processes and requires input of the following variables to perform the hydrological assessment:

- Rainfall data (time steps varying from 6 minutes to 1 days);
- Potential evapotranspiration rates;
- Catchment parameters (area, % impervious and pervious areas);
- Impervious and pervious area parameters (rainfall threshold, soil and groundwater parameters) and
- Storm event and base flow stormwater pollutant concentrations.

MUSIC can be utilised for comparison of alternative scenarios that adopt the same base inputs. Although the magnitude of the estimates may not be equivalent to actual site conditions (due to limitations in available data for a particular site), the relative differences between scenarios is expected to be appropriate for supporting decision making. MUSIC can also be applied to evaluate the performance of SQIDs against load-based objectives.

Practical guidance to assist with the development of MUSIC models in NSW is provided in the Draft NSW MUSIC Modelling Guidelines (SMCMA, 2010). Guidance on specific modelling approaches and model inputs for the Bellingen Shire Council LGA is provided below.

6.2 Rainfall

MUSIC input rainfall data shall be sourced from a local continuously recording (pluviograph) rainfall station. Continuous pluviograph data is available locally for the Glennifer, Coffs Harbour MO and Thora sites. MUSIC modelling in the Bellingen Shire Council LGA shall preferably be completed using pluviograph rainfall data sourced from the Thora station for the 1994 to 1999 period. The Thora rainfall data can be sourced from the NSW Office of Water (NoW) Pineena database.

The NSW MUSIC Modelling Guidelines recommend that data from the Coffs Harbour MO rainfall station for the 1999 to 2003 period be applied for MUSIC models developed in the NSW North Coast region. If access to the local Thora data is unavailable, the Coffs Harbour MO station data shall be used in the Bellingen Shire LGA unless justification for using an alternative data set and period is provided.

A 6-minute modelling time step should be adopted for all MUSIC models unless clear justification for adopting a longer time step is provided in the SMP.

6.3 Potential Evapotranspiration Data

Potential evapotranspiration (PET) rates required for input to MUSIC may be determined from the Bureau of Meteorology's Climatic Atlas of Australia (BoM, 2001). Default PET rates derived from the BoM climatic grids that can be adopted for all development in the Bellingen Shire Council LGA are provided in Table 6-1.

Table 6-1 Monthly Areal PET rates for the Bellingen Shire LGA

Month	PET (mm/month)
January	188
February	145
March	143
April	99
May	65
June	53
July	57
August	73
September	102
October	136
November	160
December	177

6.4 Rainfall-Runoff Parameters

Modelling of the rainfall-runoff process in MUSIC requires the definition of two impervious surface parameters (% catchment imperviousness and rainfall threshold), five pervious surface parameters and four groundwater (baseflow) parameters. These parameters can be determined through a calibration and validation exercise where concurrent stream flow, rainfall and evapotranspiration data are available for the catchment being considered.

Impervious and pervious area parameters suggested in the NSW MUSIC modelling guidelines for developed catchments (% imperviousness>10%) may be adopted from Table 6-2. These parameters shall be adopted for MUSIC modelling except where development applicants can demonstrate through justifiable rainfall-runoff modelling calibration that alternative model parameters are appropriate for their particular development site.

Table 6-2 MUSIC Rainfall-Runoff Parameters

Impervious Area Parameters	Developed Site
Rainfall Threshold (roofs, mm)	1.0
Rainfall Threshold (road pavement, mm)	2.0
Rainfall Threshold (mixed urban surfaces, mm)	1.4
Pervious Area Parameters	
Soil Storage Capacity (mm)	170
Initial Storage (% of capacity)	30
Field Capacity (mm)	70
Infiltration Capacity Coefficient – a	210
Infiltration Capacity Exponent - b	4.7
Groundwater Properties	
Initial Depth (mm)	10
Daily Recharge Rate (%)	50
Daily Baseflow Rate (%)	5
Daily Deep Seepage Rate (%)	0

6.5 Runoff Quality Parameters

Storm flow and base flow runoff quality parameters for all developments shall be adopted from the NSW MUSIC modelling guidelines (BMT WBM, 2010). These values are summarised in Table 6-3 and Table 6-4.

Table 6-3 Storm flow concentrations for MUSIC modelling in NSW (log_{10})

	TSS		TP		TN	
	mean	std. dev	mean	std. dev	mean	std. dev
Residential	2.15	0.32	-0.60	0.25	0.30	0.19
Industrial	2.15	0.32	-0.60	0.25	0.30	0.19
Commercial	2.15	0.32	-0.60	0.25	0.30	0.19
Rural	1.95	0.32	-0.66	0.25	0.30	0.19
Forest	1.60	0.20	-1.10	0.22	-0.05	0.24

Table 6-4 Base flow concentrations for MUSIC modelling in NSW (log_{10})

	TSS		TP		TN	
	mean	std. dev	mean	std. dev	mean	std. dev
Residential	1.20	0.17	-0.85	0.19	0.11	0.12
Industrial	1.20	0.17	-0.85	0.19	0.11	0.12
Commercial	1.20	0.17	-0.85	0.19	0.11	0.12
Rural	1.15	0.17	-1.22	0.19	-0.05	0.12
Forest	0.78	0.13	-1.52	0.13	-0.52	0.13

7 PREPARE CONCEPT DESIGN

Concept design drawings/sketches shall be prepared at the Development Application stage showing the location, size and conceptual configuration of the SQIDs.

A sub-catchment plan shall be provided to show all site and external catchments draining to the SQIDs. Contours should be shown at an appropriate interval that clearly indicates proposed site gradients and any distinct changes in ground levels. Where the SQIDs will intercept runoff from areas external to the development, contours and sub-catchments for the external areas shall be shown.

The location and total footprint of the SQIDs in relation to other infrastructure proposed within the development shall be shown. A conceptual stormwater management plan shall be provided to clearly how the individual SQIDs will be linked to form an effective treatment series. Sufficient information shall be provided to clearly demonstrate how the SQIDs function and co-ordinate within other components of the proposed development.

The total estimated footprint may be shown as a shaded area on a plan that indicates the other elements of the development. To confirm the total footprint of the SQIDs, it will be important that consideration is given to embankments, cutting and retaining walls necessary to construct the SQIDs. This will be particularly important within steep sites where the total footprint of a SQID may substantially exceed the MUSIC modelled internal treatment area of a particular SQID.

A conceptual plan of the SQIDs showing the configuration of all key elements of the SQIDs shall be provided. Examples of design elements that the concept plan should show include width, length, surface area, vehicular access, embankment extents, cutting extents, planting areas, maintenance access locations, proposed inlet and outlet connections to drainage systems.

A conceptual section/s through the SQIDs shall be provided showing the dimensions and key features of the SQID. Examples of the design elements that the concept sections should show include extended detention depths, internal and external batter slopes, retaining wall locations, embankment crest widths, filter media layer depths, filter media characteristics, drainage pit and pipe size/location, plant species, locations and densities, inlet location/configuration.

Locations of existing services within or external to the development site that may require adjustment to construct the SQIDs shall be shown along with proposed connections to external drainage systems (including the existing drainage system characteristics).

There are a number of resources available to assist in the development of concept designs for SQIDs. A number of these are publicly available, whilst others would need to be purchased from the relevant publisher/owner of the document. A summary of key resources is provided in Section 11**.**

A range of key concept design considerations and the relevance of these considerations to SQIDs currently accepted for use within the Bellingen LGA are summarised in Table 7-1.

Table 7-1 Concept Design Checklist

CONCEPT DESIGN CONSIDERATIONS	Rainwater Tanks	Filter Strips	Raingardens	Retention Basins	Biofiltration Basins
FLOODING AND DRAINAGE					
SQID will be positioned outside flood ways and major overland flow paths.	●			●	●
Flooding impacts of the planned SQID have been assessed and are minor.				●	●
The overland flow capacity of the road reserve and/or other key flow pathways would be sufficient to convey the 100yr ARI flood event with the SQID in place.			●	●	●
Impact of the vegetation on roughness has been considered in hydraulic calculations.			●		
SQID would not reduce the hydraulic capacity of and/or significantly increase upstream water levels within the minor drainage system.			●	●	●
The SQID has sufficient flow capacity to convey the peak 10yr ARI design flow without inundating adjacent roads or private property.			●		
SQIDs positioned adjacent to road pavements and structures have considered the potential for seepage from the SQID to impact on this infrastructure.		●	●	●	●
A concept for connection of roof and/or property drainage to the SQID has been identified.	●		●		
A concept for drainage at intersections has been identified including consideration of ponding depths and potential pedestrian conflicts.			●		
The SQID will incorporate a high flow bypass or controlled overflow structure.	●		●	●	●
Overflow from the SQID will be directed to a defined drainage or infiltration system.	●		●	●	●
Inflow to the SQID will be evenly distributed or energy dissipation measure provided.		●	●	●	●
RIPARIAN CORRIDORS					
SQID will be positioned outside riparian corridors.				●	●
Concentrated discharge of stormwater into riparian corridors will be avoided or mitigated.				●	●
TERRAIN					
Gradients are appropriate for the proposed SQID considering the potential for scouring/erosion or unwanted ponding of stormwater runoff.		●	●	●	●
Allocated space layout for the SQID in the development layout includes consideration of the likely batter extents.				●	●
Bedrock is at a sufficient depth for the proposed SQID location.			●	●	●
SOILS AND GROUNDWATER					
The performance of the SQID would not be significantly impacted by a seasonally rising groundwater table.			●	●	●
The presence of sodic, saline or reactive soils has been checked and if present SQID can be modified to address this constraint.			●	●	●

CONCEPT DESIGN CONSIDERATIONS	Rainwater Tanks	Filter Strips	Raingardens	Retention Basins	Biofiltration Basins
SERVICES					
A service search has been completed to identify existing services.	●		●	●	●
SQID will not be located within a drainage easement or over a sewer.	●			●	●
Horizontal and vertical clearances to existing services are appropriate or agreements are in place with services authorities to protect and/or relocate their infrastructure.			●	●	●
URBAN DESIGN					
SQIDs positioned in public open spaces would not limit the function of the space.		●	●	●	●
Crime Prevention Through Environmental Design principles have been considered.			●	●	●
Safety of pedestrians, cyclist, residents and motorists has been considered and potential conflicts can be mitigated. Trip hazards minimised and motorist sight lines retained.			●		
Options for excluding public vehicles during operation have been identified (e.g. fencing, gates, bollards, slotted kerbs, signage, dense planting and street trees).		●	●	●	●
The SQID would not require clearing of habitat that is planned to be retained.				●	●
The SQID can be staged to manage potentially high construction sediment loads.			●		●
The SQID has been positioned considering heritage issues.				●	●
SQID CONFIGURATION					
Pre-treatment SQID provided to remove litter, organic debris and/or coarse sediment.	●		●	●	●
Numerical modelling completed to confirm that the proposed size and configuration of the SQID would achieve the objectives and targets.	●	●	●	●	●
Dedicated space within the development layout is allocated to the SQID.	●	●	●	●	●
SQIDs with extended detention will have appropriate depths for the proposed locations.			●	●	●
Filter media is available locally.			●		●
The proposed vegetation species are available locally.		●	●		●
Vegetation species are appropriate for the local soil, topography and climatic conditions.		●	●		●
Conceptual plan and typical sections of the SQID provided.		●	●	●	●
OPERATION AND MAINTENANCE					
Legal access will be available to the SQID for maintenance.	●	●	●	●	●
Site access to the SQID is not too steep for the required maintenance vehicles.				●	●
The SQID will be accessible by the maintenance equipment available to Council.	●	●	●	●	●
Existing trees, overhead power lines, building awnings, parked vehicles or other infrastructure will not restrict future maintenance access.			●	●	●

8 OPERATION AND MAINTENANCE PLANS

The Operation and Maintenance Plan (OMP) outlines how operation and maintenance issues have been appropriately considered when preparing an SMP. A Draft OMP should be provided with a Development Application.

To ensure that the SQIDs will function effectively into the future it is important that operation and maintenance requirements are considered during early planning to ensure that the SQIDs can be efficiently maintained.

A Draft Operation and Maintenance Plan (OMP) shall be prepared at Development Application stage to outline how operation and maintenance issues have been appropriately considered when preparing the SMP. The Draft OMP shall be provided within the SMP report and include details on the elements outlined below.

A **description of the SQIDs** shall be provided including the locations and types of SQIDs proposed. This description shall also include a summary of the land uses / surfaces draining to the SQIDs and the expected types and loads of pollutants that would be captured by each SQID.

A **description of any staging** associated with the proposed development or SQID construction shall be provided. It will be important that it is demonstrated that sufficient SQIDs will be provided throughout the development and building phases to ensure that the Council's objectives and targets would be achieved from commencement to completion of all road and building construction. It is also important that SQIDs that will be exposed to potential damage and/or excessive sediment loading during a building construction phase are staged to ensure that the SQIDs will be functional once the catchment has stabilised. It shall be clearly demonstrated how the construction of SQIDs will be staged (e.g. temporary sacrificial vegetation or media layers during construction replaced by final layers prior to asset handover).

A **description of the maintenance methods** for the SQID shall be provided. A fundamental consideration for Council will be that the proposed SQIDs can be efficiently maintained using available Council equipment and personnel. The maintenance methods described shall include a summary of the inspection and maintenance frequencies, equipment and number/qualifications of maintenance personnel required.

An **estimate of the operation and maintenance costs** for the SQIDs shall be provided to ensure that Council has a good appreciation of the future long-term operation and maintenance costs associated with the SQIDs. Council requires the future operation and maintenance costs for SQIDs to be estimated at the DA stage to avoid construction of SQIDs that will ultimately be ineffective due to excessive and impractical maintenance costs. Cost estimates shall be provided for the operation, maintenance and replacement/decommissioning cost elements for each SQID. More detailed guidance on evaluating operation and maintenance costs is provided in a report titled 'An Introduction to Life Cycle Costing Involving Structural Stormwater Quality Management Measures' prepared by the Co-operative Research Centre for Catchment Hydrology (Taylor, 2003a). MUSIC can be utilised to undertake preliminary lifecycle cost estimates, although these estimates should also be checked using available local cost data.

A description of the proposed **site and SQID access** shall be provided. It will be important that a legal and geometrically viable site access for the types of equipment required to maintain the SQIDs is provided. If maintenance activities will require heavy vehicles (e.g. tip trucks, excavators) then the access pavement must be planned to have sufficient strength for these traffic loads. The access alignment and gradients shall be suitable for the required maintenance vehicles for all weather access. The site should also be checked to confirm that existing or future features/infrastructure would not impede maintenance (e.g. overhead power lines, sewerage, tree branches). The presence of other conditions that may impede future maintenance shall be confirmed (e.g. base flow, tidal flows). It will be important that safety for maintenance personnel is also considered to ensure that the SQIDs can be safely maintained in the future (e.g. conflicts with traffic should be avoided).

The **maintenance responsibility** for the SQIDs shall be confirmed at the Development Application stage. The development proponent shall confirm if the future maintenance responsibility will lie with Council, the private property owner or a body corporate/community association. Council's preference is that source control SQIDs are located within private land, and other conveyance or 'end of pipe' SQIDs are contained within public land.

The OMP shall be a living document that is progressively updated through the development stages. Further revision to the Draft OMP prepared for the Development Application shall be undertaken at the following stages:

- Construction Certificate – Revised Draft OMP providing further detail that will be applied during the construction period to maintain the SQID.
- Asset handover – Final OMP amended at the completion of construction maintenance period to take account of any modifications or lessons learnt. Further guidance on Council's handover requirements for SQIDs is provided in Section 10.

9 PREPARE STORMWATER MANAGEMENT PLAN

A Stormwater Management Plan (SMP) shall be submitted with the Development Application and concept designs to document the approach followed to prepare an SMP for the development. The SMP shall summarise the approach adopted and provide justified reasoning for the proposed SMP. The SMP shall include the following key elements (as a minimum).

A **site description** shall be provided to outline the proposed development characteristics and configuration. This description may include the site area, existing land use, proposed land use, proposed development characteristics (e.g. lots, buildings, roads, carparking, landscaping) and surrounding land uses. The development layout adopted for preparing the SMP shall either be included within the SMP or reference included to a specific drawing (including drawing reference, date, issue version etc.) that is included with the Development Application documentation.

The water management **principles, objectives and targets** applying to the development shall be summarised in the SMP. The development proponent shall provide concise statements of how the individual water management principles and objectives have been addressed in the SMP. Key sections of relevant policies, planning instruments and legislation that outline these principles, objectives and targets are summarised in Bellingen Shire Council's DCP 2010. The development proponent shall ensure that any additional legislative planning requirements applying to the development site are identified and addressed.

A **site constraints analysis** shall be provided outlining the site terrain, soil and groundwater characteristics, riparian zones, existing services and infrastructure, and other site features that potentially would offer constraints or opportunities for the SMP. Within this section sub-catchments should be defined and receiving water characteristics (including waters downstream of the site) described (e.g. aquatic/terrestrial ecology, water quality and, bed and bank conditions). Depending on the scale of the proposed development, the site analysis may also include consideration of other relevant urban design criteria that influence the SMP (e.g. flooding, ecology, landscaping, visual, bushfire, heritage, archaeology, acoustics, and transport). The site analysis should provide a summary of key constraints and opportunities, and confirm potential risks to the receiving waters if mitigation measures are not provided within the development. Any review of background reports/data and additional site investigations undertaken to inform the site analysis shall be referenced and described in this section.

A summary of the **SQIDs** considered for the development shall be provided. This section of the strategy shall identify the SQIDs that are most appropriate for the site considering the principles, objectives and targets, and assessment of site constraints. This section should outline the recommended stormwater management treatment series and summarise the reasoning for selecting these SQIDs. If there are any relevant issues remaining unresolved, recommendations shall be included to resolve these issues during detailed design. It will be important that any issues that impact on the feasibility of a particular SQID be resolved at this stage. Only issues that potentially would require minor modifications to the selected SQIDs should be addressed during detailed design.

The SMP shall include a summary of **MUSIC modelling** completed to assess the performance of the proposed series of SQIDs. This section of the report shall summarise the model input data used, modelling assumptions, modelled arrangement of SQIDs, model results and conceptual configuration of the SQIDs. The MUSIC modelling section shall include comparisons between the modelled SMP and the targets relevant to the development. A statement shall be provided confirming if the targets would be met by implementing the proposed strategy. It will be important that the MUSIC modelling results are based upon feasible and practical SQID configurations. MUSIC models shall be submitted with the SMP.

The SMP shall include **concept design drawings and/or sketches** showing the location, size and conceptual configuration of the SQIDs. The SMP shall provide a response to the concept design considerations outlined in Section 7.

A section outlining the **operation and maintenance** requirements for the proposed SQIDs shall be provided in the SMP. The SMP shall include a response to the operation and maintenance considerations outlined in Section 8.

Design, modelling and preparation of the SMP and associated stormwater treatment and conveyance infrastructure must be by a qualified and practicing Civil or Environmental Engineer with qualifications suitable for admission to Engineers Australia and who is actively practicing in the design of SQIDs.

10 HANDOVER PROCEDURE

10.1 Public Land Installations

Council will typically assume responsibility for future maintenance of SQIDs on Council land following completion of construction by a developer (and a subsequent developer maintenance period) provided the following conditions are satisfied:

- The SQID has been constructed in accordance with the approved construction drawings.
- Work-as-executed drawings and any required engineering certifications for the SQID have been provided to Council.
- Council has completed a final inspection of the SQID and confirmed that it is being maintained in accordance with the Draft Operation and Maintenance Plan (OMP).
- The Draft OMP has been reviewed and revised (if necessary) following completion of the developer maintenance period and this final plan has been issued to and approved by Council.
- A final estimate of annual operation and maintenance costs for the SQID is provided to Council. The operation and maintenance cost estimates shall be based upon verifiable expenses incurred during the maintenance period and evidence provided to confirm this.
- Details of any incidents including, OH&S incidents, public safety, and complaints received shall be provided.

If Council determines that a SQID is not complying with the applicable development consent conditions (e.g. SQID is not being maintained in accordance with the approved OMP), Council will not be obliged to accept responsibility for maintenance of the SQID. Until formal written approval is provided by Council accepting responsibility for maintenance, the developer would retain responsibility for maintaining the SQID. Where inspections identify that the SQID is not performing as designed, Council may require alterations prior to handover.

Large and other non-standard SQIDs that have increased maintenance requirements may require additional contributions from the developer to assist Council with future maintenance. Council may require that the developer agrees to contribute a lump sum contribution for operation and maintenance costs associated with the SQIDs.

Maintenance bonds may be required for some developments to ensure that maintenance is undertaken throughout the construction and developer maintenance period. Bond lodgement may be required as a condition of the subdivision certificate application.

Some SQIDs may need to be constructed in stages to minimise the risk of SQIDs constructed during the subdivision stage being overloaded with sediment during the building construction phase. For example, Council may require that a biofiltration measure is initially constructed with a sacrificial surface layer (e.g. turf) for the building stage, with the sacrificial layer only removed and the biofilter planting completed when a substantial proportion of the buildings in the development have been constructed and surfaces stabilised by landscaping. Council may require security bonds to cover the costs of the final planting.

Requirements for maintenance contributions and bonds should be discussed with Council prior to submission of a Development Application to confirm requirements.

10.2 Private Land Installations

In situations where SQIDs are installed within private property, the developer shall arrange for the creation of appropriate restrictions on user (easements) and positive covenants, and registration of these title encumbrances with the Land Titles Office. The title encumbrances shall be registered prior to the issue of a Subdivision Certificate or an Occupation Certificate for the development.

A Section 88B/88E instrument prepared under the Conveyancing Act 1919 by a solicitor, surveyor or other suitably qualified individual should provide appropriate restrictions and covenants to enable unhindered long term management and maintenance of the SQIDs. In particular, the instruments should-:

- Protect the SQID from being removed, constructed over or modified;
- Provide a legal right-of-way for Council to inspect the SQID and for maintenance vehicle access as appropriate;
- Require an owner/body corporate/community association to carry out maintenance of the SQID in accordance with the Final OMP and provide regular maintenance reports to Council;
- Give authority to Council to issue a directive to the owner/body corporate/community association to clean or repair a SQID within 14 days of notification;
- Give authority to Council to enter the property and complete maintenance if a directive to clean or repair a SQID is not complied with and recover the costs to complete this maintenance from the owner/body corporate/community association; and
- Require that the current and future owner/body corporate/community association maintains the SQID in perpetuity for the life of the development.

For private land installations, the developer shall maintain all SQIDs at their own expense until a significant proportion of dwellings (approximately 80%) are erected and occupied before maintenance responsibility is passed to the new lot owner (Torrens Title), community association (Community Title) or body corporate (Strata Title). At this stage the developer should transfer the SQID to the owner/community association/body corporate with the approved maintenance plan for the SQID. All future maintenance of the SQID would be the responsibility of the owner/community/body corporate association and typically financed through an established sinking fund or from owners funds in the case of private ownership.

The following data shall be provided to Council by the developer prior to issuing of a Subdivision Certificate or an Occupation Certificate for a development and subsequent transfer of maintenance responsibility to the new owner-:

- The SQID has been constructed in accordance with the approved construction drawings.
- Work-as-executed drawings and any required engineering certifications for the SQID have been provided to Council.
- Any necessary restrictions on user (easements) and positive covenants are created over all SQIDs and registered with the Land Titles Office;

- Council has inspected the SQID and confirmed that it is being well maintained in accordance with the Draft Operation and Maintenance Plan (OMP).
- The Draft OMP has been reviewed and revised (if necessary) following completion of the developer maintenance period and this final plan is approved by Council.
- A final estimate of annual operation and maintenance costs for the SQID is provided to Council. The operation and maintenance cost estimates shall be based upon verifiable expenses incurred during the maintenance period and evidence provided to confirm this.
- Any water quality monitoring required has been completed and monitoring results provided to Council.
- Details of any incidents including, OH&S incidents, public safety, and complaints received shall be provided.
- Evidence that the waste material from the SQID has been classified in accordance with the relevant authority guidelines.

10.3 Developer Maintenance Period

The developer maintenance period will typically commence when the Subdivision Certificate is issued by Council, but may also be linked to a particular construction milestone. The developer maintenance period concludes when maintenance responsibility for the SQID is handed over to Council. The developer maintenance period provides sufficient time for SQIDs to be fully functioning (e.g. vegetation established) and for most development surfaces disturbed during development activities to be stabilised either by covering with impervious surfaces (e.g. roads, buildings, paving) or vegetated. A maximum developer maintenance period is also specified to ensure that onerous maintenance conditions are not imposed on developers when building activities proceed slowly.

The developer shall be responsible for inspecting and maintaining SQIDs in accordance with the approved OMP during the construction and developer maintenance periods. All inspections and maintenance of the SQIDs during the developer maintenance period shall be funded by the developer.

A sign shall be at erected at a highly visible location at each major SQID installation site prior to commencement of the developer maintenance period nominating the developer's details for the public to contact during the developer maintenance period about any issues related to the SQID performance. Contact details for the relevant Council officer shall also be included as a secondary contact on the sign.

The following developer maintenance periods shall apply for new development:

- Small lot residential subdivisions (more than 5 lots) – The developer maintenance period shall be for a period up until a minimum of 80% of the dwellings have been constructed and occupation certificates issued or 24 months from the date of issue of the Subdivision Certificate for the subdivision (whichever period is shortest).
- Multiple dwelling developments (more than 5 dwellings) – Same developer maintenance period and requirements as small lot residential subdivisions.

- Large lot residential subdivisions where a new road is proposed – The developer maintenance period shall be 24 months from the date of practical completion of all road works and SQID construction.
- New commercial and industrial subdivisions – The developer maintenance period shall be for 24 months from the date of issue of the Subdivision Certificate or until 50% of the created lots are occupied (whichever period is shortest).

Council requires that the developer operates monitors and pays for all expenses in relation to a SQID in accordance with s68 of the Local Government Act in the period prior to handover.

10.4 Maintenance Inductions

At the end of the developer maintenance period, the SQID shall be inspected and maintained in Council's presence. A final inspection shall be completed and Council's maintenance personnel provided with an induction on the maintenance requirements for the SQID.

Following completion of construction, the developer shall provide Council with work-as-executed drawings, maintenance data and details of any required revisions to the OMP. An on-site meeting shall be held between the developer and Council to observe maintenance of the SQID for training purposes. The new SQID should be added to the asset database containing all background data and maintenance scheduling / reporting.

11 ADDITIONAL RESOURCES

11.1 Guidelines

Argue, J.R. (ed), 2004, *Water Sensitive Urban Design: Basic Procedures for Source Control of Stormwater,* Stormwater Industry Association, University of South Australia and Australian Water Association, ISBN 1 920927 18 2

BMT WBM, 2009, *Evaluating Options for Water Sensitive Urban Design – A National Guide*, Prepared by the Joint Steering Committee for Water Sensitive Cities in Delivery Clause 92(ii) of the National Water Initiative, downloaded May 2010 from www.nwc.gov.au

Brisbane City Council, (2005), *Water Sensitive Urban Design Engineering Guidelines: Stormwater, (Draft),* Brisbane City Council, Brisbane.

Cuncliffe, (2004) *Guidance on Use of Rainwater Tanks,* enHealth Council, Australian Government.

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

Facility for Advancing Biofiltration (FAWB) (2009), *Stormwater Biofiltration Adoption Guidelines,* Monash University.

Fletcher, T., Duncan, H., Poelsma, P. and Lloyd, S., 2005, *Stormwater Flow and Quality, and the Effectiveness of Non-Proprietary Stormwater Treatment Measures – A Review and Gap Analysis*, Report 04/8 Cooperative Research Centre for Catchment Hydrology, Monash University, Melbourne

Gold Coast City Council, (2007) *Water Sensitive Urban Design Guidelines.*

Hatt, B.E., Deletic, A., and Fletcher, T.D., 2004, *Integrated Stormwater Treatment and Re-use Systems - Inventory of Australian Practice*, Cooperative Research Centre for Catchment Hydrology.

HCCREMS, (2007) *WaterSmart Practice Notes* Hunter & Central Coast Regional Environmental Management Strategy.

HCCREMS, (2007) *Water Smart Model Planning Provisions* Hunter & Central Coast Regional Environmental Management Strategy.

Melbourne Water, (2005) *WSUD Engineering Procedures: Stormwater*. CSIRO Publishing.

Moreton Bay Waterways and Catchments Partnership 2006, *Water Sensitive Urban Design: Technical Design Guidelines for South East Queensland,* Moreton Bay Waterways and Catchments Partnership and Brisbane City Council, Brisbane.

National Water Commission,(2008) *Rainwater Tank Design and Installation Handbook,* Australian Government.

NSW Department of Environment and Conservation, (2006) *Managing Urban Stormwater – Harvesting and Reuse*

Queensland Government, 2009, *Draft Urban Stormwater Queensland Best Practice Environmental Management Guidelines 2009*, Department of Energy, Resources and Mines, downloaded May 2010 from www.derm.qld.gov.au

UPRCT (2004), *Water Sensitive Urban Design – Technical Guidelines for Western Sydney* Stormwater Trust and Upper Parramatta River Catchment Trust.

11.2 Web Sites

Water Sensitive Urban Design (WSUD) in the Sydney Region Capacity Building Program (http://www.wsud.org/index.htm).

Hunter Central Coast Regional Environmental Strategy WSUD Capacity Building Program (http://www.urbanwater.info/index.cfm).

Water by Design Capacity Building (http://www.healthywaterways.org/wbd_project_overview.html).

Clearwater Capacity Building Program (http://www.clearwater.asn.au/).

12 REFERENCES

Bellingen Shire Council, 2010, Bellingen Shire Development Control Plan.

BMT WBM, 2010, Draft NSW MUSIC Modelling Guidelines. Prepared for the Sydney Metropolitan Catchment Management Authority.

Great Lakes Council, 2009, Great Lakes Water Quality Improvement Plan: Wallis, Smiths and Myall Lakes, Forster, NSW.

Landcom, 2004, Managing Urban Stormwater: Soils and Construction, 4th Edition, NSW Government.

NSW Office of Water (NoW), 2012, Controlled Activities on Waterfront Land - Guidelines for riparian corridors on waterfront land.

NSW Rural Fire Service, 2006, Planning for Bushfire Protection.

APPENDIX A: RAINFALL ANALYSIS FOR MUSIC INPUT DATA

Continuous and daily rainfall data are available for a number of rainfall stations located within the Bellingen Shire LGA. Existing daily rainfall datasets were reviewed for a selection of these rainfall stations for comparison with the Coffs Harbour MO station located just outside the LGA. The rainfall data sets reviewed included:

- Bellingen (Post Office and Hyde Street);
- Urunga (Sunset Place);
- Glennifer (Promised Land, Crystal Creek); and
- Thora (Post Office).

Using all available daily rainfall data from these stations, mean annual rainfall volumes were determined as shown in Table 12-1. Only rainfall years with greater than 95% valid data (i.e. not more than 5% missing data) were used to estimate the averages.

Table 12-1 Annual Average Rainfall Volumes by Locality

Site Location	Station type	Mean Annual Rainfall (mm)	Years of Data
Bellingen	Daily	1502	97
Coffs Harbour	Continuous	1635	48
Urunga	Daily	1456	86
Glennifer	Continuous	2069	35
Thora	Continuous	1639	49

Table 12-1 indicates that the mean annual rainfall at Bellingen and Urunga is similar, and is approximately 10% lower than Coffs Harbour and Thora. Mean annual rainfall at Glennifer is approximately 25% higher than Coffs Harbour and Thora. Yearly rainfall totals for Bellingen, Urunga and Thora are presented in Figure 12-1 which provides a selection of wet (1996 and 1999), average (1995, 1997 and 1998) and dry years (1994). Across this period, the average annual rainfall for Bellingen was 1533 mm (close to long term average of 1502 mm), Urunga was 1364 mm (approximately 6% lower than the long term average of 1456 mm) whilst Thora recorded 1424 mm (approximately 15% lower than the long term average of 1640 mm). Despite the period of 1994 to 1999 being a slightly drier period for Thora, it more closely represents Bellingen and Urunga during this period.

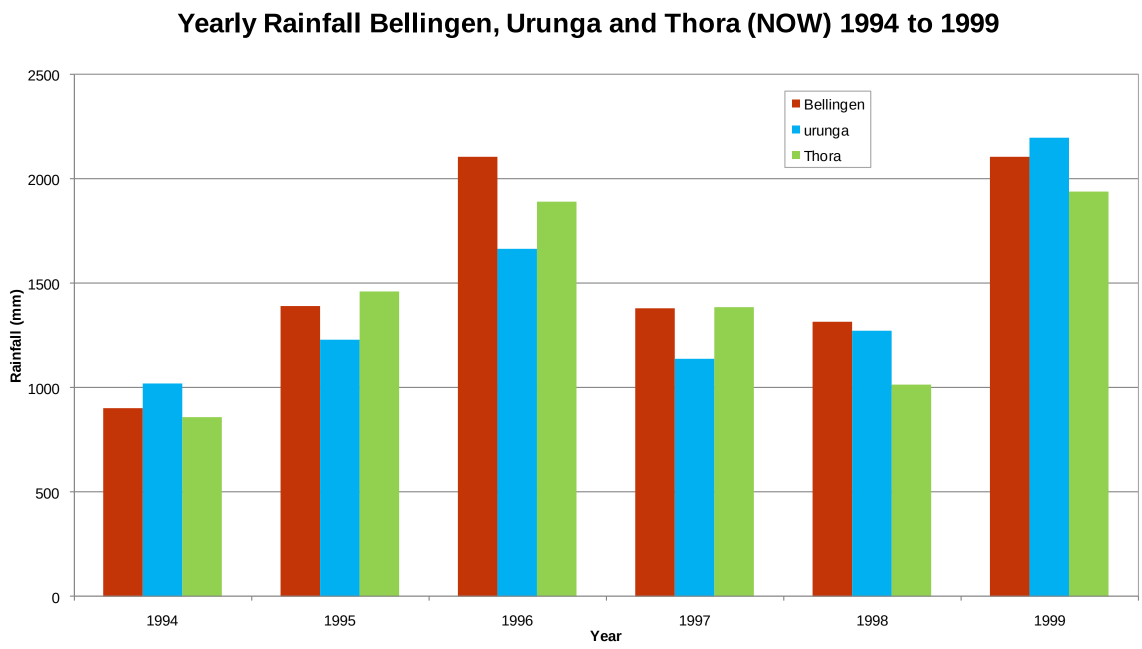

Figure 12-1 Rainfall Totals for Selected Sites, 1994 to 1999 (inclusive)

The number of rainfall days that exceed certain threshold depths were also determined over a common period for these rainfall stations. This is useful for determining if the daily rainfall distribution is similar for different locations. Figure 12-2 presents daily rainfall distributions for the locations summarised in Table 12-1 for the 1994 to 1999 period.

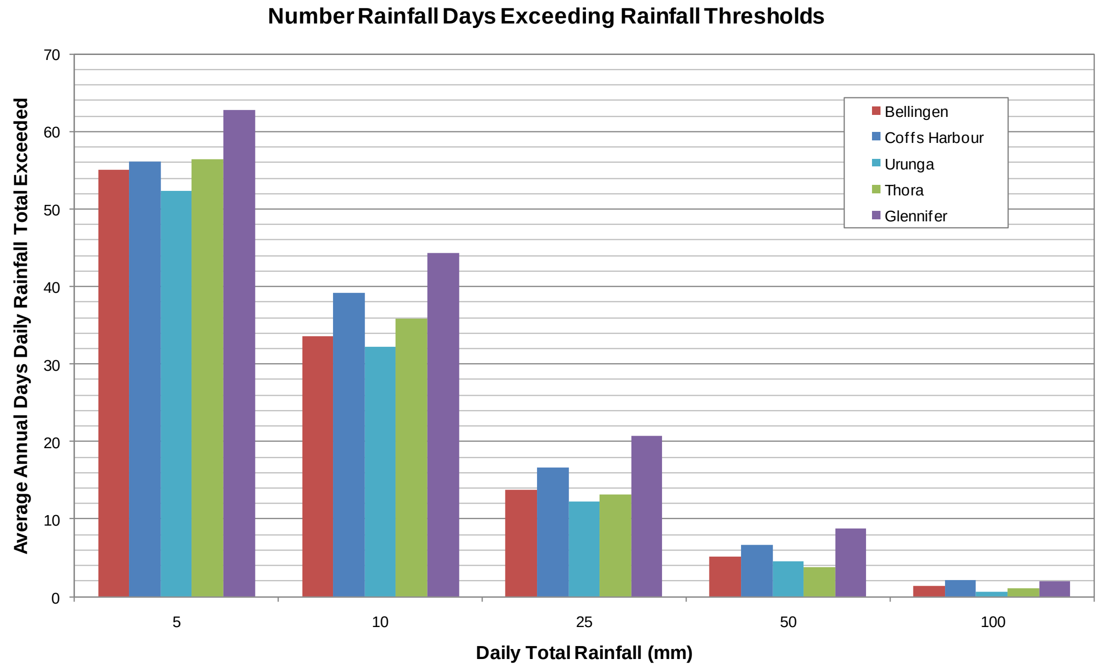

Figure 12-2 Daily Rainfall Distribution Comparison (1994 – 1999 inclusive)

Figure 12-2 indicates that the daily rainfall distribution is similar for Bellingen, Urunga and Thora over the 1994 to 1999 period. The daily rainfall distribution at Glennifer and Coffs Harbour indicates that there are a greater number of wet days at these two sites when compared to the Bellingen, Urunga and Thora sites. The daily rainfall patterns at Thora appear similar to that at Bellingen and Urunga.

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