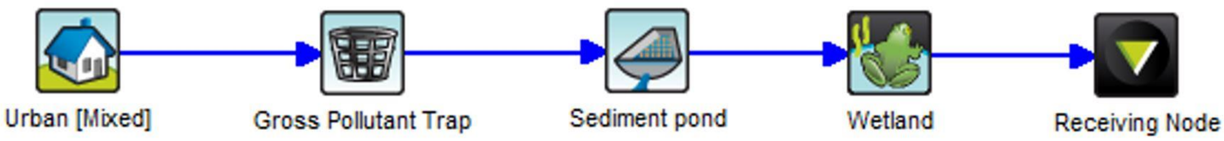
South Australian MUSIC Guidelines



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Disclaimer

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Images

Rainwater tank – Port Melbourne, E2Designlab, 2016
Sediment pond – Casey Fields, E2Designlab, 2015
Wetland – Adelaide Botanic Garden, E2Designlab, 2016
Swale – Kunshan, E2Designlab, 2017
Bioretention – Bridport Street, South Melbourne, E2Designlab, 2014
Ponds and lakes – Cranbourne Botanic Gardens, E2Designlab, 2012
Permeable pavement – St Marys Park, City of Mitcham, 2019

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1 Introduction

The urbanisation of our cities is placing valuable local waterways and other receiving environments at risk through the increased magnitude and frequency of stormwater runoff from catchment surfaces which have changed from pervious to impervious. These impacts can be effectively managed through the provision of urban green infrastructure using a water sensitive urban design (WSUD) approach. Relevant WSUD principles are to mimic pre-development natural hydrology as far as practicable in urban catchments, reduce potable water demands, manage stormwater runoff quality, integrate green infrastructure for amenity, recreation and biodiversity, and raise awareness of our valuable water resources.

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) is a software tool developed by eWater (ewater.org.au) that can be used to model urban catchments and the effectiveness of stormwater management responses. MUSIC uses local climate and soil data to simulate rainfall, stormwater runoff and pollutant generation. It simulates pollutant removal and stormwater flow volume reduction through stormwater treatment assets such as sediment ponds, wetlands, bioretention and harvesting.

MUSIC is intended as a *conceptual design* decision support tool that informs an iterative design approach. MUSIC conceptualises how development alters hydrology and pollutant runoff and allows the user to test a range of responses to first reduce these impacts, and then mitigate the residual impacts. It is noted that MUSIC is not intended as a detailed design tool and further calculations and checks may be needed for detailed design of stormwater treatment assets.

MUSIC is usually used to assess the WSUD responses proposed in a planning submission and demonstrate that these can achieve relevant stormwater quality objectives. It may also be used for the concept design of WSUD retrofit projects in existing urban areas, as well as projects involving rainwater or stormwater reuse, and to an extent broader catchment studies and plans. While MUSIC offers a high level of flexibility for the user, simpler and more accessible approaches and tools may be adopted for small-scale developments that have simple and relatively standard responses.

Figure 1.1 provides a general guide to stormwater runoff quality conceptual design and compliance tools in South Australia for projects at a range of scales.

At the time of developing these guidelines, MUSIC was in transition from Version 6.3 to the revised MUSIC X.

MUSIC X has been redesigned and rewritten into a modern software coding platform. It maintains all the same capability, methods and underlying science as MUSIC Version 6.3 but gives users additional functionality and the benefits of modern software architecture. As a result, the guidance for MUSIC Version 6.3 remains unchanged for MUSIC X. Further information on MUSIC and its versions is available on the eWater website (ewater.org.au).

In the future, MUSIC X is anticipated to enable opportunities for integration with the eWater water resources modelling tool "Source" and the eWater integrated urban water cycle management modelling tool "Urban Developer". These guidelines focus on the standalone use of MUSIC.

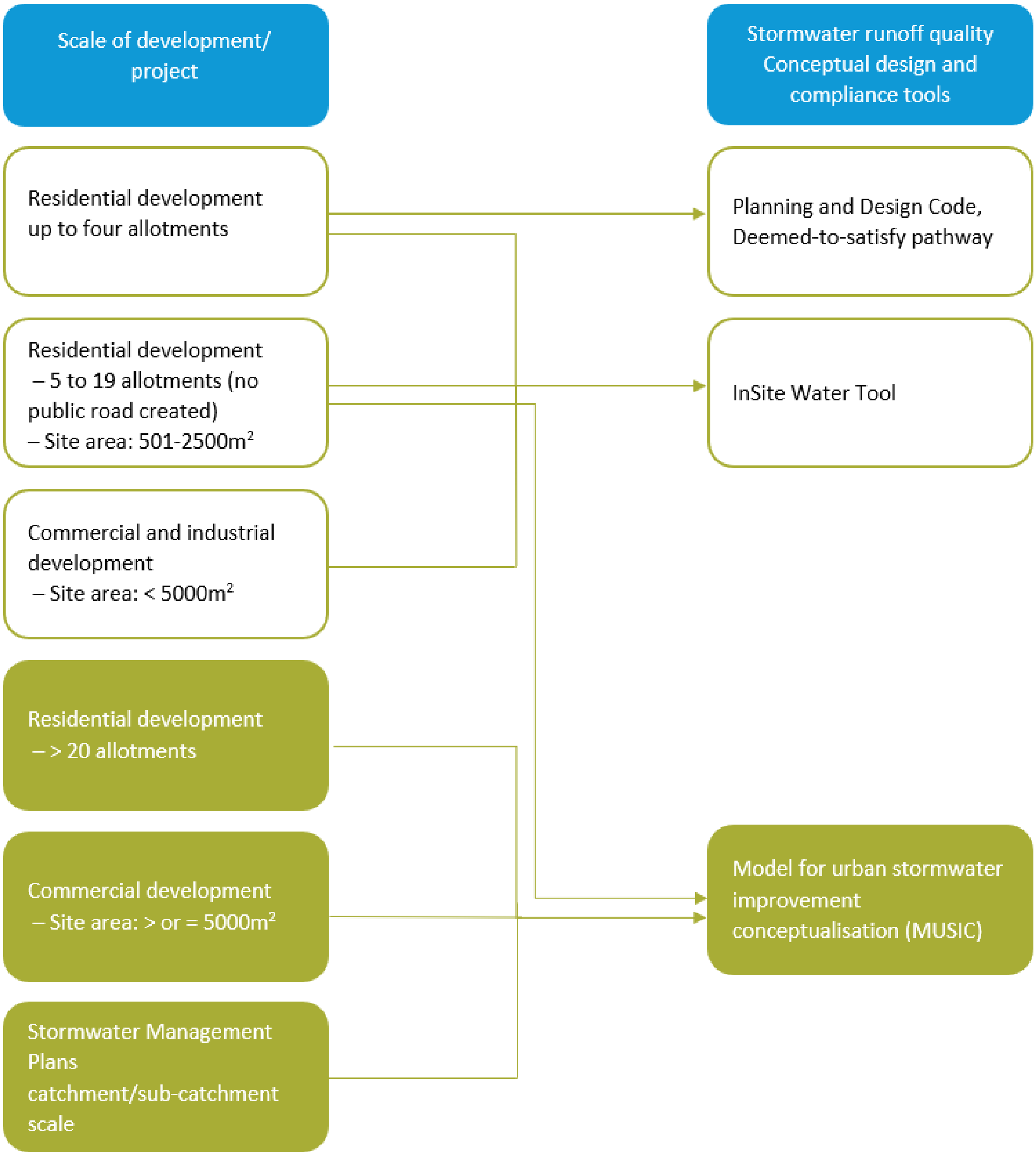


Figure 1.1 General guide to stormwater runoff quality conceptual design and compliance tools in South Australia

1.1 Purpose of guidelines

This document provides guidance on modelling approaches and input parameters for MUSIC models submitted to responsible authorities, including water authorities and Councils within South Australia.

The objectives of the guidelines are to:

- Ensure a consistent, fair and evidence-based approach for MUSIC modelling and assessment.
- Streamline processes for developing and assessing MUSIC models.
- Provide guidance specific to the climate and geology of South Australia.
- Link to relevant existing guidance from industry

Users are expected to have an understanding of WSUD principles and approaches, and have knowledge and training in the use of the MUSIC software. MUSIC can help estimate stormwater flow and pollutant load reduction performance for a design but is not the only potential check. It is not generally suitable for assessing drainage design.

The MUSIC User Manual is a useful reference for preparing a MUSIC model and users should familiarise themselves with the manual. Users should also seek to understand any guidelines or requirements of referral authorities including local government before developing a MUSIC model.

Figure 1.2 below shows where the SA MUSIC modelling guidelines sit with respect to other policy, regulatory and technical design material the user may be required to align with.

A range of other useful policy documents and resources is summarised in Section 11, References and resources.

Table 1.1 Planning, policy and guideline context for WSUD

	Policy and regulatory framework	MUSIC modelling	Detailed design
South Australia	Planning, Development and Infrastructure Act 2016 Environment Protection Act 1993 Environment Protection (Water Quality) Policy 2015, Environment Protection Authority Water sensitive urban design – Creating more liveable and water sensitive cities in South Australia (2013)	SA MUSIC Guidelines eWater MUSIC User Manual	Water sensitive urban design technical manual for the Greater Adelaide region (2009)
Other		Melbourne Water (2018) MUSIC Guidelines Healthy Land and Water (2018) MUSIC Modelling Guidelines	Melbourne Water wetland design manual (2017) Design guide – Bioretention systems in Melbourne Water development services schemes (2019) Health Land and Water draft wetland technical design guidelines (2017) Healthy Land and Water bioretention technical design guidelines (2014) Melbourne Water WSUD engineering procedures: Stormwater (2005) Australian runoff quality (2007)

Note: The documents listed in Table 1.1 are current as at November 2020, and users should refer to any future updates.

1.2 Structure of document

A schematic of the typical steps required to set up and run a model is shown in Figure 1.2. The schematic reflects the steps a user would take to create a model.

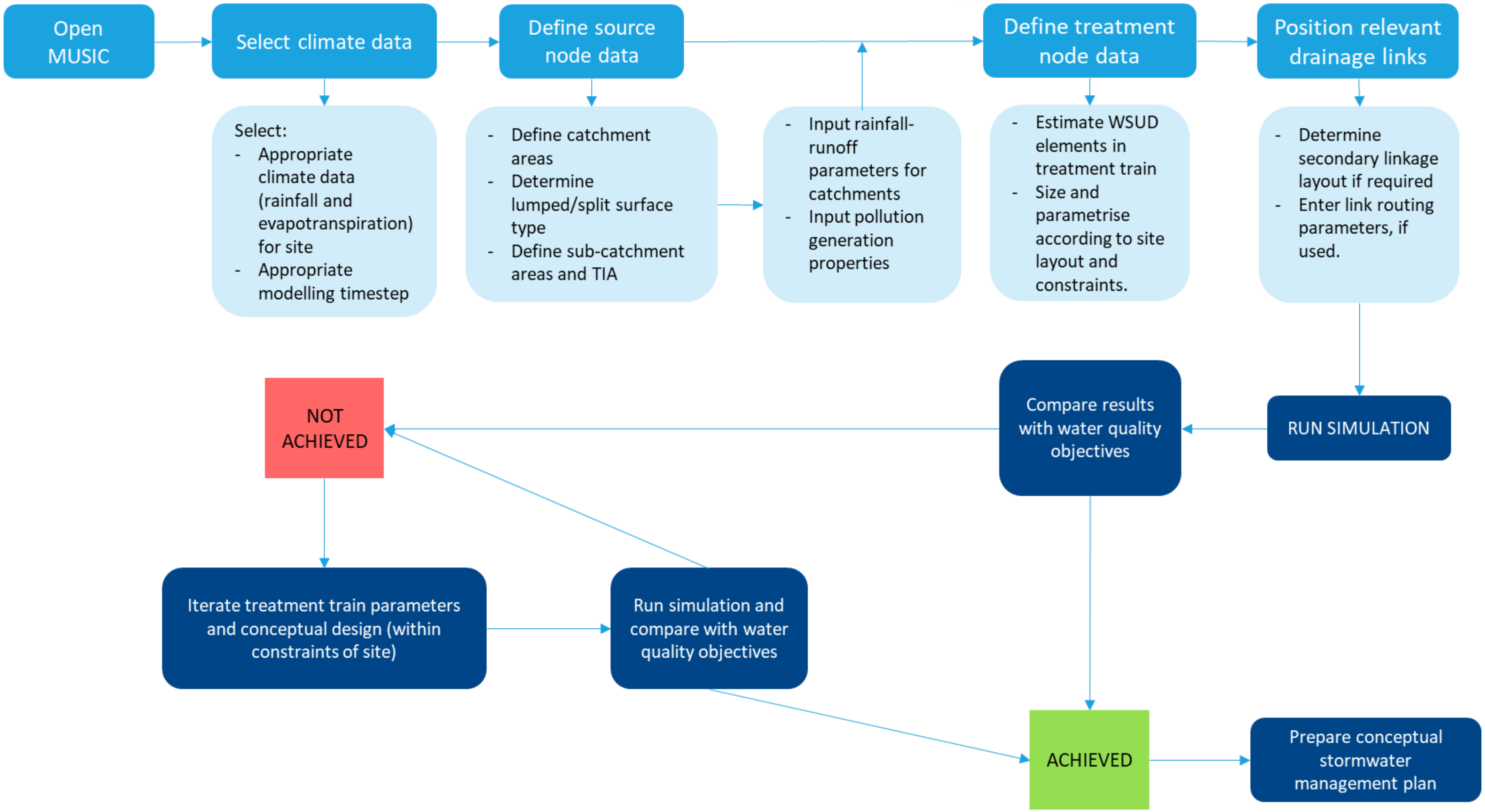


Figure 1.2 Modelling steps

(Adapted from Gold Coast City Council MUSIC modelling guidelines, 2006)

Similarly, the structure of these guidelines follows similar steps and is laid out as follows:

- Introduction
- Objectives
- Climate
- Catchments
- Treatments
- Links and routing
- Reuse demands
- Reporting and assessment.

Throughout these guidelines, the following call-out boxes indicate key guidance and recommendations, and useful additional information respectively.

Key information and quick guide default recommendations for MUSIC modelling in South Australia

Useful additional information

Links

References

Further discussion for advanced modellers

2 Context

2.1 State water sensitive urban design policy objectives

The South Australian WSUD Policy is set out in *Water sensitive urban design – Creating more liveable and water sensitive cities in South Australia* (Department of Environment, Water and Natural Resources, 2013). The policy outlines state-wide performance targets for WSUD, and can be found at http://www.environment.sa.gov.au/files/sharedassets/public/water/water-sensitive-urban-design-policy-gen.pdf.

The philosophy of WSUD is to deliver on multiple objectives including:

- Improve stormwater quality through treatment
- Improve urban amenity and liveability
- Mimic a more natural flow regime
- Provide opportunity for potable water conservation
- Increase urban greening
- Increase biodiversity
- Increase education by making water visible in the landscape.

WSUD solutions should be designed in accordance with this philosophy to deliver on as many of these objectives as possible.

The SA WSUD Policy aims for:

"Urban landscapes [that] are planned, designed and managed to be 'water sensitive' and in doing so contribute to the liveability of South Australia's urban environments and the wellbeing of South Australians. By providing green stormwater infrastructure that achieves not only water quality outcomes, but also liveability benefits, developers and local government make a substantial contribution to sustainable cities, by increasing the quality of urban places, and encouraging community interaction and participation with these systems whilst reducing construction and development costs."

South Australian WSUD Policy: *Water sensitive urban design – Creating more liveable and water sensitive cities in South Australia*

2.2 Performance targets

The key state-wide performance targets of relevance for WSUD are summarised in Figure 2.1. It is noted that the South Australian stormwater quality runoff improvement targets were set in 2013 and, as a result of recent research, may be subject to change in the future.

Water conservation

Demonstrated compliance with SA residential building requirements for water efficiency	Non-residential: Water efficient techniques in commercial, industrial & other non-residential urban settings	Irrigated open spaces: Best practice irrigation management in outdoor irrigated open spaces

Stormwater runoff quality

45% retention of typical annual urban load of total nitrogen	**60%** retention of typical annual urban load of total phosphorus	**80%** retention of typical annual urban load of suspended solids

Waterway protection

Rate of runoff discharged from the site does not exceed the pre-urban development for the 1 year average recurrence interval (ARI) peak flow

Flood management

Capacity of the existing drainage system is not exceeded	No increase in the 5 year ARI peak flow compared to existing conditions	No increase in flood risk for the 100 year ARI peak flow, compared to existing conditions

Figure 2.1 Performance targets for WSUD
(Department of Environment Water and Natural Resources, 2013, page 11)

2.3 Other supporting policy

The *Environment Protection (Water Quality) Policy 2015* (South Australian Environment Protection Authority) provides the structure for regulation and management of water quality in South Australian inland surface waters, groundwaters and marine waters. It promotes best practice environmental management and details offences for polluting activities. The policy can be found at https://www.legislation.sa.gov.au/LZ/C/POL/ENVIRONMENT%20PROTECTION%20(WATER%20QUALITY)%20POLICY%202015/CURRENT/2015.-.AUTH.PDF.

Certain stormwater management requirements and objectives may be specified in a range of planning documents (including state planning policies, regional plans, and local government planning schemes, etc.). Refer to the relevant authority to obtain applicable information on design objectives for a given development.

Note: MUSIC modelling is only considered appropriate for demonstrating compliance with stormwater runoff quality targets and some aspects of water conservation and waterway protection. More work is being undertaken on the potential use of MUSIC to demonstrate compliance with water quantity management objectives. In its current form (Version 6.3), MUSIC is not considered the best tool for demonstrating compliance with waterway protection or flood management objectives.

Local governments and other agencies may also prepare locally relevant objectives and additional requirements.

3 Climate data

3.1 Recommended climate regions and templates

MUSIC is a continuous simulation model and requires input time series for rainfall and potential evapotranspiration (PET).

It is recommended that a climate template (incorporating rainfall and PET) with a length of at least 10 years of data is used for most modelling purposes.

A range of regions across South Australia have been identified with similar mean annual rainfall within each region; see Figure 3.2. For consistency and ease of use, MUSIC climate templates for 10-year periods suitable for modelling stormwater quality treatment assets have been prepared for selected key regions including the Adelaide Metropolitan area and surrounds; see Figure 3.3. It is recommended that all models for sites within these regions submitted to authorities, including local governments, use these templates unless either a locally specific rainfall data set is specified by a relevant authority or written permission is provided by the relevant authority. The rainfall templates have been pre-filled using data from other highly-correlated rainfall stations and therefore cannot be re-created directly from the raw Bureau of Meteorology data. Further guidance is provided below on developing templates when working outside these regions or where considered necessary, for example where a longer climate period may be needed.

It is noted that these climate templates are based on long-term historical data and are considered to be representative of current climate conditions. Climate change is also an important consideration for water management and for long-term future predictions greater consideration of climate change may be needed. In South Australia, generally higher temperatures, higher evapotranspiration, lower rainfall volumes and increases in rainfall intensity are anticipated.

Research to date has found that generally climate change is not likely to substantially change WSUD performance outcomes in the short term (slight increases in stormwater quality performance and decreases in harvesting performance), hence the use of current climate data is considered a reasonable approach for the design of WSUD assets. However, the additional resilience provided by WSUD in terms of decreased pressure on potable water supplies and increased retention of soil moisture within urban landscapes may be valuable and warrants further consideration and assessment. The reader is referred to Appendix 1 for a more extensive discussion.

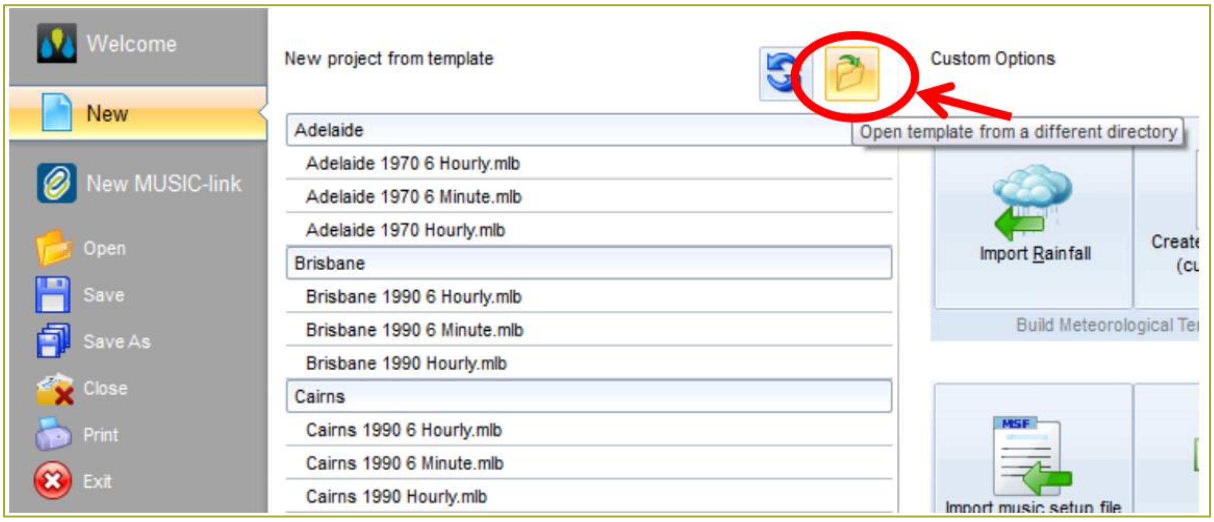


Figure 3.1 Creating a new model and selecting an existing rainfall template

The rainfall distribution maps in Figure 3.2 and Figure 3.3 below can be used to identify the appropriate rainfall template or weather station for a site. A PDF version of the map and the rainfall templates (*.mlb) files for use with MUSIC can be downloaded from the Water Sensitive South Australia website at https://www.watersensitivesa.com/resources/technical-aides/guidelines/south-australian-music-guidelines/.

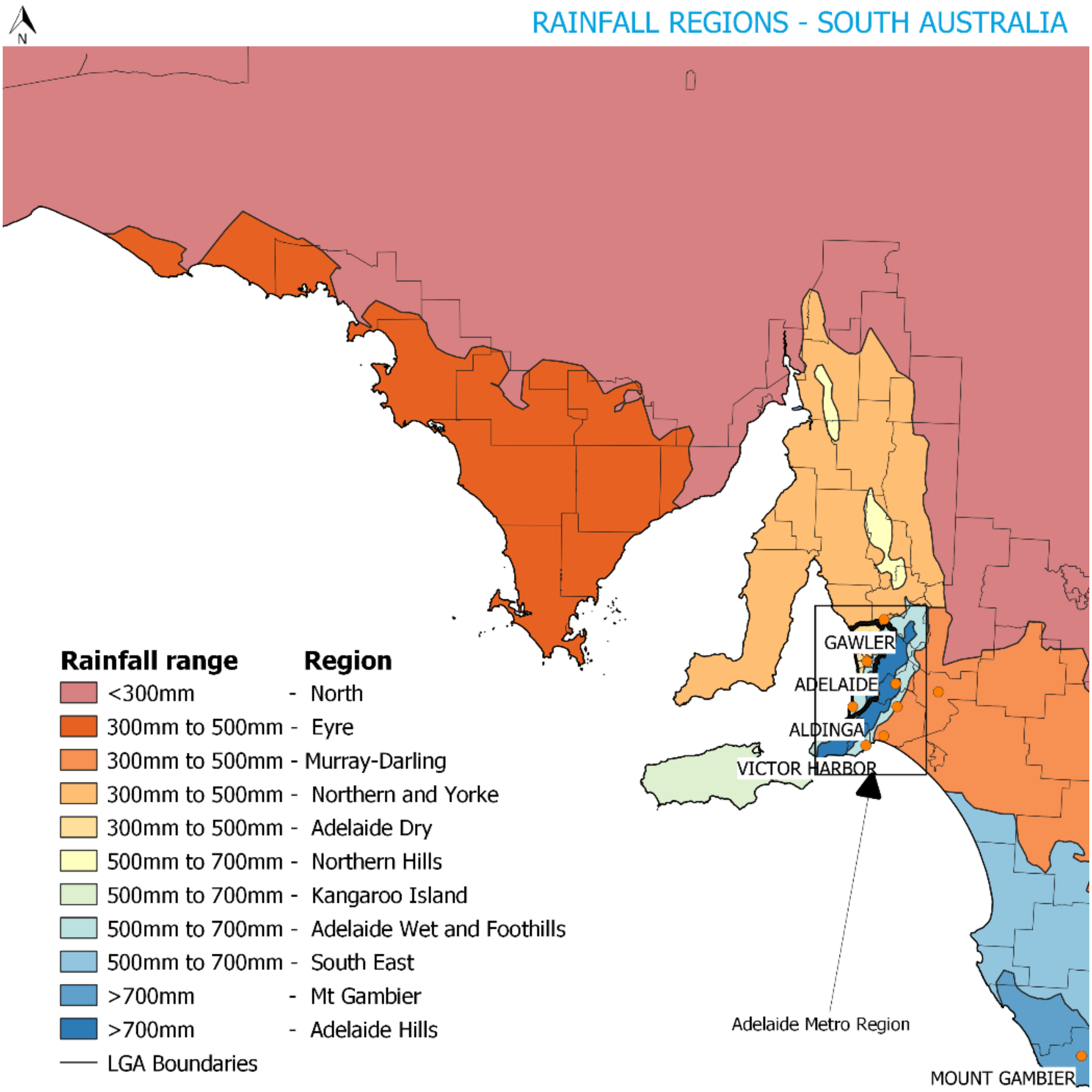


Figure 3.2 Rainfall regions for South Australia

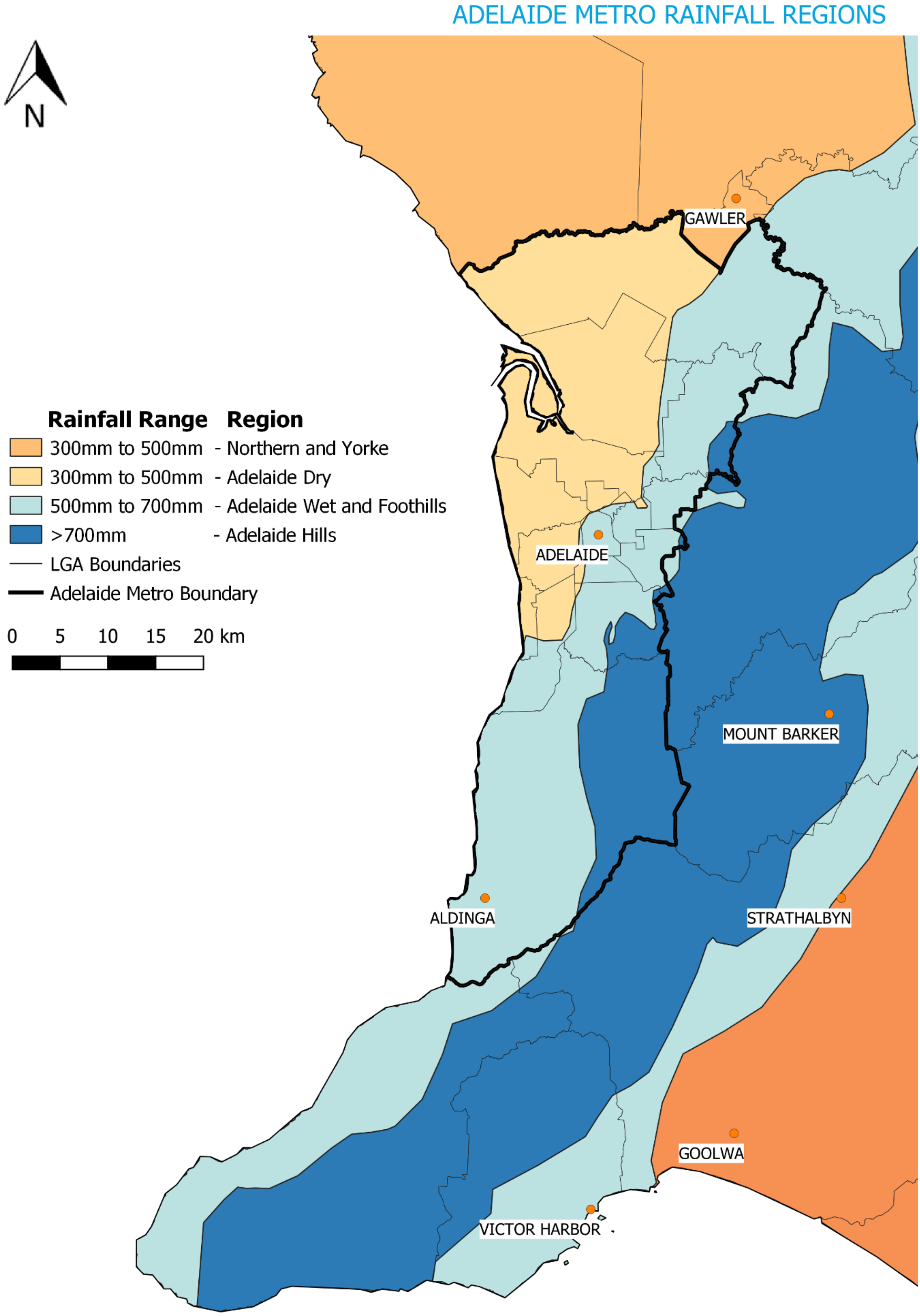


Figure 3.3 Rainfall regions for the Adelaide metropolitan area

Table 3.1 Climate templates for Adelaide region

Region	Rainfall band (mm)	Rainfall station	Period	Period mean annual rainfall (mm)	Mean annual PET (mm)
Adelaide Dry	300–500	23013 Parafield Airport	1979–1988	450	1,159
Adelaide Wet and Foothills	500–700	23090 Adelaide Kent Town	1983–1992	585	1,143
Adelaide Hills	700+	23875 Parawa (Second Valley AWS)	2001–2010	866	1,132
Northern and Yorke	300–500	23122 Roseworthy AWS	2001–2010	404	1,145

If the catchment for a project straddles two or more regions, the climate template chosen should be that data set that produces the most conservative design outcome.

3.2 Establishing a new climate template

The use of good quality local rainfall data is encouraged where available. Alternate rainfall templates may be developed to more closely represent specific local conditions or where a longer template is warranted, such as a municipal or catchment integrated water management strategy or where significant pervious areas (e.g. agricultural areas) are being modelled. However, these must be developed based on a thorough assessment of rainfall for the site and surrounding region.

If a user wishes to prepare their own climate template, data are available from the Bureau of Meteorology at a 6-minute timestep for a number of gauges across South Australia.

The selection of a rainfall gauge and period should consider:

- local rainfall patterns for the site of interest
- completeness of record
- representation of a range of conditions including wet and dry periods and a variety of storm events of varying sizes and antecedent dry periods
- purpose of the model.

3.3 Guidance on modelling period and timestep

Use a 6-minute rainfall timestep and at least 10 years of climate data

All models must be run at a 6-minute timestep where possible. The use of a longer model timestep, particularly daily, can result in significant errors and increase the variability of results. Where a different timestep is adopted, it must comply with the following:

The timestep must be equal to or less than:

- the time of concentration of the smallest sub-catchment; and
- the shortest detention time (under design flows) of the treatment measures being modelled.

Circumstances where a different modelling timestep may be appropriate include:

- concept level modelling of systems that have long times of concentration and detention times, such as rivers or lakes, where no representative 6-minute data is available
- where a larger timestep is required to interface with another model and allow consistent rainfall to be used. Depending on the outputs required, it may be possible to run MUSIC at a 6-minute time step and export results at a longer time step.

The length of the modelling period is a balance between the level of accuracy required and the time and effort required for modelling. The templates provided represent the rainfall variations across South Australia and metropolitan Adelaide.

The following climate data record periods are recommended for modelling:

10-year period: Using 10 years of climate data ensures the model captures sufficient data to represent a range of rainfall patterns over time. It allows a reasonable balance between model accuracy, computer memory requirements, simulation run time, and the size of the output file. A minimum period of 10 years is required for:

- Stormwater quality and pollutant load reduction objectives
- Development planning and design
- Modelling of areas including significant areas of pre-development, rural or pervious land
- Modelling of stormwater harvesting schemes.

The templates provided may be adopted for these purposes or a local alternate template adopted where preferred, subject to agreement by the relevant authority.

20+ year period:

- Municipal and larger integrated water management strategies
- Waterway flow analyses
- Analysis of large pervious catchments (> 100 ha).

It is recommended that users seek to establish a relevant template for these types of analyses. Where data of a sufficient length and quality are unavailable, the reference templates may be used. Sensitivity analysis should be conducted where modelling results are considered likely to be influenced by the modelling period.

4 Catchments

The catchment and sub-catchments are represented in the MUSIC model using source nodes with a sub-catchment breakdown based on drainage paths, land-use, and/or surface type. The user should choose the catchment breakdown that is most appropriate for the purpose of the modelling, and establish the area for each sub-catchment from development plans, preferably in a digital format (i.e. CAD, GIS or other).

Defining the characteristics of the MUSIC source nodes (catchment nodes) involves:

- defining the total catchment area (including areas of the development that will not receive treatment as well as any upstream areas passing through the development area or flowing into any relevant stormwater treatment assets)
- splitting the catchment into sub-catchment areas based on their flow paths
- splitting sub-catchment areas into similar land use or surface types (e.g. separating roofs, roads and other pervious and impervious areas, or lumping land uses together) as appropriate to the modelling
- defining the percentage of impervious area for each sub-catchment
- selecting rainfall runoff parameters
- selecting pollutant export parameters.

These steps are detailed in the following sections.

Significant areas of preserved vegetation, waterways and riparian zone revegetation do not need to be included in the MUSIC model to determine baseline urban stormwater pollutant loads as they are not considered part of the development footprint leading to increases in urban stormwater runoff. However, where such areas contribute to flows into a WSUD asset they should be included in the model to account for their effects on treatment assets. In this case, these catchments would not be included when calculating the urban pollutant loads generated and corresponding required pollutant load reductions. This can be achieved by only summing the pollutant loads for the remaining urbanising areas when calculating the required pollutant load reductions.

4.1 Source nodes and catchment breakdown

For most catchment modelling purposes, urban land uses and surface types can be lumped together and represented by a source node with a single set of pollutant generation parameters.

In other cases, a split surface type approach can be used. Both methods are described below.

4.1.1 Lumped surface type approach

The following source nodes are recommended for the representation of urban catchments:

- **Urban node** with “mixed” zoning/surface type for most modelling purposes to represent existing and new urban areas (including residential, commercial, industrial, parkland, and other land uses within an urban area).

- **Forest nodes** should be used only for representing catchments that are mostly old growth or well-established forested areas and potentially well-managed plantations expected to have similar pollutant discharge characteristics.
- **Agricultural nodes** for actively farmed rural areas that may have elevated nutrient concentrations.

Table 4.1 shows the pollutant generation parameters that should be adopted based on a lumped surface type approach. The pollution generation parameters referred to in Table 4.1 are discussed further in Section 4.4.

Table 4.1 Land use and surface type recommendations – lumped approach

Surface type/land use	Surface type/pollutant generation parameters for
Land use/zoning (lumped approach)	
Urban residential zones	Urban
Commercial	Urban
Industrial	Urban
Schools	Urban
Urban parks	Urban
National parks/protected land	Forest
Rural residential	Urban
Rural grazing	Agriculture
Nurseries, horticulture	Agriculture

4.1.2 Split surface type approach

It is recognised that within urban land use, pollutant concentrations may be significantly different for road and roof surface types. For this reason, source nodes may be split to represent different surface types and provide more accurate modelling in the following circumstances:

- Roof water harvesting (rainwater tanks)
- Direct streetscape treatments treating only roads and not a mix of surface types
- Where the catchment has a distribution of surface types that is very different to a typical urban area (e.g. mostly roof or mostly road).

In these cases, “road”, “roof” and “all other urban” areas should be represented using the stormwater pollutant concentrations listed in the tables in Section 4.4.

Table 4.2 describes the land uses applicable to each of the split surface type pollutant generation parameters. The pollution generation parameters referred to are discussed further in Section 4.4.

Table 4.2 Split surface type approach

Surface type	Description
Roof	Building roofs Split roof areas where some areas drain to a rainwater tank and others direct to drainage
Road	Roads and carparks The impervious fraction should be used to account for impervious roads and pavements relative to vegetated road verges or landscaping
All other urban	Any remaining area that is not a road or roof Includes parks, backyards, landscaped areas and small impervious areas such as patios, walkways, paving, pergolas and residential driveways

Table 4.3 shows typical percentage splits of surface types for different development types. These estimations should only be used in the case where no information is available regarding the details of the proposed development. Split surface type areas should be estimated from spatial information in all cases where this exists.

Table 4.3 Typical surface type % splits for various development types
(Adapted from Healthy Land and Water, 2018)

Development type	MUSIC surface node type		
	Road	Roof	All other ground
Residential 10 dwellings/ha	25%	30%	45%
Residential 15 dwellings/ha	25%	35%	40%
Residential 40 dwellings/ha	30%	35%	35%
Residential 80+ dwellings/ha	32.5%	35%	32.5%
Industrial	25%	45%	30%
Commercial	25%	45%	30%

4.1.3 User-defined source node

The user-defined source node is similar to the catchment nodes in that MUSIC generates runoff based on defined rainfall–runoff and pollutant parameters. The main purpose of this node is as a visual reminder that data other than default rainfall–runoff and pollutant export data is being used. If the parameters used differ from the recommended parameters for the general source nodes, they must be referenced in the MUSIC model reporting. The parameters including those for rainfall runoff and pollutants in a user-defined node must be modified from the defaults to be valid.

4.1.4 Imported data node

The imported data node allows historical or model-generated runoff and flow data to be used as input in the model. One possible application of this node is in combining a number of MUSIC models into one. Rather than including all the source nodes from each model (which can make the model complicated and large), the results from the smaller models can be imported into one overall model, which can reduce complexity and run-time of the one larger model. Refer to the “MUSIC Help” for information on using the imported data node.

Where this node is used, the source and underlying basis must be clearly documented.

4.2 Impervious fraction

Impervious areas dominate the rainfall runoff process in urban catchments because they generate much more runoff and more frequent runoff than pervious areas. Therefore, ensure impervious areas are accurately represented in MUSIC models.

4.2.1 Total and effective impervious areas

The impervious fraction is the proportion of a catchment that is impervious to rainfall and produces significant amounts of surface runoff. This is a key input for modelling catchments in MUSIC.

The impervious area is commonly referred to as total impervious area (TIA). Generally, the TIA will be used for all water quality modelling in MUSIC including development applications.

The effective impervious area (EIA) describes the proportion of a catchment that is both impervious and is connected to the drainage system, recognising that some impervious areas may not be directly connected.

Figure 4.1 below describes the difference between TIA and EIA for a standard residential lot. The impervious areas outlined in blue are directly connected to the stormwater drainage system. Those outlined in yellow are “indirectly” connected; that is, stormwater from these impervious areas is directed over vegetated pervious areas before reaching the drainage system. The TIA is the sum of both the blue and yellow areas.

4.2.2 Use of total impervious area and effective impervious area

Studies of existing urban areas have shown the EIA can vary from 30% to 90% of the TIA. The EIA may be lower than the TIA due to impervious areas discharging over adjacent pervious areas, leakage within drainage systems, and other factors. In most new development areas there is usually a relatively high EIA and TIA, with limited availability of pervious areas where losses can potentially occur.

It is prudent for a conservative estimate of the impervious fraction to be made. Therefore, the impervious fraction is usually based on the TIA.

Alternatively, a conservative estimate of EIA may be adopted if it can be justified that this is a reasonable long-term assumption and is agreed to by the relevant authority.

Given the uncertainty in the estimation of EIA, especially for new development, the use of TIA is required to be adopted for sizing stormwater treatment measures to ensure they are not undersized to treat their catchment.

Note: There is more uncertainty with EIA in older development areas. For new development, TIA approximately equals EIA.

Impervious fraction estimates for development applications and modelling of existing catchments should be undertaken using plans and aerial photography as appropriate.

Table 4.4 and Table 4.5 may be used to estimate the impervious fraction for different land uses where detailed information is not available, such as for broad-scale master planning and conceptual design. Significant deviations from the figures in the table should be supported by relevant information such as plans and description of proposed urban form.

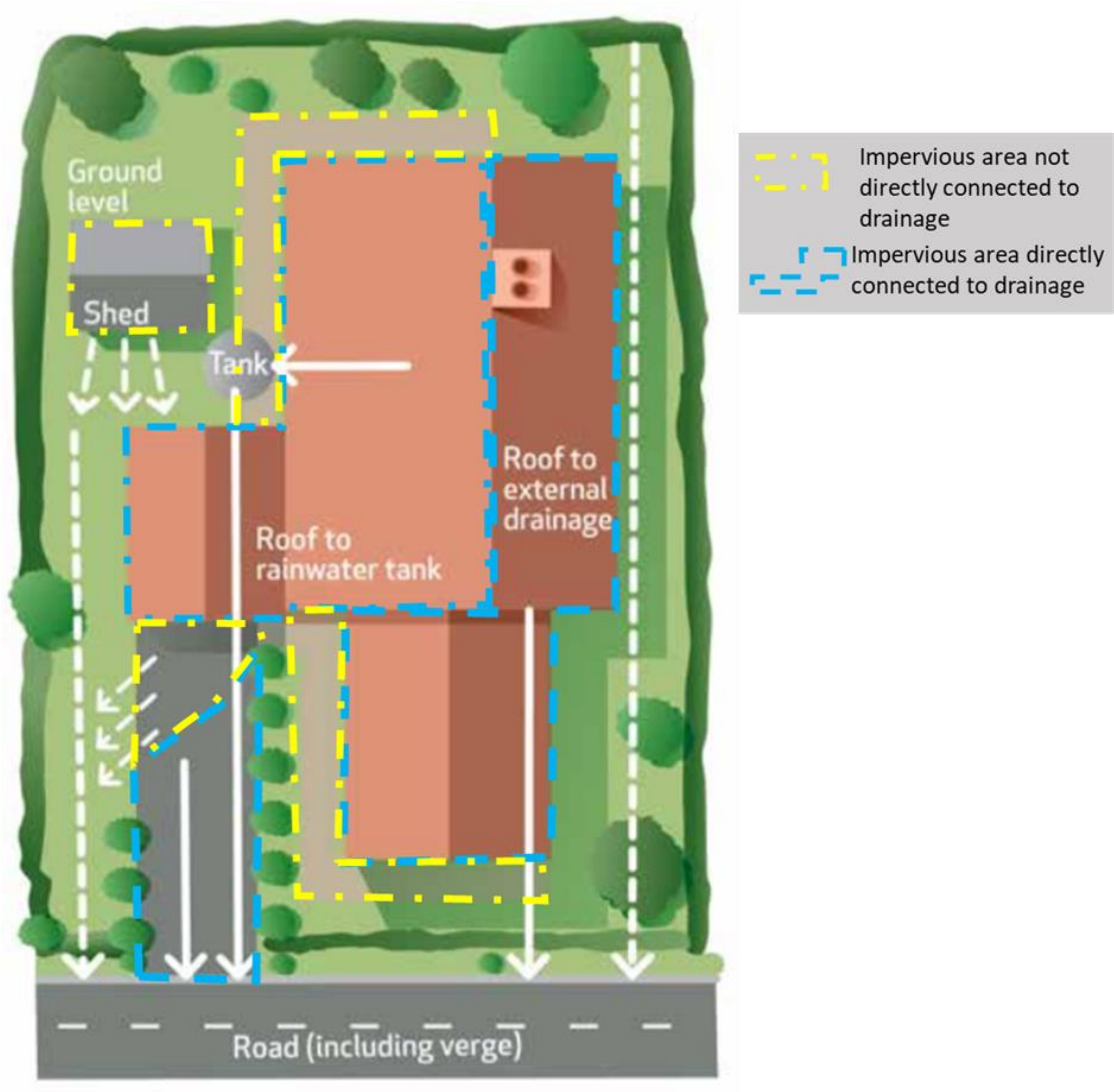


Figure 4.1 Schematic describing total and effective impervious areas (Adapted from Healthy Land and Water, 2016)

Table 4.4 Impervious fraction (based on TIA) for lumped catchment land use approach (Adapted from Healthy Land and Water, 2018, MUSIC Modelling Guidelines, 2018)

Surface type	Impervious fraction (%)	
	Range	Recommended minimum
Residential or mixed use		
Residential 10 dwellings/ha (typical lot size = ~750 m^2)	45–75	60
Residential 15 dwellings/ha (typical lot size = ~500 m^2)	50–80	65
Residential 25 dwellings/ha (typical lot size = ~250–300 m^2)	70–80	75
Residential 40 dwellings/ha (typical lot size = ~150–200 m^2)	70–90	80
Residential 80+ dwellings/ha (typical lot size < or = ~100 m^2)	80–95	85
Industrial		
Typical industrial (warehouse, manufacturing, workshop, etc.)	70–95	90
Garden and landscape supplies	30–60	50
Commercial		
Business or town centre	70–95	90
Offices	70–95	90
Bulky goods	70–95	90
Public zones		
Public open space	5–50	20
Car parks	70–95	90
Library, sporting, depots	50–90	70
Schools and universities	50–80	70
Infrastructure projects		
Highways and roads	60–90	70
Rail	50–80	65
Other		
Rural residential (greater than 0.4 ha/lot)	5–20	10
Rural residential (smaller than 0.4 ha/lot)	10–25	20
Rural	0–5	2
Forest or conservation	0–5	0

Table 4.5 Impervious fraction (based on TIA) for split catchment and land use approach (Healthy Land and Water, 2018)

Surface type	Impervious fraction (%)		
	Road reserve	Roof	Ground level
Residential or mixed use			
Residential 10 dwellings/ha (Typical lot size = ~1,000 m^2)	60	100	15
Residential 17 dwellings/ha (Typical lot size = ~600 m^2)	60	100	20
Residential 25 dwellings/ha (Typical lot size = ~400 m^2)	60	100	30
Residential 40 dwellings/ha (Typical lot size = ~250 m^2)	70	100	40
Residential 80+ dwellings/ha (Typical lot size = ~125 m^2)	80	100	50
Industrial	75	100	60
Commercial	75	100	80

4.2.3 Use of effective impervious area for stormwater harvesting in existing urban areas

It is recognised that TIA may over-estimate flow volumes from existing urban areas for the purposes of stormwater harvesting. For the design of retrofit stormwater harvesting schemes within existing areas it is recommended that stormwater reuse volumes are estimated using a reduced EIA. This should preferably be calculated based on any known EIA data for existing urban areas, or in the absence of data assumed to be 67% of the TIA[A].

The user should use discretion to ensure the choice of TIA/EIA adopted best reflects the purposes of the modelling with a view to minimising risk (whether it be risk of oversized stormwater harvesting infrastructure or under-sized stormwater treatment systems).

An example calculation of EIA for a typical residential lot can be seen in Appendix 1.

[A] Review of relevant references (Fletcher, 2007; Dotto, Deletic, Fletcher, & McCarthy, 2009; Ball, et al., 2019; Myers, et al., 2014), suggests this ratio could vary between 30% and 90% for different catchments. A value slightly above the average for these studies (~60%) was adopted as a preliminary estimate.

4.3 Rainfall runoff parameters

4.3.1 Soil type

The pervious soil area parameters should ideally be modified and defined to reflect conditions relevant to the site based on knowledge of the site soil characteristics.

Soil parameters are primarily influenced by soil type (although climate and other factors can influence calibrated outcomes). Where local data are not available, an indication of potential soil types for a site can be identified from state mapping data such as:

- Metropolitan Adelaide – the South Australian Resources Industry Gateway (https://products.sarig.sa.gov.au/Products/Index/244). Provides a digitised version of the *Soil Association Map of the Adelaide Region.* Refer to Figure 4.2*.*
- Agricultural areas – Nature Maps (https://data.environment.sa.gov.au/NatureMaps/Pages/default.aspx). For instructions on how to navigate Nature Maps refer to Appendix 4.

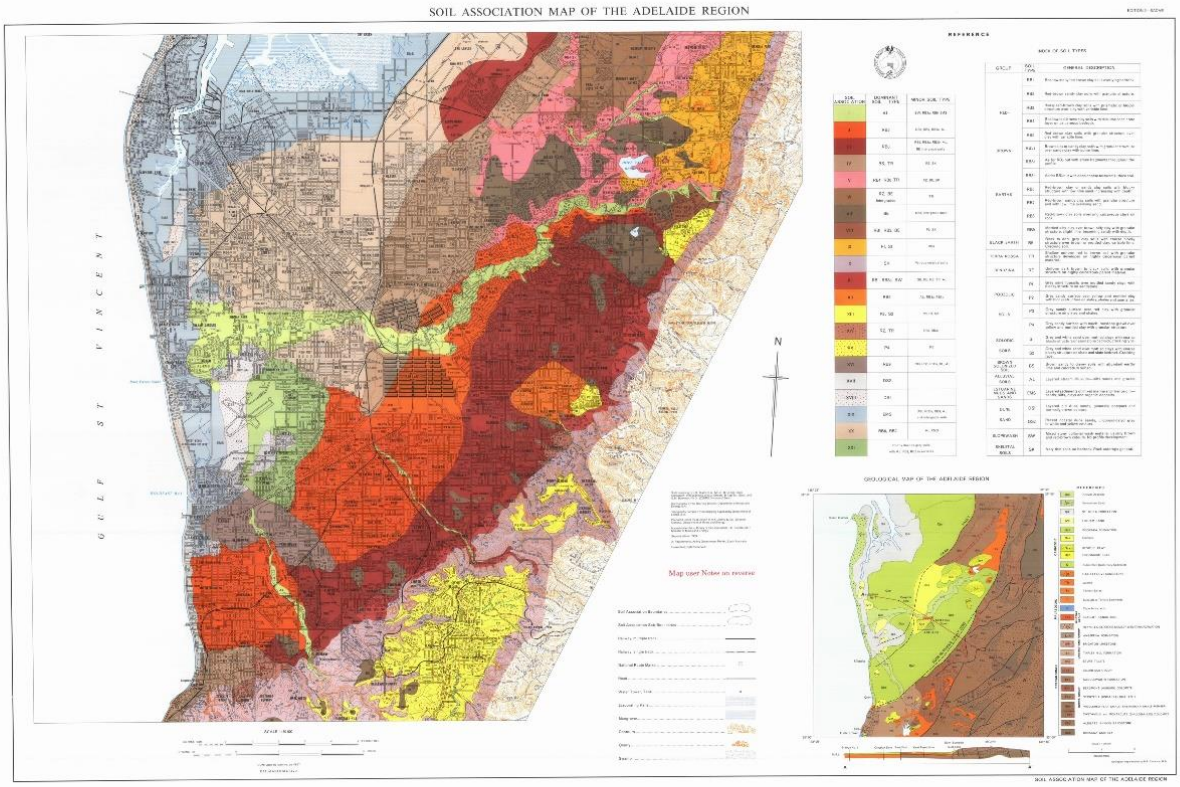


Figure 4.2 Soil association map of the Adelaide Region

4.3.2 Soil moisture storage capacity and field capacity values – default (no local data available)

For urban developments with an impervious fraction of ≥30% on clay soils or where soils data are unavailable, it is recommended the 2014 eWater soil parameter values for Adelaide be adopted as shown in Table 4.6. These set the most important soil parameters after impervious fraction. These parameters may be considered generally suitable for heavier soils such as clays. These were adopted on the basis that the only two calibrated data sets identified for South Australia had relatively comparable soil parameters (Myers, et. al., n.d.). Any variation from these should be described in the report provided with the model along with supporting evidence.

Table 4.6 eWater soil parameters for Adelaide

Parameter	Recommendation	Source of guidance
Soil moisture storage capacity bypass	40 mm	Default
Field capacity	30 mm	Default
All other soil parameters	Variable	Default

It is recommended that greater attention to soil parameters is given for catchments where pervious area runoff is likely to be significant, e.g. where the catchment has an impervious fraction of less than 30% (Dotto, Deletic, Fletcher & McCarthy, 2009) or where significantly different soils such as sandy soils are expected. In these areas, reference may be made to the parameters proposed by Macleod (2008) with the interpretation provided by Sydney Catchment Authority (2012) for an assumed 0.5 m effective root depth being a useful and reasonable reference. The user should establish parameters based on soil type as described in Table 4.7 and Table 4.8.

It is noted that the outcomes produced by these parameters have not been tested or calibrated to flow data and they should be used with caution. However, they do provide a rational basis for representing a range of soil types and this information is the best available providing an indication of the likely variations in likely behaviour with changes in soil type.

4.3.3 Soil moisture store capacity and field capacity values - local data available

Where it is possible to calibrate soil parameters using local data (flow, catchment area, impervious fraction, etc.), the result of a calibration would usually be preferred over the default eWater or general soil parameters and may be adopted subject to agreement by the relevant authority.

Note: It is not recommended that soil parameters be varied by land use within a given catchment or area since this bears no relation to the underlying soils or geology.

Table 4.7 Soil moisture store capacity and field capacity values.
(Sydney Catchment Authority, 2012, adapted from Macleod, 2008)

	Root zone soil depth (0.5 m)	
Parameter	Soil moisture store capacity (mm)	Field capacity (mm)
Sand	175	74
Loamy sand	139	69
Clayey sand	107	75
Sandy loam	98	70
Loam	97	79
Silty loam	100	87
Sandy clay loam	108	73
Clay loam	119	99
Clay loam, sandy	133	89
Silty clay loam	88	70
Sandy clay	142	94
Silty clay	54	51
Light clay	98	73

Parameter	Root zone soil depth (0.5 m)	
	Soil moisture store capacity (mm)	Field capacity (mm)
Light–medium clay	90	67
Medium clay	94	70
Medium–heavy clay	94	70
Heavy clay	90	58

Table 4.8 Other soil parameters
(Sydney Catchment Authority, 2012, adapted from Macleod, 2008)

Dominant soil description	Soil rainfall runoff parameters[B]				
	Infiltration capacity coefficient – a (mm/d)	Infiltration capacity exponent – b	Daily recharge rate (%)	Daily baseflow rate (%)	Daily seepage rate (%)
Sand, loamy sand	360	0.5	100	50	0
Clayey sand, sandy loam, loam, silty loam, sandy clay loam	250	1.3	60	45	0
Clay loam, sandy clay loam, silty clay loam, sandy clay, silty clay	180	3.0	25	25	0
Light clay, light medium clay, medium clay, medium heavy clay, heavy clay	135	4.0	10	10	0

4.4 Pollutant concentrations

The pollution concentrations in Table 4.9 shall be used unless written permission is provided by the relevant authority to use other values.

Stormwater pollutant concentrations have been estimated for use in MUSIC based on a study of worldwide data (Duncan, 1999) and its update (Fletcher, Duncan, Poelsma & Lloyd, 2005; Fletcher, 2007), and these provide the basis for the default parameters provided in the model. There are some data available for Adelaide, however, as this is limited it is currently recommended to rely on the global data.

It is recommended that either:

- **Option 1 The split surface types approach** (preferred – best practice) – is used with the concentrations as set out in Table 4.9. These values should be adopted unless written permission to use other parameters is provided by the relevant authority.

[B] These parameter estimates are based on soil properties only. There is no allowance for rainfall losses associated with depression storage, mulch, vegetation interception and other non-soil sources of water storage in a catchment.

- **Option 2 Lumped land use parameters** (user discretion, e.g. large catchment-based schemes):
    - The default parameters are used for the Urban (Mixed surface type/land use), Agricultural and Forest node pollutant concentrations
    - The lumped land use parameters set out in Table 4.10 are used

unless written permission to use other parameters is provided by the relevant authority.

Option 1 – The split surface types approach (preferred – best practice)

Where split surface types are adopted, these should be consistently used to represent all urban catchment areas and not mixed in the same model with nodes using the Urban (Mixed surface type/land use) node pollutant concentrations.

Table 4.9 Pollutant concentration data for source nodes where surface types are split (Fletcher, 2007)

Landuse	Flow type	Total suspended solids (TSS)		Total phosphorus (TP)		Total nitrogen (TN)	
		Mean (log mg/L)	SD (log mg/L)	Mean (log mg/L)	SD (log mg/L)	Mean (log mg/L)	SD (log mg/L)
Road	Baseflow	0.96	0.401	-0.731	0.36	0.346	0.309
	Stormflow	2.431	0.333	-0.301	0.242	0.342	0.205
Roof	Baseflow	n/a*	n/a	n/a	n/a	n/a	n/a
	Stormflow	1.301	0.333	-0.886	0.242	0.301	0.205
All other urban	Baseflow	0.96	0.401	-0.731	0.36	0.346	0.309
	Stormflow	1.882	0.333	-0.68	0.242	0.224	0.205

** n/a as base flow does not occur from roof surfaces (Impervious fraction must be set to 100%)*

Note: *Concentrations that are less than 1 have a negative value in the log domain, e.g. 0.13 mg/L translates to -0.886 in log domain*

Option 2 Lumped land use parameters (user discretion)

Alternate stormwater pollutant concentration parameters may be accepted if there is suitable published data to support this, subject to prior written agreement by the relevant authority.

Table 4.10 Pollutant concentration data for lumped catchments by land use (Fletcher, 2007)

Pollutant	Land use	Total suspended solids (TSS)		Total phosphorus (TP)		Total nitrogen (TN)	
		Mean (log mg/L)	SD (log mg/L)	Mean (log mg/L)	SD (log mg/L)	Mean (log mg/L)	SD (log mg/L)
Urban residential	Baseflow	1	0.34	-0.97	0.31	0.2	0.2
	Stormflow	2.18	0.39	-0.47	0.32	0.26	0.23
Commercial	Baseflow	0.78	0.39	-0.6	0.5	0.32	0.3
	Stormflow	2.16	0.38	-0.39	0.34	0.37	0.34
Industrial	Baseflow	0.78	0.45	-1.11	0.48	0.14	0.2
	Stormflow	1.92	0.44	-0.59	0.36	0.25	0.32
Rural residential	Baseflow	0.53	0.24	-1.54	0.38	-0.52	0.39
	Stormflow	2.26	0.51	-0.56	0.28	0.32	0.3
Agriculture	Baseflow	1	0.13	-1.155	0.13	-0.155	0.13
	Stormflow	2.477	0.31	-0.495	0.3	0.29	0.26
Forest	Baseflow	0.51	0.28	-1.79	0.28	-0.59	0.22
	Stormflow	1.9	0.2	-1.1	0.22	-0.075	0.24

The serial correlation (R squared) shall be set to
= 0 (default) for TSS, TP and TN, for analysis of stormwater quality

1. Serial correlation

The serial correlation relates the stormwater pollutant concentration at a given timestep with the preceding timestep. A serial correlation value close to 1 produces more realistic muted variability of concentrations within a storm. However, it also means that all concentrations within a single event are related. This can have the effect of reducing independence of loads and variability within a model and lead to wider fluctuations in the predicted stormwater concentrations and resulting pollutant load reductions. Usually this is not significant for 10 years of 6-minute data, however it can cause large fluctuations for models with shorter run periods, larger timesteps or few effective storm events (such as largely pervious catchments).

The serial correlation shall be set to zero. An exception to this may be made subject to:

- Satisfactory justification and reasoning for the need to use serial correlation
- Agreement in writing by the relevant authority
- Calculation of pollutant load reductions using an average of not less than 5 x 10-year model runs.

4.4.2 Stochastic and mean concentrations

MUSIC allows stormwater pollutant concentrations to be predicted using mean values or stochastic generation. Mean pollutant concentrations use a single mean concentration. Stochastic pollutant generation predicts a new pollutant concentration for each timestep using a mean and standard deviation to produce a distribution of concentrations that is consistent with the input parameters of the model, which are in turn based on monitored data.

It is well recognised that stormwater pollutant concentrations vary widely within and between storm events due to a range of climate, catchment and hydraulic factors. The variability makes treatment more challenging. It is important this is represented so treatment assets are designed to cope with the expected range and variability of stormwater concentrations that will occur.

Stochastically generated pollutant concentrations shall be used

The use of mean concentrations may be accepted for specific purposes. These may include:

- Calibration or examining behaviour for a particular storm event or set of operating conditions (but not general stormwater treatment design).
- Representing an inflow source such as groundwater or wastewater with a known mean concentration.

5 Stormwater treatment assets – general guidance

This section provides general guidance on modelling stormwater treatment assets applicable across some or different treatment assets.

5.1 Treatment trains

Treatment nodes within a MUSIC model must be linked in an appropriate order, with primary treatment devices first and tertiary treatment devices last (if present). Table 5.1 below shows the appropriate stages of a treatment train; which pollutants are targeted at each stage of the treatment train, and typical applications for primary, secondary and tertiary treatments.

Figure 5.1 shows a simple treatment train as modelled in MUSIC.

Table 5.1 Target pollutants through the treatment train (Melbourne Water)

Treatment	Processes	Pollutants	Typical application
Primary treatment	Physical screening Rapid sedimentation	Gross pollutants Coarse sediment	Litter traps Sediment ponds Swales Gross pollutant traps
Secondary treatment	Fine particle sedimentation Filtration	Fine sediment Attached pollutants	Swales Infiltration trenches Porous paving Bioretention
Tertiary treatment	Enhanced sedimentation and filtration Biological uptake Adsorption into sediments	Nutrients Dissolved heavy metals	Wetlands Bioretention Proprietary filters

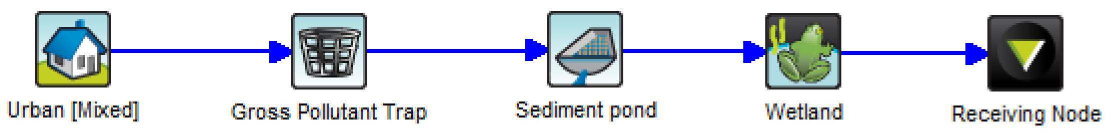


Figure 5.1 Example MUSIC model treatment train

5.2 Exfiltration (infiltration to surrounding soils)

In MUSIC treatment nodes, the “Exfiltration rate (mm/hr)” refers to the saturated hydraulic conductivity of the soil surrounding and underlying a treatment system. It is used to represent losses from a treatment system into the surrounding soils. The “Saturated hydraulic conductivity (mm/hour)" parameter is used to define the saturated hydraulic conductivity of the filter media within the treatment itself.

For all nodes, adoption of an exfiltration rate greater than 0 mm/hr must be supported by appropriate geotechnical information and may be subject to agreement by the relevant authority as follows:

- Where infiltration may be significant or where required by the relevant authority, parameters used for modelling must be supported by geotechnical testing.
- Where infiltration is expected to be minor such as where it will be < 5% of inflows and < 500 kL/year for assets such as passively irrigated streetscape tree pits and individual

allotment scale raingardens, a desktop or general conservative estimate of infiltration rates based on soil type may be accepted at the discretion of the relevant authority.

Exfiltration is encouraged where practical, especially in cases where replenishment of groundwater and baseflow is important and/or stormwater volume reduction targets are in place. In these cases, exfiltration losses can be counted in the water balance.

Groundwater is a receiving water and the quality of groundwater resources must be protected to the same extent as that of visible surface receiving waters. As a general principle, groundwater should always be treated as a receiving water for assessment of stormwater quality.

Any runoff entering groundwater aquifers must be treated to meet the stormwater quality improvement targets (outlined in Section 2.1), before infiltration to surrounding soils. In MUSIC version 6, secondary drainage links (see Section 7.2) may be used to convey infiltrated flows downstream within models such that they (and their associated pollution) are accounted for in load reduction targets. Alternately, pollutant loads discharged to groundwater may be added back to the output loads for the purposes of calculating stormwater pollutant load reductions. The volume of groundwater recharge may be reported as an additional item of interest as increased groundwater recharge (within the bounds of what may occur naturally) is usually desirable within urban areas.

Exfiltration rates should:

- be set conservatively based on the soil type making allowance for potential clogging and
- only be used for water that has passed through the full treatment zone of a vegetated asset (e.g. through the base of a bioretention asset or at the end of a wetland) or equivalent tertiary treatment.

5.3 Modelling high flow bypass

It is good practice and a requirement of design guidelines to design treatment assets with overflow and bypass arrangements for flows above a threshold design flow. This means that the main treatment element, which may be a vegetated area or a filter bed, is only exposed to flow rates up to this design flow. The value of the high flow by-pass needs to be based on the physical treatment flow rate of the device – whether it be for a proprietary device of designed vegetated blue-green system.

Design flows for treatment assets are usually calculated using one of the following methods:

- Rational Method calculation of $Q_{3\text{-month}}$ (4EY) – using ARR 2019 data and IFD parameters for frequent flows events such as the 4EY. This may be an appropriate method if no retarding basins or detention are proposed upstream of the treatment asset and the catchment is less than 100 ha.
- Hydrologic model (e.g. DRAINS, XP-RAFTS, RORB)
    - Recommended for catchments greater than 100 ha or containing a retarding basin or detention upstream of the treatment asset.
- Partial series analysis.

The user is referred to the Australian Rainfall and Runoff (ARR) Guidelines 2019 and, until such time as a comparable guideline for South Australia is available, to Part D of the Constructed Wetlands Design Manual (Melbourne Water, 2016, https://www.melbournewater.com.au/media/533/download) for calculation approaches including guidance on the use of hydrologic models for calculating flows.

For catchments less than 100 ha, the relevant authority may accept the use of the Rational Method for designing assets. However, project specific written consent must be obtained to confirm this approach is acceptable. In all other situations hydrologic/hydraulic models must be prepared.

Intensity frequency duration (IFD) data for the rational method can be obtained from the Bureau of Meteorology as follows:

- Go to http://www.bom.gov.au/water/designRainfalls/revised-ifd/
- Input Latitude and Longitude or select from map and press submit
- Under "Design Rainfalls" on the left tab, click "Very Frequent" and "Update"
- Determine rainfall intensity by changing the "units" dropdown menu to mm/hr and read from the displayed table where Duration = time of concentration (Tc) and $Q_{3\text{-month}}$ = 4EY

5.4 k and C*

Treatment performance is modelled using a first-order decay equation for most treatment types in MUSIC. The equation is parameterised using:

k – decay parameter (m/year); and

C* – The background pollutant concentration or asymptote that pollutant concentrations will approach (mg/L)

The development of these parameters and calibration process for various treatment types is described in the MUSIC Manual, Appendix G and this may be used as a basis where future calibration/validation is needed.

It is noted that the k and C* parameters make inherent assumptions about the position of treatments within the treatment train. For example, sediment basins and swales are primary treatments expected to receive untreated stormwater. Wetlands are anticipated to have either an inlet pond or upstream sediment basin and provide secondary/tertiary treatment (hence have a lower k and lower C* value). Ponds are assumed to usually receive treated water since it is good practice to ensure such open water bodies are protected from untreated stormwater to avoid algal problems but provide less effective sediment removal than wetlands due to the lack of vegetation.

Recommendations for k and C* are shown in Table 5.2.

Table 5.2 k and C – typical parameters*

Parameter	Recommendation	Source of guidance
k	Default (refer to eWater MUSIC Manual, Appendix G)	Default Recommended
C*	Default (refer to eWater MUSIC Manual, Appendix G)	Default Recommended

Where changes to these parameters are proposed, they should have a clear rational basis or be supported by appropriate calibration and validation data.

5.5 CSTRs – hydrologic routing through treatment systems

The efficiency with which water moves within a treatment system is a function of the system's shape. Systems with low length–width ratios (e.g. ponds) have high potential for turbulence and short-circuiting; systems with high length–width ratios (e.g. swales) approximate plug flow. This is simulated in MUSIC by the number of "continuously stirred tank reactors" (CSTRs). The CSTR input parameter in MUSIC represents the mixing behaviour of treatment nodes. The number of CSTRs is a calibration parameter in MUSIC used in all treatment systems.

The default number of CSTR cells for a treatment node can be changed through the “More” button. The number of CSTR cells for sedimentation basins can also be changed through the “Estimate Parameters” button. The length to width ratios for the shapes used to estimate the number of CSTR cells is listed in Figure 5.2 below. **Users are encouraged to keep default parameters for most applications** and seek to achieve designs that will deliver at least this level of hydraulic efficiency.

> Users are encouraged to keep default parameters for CSTR for most applications

Changes to the number of CSTRs may be made at the request of either the user (subject to agreement by the relevant authority) or by the relevant authority to most closely match the proposed shape and anticipated hydraulic efficiency of the proposed design where this deviates significantly from the default values.

Options available to vary the number of CSTRs

Option 1. Selection of number of CSTRs based on guidance provided in MUSIC based on shape of treatment (click on the picture matching the shape). The designer would generally only use this to decrease CSTRs to represent an existing system and not increase it to represent better treatment (the defaults in MUSIC are already reasonably generous). The parameter has limited effect on the model performance.

Option 2. Calibration of a treatment system through application of the approaches described in eWater MUSIC Manual.

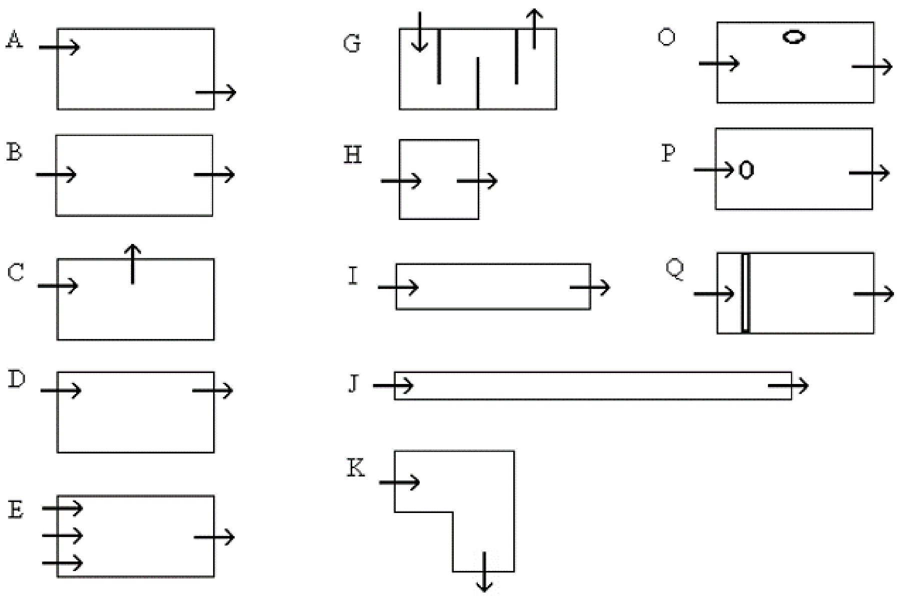


Figure 5.2 Treatment node shape to determine the number of STR cells (Persson, 2000). Length to width ratio: A, B, C, D, E, G, O, P, Q – 2:1; H – 1:1; I – 4:1; J

5.6 Plant survival

MUSIC does not model plant survival or the effects of long dry periods or excessive water depths on plant health and survival. Further analyses and input from competent ecologists are needed to ensure the plants selected will contribute to pollutant removal over the life of a treatment asset, particularly if non-standard designs are used. The wetland analysis tool on the MUSIC Auditor website (http://musicauditor.com.au/) can help provide preliminary evidence that the plants are likely to be able to cope with the expected inundation patterns experienced within a wetland.

5.7 Proprietary and custom products

The selection of a proprietary device or system should be supported at a minimum by a Stormwater Quality Improvement Device Evaluation Process (SQIDEP) evaluation (https://stormwater.asn.au/sqidep/about-sqidep). However other factors may form part of a decision to approve a device by the relevant authority. This may include, but may not be limited to, the ability of the relevant authority to maintain the device in question.

Any proposed proprietary device or system shall have the capacity to remove target pollutants demonstrated through verified testing. Technical specifications and modelling parameters for any device or system shall be reviewed and accepted by the relevant authority.

Regardless, the end asset owner (typically a local government) retains final discretion about what devices, systems or other WSUD assets it is willing to accept within the bounds of such approval.

5.8 External catchments

Relevant authorities may have different approaches to managing external catchments draining to a site and consultation should occur to understand these where upstream external catchments are identified.

Consideration should be given to whether these catchments are likely to be developed, would be required to be treated to best practice and will impact on stormwater management assets proposed for the site. Where these areas are likely to be treated, this should be taken into account within the model with the corresponding treatment represented.

Where external catchments are included, only the pollutant loads generated from the site itself should be accounted for in determining the pollutant load reduction requirement. These should be compared with the sum of pollutant load reductions achieved by the proposed stormwater treatment assets for the site.

Particular care should be given to ensuring assets treating upstream external catchments are designed to cope with the expected hydraulic loading to mitigate against extended periods of inundation and wetting as well as erosion risk.

Upstream treatments may dilute pollutant concentrations and affect treatment performance, therefore these shall be included even if future upstream development and treatment has to be estimated.

6 Stormwater treatment assets – specific guidance

Specific guidance is provided for a range of stormwater treatment assets. The user is also referred to the MUSIC User Manual (eWater, 2019) at https://ewater.org.au for further guidance on model parameters and configuration of treatment nodes.

A series of tables are provided for each stormwater asset type, indicating the recommended values for key MUSIC input parameters and the source of that guidance, as follows:

Table 6.1 Different sources of guidance provided on model parameters

Source of guidance	Description
Default	Parameter should be set to the default value in MUSIC
Guideline requirement	Parameter value or range has been sourced from a third-party guideline document
Internal guideline requirement	Parameter value or range required in this guideline (modelling requirement or design requirement in absence of available external design guidance for essential considerations)
Recommendation	Parameter is based upon the experience of the authors and the best available data at the time of publishing
N/A	Parameter is user defined based upon specific site, catchment or proprietary product characteristics

6.1 Rainwater tanks

Rainwater tanks are a useful way of managing stormwater offering multiple benefits including alternative water supply, reduction of stormwater volumes and potentially detention of storm peaks if designed accordingly. Each local government may have its own requirements for the specification of rainwater tanks. Where tanks are included in the development design and associated MUSIC model to achieve stormwater quality improvement targets, the development application shall demonstrate how the tanks will be installed and maintained appropriately by each new homeowner. It should also be demonstrated that the tanks can realistically be connected to proposed demands and the relevant authority may request evidence of connections following construction.

The rainwater tank node can be used for simulating water balance within tanks and estimating pollution reduction through sedimentation and reuse. Rainwater tank typical parameters are illustrated in Figure 6.1 and summarised in Table 6.2.

Where rainwater tanks are a significant portion of the treatment train, it is preferable to adopt the "split surface types" approach for representing the catchment with "roof" areas directed to rainwater tanks.

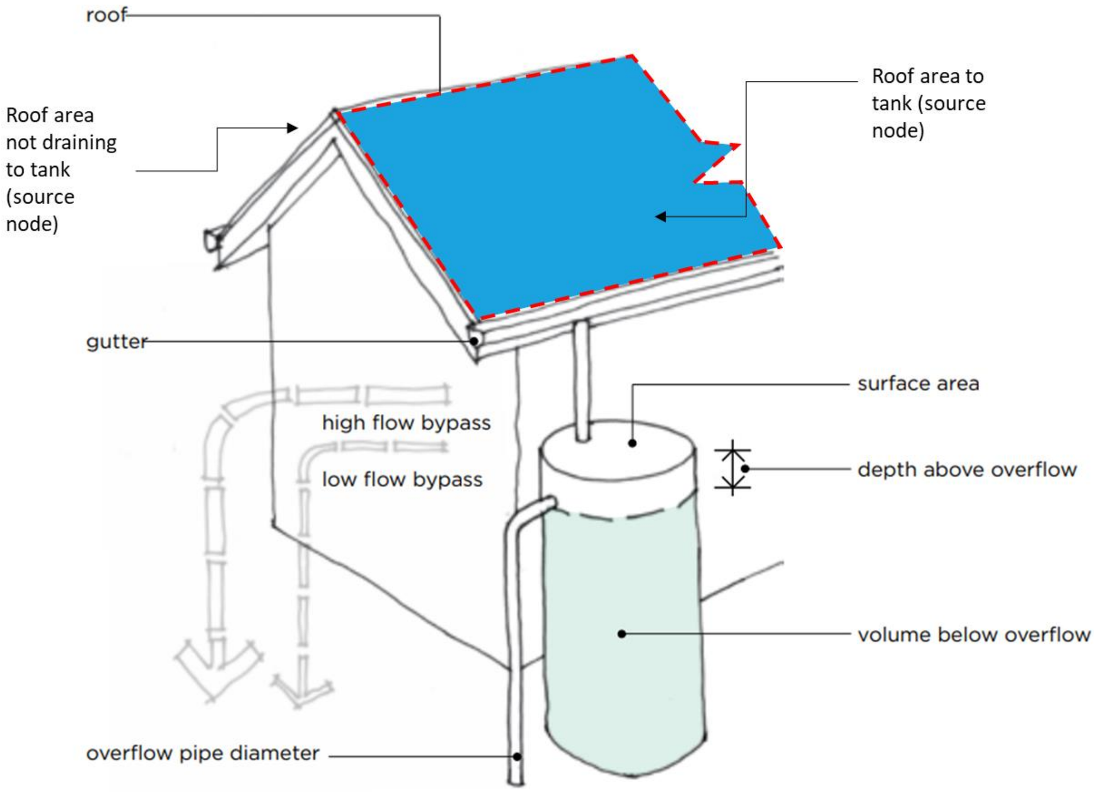


Figure 6.1 Tank schematic
(Adapted from Healthy Land and Water, 2018)

Lumped versus individual tanks

When modelling a catchment with more than one tank, and the ratio of roof area to tank volume and reuse demand is relatively constant, the roof areas and rainwater tanks within a catchment can be lumped together.

Specify the number of tanks and dimensions of an individual tank, MUSIC will then calculate the total parameters for all of the tanks combined.

When lumping rainwater tanks in this way, the tank node size is scaled up to reflect the combined volumes of the individual tanks. When scaling up the dimensions of the tank, the depth in the tank will remain constant (i.e. depth of one tank is used in the lumped tank), with the surface area increased to make up the required volume. The diameter of the overflow pipe from the tank is equivalent to the diameter of the overflow pipe of a single tank multiplied by the square root of the number of tanks to calculate the combined capacity of the individual overflow pipes.

Reuse demands entered are the **total for all tanks** where the number of tanks is greater than 1. Also, the reuse demands (annual, daily and monthly) are summed so each reuse demand being supplied should only be included within one of these categories.

Table 6.2 Rainwater tank – typical parameters

Parameter	Recommendation	Source of guidance
Low flow bypass	0 m^3/s unless design specifies otherwise	Default Recommended
High flow bypass	Calculated as the capacity of the inlet to the tank. This should usually be set to the 5% Annual Exceedance Probability (AEP) flow as per AS3500.3. May be set to default of 100 m^3/s if an upstream node regulates flow into tank.	Guideline requirement
Individual tank properties		
Number of tanks	Allows user to enter following properties for one tank and indicate number of similar tanks. Default = 1 (further discussion below)	N/A
Storage properties		
Volume below overflow pipe (kL)	User defined (should be greater than, or equal to five times the maximum daily demand)	Recommendation
Depth above overflow (m)	User defined (0.1 m minimum – it is recommended some EDD is allowed for air gap above invert of overflow pipe and to support MUSIC's calculations).	Recommendation
Surface area (m^2)	User defined – Should be consistent with proposed volume and a sensible tank height (e.g. 1–2 m for residential, 1–4 m for stormwater harvesting)	N/A
Outlet properties		
Overflow pipe diameter (mm)	User defined (typically 90 mm for residential)	Recommendation
Use custom outflow and storage relationship	At user discretion	N/A
Reuse parameters		
Annual demand (kL/year)	User defined *seasonal* demands (including irrigation, see Section 8, Outdoor demands).	Recommendation
Distribution of annual demand	PET – rain. This option provides a more realistic representation of irrigation varied accounting for PET and rainfall as an automated irrigation system would do. A monthly pattern may be used where preferred.	Recommendation
Daily demand (kL/day)	User defined *constant* demands (including toilet, laundry etc), see Section 8.	Recommendation
Monthly distribution of annual demand (kL/yr)	User defined *seasonal* demands (including irrigation) May be adopted as alternative to annual demand. Monthly distributions are useful for atypical seasonal demands (e.g. variations due to tourism)	Default
User-defined time series	At user discretion	N/A

6.2 Sediment ponds

Sediment basins or ponds can be represented in MUSIC. However, the required size of the basin typically needs to be calculated first by the user. Sediment ponds are frequently used for pre-treatment upstream of other treatment measures such as wetlands. The MUSIC model parameters for this node are tabulated in Table 6.3.

This section does not cover construction phase sediment basins, as MUSIC is generally not suitable for modelling the pollutant removal capacity of this type of basin. Refer to guidelines such as the Best Practice Erosion and Sediment Control Guidelines (IECA, 2008) for guidance.

Figure 6.2 Sediment pond at Case Fields (E2Designlab, 2015)

Table 6.3 Parameters for MUSIC sedimentation node

Parameter	Recommendation	Source of guidance
Low flow bypass	0 m^3/s unless design specifies otherwise	Recommendation
High flow bypass	Calculated as the capacity of the inlet to the sediment pond. This should be based on the design flows for the sediment pond, generally the 20% AEP flow.	Guideline requirement
Storage properties		
Surface area	The surface area of the sediment pond. This should include the sum of the coarse sediment compartment, calculated using Fair & Geyer equation, and the fine compartment, if required. The surface area should match the dimensions shown on the functional design plans.	N/A
Extended detention depth	≤ 0.35 m The extended detention depth should match that shown on the functional design plans.	Recommendation User defined
Permanent pool volume	Represents the volume of the sediment pond extending from halfway up the sediment accumulation zone to Normal Water Level. Refer to Figure 6.3	N/A
Initial volume	Set equal to Permanent Pool Volume	Recommendation
Exfiltration	0 mm/hr	Recommendation
Evaporative loss	75% of PET	Default

Parameter	Recommendation	Source of guidance
Equivalent pipe diameter	Sized to achieve approx. 12 hours notional detention time (concept)	Recommendation
Notional detention time	It is recommended that the time should at least be greater than the particle settling time and the use of very short and unrealistic times avoided. The storage volume should preferably be ~5–10 times greater than the potential flux in a timestep to avoid potential model errors or unrealistic behaviour due to numerical instability.	Recommendation
Overflow weir width	Sized using appropriate weir equation for outlet pit or overflow weir.	N/A
Advanced properties – more	Default	Default
Number of CSTR cells	1	Default

Calculate the modelled sediment pond volume from halfway up the sediment accumulation zone to the normal water level, as illustrated in Figure 6.3 below.

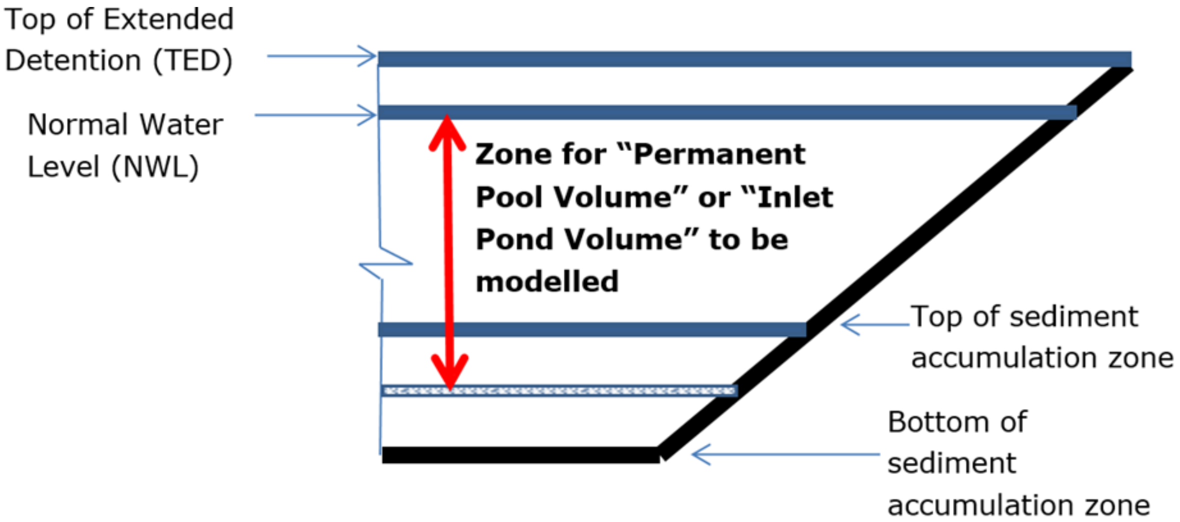


Figure 6.3 Method to parameterise sedimentation basin volume in MUSIC

6.3 Wetlands

Wetlands are densely vegetated shallow water-bodies. They provide effective secondary treatment of stormwater through sedimentation of fine particles and filtration and uptake of pollutants including nutrients through the wetland plants. To qualify as a wetland, the asset should have an area which consists of 80% shallow and deep marsh (40% of each) that is densely vegetated while the remaining 20% of the area may be submerged marsh and open water. It is essential that water depths and inundation patterns are designed and managed so they are not excessive and can support healthy plant growth. Wetlands will usually have a sediment pond upstream, referred to as an inlet pond where it is integrated at the same level as the wetland.

An illustration of a wetland and relevant parameters is shown in Figure 6.3 and a summary of appropriate parameters presented in

Table 6.4.

For more information on modelling and designing wetlands, refer to:

- The MUSIC User Manual (eWater, 2019)
- Australian Runoff Quality (Engineers Australia, 2007)
- Melbourne Water Constructed Wetlands Design Manual (Melbourne Water, 2017)
- Wetland Technical Design Guidelines (Healthy Land and Water, 2017)

Figure 6.4 First Creek Wetland at Adelaide Botanic Garden (E2Designlab, 2016)

Table 6.4 Wetland modelling parameters

Parameter	Recommendation	Source of guidance
Inlet properties		
Low flow bypass	0 m^3/s unless design specifies otherwise	Recommendation
High flow bypass	Calculated as the capacity of the balance pipe or diversion weir from the sediment pond. This should be based on the design flow for the wetland, generally the 4EY flow Set to 100 m^3/s if wetland has perched (separate upstream) sediment basin/s or bypass is achieved using an overflow weir [Note 1]	Guideline requirement
Inlet pond volume	Volume of inlet pond, usually sized to remove 95% coarse sediment (>125 μm) for 4 EY event. Set to 0 if wetland has separate upstream sediment pond	Guideline requirement
Storage properties		
Surface area	User defined macrophyte zone area at NWL. Iteratively sized in MUSIC to meet performance objectives.	N/A
Extended detention	0.2–0.35 m Note: The default value for the extended detention depth of 1.0 m is not acceptable.	Internal guideline requirement (<0.35 m)
Permanent pool volume	Generally, 0.35 to 0.4 m × Surface Area, that is the average depth in the macrophyte zone should be 0.35–0.4 m.	Internal guideline requirement (<0.4 m)
Initial volume	Set equal to Permanent Pool Volume (assumed full)	Recommendation
Exfiltration	0 mm/hr. Exceptions only for specifically designed ephemeral wetlands. This shall be supported by geotechnical information on exfiltration rates for wetland subsoils and a wetland inundation frequency analysis demonstrating plants will not dry out excessively and is subject to approval by the relevant authority. Exfiltrated water shall be directed to outlet for calculation of pollutant loads.	Guideline requirement
Evaporative loss	125% of PET (default)	Default
Outlet properties		
Equivalent pipe diameter	For planning and concept design of wetlands, set the equivalent pipe diameter so that notional detention time is as close to 72 hours as possible for all new development and not less than 48 hours (retrofit assets only)	Recommendation
Notional detention time	Between 48 and 72 hours Note: As close to 72 hours as practical is acceptable for all new development. Values at low end of range require justification for situations where a higher notional detention time is not practical, e.g. retrofit assets.	Guideline requirement
Overflow weir width	User defined Note: An undersized overflow weir results in water backing up, effectively adding extended detention depth in the model so it is better for this parameter to be over-estimated than under-estimated.	Recommendation

Parameter	Recommendation	Source of guidance
Custom outflow and storage relationships	User defined. These may be used optionally by the user to more realistically represent the stage–storage–discharge relationship of the wetland. This is useful for assessing wetland inundation patterns and corresponding plant health and survival. It is recommended the reviewer check that the hydraulic calculations (which shall be provided separately) are suitable for the proposed outlet structures with reference to a hydraulic engineering textbook and are correct. If used, the orifice and weir dimensions and coefficients become redundant.	Recommendation
Advanced properties		
Orifice discharge coefficient	Default required unless justification for changing. The default is suitable for a circular outlet orifice and most models. Where a different shaped outlet is used a modified coefficient matching the proposed shape may be adopted based on suitable hydraulic textbook reference – or replace with a custom outflow relationship.	Default Guideline requirement
Weir coefficient	Default required unless justification for changing. The default is suitable for a sharp crested weir and most models. May be modified for different overflow weir types – or replace with a custom outflow relationship.	Default Guideline requirement
Number of CSTR cells	4	Default Guideline requirement
Total suspended solids	k (m/year) = default, C* (mg/L) = default	Default Guideline requirement
Total phosphorous	k (m/year) = default, C* (mg/L) = default	Default Guideline requirement
Total nitrogen	k (m/year) = default, C* (mg/L) = default	Default Guideline requirement

Note 1: Velocity requirements for sediment basin – sediment re-entrainment shall be met

Use of separate sedimentation pond and wetland node

In most cases, a wetland should be modelled with an integrated sediment pond (an inlet pond). In certain cases, it may be appropriate to represent the sediment pond as a separate upstream node.

A single wetland node should be used where the sediment pond outflow will be dependent upon or significantly influenced by the water level in the wetland or wetland outlet flows.

Examples of when a separate sediment pond may be considered to be independent and modelled as a separate upstream node include:

- When the level in the sediment pond basin is not connected or significantly influenced by water levels in the wetland macrophyte zone
- When information about sediment basin outflows needs to be obtained independently from macrophyte zone outflows; and
- When splitting sediment basin outflows between different downstream nodes.

To determine whether the wetland is likely to significantly influence the sediment pond, determine whether the difference between the sediment basin and wetland macrophyte zone extended detention levels (X) is less than or greater than half of the extended detention depth of the macrophyte zone (Y). Refer to Figure 6.5 for illustration.

- If X ≤ ½ Y, a single “wetland” node with an integrated inlet pond to represent the sediment pond shall be used.
- If X > ½ Y, a separate upstream sediment basin treatment node may be used to represent the sediment pond.

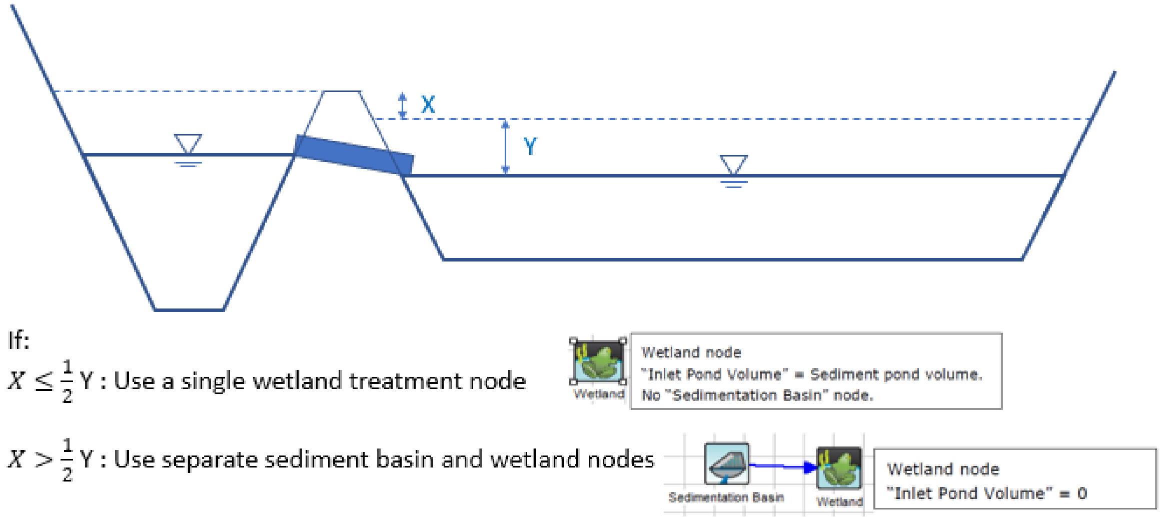


Figure 6.5 Sediment pond and wetland extended detention levels

Where a sediment pond and wetland are used in series, they should generally be modelled as a single wetland node with an integrated sediment pond (i.e. inlet pond) unless it is clear (taking into consideration the criteria in this section) that the sediment pond will mostly function independently of the wetland.

Where doubt exists about whether a sediment pond is independent or influenced by the wetland it shall be modelled using a single wetland node unless agreed in writing by the relevant authority.

6.4 Swales

A summary of appropriate swale parameters is presented in Table 6.5 with further details outlined below. For more details on modelling swales in MUSIC, refer to the MUSIC manual.

Figure 6.6 Swale in Park 25 in the Western Parklands. Adelaide City Council, 2020

Table 6.5 Swale parameters

Parameter	Recommendation	Source of guidance
Low flow bypass	0 m^3/s unless design requires otherwise	Recommendation
Storage properties		
Length (m)	User defined The total length of swale should account for conveyance capacity and safety limitations. Users shall ensure that the system being modelled can actually be constructed. See notes below on lengths for different configurations.	N/A
Bed slope (%)	A range of 1–4% for longitudinal grade. If grade is 5% or greater, the system will primarily act as a conveyance and not provide suitable treatment of stormwater. These swales should not be included in the MUSIC model as treatment nodes. If grade is <1%, consideration should be given to managing the risk of standing and stagnant water in minor depressions or behind local sediment build-ups.	Recommendation (HLW)
Base width (m)	User defined	N/A
Top width (m)	User defined	N/A
Depth (m)	User defined	N/A
Vegetation height (m)	User defined The height of vegetation in the model should reflect vegetation species being used- depending on the landscape treatment: Mown grass swales: 50 mm (10–100 mm) Native grasses and sedges (not mown): 300 mm (100–400 mm) Advice from a landscape architect or ecologist should be sought in selecting appropriate grass and sedge species.	Recommendation
Exfiltration rate (mm/hour)	0 OR A non-zero rate may be adopted if justified through in-situ soil testing.	Default

Swale length

The swale length should consider the inflow and outflow conditions. Potential conditions are described below and illustrated in Figure 6.7.

- **Option A**: If flows enter at the upstream end of a swale and flow through its entire length, they will receive a certain level of treatment. This is what is assumed by the swale node in MUSIC.
- **Option B**: If flows enter laterally along the length of a swale, flows at the upstream end will receive more treatment and those at the downstream end receive less. It is considered reasonable to model this using a single catchment source node and 50% of the length of the swale in a single swale node.
- **Option C**: If flows enter a series of swale segments that drain to underdrainage at intervals, the segments are operating in parallel. The lengths of the segments (not the full length of the swale) shall be used. These should be modelled separately in parallel if the catchments or segments vary in size. If the catchments and segments are the same size, the catchment and

swale may be lumped to provide a reasonable approximation. This shall be done by increasing the *width* and not the *length* of the swale.

- **Option D**: If flows enter a swale at point locations with each segment flowing into the next segment, flows into the upstream end will receive more treatment and flows into the downstream end receive less. The swale should be modelled as a series of swale nodes with one for each segment. Each swale segment will receive inflows from the upstream segment and local catchment.

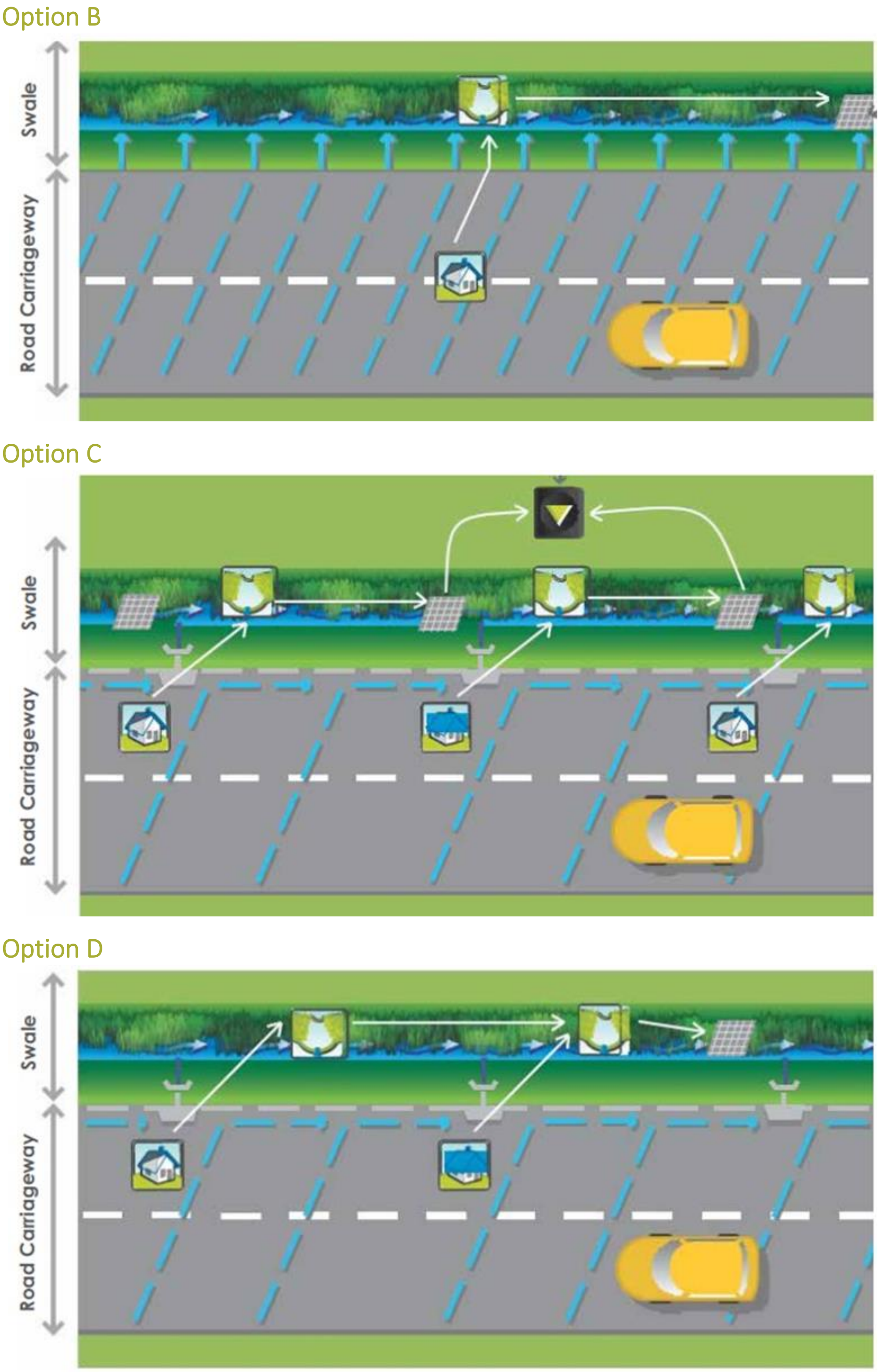


Figure 6.7 Typical swale arrangements

Lateral and local inflows (B) receives lateral inflows and has a single outlet, (C) receives lateral inflows and has multiple outlets, (D) receives point inflows at multiple locations with a single outlet (Adapted from Healthy Land and Water, 2018)

6.5 Bioretention assets

Bioretention assets may also be referred to as raingardens, which is a more commonly-used term for smaller bioretention assets used at the lot or streetscape scale. A summary of appropriate bioretention parameters is presented in Table 6.6 with further details below. A typical layout and cross section are shown in

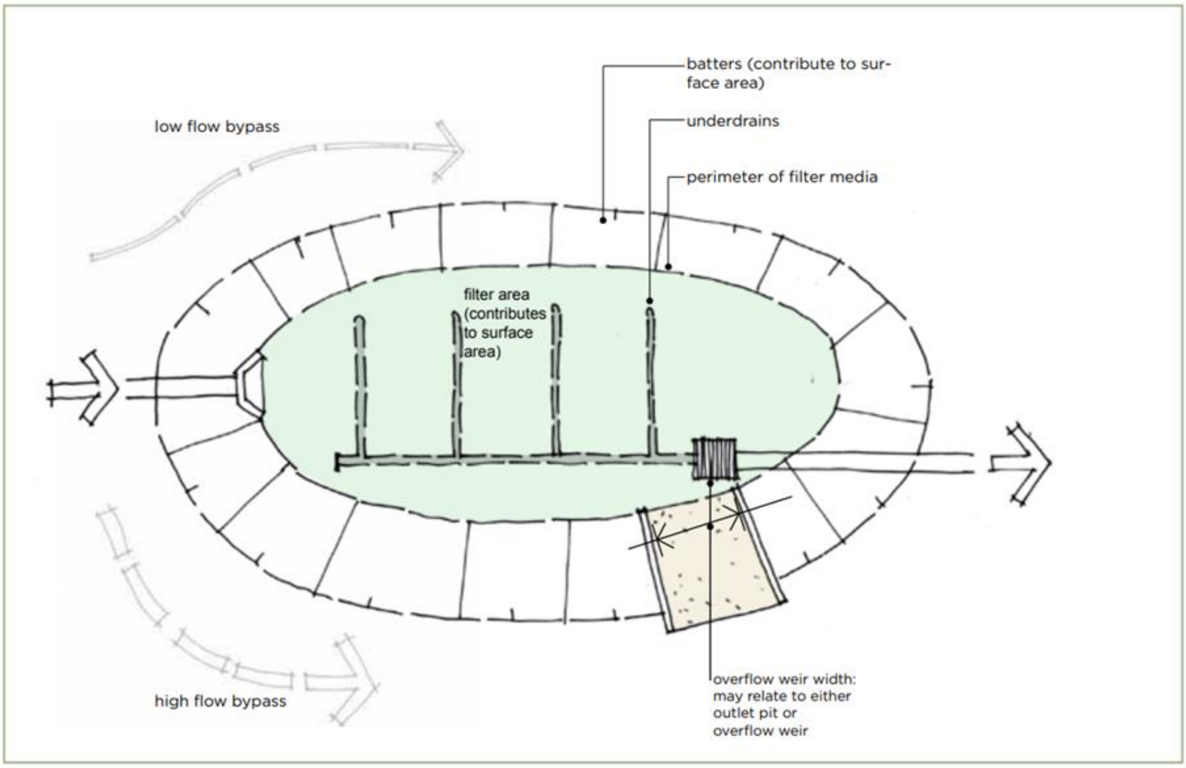


Figure 6.9 and Figure 6.10.

National design guidance for biofilters is provided in the Cooperative Research Centre for Water Sensitive Cities Biofilter Adoption Guidelines (Payne, et al., 2015)

Figure 6.8 Streetscape bioretention, South Melbourne (E2Designlab, 2014)

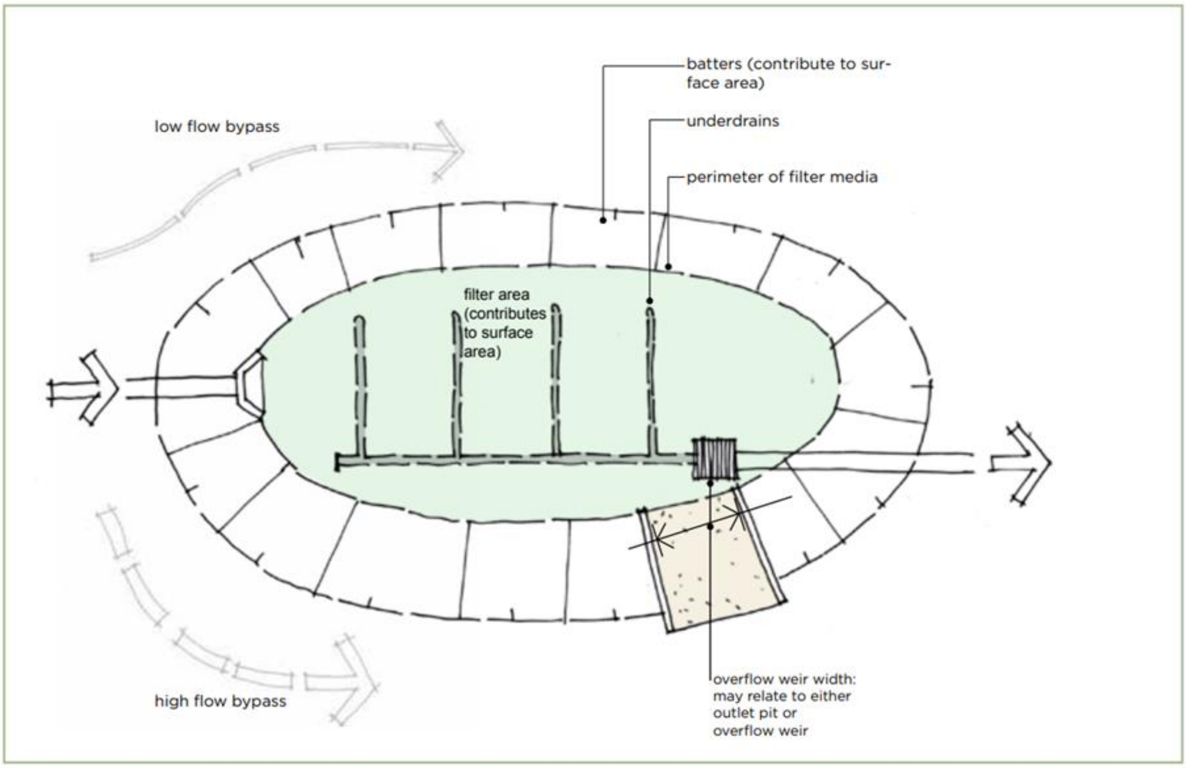


Figure 6.9 Typical bioretention layout (Healthy Land and Water, 2018)

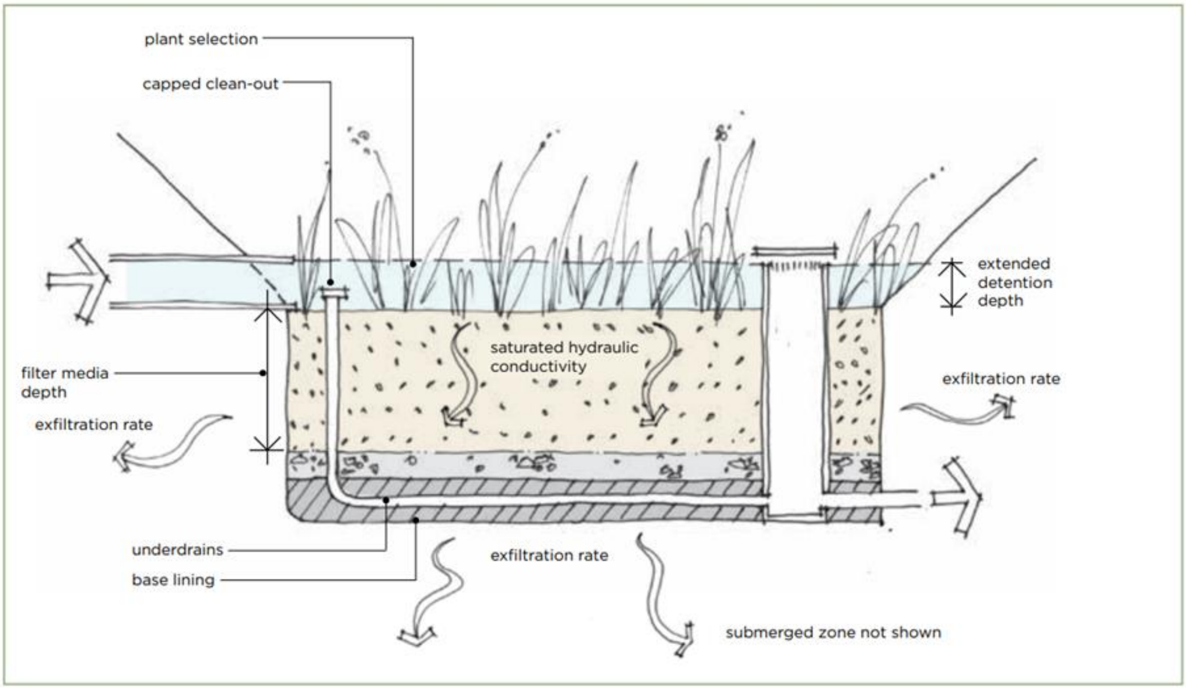


Figure 6.10 Vertical section of bioretention system (Healthy Land and Water, 2018)

Table 6.6 Bioretention modelling parameters

Parameter	Recommendation	Source of guidance
Inlet properties		
Low flow bypass	0 m^3/s unless design specifies otherwise	Recommendation
High flow bypass	Calculated as the capacity of the inlet to the bioretention system – usually the 4EY event. If no detail available, assume capacity of the underground drainage system (e.g. 0.2 EY or 1 in 5 year ARI for residential development)	Guideline requirement
Storage properties		
Surface area	User defined Surface area of storage above filter up to extended detention depth (m^2)	
Extended detention depth (EDD)	0.1 to 0.3 m	Recommendation
Filter media properties		
Filter area	Surface area of filter, m^2	
Unlined filter media perimeter	Length of unlined sides. Adopt plan view perimeter of filter area if no sides lined. If sides are lined – adopt 0.01 m.	Recommendation
Saturated hydraulic conductivity	CRCWSC recommended range 100–300 mm/hour. 100 mm/hour preferred model setting for all designs with design specified hydraulic conductivity > 100 mm/hour to allow for reduction in capacity ≤150 mm/hour for intensively maintained systems for stormwater harvesting	Recommendation
Filter depth	0.4–0.6 m raingardens, bioretention and bioswales 0.6–1.0 m tree pits or assets with trees Do not model the depth of the drainage layer, intermediate layer or submerged zone as part of the filter media depth	Guideline requirement
TN content of filter media	400–1,000 mg/kg	Guideline requirement
Orthophosphate content in filter media	30–50 mg/kg It is considered reasonable to set this to 50 mg/kg as higher values will often make it difficult to achieve total phosphorus targets. Typical raingarden media usually has lower phosphorus levels.	Recommendation
Lining properties		
Is the base lined?	If base lined, set to “Yes” and exfiltration rate shall be zero. If base unlined, set this to “No”.	Recommendation
Vegetation properties	Effective Nutrient Removal vegetation It is recommended that at least 50% of plants for a bioretention node are chosen for effective nitrogen removal based on known effective types or plants with relevant characteristics likely be effective. Guidance on suitable plants for the Greater Adelaide region is available in the Raingarden plant guide (WSSA, undated) Guidance on plants and characteristics is available in the Biofilter Adoption Guidelines (Payne, et al., 2015)	Recommendation

Parameter	Recommendation	Source of guidance
Infiltration and outlet properties		
Overflow weir width	Estimate based on the size of the asset.	Recommendation
Exfiltration rate	0 mm/hour – including if exfiltration is likely to be relatively insignificant (<5% of inflow and <500 kL/year) OR based up known soil type – supported by a site-specific geotechnical report	Recommendation
Underdrain present	Yes, unless design specifies otherwise. Note that if "no" is selected, the system shall be configured with exfiltration into the surrounding soils. This will require consideration of the appropriate lining and exfiltration parameters (see Section 5.2), as well as the use of the secondary drainage link (see Section 7.2).	Recommendation
Submerged zone (with carbon present)	Based on design. A submerged zone (lined system) is strongly recommended for lower rainfall areas <500 mm/year and recommended elsewhere, to improve the potential for denitrification in bioretention systems, and to provide a moisture storage for the plants. A depth of 0.2–0.4 m is recommended.	Recommendation
Submerged zone depth	0.2 m ≤ submerged zone depth ≤ 0.4 m	Recommendation
CSTRs	3 Variations to be justified	Default

The surface area parameter in MUSIC represents the area water can pond above the filter media. There are two common methods for defining the surface area:

- Surface area = filter area where the bioretention basin has vertical sides such as a kerb or as a conservative approach where the surface area is actually greater than the filter area (preferred).
- Surface area calculated at the median depth of ponding. This requires a water level analysis to determine this and iteration of the design so is not the preferred approach.

When a bioretention asset is incorporated into the base of a detention basin, the volume of the retarding basin above the extended detention depth and retarding basin outlet weir or spillway shall not be included in the model for water quality assessment. Flood storage is not creditable as extended detention depth or volume.

6.6 Bioretention swales

The difference between a normal swale and a bioretention swale is that the latter has filter media and underdrainage (much like a bioretention basin). Bioretention swales should be modelled as a bioretention system with zero (nominal) extended detention followed by a swale with a low-flow bypass set to the infiltration rate of the filter area. The appropriate MUSIC layout is shown in

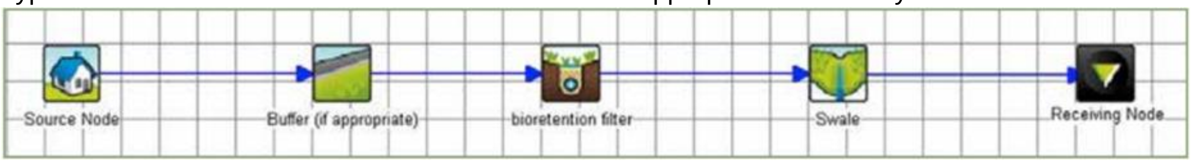


Figure 6.11 with further discussion below. Provide a copy of calculations to the assessment authority.

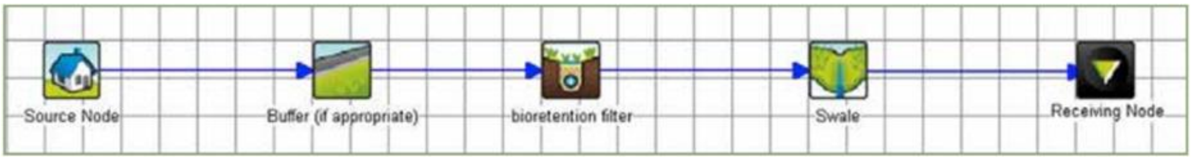


Figure 6.11 Example bioretention swale model

To model pollutant reductions from bioretention swales, separate the treatment system into its various components:

- Batter slopes or buffers, this only applies where inflows reach the base of the swale through lateral inflow over a vegetated flow path outside the swale (e.g. roadside swale). For further guidance on setting up the buffer node refer to Section 6.8.
- Bioretention filter media components, refer to Section 6.5.
- Surface swale components. For further guidance on setting up the swale node refer to Section 6.4. The majority of the treatment node parameters should be set in accordance with the advice provided in the buffer, bioretention and swale sections of the guideline. The exceptions to this are:
    - The bioretention node component should be modelled with no extended detention depth. This is because for most rainfall events, only minimal ponding occurs above the surface of bioretention swales and conveyance flow is represented in the swale node.
    - The low flow bypass for the swale node shall be established using the following equation which represents infiltration flow into the bioretention:

      Low flow bypass (m^3/s) = (Infiltration rate of surface) ÷ (3,600 × 1,000)

      where

      Infiltration rate of surface = length (m) × base width (m) × saturated hydraulic conductivity of filter media (mm/hour)

6.7 Ponds and lakes

Ponds and lakes, including any fresh or brackish water bodies that are not extensively vegetated, are considered receiving water bodies with the exception of appropriately-sized sediment basins. It is important that these assets are protected from stormwater pollutants, including sediment and nutrients, to minimise the risk of poor water quality and algal blooms. These assets should not be modelled as effective treatment nodes and stormwater should be treated before it is allowed to discharge to these bodies.

Ponds and lakes shall not be considered as contributing to stormwater quality treatment regardless of whether they are naturally occurring or constructed as part of a development.

MUSIC is not considered a suitable model for in-lake processes, other than water balance assessments. In the absence of local guidance, further guidance on this topic can be found in documents such as Melbourne Water's "Constructed Shallow Lake Systems for Developers". This document is available as a PDF download from Melbourne Water's website https://www.melbournewater.com.au/media/607/download).

In some circumstances, it may be necessary to represent a pond or lake within a model as it performs a storage function or influences the behaviour of other downstream treatment assets (e.g. stormwater harvesting schemes). In these cases, the treatment effect of the pond or lake may be subtracted from the calculated reductions in stormwater pollutant loads.

Figure 6.12 Cranbourne Botanic Gardens (E2Designlab, 2012)

6.8 Buffers

The buffer node is described in the MUSIC Help Manual. Buffer nodes are generally used to represent sheet flow or stormwater dispersed over grassed or well vegetated areas before draining to other stormwater treatment nodes. For example, stormwater from a road catchment flowing over a grass verge before entering a swale or pit.

The exfiltration rate should generally be set to zero. A non-zero rate may be adopted if justified through in-situ soil testing. If a value other than zero is adopted, the exfiltrated water shall be retained in the model using a secondary drainage link. Buffers are only appropriate for simulating situations where flow is dispersed (sheet flow). If vegetation accepts concentrated flows or pipe flows, then using the buffer node in the MUSIC model is not appropriate (i.e. minimal stormwater treatment will occur).

It is possible to model buffers as modified swale treatment nodes, however they need to be clearly designed with flow dispersal across the full width of the vegetated area. Care needs to be taken in setting up and assessing MUSIC models to ensure that source catchment areas can actually drain to the buffer node. The treatment processes in a buffer strip are modelled by a set of simple transfer functions derived from a review of worldwide literature. These transfer functions cannot be adjusted.

Table 6.7 Buffer modelling parameters

Parameter	Recommendation	Source of guidance
Percentage of upstream area buffered (%)	User defined	N/A
Buffer area (% of upstream impervious area)	User defined	N/A
Exfiltration rate (mm/hour)	0 This recommendation is based on the Healthy Land & Water (2018) MUSIC Guidelines. No evapotranspiration is represented in a buffer node. May be set to a conservative level, e.g. 0.1 mm/hour to represent evapotranspiration where an accurate water balance is needed, subject to meeting treatment objectives with exfiltration rate set to 0 mm/hour.	Recommendation

6.9 Infiltration assets

The MUSIC User Manual describes the parameters for the infiltration node. Infiltration is an important aspect of urban stormwater management, particularly for recharge of groundwater and compliance with frequent flow management objectives.

Infiltration assets can potentially be clogged by sediment and organic matter so it is important to minimise inflows of sediment, particularly fine sediment.

The suitability of subsoils should be considered when planning infiltration systems, e.g. avoid infiltration into dispersive or sodic soils, highly sensitive groundwater, shallow soils or steep slopes. Appropriate separation from infrastructure and consideration of potential interactions with down-slope infrastructure should also be considered.

Stormwater must be treated to meet water quality targets before infiltration

Table 6.8 Infiltration modelling parameters

Parameter	Recommendation	Source of guidance
Inlet properties		
Low flow bypass	0 m^3/s unless design specifies otherwise	Recommendation
High flow bypass	Calculated as the capacity of the inlet to the infiltration system – usually the 4EY event. If no detail available, assume capacity of the underground drainage system (e.g. 0.2 EY or 1 in 5 year ARI for residential development)	Guideline requirement
Storage and infiltration properties		
Pond surface area	Average surface area of storage above filter up to EDD, m^2	N/A
Extended detention depth	to 0.5 m ≤ 0.3 m recommended for safety in public areas Set to 0.01 m for infiltration trenches	Recommendation
Filter area	Surface area of filter, m^2 Surface area of filter not less than 70% of surface area	Recommendation
Unlined filter media perimeter	Length of unlined sides. Adopt plan view perimeter of filter area if no sides lined. If sides are lined – adopt 0.01 m.	Recommendation
Depth of infiltration media	Typically 0.3–1.0 m for infiltration trenches or soakwells Adopt 0.01 m for surface infiltration basins.	Internal guideline requirement
Exfiltration rate	Exfiltration rate shall be justified with a site-specific geotechnical report including saturated hydraulic conductivity for underlying soils. A conservative estimate based on soil type may be accepted for concept design of assets <100 m^2. Design shall consider site suitability for infiltration (soils, bedrock, groundwater, slope, nearby infrastructure). Refer to Section 5.2 for further discussion.	Recommendation
Evaporative Loss as % of PET	100	Default
Outlet properties		
Overflow weir width	Adopt design weir width if known, otherwise estimate based on the size of the asset. Size large enough to prevent constriction of flows during overflow events. An undersized overflow weir results in water backing up, effectively adding additional extended detention. To avoid this, it is recommended that, where the weir design is unknown, the overflow weir width (m) is set as the surface area (m^2) divided by 10.	Recommendation

6.10 Gross pollutant traps

A range of proprietary and custom products such as gross pollutant traps (GPTs), trash racks and filters is available. These may be used at different stages of the treatment train.

- Gross pollutants traps are structures that use physical processes to trap solid waste such as litter and coarse sediment.
- Proprietary filters refer to various devices all relying on a media filter or filters to remove stormwater pollutants.

These can be modelled in MUSIC. Several different nodes may be used depending on the device being modelled including the **gross pollutant trap, generic** and **media filtration** nodes.

However, most commonly the GPT node will be used for the following purposes:

- To represent pollutant load reductions for gross pollutant traps (GPTs).
- To represent pollutant load reductions in secondary filters and other proprietary and custom products.

It is the responsibility of the designer to select a proprietary device that meets the design criteria. One way of assuring performance is to choose products that are supported by a SQIDEP assessment.

6.10.1 Modelling gross pollutant traps in MUSIC

It is a flexible node allowing the user to define the relationship between concentration and pollutant capture efficiency. The parameters defined for the gross pollutant trap (GPT) node are described in the MUSIC User Manual.

GPTs shall only be assumed to provide effective reductions in gross pollutants and total suspended solids at this time. Reductions in total phosphorus and total nitrogen should not be assumed or included.

The user shall ensure the following have been considered in the modelling of gross pollutant traps:

- Appropriate treatment capacity flow rates have been entered in the high flow bypass value. These should reflect average flow rates for stormwater over a maintenance cycle
- The treatment performance is correctly represented and based on the approved performance assessment, using either:
    - Percentage reductions, or
    - Performance curves with different reductions for different concentrations.

Modelling proprietary filters in MUSIC:

In addition to the above, the user should consider the following for modelling proprietary filters:

- Check that the vault volume or storage of the device has been accurately represented:
    - Excluding the cartridge volume, and
    - Excluding the flood detention storage volume

6.10.2 High-flow bypass

Proprietary products generally operate with a high-flow bypass. It is important to enter the correct high-flow bypass rate for the proposed unit into the gross pollutant node in MUSIC so that no pollutant reductions are attributed to flows that will bypass the device. The **default value in MUSIC is set to 100 m^3/sec** and this should be changed by the user to represent the modelled unit.

The high-flow bypass rate should equal the treatable flow rate of proprietary device used.

For devices which include a storage volume, a detention basin node upstream of the GPT node may be used to represent the storage within the device. Where treatment performance of the device <u>exclusive</u> of any effects of the upstream storage are provided by the supplier then this node should adopt the standard or calibrated k and C* values. Where treatment performance of the device including its storage are already accounted for through percentage reductions in pollutant loads (which is often the case), the k and C* values for the detention basin may be modified to minimise any pollutant removal (set k to 1).

6.10.3 Modelling caveat

The gross pollutant loading rates used in the MUSIC software are based on limited data and have been found by some studies to underestimate loads issuing from impervious catchments. Available data from council GPT removal rates or local studies may be used where available to estimate loading rates in the model, subject to review and approval by the relevant authority. It is noted that this parameter cannot currently be modified in MUSIC but may be added as a feature in future versions.

In modelling the storage of the proprietary product, consideration should be given to appropriate representation of:

- Expected pollutant loads, and
- Expected cleanout frequency.

6.11 Media filtration assets

The media filtration node allows representation of filtration assets (both proprietary and non-proprietary) such as sand and media filters. They are generally used to represent sand filters but may be used for some other proprietary filtration assets and permeable pavements with careful choice of parameters.

This node requires the user to specify the pollutant removal efficiency (under Advanced Properties), and therefore the development application will need to include information to demonstrate to the assessment authority that the proposed treatment measure operates in a manner which cannot be represented using one of the other MUSIC treatment nodes, or configured using the guidance provided for other treatment measures.

Filter media particle diameter and saturated hydraulic conductivity should be set consistent with manufacturer information. The values of k and C* (representing treatment only in the detention storage above or immediately upstream of the filter) should be retained as default values unless otherwise suitably justified.

It is noted that the default treatment parameterisation within the media filtration node was established based on a selection of performance outcomes for sand and media filters with particle sizes ranging from sand through to gravel and the parameters in this node are best suited for these purposes.

Table 6.9 Filtration media modelling parameters

Parameter	Recommendation	Source of guidance
Low-flow bypass	0 m^3/s unless design specifies otherwise	Recommendation
High-flow bypass	Calculated as the flow capacity of the asset for treating stormwater after receiving stormwater for an extended period of time (nominally 50% of asset design life or maintenance frequency)	Guideline requirement
Storage properties		
Extended detention depth (m)	User defined	N/A
Surface area (m^2)	User defined	N/A
Exfiltration rate (mm/hour)	0	Default
Filtration properties		
Filter area (m^2)	User defined	N/A
Filter depth (m)	User defined	N/A
Filter median particle diameter (mm)	Set consistent with material or manufacturer information or expected particle diameter (larger is more conservative)	N/A
Saturated hydraulic conductivity (mm/hour)	Set consistent with material or manufacturer information, taking into consideration expected clogging over the life cycle of the asset	N/A
Depth below underdrain pipe (% of filter depth)	0%	Recommendation
Outlet properties		
Overflow weir width (m)	Estimate based on the size of the asset. Size large enough to prevent constriction of flows during overflow events. An undersized overflow weir results in water backing up, effectively adding additional extended detention. To avoid this, it is recommended that, where the weir design is unknown, the overflow weir width (m) is set as the surface area (m^2) divided by 10.	Recommendation

In MUSIC, any unvegetated filtration system with filter media such as a sand filter or permeable pavement may be modelled using the **media filtration node**. However, it is more common to use the GPT node for proprietary secondary-treatment media filters as it is easier to transfer performance data from monitoring to the GPT node.

6.12 Permeable and porous pavements

A summary of recommended permeable/porous pavement parameters is presented in Table 6.10 with further details below. Permeable/porous pavements allow runoff to drain through the pavement surface or between paving units and infiltrate the underlying media. Such pavements can provide some degree of stormwater treatment, however more importantly this approach increases the effective pervious area of the developed catchment and promotes infiltration.

Permeable/porous pavement can be considered a type of unvegetated filter and may be modelled using the **media filtration node**.

Care should be taken in setting up the node to only represent the filtration zone, not the underlying drainage layer. The drainage layer is usually imported coarse material with limited treatment capacity. Removal of particulates and some dissolved pollutants is achieved through filtration and adsorption onto soil particles in the treatment zone or filter media (typically a base course of sand, loamy sand or other mix of finer material or aggregate). For further detail on using the media filtration node refer to Section 6.11.

Figure 6.13 City of Mitcham, St Marys Park carpark, crumb rubber porous asphalt and permeable paving trial

Table 6.10 Parameters for permeable and porous pavements

Parameter	Recommendation	Source of guidance
Inflow properties		
Low flow bypass	User defined	N/A
High flow bypass	User defined	N/A
Storage properties		
Extended detention	Set to 0 m (or a nominal depth, e.g. 0.01 m) if water overflows freely from the permeable pavement. May be set higher if there is a specific design intent to allow frequent ponding above the paving	Recommendation
Surface area	User defined	N/A
Exfiltration rate	Design to allow infiltration is encouraged where possible. Preferably set based on site-specific geotechnical report May be set based on soil type (where infiltration is relatively insignificant (<5% of inflow and <500 kL/year) (however geotechnical testing is recommended). Design shall consider site suitability as well as constraints for infiltration such as reactive clay soils, bedrock, groundwater, slope and nearby infrastructure. Refer to Section 5.2 for further discussion.	Recommendation
Filtration properties		
Filter area	For permeable interlocking pavers or similar with openings to allow infiltration, it is recommended to set the opening area of the permeable pavement (not the total surface area), as the filter area. This may be estimated from the product specifications.	Recommendation
Filter depth	Set the filter depth to represent the depth of the treatment zone or filter media and base course. Generally, any drainage layer will have coarse gravel and should be excluded from the filter depth.	Recommendation
Filter median particle diameter	Set to median particle size, e.g. 2 mm (a range of 1–5 mm depending on design is acceptable).	Recommendation
Saturated hydraulic conductivity	Set to 100 mm/hour. It is recommended a conservative value of 100–200 mm/hour is used to allow for clogging of the pavement surface over time. See further discussion on clogging below.	Recommendation
Depth below underdrain pipe (% of filter depth)	0% if no submerged zone below underdrainage. Set to appropriate percentage underdrainage provided to encourage additional infiltration.	Recommendation
Outlet properties		
Overflow weir width	Equal to the length of the asset on the low side or defined spillway weir width where provision is made to control high flows.	

6.12.1 Clogging

Permeable pavements will initially have very high infiltration rates, commonly thousands of millimetres per hour. These can be expected to decline exponentially over time. However, even an apparently low infiltration rate of 100–200 mm/hour can deliver a high level of functional performance. Clogging is commonly raised as a concern. Clogging is highly variable depending on catchment context. Factors include catchment sediment and leaf litter loads as well as maintenance such as street sweeping. Key risks to consider, avoid or manage include leaf drop from deciduous trees and sediment from over-filled garden beds or construction. Within an asset, clogging can vary widely so while some areas may experience clogging, others may continue to function and compensate. As a result of the various factors involved, field experiences vary widely with some assets clogging within a few years and others requiring no maintenance for 10 years or more.

6.12.2 Source node set up

While most treatment assets represent a small proportion of their catchment, permeable pavements usually account for a large portion of their catchment and do not have a large external catchment.

MUSIC does not directly represent rainfall falling onto a treatment node. Rather, it is assumed the area of the treatment is included within an upstream catchment area. Where the treatment asset will be a significant part of its catchment, it becomes important that its area is represented. This is because direct rainfall on the actual area of the paving may represent a significant portion (or all) of the total flow treated and therefore has an influence on treatment outcomes. Since all rainfall falling on a WSUD asset will enter it the area should be represented as impervious surface area to ensure a correct water balance. A "roof" surface type may be adopted to better approximate pollutant concentrations if preferred.

For clarity, separate the catchment draining to the permeable paving into two (or more) nodes. One node to represent surface flows from external areas to the permeable paving and the other to represent the direct rainfall on the permeable pavement.

For the source node representing direct rainfall on the permeable pavement area itself, use a 100% impervious fraction so that all direct rainfall becomes inflow to the asset.

6.13 Generic nodes

Generic nodes offer the user flexibility to model something that cannot be represented by an existing treatment node. This node requires the user to specify the flow and pollutant reduction rates using Transfer Functions. The MUSIC User Manual describes the parameters that can be defined for the generic node. The generic node is well suited to be used to represent things such as a diversion or split flow scenario or a pump. It may also be used to model custom pollutant treatment devices such as GPTs, but it is recommended that the GPT node be used in these cases, for modelling clarity.

Within a transfer curve, the outflows, or pollutant concentrations out, must not exceed the inflows, or pollutant concentrations in. A pollutant balance should be done to check that pollutants are not created or lost, as generic treatment node outputs can easily be misinterpreted.

6.14 Imported data nodes

Supporting documentation will be required to demonstrate the use of any imported data nodes in models. These are usually used to bring flows and pollutant loads from one MUSIC model into another to reduce run-time and model complexity. They may however also be used to represent wastewater, groundwater or other inflows to WSUD assets. These should be carefully documented to explain the design and how the model and results should be interpreted.

7 Links and routing

7.1 Linking nodes – link routing

Primary and secondary links transfer or route water from one point or node to the next. Primary drainage links are the main type of link.

Hydrologic routing can be used to adjust the timing and magnitude of flow arriving at a downstream node. It should be used where appropriate to reflect the time of concentration of the catchment as calculated using a recognised procedure.

Routing may be ignored for most smaller-scale applications (except where flow rates are critical, e.g. diversions and environmental flow analyses considering flow rates) to reduce the complexity of the model. The default setting of “no translation or routing” is a conservative approach for assessing treatment performance. In this instance, the model assumes that flows and associated pollutants from all parts of a catchment arrive at a treatment node at the same time. This means that MUSIC may overestimate the overflow volume. Not using routing is most likely to result in the performance of treatment systems being underestimated.

If routing is used, it should be calculated and applied consistently across the whole model and a summary of underlying calculations or hydraulic modelling shall be provided to the satisfaction of the relevant authority. This may include estimates or modelling of velocities, time of concentration and travel times.

If a hydraulic model is available, it may be used to inform the time of concentration and travel times.

Routing is recommended for models with flow rate diversions such as weirs or pumped diversions from channels or pipes for stormwater harvesting.

7.2 Secondary links

Secondary drainage links allow different components of the flow to be conveyed downstream separately. Secondary drainage links depart from the same node as their associated primary drainage link but must discharge to a different downstream node. A secondary link cannot be connected from a node until a primary link is connected.

Figure 7.1 demonstrates a simple model including a secondary drainage link. The primary drainage link routes the standard bioretention outflow components (low flow bypass, high flow bypass, piped outflow and weir overflow) downstream. The secondary drainage link conveys downstream the water that has exfiltrated from the base of the bioretention system into the surrounding soil.

Note that selecting a flow component in a secondary link will turn off that component in the primary link if it would normally have been included (e.g. low flow bypass, high flow bypass, piped outflow and weir overflow). The options for turning flows off in a primary link are more limited until a corresponding secondary link is added.

The use of secondary links can create unintended effects and care should be taken to ensure flows are returned to the model where appropriate. For this reason, the “Treatment Train Effectiveness” result will be unavailable for any given node where MUSIC detects that flows are routed out of the model at any point upstream. Results reported at a node may also be different when it has secondary links from its outlet (particularly where these include infiltration or reuse) and care should be taken to ensure that the results reported are representative of the expected behaviour of the asset being modelled.

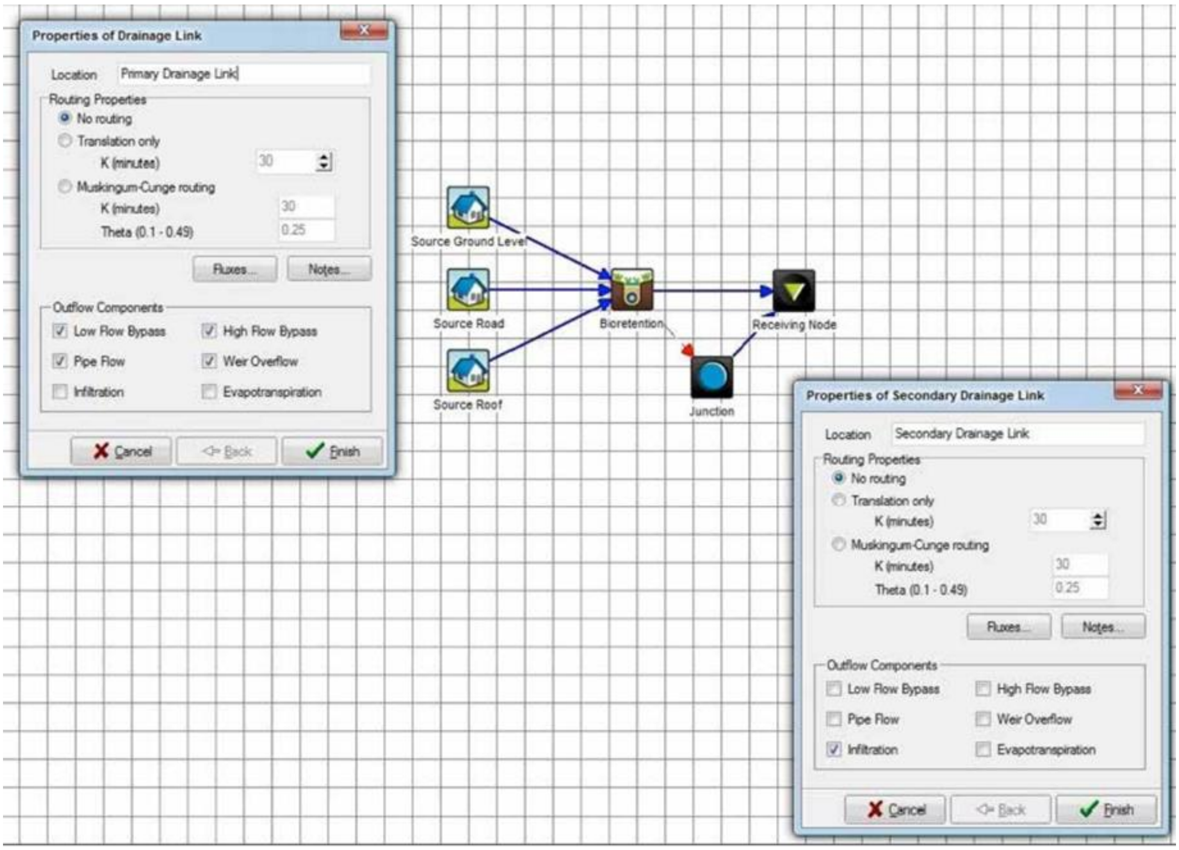


Figure 7.1 Example of secondary link usage

8 Reuse demands

Rainwater and stormwater harvesting from tanks, wetlands and storages can contribute to treatment train performance and stormwater volume reduction if the demands are reliable (e.g. residential uses such as toilet flushing and laundry, or large-scale irrigation such as ovals or agriculture).

Irrigation of residential blocks is not always a reliable demand and it is up to the relevant authority whether or not it should be included in modelling for the purposes of achieving stormwater quality objectives.

If possible, the modeller should calculate the appropriate demands, based on end-use studies or suitable calculations using monitoring data or knowledge specific to the site design. These calculations and assumptions need to be explained and accepted by the relevant authority.

8.1 Rainwater harvesting

8.1.1 Indoor demands – Residential

Table 8.1 provides general guidance for typical/acceptable demands to use when modelling for rainwater harvesting. If no locally specific data are available, the modeller may use this estimated demand breakdown with consideration as to which demands are intended to be supplied by rainwater. The indicative household demands are from the recent study of water use characteristics carried out by Arbon et al. for the Goyder Institute for Water Research (2014). The study presents the estimated breakdown of indoor end-uses as well as valuable findings regarding the seasonality of outdoor demands.

Table 8.1 Estimated domestic indoor water demand breakdown (Arbon, Hatton MacDonald, Beverley and Lambert, 2014)

Indoor demand type	Demand (L/p/day)
Toilet flushing	28
Showers	48
Washing machine	25
Taps	29
Dishwashers and baths	5
Total indoor demand	135

8.1.2 Indoor demands – Other

Occupancy is required to work out the building's water demand as part of the volume and efficiency calculations.

Estimated Building Occupancy = Maximum Peak Occupancy × Occupancy Hours Profile × Building Size.

- Maximum occupancy can be found in Building Code of Australia (BCA) Volume 1, Table D1.13 "Area per Person According to Use"
- Occupancy Profile is the average % of people using the building at any one time (occupancy hours profile) as defined within the BCA Section J.

Table 8.2 Building Code of Australia occupancy profiles

(Water Sensitive SA InSite Water Management Tool Stormwater management for small-scale development – Insite Water Engineering Methods report January 2020)

BCA Class	Building type	Average occupancy profile (based on a Building Peak Occupancy = 1)
Class 1	Individual dwellings	1
Class 2	Apartments	0.9
Class 3	Hotel or other residential building	0.6
Class 4	Penthouse or dwelling in a non-residential building	0.9
Class 5	Office	0.4
Class 6	Shop, restaurant or retail	0.3
Class 7	Industrial or storage	0.4
Class 8	Industrial laboratory or process building	0.4
Class 9	Public buildings	0.5
Class 9A	Healthcare	0.8
Class 9B	School or childcare	0.3
Class 9C	Aged care building	0.6
	Maximum occupancy – 100% occupied 24/7	2

The Arbon et al. report states that overall demands reduce by approximately 15% if water efficient appliances are used (Arbon, M., Hatton MacDonald, Beverley, & Lambert, 2014). It is noted that water efficient appliances included showers and toilets rated at “3 stars” and above, and only front-loading washing machines. When representing new developments with mandated “water smart” appliances, corresponding demands may potentially be reduced accordingly.

For modelling inputs associated with a roof water harvesting tank, the user should estimate the number of people per dwelling and consider which demands are supplied by tank water. The most common demands supplied are one or more of toilet, irrigation and laundry. In South Australia, water harvested in a rainwater tank may potentially also be used across a wider range of indoor demands. If uses are indoor only (e.g. for residential apartment blocks with no or little garden area) the user can calculate the mean daily demand as the sum of the identified uses.

8.1.3 Outdoor demands

Estimates for residential outdoor demand may be made based on the results of the end use study (Arbon, et al., 2014). These were adapted (Myers, et al., 2014) to provide the estimated outdoor demands (litres/person/day) shown in Figure 8.1. However, it is noted the data were only for a single summer and there is a need for extended monitoring.

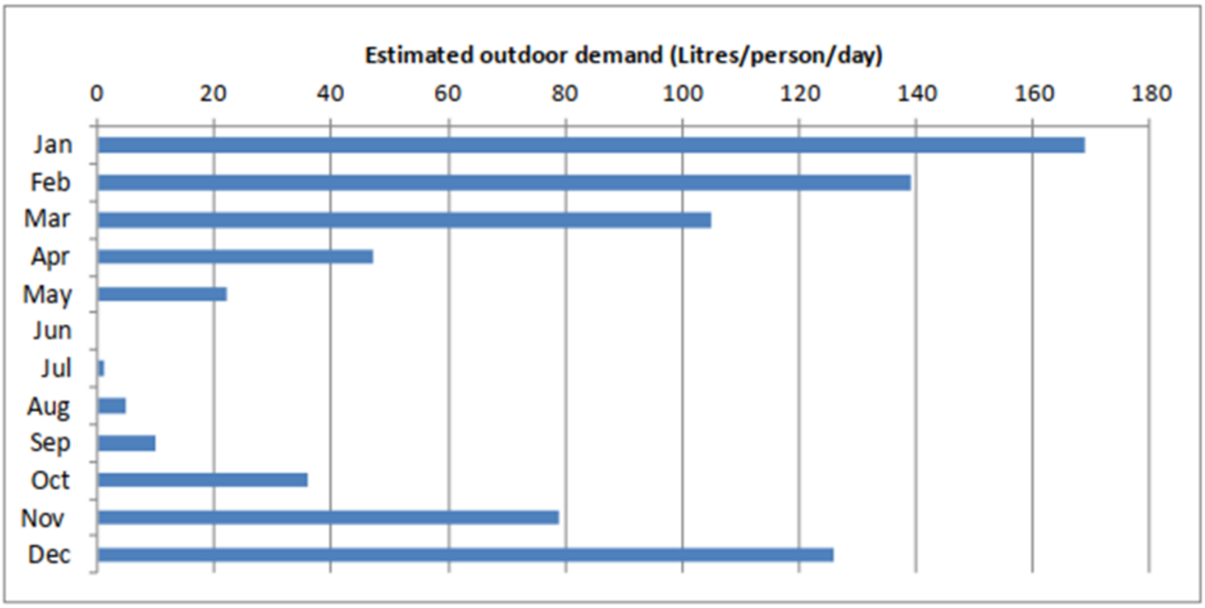


Figure 8.1 Seasonality of residential outdoor demand in Greater Adelaide

(In Myers, Cook, Pezzaniti, Kemp & Newland, adapted from Arbon, M, Hatton MacDonald, Beverley & Lambert, 2014)

Irrigation demands (and other demands that vary seasonally such as cooling towers) should be modelled to reflect seasonal variation. Irrigation demands should preferably be calculated based on relevant climate data for the region (i.e. rainfall and evapotranspiration) and should be represented as a seasonal demand in MUSIC.

A tool for estimating irrigation demands in South Australia, the SA Water Irrigation Management Calculator, is available from SA Water or Water Sensitive SA and may be used as a starting point to estimate irrigation demands for uses such as public open spaces and sports fields.

A link to this tool is available on the Water Sensitive SA MUSIC Guidelines webpage (https://www.watersensitivesa.com/resources/technical-aides/guidelines/south-australian-music-guidelines/).

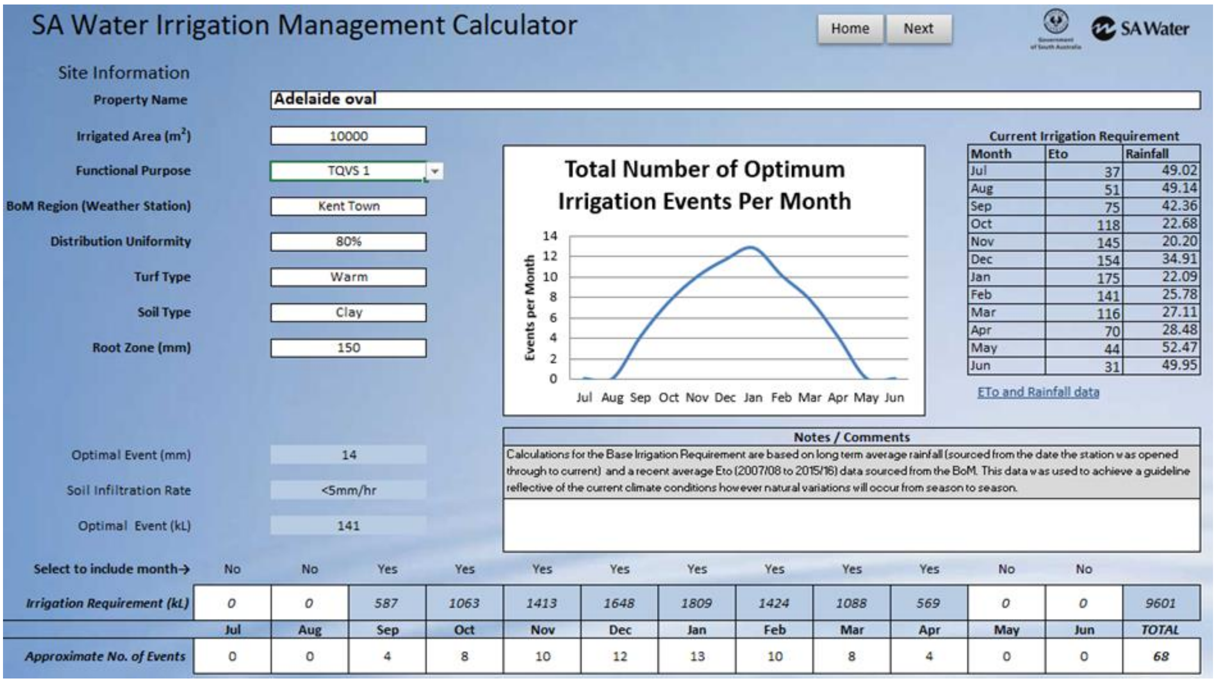


Figure 8.2 Calculation of irrigation demands using the SA Water Irrigation Management Calculator

There are three options for representing seasonal demands in MUSIC, listed here in order of preference:

1. (Preferred) Mean annual demand varied by PET minus Rain. Rainfall subtracted to better represent an irrigation system that does not irrigate on days with significant rain.
2. Mean annual demand varied by monthly distribution. The most flexible option and may be used for entering a monthly demand pattern such as the one shown in Figure 8.1 or obtained from the calculator Figure 8.2 above.
3. Mean annual demand varied by PET. This allows just a mean annual demand to be entered and MUSIC will distribute this based on the potential evapotranspiration (PET) used in the model's climate template. Rainfall is not taken into consideration.

8.2 Stormwater harvesting

Stormwater harvesting refers to the capture, treatment, storage and reuse of runoff from a catchment.

The following provides some general guidance on the modelling of stormwater harvesting schemes.

- Stormwater may be stored in open water bodies (such as ponds) or in above or below ground tanks. The appropriate corresponding node should be used in MUSIC. This is usually the pond node for an open storage with evaporation and the tank node for a closed storage with no evaporation (above or below ground).
- Where a stormwater harvesting scheme intercepts baseflows derived from groundwater, these should generally be bypassed and not extracted so that low flow hydrology of the downstream waterway is not compromised. This may be achieved using a low flow bypass or similar.
- Where stormwater is treated then directed into a storage, usually only treated flows should enter the storage with untreated flows (i.e. flows that bypass or pass over the overflow weir) directed around the storage. This may be achieved with a secondary link or the use of a generic node to split flows. Note that both bypassed flows and overflows from the storage need to be combined and accounted downstream.

- It is recommended that a six-minute timestep is always used for any system with a flow-rate diversion and also storages where the storage size is small relative to the demands.
- It is recommended that the tank volume should preferably be at least four or five times the average daily demand (the storage should always be much larger than the flux passing through it). MUSIC may oscillate, have other numerical errors and over-estimate yields where this is not followed. The mass balance should be checked including comparing the sum of inflows with sum of outflows (use the Node Water Balance) for models where this may be in doubt or results look questionable.

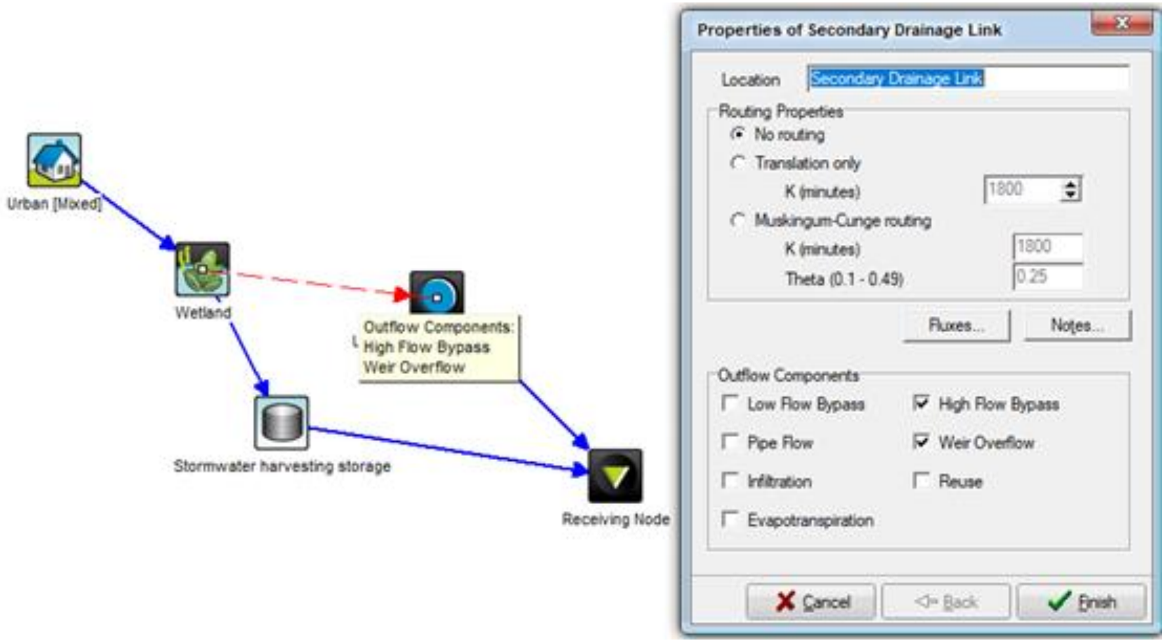


Figure 8.3 Only treated flows directed to a stormwater storage with untreated flows bypassed then re-combined with any overflows from the storage at the downstream outlet

9 Reporting and assessment

9.1 Interpreting results

MUSIC produces a variety of outputs and results including mean annual loads, statistics, summaries of inputs and outputs, and graphs of pollutant concentrations and loads.

The performance results should be compared with the objectives and targets set out in Section 2.1. The key question is whether these *performance targets are achieved for the development overall.*

To demonstrate compliance with the stormwater quality management objective, use the “mean annual loads” and “treatment train effectiveness” statistic functions. Usually the treatment train effectiveness at the outlet of the development or catchment, see Figure 9.1, will provide a summary of pollutant loads from all catchments and pollutant load reductions achieved by all stormwater treatment assets combined. This can be used to determine whether the overall development or project meets pollutant load reduction objectives.

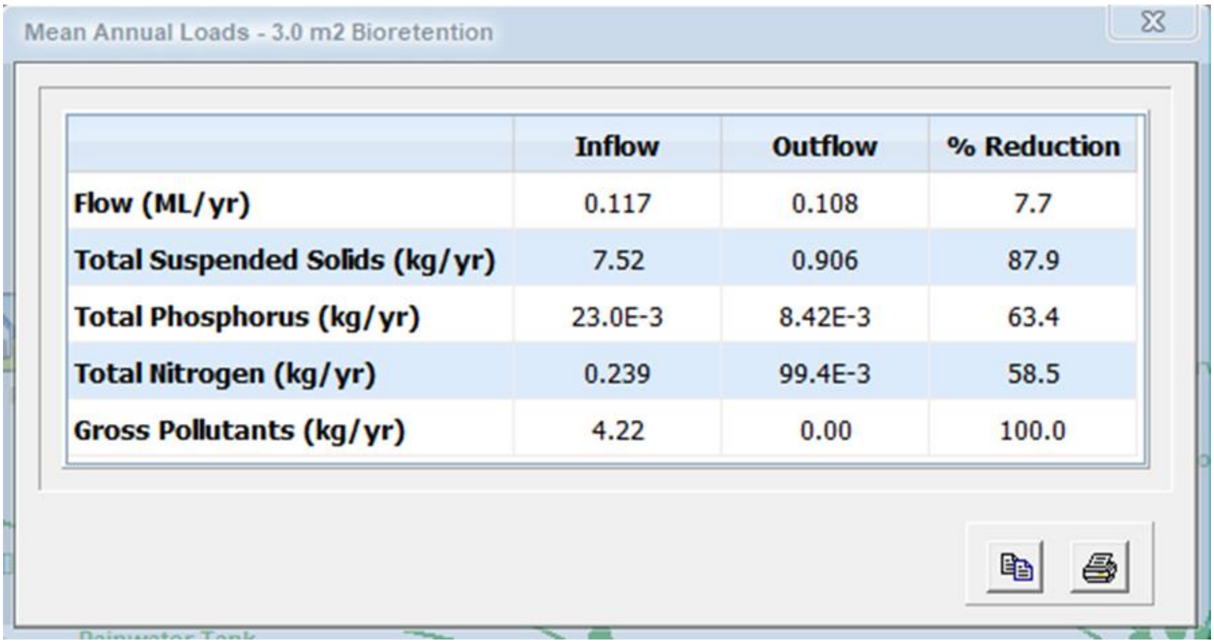
	Sources	Residual Load	% Reduction
Flow (ML/yr)	0.21	0.158	25
Total Suspended Solids (kg/yr)	10	1.93	80.8
Total Phosphorus (kg/yr)	0.038	0.0164	56.8
Total Nitrogen (kg/yr)	0.458	0.215	53
Gross Pollutants (kg/yr)	7.39	0	100

Figure 9.1 Treatment train effectiveness results example

In some cases, flows and pollutant loads from external catchments may enter the model or there may be diversions or transfer functions where flows and pollutant loads are lost. In these cases, it may be preferable to calculate pollutant loads by summing loads from each of the relevant catchments and pollutant load reductions by summing reductions from each of the treatments.

To do this, the mean annual loads for each node can be exported to Excel for calculation. Note that mean annual loads and treatment train effectiveness can be copied using the “copy” button, see Figure 9.2.

Alternatively, a summary report file (*.mrt) file can be exported from MUSIC, see Figure 9.3. This is most useful for reporting inputs and results for larger models.



Mean Annual Loads - 3.0 m2 Bioretention

	Inflow	Outflow	% Reduction
Flow (ML/yr)	0.117	0.108	7.7
Total Suspended Solids (kg/yr)	7.52	0.906	87.9
Total Phosphorus (kg/yr)	23.0E-3	8.42E-3	63.4
Total Nitrogen (kg/yr)	0.239	99.4E-3	58.5
Gross Pollutants (kg/yr)	4.22	0.00	100.0

Figure 9.2 Mean annual load results for a treatment node with the pollutant load "% reductions" and "copy" button shown

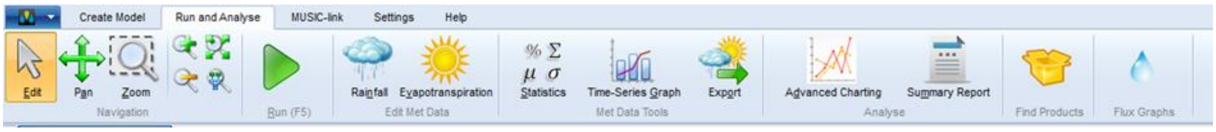


Figure 9.3 Menu showing button to generate a summary report

9.2 Submission requirements

This section provides a summary of the information that should be submitted to the relevant authority with respect to MUSIC modelling and associated reporting. In most cases, MUSIC modelling will be required to support a development application or design of a WSUD asset.

Usually, the reporting of MUSIC modelling will comprise:

- A stand-alone MUSIC modelling report;
- Part of a stormwater management plan;
- Part of an integrated water management plan; or
- Part of a design of a WSUD asset

A MUSIC report or chapter should be accompanied by plans illustrating the proposed treatment assets with dimensions that are consistent with the model. The plans should demonstrate that the assets can be readily constructed and maintained with appropriate allowance of space for batters, maintenance access and management (e.g. sediment drying areas) and integration with the surrounding landscape. *In most cases, the footprint that should be allowed will be greater than the modelled asset surface area.*

For further guidance on reporting requirements, proponents should consult with the relevant authorities and refer to relevant local and state policies and guidelines.

9.2.1 MUSIC model report

A typical MUSIC model report should include the following:

- Introduction

- Site and drainage characteristics
- Stormwater management strategy
- MUSIC modelling summary
- Performance reporting
- Audit report

Introduction

The introduction should contain at least:

- A description of the site location including lot and plan number(s), street address where applicable and longitude/latitude.
- Reference to relevant documents and files such as plans and drawings, models and background reports.
- Outline of applicable stormwater management objectives.

Site and drainage characteristics

The following site and drainage information should be provided:

- Current and proposed land use of site.
- Define sub-catchments and flow directions for the proposed developed site demonstrating how drainage will be managed. This should include description of how existing topography, future topography following earthworks and drainage will be configured
- Define sub-catchments for any external areas draining through the site affecting stormwater treatment assets.
- Show location of proposed treatment measures (needed to define sub-catchments).
- Show site discharge point(s).
- Demonstrate that modelled total catchment area matches that shown on catchment plans (including any relevant external catchments).

Stormwater management strategy

The stormwater management strategy should describe the site opportunities and constraints for stormwater controls. This should include soils and topography and any limitations these may impose. The assets selected for the site should be identified and a brief explanation provided to demonstrate these are:

- Appropriate for the specific site and development scale.
- Have been designed with the intent of achieving the broader objectives of *Water sensitive urban design – Creating more liveable and water sensitive cities in South Australia* (Department of Environment, Water and Natural Resources, 2013) including urban greening, cooling and landscape integration.
- Consistent with any stated preferences or requirements of the relevant authority or appropriate justification where the design varies from these.
- Have adequate area for implementation including associated requirements such as batters, bypass and overflow paths, maintenance access and any drying areas
- Are appropriately positioned.
- Provide safe overland flow paths for storm events above design levels.
- Are hydraulically sound with safe conveyance of design events, management of flow rates to mitigate erosion risks and detention times appropriate for the asset and performance levels required.
- Have identified appropriate maintenance access.

MUSIC modelling summary

This section shall provide a summary of the MUSIC modelling including modelling parameters and assumptions. This should include:

- Climate data used – reference or other (station, period and timestep) with explanation and justification where climate data other than the relevant reference data is used
- Catchment (source node) parameters:
    - Area
    - Impervious fraction and corresponding assumptions and calculations
    - Soil parameters
    - Pollutant concentrations
- Treatment parameters.
- Routing parameters and corresponding assumptions and calculations (if used).

Where default or standard guideline parameters (e.g. pollutant concentrations for urban or roof) are used, a simple statement to this effect may be used.

Where parameters vary from these guidelines, an explanation and justification should be provided for consideration by the relevant authority. The following considerations should be taken into account by both proponents and authorities regarding proposed variations:

- Does the variation follow a “precautionary principle” approach, erring on the side of ensuring adequate protection of the environment where there is uncertainty?
- Is the variation likely to result in a more realistic representation of “real-world” conditions; is it consistent with independent or well-established science and is it reasonable?
- Is the guideline parameter value or range a requirement or recommendation? Requirements should only be varied in clear and exceptional circumstances; recommendations may be varied more readily where there is a clear reason and there is mutual agreement on the approach.
- Is the variation applied consistently across the model? For example, if roof concentrations are used, then corresponding general and road concentrations should also be used where appropriate.
- Is the variation appropriate for the specific context of the site?
- Is the level of detail justified given the level of effort being put into other model parameters? For example, refinements to improve the accuracy of the impervious fraction and use of appropriate asset depths, areas and volumes (and considering batters) are usually far more critical (and should receive more attention) than less sensitive soil and treatment parameters like initial storages and the number of CSTRs.

Acceptance of any variations shall be entirely at the discretion of the relevant authority. Where appropriate, authorities may seek to obtain a review or advice from an independent third party.

Performance reporting

The modelled treatment performance shall be reported. This should include:

- Overall treatment performance including consideration of site pollutant loads and treatment train pollutant load reductions.
- Treatment performance (mean annual loads) of individual stormwater treatment assets.
- Calculations for site pollutant loads, pollutant load reductions and external catchments where relevant.

9.2.2 MUSIC model

A copy of the latest version of the MUSIC model, preferably in *.sqz format, corresponding to the report shall be provided.

If a *.msf file is provided instead, a copy of the climate template in *.mlb format shall also be provided.

A copy of the corresponding summary report file (*.mrt) should also be provided.

9.2.3 Audit report

An audit report for the latest version of the MUSIC model should be generated and provided (see Section 9.3 below).

9.2.4 Plans

The following plans should typically be provided:

- Catchment and drainage plan clearly showing catchments for all treatments, untreated areas and external catchments as well as drainage and connections to and from stormwater treatment assets and to legal point of discharge.
- Asset plans indicating dimensions of assets and clearly showing inlet, outlet and overflow arrangements.

9.3 Compliance tools and checks

9.3.1 Use of MUSIC Auditor

A web-based auditor tool has been developed to assist relevant authorities in reviewing MUSIC models. The MUSIC Auditor checks the parameter inputs to MUSIC models to ensure they comply with relevant guidelines and are within expected or reasonable ranges. The MUSIC Auditor is intended for use by suitably experienced professionals with an understanding of WSUD and the MUSIC software.

The MUSIC Auditor is free for anyone to use within South Australia and can be accessed using the following website: http://www.musicauditor.com.au/.

The auditor will highlight any differences between the model and pre-defined local parameters, flag where parameters may be different to common or expected values or ranges, and provide guiding notes to help an assessor decide whether the proposed parameter value is appropriate and acceptable or not. It is expected most assessment authorities will rely on these guidelines. Development planning proponents should use the auditor to self-assess their models prior to lodging a development application. This will allow the proponent to understand whether any aspect of their modelling is inconsistent with expected parameters and, if necessary, amend modelling practice or provide suitable justification for using alternative parameters when lodging development applications.

In addition to the use of the MUSIC Auditor, an assessor should undertake appropriate checks on the design including but not limited to:

- Design
- Achievement of other WSUD objectives
- Spatial areas and asset footprints
- Civil design and drainage
- Maintenance management and access
- Landscape integration
- Vegetation

The following steps provide a guide to using the MUSIC Auditor:

Step 1: From within MUSIC, export a MUSIC Summary file (*.mrt) which can be uploaded to the web-based MUSIC Auditor, see Figure 9.4.

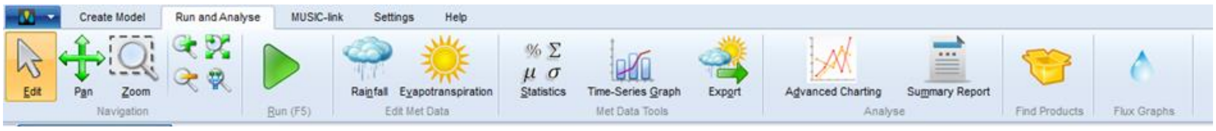


Figure 9.4 Menu showing button to generate a summary report

Step 2: Open the MUSIC Auditor website at: http://www.musicauditor.com.au/ and login (or register and login), see Figure 9.5.

Step 3: Click on "MUSIC Auditor" and select the appropriate authority (South Australia) and guidelines, see Figure 9.6.

Step 4: Click "Browse" and choose the summary report file (*.mrt) then press "Submit".

Step 5: Review the results and consider whether any proposed variations are appropriate and adequately justified; see Figure 9.7 for an example report.

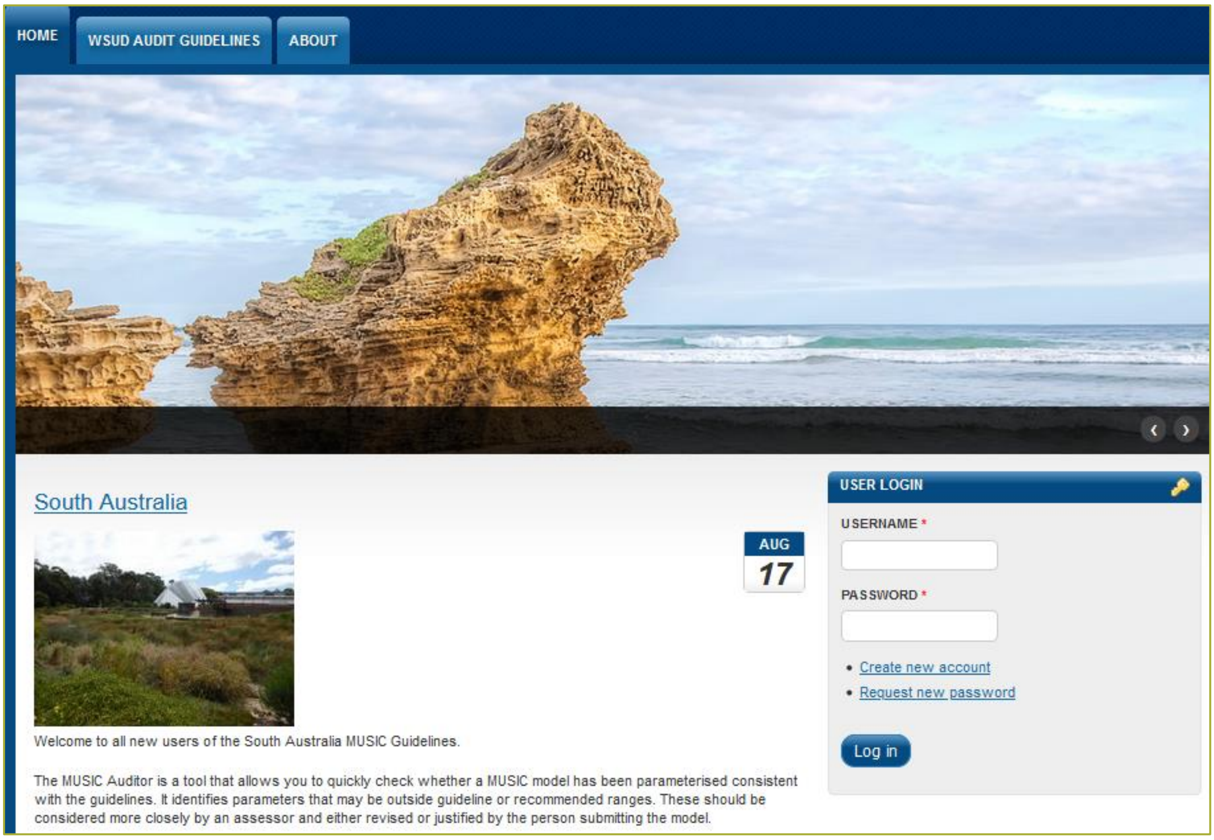


Figure 9.5 MUSIC Auditor home page and login

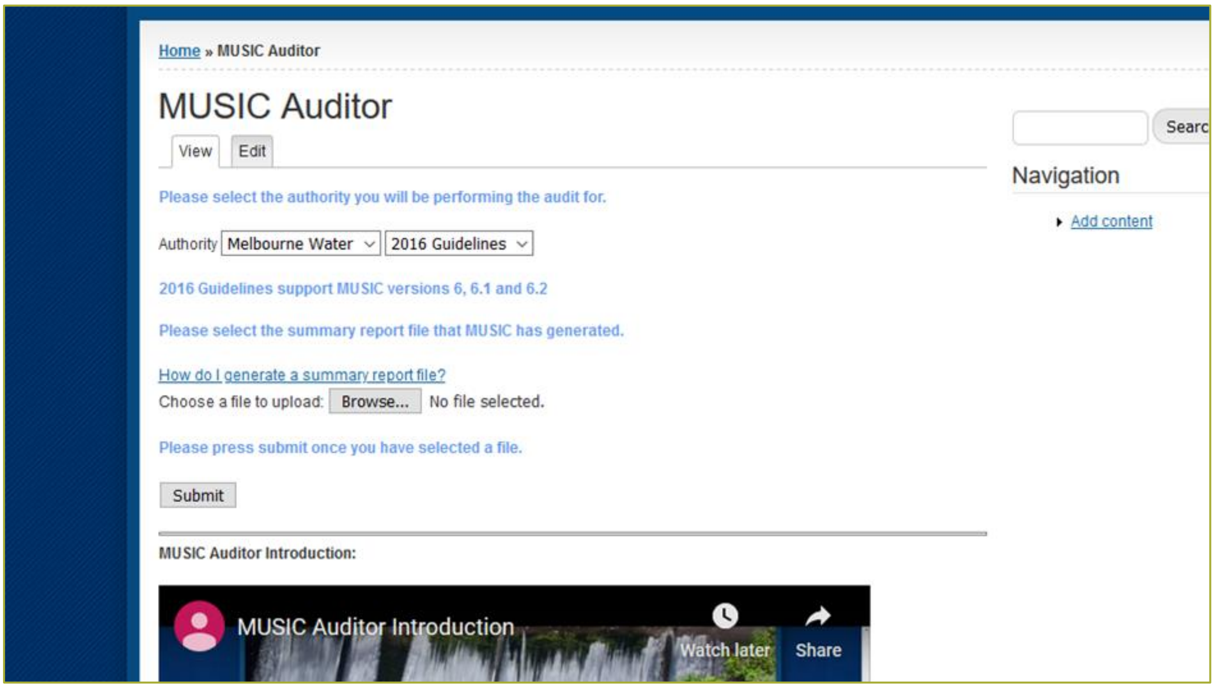


Figure 9.6 MUSIC Auditor page to select authority and submit a summary report file

WATER SENSITIVE SA

Date Completed: 17-08-2
MUSIC Guideline Audited: 2020 Guidelin
MUSIC Version Audited: 6.2 or 6.
Filename i
AdelaideDry_ParafieldAirport_1979-1988_6min_Wetland.m

PDF Downloa

Source Nodes				
Parameter	User Input	Check	Guideline	Comments
Urban (Node 1) Music Help				
Total Area (ha)	1	=	1	Check catchment area correct, default adopted.
Field Capacity (mm)	80	not equal	30	Use of 30 mm recommended in SA MUSIC guidelines based on reference to eWater MUSIC manual and consideration of limited calibrations by Goyder Institute. Variations should be justified and preferably based on a calibrated model representative of the catchment, soils and climate of the area of interest
Soil Storage Capacity (mm)	120	not equal	40	Use of 40 mm recommended in SA MUSIC guidelines based on reference to eWater MUSIC manual and consideration of limited calibrations by Goyder Institute. Variations should be justified and preferably based on a calibrated model representative of the catchment, soils and climate of the area of interest FAQ

Treatment Nodes				
Parameter	User Input	Check	Guideline	Comments
Wetland 1 (Node 2) Music Help				
Overflow weir width (m)	1.8	<	10	Warning - check is large enough to ensure wetland can overflow freely, if not may result in system filling to unrealistic depths. FAQ
Rainwater Tank (Node 6) Music Help				
Annual Demand Value (ML/year)	0.575	not equal		Check reuse demands are justified and reasonable.
Open water pond (Node 12) Music Help				
Extended detention depth (m)	0.01	<	0.2	Shallow average depth. FAQ
Overflow weir width (m)	7	<	10	Warning - check is large enough to ensure pond can overflow freely, if not may result in system filling to unrealistic depths. FAQ
Bioretention (Node 15) Music Help				
Is Submerged Zone Present?	Yes	not equal	No	Advisory only. This system has a submerged zone. Review design to ensure this is appropriate and that there is pre-treatment or adequate sizing to minimise clogging risks. Submerged zones are most useful in dryer areas to ensure water is available for plants. It is recommended that the submerged zone is at least 0.3m deep and no more than 0.5m deep as depths greater than the rooting zone can potentially increase leaching of phosphorus from the submerged zone.

Catchment Details				
Parameter	User Input	Check	Guideline	Comments
Node AdelaideDry_ParafieldAirport_1979-1988_6min_Wetland does not have any errors. (Node 6 Minutes)				

Figure 9.7 MUSIC Auditor typical summary report

10 Glossary

The following summarises key terms used in these guidelines. The MUSIC Users Manual (MUSIC Documentation and Help) as revised contains definitions for all input parameters for nodes.

Bioretention – A system of vegetation and layered filter media that captures, retains and treats stormwater before slowly releasing it to receiving waterways.

C* – The background pollutant concentration or asymptote that pollutant concentrations will approach used in USTM (see definition of USTM below).

Daily recharge rate (%) – Percentage of water stored above field capacity allowed to recharge from soil moisture storage to groundwater storage.

Daily baseflow rate (%) – Percentage of water stored in groundwater storage allowed to discharge as baseflow (flows to downstream node).

Daily seepage rate (%) – Percentage of water stored in groundwater storage allowed to recharge deep groundwater (lost from model).

Evapotranspiration – The loss of water to the atmosphere through the combined processes of evaporation (i.e. the transfer of water from the land to the atmosphere) and transpiration (i.e. the transfer of water from plants to the atmosphere).

Exfiltration – The process by which water flows from a treatment into the surrounding soil (technically soil infiltration).

Extended detention depth – The active water ponding depth above the filter media surface or normal water level of a stormwater treatment.

Field capacity (mm) – Field capacity of soil moisture store, the depth that can be stored before groundwater recharge starts to occur.

Filter media – Soil media that retains pollutants as stormwater passes through it.

Gross pollutants traps (GPTs) – Structures that use physical processes to trap solid waste such as litter and coarse sediment.

Impervious surface – Surfaces that do not allow natural infiltration of rainfall to the underlying soil, thereby increasing the volume and peak flow rate of surface runoff.

Infiltration – The process by which surface water enters the filter media in a treatment.

Infiltration capacity coefficient (mm) – Maximum infiltration loss into soil before infiltration excess runoff begins to occur.

Infiltration capacity exponent – Infiltration loss equation exponent.

k – Decay parameter used in first order decay equation in USTM (see definition of USTM below).

MUSIC – Model for Urban Stormwater Improvement Conceptualisation, a stormwater modelling software tool available through eWater used for modelling water sensitive urban design including the planning and conceptual design of stormwater management assets.

Normal water level – The water level of the lowest outlet on a wetland, pond or tank to which it will drain by gravity. Water levels may drop below this through infiltration or evapotranspiration.

Permanent pool volume – The volume of water stored within a wetland, pond or tank below the normal water level.

Raingarden or **rain garden** – Generally a streetscape-scale or lot-scale bioretention installation.

Receiving environment – The (typically) natural environment into which water flows. This includes waterways (streams, creeks, rivers, estuaries), wetlands, lakes, groundwater, bays and the ocean.

Saturated hydraulic conductivity – The ease with which water moves through a porous media such as a filter media or soil when it is saturated.

Saturated zone – An area beneath or adjacent to a bioretention filter media designed to hold water.

Soil moisture store capacity (mm) – The depth that can be stored before saturation excess runoff starts to occur.

Universal Stormwater Treatment Model (**USTM)** – Name given to general modelling approach in MUSIC to represent stormwater treatments including representation of flows and storage through treatment (hydrology), flow hydrodynamics and pollutant concentration reductions represented using a first order decay equation or k-–C* equation.

Water sensitive urban design (WSUD) – An approach to urban planning and design that integrates the management of the total water cycle into the land use and development process.

11 References and resources

Further information regarding South Australia Environment Protection and WSUD Policies can be found in the following references:

- Planning, Development and Infrastructure Act 2016 https://www.legislation.sa.gov.au/LZ/C/A/PLANNING%20DEVELOPMENT%20AND%20INFRASTRUCTURE%20ACT%202016.aspx
- Environment Protection Act 1993 https://www.legislation.sa.gov.au/LZ/C/A/Environment%20Protection%20Act%201993.aspx
- Environment Protection (Water Quality) Policy 2015 https://www.epa.sa.gov.au/data_and_publications/standards_and_laws/environment_protection_water_quality_policy
- Department of Environment, Water and Natural Resources (2013). *Water sensitive urban design – Creating more liveable and water sensitive cities in South Australia*, http://www.environment.sa.gov.au/files/sharedassets/public/water/water-sensitive-urban-design-policy-gen.pdf
- Department for Environment and Water website https://www.environment.sa.gov.au/Home

Key WSUD and MUSIC Guidelines for users in South Australia include:

- Department of Planning and Local Government (2009). Water Sensitive Urban Design Technical Manual for WSUD for the Greater Adelaide Region, Government of South Australia, Adelaide: https://www.sa.gov.au/topics/planning-and-property/land-and-property-development/planning-professionals/water-sensitive-urban-design
- Water Sensitive SA (2020). South Australia MUSIC Guidelines (this document)
- Water Sensitive SA (2016). A guide to raingarden plant selection and placement – https://www.watersensitivesa.com/raingarden-plant-selection-and-placement-fact-sheet/

Specific references for stormwater harvesting schemes include:

- Natural Resource Management Ministerial Council, Environment Protection and Heritage Council and National Health and Medical Research Council (2009). Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Stormwater Harvesting and Reuse
- Department for Health and Ageing (2012). South Australian Recycled Water Guidelines, Department for Health and Ageing, Adelaide https://www.sahealth.sa.gov.au/wps/wcm/connect/public+content/sa+health+internet/resources/policies/south+australian+recycled+water+guidelines

There are many other excellent WSUD references and design guidelines that may be of interest. These include:

- eWater (2019). MUSIC by eWater, User Manual https://wiki.ewater.org.au/display/MD6/MUSIC+Version+6+Documentation+and+Help+Home
- Melbourne Water (2018). MUSIC Guidelines, Melbourne, Victoria https://www.melbournewater.com.au/media/4806/download
- Healthy Land and Water (2018). MUSIC Modelling Guidelines, Brisbane, Queensland https://hlw.org.au/download/music-modelling-guidelines/
- CRCWSC (2015). Adoption Guidelines for Biofiltration Systems https://watersensitivecities.org.au/content/stormwater-biofilter-design/
- Melbourne Water (2014). Constructed Wetlands Design Manual, Melbourne, Victoria https://www.melbournewater.com.au/planning-and-building/developer-guides-and-resources/standards-and-specifications/constructed-0
- Melbourne Water (2019). Draft Bioretention Design Guide, Melbourne, Victoria

- Healthy Land and Water (2014). Bioretention Technical Design Guidelines, Brisbane, Queensland https://hlw.org.au/download/bioretention-technical-design-guidelines/
- Healthy Land and Water (2017). Wetland Technical Design Guidelines, Brisbane, Queensland https://hlw.org.au/download/wetland-technical-design-guidelines/
- Melbourne Water (2005). WSUD Engineering Procedures: Stormwater, Melbourne, Victoria
- Engineers Australia (2007). Australian Runoff Quality

Water use demand:

- Arbon, N., Thyer. M., Hatton MacDonald, D, Beverley, K., Lambert, M (2014). *Understanding and Predicting Household Water Use for Adelaide*, Goyder Institute for Water Research Technical Report Series No. 14/15, Adelaide, South Australia.

Impervious fractions:

- Ball, J., Babister, M., Nathan, R., Weeks, W., Weinmann, E., Retallick, M., & Testoni, I. (2019). *Australian Rainfall and Runoff: A Guide to Flood Estimation.* Commonwealth of Australia. Retrieved from http://arr.ga.gov.au/arr-guideline
- Dotto, C., Deletic, A., Fletcher, T., & McCarthy, D. (2009). Parameter Sensitivity Analysis of Stormwater Models. *Towards Water Sensitive Cities and Citizens: The 6th International Water Sensitive Urban Design Conference and Hydrolopolis #3*. Perth.
- Fletcher, T. (2007). *Background study for the revision of Melbourne Water's MUSIC input parameter guidelines*. Unpublished.
- Myers, B., Pezzaniti, D., Kemp, D., Chavoshi, S., Montazeri, M., Sharma, A., Hewa, G. (2014). *Water sensitive urban design impediments and potential: contributions to the Urban Water Blueprint (Phase 1) Task 3: The potential role of WSUD in urban service provision*. Adelaide, South Australia: Goyder Institute for Water Research.

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Arbon, N., M., T., Hatton MacDonald, D., Beverley, K., & Lambert, M. (2014). *Understanding and Predicting Household Water Use for Adelaide.* Adelaide, South Australia: Goyder Institute for Water Research.

Ball, J., Babister, M., Nathan, R., Weeks, W., Weinmann, E., Retallick, M., & Testoni, I. (2019). *Australian Rainfall and Runoff: A Guide to Flood Estimation.* Commonwealth of Australia. Retrieved from http://arr.ga.gov.au/arr-guideline

Burge, K., Browne, D., Breen, P., & Wingad, J. (2012). Water Sensitive Urban Design in a changing climate: estimating the performance of WSUD treatment measures under various climate change scenarios.

DELWP. (2016). Guidelines for Assessing the Impact of Climate Change on Water Supplies in Victoria. Melbourne: The State of Victoria Department of Environment, Land Water and Planning 2016.

Department of Environment Water, and Natural Resources. (2013). *Water sensitive urban design - Creating more liveable and water sensitive cities in South Australia.* Department of Environment Water, and Natural Resources, Adelaide.

Dotto, C., Deletic, A., Fletcher, T., & McCarthy, D. (2009). Parameter Sensitivity Analysis of Stormwater Models. *Towards Water Sensitive Cities and Citizens: The 6th International Water Sensitive Urban Design Conference and Hydrolopolis #3.* Perth.

eWater. (2018). *MUSIC Version 6 Documentation and Help.* Canberra: eWater. Retrieved from https://wiki.ewater.org.au/display/MD6/MUSIC+Version+6+Documentation+and+Help+Home

Fletcher, T. (2007). *Background Study for the Revision of Melbourne Water's MUSIC Input Parameter Guidelines.* Unpublished.

Fletcher, T. D., Duncan, H. P., Poelsma, P., & Lloyd, S. D. (2005). *Stormwater flow and quality, and the effectiveness of non-proprietary stormwater treatment measures - a review and gap analysis.* Melbourne: Cooperative Research Centre for Catchment Hydrology.

Healthy Land and Water. (2018). *Healthy Land and Water (2018) MUSIC Modelling Guidelines.* Brisbane, Queensland: Healthy Land and Water Limited.

IECA. (2008). *Best Practice Erosion and Sediment Control.* IECA.

Jamali, B., Bach, P. M., & Deletic, A. (2019). A cellular automata fast flood evaluation (CA-ffe) model. Coffs Harbour: Stormwater NSW.

Macleod, A. (2008). MUSIC Calibration Based on Soil Conditions. *Stormwater 08* (pp. 80-92). Surfers Paradise, QLD: Stormwater NSW & QLD Industry Association.

Myers, B., Cook, S., Pezzaniti, D., Kemp, D., & Newland, P. (n.d.). *Implementing Water Sensitive Urban Design in Stormwater Management Plans.* Adelaide, South Australia: Goyder Institute for Water Research Technical Report Series No 16/7.

Myers, B., Pezzaniti, D., Kemp, D., Chavoshi, S., Montazeri, M., Sharma, A., . . . Hewa, G. (2014). *Water Sensitive Urban Design Impediments and Potential: Contributions to the Urban Water Blueprint (Phase 1) Task 3: The Potential Role of WSUD in Urban Service Provision.* Adelaide, South Australia: Goyder Institute for Water Research.

NRMMC, EPHC and NHMRC. (2009). *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) - Stormwater harvesting and reuse.* Natural Resource Management Ministerial Council, Environment Protection and Heritage Council, National Health and Medical Research Council.

Payne, E., Hatt, B., Deletic, A., Dobbie, M., McCarthy, D., & Chandrasena, G. (2015). *Adoption Guidelines for Stormwater Biofiltration Systems.* Melbourne: Cooperative Research Centre for Water Sensitive Cities.

SA EPA. (2015). *South Australia Environment Protection (Water Quality) Policy 2015 under the Environment Protection Act 1993.* Adelaide: South Australia Environment Protection Authority.

Sydney Catchment Authority. (2012). *Using MUSIC in Sydney's Drinking Water Catchment.* Penrith: Sydney Catchment Authority.

Zhang, K., Manuelpillaia, D., Raut, B., Deletic, A., & Bach, P. M. (2018). Evaluating the reliability of stormwater treatment systems under various future climate conditions. *Journal of Hydrology*, 57-66.

Appendix 1: EIA example calculation

A method for determining EIA for developed catchments smaller than around 10 hectares, where accurate details of the drainage system is known, is to estimate the proportion of impervious surfaces that are effectively connected to the drainage system. An example estimate of effective imperviousness for a small catchment is provided in Figure 12.1 below with calculations in Table 12.1.

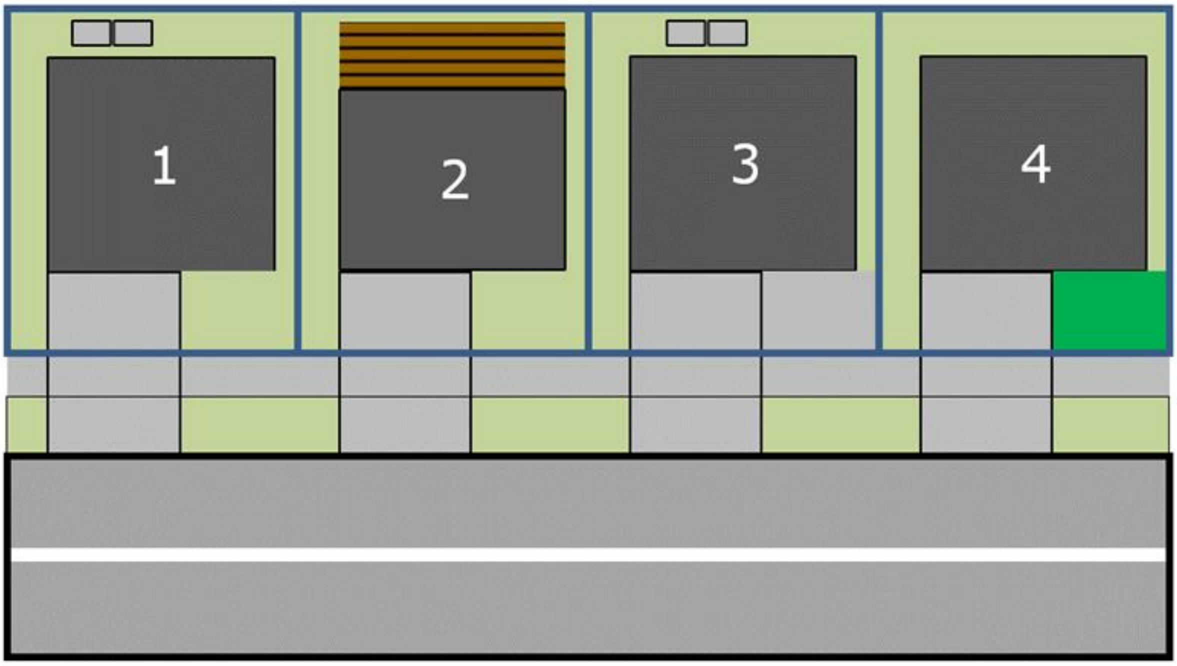

Figure 12.1 Impervious fraction calculation example

Property 1 has a 15 m^2 paved area in the back yard that drains to an equivalent area of surrounding grass, not directly connected to the drainage system.

Property 2 has an uncovered wooden deck in the back yard that allows rainwater to fall through to the ground below. This deck is not counted as an impervious surface.

Property 3 has an additional paved area in the front yard connected to the drainage system and a 15 m^2 paved area in the backyard that drains to an equivalent area of surrounding grass, not directly connected to the drainage system.

Property 4 has synthetic grass in the front yard that connects to the drainage system.

Table 12.1 Effective impervious area calculation example

Total area	3,000 m^2
Impervious area directly connected	
All roofs	744 m^2
Road	933 m^2
Driveways	387 m^2
Footpath	104 m^2
House 4 synthetic turf	38 m^2
House 3 additional front yard paving	38 m^2
Impervious area not directly connected	
House 1 & 3 backyard paving	30 m^2
Total impervious fraction = (744 + 933 + 387 + 104 + 38 + 38 + 30) ÷ 3,000	76%
Effective impervious fraction (**to be used in MUSIC**) = (744 + 933 + 387 + 104 + 38 + 38) ÷ 3,000	**75%**

Note – All impervious areas that drain to WSUD features, such as the rainwater tank in this example, must be counted in the effective impervious fraction.

Note: If the catchment of interest is already fully developed, an alternate approach for determining EIA may be through calibration using rainfall and flow data for a drain or waterway. However, usually this is not possible.

Appendix 2: Pollutant concentrations

Pollutant concentrations for urban stormwater vary spatially and temporally and are influenced by geology, climate, surface type, land use, and activity type within each land use, as well as by a range of potential contaminant sources. Most available monitoring studies are for waterways with large and heterogeneous catchments. Studies for smaller catchments with more homogenous surfaces and/or land uses exist but these can also be influenced by the specific characteristics of the catchment monitored.

A wide range of pollutants is found in stormwater, including sediment, nutrients, heavy metals, hydrocarbons, pathogens and others. The range of pollutants and observed concentrations are documented in a range of sources. These include broad meta-analyses:

- Brisbane City Council, (2004) *Stormwater Quality Monitoring Program 2002/2003 Final*, October 2004. Water & Environment, City Design
- Duncan (1999) *Urban stormwater quality: A statistical overview*
- Engineers Australia (2006) *Australian Runoff Quality: A guide to water sensitive urban design*
- Fletcher et. al. (2004) *Stormwater flow and quality, and the effectiveness of non-proprietary stormwater treatment measures – A review and gap analysis*
- Fletcher (2007) *Background study for the revision of Melbourne Water's MUSIC Input Parameter Guidelines*
- Pitt, R., Maestre, A., Clary, J. (2015) *National Stormwater Quality Database (NSQD)*, Version 4.02.

The following monitoring studies were identified with locally relevant data for South Australia:

- Fleming N., Cox J., He, Y., Thomas, S., Fritzenschaf, J. (2010) Analysis of Constituent Concentrations in the Mount Lofty Ranges for Modelling Purposes

There are also several more recent studies containing data from other states:

Victoria

- Francey (2010)
- Taylor, Fletcher, Wong, Breen & Duncan (2005)
- Hatt, Fletcher & Deletic (2009)
- GHD and EPA Victoria (1981)

Queensland:

- Drapper and Lucke (2015) *Characterisation of stormwater in Southeast Queensland*
- Liu (2011) *Influence of rainfall and catchment characteristics on urban stormwater quality*
- Lucke, Drapper & Hornbuckle (2018) *Urban stormwater characterisation and nitrogen composition from lot-scale catchments — New management implications*

Surface types

The data indicate that pollutant concentrations are significantly different for surface types including road and roof, relative to general or typical urban concentrations. This is particularly significant for total suspended solids. It is therefore recommended that support for modelling of split surface types is provided for the following surface types:

- Roads
- Roofs
- General

Land uses

Based on a review of pollutant concentrations we challenge the common view that pollutant concentrations are significantly different across broad urban land uses such as residential, commercial and industrial as the data do not strongly support this view, and several researchers have observed that land use does not appear to be an effective explanatory variable for pollutant concentration (Duncan, 1999, Liu, 2011). Where differences have been demonstrated, these are usually for road and open space land uses relative to the above. Given the limited data available we instead recommend adopting a general data set for urban land uses.

Range of pollutants for modelling

The pollutants that have been most extensively monitored and have the largest datasets available include:

- Total suspended solids
- Total phosphorus
- Total nitrogen

Most modelling of stormwater in Australia focusses on these common pollutants where predictions can be made with greater confidence drawing on a larger underlying monitored data set.

It is considered that this is a reasonable approach for typical urban catchments. Pollutants in stormwater may be particulate or bound to sediment (as is the case for a proportion of heavy metals) or they may be dissolved, such as nitrogen. Therefore, if a treatment train can effectively manage both total suspended solids and nitrogen, it is likely to be effective for a wide range of other pollutants amenable to treatment. In this way, total suspended solids and total nitrogen are used as surrogates for a broad range of pollutants. This simplifies modelling for the majority of use cases for typical urban development and catchments.

At this time, continued adoption of this approach for typical urban developments and catchments is recommended.

However, it is important to recognise that stormwater pollutants are more complex and certain surface types, land uses or activity (e.g. business, industry) types may produce higher concentrations of some pollutants. Where a study is focussing on an area with surface types, land uses or activity types that are known to be likely to generate higher concentrations of certain pollutants, this should also be taken into consideration in the design process. This may involve, for example, identifying other pollutants likely to be of concern and checking that the selected treatment responses are known to be effective for removing these or providing additional treatment to address specific risks.

Research into stormwater pollutant concentrations for specific activity types is continuing and improved information supporting more sophisticated consideration of the expected range of pollutants is likely to be available in the future.

Consideration may also be given to the receiving waters and anticipated uses of stormwater. Pollutants such as heavy metals and pesticides are important for considering impacts on receiving waters while pathogens may be more important for stormwater reuse systems.

For stormwater reuse, a risk-based approach to management should be pursued consistent with the Australian Guidelines for Water Recycling: Stormwater Harvesting and Reuse (NRMMC, EPHC and NHMRC, 2009), in addition to modelling in MUSIC. Pathogens will be a key focus and consideration may also need to be given to other potential pollutants. It is recognised that WSUD assets can remove some pathogens and also help deliver more consistent water quality but there are challenges in consistently treating pathogens. As such, a treatment train including both WSUD and additional treatment assets or controls is usually appropriate to ensure stormwater can be reused safely. WSUD treatment to remove sediment to at least best-practice standards can be valuable in protecting downstream treatment and irrigation infrastructure and improve the effectiveness of disinfection measures such as ultraviolet (UV) disinfection. Treatment of sediment and nitrogen to best practice generally requires the use of a range of treatments that will also be effective in removing a broad range of pollutants, both sediment and dissolved. The more consistent water quality allows downstream treatments to be better targeted to mitigate residual risks.

Adopted approach

It is proposed that the stormwater pollutant concentrations adopted for use in MUSIC should consider:

- Locally relevant monitored data from South Australia.
- Key principles and learnings that can be derived from the literature including studies conducted locally and elsewhere.
- Outcomes of meta-analyses.
- Other Australian or international data, preferably with similar climate, geology, urban form and conditions.

Taking into consideration the available local data it was considered there were insufficient data and consistency within it to rely solely on local South Australian data to establish new pollutant concentrations. There is also no study solely considering Australian data or a filtered set of world-wide data with comparable conditions at this time. Key principles proposed to be adopted include:

- Differentiation of pollutant concentrations based on surface types.
- No differentiation of pollutant concentrations based on land use [see note].
- Adoption of pollutant concentrations based on a broad global dataset.

Note: It is recommended that this may be given further consideration for specific sites considered of high risk such as predominantly existing industrial catchments (new developments should employ structural separation of work areas from stormwater) or major roads.

While this approach is proposed, it is noted that recent studies such as Francey (2010) and Fleming (2010) suggest lower pollutant concentrations than indicated by the global data sets, particularly total suspended solids. The reasons for this are not entirely clear but the locations, catchment scale and potentially methods for sampling are likely to have an influence. It is not considered that there is clear evidence for pollutant concentrations either reducing over time or being lower in Australia than other parts of the world. Any update to reflect reduced concentrations should occur simultaneous with a review of best practice requirements for consistency of assumptions.

Recommendations were made for adoption of interim parameters referencing Fletcher (2004) and Fletcher (2007) values with a more in-depth studies needed to determine pollutant concentrations to support a broader range and differentiation of surface types and land uses. These are summarised in Section 4.4.

Appendix 3: Model calibration

Calibration may involve hydrologic calibration to observed flow data, water quality calibration to observed water quality or calibration.

Hydrologic calibration

Calibration to local data should be undertaken if good quality data sets are available.

The impervious fraction will usually be the dominant parameter for urbanised catchments. As a first step, the EIA or directly connected impervious area of a catchment should be calculated and used if data are available, as this will provide a better estimate of overall flow volumes than the more conservative total impervious fraction. The impervious fraction can be further adjusted to best match the observed mean annual flow volumes.

Most urban developments have a relatively high impervious fraction. For these, the influence of the soil parameters and corresponding pervious area runoff are usually relatively small. This means that while calibration of the soil parameters is desirable where possible, they will have lesser influence on model outcomes. It would be highly desirable for more calibrated models for urban areas to be developed given the relative paucity of peer-reviewed calibrations to confirm model parameters suitable for urban areas.

For largely rural, natural or waterway catchments with lower impervious fractions (e.g. up to 20–30%), the influence of the soil parameters is greater and it becomes critical in these cases that the soil parameters are calibrated.

Consideration should be given to specific soil conditions (e.g. freely draining coastal soils) or treatment approaches that may be affected by baseflows (such as on-line wetlands) where calibration or further investigation to more accurately represent soil and groundwater flow conditions are warranted.

When undertaking calibration care is needed when:

- Selecting suitable data sets,
- Analysing catchment characteristics,
- Determining the period of calibration,
- Verifying and validating the calibrated model,
- Selecting the objective functions used for assessment, and
- Transferring the parameters to ungauged catchments.

The impact of hydrologic calibration on the predictive capability of the water quality model shall be considered. It may impact treatment sizing, event responses and compliance with mean annual pollutant load performance objectives. Where calibration is undertaken and revised source node parameters are used in development applications, a full calibration report outlining responses to these issues should be provided to relevant authorities. The relevant authority will decide if the revised parameters are suitable and acceptable.

Water quality calibration

Water quality calibration would usually include hydrologic calibration. Additionally, it would include adjustment of pollutant concentrations to match observed data. Generally, stormwater pollutant concentrations are set based on observed stormwater quality for flows generated from catchments. These should ideally be based on data from stormwater drains rather than data taken within waterways which may be subject to attenuation processes through the waterway itself.

Treatment node calibration

The MUSIC manual outlines the process undertaken to calibrate the model for various treatment nodes. Where monitored data are available this may potentially be repeated to obtain an improved local or general basis for the treatment parameters adopted.

It is important that N_{CSTR}, k and C* are calibrated together with selection of an appropriate value for N_{CSTR} as a prerequisite for calibrating k and C*.

Where:

- N_{CSTR} is the number of CSTRs or Continuously Stirred Tank Reactors used in the USTM or Universal Stormwater Treatment Model
- C* – The background pollutant concentration or asymptote that pollutant concentrations will approach used in USTM
- k – decay parameter used in first order decay equation in USTM

It would be highly desirable for additional calibrations to be undertaken to build the knowledge base supporting MUSIC.

Appendix 4: Navigating Nature Maps

Following are instructions on how to navigate Nature Maps to access the most detailed soils information in agricultural areas outside of the metropolitan area.

- Click on the green “Start using Nature Maps” button.
- Select “Switch to Layer View”.
- Check-select the Soils menu and expand it by clicking the +.
- Expand the Soil Type Attributes menu by clicking the + next to it, but do not select the check box just yet.
- Select the check box next to “Land Systems”.
- Click on your location of interest on the map. A polygon will be highlighted and a Land System name and code will pop up in the information box.
- Click on “Land System Report” in the information box. This will open a PDF with all the information for that land system unit, including descriptions for each “Soil Landscape Unit”.
- Back in the map, select the check box next to “Soil Type Attributes” and then select the check box next to “Soil Landscape Units”.
- You may have to zoom the map out a little for the layer to appear.
- You can adjust the transparency slider next to the Soils menu heading to see the topographic/ street map under the Soil Landscape Unit layer.
- You can then click-select points of interest on the map to be shown more details of individual Soil Landscape Unit (SLU) polygons. You can then cross-refer the SLUs you find in the map with the SLU description in the Land System Report pdf.