WATER SENSITIVE URBAN DESIGN

STORMWATER QUALITY MODELLING GUIDE

FINAL

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Table of Contents

1 INTRODUCTION

As part of preparing a WSUD Strategy, stormwater quality modelling is required to quantify stormwater pollutant loads and test management measures to reduce pollutant loads in line with the stormwater quality targets. The sizing of stormwater treatment measures can be refined using a stormwater quality model.

1.1 Purpose of this Document

This document has been developed as part of Task 16 (Stage 6) of the Workplan. It is intended as a guide for developers, consultants, local councils, the Development Consent Authority (DCA) and the Department of Planning and Infrastructure (DPI) on undertaking stormwater quality modelling. This document accompanies the "WSUD Planning Guide", "Site Assessment Guide" and "WSUD Practice Guide" to form a set of guidelines on preparing a WSUD Strategy for a development application. The framework of guideline documents is shown in Figure 1.
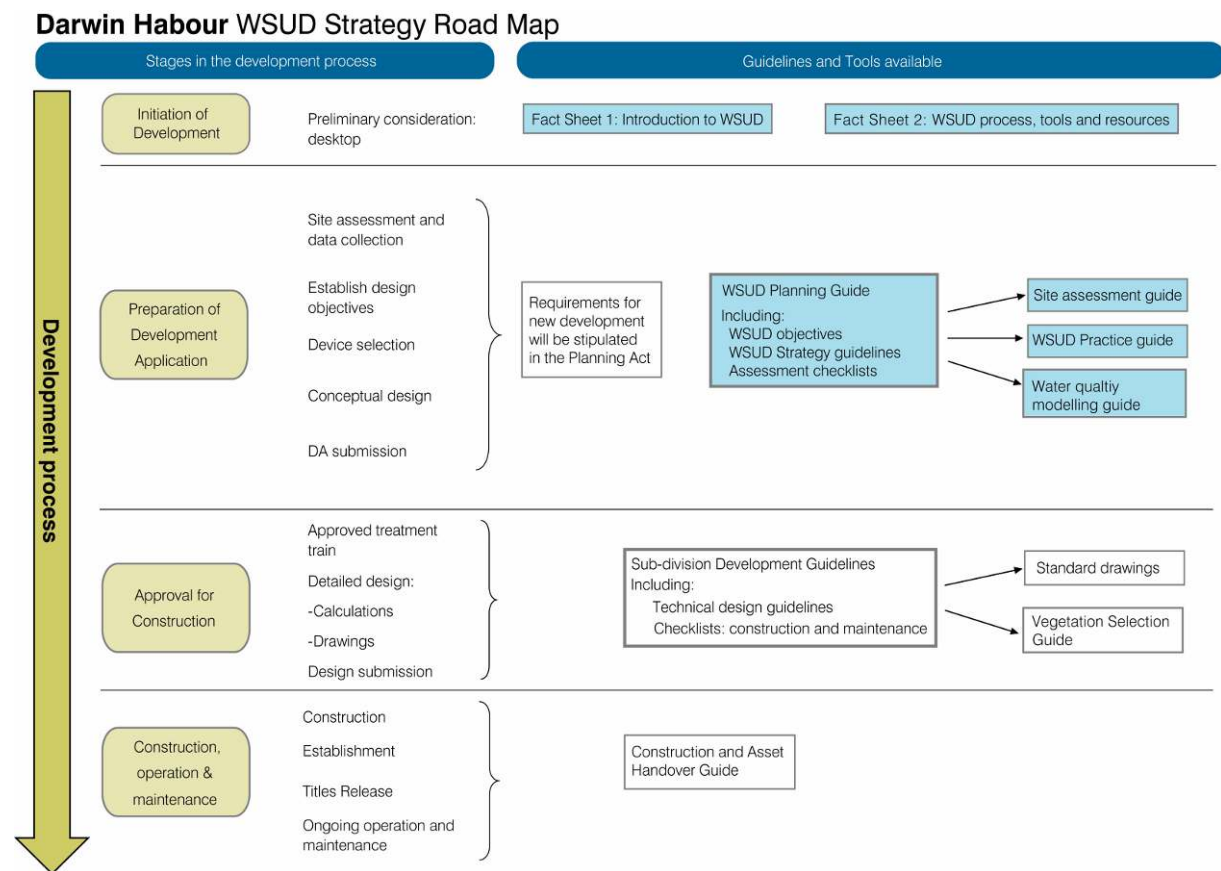
Figure 1: Relationship of the "Stormwater Quality Modelling Guide" to other guidelines and tools

This document explains how to undertake stormwater quality modelling for a typical WSUD Strategy for a subdivision development, including:

- Data inputs

- Model set up

- Extracting relevant results

1.2   Outline of this Document

This document is organised into the following sections:

- Section 2 is an introduction to stormwater quality modelling, including its purposes and key considerations in undertaking stormwater quality modelling

- Section 3 introduces the MUSIC model, which has become the industry standard tool for stormwater quality modelling in Australia and is also used overseas

- Section 4 recommends interim MUSIC model parameters to be used in Darwin (until additional local data is available)

- Section 5 is a guide to using the MUSIC model in the Darwin Region using the local parameters recommended in Section 4

2 STORMWATER QUALITY MODELLING

Stormwater quality modelling allows simulation of key water quality processes in catchments and treatment systems and has become an important part of catchment management and urban stormwater quality planning and design.

A typical stormwater quality model allows the simulation of key stormwater pollutants such as suspended solids and nutrients. Stormwater quality models have been designed to simulate:

- Pollutant loads generated in the catchment

- Concentrations and loads in stormwater runoff

- Pollutant removal in stormwater treatment systems

- Loads exported to receiving waters

Receiving water quality models also exist, to simulate processes that occur within rivers, lakes and estuaries when there is a stormwater input.

Models can range from a simple spreadsheet to a software package; the focus in this document is on software packages with the capability to simulate the performance of stormwater treatment measures.

2.1 Purpose of Stormwater Quality Modelling

Urban stormwater systems are complex and the properties of stormwater runoff are difficult to predict. Some of the key aspects to this complexity are:

- Urban catchments include multiple land uses and an extensive drainage network

- Every rainfall event is different

- Stormwater pollutant loads in stormwater are highly non-linear; pollutant loads depend partly on antecedent conditions but are also stochastic in nature

- There are typically a wide range of alternative management options

- Stormwater treatment performance depends on a large number of variables including the season, antecedent rainfall and individual storm pattern

Computer models can capture much of this complexity, and therefore allow complex catchments to be studied and management measures to be tested.

While the primary focus of stormwater quality modelling is on pollutant loads and the pollutant removal performance of treatment measures, stormwater quality models can contribute to analysis of other important issues:

- Life cycle costs of management measures

- Risk analysis

- Ecosystem response

2.2 Modelling Considerations

Key considerations in selecting an appropriate model and undertaking stormwater quality modelling are as follows:

- **Runoff quality and quantity**: stormwater quality models need to be able to make an accurate prediction of both stormwater quality and quantity. Estimation of pollutant loads requires knowledge of both pollutant concentrations in stormwater and total stormwater volumes.

- **Spatial and temporal scale**: stormwater quality models need to be able to simulate processes from the catchment scale to individual treatment systems. Within a treatment system, pollutant removal processes occur over short time periods (e.g. minutes to hours) and therefore the modelling timestep needs to be short enough to capture these processes. The total period of simulated needs to be long enough to capture a wide range of storm events and provide a representative result.

- **Data requirements**: stormwater quality modelling requires local rainfall data, catchment data, pollutant export data, treatment system performance data and calibration data. Local information should be used wherever possible, although local information may not be available in all cases.

2.3 Stormwater Quality Models

Australian Runoff Quality (Wong, 2006) identifies a number of types of stormwater quality models, according to their model structure and function. The range of options is outlined in Table 1. Some of the modelling packages most commonly used in Australia are:

- **MUSIC**: MUSIC is a planning and conceptual design tool. It can be used to estimate stormwater pollutant loads that will be generated in a catchment, predict the performance of stormwater treatment measures, develop a stormwater management strategy for a catchment and estimate life cycle costs for stormwater treatment systems.

- **XP-AQUALM**: XP-AQUALM is a planning tool. It allows assessment of the effects of land use changes and alternative catchment management practices. It can be used to estimate preliminary life cycle costs.

- **E2**: E2 is a whole-of-catchment planning tool. It is normally applied on a regional scale for pollutant load estimation and prioritisation of management actions. E2 is useful for understanding where pollutants originate in a catchment, how they are transported to receiving waters, and how pollutant loads are modified by management actions.

- **XP-SWMM**: XP-SWMM is a planning and conceptual design tool. It is a combined hydrology, hydraulics, wastewater and stormwater quality model and therefore has a wide range of applications.

- **AQUACYCLE**: Aquacycle is a planning tool. It allows urban water cycle scenario modelling, including water supply, wastewater and stormwater. Alternative water servicing schemes can be compared and their performance evaluated in terms of water volumes.

- **SWITCH**: SWITCH2 is a design tool for infiltration systems, rainwater tanks, grass swales, bioretention systems and sand filters.

At the WSUD Strategy stage, a tool that allows subdivision-scale planning and conceptual design is ideal. MUSIC has become the most commonly applied model for this purpose in Australia. MUSIC is discussed in more detail in Section 3.

Table 1: Stormwater quality modelling options

| Aspect	Options			Recommendation
Modelling period	*Event-based* models simulate single rainfall events, normally design events	*Continuous simulation* models simulate a long rainfall data series, which may cover months or years.		Continuous simulation is preferred, as it is better able to approximate the range of conditions which may be encountered in reality, and to simulate cumulative and long-term impacts on receiving waters.
Modelling approach	*Empirical* models relate runoff quality and quantity directly to catchment and rainfall parameters, without modelling the various processes occurring. Sizing curves presented in the Practice Guide are essentially an empirical model	*Conceptual* models use interlinked storage and process components to represent the system. Parameters usually need to be determined through calibration and verification. MUSIC is a conceptual model	*Process-based* models use fundamental equations to represent the system. The model parameters have a direct physical meaning and can be measured in the field.	Empirical models are simple to use and require relatively little data input. Process based models are complex and require significant data input. For the purposes of sizing stormwater treatment measures as part of a WSUD Strategy, conceptual models represent a good balance between simplicity and accuracy.
Spatial resolution	*Spatially-lumped* models use a single set of parameters to represent the whole catchment	*Distributed* models divide the catchment into a series of smaller subcatchments, each having different properties.		Distributed models are able to represent heterogeneity within a catchment and provide a more accurate result. Most modelling packages allow the model set up to be either spatially lumped or distributed, and the model set up can be refined over time as more information is available to define the properties in a distributed set up.
Parameter type	*Deterministic* models always produce the same results for a given set of input parameters	*Stochastic* models contain one or more parameters with random behaviour, usually with a statistical distribution. Stochastic models may include both deterministic and probabilistic components. Stochastic models do not always produce the same results for a given set of input parameters		Stochastic models allow more realistic simulation of parameters such as pollutant concentrations in runoff, which are log-normally distributed when measured in the field.
Purpose	*Planning* models are normally used to compare the outcomes of different management options for a catchment	*Design* models are normally used to optimise the size and configuration of stormwater treatment measures for to achieve best practice pollutant removal performance	*Operational* models are normally used to optimise the performance of stormwater drainage and wastewater networks once they are operational	All three types of models are important at different stages.

3   THE MUSIC MODEL

MUSIC has been designed to help evaluate concept designs for stormwater management systems at the planning and conceptual design stage. It has been used in NSW, Queensland, Victoria, South Australia and Western Australia , and has enough flexibility in the choice of parameters so that it can be adapted to local conditions anywhere. This section discusses the parameters included in the MUSIC model, the data available in Darwin and potential sources of future data to improve the application of MUSIC in the Darwin Region.

3.1   Rainfall-Runoff Simulation

MUSIC includes a rainfall-runoff model, which relies on the following parameters:

- **Rainfall data**: suitable rainfall data is available in the Darwin Region, with approximately 50 years of 6-minute pluviograph rainfall data available from Darwin Airport meteorology station.

- **Catchment data**: catchment data (area and impervious fraction) can be estimated for any new or existing development

- **Soil parameters**: pervious area losses are modelled in MUSIC with a soil storage model as shown in Figure 2. Several soil parameters need to be specified in the model. These can be estimated from field tests and can be refined in the model calibration process. The MUSIC User Guide also recommends some initial values suitable for Darwin.
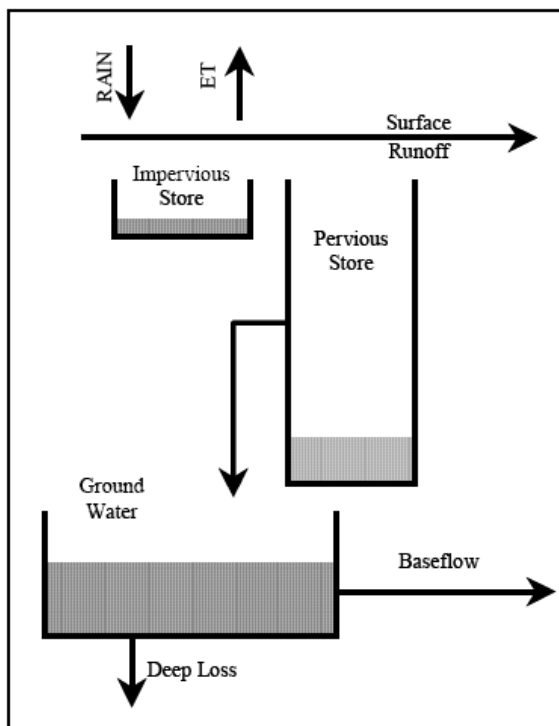
Soil parameters:

- Rainfall Threshold (mm)
- Soil Capacity (mm)
- Initial Storage (%)
- Field Capacity
- Infiltration Capacity Coefficients a and b
- Initial Depth (mm)
- Daily Recharge Rate (%)
- Daily Baseflow Rate (%)
- Deep Seepage (%)

Figure 2: MUSIC rainfall runoff model and key parameters

3.2   Pollutant Load Simulation

MUSIC models pollutants using stochastically generated event mean concentrations (EMCs). An example of the MUSIC's pollutant data page is shown in Figure 3. Baseflow and stormflow EMCs are entered separately. The EMCs are log-normally distributed, therefore it is necessary to specify a mean and standard deviation for each pollutant. MUSIC is set up with default parameters for total suspended solids (TSS), total phosphorus (TP) and total nitrogen (TN). The default parameters are derived from a comprehensive review of stormwater quality monitored in urban catchments (Duncan 1999).
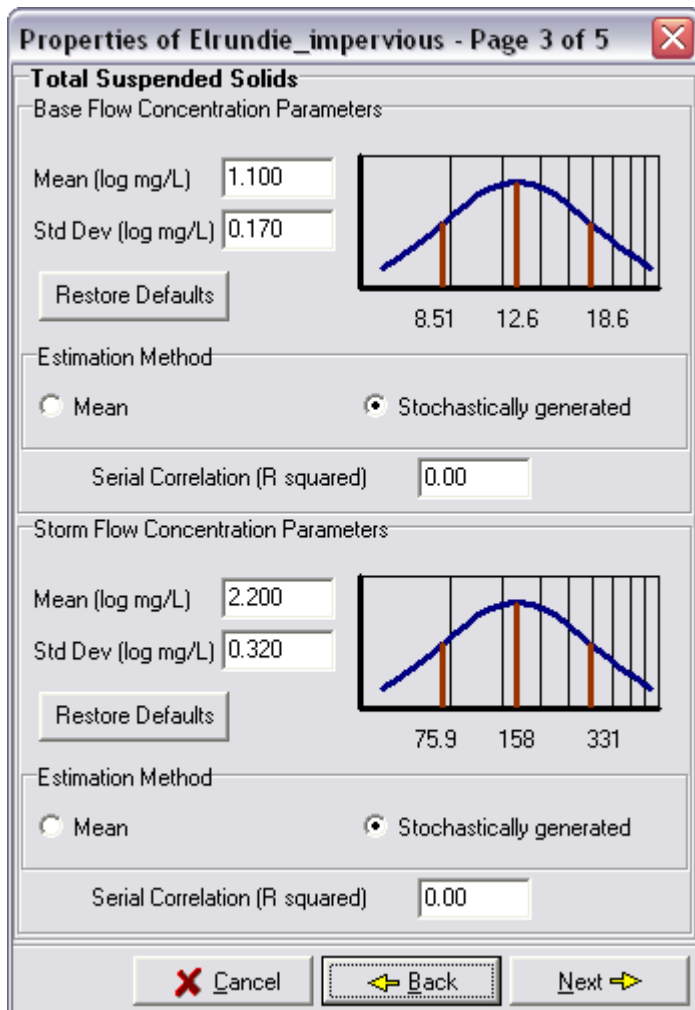
Figure 3: Example pollutant data in MUSIC

Australian Runoff Quality (Wong (Ed) 2006) includes a summary of the pollutant data from Duncan (1999) including:

- EMC mean and standard deviation values for additional pollutants, including metals, organic pollutants and pathogens.

- EMC mean and standard deviation values for a range of different catchment types, including roads, roofs, residential areas, commercial areas, industrial areas, rural and forested catchments (where data is available).

Further, some local monitoring has been undertaken in the Darwin Region to measure pollutant loads from urban catchments. This is published in Padovan (2001a and b, 2002) and Kernohan and Townsend (2000).

Additional local monitoring data will improve the application of MUSIC in the Darwin region.

3.3 Treatment Nodes

Stormwater treatment nodes in MUSIC use the "Universal Stormwater Treatment Model" (USTM) to simulate pollutant load reduction in stormwater treatment measures. The USTM uses both a hydrologic routing algorithm and a first order kinetic model to simulate pollutant transport and removal.

The first order kinetic model uses two key parameters to describe pollutant removal: k and C*. C* is the equilibrium value or background concentration, and k is the exponential rate constant.

Default k and C* values have been built into the MUSIC model. However where local data is available (e.g. from monitoring stormwater treatment devices), this can be entered in place of the default values. When stormwater treatment measures are monitored in Darwin, this will provide relevant local data that can be used in the MUSIC model for an improved representation of local conditions.

3.4   Model Calibration

Wherever possible, MUSIC should be calibrated to local conditions using local data. Elements of the model that should be calibrated are:

1. **The rainfall-runoff model**, which can be calibrated by modifying the soil parameters to reflect local values. It is assumed that the catchment area and impervious fraction are known. MUSIC should be calibrated to observed flow data over a given period.

2. **Pollutant parameters** can be calibrated where data is available. MUSIC results would need to be calibrated against continuous monitoring of pollutant loads from urban catchment/s (i.e. concentration and flow data would be required) over a given period. Total loads could be used as a check.

3. **Stormwater treatment parameters** can also be calibrated where data is available.   MUSIC results would need to be calibrated against continuous monitoring of pollutants upstream and downstream of stormwater treatment measures, for a period covering a large set of rainfall events.

Data requirements for calibration can be onerous, however the task of calibrating MUSIC for use in the Darwin Region is a task that could be undertaken over many years as WSUD becomes more widespread and monitoring data gradually becomes available. It is recommended that calibration should proceed in the order outlined above (i.e. the rainfall-runoff model should be calibrated first, followed by the pollutant parameters then the stormwater treatment parameters) for the best results.

4   RECOMMENDATIONS

Recent developments in urban stormwater quality modelling software have resulted in a significant advancement in the ability to simulate the pollutant removal efficiency of a range of stormwater treatment devices configured to form stormwater treatment trains. Specifically, MUSIC now provides stormwater practitioners with a state of the art model. MUSIC can be used by designers, consultants, developers and councils to:

- Undertake conceptual design (size, configuration, depths) of stormwater treatment elements

- Where required, undertake storage modelling to establish the size of rainwater tanks and stormwater storages

- Estimate life cycle costs for stormwater treatment measures

At this stage, despite the current lack of local parameters, it is recommended that MUSIC should be adopted for use in the Darwin Region.   MUSIC is capable of providing initial estimates of the performance of stormwater treatment measures, and it can gradually be calibrated to local conditions as WSUD becomes more widespread in the Darwin Region.

A set of MUSIC modelling guidelines for the Darwin Region have been provided in Section 5.   These guidelines should be refined as MUSIC is calibrated to local conditions. They form a suitable starting point for consultants preparing WSUD Strategies for new subdivision development now, as they need to undertake water quality modelling as part of the WSUD Strategy.

5 MUSIC MODELLING GUIDELINES FOR THE DARWIN REGION

These guidelines are provided to ensure consultants, developers and councils have a consistent and uniform approach to stormwater quality and harvesting modelling within the Darwin Region. These guidelines are provided to allow practitioners to conceptualise stormwater treatment systems to meet the objectives of the Darwin Harbour WSUD Strategy. The guidelines provide specific guidance on rainfall and evaporation inputs, source node selection, rainfall runoff parameters, pollutant generation parameters, stormwater treatment nodes and stormwater storage nodes. Any MUSIC models that are not consistent with the MUSIC guidelines should justify the differences in parameters and/or assessment methods.

These guidelines are an adaptation of the Gold Coast City Council MUSIC Modelling Guidelines and should be read in combination with the MUSIC User Guide (MUSIC Development Team, 2005), which outlines all the definitions, assumptions and methodologies provided within the MUSIC tool. These guidelines are not intended to replace the MUSIC User Guide, but to provide additional information on its application to stormwater quality modelling for subdivision development in the Darwin Region.

5.1 MUSIC model setup

There are several steps to be undertaken prior to running a MUSIC model network, as summarised in Figure 4. These steps include:

- Selection of appropriate meteorological data (rainfall and evaporation inputs);

- Defining catchment areas (source nodes) to be incorporated into the model;

- Input of soil properties (rainfall runoff properties); and

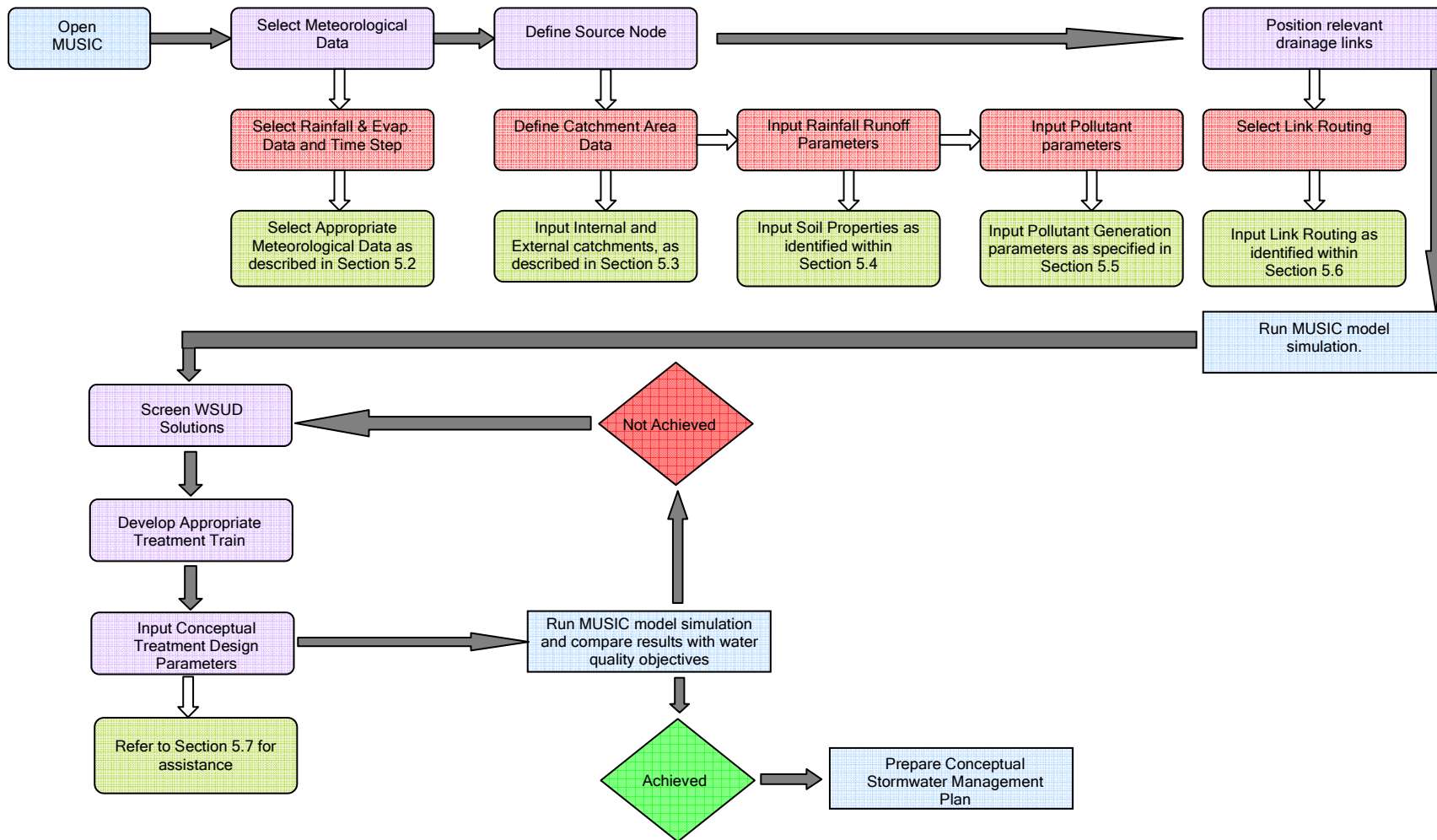- Input of pollutant generation characteristics for selected source nodes.

Figure 4: Schematic of MUSIC modelling process (adapted from the Gold Coast City Council MUSIC Guidelines)

5.2 Rainfall & evaporation inputs

Stormwater runoff (represented as surface runoff and baseflow) is generated in MUSIC through the interaction of rainfall, evapotranspiration and the MUSIC Rainfall-Runoff Model (see MUSIC User Guide for full description of Rainfall-Runoff Model). The following sections outline the preferred rainfall and evapotranspiration datasets to be used when undertaking stormwater quality and quantity modelling in the Darwin Region.

5.2.1 Rainfall Data for Water Quality Modelling

When undertaking stormwater quality modelling, the following approach is recommended:

- Continuous simulation of a minimum of 10 years should be used; and

- A six (6) minute time step is to be utilised as this allows for the appropriate definition of storm hydrograph movement through small-scale stormwater treatment processes such as vegetated swales and bioretention systems.

6-minute rainfall data is available from Darwin Airport (Bureau of Meteorology Station 014015) from September 1953. The period 1987-1996 is recommended as a representative period. This recommendation is presented in Table 2.

Table 2: Recommended rainfall data for stormwater quality modelling

Station	Recommended period
014015 Darwin Airport	1 Jan 1987 – 31 Dec 1996

5.2.2 Rainfall Data for Stormwater Quantity Modelling (Rainwater Tanks and Stormwater Harvesting)

For the purposes of stormwater quantity modelling (e.g. for rainwater tank sizing or stormwater harvesting and reuse analysis), the following approach is recommended:

- Continuous simulation of a minimum of 50 years should be used; and

- A daily time step should be used

Twenty rain gauges in the Darwin region were examined for data quality and length of record. Four of these gauges were selected, based on continuity and location, in order to assess the spatial distribution of rainfall over the Darwin region. Four rainfall stations were chosen along an east-west gradient with approximately 20 km spacing between all the stations. A common 35 year period of rainfall data was used to calculate the average precipitation and number of raindays per month for each gauge and is summarised in Figure 5.

As is shown in Figure 5, differences between the rainfall gauges are minimal. There were minor differences in monthly precipitation and the variation in the number of raindays was greatest during the wet season (December to March). Therefore the spatial distribution of rainfall is relatively uniform over this spatial range. For the purpose of sizing rainwater tanks and conceptual design of stormwater reuse schemes in the Darwin region it is possible to use one rainfall station to accurately estimate reuse reliability. The Darwin Airport station is recommended due to its central location within the study area and the high data continuity of this record. This recommendation is presented in Table 3.
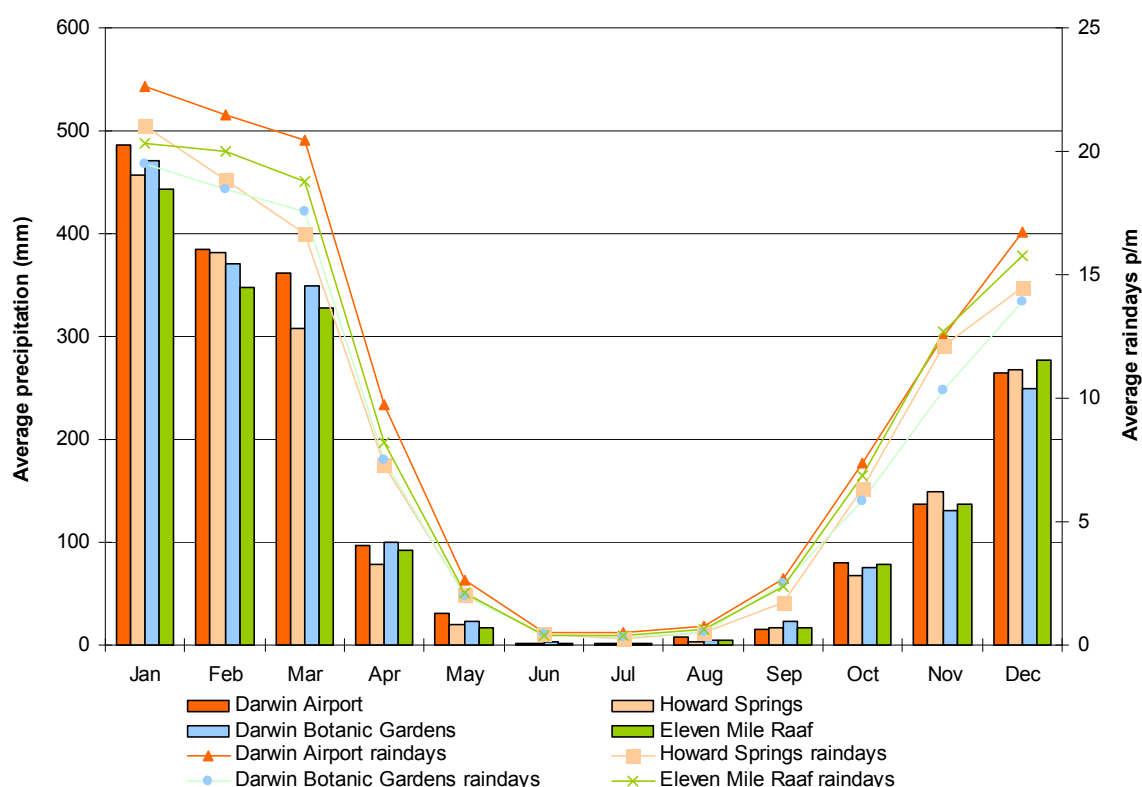
Figure 5 Rain gauge comparison for average monthly precipitation (mm) and number of raindays per month

Table 3: Recommended rainfall data for stormwater quality modelling

Station	Recommended period
014015 Darwin Airport	1941-2006

5.2.3 Potential Evapotranspiration Data

Local potential evapotranspiration data for Darwin is available within the MUSIC model and is shown in Table 4.

Table 4: Monthly Potential Evapotranspiration (PET) for Darwin Region

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PET (mm)	199.95	159.88	217	180	158.1	129.9	137.02	155	176.1	212.97	201.9	213.9

5.3 Source Nodes

Once the meteorological data has been input into the model the user must then define the source nodes to reflect the details (i.e. area, landuse) of the contributing catchments. MUSIC Version 3 currently has five land uses:

- Forest;

- Agricultural;

- Urban;

- User Defined; and

- Imported Data.

Source Nodes for Darwin catchments are defined below:

- The <u>Urban Source Node</u> in MUSIC is used to describe low to high density residential, retail, and commercial areas. These areas comprise private allotments together with all associated facilities, such as roads, parks, school grounds, etc.

- The <u>Agricultural Source Node</u> refers to areas of large scale cropping or grazing. This node should be used for low density rural areas situated in predominantly agricultural settings. Otherwise residential areas are to use the Urban Source Node.

- The <u>Forested Source Node</u> is to be used for natural bushland areas. This node is to be utilised in areas where canopy densities are greater than 50%.

- The <u>Imported Data Source Nodes</u> are required when modelling pervious areas, in order to separate surface and baseflows. This is discussed further below.

The steps for setting up source node data include:

1. Set area and impervious fraction (see Section 5.3.1)

2. Input soil parameters (see Section 5.3.2)

3. Input pollutant generation parameters (see Section 5.3.3)

5.3.1 Area and land use

Each individual Source Node, with the exception of the Imported Data Node, requires the total area and impervious fraction to be defined. The impervious area for future development can be estimated on the basis of building density controls such as minimum soft landscaping area, maximum building envelopes, floor space ratios and road design guidelines. These estimates should also be compared to aerial photos of similar recent developments in the vicinity of the proposed development. Where differences between the estimates and the on ground impervious area are significant then estimates should be revised or the differences justified.

It is recommended that in urban areas, pervious and impervious areas should be modelled as separate source nodes. It is also good practice to separate urban impervious areas into different types (e.g. roads, roofs, other paved areas). When utilising this approach, the pollutant generation rates should be varied according to land use. Section 5.3.3 includes pollutant generation rates for roads, roofs and "general urban" areas. The "general urban" parameters should be used for pervious areas and paved areas (other than roads).

It is also recommended that pervious areas should be modelled so as to separate surface and baseflows. While impervious areas only allow surface runoff, pervious areas allow some infiltration which contributes to baseflows. Surface flows are treated in stormwater treatment systems, while baseflows bypass stormwater treatment systems.

An example MUSIC model setup is provided in Figure 6 below. The catchment includes:

- A total of 20.75 ha impervious area, including roads, roofs and other impervious surfaces.

- A total of 31.48 ha pervious area
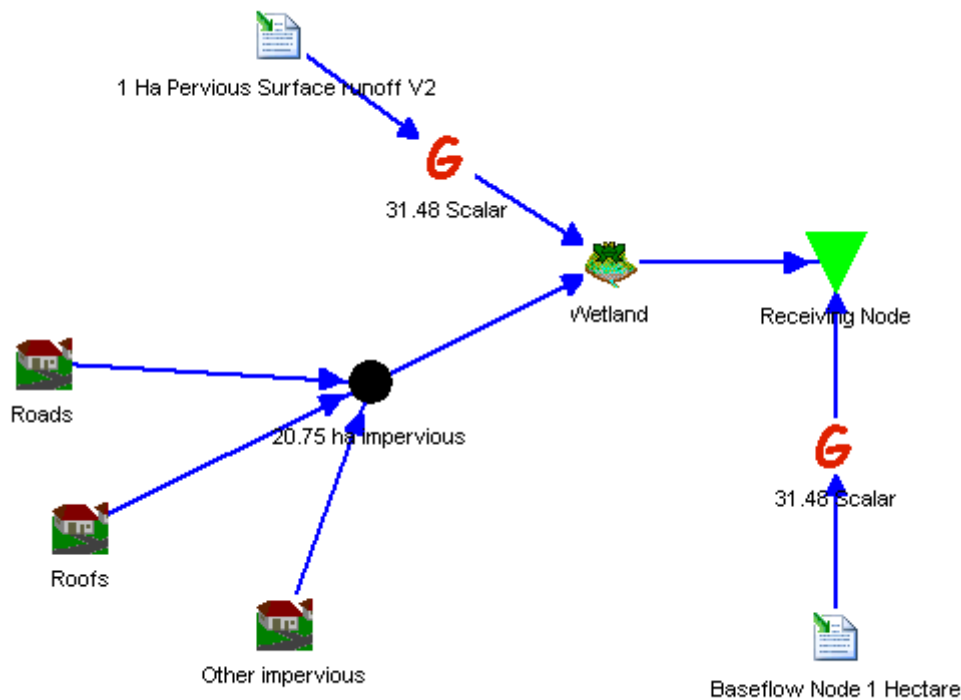
Figure 6: Example MUSIC model setup including surface and baseflow separation

If baseflows are not separated from surface flows as in Figure 6, then it is recommended that pervious area runoff should bypass stormwater treatment systems. This is a conservative approach for stormwater treatment system sizing.

5.3.2 Rainfall runoff parameters

As outlined in Section 5.2, stormwater runoff (represented as storm flow and baseflow) is generated in MUSIC through the interaction of rainfall, evapotranspiration and the MUSIC Rainfall-Runoff Model[1].

MUSIC rainfall-runoff parameters recommended for Darwin are shown in Table 5. These are the parameters recommended in the MUSIC User Guide.

Table 5: Soil Characteristics

Parameter	Recommended value
Rainfall Threshold (mm)	1
Soil Capacity (mm)	300
Initial Storage (%)	30
Field Capacity	250

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[1] A full description of the MUSIC Rainfall-Runoff Model is provided in the MUSIC User Guide. If the reader of this document has no MUSIC modelling experience they should review Appendix A of the User Guide before reading below.

Parameter	Recommended value
Infiltration Capacity Coefficient a	200
Infiltration Capacity Coefficient b	1
Initial Depth (mm)	10
Daily Recharge Rate (%)	25
Daily Baseflow Rate (%)	5
Deep Seepage (%)	0

5.3.3 Pollutant generation

As outlined in the MUSIC User Guide, a comprehensive review of stormwater quality in urban catchments was undertaken by Duncan (1999) and this review forms the basis for the default values of event mean concentrations in MUSIC for TSS, TP and TN. More recently, Fletcher et al (2004) has updated the values provided in Duncan (1999) and specifically provides guidance on appropriate land type breakdown. Table 6 presents the recommended model defaults for various land use categories. Note that TN is consistent across each urban land use as TN is substantially influenced by atmospheric deposition.

Table 6: Stormwater Water Quality Parameters for MUSIC Source Nodes

Land-use category		Log10 TSS (mg/L)		Log10 TP (mg/L)		Log10 TN(mg/L)	
		Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow
Forest	Mean	1.90	0.9	-1.10	-1.5	-0.075	-0.14
	Std Dev	0.20	0.13	0.22	0.13	0.24	0.13
Agriculture	Mean	2.30	1.40	-0.27	-0.88	0.59	0.074
	Std Dev	0.31	0.13	0.30	0.13	0.26	0.13
Roof Areas	Mean	1.55	1.1	-0.92	-0.82	0.42	0.32
	Std Dev	0.39	0.17	0.29	0.19	0.19	0.12
Road Reserves	Mean	2.38	1.1	-0.6	-0.82	0.42	0.32
	Std Dev	0.4	0.17	0.5	0.19	0.19	0.12
General Urban	Mean	2.2	1.1	-0.45	-0.82	0.42	0.32
	Std Dev	0.32	0.17	0.25	0.19	0.19	0.12

Note: For all simulations the MUSIC model must be run with pollutant export estimation method set to "stochastic generated".

5.4 Link routing

For all MUSIC model simulations it is recommended that the channel routing option in MUSIC be set to "No Routing" as this is the most conservative modelling scenario. Routing may be used to reflect the travel time for flood wave propagation through the catchment, however any use of routing must be supplemented with justification of the selection of the method of routing (translation only method or Muskingham-Cunge method) and the values used in routing. The user is referred to the MUSIC User Guide for further details.

5.5 Stormwater quality treatment nodes

Stormwater quality treatment will be required to meet the stormwater quality objectives for Darwin Harbour. The MUSIC model can be used to develop an appropriate treatment train for the development dependent on site constraints and opportunities.

Within the current version of MUSIC (3.01) there are several treatment options available:

- Wetland;
- Pond;
- Sedimentation Basin;
- Infiltration Basin;
- Gross Pollutant Trap;
- Buffer;
- Bio-Retention;
- Swale;
- Rainwater Tank; and
- Generic Node.

The default parameters in MUSIC for the first order decay $k \cdot c^*$ model used to define the treatment efficiency of each treatment device should be used unless local relevant treatment performance monitoring can be used as reasonable justification for modification of the default parameters. Reference should be made to the MUSIC User Guide.

Note: The following devices are not to be modelled within the MUSIC program: natural waterways, natural wetlands, naturalised channel systems, environmental buffers and natural lake/pond systems.

5.5.1 Wetland

Constructed wetland systems use enhanced sedimentation, fine filtration and pollutant uptake processes to remove pollutants from stormwater. Constructed wetland systems consist of an inlet zone (sediment basin to remove coarse sediments), a macrophyte zone (a shallow heavily vegetated area to remove fine particulates and uptake of soluble pollutants) and a high flow bypass channel (to protect the macrophyte zone).

Input Parameters

a) Input the appropriate bypass characteristics to reduce the impacts on macrophytes within the wetland;

b) Calculate the inlet pond volume for capturing sediment (e.g. 125 цm).

e.g. $$\text{Area} = \frac{Q_{3month}}{\text{Settling Velocity of Sediment}}$$

Alternatively an initial estimate of the inlet basin can be used. A reasonable estimate of the initial volume of the inlet pond is 10% of the surface area.

c) Proposed surface area of wetland macrophyte zone;

d) Set extended detention depth of between 0.25-0.75m. Note that any flood storage above the extended detention depth must not be included in the extended detention depth;

Properties of Wetland

Location: Wetland

Inlet Properties
- Low Flow By-Pass (cubic metres per sec): 0.000
- High Flow By-pass (cubic metres per sec): 100.000
- Inlet Pond Volume (cubic metres): 187.5

Storage Properties
- Surface Area (square metres): 2000.0
- Extended Detention Depth (metres): 0.50
- Permanent Pool Volume (cubic metres): 600.0
- Vegetation Cover (% of surface area): 50.0
- Seepage Loss (mm/hr): 0.00
- Evaporative Loss as % of PET: 125.00

Outlet Properties
- Equivalent Pipe Diameter (mm): 48
- Overflow Weir Width (metres): 5.0
- Notional Detention Time (hrs): 73.2

Re-use... | Fluxes... | Notes... | More

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e) The volume of water permanently submerging macrophytes. Set by multiplying the average depth (typically 0.25m to 0.4m) by the surface area;

f) Seepage = water lost from the device into the surrounding soil. Seepage is only appropriate given certain soil conditions and most wetlands should be lined to prevent seepage. When modelling a wetland, seepage losses should generally be set to zero;

g) Adjust the pipe diameter to ensure the device has a notional detention time of approximately 72 hrs.

5.5.2   Sedimentation Basin

Sediment basins are used to retain coarse sediments from runoff. They operate by reducing flow velocities and encouraging sediments to settle out of the water column.

They are frequently used for trapping sediment in runoff during construction activities and for pre-treatment to measures such as wetlands (eg. an inlet pond). They can drain during periods without rainfall and then fill during runoff events. They are sized according to the design storm discharge and the target particle size for trapping (generally 0.125 mm).

Input Parameters

a) Identify any high flow or low flow bypasses proposed for the device;

b) Input the surface area of the basin;

c) Identify the depth between the top of the permanent pool (or ground if no permanent pool) and the lip of the overflow weir;

d) Calculate the permanent volume of water within the device;

e) Seepage = water lost from the device into the surrounding soil. Seepage is only appropriate given certain soil conditions and most sedimentation basins should be lined to prevent seepage. When modelling a sedimentation basin, seepage losses should generally be set to zero;

f) Modify the discharge pipe diameter to ensure a detention time of approximately 1-2 hrs.

Properties of Sedimentation Basin

Location	Sedimentation Basin

Inlet Properties
Low Flow By-pass (cubic metres per sec)	0.000
High Flow By-pass (cubic metres per sec)	100.000

Storage Properties
Surface Area (square metres)	200.0
Extended Detention Depth (metres)	1.00
Permanent Pool Volume (cubic metres)	50.0
Seepage Loss (mm/hr)	0.00
Evaporative Loss as % of PET	75.00

Outlet Properties
Equivalent Pipe Diameter (mm)	150
Overflow Weir Width (metres)	2.0
Notional Detention Time (hrs)	1.06

Re-use...   Fluxes...   Notes...   More

X Cancel   ⇐ Back   ✓ Finish

Note: These devices can be utilised as pre-treatment devices upstream of bioretention devices to allow for a diversion of flows above recommended scour velocities.

5.5.3 Infiltration Basin

Infiltration measures encourage stormwater to infiltrate into surrounding soils. Infiltration measures are highly dependent on local soil characteristics and are best suited to sandy and sandy clay soils with deep groundwater. This allows adequate filtration of stormwater through the soil before reaching the groundwater body. A geotechnical assessment should be undertaken before infiltration is considered at a particular site. Infiltration is not recommended in areas of sodic or saline soils or soil contamination, where infiltration could mobilise salts or contaminants. The "WSUD Practice Guide" includes advice on appropriate use of infiltration systems in the Darwin Region.

Note that infiltration measures should not be used in place of stormwater treatment systems and suitable pre-treatment of stormwater is required prior to entering the infiltration measure. When assessing pollutant removal performance in MUSIC, the water quality objectives should be met upstream of any infiltration system.

Input Parameters

a) Identify surface area of the device;

b) Calculate the depth to the overflow weir of the proposed device; and

c) Establish the infiltration rate based on findings from a geotechnical engineering report or soil percolation test to determine the likely infiltration rate from the device to the surrounding soils.

Note: Provide all supporting information with regard to infiltration in the WSUD Strategy.

Properties of Infiltration System

Location: Infiltration System

Inlet Properties
Low Flow By-pass (cubic metres per sec) — 0.000
High Flow By-pass (cubic metres per sec) — 100.000

Storage Properties
Surface Area (square metres) — 300.0
Depth to Overflow Weir (metres) — 0.50
Infiltration Rate (mm/hr) — 3.60
Evaporative Loss as % of PET — 100.00

Outlet Properties
Overflow Weir Width (metres) — 2.0

Re-use...   Fluxes...   Notes...   More

X Cancel   Back   ✓ Finish

5.5.4 Gross Pollutant Trap

GPTs typically remove rubbish, sediment and hydrocarbons from stormwater runoff. This device can be very effective at removal of solids conveyed within stormwater which are typically larger than 5 mm in size.

Input Parameters

a) Calculate the required high flow bypass for the device. (typically $Q_{3\ month}$);

b) Choose the required pollutant to apply a pollutant reduction to;

c) Modify input and output parameters of chosen pollutant.

Supported Removal Efficiencies:

- TSS Input: 1000
    Output: 500
- TP   Input: 5
    Output: 4
- TN   Input: 50
    Output: 50

Note: in general, GPTs should not be expected to remove any nutrients. Nutrient removal rates stated by manufacturers should only be accepted on the basis of an independent assessment of the chosen device following continuous monitoring of the product for a time frame of three months after an initial storm event. This three month period is to include various documented design events (and include typical stormwater runoff from the chosen land use) to determine whether the device contributes to pollutants discharging from the product due to the potential anaerobic conditions created within the storage sump of the device. No pollutants are to be removed from the device during the assessment of the device to mimic the actual maintenance regime of typical GPTs.
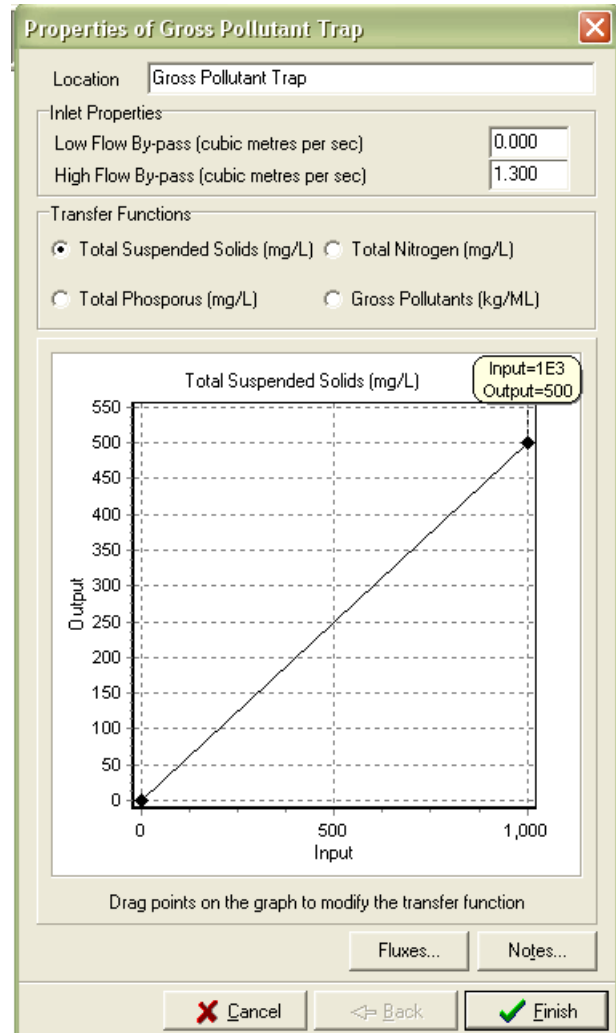
5.5.5 Buffer

Buffer or filter strips, in the context of urban stormwater, are grassed or vegetated areas over which stormwater runoff from adjoining impervious catchments traverses enroute to the stormwater drainage system or receiving environment. Buffer strips are intended to provide discontinuity between impervious surfaces and the drainage system. They take water from impervious surfaces in a distributed manner, promote even flows and filter sediments and coarse pollutants entrained in the runoff. The key to their operation is an even shallow flow over a wide vegetated area. The low hydraulic loading over the vegetation allows flows to filter through the vegetation and pollutants to settle out. They also provide a detention role to slow flows down.

Input Parameters

a) Calculate the percentage of upstream area that shall actually pass over buffer;

b) Calculate the size of the proposed buffer area as a percentage of the upstream catchments impervious area; and

c) Seepage = water lost from the device into the surrounding soil. Seepage is only appropriate given certain soil conditions and most buffers will not allow significant seepage. When modelling a buffer, seepage losses should generally be set to zero.

Properties of Buffer

Location: Buffer

Treatment Properties
Percentage of upstream area buffered (%): 50.0
Buffer Area (% of upstream impervious area): 5.0
Seepage Loss (mm/hr): 0.00

Fluxes... Notes...

Cancel   Back   Finish

Note: Utilise buffer devices upstream of other treatment devices to assist in sediment drop out prior to stormwater entering secondary treatment devices i.e. swales.
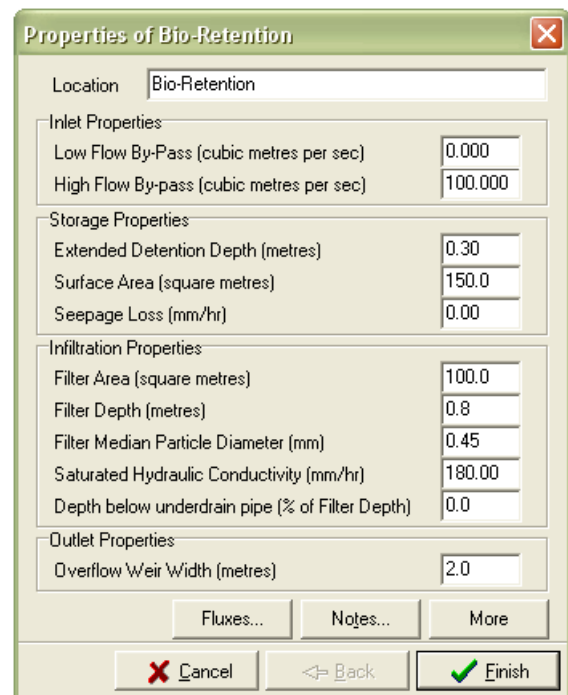
5.5.6 Bioretention

Bioretention systems (also known as biofiltration trenches) are a combination of vegetation and filter substrate that provides treatment of stormwater through filtration, extended detention and some biological uptake.

The systems are designed to accept stormwater runoff and allow it to percolate through the filtration media and then discharge within a drainage layer comprising a system of perforated pipes to ensure the devices are drained adequately. The bioretention systems are to be densely planted out with endemic ground cover, shrubs and plants to promote the feeling of a landscaped form/feature and ensure the conductivity of the filter media is not compromised.

Input Parameters

a) Identify whether a bypass structure shall be included within / upstream of the device to control flows;

b) Identify the ponding depth of stormwater runoff prior to its overflowing the control weir of the device. Depths greater than 0.4 m are not recommended with 0.1-0.3m recommended for plant sustainability and adequate draining times;

c) Provide the estimated surface area of the device based upon site constraints and opportunities;

d) Seepage = water lost from the device into the surrounding soil. Seepage is only appropriate given certain soil conditions and most bioretention systems should be lined to prevent seepage. When modelling a bioretention system, seepage losses should generally be set to zero;

Properties of Bio-Retention

Location: Bio-Retention

Inlet Properties
Low Flow By-Pass (cubic metres per sec): 0.000
High Flow By-pass (cubic metres per sec): 100.000

Storage Properties
Extended Detention Depth (metres): 0.30
Surface Area (square metres): 150.0
Seepage Loss (mm/hr): 0.00

Infiltration Properties
Filter Area (square metres): 100.0
Filter Depth (metres): 0.8
Filter Median Particle Diameter (mm): 0.45
Saturated Hydraulic Conductivity (mm/hr): 180.00
Depth below underdrain pipe (% of Filter Depth): 0.0

Outlet Properties
Overflow Weir Width (metres): 2.0

[Fluxes...] [Notes...] [More]

[✗ Cancel] [⇐ Back] [✓ Finish]

e) Input the surface area of the filter media within the device;

f) Provide the proposed depth of filter media within the device. The following depths are recommended as a minimum within the device: > 0.5 m for rushes and shrubs and > 0.8 m for tree species proposed to ensure adequate area for root growth are provided within the device. This depth does not include the drainage layer;

g) Identify the type of filter media proposed based upon particle size and hydraulic conductivity. A sandy-loam mixture is recommended to provide adequate organic material for vegetation/root yet still has sufficient drainage characteristics;

h) The depth below underdrain pipe is the percentage of filter below the slotted drainage pipe;

Note: When locating bioretention devices ensure the ability of the devices to drain adequately has been assessed. Also ensure the device has sufficient pre treatment bypass flows or contains structures to ensure flows within the device are kept below the scour velocity of the chosen filter media.
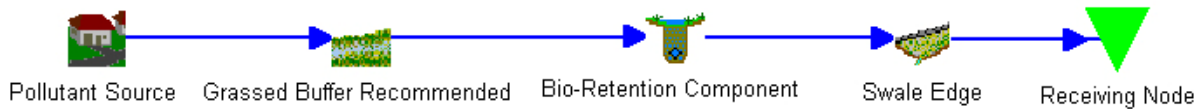
5.5.7   Swale

Vegetated swales are open vegetated channels that can be used as an alternative stormwater conveyance system to conventional kerb and channel along roads and associated underground pipe. The interaction of surface flows with the vegetation in a swale facilitates an even distribution and slowing of flows thus encouraging particulate pollutant settlement. Swales can be incorporated into streetscape designs and can add to the aesthetic character of an area.

Input Parameters

a) Identify the length of the swale based upon location and site constraints;

b) Determine the slope of the swale. Swales with bed slopes > 5% are not recommended as treatment devices as rock check dams are not recommended.   These can be used as conveyance channels if required. Swales with bed slopes < 1% are to incorporate a drainage line within the base of the device;

c) Provide dimensions for the base and top width of the swale.   Ensure side batters are in accordance with requirements of minimum slope of 1:4 (V:H);

Properties of Swale

Location   Swale

Inlet Properties
Low Flow By-Pass (cubic metres per sec)   0.000

Storage Properties
Length (metres)   100.0
Bed Slope (%)   3.00
Base Width (metres)   1.0
Top Width (metres)   5.0
Depth (metres)   0.50
Vegetation Height (metres)   0.250
Seepage Loss (mm/hr)   0.00

Fluxes...   Notes...   More

✗ Cancel   ⇦ Back   ✔ Finish

d) Calculate the depth of the device based upon the base and top width characteristics and identify the height of vegetation within the device and

e) Seepage = water lost from the device into the surrounding soil. Seepage is only appropriate given certain soil conditions and most swales would not allow significant seepage. When modelling a swale, seepage losses should generally be set to zero.

5.5.8 Bioretention Swales

Pollutant Source · Grassed Buffer Recommended · Bio-Retention Component · Swale Edge · Receiving Node

In order to model the proposed treatment efficiency of a bioretention swale within a treatment train, it is recommended that the device should separated into its various components. These are the bioretention filter surface and battered slopes of the grassed channel. The image above depicts a standard layout for incorporating a bioretention swale within a treatment train. It is recommended that the following parameters be utilised within the proposed network:

Input Parameters

Bioretention Component:

a) The device should have no extended detention depth as runoff is anticipated to be conveyed through the device and not ponded to a design depth;

b) Seepage = water lost from the device into the surrounding soil. Seepage is only appropriate given certain soil conditions and most bioretention systems should be lined to prevent seepage. When modelling a bioretention system, seepage losses should generally be set to zero; and

c) The filter media reflect a sandy-loam material to ensure vegetation can establish on the surface of the filter media.

Refer to Section 5.5.6 for other parameters.

Grassed Swale Component:

a) The low flow bypass into the device is to be calculated. This is undertaken by the following formulae:

Bypass = SA x (k_{sat} / 1000) x 3600

Where:

SA = Bioretention surface area

(k_{sat} / 1000) x 3600 = Hydraulic conductivity of filter media in metres per second

b) Ensure that the bed slope of the swale does not exceed 5%;

c) Seepage = water lost from the device into the surrounding soil. Seepage is only appropriate given certain soil conditions and most swales would not allow significant seepage. When modelling a swale, seepage losses should generally be set to zero.

5.5.9 Rainwater Tank

In order to appropriately model the treatment efficiency of a rainwater tank , the following methodology is recommended:

- Consideration should be given to the total roof area that can drain to the proposed rainwater tank. Normally it will not be possible to drain the whole roof to a single tank. The model should be set up with the

- Consideration should be given to the demands for rainwater. Rainwater can be used for garden irrigation, toilet flushing, laundry and hot water. Some information to help estimate these demands is provided in the "WSUD Practice Guide"

- When the tank is sized for demand management, it is best to model a long time series of daily data.

- Where rainwater tanks are used as part of a stormwater quality management strategy, and the rainwater tank forms part of the stormwater treatment train, it is best to re-run the model using 6-minute rainfall data. Ensure that the roof draining to the tank has been set up with the appropriate pollutant parameters for roofs (see Section 5.3.3), as roofs generate fewer pollutants than other urban surfaces.

Input Parameters

a) Storage and outlet properties shall be designed as the consultant feels appropriate for the site.

b) With regard to re-use ensure that the "Use stored water for irrigation or other purpose box" is checked.

c) Relatively constant demands such as toilet flushing should be entered as a daily demand in kL/day

d) Seasonal demands such as irrigation should be entered as an annual demand in ML/year, and should be scaled according to the expected seasonal demand pattern.

e) Where demand information is not available the relevant demands should be clearly documented.

Properties of Rainwater Tank

Location: Rainwater Tank

Inlet Properties
Low Flow By-pass (cubic metres per sec): 0.0000
High Flow By-pass (cubic metres per sec): 100.000

Storage Properties
Volume below overflow pipe (kL): 10.00
Depth above overflow (metres): 0.20
Surface Area (square metres): 5.0

Outlet Properties
Overflow Pipe Diameter (mm): 50

Re-use Properties
☐ Use stored water for irrigation or other purpose
Annual Demand (kL/yr) scaled by daily PET: 0.000
Daily Demand (kL/day): 0.000
Monthly distribution of Annual Demand (kL/yr): 0.000

Fluxes...   Notes...   More

✗ Cancel   ⇐ Back   ✔ Finish

5.5.10 Generic Node G

This node allows the user to simulate the treatment performance of devices not listed within the default parameters.

This use of this device is similar to the processes identified for a Gross Pollutant Trap with the exception of a Flow transfer function to replicate any flow attenuation produced by the proposed device.

Note: The use of the Generic Node shall only be permitted if sufficient justification can be provided. If this node is utilised the user is to identify the proposed treatment efficiency along with any additional supporting information.
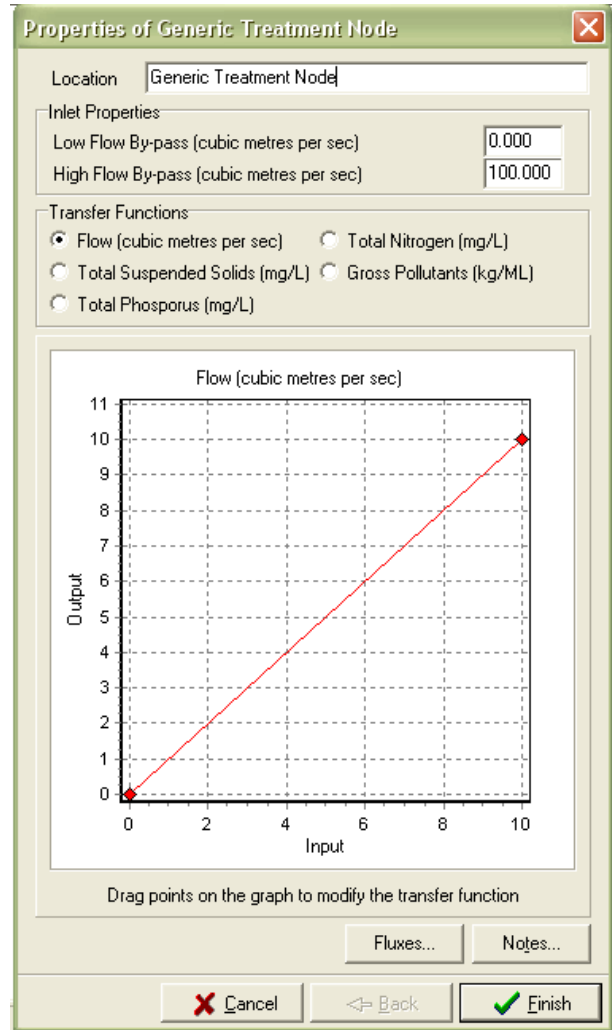
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