Wyndham City

MUSIC Software Guidelines

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EXECUTIVE SUMMARY

The MUSIC model is commonly used to size Water Sensitive Urban Design features to comply with standard Best Practice Management water quality targets in urban and peri-urban environments.

These guidelines present the preferred MUSIC modelling parameters to be used within the Wyndham City Council municipality. Directions for designing Water Sensitive Urban Design (WSUD) assets in Wyndham are also provided based on local climate and soil conditions.

The development of this document follows the strategic actions identified as one of the priority actions in the Wyndham Stormwater Management Plan, dated 2015.

Treatment Performance Curves were generated with MUSIC using the Wyndham 20-year climate template data (6 minute timestep). These curves were generated with typical parameters and can be used as an initial determination of the required treatment area for sedimentation basin, constructed wetland, bioretention and tree pit bioretention systems. It does not replace the concept design stage.

Key recommendations for the municipality are as follows:

Design Rainfall	For WSUD sizing, concept and functional design, a 10-year reference dataset has been provided from the Little River rainfall station (station 87033) from 1992 to 2001. The six-minute rainfall data is the most appropriate for urban applications.
Harvesting / water balance rainfall	If long term daily rainfall data is required for stormwater harvesting or water balance studies, the period from 1988 to 2007 at Little River rainfall station provides variable conditions including wet and dry years.
Evapotranspiration	Monthly evapotranspiration values from long term averages are provided in Figure 2-1 of these guidelines.
Impervious Fraction	Detailed impervious fractions are presented in this guide. Common fraction impervious values are: Urban standard density residential: 0.75 Rural residential: 0.2 Industrial and commercial: 0.9 Agricultural areas in Werribee South: 0.1

The MUSIC model default values should be used for the model parameters that are not mentioned in these Guidelines. Default values should only be changed if replaced by local calibrated parameters.

This modelling guidelines provide a local context for the application of MUSIC models within the Wyndham municipality. Values outside the provided ranges may be accepted; however the relevant officers at the Council will need to be consulted.

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1 INTRODUCTION

Currently, stormwater quality improvement technologies must adhere to the Best Practice Environmental Management Guidelines (CSIRO,1999). This requires:

- 80% reduction in Total Suspended Solids (TSS) from typical urban loads;
- 45% reduction in Total Nitrogen (TN) from typical urban loads;
- 45% reduction in Total Phosphorus (TP) from typical urban loads;
- 70% reduction in Litter from typical urban loads; and,
- Maintain discharges for the 1.5 year ARI event at pre-development levels.

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) was developed by eWater as a conceptual tool to estimate both the quantity and quality of runoff from different land uses within a particular catchment. The software also allows the user to simultaneously assess the performance of a variety of stormwater treatment systems. The use of MUSIC ensures that stormwater runoff is managed and that receiving waterways or systems are protected.

The increasing number of Water Sensitive Urban Design (WSUD) features being constructed in Wyndham raised the importance of using consistent MUSIC parameters to assess WSUD feature design. This MUSIC Guidelines document specific to Wyndham City Council (WCC) is part of a series of documents which should be consulted in conjunction when proposing and/or designing a WSUD asset in the Wyndham City region. Refer to Council's website for a list of relevant documents https://www.wyndham.vic.gov.au/

This document has been developed based on the latest version of relevant guidelines and documents, including:

- Melbourne Water MUSIC Guidelines: recommended input parameters and modelling approaches for MUSIC users, , January 2016.
- Melbourne Water Wetland Guidelines: Melbourne Water Design, Construction and Establishment of Constructed Wetlands, 2015.
- MUSIC (Version 6) user guide, 2015.
- Adoption Guidelines for Stormwater Biofiltration Systems by the Cooperative Research Centre for Water Sensitive Cities from 2015.

1.1 Purpose of this document

This document provides guidance on input parameters and modelling approaches for MUSIC specific to WCC. They have been developed to:

- Ensure a consistent and uniform approach is applied to MUSIC models developed for stormwater management within WCC;
- Provide advice on the use of the MUSIC model in WCC; and to
- Provide guidance on region specific input parameters to be used in MUSIC models.

At the time of writing these guidelines, the current version of the MUSIC software was Version 6.2.

Users of these guidelines are assumed to be experienced with stormwater management investigations and familiar with the MUSIC software. This document should be used in conjunction

with the MUSIC Users Guide (eWater, 2014). The document is not intended to be a design guideline and should be used in conjunction with site constraints / opportunities.

A design report and accompanying MUSIC model will need to be submitted with an application. This includes a concept design plan and typical cross sections of the WSUD systems with appropriate landscaping and consideration of site constraints and opportunities.

Residential developments in Wyndham must treat stormwater to Best Practice Removal Targets:

80% of TSS
45% of TP
45% of TN

2 METEOROLOGICAL DATA

2.1 Rainfall Data for Water Quality Modelling

Council requires the following approach to rainfall simulation be adopted for stormwater quality modelling:

- continuous simulation of a minimum of 10 years; 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.

A selected 10-year period (1992 to 2001) from the weather station at Little River was identified (87033) as a representative period for the region. Please refer to Appendix A for details of the data analysis and selection process. **Please note that this dataset differs from the recent rainfall template recommended by Melbourne Water (2016) using the same 10 year period as the data in this work has been infilled with data from a neighbouring station to generate a better representation of the Wyndham region.**

If a rainfall data set with higher mean annual rainfall is required, the template file prepared in the Wyndham Integrated Water Cycle Management Plan (WCC, 2017) for the same station between 1988 and 1997 should be utilised. This is recommended, for example, when the development site is located in Laverton and Laverton North.

For catchment areas within a previously gazetted Precinct Structural Plan (PSP) or a Melbourne Water's development services scheme, Wyndham City Council accepts the use of rainfall data from Melbourne Airport. However, all future water quality modelling for stormwater treatment systems should use the recommended rainfall data set for Little River (Litter River, 1992 to 2001).

Table 2-1 10 Year Best Available Representative Rainfall for Wyndham Region

Rainfall Station	Modelling Period	Mean Annual Rainfall (mm)
Little River (station 87033)	1992 - 2001	495
Little River (station 87033)	1988 - 1997	533

2.2 Rainfall Data for Hydrologic Modelling

It is recommended that a minimum of 20 years of continuous rainfall data should be utilised for stormwater storage and harvesting design and water balance analysis.

Table 2-2 20 Year Best Available Representative Rainfall for Wyndham Region

Rainfall Station	Modelling Period	Mean Annual Rainfall (mm)
Little River (station 87033) - 6 min	1982 - 2001	550

In addition, the 20-year dataset should be used for municipal scale stormwater harvesting and larger integrated water management strategies, waterway flow analyses, and analysis of large pervious catchments (> 100 ha).

In applications where a larger timestep is required to interface with another model, it is recommended to run MUSIC at a 6 minute time step and export results at a larger timestep. For example, if flows from MUSIC will be imported in to a separate water balance and/or demand model that runs in a daily step.

2.3 Evapotranspiration Data

BOM gridded average monthly potential evapotranspiration data was overlain with the Wyndham Municipality to determine the degree of spatial variation across the region (Appendix A). The difference in values between the east and west regions of the municipality was approximately ±5% compared with the average value within Wyndham. This was not considered significant enough to warrant using multiple locations, so a single location was used. Values were extracted from the Werribee region grid can be used for both water quality and hydrology modelling. Monthly values adopted are shown in Figure 2-1.

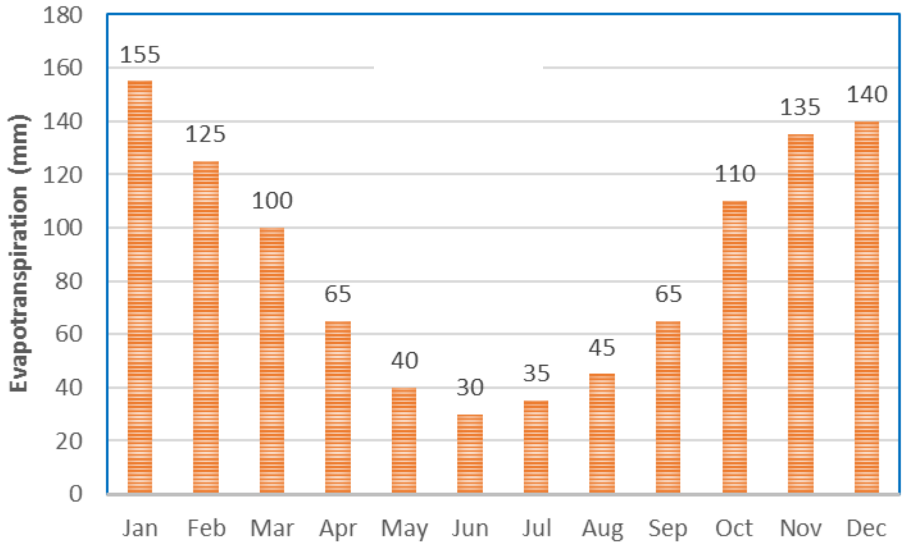


Figure 2-1 Monthly Evapotranspiration Values Adopted for the MUSIC Climate Data Template

3 SOURCE NODES

3.1 Source Node Type

The nodes represent the hydrological catchments or subcatchments. The model currently includes five types of nodes:

- Urban
- Agricultural
- Forest
- User defined
- Imported Data

Wyndham City Council recommends the use of the urban, agricultural and forest nodes for standard development models. Table 3-1 indicates which node should be used for to represent different land uses and land zonings.

Table 3-1 Source Node Types to Represent Different Land Use and Land Zoning

Note Type	Lan Use/Zoning
Urban	■ Urban and rural residential ■ Urban open space (e.g. parkland, conservation grassland, sport and recreation areas) ■ Commercial and multi-purpose centres ■ Industrial
Agricultural	■ Large scale grazing and cropping (e.g. rural agricultural areas in Werribee South) ■ Golf course
Forest	■ Natural bushland areas ■ Woodlands ■ Open and closed forest

Each of these three source nodes has its own default discharge pollutant concentrations, but they have the same default rainfall/runoff related parameters (such as soil storage and soil infiltration parameters). The urban node is recommended for most of the urban and peri-urban applications.

3.1.1 Urban Node

When using an Urban Node, one of the land uses or surface types listed in the Zoning/Surface Type dropdown menu should be selected to specifically represent its pollution generation characteristics. For example, where flows from a sealed road are being directed to bioretention system, the selection of the appropriate land cover will ensure the correct representation of the pollutants entering WSUD feature.

Table 3-2 indicates which land use and surface cover types to represent different land use and surface cover types in the urban node.

Table 3-2 Land Use and Surface Cover Types to Represent Different Land Use and Surface Cover Types in the Urban Node

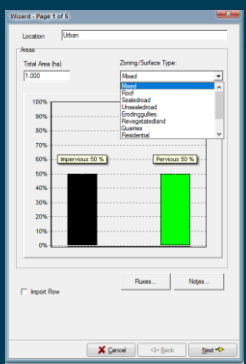
Lan Use / Surface Cover in MUSIC	Lan Use / Surface Cover in MUSIC

Mixed	■ Mix of residential, commercial, industrial, roads and hospitals
	■ Urban open space
	  ■ Parkland
	  ■ Sport and recreation areas

Roof	■ Roofs
Sealed Road	■ Urban and rural sealed roads
Unsealed road	■ Unsealed and partially sealed roads
Eroding gullies	■ Eroded gullies
Revegetated land	■ Cleared land that has been revegetated and not used for grazing (e.g. nature strip and garden bed)
Quarries	■ Quarries
Residential	■ All urban residential (including their related roads and pathways) ■ Private residential gardens
Commercial	■ Commercial ■ Multi-purpose centres
Industrial	■ All industrial
Rural Residential	■ All rural residential (e.g. residential areas in Werribee South)

MUSIC TIP

Use the dropdown menu to select Land Use and Surface Cover Types in MUSIC



Previous versions of MUSIC did not have the option of selecting different land use/land cover type. In those versions, the pollutant generation parameters from the urban node were derived from mixed use land use type. If in doubt, mixed-use should be adopted.

The choice of different land use / surface types will not impact on the flow estimates, only on the pollution generation.

For catchments smaller or equal to 10 hectares, the recommendation is to measure the proportion of impervious surfaces that are directly connected to the drainage system (i.e. the use of different surface types within the urban node: road, roof and ground level areas).

For catchments larger than 10 hectares, if the MUSIC model cannot be calibrated with local flow data, please refer to Table 3-3 for an indication of an appropriate fraction impervious value based on the land use (as per Melbourne Water, 2016).

Table 3-3 Effective Impervious Fraction for Source Nodes (Source: Melbourne Water, 2016)

Zone	Zone Code	Description / Example	Normal Range	Typical Value
Residential Zones				
Residential Growth Zone, General Residential Zone and Neighbourhood Residential Zone	RGZ, GRZ & NRZ	Large Residential (Lot size 601m² - 1000m²)	0.50 – 0.80	0.6
		Standard densities (Lot size 300m² - 600m²)	0.70 – 0.80	0.75
		High Densities (Lot size < 300m²)	0.80 – 0.95	0.85
Low Density Residential Zone	LDRZ	Low densities (Lot size > 1001m²)	0.10 – 0.30	0.20
Mixed Use Zone	MUZ	Mix of residential commercial, industrial and hospitals	0.60 - 0.90	0.75
Township Zone	TZ	Small townships with no specific zoning structures	0.40 – 0.70	0.55
Industrial Zones				
Industrial Zone 1	IN1Z	Main zone to be applied in most industrial areas	0.70 – 0.95	0.90
Industrial Zone 2	IN2Z	Large industrial zones away from residential areas	0.70 – 0.95	0.90
Industrial Zone 3	IN3Z	Buffer between Zone 1 and Zone 3	0.70 – 0.95	0.90
		garden supplies/nurseries	0.30 – 0.60	0.50
		quarries	0.10 – 0.30	0.20
Commercial Zones				
Commercial Zone 1	C1Z	Main zone to be applied in most commercial areas	0.70 – 0.95	0.90
Commercial Zone 2	C2Z	Offices, manufacturing industries and associated uses	0.70 – 0.95	0.90

Zone	Zone Code	Description / Example	Normal Range	Typical Value
Rural Zones				
Rural Zone	RUZ	Main zone to be applied in most rural areas	0.05 – 0.20	0.10
Rural Living Zone	RLZ	Predominantly residential use in rural areas	0.10 – 0.30	0.20
Public Land Zones				
Education	PU2Z	Schools and universities	0.60 – 0.80	0.70
Service and Utility	PU1Z	Power lines, pipe tracks and retarding basins	0.00 – 0.10	0.05
		Reservoir	0.40 – 0.60	0.50
Health and Community	PU3Z	Hospitals	0.80 – 0.90	0.85
Transport	PU4Z	Railways and tramways	0.60 – 0.80	0.70
Cemetery / Crematorium	PU5Z	Cemeteries and crematoriums	0.50 – 0.70	0.60
Local Government	PU6Z	Libraries, sports complexes and offices/depots	0.50 – 0.90	0.70
Other Public Use	PU7Z	Museums	0.50 – 0.80	0.60
Public Park & Recreation Zone	PPRZ	Main zone for public open space including golf courses	0.00 – 0.20	0.10
Public Conservation & Resource Zone	PCRZ	Protection of natural environment or resources	0.00 – 0.05	0.00
Road Zone – Category 1	RDZ1	Major roads and freeways	0.60 – 0.90	0.70
Road Zone – Category 2	RDZ2	Secondary and local roads	0.50 – 0.80	0.60

Zone	Zone Code	Description / Example	Normal Range	Typical Value
Special Purpose Zones				
Special Use Zone	SUZn	Development for specific purposes	0.50 – 0.80	0.60
Comprehensive Development Zone	CDZn	Large and complex developments – residential	0.40 – 0.80	0.50
Urban Floodway Zone	UFZ	Land identified as part of an active floodway	0.00 – 0.05	0.00
Commonwealth Land				
Commonwealth Land	CA	Army barracks, CSIRO	0.50 – 0.80	0.60

3.1.2 Agricultural Node

In rural catchments with low levels of built up areas (i.e. from catchments with little or no impervious surfaces), such as Werribee South the impervious fraction should be adjusted to match typical runoff coefficients for that type of catchment. The impervious fraction should therefore be considered to act more like a runoff coefficient factor than a direct relationship to catchment imperviousness (please refer to the MUSIC Users Guide, 2015 for more details).

Literature is available with a range of methods to estimate runoff coefficient. For simplicity, the values suggested in this Guidelines are based on the analysis of measured flow data in a number of drains in Werribee South combined with the local rainfall during the same period. The analysis of the measured flow data suggested that the runoff coefficient in the agricultural areas in Werribee South ranged from 0.09 to 0.12.

When modelling areas within Werribee South, it is recommended to split the urban node to represent urban areas and the agricultural areas separately. In the absence of local calibrated data, urban areas should have the Fraction Impervious determined from Table 3-3 and agricultural areas should have a Fraction Impervious equal to 0.10.

3.1.3 Forest Node

The forest node is not often used in MUSIC. When utilised, it usually represents a pre-developed area and an impervious fraction of zero can be adopted.

3.2 Rainfall Threshold

The default value of 1.0 mm is recommended to be adopted for all applications, unless modelling roofs, in which the value of 0.5 mm is acceptable. The use of other values should be clearly supported in the report and preferably discussed with the Council prior to submitting the model.

3.3 Soil Parameters

In urban areas, surface runoff on impervious area is predominantly and therefore changes in the soil parameters related to pervious area flow do not significantly impact on the model results. Unless model calibrated values are available (and appropriately supported in the application report), the values recommended by Melbourne Water (2016) should be adopted for all applications within Wyndham.

Table 3-4 Soil Parameters

Model Parameter	Melbourne Water (2016)
Soil Store Capacity	120 mm
Field Capacity	50 mm

Other values can be used if a model is developed and calibrated to the local catchment data.

MUSIC TIP

While the Soil Parameters are somewhat related to soil properties, they are not a directly measurable catchment characteristics such as soil and geological properties

3.4 Pollutant Concentration Data

The default pollutant concentration parameter values associated with the different land uses and surfaces type should be adopted for MUSIC models developed for Wyndham municipality. These values are presented in Appendix B.

For all simulations, the MUSIC model must be run with pollutant export estimation method set to “stochastic generated”.

4 DRAINAGE LINKS

4.1 Primary Drainage Link

Where appropriate, hydrologic routing can be used to best represent the catchment's Time of Concentration. The user may, however, choose not to use hydrologic routing as MUSIC is not aimed for detailed hydrological analysis. In general, not using routing will generate conservative results for the treatment system. Consistency of applying or not applying routing throughout the model is necessary for correct modelling of the timing of peak flows.

4.2 Secondary Drainage Link

The secondary link is not commonly use in treatment design but can be used when it is advantageous to assess a certain component of the outflows separately. They can be used if not all the outflow components are being directed to a treatment or other water feature. For example, if only treated flows from a wetland are being directed to a frog pond. In this case only the pipe and weir flows will be directed (see Figure below). Please note, that any sort of open water ponds (e.g. lakes) should not be considered as part of the treatment train and therefore the final results to be submitted to the Council should be the ones recorded before the pond/lake.

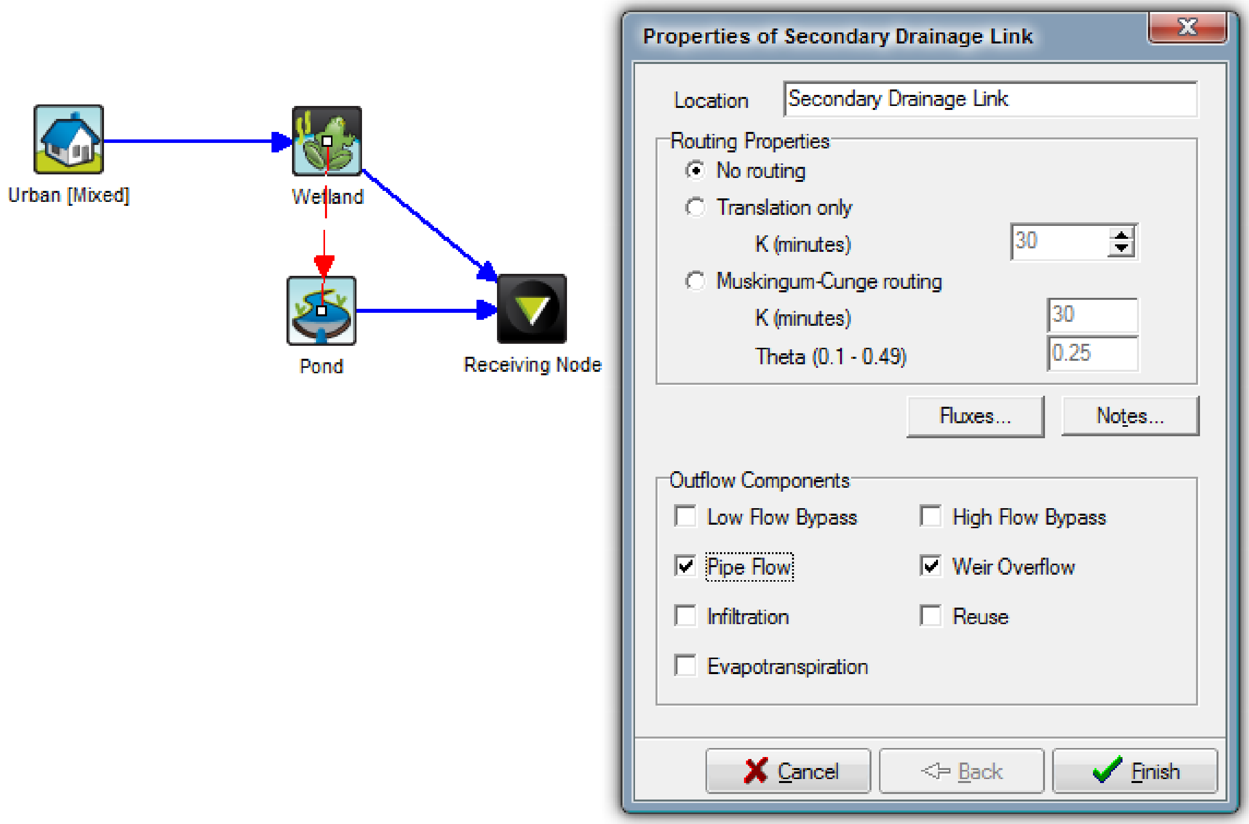


Figure 4-1 Example of a Model Setup to Size a Pond using a Secondary Link

Another example is when only treated flows are directed to a tank for re-use. In this case, ensure that all the flow components are directed back to the final receiving node to ensure flows are not lost.

The use of secondary links can also be used to facilitate water balance type of analysis. Refer to the MUSIC manual for further information.

5 TREATMENT NODES

The model should be constructed with respect to the treatment train order presented in Figure 5-1 below. For example, a Tertiary Treatment feature should not be designed before a Primary Treatment.

Primary Treatment

For gross pollutant and coarse particles

- Gross Pollutant Trap (GPT)
- Vegetated Swale
- Porous Pavement

Secondary Treatment

For finer sediment and attached pollutants

- Sedimentation Basin
- Infiltration Trench

Tertiary Treatment

For very fine sediments and attached nutrients

- Wetland
- Bioretention Basin/Raingarden
- Tree pit bioretention

Figure 5-1 Treatment Train Order

5.1 Modelling Considerations

5.1.1 What Not to Model

Lakes, ponds and natural wetlands are not considered as part of the treatment train and should not be modelled as such in MUSIC.

Any works within the receiving waters should NOT be included in any treatment train models. Online wetland treatment trains are no longer acceptable by Melbourne Water and will only be acceptable if permission has been given by Wyndham City Council and Melbourne Water prior to the modelling stage.

The above has been established in the latest Wetland Guidelines by Melbourne Water (2015) which Council adheres to.

DESIGN TIP

Natural waterways or wetlands should not be included as a treatment measure

DESIGN TIP

Ponds can be modelled in MUSIC for storage and water balance purposes but not for water quality treatment purposes

5.1.2 Bypass

Any flows greater than the 4 EY[1] or 3 month ARI event should be bypassed around the system. This will be included in the inlet properties for each WSUD device. Any change to this should be clearly stated in the report and is subject to Council's approval.

5.1.3 Losses from the System

The exfiltration rate within a treatment node refers to the seepage rate of the surrounding soil. This should be set zero to represent standard clay lined systems. The use of a different value should be supported by local geotechnical studies.

A review of the soils in Wyndham from the surface to approximately 500 mm deep shows that the soils range from sandy clay loams around the cost to medium clays towards the north. **Error! Reference source not found.** shows a map of the soils between 100 mm and 200 mm.

In most urban and peri-urban applications, the soil condition does not reflect the characteristics of the original soil once characterised in the area. It is often that the surface and sub-surface soils have gone through compaction and therefore no longer present the same infiltration rates as the soil once characterised. Werribee South is an example of a region where the intense agricultural practice has significantly altered the surface and subsurface soils (SRW, 2009).

As such, it is very important that the exfiltration rate value reflects the current soil conditions and it is not simply adjusted based on the MUSIC-soil type recommended values.

If field experiment data is not available, a maximum value of 3.6 mm/hr should be used in Wyndham. It is imperative that the hydraulic conductivity is measured and the model updated during the detailed design.

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[1] Exceedance per Year

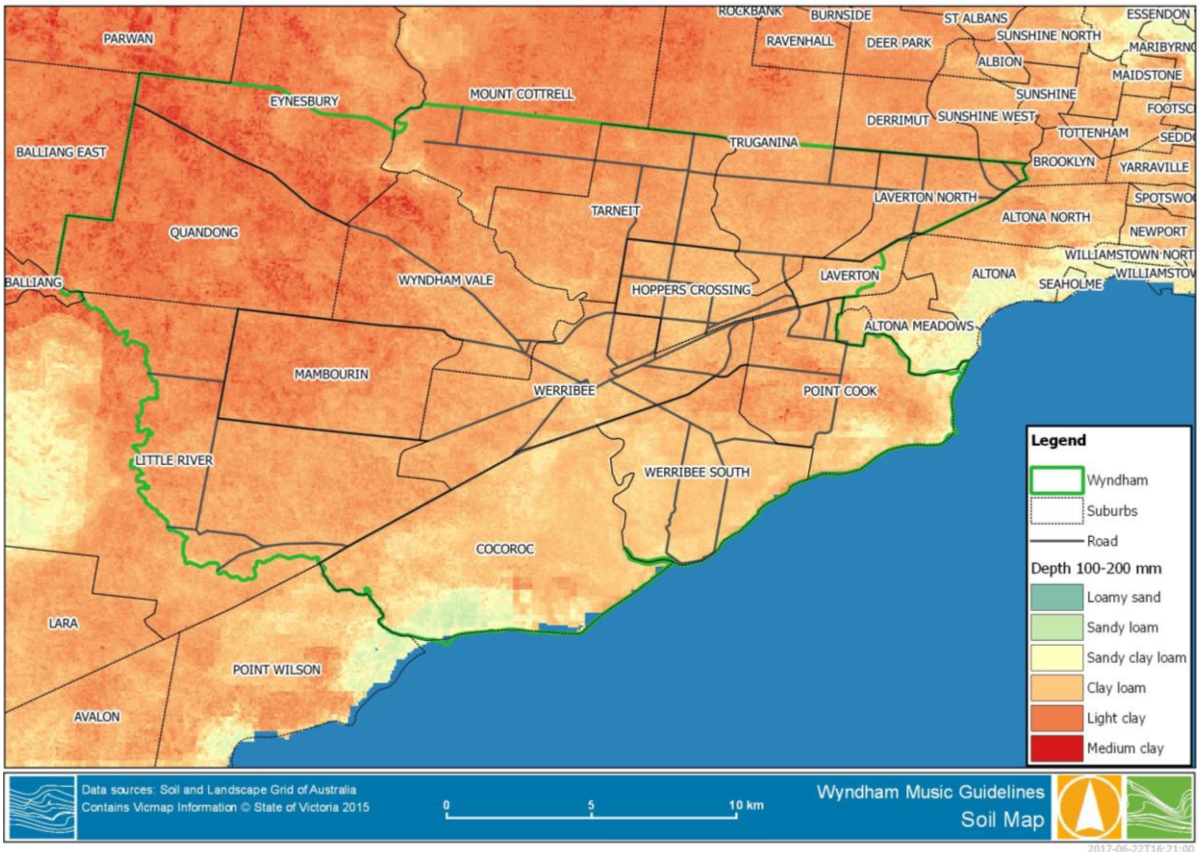

Figure 5-2 Wyndham Municipality Sub-Surface Soil Map (CSIRO, 2015)

5.1.4 Staged Development

Where works are intended to be staged, a separate MUSIC model needs to be developed to show how water quality requirements will be achieved in the temporary conditions and how the ultimate outcome will be implemented.

5.1.5 Generic Treatment Nodes

Generic Nodes are not recommended to be used for treatment purposes (except for GPTs as specified in Section 5.2.1.1 The generic treatment node may be used to split flows when a diversion or pump is designed. The corresponding assumptions and calculations should be provided when a generic node is used.

5.2 Treatment Types

5.2.1 Primary Treatment

5.2.1.1 Gross Pollutant Traps (GPT's)

GPT's are sediment traps which screen and store litter and debris. Only stormwater treatment proven by reputable studies shall be attributed to a GPT. No nitrogen reductions will be accepted in the treatment train performance. The high flow bypass should reflect the flow capacity of the GPT, which is provided by the GPT fabricant manufacturer.

Since there is no local data, TN and TP reductions should be set to 0, and 70% sediment removal for concentrations greater than 75 mg/L. In MUSIC, this can be done by selecting a Total Suspended Solids Transfer Function with Concentration Based Capture Efficiency then editing the input and output points to reflect the 70% removal. Figure 5-3 shows a screen shot of this setup.

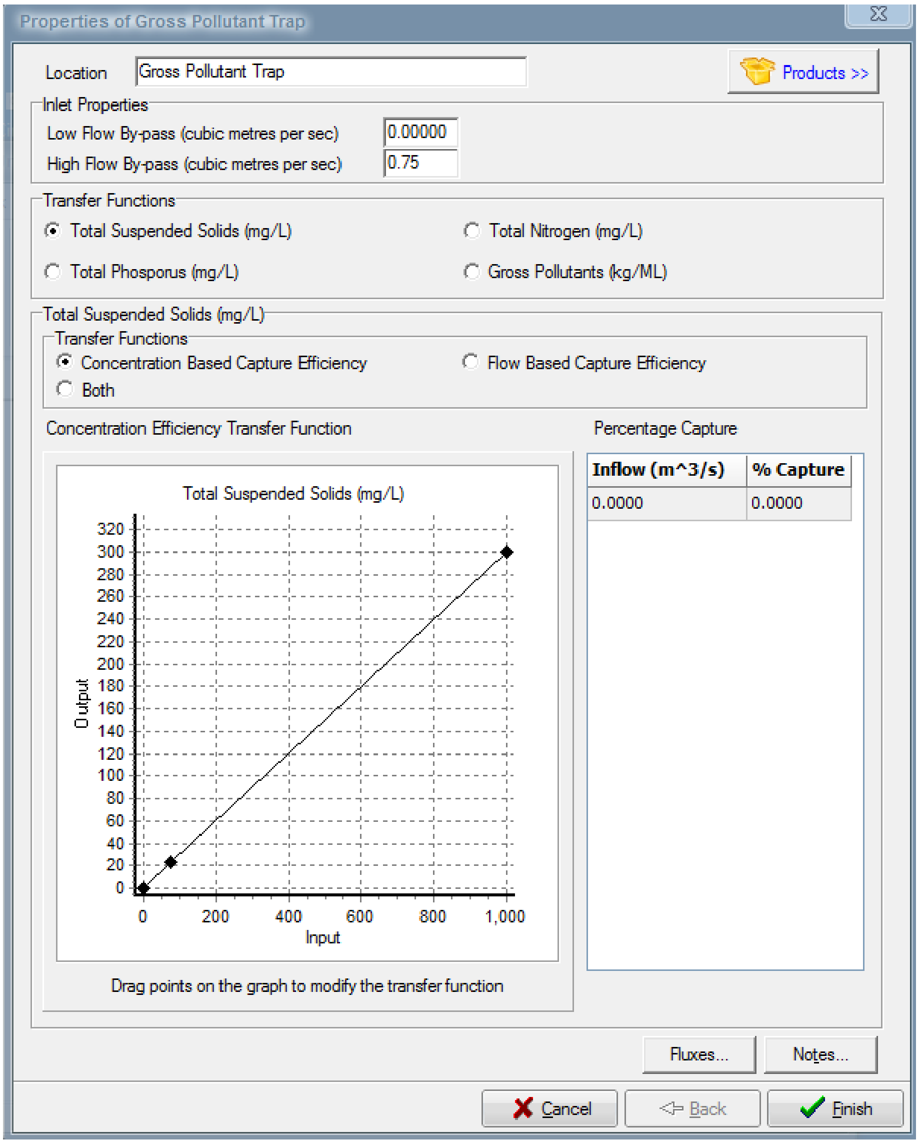

Figure 5-3 Example of a GPT Setup

Before a model can be approved, copies of the product specifications, installation manual and maintenance requirements need to be provided as part of the report submission.

5.2.1.2 Vegetated Swales

Swales are grassed or vegetated channels which collect and transport stormwater. They can be coupled with underground drainage. The vegetation in a swale treats stormwater and reduces pollutant loads. Swales are typically constructed with a low grade in order to reduce the velocity of stormwater flows.

In urban areas, swales within the nature strip of the development are not preferred due to the reliance on residents to maintain the systems. Boulevard style in the centre of roadway, and swales in drainage reserves are more appropriate. Vegetated swales may be used with the sealing of rural roads to reduce negative impacts from increased stormwater run-off in rural areas with enough space and slope. As such, swales within the nature strips are generally acceptable. Particularly in Werribee South, the adoption of unlined swales to convey and pre-treat stormwater before reaching the bay may be a practical option.

Key MUSIC design considerations:

- The longitudinal bed slope should be between 1% to 4%. In cases where it exceeds these slopes, the adoption of shallow pools along the way should be considered to ensure that the slope between pools does not exceed 4%. Steeper swales are considered to function as drains and should not be modelled as part of the treatment train.
- Swales within the road reserve should be between 0.15 m and 0.30 m deep to allow suitable side slopes.
- A side slope should be minimum 1H:1V.
- The suggested vegetation heights for swales are:
  - 0.005 to 0.1 m for mowed grass swales. In urban areas, where mowing is regular, the lower limit of 0.005 m is often the case.
  - 0.1 to 0.4 m for unmown vegetation. Mostly in peri-urban and rural areas, a vegetation plan and a maintenance plan should be provided.

  Note that the vegetation height selected in the MUSIC model must represent the average height of the vegetation in the base of the swale.
- Swales with rock lining in the base provide no water quality treatment.
- Peak flow velocity must not exceed 0.5 m/s for storms up to the 20% AEP event and 1.0 m/s in the 1% AEP event.
- Waterways within a development cannot be deemed to be swales and should therefore not be included in the MUSIC model.
- Exfiltration rate is recommended to be set zero in all urban setups.

Council recommends that the configuration of the vegetated swale within the development should be considered in the MUSIC design stage. If the vegetated swale is long and has a number of inlets through its longitudinal side, the swale should be modelled in individual sections as in Figure 5-4Figure 5-4. An example is when residential blocks are connected to a long street swale. If the inflows are concentrated and enter the swale through its initial cross section the setup in Figure 5-5 should be adopted.

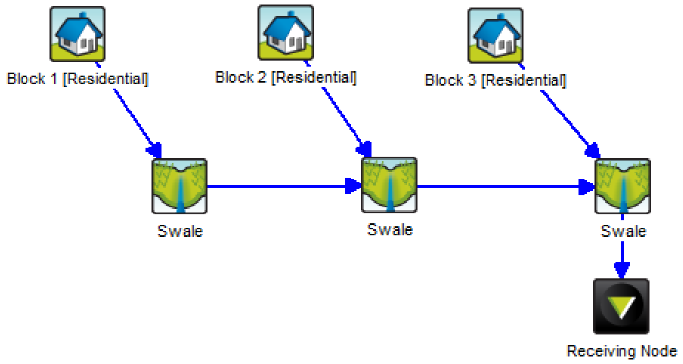

Figure 5-4 Swale with Multiple Inlets

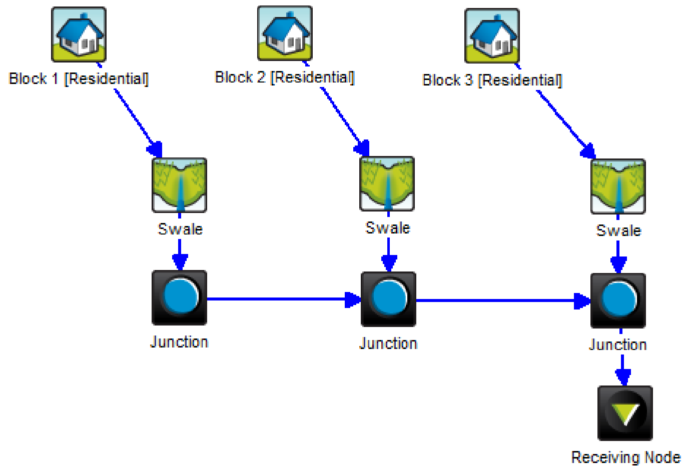

Figure 5-5 Swales with Concentrated Inlets

5.2.1.3 Porous Paving

Permeable pavements are paved surfaces which allow for the infiltration of stormwater and therefore reduce runoff flows. Permeable pavement should be modelled as per the manufacturer's guidelines. In order to gain approval for the use of permeable pavement supporting documents should be included.

5.2.1.4 Buffer Strips

Buffer strips are often used upstream of other treatment devices to assist in sediment drop out prior to stormwater entering secondary treatment devices i.e. swales. They filter diffuse shallow flows from impervious areas. If the inflows are concentrated (e.g. discharging from an outlet), a swale should be modelled instead.

Buffers must be located directly downstream of an urban surface type of source node; they are not recommended for rural settings.

5.2.2 Secondary Treatment

5.2.2.1 Sedimentation Basins

Sedimentation basins (or sediment ponds) are used to trap fine and coarse sediments. They are often followed by bioretention or wetland systems in the treatment train. Sediment ponds are also often temporarily used during construction activities as they assist in controlling and removing elevated sediment levels.

Key MUSIC design considerations for urban (mixed, residential, commercial) applications:

- The extended detention depth should not be higher than 0.35 m;
- The equivalent pipe diameter should be adjusted to achieve a notional detention time between 6 to 8 hours; and
- Sediment ponds are often lined and therefore the exfiltration rate should be set to zero, which is the MUSIC default value.

For standard urban development applications, a Preliminary Design assessment utilising the “Estimate Parameters” option in the Sedimentation Basin node is acceptable. The main parameters recommended to be used for urban (mixed, residential, commercial) applications are shown in Table 5-1.

Table 5-1 Sediment Pond Parameters for Urban Developments

Properties	Mixed Residential Developments
Settling Velocity of Very Fine Sand (mm/s)	11
Design Flow (m^3/s)	3 month ARI
Sediment Loading Rate (m^3/ha/yr)	1.6
Capture Efficiency (%)	95
Clean-out frequency (years)	Minimum 5 years
Turbulence (number of CSTR cells)	Refer to Section 5.4.2
Extended Detention Depth (m)	0.35
Permanent Pool Volume Depth	1.5

When sediment ponds are designed for other applications (e.g. quarries, unsealed roads and intensive horticulture), as well as for the Functional Design Stage for urban developments, the sizing of the systems should be undertaken using the Fair and Geyer Equation (refer to Equation 10.3 in the WSUD Stormwater Technical Manual, 2005 and Appendix C).

The MUSIC model should be refined during the Functional Design Stage, and the applications for urban developments should also consider:

- Maintenance considerations: Sediment ponds should be cleaned when sediment deposition reaches 0.5 m from the Normal Water Level. Council require that the cleanout frequency should not be more frequent than every 5 years.
- The permanent pool volume divided by the surface area should not be more than 600 mm.

DESIGN TIP

100 year ARI flow velocity within

5.2.3 Tertiary Treatment

5.2.3.1 Constructed Wetlands

Wetlands are shallow, vegetated WSUD assets which treat stormwater by allowing for sedimentation, filtration and biological uptake. Wetlands often follow a sediment pond, which settles the coarse sediment.

Due to their typology and treatment process, wetlands are not well suited to steep terrain.

Melbourne Water released comprehensive guidelines for wetland design: Design, Construction and Establishment of Constructed Wetlands: Design Manual[2]. Wyndham City Council follow the recommendations in the Melbourne Water's Guidelines, and the key MUSIC design considerations are summarised in this Section.

The key MUSIC considerations can be adopted during the Preliminary Design assessment (i.e. to demonstrate water quality objectives):

- The extended detention depth should not be higher than 0.35 m;
- The sediment pond can be set to 10% of the designed macrophyte zone area.
- The permanent pool volume divided by the surface area should not be more than 0.4 m.
- The equivalent pipe diameter should be adjusted to achieve a notional detention time of 72 hours; and
- Wetlands are often lined and therefore the exfiltration rate should be set to zero, which is the MUSIC default value.

DESIGN TIP

A minimum of 80% coverage of emergent macrophytes is required within the normal water level surface area of the wetland.

During the later design stages (Functional and Detailed), the MUSIC model should be updated/refined. The main considerations are:

- The Normal Water Level (NWL) at the wetland should be set 100 mm lower than the NWL of the sediment pond. As such, a separate sedimentation pond node should be adopted in MUSIC to model the sedimentation inlet pond.
- The extended detention depth of the sediment pond and wetland should not be higher than 0.35 m;
- The stage storage discharge relationships of the wetland extended detention should be represented in the model. This can be done by using the Custom Outflow and Storage Relationship function in MUSIC. The use of this functionality is explained in Appendix D. The stage storage discharged relationships

[2] Available from: http://www.melbournewater.com.au/planning-and-building/standards-and-specifications/design-wsud/pages/constructed-wetlands-design-manual.aspx

should be derived from the bathymetry and outlet arrangements that ensure that the detention time is 72 hours for 90% of time[3].

- In order to undertake the analysis of the detention time of 72 hours for 90% of time and the inundation frequency analysis (both requirements of the functional design stage), a daily flux file should be generated in MUSIC. Guidance on how to generate a flux file is in Appendix D.

DESIGN TIP

3 month ARI flow velocity be ≤ 0.05 m/s
100 year ARI flow velocity be ≤ 0.5 m/s

5.2.3.2 Bioretention Systems / Raingardens

Bioretention systems are shallow systems that treat stormwater by filtering water through a filtration media. The CRC for Water Sensitive Cities have released the Adoption Guidelines for Stormwater Biofiltration Systems (Payne et al.,2015). Wyndham City Council adheres to these Guidelines for the design of Bioretention systems, as well as to the WSUD Engineers Procedures: Stormwater Manual (CSIRO, 2005).

Bioretention systems can be designed for a range of scales, from private backyards to street-scale applications and car parks (e.g. raingardens and bio-swales), up to larger basins in public parks and reserves (e.g. bioretention basins). The systems can be lines or unlined.

Wyndham City Council recognised that the bioretention systems built within the municipality have not been performing well. It is likely that the causes are related to incorrect design, specifications and/or construction, which can be leading to the death of vegetation. For example, shallow filter depths combined with oversized systems contribute to insufficient soil moisture to sustain plants. To better understand the parameters that impact on the filter media soil moisture in Wyndham, a MUSIC modelling assessment has been undertaken. The assessment presented in Appendix E and the results have been used to inform the key MUSIC design parameters for bioretention systems in Wyndham:

- Extended detention depths should not be higher than 0.3 m; this ponding depth should be safe for construction operation and maintenance. The average value should be used in the case of a longitudinal slope.
- Include a minimum of 0.5 m filter depth to avoid long dry spells;
- Include a 0.45 m storage (submerged) zone to support plants during the dry periods;
- Saturated hydraulic conductivity of the filter media should be specified as 200 mm/hr in the design report and plans, however modelled as 100 mm/hr in MUSIC (this is a conservative approach to account for compaction and clogging effects during the first years);
- Include an assessment of the frequency of the dry spells; and
- Outlet properties in MUSIC:

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[3] Methods are provided in Part D of the Design, Construction and Establishment of Constructed Wetlands: Design Manual. Tools are available in www.MUSICauditor.com.au

- Lined systems will have under drain to convey the flows out of the system.
- Unlined systems will have an exfiltration rate and are unlikely to have an under drain as the water will infiltrate into the surrounding soil.

Wyndham City Council recommends that the systems should not be oversized to avoid long periods of dry spells and that they should follow a vegetated swale, GPT or sediment trap type of system to avoid clogging by sediments. However, if the system is smaller than 1% of the impervious catchment, adopting lower ponding depths and larger filter area is preferable.

Unlined Bioretention

Unlined bioretention systems are recommended when decreasing the annual runoff volume and increasing baseflow is desired. However, the adoption of unlined systems should be made with care to ensure that any structure around is not compromised (e.g. roads, pipes, etc) by the percolation of subsurface water.

For example, when a bioretention is located in a parkland but one of its side is close to the road reserve, it might be an option to have only the inner park side unlined to promote infiltration into the soil and the other sides lined to protect underground structures within the road reserve. In MUSIC, the Unlined Filter Media Perimeter should reflect the choice of such design.

The exfiltration rate should be set to reflect the infiltration rate of the souring soils. In most urban and peri-urban applications, the soil condition does not reflect the characteristics of the original soil once characterised in the area. It is often that the surface and sub-surface soils have gone through compaction and therefore no longer present the same infiltration rates as the soil once characterised.

In addition, in deeper conditions, the hydraulic conductivity of the soils decreases. Please refer to Section 6.1.3 for more details. As such, it is very important that the exfiltration rate value reflects reality and it is not simple adjusted based on the MUSIC-soil type recommended values.

It is imperative that the hydraulic conductivity is measured and the model updated during the detailed design.

The remaining properties in MUSIC should be used at their default values. If the design is to vary from the design parameters listed in this Section, the reasons should be stated in the report.

5.2.3.3 Tree Pits Bioretention

Tree pits (for stormwater management applications) are small biorientation systems that consist of a tree or large shrub planted within an underground filtration module. They are often constructed into the kerb to treat stormwater before it reaches the stormwater drain. Design Guidelines adopted for bioretention systems (i.e. The Adoption Guidelines for Stormwater Biofiltration Systems by Payne et al. (2015) and WSUD Engineers Procedures: Stormwater Manual (CSIRO, 2005)) combined with recent specifications for tree pit bioretention design as described in the Raingarden Tree Pit Program by City of Melbourne (2015) should be adopted when designing these systems.

The key MUSIC considerations recemented for Wyndham are:

- At least 500 mm filter media depth to provide enough room for roots and avoid long dry periods.
- A sandy loam with 50 mm/hr saturated hydraulic conductivity provides a good soil base and is appropriate for healthy tree growth.
- Orthophosphate content should be lower than 55 mg/kg.
- The appropriate ratio of the surface area of the soil cell to the drained impervious catchment area will vary based on location, tree size and required rooting area and soil moisture. A sensitivity analysis of the treatment performance and filter media soil moisture was conducted to determine the appropriated ratios for Wyndham.

Based on the results from modelling the soil moisture with MUSIC in bioretention system in Wyndham, Council recommends that bioretention should between 1.5 and 3% of the catchment area. Systems within this range are likely to be small enough to keep the system moist while achieve best practice targets and also large enough without being too dry. A summary of this analysis if presented in Appendix F.

5.2.3.4 Rainwater Tanks

Rainwater tanks are often used to store rainwater from the roofs for re-use. They are also used for stormwater retention purposes attenuate and/or reduce the runoff from the site. Rainwater tanks can be constructed above the ground or underground.

The design of rain tanks should be undertaken according to the WSUD Engineers Procedures: Stormwater Manual (CSIRO, 2005). The key MUSIC design considerations are:

- The MUSIC model setup should reflect the proportion of the roof area having the runoff directed to the tank:
  - If above the ground, it is unlikely that the rainwater from the entire roof will be directed to the tank by gravity. In this case it is important to clearly define this arrangement in MUSIC[4]. One simple way of doing that is splitting the source node in two, in which one is linked to the tank and the other is not.

    If the roof area being directed to the tank has not yet been defined in the project, a value of 0.75 is recommended.
  - If underground, it is likely that that the rainwater from the entire roof can be directed to the tank by gravity.
- A low flow by pass of 0 should be adopted, unless specific reason is provided for a different setup.
- If two or more of the same tank are being modelled, the number of tanks should be specified, and the properties corresponding to an individual tank should be provided.
- A conservative assumption of a full tank should be assumed at the start of the modelling, unless a smart or leaky tank is planned.

Reuse should be setup with reliable demands (e.g. toilet flushing) associated with it. Please refer to the specifications in Section 5.2 of these Guidelines to provide the required model inputs.

There should be an understanding and agreement between relevant stakeholders before reuse is accepted for the MUSIC model. Modelling rainwater reuse should be in accordance with the specifications in the Meteorological Data Section within these guidelines.

5.3 Water Re-use from Treatment Nodes

Local data is preferred to be used in MUSIC, if local information is not available, the values presented in this Section are recommend.

5.3.1 Daily Demands

Daily demands are from indoor use and do not vary with seasons and rainfall patterns. They should be modelled as kL/day and the following demands are recommended:

- Residential toilet flushing use: 20 L/person per day (Gan and Redhead, 2013)
- Residential for laundry use: 80 L/household per day (Gan and Redhead, 2013)

[4] The proportion of the roof are should be determined based on realistic roof gutter grades and downpipe position.

- Commercial for toilet use: 18 L/person per day (Othman and Jayasuriya, 2006)

5.3.2 Annual Demands

Annual demands for outdoor uses should be used as flows:

- Residential outdoor use: 1,200 kL/ha per year (Mitchell et al., 2008)
- Sports Field Irrigation use: 3,875 kL/ha per year (WCC, 2015b)
- Green wall irrigation: 1 kL/m^2 per year (Hopkins, et al., 2010)
- Tree irrigation: 100 kL/tree per year (Lawry, 2008)

The irrigation distribution varies with the different rainfall patterns throughout the year. As such, the re-use for external purposes should be modelled as the annual demand scaled by daily rainfall - potential evapotranspiration (PET - Rainfall).

MUSIC TIP

The demand x supply efficiency of the tank can be viewed in the Node Water Balance statistics output

5.4 Advanced Parameters

5.4.1 K, C*, C**

These parameters should not be altered unless a significant amount of relevant published data suggests otherwise.

5.4.2 Number of CSTR cells

The default parameters can be altered under the "more" button in each treatment node. It reflects the mixing behaviour of the treatment systems. Figure 5-6 below presents the number of CSTR cells for different system arrangements (shapes). **If unsure, the default values should be used.**

This parameter can also be customised when using the "Estimate Inlet Volume" for preliminary sizing of the inlet pond of a wetland and using the "Estimate Parameters" button for preliminary sizing of a sediment basin (Sections 5.2.2.1 and 5.2.3.1).

The difference between B, I and J is the ration between length and width. There is no specific ratio guidelines, but the below is an indication:

- B: Length/width ≤ 3
- I: 3 < Length/width ≤ 6
- J: Length/width > 6

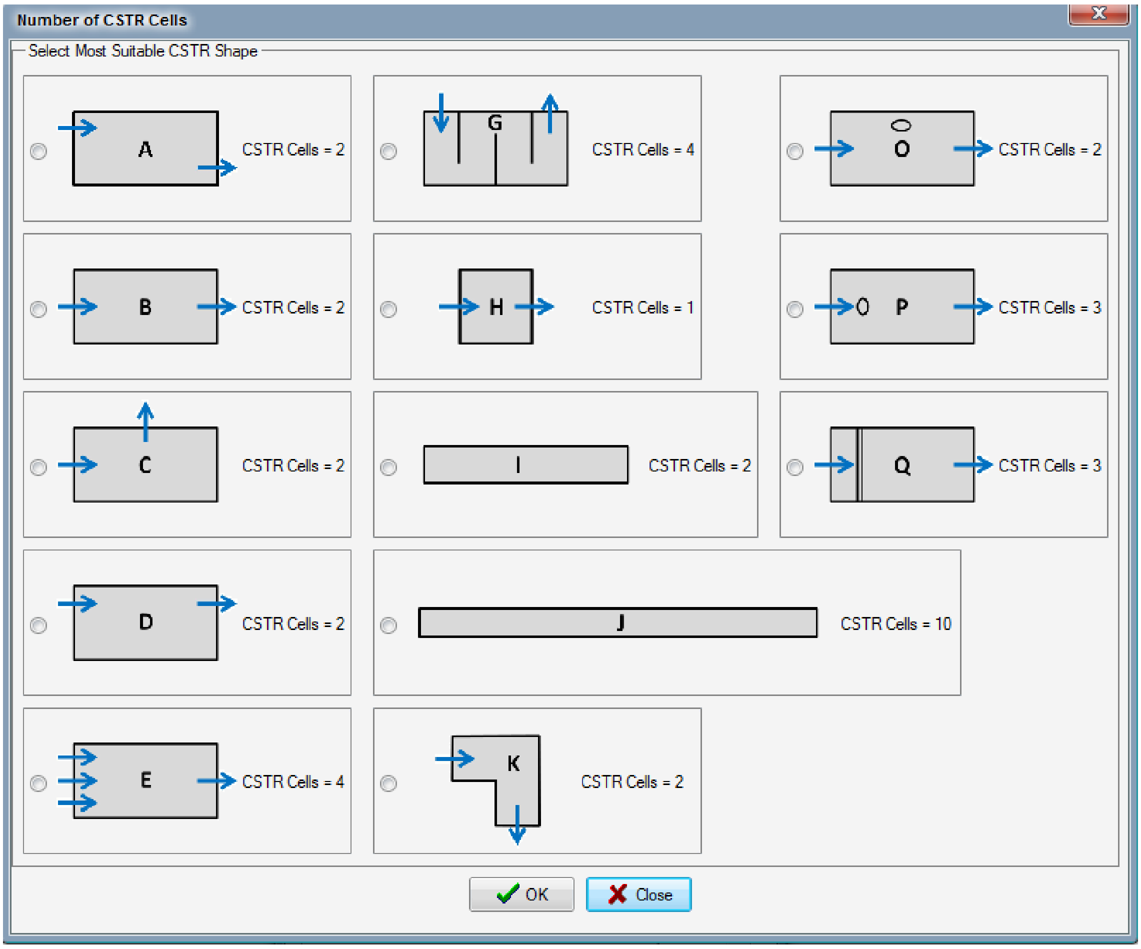

Figure 5-6 Number of CSTR Cells for Different Treatment Shapes (Source: Screenshot MUSIC Version 6.2)

6 STORMWATER TREATMENT DESIGN CURVES

Treatment Performance Curves were generated with MUSIC using the Wyndham 20-year climate template data (6 minute timestep). These curves were generated with typical parameters and can be used as an initial determination of the required treatment area for sedimentation basin, constructed wetland, bioretention and tree pit bioretention systems. It does not replace the concept design stage.

6.1 Sedimentation Basin

The adopted modelling parameters are presented in Table 6-1.

Table 6-1 Modelling Parameters Utilised in the Treatment Performance Curve

Properties	Mixed Residential Developments
Settling Velocity of Very Fine Sand (mm/s)	11
Capture Efficiency (%)	95
Turbulence (number of CSTR cells)	2.6 (Refer to Section 5.4.2)
Extended Detention Depth (m)	0.35
Permanent Pool Volume Depth	1.5

Figure 6-1 presents the relationship between the required sedimention basin area and design flow for 125 µm sediment capture efficiency of 95%. The curve was derived assuming the sedimentation basin receives direct runoff without any pre-treatment. The permanent pool volume in a sedimentation basin should be designed with sufficient capacity to ensure that desilting of the basin is not more frequent than five years.

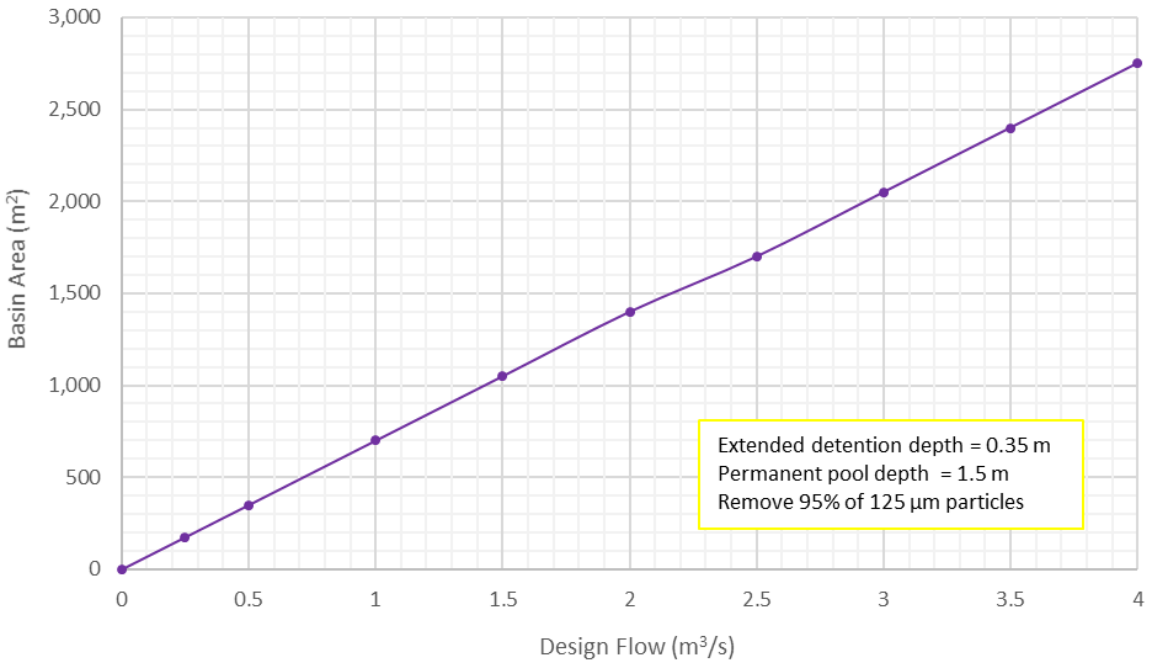

Figure 6-1 Sedimentation Basin Area Versus Design Flow – 95% Capture of 125 µm Sediment

6.2 Constructed Wetland

The adopted modelling parameters are presented in Table 6-2.

Table 6-2 Modelling Parameters Utilised in the Treatment Performance Curve

Properties	Mixed Residential Developments
Extended Detention Depth (m)	0.35
Mean Permanent Pool Volume Depth (m)	0.4
Notional Detention Time (hrs)	75

Figure 6-2 shows the expected performance of a wetland system to remove TSS, TP and TN in Wyndham. The x-axis is the area of the wetland (at the NWL) expressed as a percentage of the contributing impervious catchment.

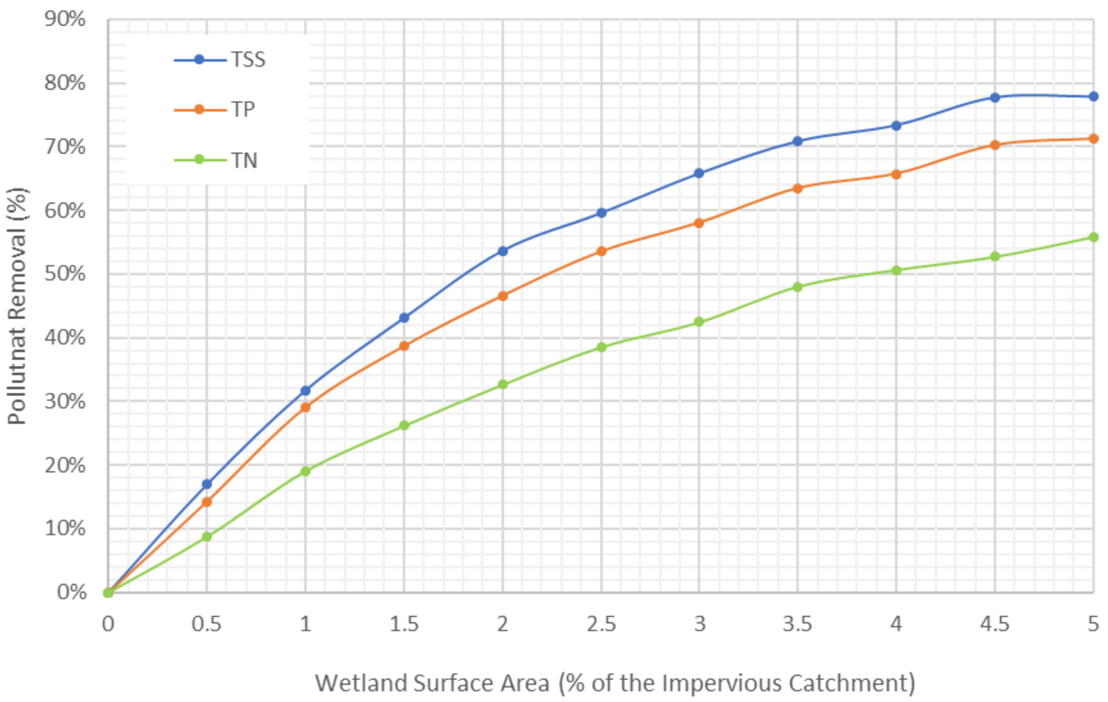

Figure 6-2 Performance of a Wetland in Removing TSS, TP and TN in Wyndham

For example, a wetland with a size equivalent to 3% - 3.5% of the impervious contributing catchment should be required to treat stormwater to best treatment practices (i.e. 45% removal of TN).

6.3 Bioretention Systems / Raingardens

Table 6-3 Modelling Parameters Utilised in the Treatment Performance Curve

Properties	Mixed Residential Developments
Extended Detention Depth (m)	0.2
Filter Media Depth (m)	0.5
Filter Media Hydraulic Conductivity (mm/hr)	180

The system has been assumed to be lined. Figure 6-2 shows the expected performance of a bioretention basin to remove TSS, TP and TN. The x-axis is the area of the bioretention (at the filter media top level) expressed as a percentage of the contributing impervious catchment.

The curve was derived assuming the sedimentation basin receives direct runoff without any pre-treatment.

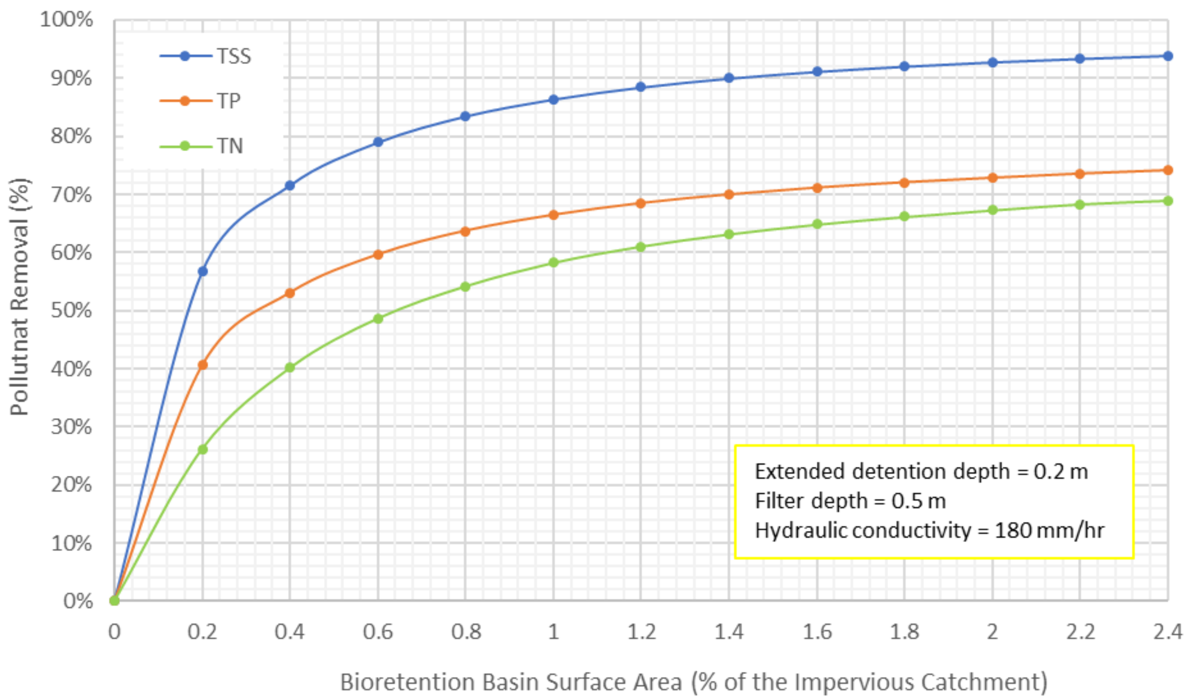

Figure 6-3 Performance of a Bioretention Basin in Removing TSS, TP and TN in Wyndham

Wyndham City Council recommends that the systems should not be oversized to avoid long periods of dry spells and that they should follow a vegetated swale, GPT or sediment trap type of system to avoid clogging by sediments. However, if the system is smaller than 1% of the impervious catchment, adopting lower ponding depths and larger filter area is preferable.

7 SUBMISSION REQUIREMENTS FOR MUSIC MODELLING

Wyndham Council adhere to Melbourne Water's Guidelines for the **submission requirements for MUSIC modelling**. These requirements are reproduced here.

7.1 Concept Design

1. Description of the function and intent of the treatment system.
2. Description of how fraction impervious was calculated (what figures were used for different zonings).
3. Specification for the treatment system, including any soil or filter media (if applicable).
4. Vegetation specification for bioretention systems.
5. Description of any updates to the MUSIC model at each stage of the design.
6. Summary of MUSIC modelling, including the following information must be shown in the SWMS:
   - version of MUSIC
   - meteorological data used
   - map outlining catchment areas and direction of flows
   - justification for choice of source node impervious percentage
   - any routing used
   - treatment node parameters
   - any modelling parameters that are not in accordance with these Guidelines
   - pollutant removal results
7. A copy of the MUSIC model

7.1.1 Functional/Detailed Design

1. Summary of the MUSIC model (as above) and a description of any update, including:
   - the stage-storage-discharge relationships adopted from the bathymetry and inlets/outlets arrangements (Appendix D) (for wetland and sedimentation basin)
   - the high flow bypass configuration to the design
   - the extended detention controlled outlet configuration to the design
2. An inundation frequency analysis of water levels in the macrophyte zone (for wetland only).
3. The 90^{th} percentile residence time in the in the macrophyte zone (for wetland only).

8 SUMMARY

The modelling guidelines provided within this document are intended to provide a local context for the MUSIC models. Values outside the provided ranges may be accepted; however Council will need to be consulted. Parameters that have not been mentioned in the Guidelines should be adopted at their default values.

9 REFERENCES

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APPENDIX A
CLIMATE DATA ANALYSIS

A-1 Rainfall

The Wyndham municipality covers an area of approximately 542 km^2, and has 27.4 km of coastline[5]. The key areas in terms of population are Point Cook, Werribee, Hoppers Crossing and Tarneit. Significant portions of land are being opened up to residential development, with a number of drainage schemes (e.g. Developer Services Schemes produced by Melbourne Water) being finalised. Wyndham City is within the Werribee drainage catchment which in total covers about 2,715 km^2.

In general, mean annual rainfall values increase from west to east of Melbourne. As such the west region of Melbourne, where Wyndham is located, experiences some of the lowest rainfall in Melbourne.

Analysis of long historical rainfall data, ranging from early 1900 to 1990[6] indicate that the mean annual rainfall ranges from 474 mm/yr at Little River to 569 mm/y at Point Cook RAAF Academy. The Figure below shows the average rainfall for the period between 1961 to 1990.

[5] WCC (2014). State of Environment Report, 2013-2014. Wyndham City Council

[6] BOM website, accessed in 2017

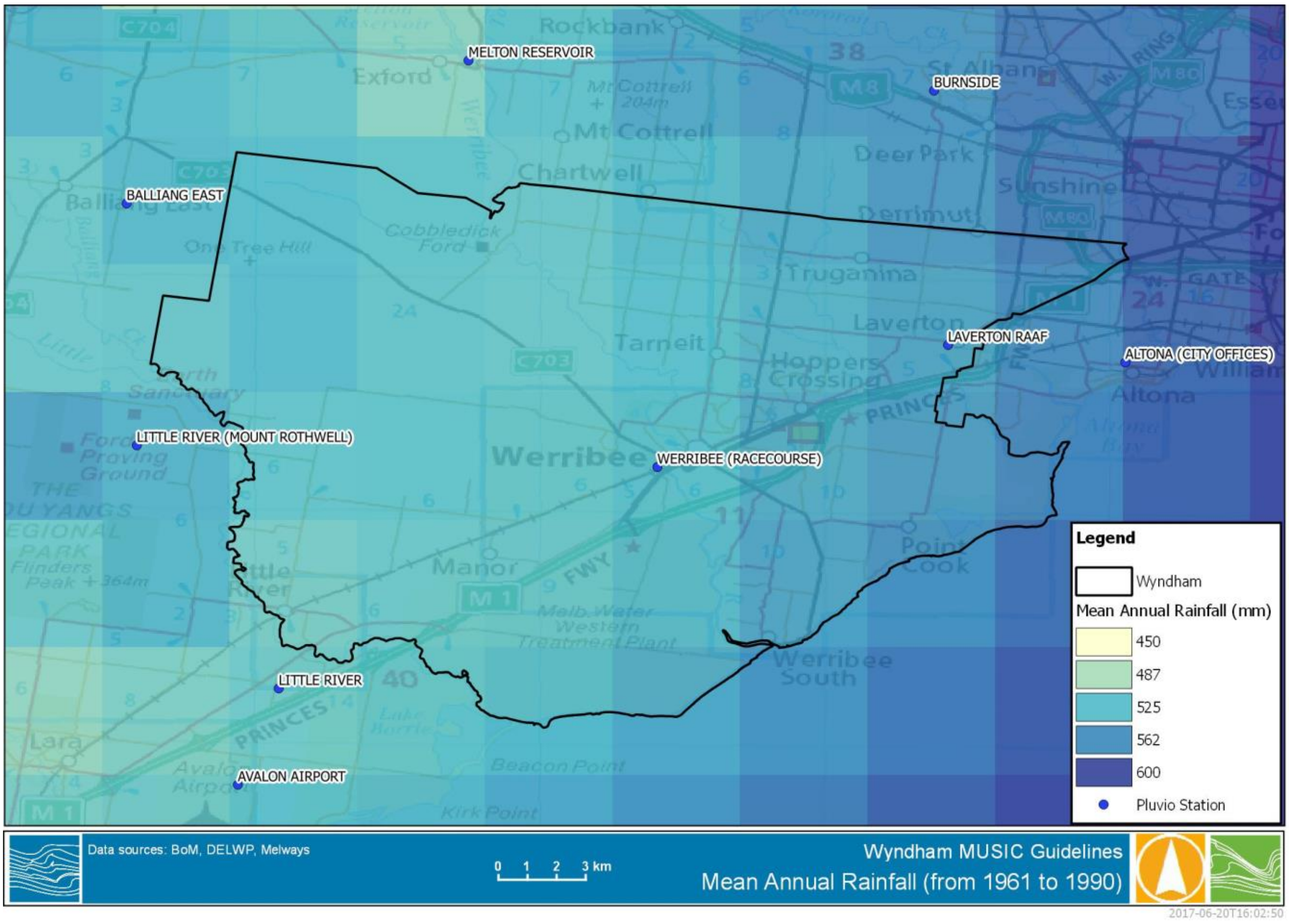


Figure A-1 Mean Annual Rainfall from 1961 to 1990 showing Currently Opened Rainfall Stations[7]

Wyndham region experienced a significant reduction in rainfall during the millennium drought. It has been reported that the average annual rainfall in the Werribee catchment has decreased by 15% since 1997[8]. Figure A-2 shows the annual rainfall totals for the BOM registered open stations in the area with daily data records.

[7] BOM website, accessed in 2017

[8] SRW (2009). Western Irrigation Futures Atlas. Southern Rural Water

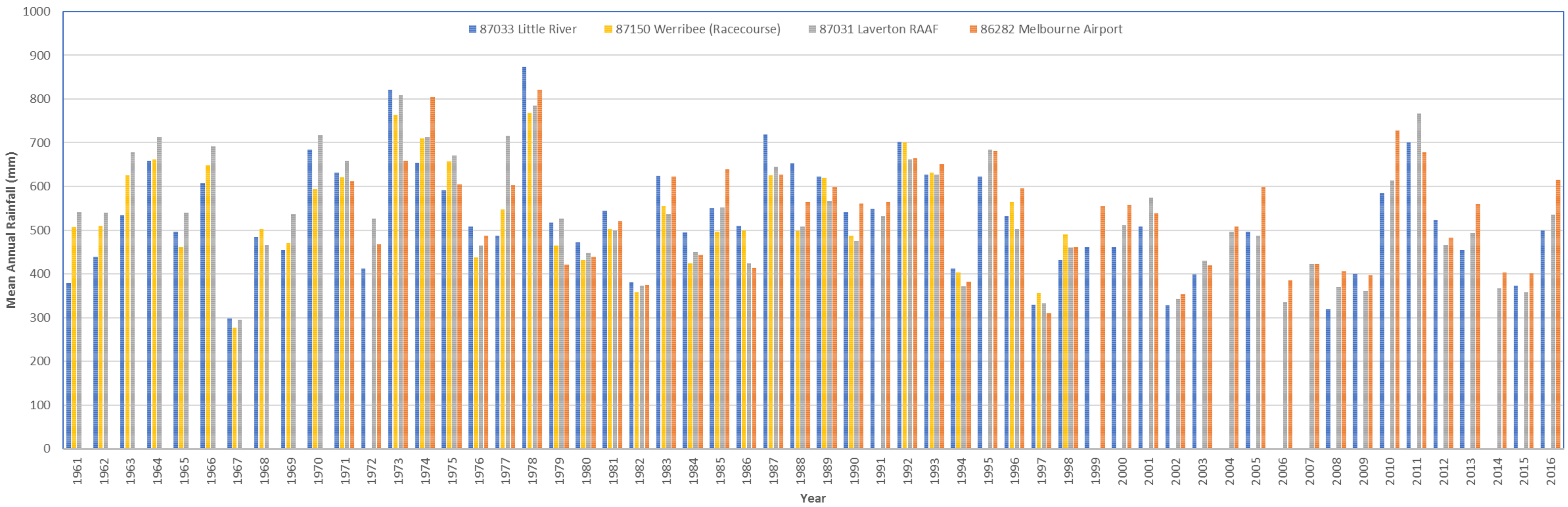


Figure A-2 Annual Rainfall Totals for Little River, Laverton RAAF, Melbourne Airport and Werribee Stations

The analysis of longer historical data period, by means of including the annual rainfall totals of the last decades, suggests that mean annual rainfall within Wyndham municipality and its surroundings is in fact lower, with a regional average around 500 mm/yr. Table A-1 illustrates this discussion.

Table A-1 Rainfall Gauges with Recent Rainfall Records

Rain Station Name	Rain Station Number	Mean Annual Rainfall (mm/yr) 1961 - 1990	Mean Annual Rainfall (mm/yr) & Record Interval	
Little River	87033	516	485	1906 – 2016
Laverton RAAF	87031	547	536	1941 – 2016
Little River (Mount Rothwell)	87048	535	458	1906 – 2016
Melton Reservoir	87040	502	485	1948 – 2016
Melton	87039	516	482	1906 – 2016
Melbourne Airport	86282	602	535	1970 - 2016
Werribee (Racecourse)	87150	526	542	1958 - 2010
Mean Regional Rainfall			**503**	

Little River station has 6-minute data available for the period between 1965 and 2010 and was selected to derive a 10-year period of representative data. The period between 1992 to 2001 presented an annual mean rainfall value close to 491 mm/yr. The period was closely inspected and many data gaps were identified. Where possible, the data was infilled with data from the 6-minute data from the Laverton RAAF station. The final dataset has an annual rainfall of **495 mm/hr.**

Please note that this dataset differs from the recent rainfall template recommended by Melbourne Water using the same 10-year period as the data in this work has been infilled with data from a neighbouring station to generate a better dataset and better represent the Wyndham region.

A-2 Evapotranspiration

The Figure below shows the mean annual potential evapotranspiration across Wyndham.

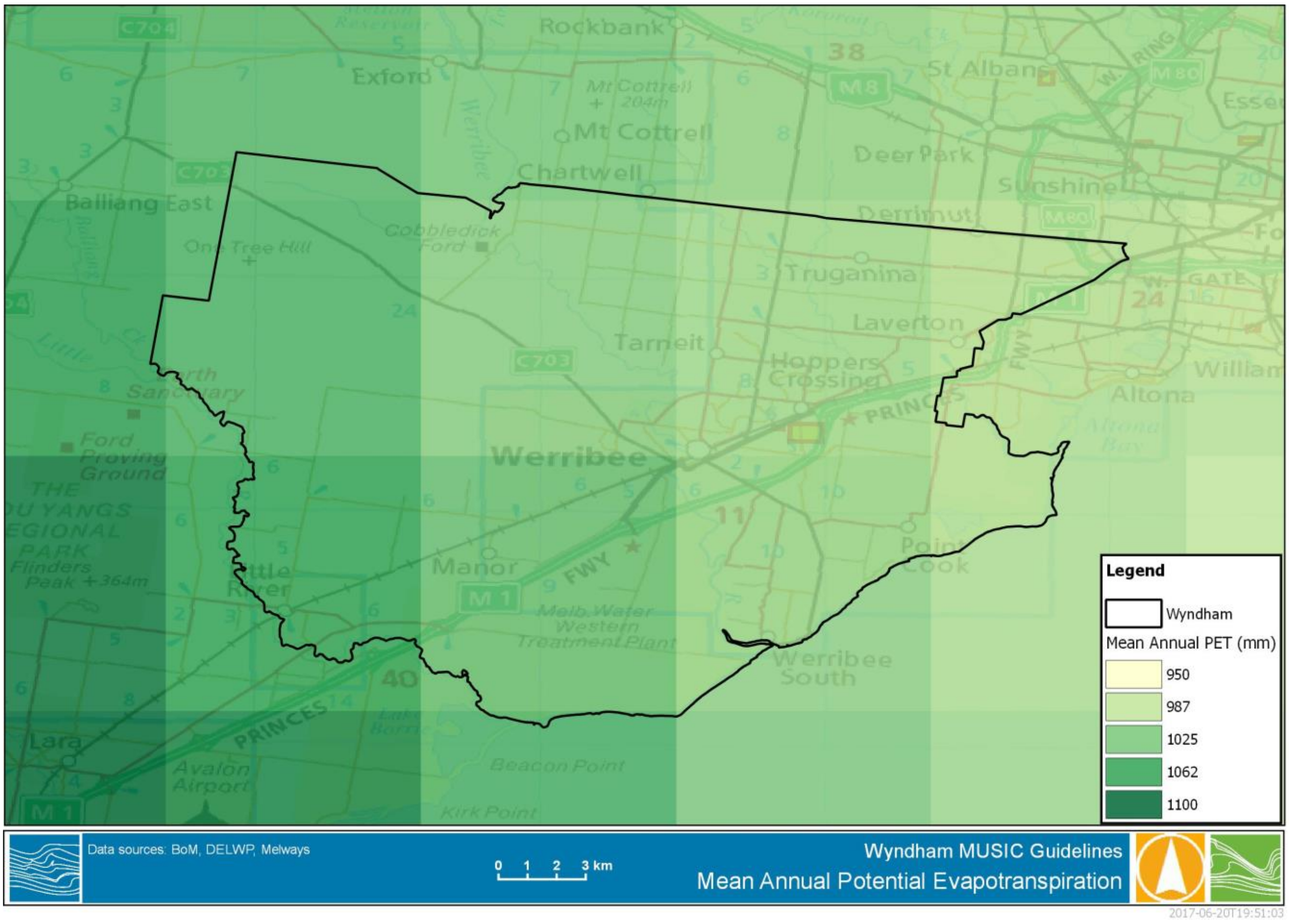


Figure A-3 Mean Annual Potential Evapotranspiration[9]

[9] BOM website, accessed in 2017

APPENDIX B
POLLUTANT CONCENTRATION DATA

Table B-2 Default Pollutant Concentrations for Each Source Node (Source: https://wiki.ewater.org.au/display/MD6/Editing+Source+Node+Properties)

Source Node Type	Zoning/Surface Type	Pollutant Concentration (log mg/L)											
		Total Suspended Solids				Total Phosphorus				Total Nitrogen			
		Base Flow		Storm Flow		Base Flow		Storm Flow		Base		Storm	
		Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Agricultural	-	1.40	0.13	2.30	0.31	-0.88	0.13	-0.27	0.30	0.074	0.130	0.59	0.26
Forest	-	0.90	0.13	1.90	0.20	-1.50	0.13	-1.10	0.22	-0.14	0.13	-0.075	0.240
Urban	Mixed	1.10	0.17	2.20	0.32	-8.20	0.19	-0.45	0.25	0.32	0.12	0.42	0.19
	Roof	1.10	0.17	1.30	0.32	-8.20	0.19	-0.89	0.25	0.32	0.12	0.30	0.19
	Sealed Road	1.20	0.17	2.43	0.32	-8.50	0.19	-0.30	0.25	0.11	0.12	0.34	0.19
	Unsealed road	1.20	0.17	3.00	0.32	-8.50	0.19	-0.30	0.25	0.11	0.12	0.34	0.19
	Eroding gullies	1.20	0.17	3.00	0.32	-8.50	0.19	-0.30	0.25	0.11	0.12	0.34	0.19
	Revegetated land	1.15	0.17	1.95	0.32	-1.22	0.19	-0.66	0.25	-0.05	0.12	0.30	0.19
	Quarries	1.20	0.17	3.00	0.32	-0.85	0.19	-0.30	0.25	0.11	0.12	0.34	0.19
	Residential	1.20	0.17	2.15	0.32	-0.85	0.19	-0.60	0.25	0.11	0.12	0.30	0.19
	Commercial	1.20	0.17	2.15	0.32	-0.85	0.19	-0.60	0.25	0.11	0.12	0.30	0.19
	Industrial	1.20	0.17	2.15	0.32	-0.85	0.19	-0.60	0.25	0.11	0.12	0.30	0.19
	Rural residential	1.15	0.17	1.95	0.32	-1.22	0.19	-0.66	0.25	-0.05	0.12	0.30	0.19

APPENDIX C
SIZING SEDIMENT PONDS OUTSIDE OF MUSIC

For standard urban developments, the design of the sediment pond should:

- Remove 95% of the **125** µm particles (very fine sand)
- Be cleaned when sediment deposition reaches 0.5 m from the Normal Water Level. Council require that the cleanout frequency should not be more frequent than every 5 years.

Sizing sediment ponds to achieve the above objectives some calculations to be undertaken outside of MUSIC. The Fair and Geyer Equation (refer to Equation 10.3 in the WSUD Stormwater Technical Manual[10] should be used. The steps are summarised here.

1. The area of the basin is calculated to achieve a sediment removal efficiency:

$$R = 1 - \left[1 + \frac{1}{n} \cdot \frac{v_s}{Q/A} \cdot \frac{(d_e + d_p)}{(d_e + d^*)}\right]^{-n}$$

Where:

R = fraction of target sediment removed (%);

v_s = settling velocity of target sediment (Refer to Table C-3).

Q/A = design flow rate divided by basin surface area ($m^3/s/m^2$).

n = turbulence or short-circuiting parameter $n = \frac{1}{n-\lambda}$. Refer to Figure C-4 for λ value based on the shape, inlet and outlet position.

d_e = extended detention depth (m) above permanent pool level;

d_p = depth (m) of the permanent pool;

d^* = depth below the permanent pool level that is sufficient to retain the target sediment (m) – adopt 1.0 m or d_p whichever is lower.

Refer to Table 5-1, for the set of parameters recommended for standard urban developments.

Table C-3 Settling Velocities

Classification of Particle Size Range	Particle Size (µm)	Settling Velocities (mm/s)
Very coarse sand	2000	200
Coarse sand	1000	100
Medium sand	500	52
Fine sand	250	26
Very fine sand	**125**	**11**
Coarse silt	62	2.3
Medium silt	31	0.66
Fine silt	16	0.18
Very fine silt	8	0.04
Clay	4	0.011

[10] CSIRO (2005). WSUD Engineering Procedures: Stormwater. CSIRO Publishing.

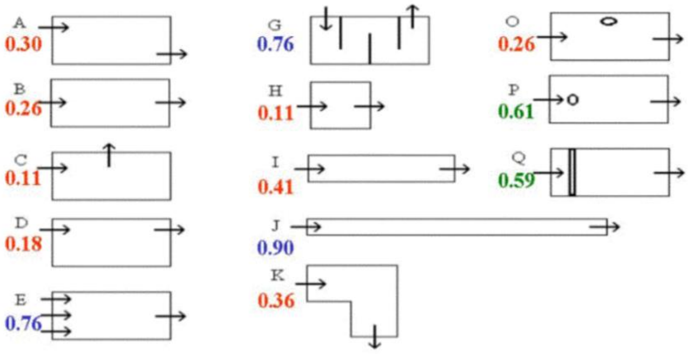


Figure C-4 Hydraulic Efficiency (λ ranges from 0 to 1, with 1 representing the best hydrodynamic conditions for stormwater treatment)

2. Cleaning frequency:

$$\text{Cleanout frequency} = \frac{Vol}{CA \cdot R \cdot L}$$

Where:

Cleanout frequency = desired cleanout frequency (years)

Vol = volume of sediment in the basin (m^3)

CA = Contribution catchment area (m^2).

R = fraction sediment removed (%)

L= sediment loading rate (m^3/ha/year); consisted of the sum of the sediment load (Table C-4) and the gross pollutant load (Table C-5).

Table C-4 Sediment Loads

Land Use	Sediment Load (m^3/ha/year)
Urban[11]	1.6
Agricultural[12]	2
Developing Stage Urban	50 to 200

[11] Willing and Partners, 1992, Design Guidelines for Gross Pollutant Traps.

[12] MUSIC model results.

Table C-5 Gross Pollutant Loads

Land Use	Gross Pollutant Load (m^3/ha/year)
Urban[13]	0.40
Commercial[14]	0.53
Residential[14]	0.28
Light Industrial[14]	0.15

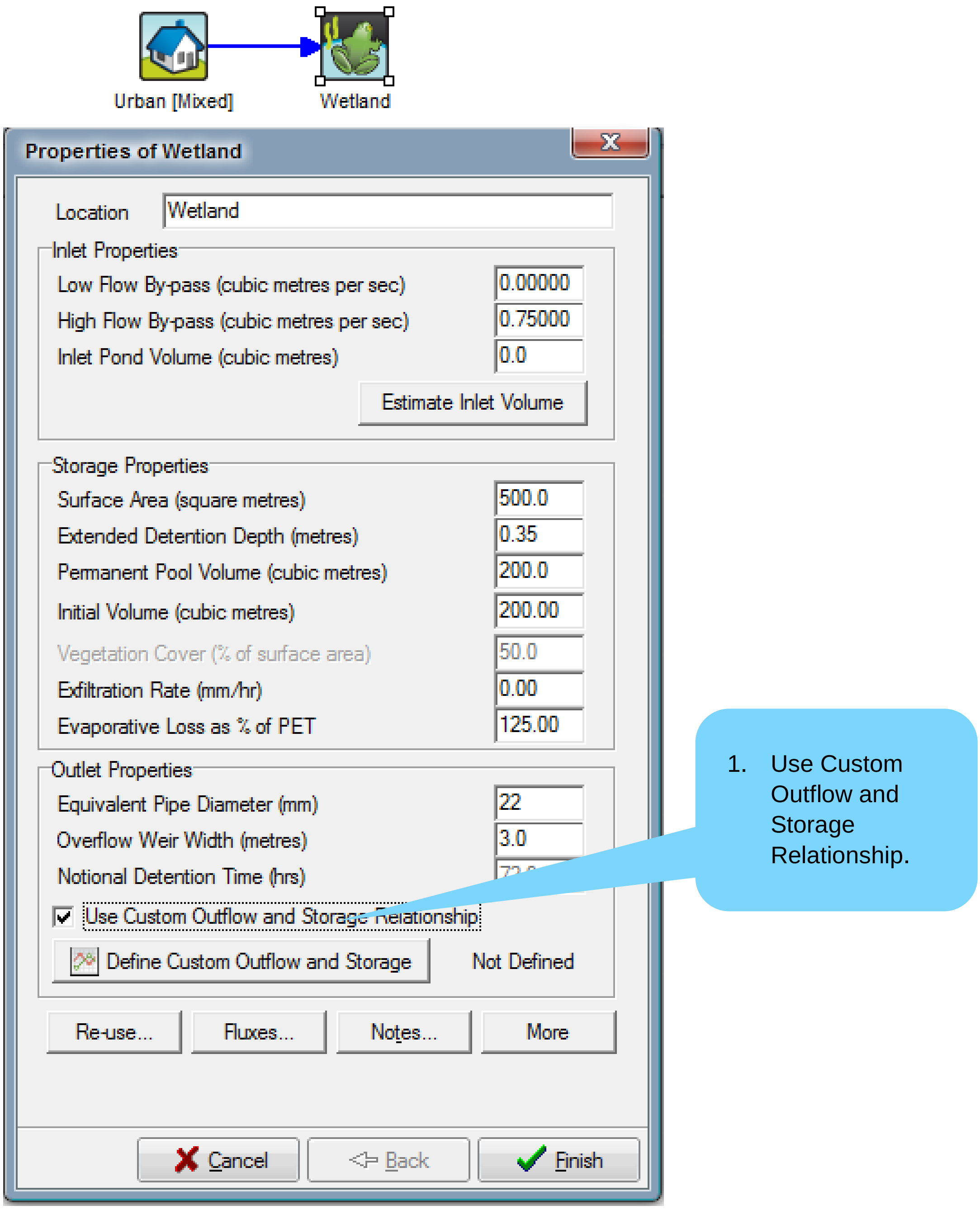
[13] Allison, R., Chiew, F. H. S., McMahon, T. (1998). A Decision Support System for Determining Effective Trapping Efficiencies for Gross Pollutants. Cooperative Centre for Catchment Hydrology.

[14] Approximate Litter and Gross Pollutant Loading Rates for Melbourne in IEAust (2006). Australian Runoff Quality: A Guide to Water Sensitive Urban Design. New South Wales.

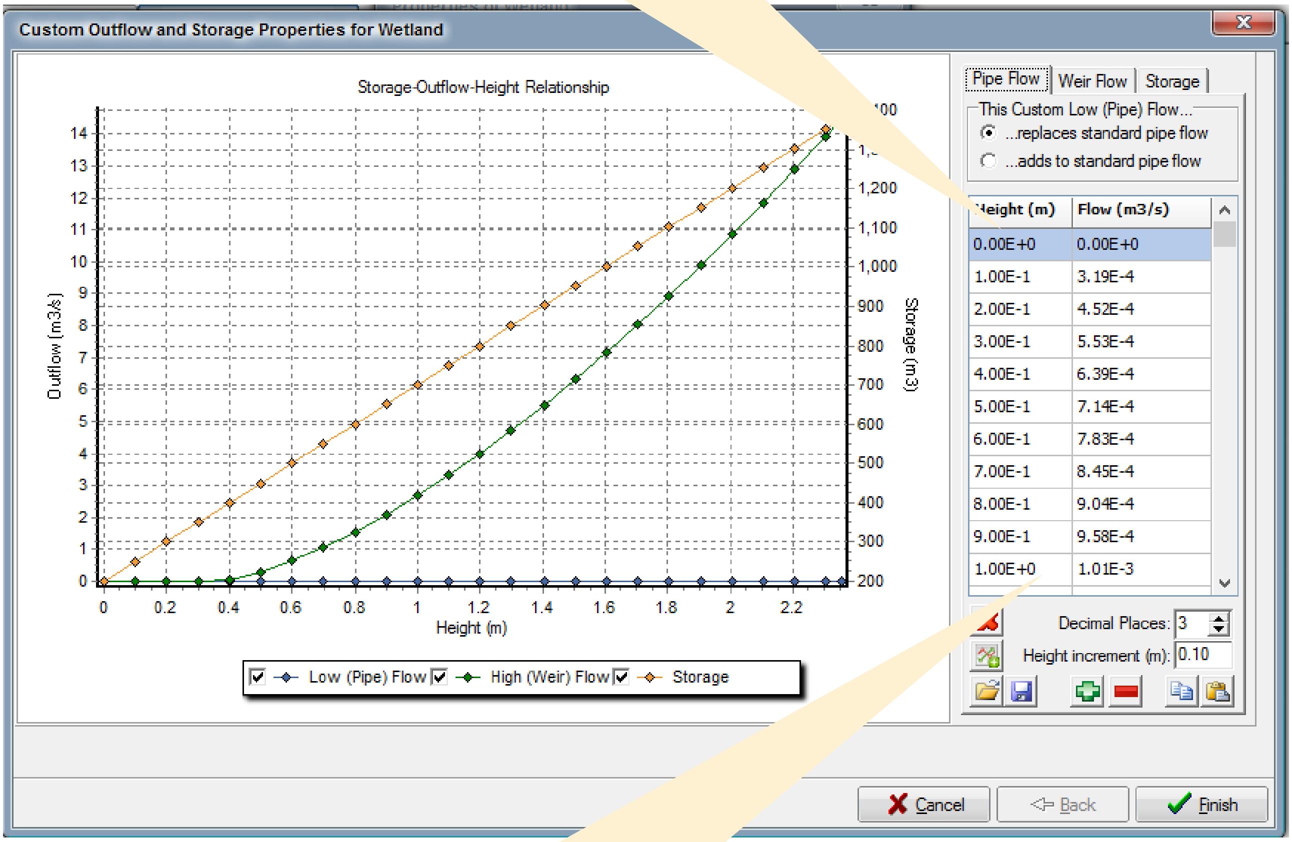
APPENDIX D
RELEVANT FUNCTIONS IN MUSIC

D-1 Stage Storage Discharge Relationships

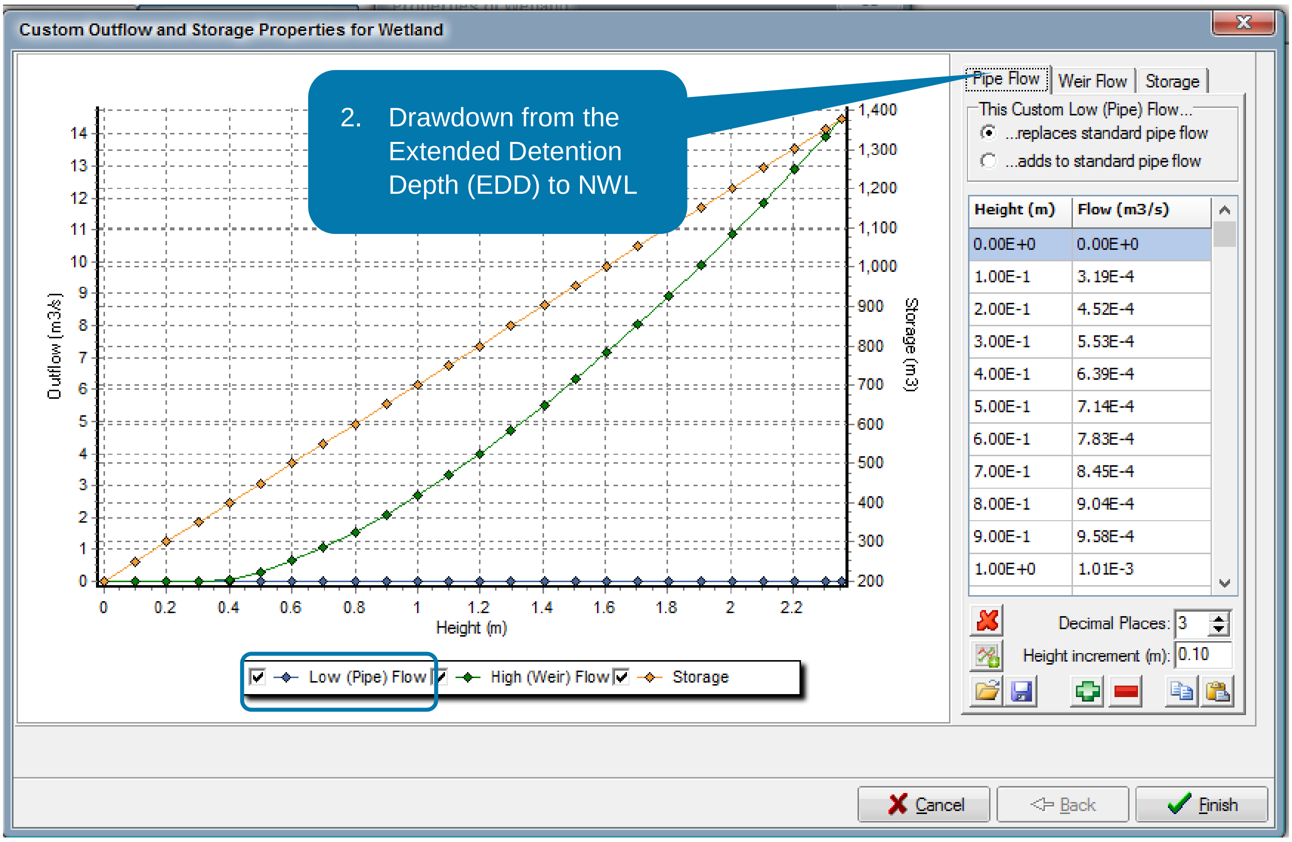
Directions for using the Custom Outflow and Storage Relationship function is shown the diagrams below. The stage-storage-discharge relationships should be obtained from the bathymetry of the systems with the proposed inlet/outlet arrangements (outside of MUSIC).

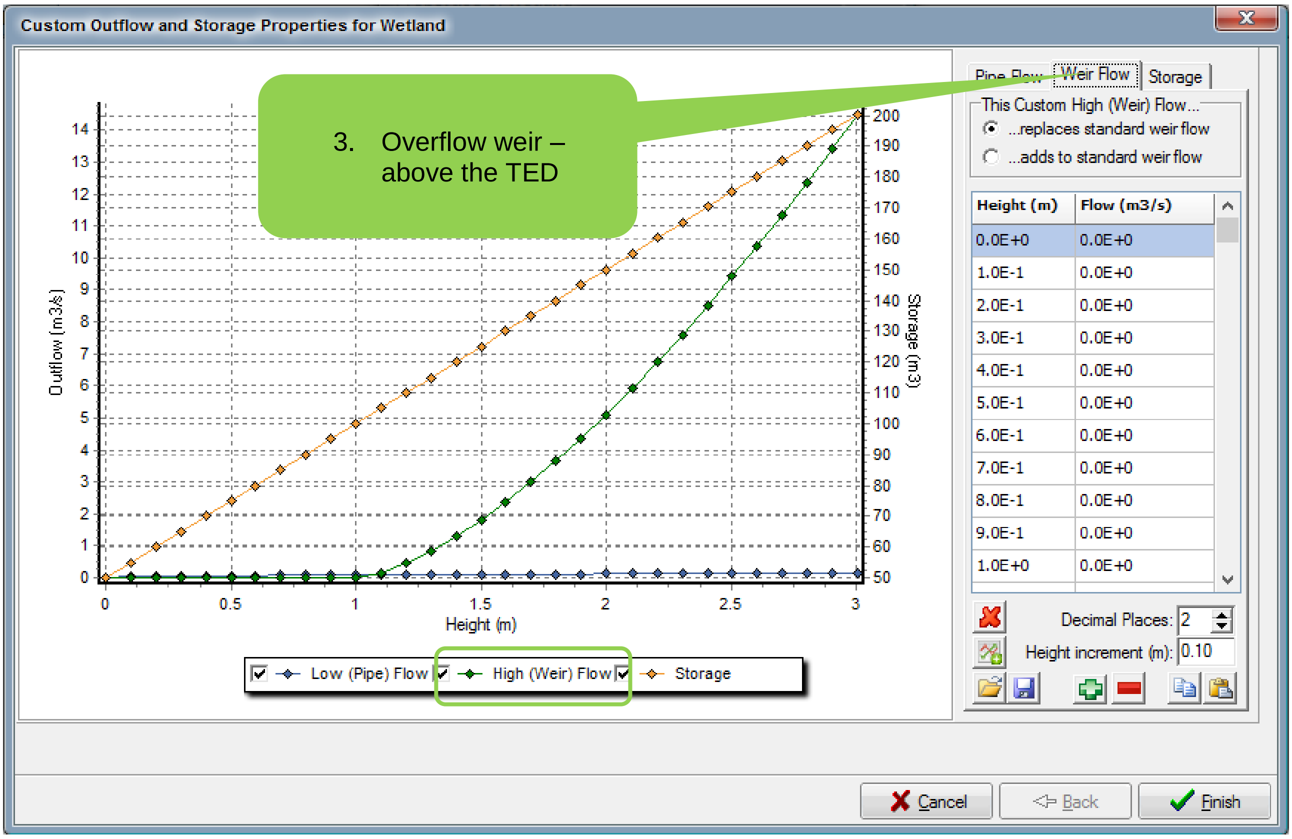


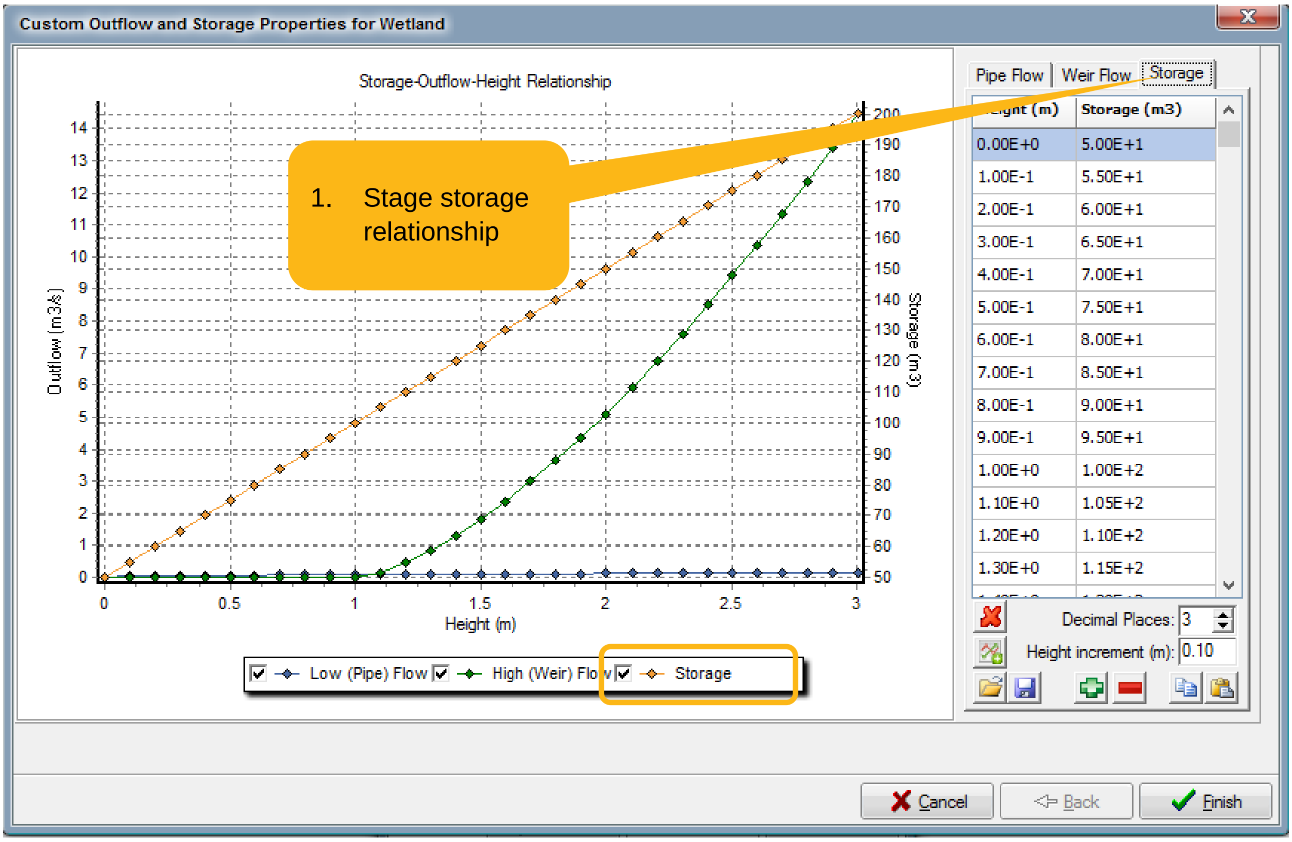
The Stage Storage Discharge Relationships in MUSIC are for the extended detention only. This means that zero height in the table below corresponds to the Normal Water Level (NWL).



MUSIC requires the Stage Storage Discharge Relationships up to 2 m above the Total Extended Depth (TED) level.

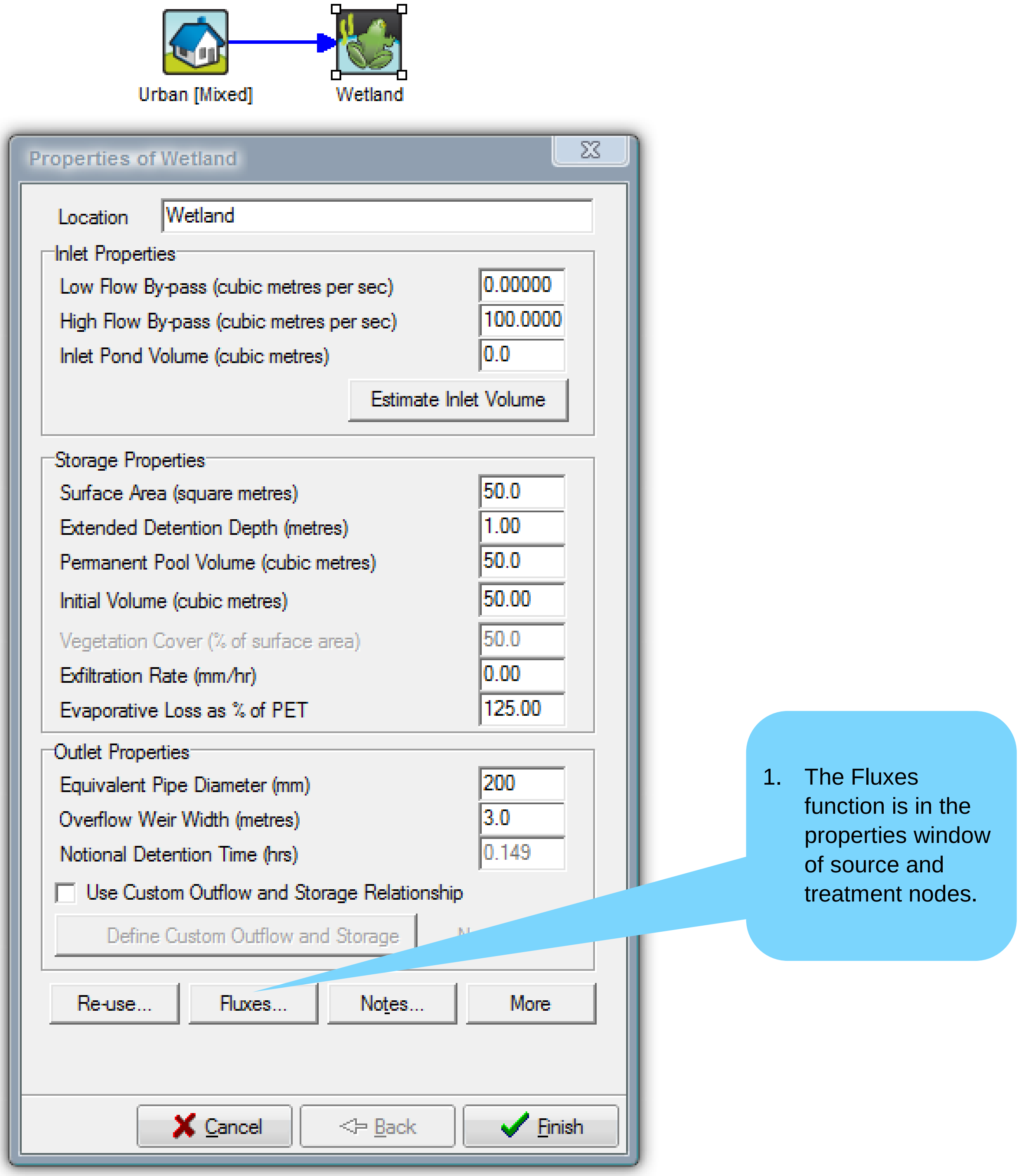

Custom Outflow and Storage Properties for Wetland
2. Drawdown from the Extended Detention Depth (EDD) to NWL
Pipe Flow
Weir Flow
Storage
This Custom Low (Pipe) Flow...
...replaces standard pipe flow
...adds to standard pipe flow
Height (m) | Flow (m3/s)
0.00E+0 | 0.00E+0
1.00E-1 | 3.19E-4
2.00E-1 | 4.52E-4
3.00E-1 | 5.53E-4
4.00E-1 | 6.39E-4
5.00E-1 | 7.14E-4
6.00E-1 | 7.83E-4
7.00E-1 | 8.45E-4
8.00E-1 | 9.04E-4
9.00E-1 | 9.58E-4
1.00E+0 | 1.01E-3
Decimal Places: 3
Height increment (m): 0.10
Outflow (m3/s)
Storage (m3)
Height (m)
Low (Pipe) Flow
High (Weir) Flow
Storage
Cancel
Back
Finish

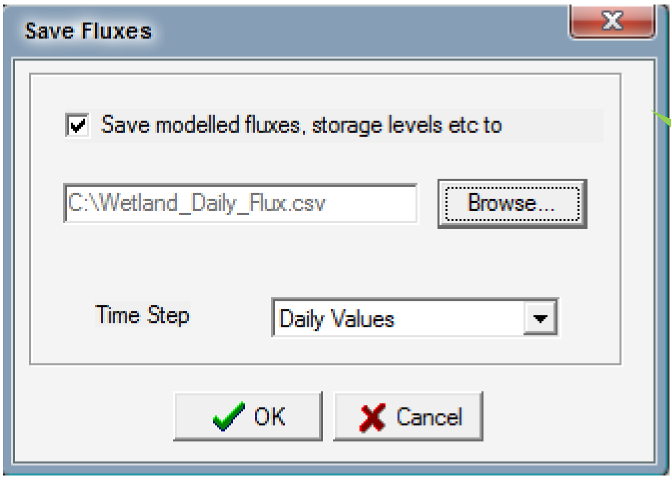

Custom Outflow and Storage Properties for Wetland
3. Overflow weir – above the TED
Pipe Flow
Weir Flow
Storage
This Custom High (Weir) Flow...
...replaces standard weir flow
...adds to standard weir flow
Height (m) | Flow (m3/s)
0.0E+0 | 0.0E+0
1.0E-1 | 0.0E+0
2.0E-1 | 0.0E+0
3.0E-1 | 0.0E+0
4.0E-1 | 0.0E+0
5.0E-1 | 0.0E+0
6.0E-1 | 0.0E+0
7.0E-1 | 0.0E+0
8.0E-1 | 0.0E+0
9.0E-1 | 0.0E+0
1.0E+0 | 0.0E+0
Decimal Places: 2
Height increment (m): 0.10
Outflow (m3/s)
Storage (m3)
Height (m)
Low (Pipe) Flow
High (Weir) Flow
Storage
Cancel
Back
Finish


Custom Outflow and Storage Properties for Wetland
Storage-Outflow-Height Relationship
1. Stage storage relationship
Outflow (m3/s)
Storage (m3)
Height (m)
Low (Pipe) Flow
High (Weir) Flow
Storage
Pipe Flow
Weir Flow
Storage
Storage (m3)
0.00E+0 5.00E+1
1.00E-1 5.50E+1
2.00E-1 6.00E+1
3.00E-1 6.50E+1
4.00E-1 7.00E+1
5.00E-1 7.50E+1
6.00E-1 8.00E+1
7.00E-1 8.50E+1
8.00E-1 9.00E+1
9.00E-1 9.50E+1
1.00E+0 1.00E+2
1.10E+0 1.05E+2
1.20E+0 1.10E+2
1.30E+0 1.15E+2
Decimal Places: 3
Height increment (m): 0.10
Cancel
Back
Finish

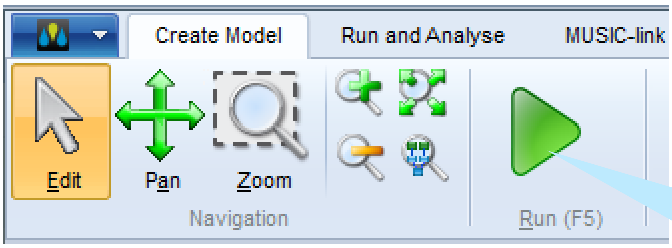
D-2 Flux File

Directions for saving a daily flux file is shown the diagrams below.





2. In the Fluxes window, click to save the fluxes, browse a directory to save the file, select daily values and click ok.



3. Run the model and the file should be saved in the selected directory.

APPENDIX E
BIORETENTION SOIL MOISTURE ANALYSIS

E-1 Soil Moisture Analysis

Wyndham City Council recognises that the bioretention systems built within the municipality are not performing well. It is likely that the causes are related to incorrect design and/or construction which leads to the death of vegetation. Recent assessments of streetscape bioretention systems for the City of Port Phillip by E2Designlab in 2014[15] indicated that many systems had insufficient soil moisture to sustain plants. The work suggested that this is often due to media being too shallow or very sandy with little soil moisture holding capacity.

This situation is potentially worse in Wyndham where the annual rainfall volumes have decreased during the millennium drought to less than 500 mm/yr and the systems within the municipality have been sized in MUSIC using the data from Melbourne Airport area with a mean annual rainfall of nearly 580 mm/yr. It is hypothesised that the death of plants (due to the lack in soil moisture) in the existing bioretention systems are due to the lack of flow, meaning that the systems are oversized for the real current rainfall and associated runoff generation.

MUSIC models were set up and run with two different rainfall data sets, from different rainfall stations to understand the impact on the size of the bioretention to achieve best practice treatment targets. 10-year reference rainfall templates for Melbourne Airport and Little River stations were utilised:

- Melbourne Airport from 1971 to 1980 with a mean annual rainfall of 575 mm/yr; and,
- Little River from 1992 to 2001 with a mean annual rainfall of 472 mm/yr. This station has the lowest rainfall volumes in Melbourne.

A range of catchments areas and land uses were also assessed.

Subsequently, a sensitivity analysis of the modelled soil moisture and frequency of dry spells to a range of input data and model parameters was undertaken to understand this issue further. The following input data and paraments were varied to undertake the sensitivity analysis:

- Size of the biorientation as a proportion of the catchment area. 1 and 2% of the catchment area were tested. It is often that bioretention systems in this range achieve best practice treatment targets in residential developments.
- Filter depth. 300 mm and 500 mm depth filer media were tested. While the new Adoption Guidelines for Biorientation[16] do not recommend filter media depths lower than 500 mm, its common that values around 300 mm are adopted.
- Presence or not of saturated zone of 0.45 m.
- PET scaling factor. 1.78 and 2.10 were tested.

The climate data template presented in Section 2 and Appendix A was used for this analysis.

E-2 Results and Discussion

The modelling results indicated that using the rainfall from Little River station resulted in systems approximately 10% smaller than the ones designed with rainfall from Melbourne Airport station to achieved

[15] Browne, D. Burge, K. Long, C. (2014). Streetscape Raingardens: Lessons from the Field. Presented at 13th International Conference on Urban Drainage, Sarawak, Malaysia, September 2014.

[16] Payne, E.G.I., Hatt, B.E., Deletic, A., Dobbie, M.F., McCarthy, D.T. and Chandrasena, G.I., 2015. Adoption Guidelines for Stormwater Biofiltration Systems, Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

best practice targets. The reduction in the system size did not change with different catchment sizes with the same land use.

Figure E-5 shows the modelled filter media saturation and the percent of its exceedance over the modelling period for the same size of bioretention using the rainfall data from the two different stations. The optimal soil moisture for plants is between the Field Capacity and the Stress Point, sub-optimal is between the Stress Point to the Wilting Point, and water is no longer available for plants below the Wilting Point. Please refer to MUSIC manual[17] and the MUSIC Auditor website[18] for more details on the relationship of soil moisture and water availability for plants.

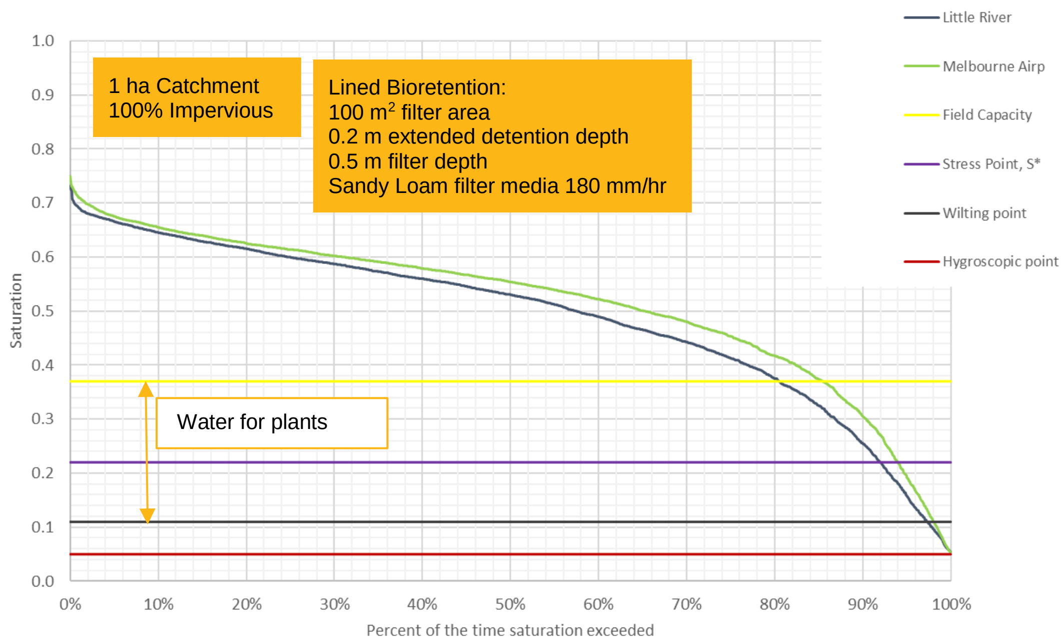


Figure E-5 Filter Media Saturation Exceedance Over the Modelling Period. The x-axis shows the percent of time that soil saturation is lower or equal to the saturation in the y-axis.

[17] eWater (2015). Model for Urban Stormwater Improvement Conceptualisation (MUSIC) Users Guide. Version 6.1

[18] http://www.musicauditor.com.au/

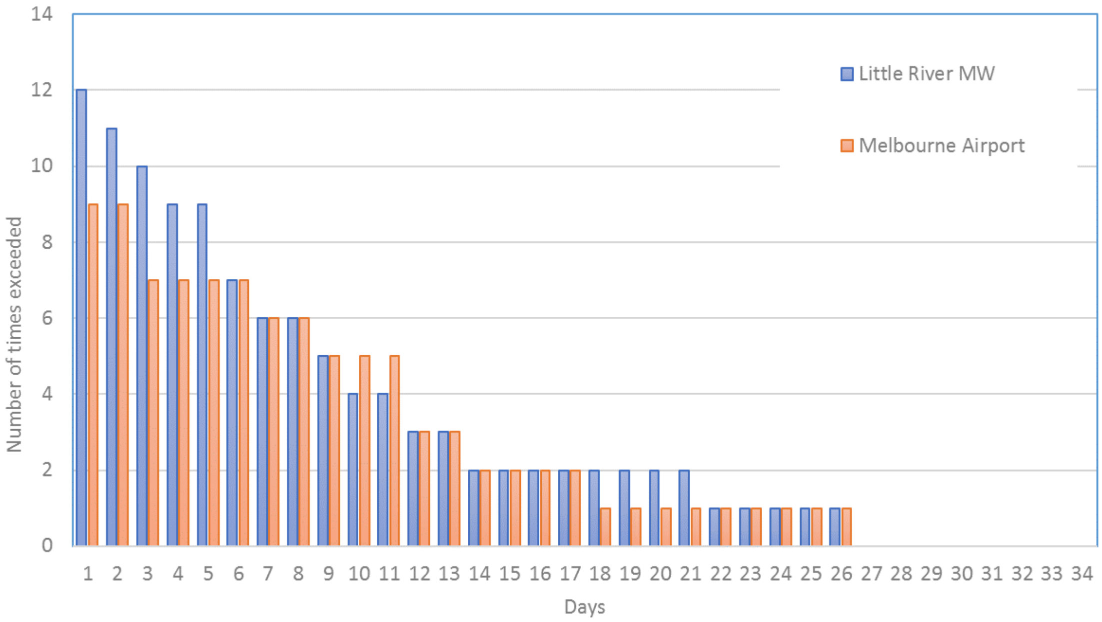


Figure E-6 Frequency of Modelled Dry Spells. The y-axis shows the number of times that the dry period in x-axis occurred.

While the results suggest that bioretention systems have been slightly oversized when using Melbourne Rainfall to design systems in Wyndham, the frequency of modelled dry spells using both rainfall datasets (Figure E-6) did not indicate that any increase in in the number and frequency of long dry periods.

These results suggest that the use of the rainfall from the Melbourne Airport station might not be the main reason for the death of plants in the systems around the municipality.

On the other hand, the system size, filter media depth and the adoption of a submerged zone impacted on the soil moisture distribution over the modelling period. Figure E-7 presents the filter media saturation exceedance over the modelling period for a range of scenarios. The results suggest that the adoption of a submerged zone reduced the frequency of the filter saturation lower than the wilting point.

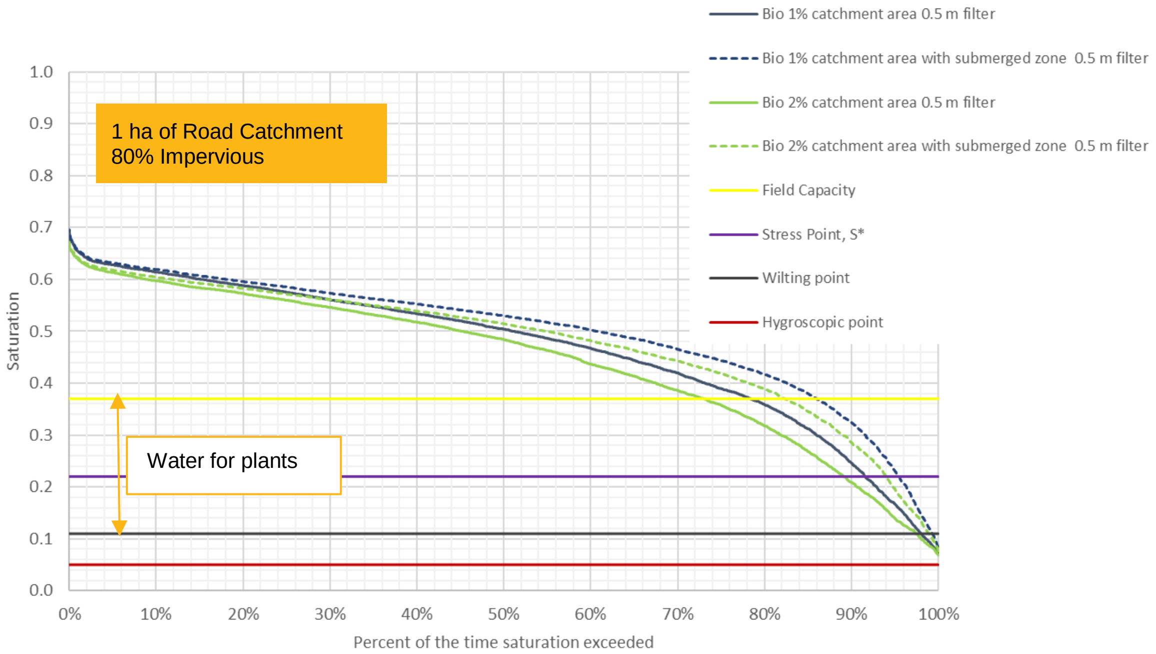


Figure E-7 Filter Media Saturation Exceedance Over the Modelling Period. The x-axis shows the percent of time that soil saturation is lower or equal to the saturation in the y-axis.

Figure E-8 to Figure E-10 show the frequency of modelled dry spells for the different scenarios. Standard bioretention with an area equal to 2% of the catchment area had more frequent and longer dry spells than the one with an area equal to 1% of the catchment impervious area.

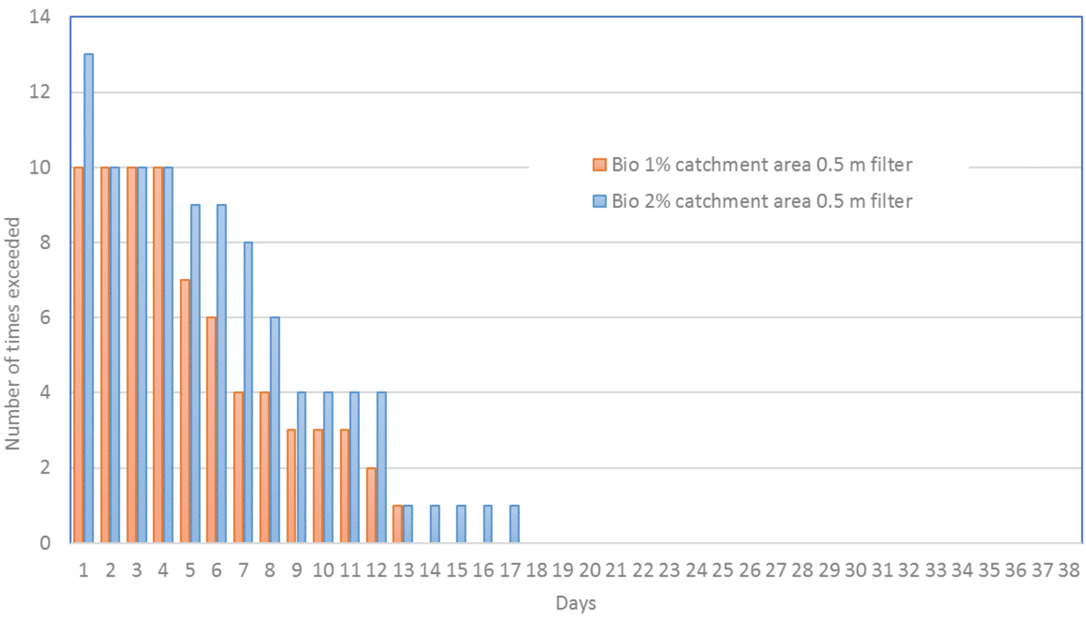


Figure E-8 Frequency of Modelled Dry Spells. The y-axis shows the number of times that the dry period in x-axis occurred.

Standard bioretention with an area equal to 1% of the catchment area and filter depth of 0.3 m had more frequent and dry spells than the one with the same size and filter depth of 0.5 m. This is in accordance with the previous work undertaken by E2Designlab in 2013[19], which showed that shallow filter depths of 0.3 m or less were likely to result in long dry spells causing plant stress.

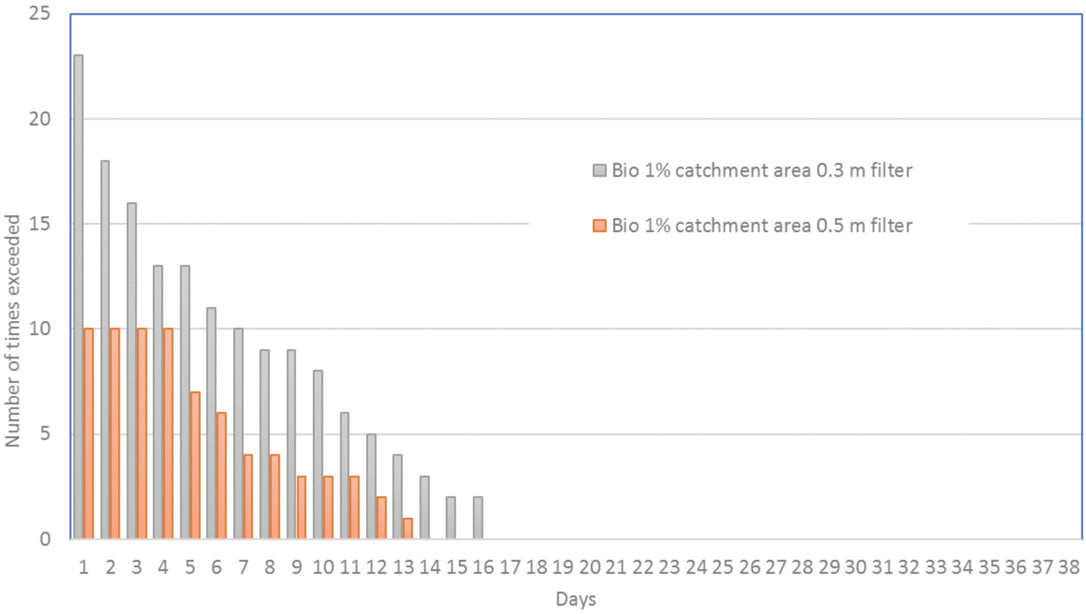


Figure E-9 Frequency of Modelled Dry Spells. The y-axis shows the number of times that the dry period in x-axis occurred.

The adoption of a saturated zone of 0.45 m improved the soil moisture conditions significantly. This has been previously identified through laboratory tests (eWater, 2015) and is confirmed via MUSIC modelling.

[19] E2DesignLab (2013). Design of Dry Climate Biofiltration Systems in the West. Accessed from http://e2designlab.com.au/projects/industry-tools-support/i_114-design-of-dry-climate-biofiltration-systems-in-the-west-

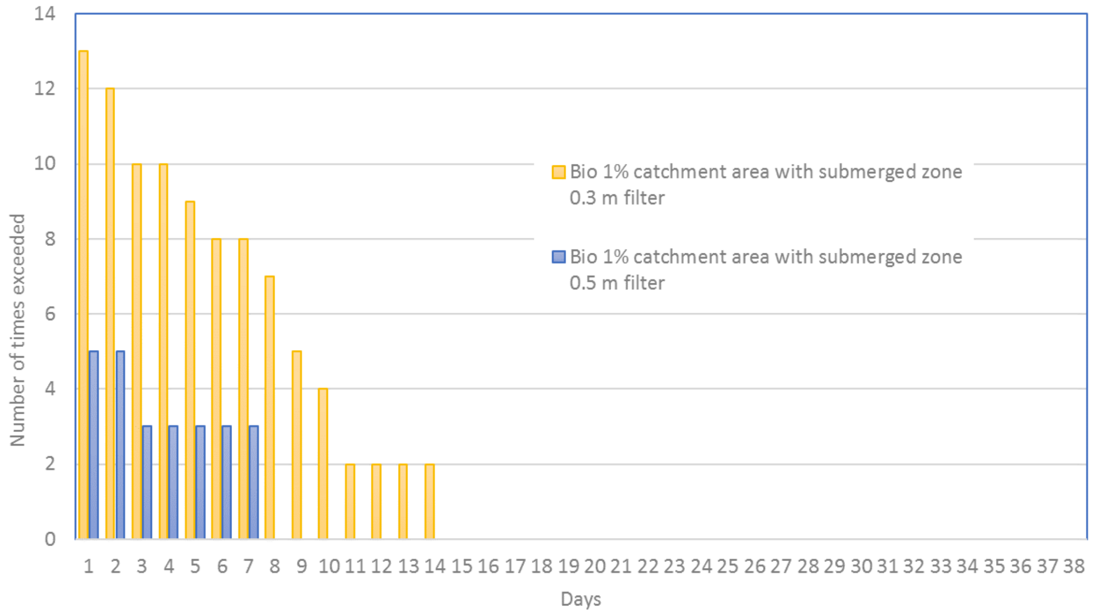


Figure E-10 Frequency of Modelled Dry Spells. The y-axis shows the number of times that the dry period in x-axis occurred.

From the results above, it is recommended that the design of bioretention systems in Wyndham should:

- Not oversize systems to avoid long periods of dry spells.
- Include a 500 mm filter depth.
- Include a submerged zone to support plants during the dry periods.
- Include an assessment of the frequency of the dry spells.

E-3 Plant Selection

Adoption Guidelines for Stormwater Biofiltration Systems recommend plant species. The design must provide adequate soil moister to sustain plants. In addition, the plant species should be compatible with the surrounding vegetation, in terms of aesthetics and biodiversity.

Plant species that are commonly used in raingardens can be grouped into three general categories[20]:

- Tolerant of both wet and dry conditions once established; e.g. *Carex appressa (tall sedge)*
- Tolerant of dry conditions once established; e.g. *Ficinia nodosa, Lomandra longifolia* and *Juncus amibilis*
- Prefer more constant conditions without wet/dry extremes; e.g. *Goodenia ovate* and *Juncus flavidis*

[20] Raingarden Design for Melbourne's West. Available at https://www.melbournewater.com.au/Planning-and-building/Stormwater-management/Documents/Raingarden-design-Melbourne-west.pdf

However, other plant species may be appropriate, and the plant selection should be guided by expert opinion, based on the particular local conditions. It is recommended that the parks and bushland team should be engaged to develop a list of preferred plants for bioretention in Wyndham.

APPENDIX F
TREE PIT BIORETENTION SIZING FOR WYNDHAM

F-1 Soil Moisture Analysis

Tree pits (for stormwater management applications) are small biorientation systems that consist of a tree or large shrub planted within an underground filtration module. They are often constructed into the kerb to treat stormwater before it reaches the stormwater drain.

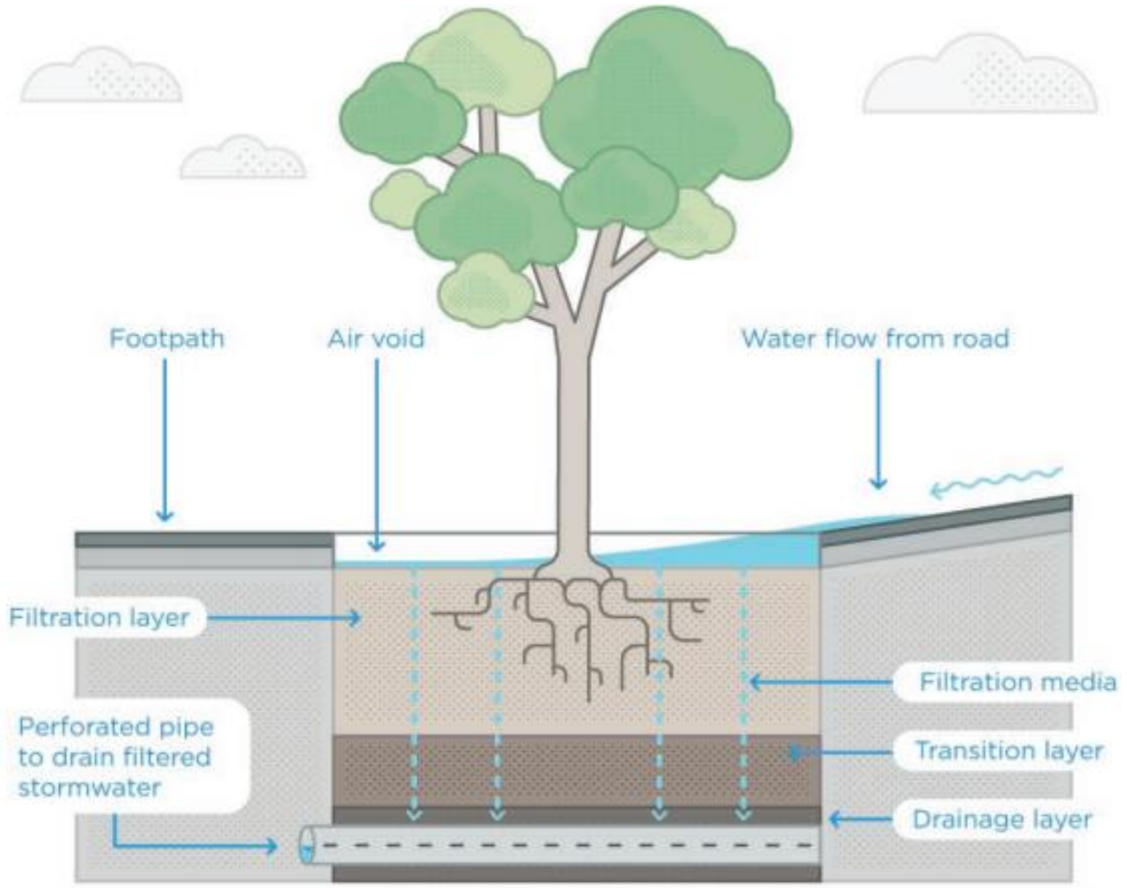


Figure F-11 Concept Arrangement of a Tree Pit Bioretention System (Source: Raingarden Tree Pit Program by City of Melbourne[21])

Design Guidelines adopted for bioretention systems (i.e. The Adoption Guidelines for Stormwater Biofiltration Systems[22] and WSUD Engineers Procedures: Stormwater Manual[23] should be adopted. In addition to those, the design specification described in the Raingarden Tree Pit Program by City of Melbourne[24] should be also be taken into consideration.

---

[21] City of Melbourne (2015). Raingarden tree pit program. Case study. Written for the Urban Water website, 2015.

[22] Payne, E.G.I., Hatt, B.E., Deletic, A., Dobbie, M.F., McCarthy, D.T. and Chandrasena, G.I., 2015. Adoption Guidelines for Stormwater Biofiltration Systems, Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

[23] CSIRO (2005). WSUD Engineering Procedures: Stormwater. CSIRO Publishing.

[24] City of Melbourne (2015). Raingarden tree pit program. Case study. Written for the Urban Water website, 2015.

The appropriate ratio of the surface area of the soil pit to the impervious drainage catchment area varies based on location, tree size and required rooting area and soil moisture[25]. A sensitivity analysis of filter media soil moisture and the system treatment performance and was conducted to determine the appropriated area ratios for Wyndham. A range of tree pit biorientation sizes were tested and the results are presented in the next Section. They all were assumed to have the design characteristics as listed in the orange text box in Figure F-12. The remaining MUSIC paraments were adopted according to the recommendations

F-2 Results and Discussion

Figure F-12 shows the modelled filter media saturation and the percent of its exceedance over the modelling period for a range of tree pit bioretention sizes using the climate data template presented in Section 2 and Appendix A. The tree pit biorientation sizes are presented as a percentage of the impervious catchment area.

The optimal soil moisture for plants is between the Field Capacity and the Stress Point, sub-optimal is between the Stress Point to the Wilting Point, and water is no longer available for plants below the Wilting Point. Please refer to MUSIC manual[26] and the MUSIC Auditor website[27] for more details on the relationship of soil moisture and water availability for plants.

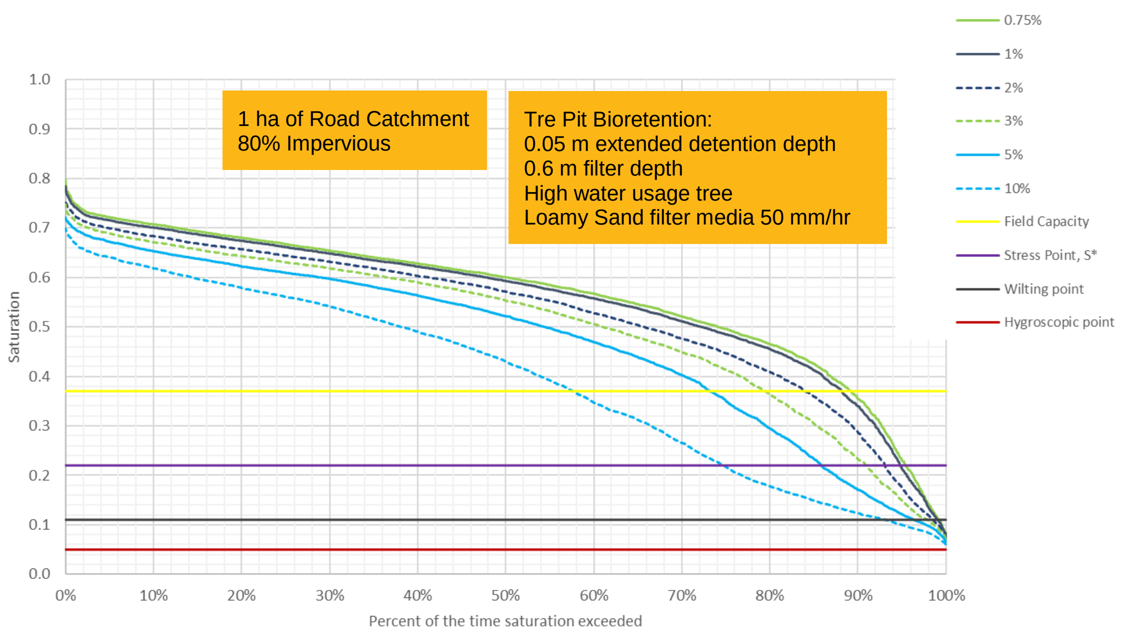


Figure F-12 Filter Media Saturation Exceedance Over the Modelling Period. The x-axis shows the percent of time that soil saturation is lower or equal to the saturation in the y-axis.

Figure F-13 shows the frequency of dry days over the modelling period. A combined assessment of Figure F-12 and Figure F-13 suggest that tree pit bioretention basin larger than 3% of the impervious drainage

[25] E2Designlab, 2016. Strataflow Cost-Benefit Analysis. Prepared by E2Designlab for CityGreen.

[26] eWater (2015). Model for Urban Stormwater Improvement Conceptualisation (MUSIC) Users Guide. Version 6.1

[27] http://www.musicauditor.com.au/

catchment are likely to experience increased frequency and longer periods under the wilting point than the smaller systems.

The pollutant removal efficiency (%) modelled with MUSIC is presented in Table F-6. The modelling results indicate the systems smaller than 1% of the impervious catchment area do not treat stormwater to best practice targets[28].

Table F-6 Pollutant Removal Efficiency (%) Modelled with MUSIC

Tree Pit Bioretention Area as a Percentage af the Impervious Catchment Area	0.75%	1%	2%	5%	10%
Total Suspended Solids Removal	82.8%	85.4%	93.3%	97.8%	99%
Total Phosphorus Removal	59.3%	63.7%	70%	77.7%	85.3%
Total Nitrogen Removal	38.7%	45%	61.2%	78.3%	87.5%

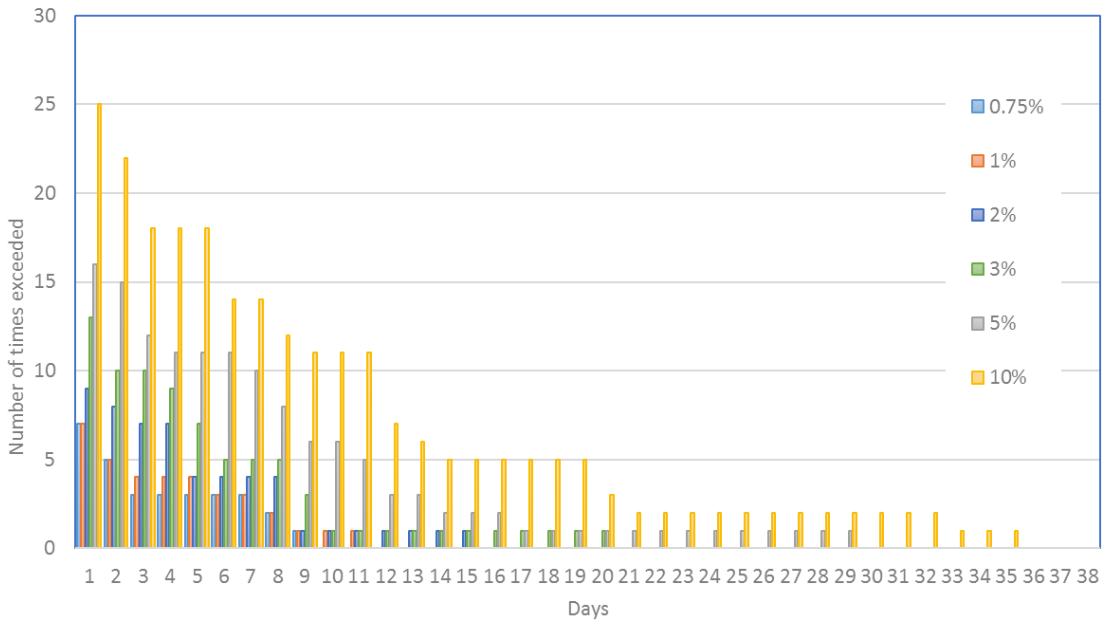


Figure F-13 Frequency of Modelled Dry Spells. The y-axis shows the number of times that the dry period in x-axis occurred.

From the results above, it is recommended that tree pit bioretention between 1% and 2% of the impervious catchment area should be adopted and designed in MUSIC with the set of parameters recommended in Section 5.3.7.

[28] 80% removal of TSS, 45% removal of Total Phosphorous and Total Nitrogen. CSIRO (1999). Best Practice Environmental Management Guidelines.

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