Liverpool City Council WSUD Technical Guidelines

January 2016

# Document history

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# Contents

# 1 Introduction

The WSUD technical guidelines outlined in this document have been developed for the Liverpool City Council (LCC) as part of their Water Quality Management Strategy. The technical guide includes a range of design information:

- Key local design considerations including soil types and acid sulphate soils.
- Identification and summary of WSUD elements appropriate to meet the WSUD targets of LCC. This includes sizing of WSUD elements.
- MUSIC Modelling Guideline including MUSIC modelling input parameters for the LCC including rainfall data, soil characteristics, pollutant generation and key parameter values/acceptable parameter ranges for treatment nodes.
- Description and cross sections, as well as design information on appropriate location, design considerations, soil and vegetation, sizing, maintenance and where to find further information

The guideline can be used by both Council and developers in implementing WSUD through the Liverpool City Council Local Government Area (LGA).

# 2 Liverpool City Council Environment

The WSUD strategy for a development should be informed by the local environment at the site of the proposed development as well as downstream of the site.

## 2.1 Soil landscapes

The soil landscapes within the Liverpool City Council are shown in Figure 1 and described in Table 1. The soil conditions at the site will affect the generation of runoff (for MUSIC modelling) and the ability of water to exfiltrate from stormwater treatment systems. Infiltration systems are only appropriate at sites where a deep sandy soil is found and where there will be no impacts on adjacent infrastructure. Whilst the information provided in Figure 1 and described in Table 1 provides an indication of the expected conditions, basic site investigations will be required to confirm whether infiltration will be possible. Site investigation should include a site specific physical investigation of the soil types by hand auger or equivalent to a depth of at least 2m and a field or lab hydraulic conductivity test undertaken by a suitably qualified person.

The following soil landscapes are generally the most likely to be suitable for infiltration:

- Freemans Reach
- Richmond
- South Creek

The following soil groups may also be suitable for infiltration depending on site conditions:

- Hawkesbury
- Gymea
- Luddenham
- Picton

The following soil groups are unlikely to be suitable for infiltration:

- Berkshire Park
- Blacktown
- Faulconbridge
- Lucas Heights
- Disturbed terrain

Whilst small infiltration systems are not likely to create significant risks, a WSUD program to encourage broad infiltration across the wider area could require a detailed assessment to confirm that there would not be any adverse impacts and that the groundwater system would be protected. The assessment may need to demonstrate compliance with the Australian Managed Aquifer Recharge guidelines. Further information should be sought from the Office of Water prior to implementing infiltration systems.

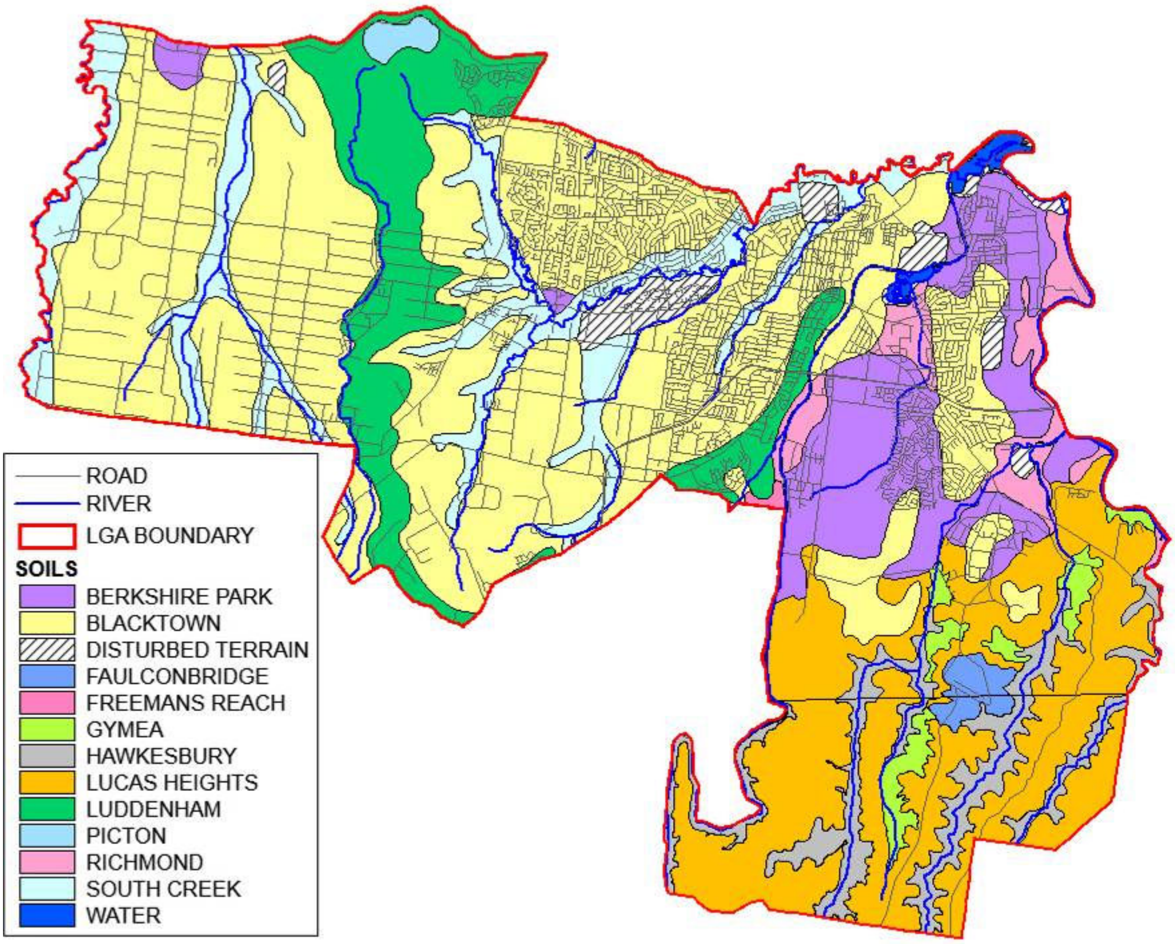



**Figure 1: Liverpool soils, with roads and rivers**

**Table 1: Soil Landscapes (Chapman and Murphy 1989)**

| Code | Name | Process | Description |
|---|---|---|---|
| bp | Berkshire Park | Alluvial | Soils generally have increasing clay content with depth although erosion and deposition cycles may have caused the occasional reversal of this trend. Most areas are characterized by up to 50 cm of sandy clay which overlies >50 cm of high chroma, clay. Total soil depth is usually <450 cm.<br><br>At higher elevations the mixing of these two materials shows as vertically piped grey or white mottles in the high chroma clay (*red podzolic soils, chocolate soils*). Lower in the landscape where drainage conditions are poor there can be a thin (<20 cm) layers of surface material (*solods, yellow podzolic soils*). |
| bt | Blacktown | Residual | Shallow to moderately deep *Red* and *Brown Podzolic Soils* on crests, upper slopes and well drained areas; deep *Yellow Podzolic Soils* and *Soloth*s on lower slopes and in areas of poor drainage. |
| dc | Deep Creek | Alluvial | Deep *Podzols* on well drained terraces, *Silliceous Sands* on current floodplain and *Humus Podzols* in low lying areas. |
| gy | Gymea | Erosional | Shallow to moderately deep *Yellow Earths* and *Earthy Sands* on crests and inside of benches; shallow *Siliceous Sands* on leading edges of benches; localised *Gleyed Podzolic Soils* and *Yellow Podzolic Soils* on shales lenses; shallow to moderately deep *Siliceous Sands* and *Leached Sands* along drainage lines. |
| fb | Faulconbridge | Residual | Shallow brownish black loamy sands generally overlie sandstone bedrock producing *lithosols* or *siliceous sands*. It can also overlie 15–30 cm of earthy, yellow clayey sand and up to 30 cm of yellow, earthy, sandy clay loam. |
| fr | Freemans Reach | Alluvial | Deep brown sands and loams, apedal to moderately structured, usually friable. *Alluvial soils*, *solods*, and *dark podzolic soils*. |
| ha | Hawkesbury | Colluvial | Shallow discontinuous *Lithosols/Siliceous Sands* associated with rock outcrop; *Earthy Sands*, *Yellow Earths*, and some *Yellow Podzolic Soils* on inside of benches and along joints and fractures; localised *Yellow and Red Podzolic Soils* associated with shale lenses; *Siliceous Sands* and secondary *Yellow Earths* along drainage lines. |
| lu | Luddenham | Erosional | Shallow (<100 cm) *dark podzolic soils* or massive earthy clays on crests; moderately deep (70–150 cm) *red podzolic soils* on upper slopes; moderately deep (<150 cm) *yellow podzolic soils* and *prairie soils* on lower slopes and drainage lines. |
| lh | Lucas Heights | Residual | Moderately deep, hardsetting *Yellow Podzolic Soils* and *Yellow Soloths*; *Yellow Earths* on outer edges of crests. |
| pn | Picton | Colluvial | Shallow to deep (50–200 cm) *red and brown podzolic soils* on upper slopes. *Brown and yellow podzolic soils* on colluvial material. *Yellow podzolic soils* on lower slopes and in drainage lines. |
| ri | Richmond | Alluvial | Poorly structured orange to *red clay loams, clays and sands*. Texture may increase with depth. Ironstone nodules may be present. *Plastic clays* in drainage lines. Deep *acid non-calcic brown soils, red earths* and *red podzolic soils*, occur on terrace surfaces with earthy sands on terrace edges. |
| sc | South Creek | Alluvial | Often very deep *layered sediments* over bedrock or relict soils. Where pedogenesis has occurred structured plastic clays or structured loams in and immediately adjacent to drainage lines; red and *yellow podzolic soils* are most common on terraces with small areas of structured *grey clays, leached clay* and *yellow solodic soils*. |
| xx | Disturbed Terrain | Disturbed Terrain | Fill areas commonly capped with up to 40cm of sandy loam or up to 60cm of compacted clay over fill or waste materials. |

## 2.2 Acid Sulphate Soils

Acid Sulphate Soils (ASS) must be taken into consideration in designing for stormwater treatment systems. The ASS mapping for Liverpool City Council is shown in Figure 2 based on data from NSW Office of Environment and Heritage (OEH). Further detail on ASS is provided in the Liverpool City Council Local Environmental Plan (LEP) including Classes of ASS.

Generally any development sites located within Class 1 or Class 2 ASS are unlikely to be appropriate for infiltration. Sites within Class 3, Class 4 or Class 5 areas may be appropriate for infiltration depending on local conditions (such as elevation and depth to the water table) and site specific investigations should be carried out to confirm whether there is any risk of ASS issues including site soil testing for Potential ASS and actual ASS.

Deep excavation for treatment systems should also generally be avoided in ASS areas, where the excavation is likely to expose potential or actual acid sulphate soils. In these areas the WSUD strategy will need to consider appropriate treatment system measures which have the least disturbance to ASS.

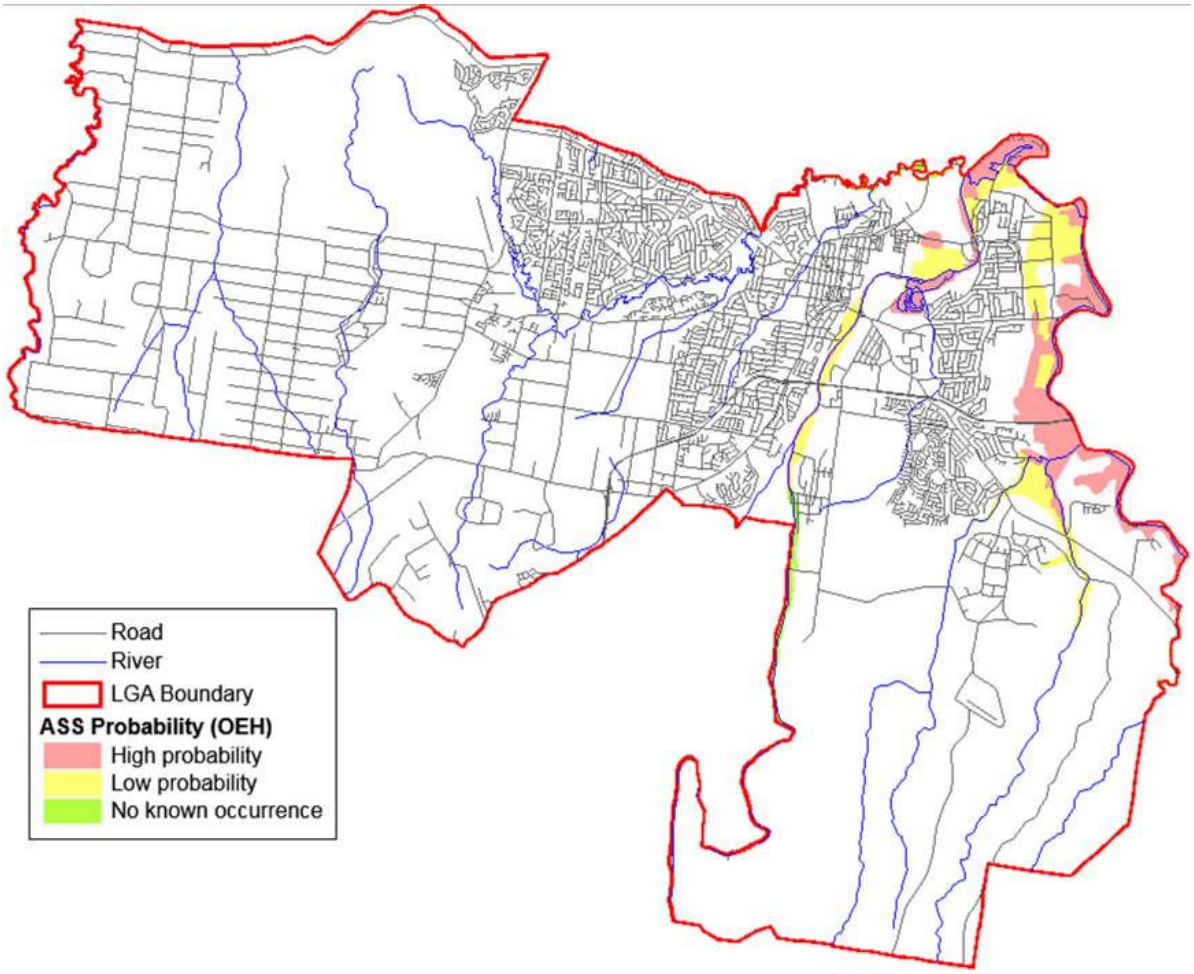



**Figure 2: Acid Sulphate Soil mapping (OEH, 2011)**

## 2.3 Endangered Ecological Communities

There are numerous vegetation communities within Liverpool City Council listed as vulnerable, endangered or critically endangered under either or both the NSW Threatened Species Conservation Act 1995 or the Commonwealth Environment Protection and Biodiversity Conservation Act 1999. A map identifying Endangered Ecological Communities is provided in Figure 3 based on mapping undertaken by Sydney Metro Catchment Management Authority (2013). It is noted that no data is available for the western portion of the Liverpool City Council LGA.

The Endangered Ecological Communities (EECs) include:

- Castlereagh Scribbly Gum Woodland;
- Castlereagh swamp woodland;
- Coastal saltmarsh;
- Coastal upland swamp;
- Cooks River/Castlereagh ironbark forest;
- Freshwater wetlands on coastal floodplains;
- Moist Shale Woodland;
- River Flat Eucalypt Forest on Coastal Floodplains;
- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest;
- Swamp oak floodplain forest; and
- Swamp Sclerophyll Forest on Coastal Floodplains.

Any proposed developments that drain to these EECs must take particular care to ensure that there are no impacts from stormwater runoff. For these sites the WSUD strategy must address how stormwater runoff volumes will be managed to ensure the EECs will not be impacted.

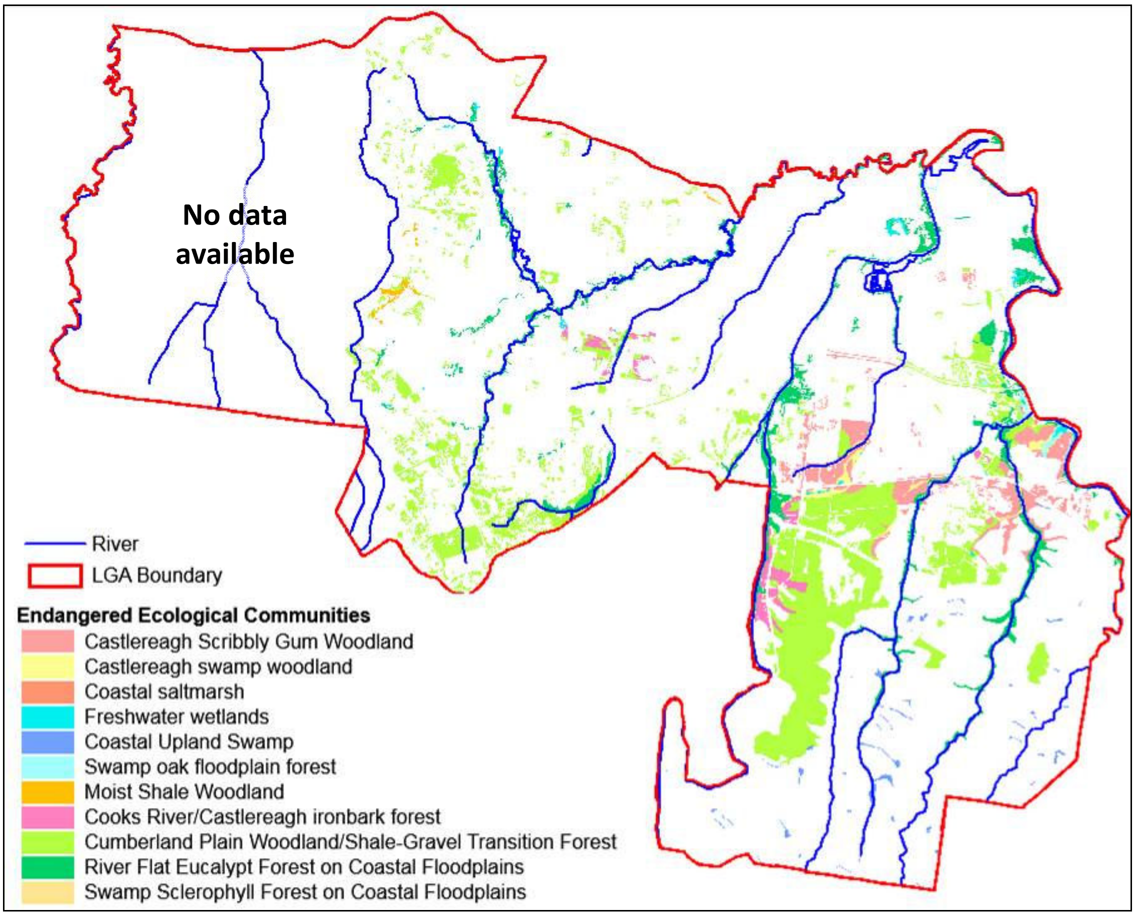



**Figure 3: Liverpool City Council Endangered Ecological Communities (SMCMA, 2013)**

# 3 WSUD Options for Liverpool City Council

WSUD can be applied at all scales and in all types of urban development and redevelopment to meet stormwater treatment targets identified in Council's DCP including:

- reduce the baseline annual pollutant load for litter and vegetation larger than 5mm by 90%;
- reduce the baseline annual pollutant load for total suspended solids by 85%;
- reduce the baseline annual pollutant load for total phosphorous by 65%; and
- reduce the baseline annual pollutant load for total nitrogen by 45%.

Elements of WSUD can also be retrofitted to existing buildings and incorporated into upgrades or replacements of existing infrastructure including council projects such as city centre, road, laneway and park upgrades. WSUD can be used to provide stormwater harvesting at council parks, passive irrigation of vegetated areas, and has added benefits of improving biodiversity, amenity and micro-climate.

The suite of WSUD elements can be applied at varying development scales and are outlined in Table 2. Key WSUD elements which can be applied in Liverpool City Council LGA include gross pollutant traps, porous or permeable paving, green roofs/walls, bioretention systems and wetlands. A description of these systems is provided in the following sections. Further information on WSUD elements is available in the South East Queensland Conceptual Design Guidelines for WSUD (Water by Design 2009) and the South East Queensland Technical Design Guide (Water by Design 2007). Both of these guidelines are considered the National benchmark for WSUD practitioners.

**Table 2: The application of WSUD elements at varying scales (after Engineers Australia 2006)**

| WSUD Element | Allotments | Streets, Public Open Space and Precincts | Regional elements |
|---|---|---|---|
| Water Conservation | 3★ WELS or above fixtures & appliances | Water use education | Water use education |
| Landscaping | Landscaping (local indigenous) | Landscaping (local indigenous) | Landscaping (local indigenous) |
| Stormwater Reuse | Rainwater tanks | Ponds and storage for reuse | Ponds and storage for reuse |
| Wastewater reuse | Greywater reuse | Greywater / Reclaimed water reuse | Reclaimed water reuse |
| Stormwater Quality Treatment | On-site infiltration | Precinct infiltration | |
| | Vegetated swales | Vegetated swales | Rehabilitated waterways |
| | Raingardens / Bioretention systems | Bioretention systems | Bioretention systems |
| | Permeable / Porous Paving | Wetlands | Wetlands / Urban forest |
| Stormwater Quantity Treatment | On-site detention | Retarding basins | Retarding basins |

## 3.1 Gross Pollutant Traps

Gross pollutant traps (GPTs) target gross pollutants including litter, leaves and other vegetative matter. Many GPTs will also capture significant loads of coarse suspended solids. GPTs are often the first treatment measure in a treatment train, for example they can be used upstream of wetlands and other water bodies to protect them from gross pollutants. GPTs are available in a range of different types and sizes, suitable for a wide range of applications. Examples of GPTs are shown in Figure 4.

Pollutant capture efficiency of coarse material varies between different types of GPTs, however most GPTs cannot remove fine sediments, nutrients or other pollutants to any significant degree. Therefore GPTs are not recommended as a sole treatment system if a project is seeking to meet the WSUD targets identified by Council.

Issues when installing GPT's include consideration of their efficiency in trapping pollutants which will affect the frequency and magnitude of cleanouts, and the volume of waste material that must be disposed. It should be noted that some GPTs store captured pollutants in a drained state, while others hold them in stagnant water. Anaerobic conditions in wet sumps can lead to odours, and wet pollutants may be more difficult to clean out and dispose of than dry pollutants.

**Figure 4: GPT in Centennial Park (left), inlet basket (right) (Photos: Alluvium)**

## 3.2 Bioretention Systems / Raingardens

Bioretention systems, also known as raingardens, are commonly constructed in Sydney to meet stormwater quality targets such as those identified by Council. They are suitable in hard urban areas found in Liverpool City Council LGA, and can be implemented at a range of scales.

Bioretention systems are vegetated soil filters that treat a spectrum of pollutants including total suspended solids, nitrogen and phosphorus. Stormwater runoff is treated by draining vertically through a vegetated filter media (typically a sandy loam). Treated stormwater is then collected by a perforated underdrain and directed to the downstream stormwater drainage system. A schematic of a typical bioretention system is shown in Figure 5.

Bioretention systems have a temporary ponding depth (extended detention) of between 100-300 mm above the filter media surface to temporarily store stormwater thereby increasing the volume of runoff treated through the filter media.

Vegetation plays a key role in bioretention systems. The surface is densely planted with ground level grasses, sedges, and also some selected tree and shrub species. The agitation of the surface of the bioretention caused by movement of the vegetation and the growth and die off of root systems helps to prevent sediments from clogging the filtration media. Beneath the surface, vegetation provides a substrate for biofilm growth within the upper layer of the filter media. Vegetation facilitates the transport of oxygen to the soil and enhances soil microbial communities which enhance biological transformation of pollutants.

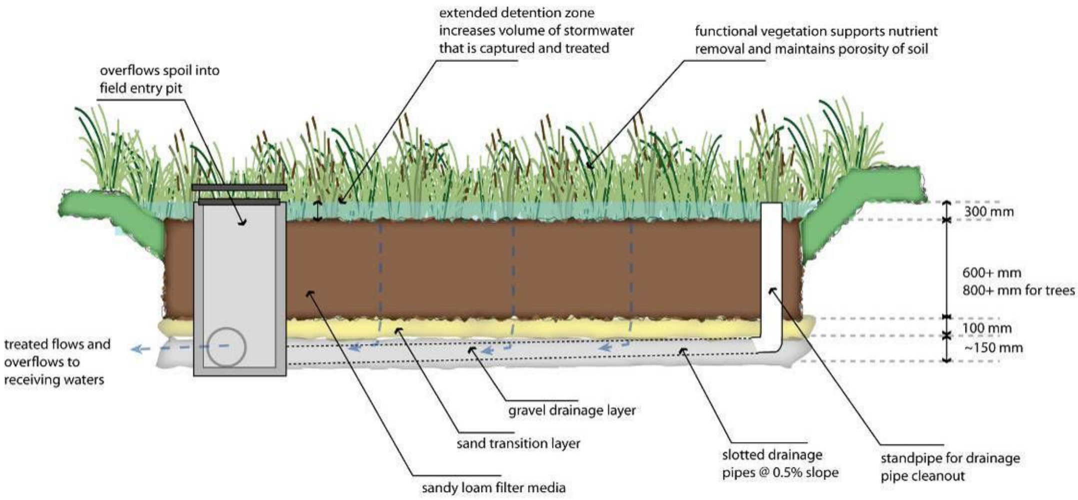



**Figure 5: Schematic section through a typical bioretention system**

Bioretention systems can be implemented in almost any size and shape, in many different locations including street trees in the footpath, or road or traffic calming devices within streetscapes. It is important to have sufficient depth (normally at least 0.8 m) between the inlet and outlet of a bioretention system, therefore they may not be suitable at sites with major underground services, shallow bedrock or other depth constraints, however they are otherwise a very flexible and effective treatment measure for both suspended and dissolved pollutants.

Bioretention systems can be constructed without a liner, to allow some of the treated stormwater can infiltrate into the underlying ground, if conditions are appropriate. These systems still require underdrainage to ensure that the hydraulic conductivity through the filter media is maintained.

The outlet structure for bioretention systems may also be constructed to create a saturated zone, where the system is not free drainage but rather the standing water level is allowed to be kept within the filter drainage layer or filter media. These systems have been found to promote better establishment of the vegetation and improved nutrient removal. The saturated zone requires a carbon source (such as hardwood chips) to gain full effect of the denitrification process.

Bioretention systems are able to meet the stormwater treatment targets identified in the Liverpool City Council DCP and are typically sized to be approximately 1-2.5% of the catchment draining to the treatment system. This is shown by the expected bioretention performance for roads in Figure 6, and typical development in Figure 7, both derived from MUSIC modelling.

Based on the curves in Figure 6, a streetscape bioretention system treating only road runoff needs to be at least 1.45% of the catchment area to meet the TSS target of 85% load removed. Based on the curves in Figure 7, a bioretention system for a typical development needs to least 1.55% of the catchment area to meet the TSS target of 85% load removed.

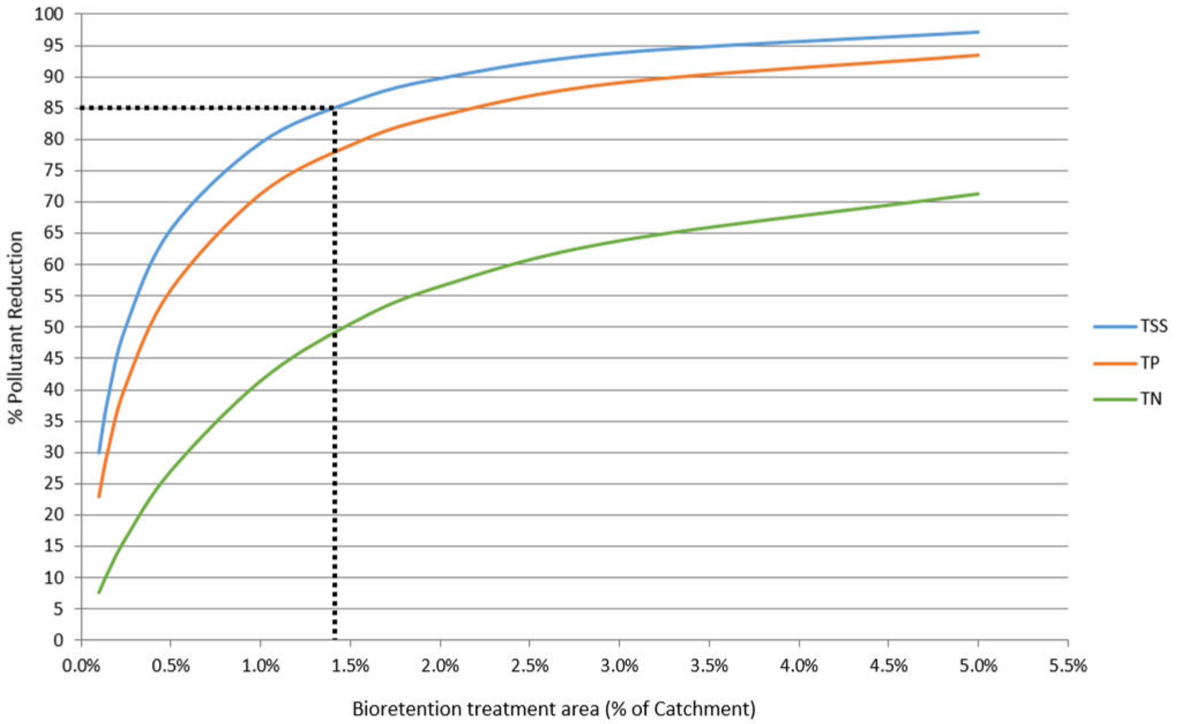



**Figure 6: Bioretention Performance – 100% road catchment**

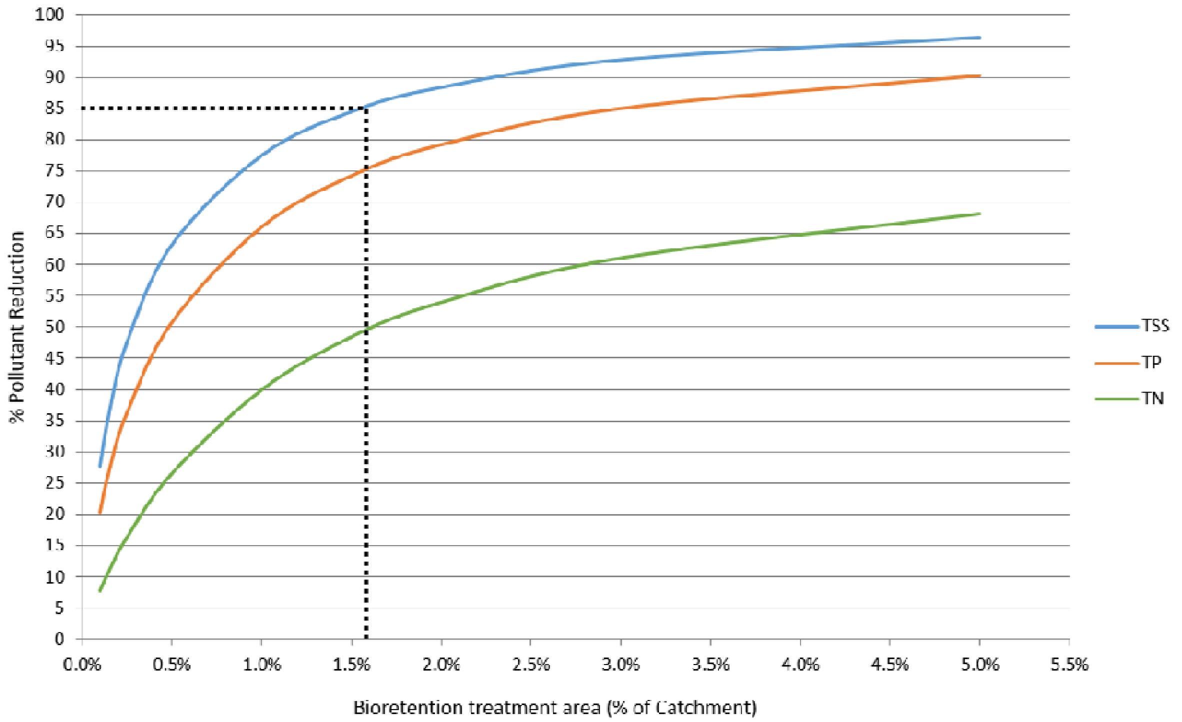



**Figure 7: Bioretention Performance – 25% road catchment, 25% roof catchment and 50% pervious catchment**

Note that the bioretention systems were modelled with the following parameters:

- Extended detention depth – 200 mm
- Saturated Hydraulic conductivity – 100 mm/hr
- Filter Depth 0.6 m
- TN content of the filter media – 600 mg/kg
- Ortho-phosphate content of the filter media – 30 mg/kg
- Exfiltration – 0 mm/hr (i.e. assuming the system would be fully lined)
- Vegetation with Effective Nutrient Removal plants.

The pollutant removal performance will change with each of these parameters.

## 3.3 Rainwater and Stormwater Harvesting

Rainwater or stormwater harvesting can reduce stormwater flows (and pollutant loads) discharging to waterways as well as minimising the demand for imported potable water. Throughout Liverpool City Council LGA there is a significant opportunity to harvest stormwater however a major constraint is the delivery of harvested water to locations where there is a demand for reuse. Demands for harvested and treated stormwater can include irrigation, cooling towers and internal demands such as toilet flushing and hot water supplies.

Stormwater harvesting can achieve pollutant removal by preventing a proportion of stormwater flows from reaching the downstream environment, instead reusing the water for irrigation (which is then evaporated with suspended solids and nutrients going to the soil and plants) or internal demands (with the suspended solids and nutrients removed by treatment or directed to the sewer). The effectiveness of stormwater harvesting as a pollutant load reduction tool depends on the size and type of the catchment, the tank storage volume, and the demand for treated water. The higher the demands, the greater the potential pollutant load reduction.

A series of typical rainwater harvesting curves have been prepared for a Liverpool City Council building with a 500 $m^2$ roof area. These have been prepared to illustrate a typical scenario, however the results from these curves can easily be scaled to other roof areas, where buildings are smaller or larger.

Figure 8 shows results for a range of scenarios:

- Rainwater demands were varied from 0.5 to 10 kL/day (182-3,650 kL/year)
- Tank sizes were varied from 25 to 500 kL

Note that typical water demands for typical Sydney commercial buildings (Sydney Water 2007) are within the following range (measured according to the net lettable area):

- Office buildings: 0.4-1.0 $kL/m^2$/year
- Shopping centres: 1.35-1.70 $kL/m^2$/year

Lower demands are achieved by well-managed buildings with no cooling towers, while the higher demands represent median market practice with no leaks. Note that a large proportion of water demands in commercial buildings are for non-potable uses including toilet flushing, cooling towers, cleaning, etc.

A building with a 500 $m^2$ roof area could have a net lettable area ranging from less than 500 to more than 10,000 $m^2$, depending on the number of floors. Therefore the range of demands presented in Figure 8 is a wide range, to represent a wide range of different building types.

Figure 8 shows that a 500 $m^2$ building with low water demands (0.5 kL/day) can potentially meet all, or a high proportion of, these demands with rainwater. Buildings with larger demands can only meet a small proportion of the total, however the potential total water savings are more significant.

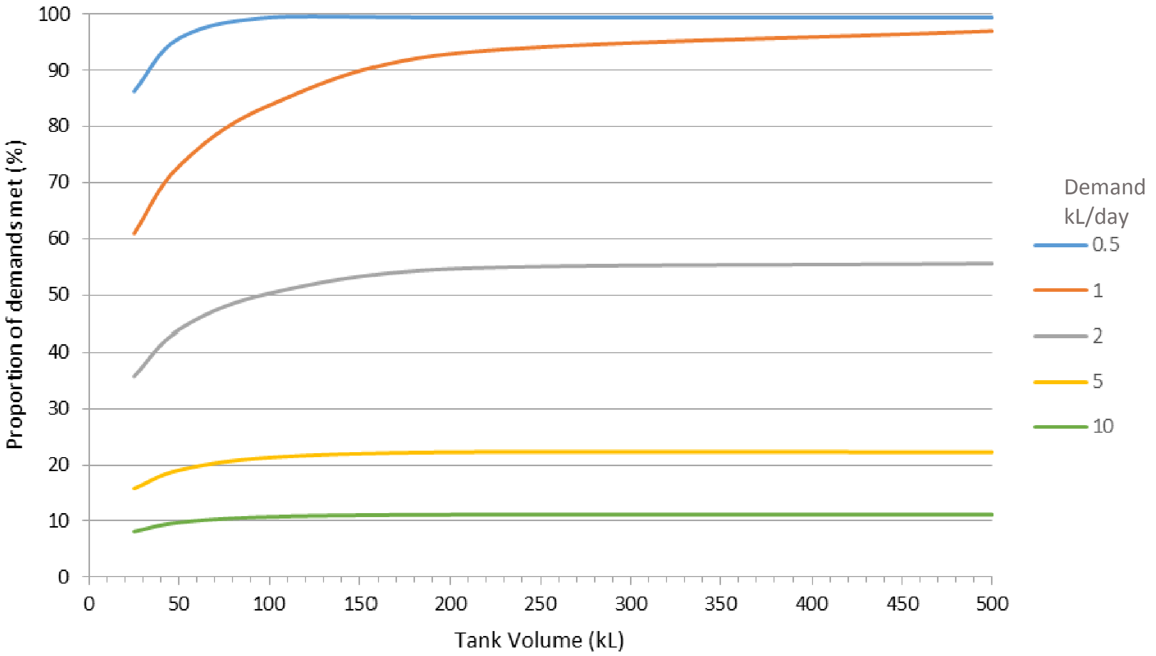



**Figure 8: Rainwater tank efficiency curves for a Liverpool City Council building with 500 $m^2$ roof area**

## 3.4 Wetlands

Constructed surface flow wetland systems use enhanced sedimentation, fine filtration and biological uptake processes to remove pollutants from stormwater. They generally consist of:

- An inlet zone (such as a sediment basin or GPT)
- A macrophyte zone (a shallow heavily vegetated area to remove fine particulates and take up soluble pollutants), and
- A high-flow bypass channel (to protect the macrophyte zone).

Wetland systems can incorporate open water areas. Wetland processes are engaged by slowly passing runoff through heavily vegetated areas where plants filter sediments and pollutants from the water. Biofilms that grow on the plants absorb nutrients and other associated contaminants. While wetlands can play an important role in stormwater treatment, they can also have significant community benefits. They provide habitat for wildlife and a focus for recreation, such as walking paths and resting areas. They can also improve the aesthetics of new developments and can be a central landscape feature.

Examples of wetlands are shown in Figure 9. Wetlands need to be lined with an impermeable liner, which can either be a layer of compacted clay or a strong plastic liner. Wetlands should include at least 200-300 mm good quality topsoil to support the vegetation.

**Figure 9: Wetland at Sydney University (left), and in a Marrickville Residence (right)**

# 4 Supporting Information for Preparation of a WSUD Strategy

It is recommended that DA proponents prepare a Stormwater Management and WSUD Strategy to support their application to meet the WSUD targets. A Stormwater Management and WSUD Strategy is a written report detailing potable water savings and stormwater quality control measures that are to be implemented on a proposed development site, and would include:

- Proposed development – Describe the proposed development at the site, including site boundaries, proposed land uses.
- WSUD objectives – Identify the WSUD objectives that apply to the proposed development.
- Water conservation – Demonstrate how the potable water conservation targets will be met. For residential developments this maybe in the form of a BASIX Certificate.
- Stormwater quality – Demonstrate how the stormwater quality targets will be met, including the location, size and configuration of stormwater treatment measures proposed for the development.
- Details of MUSIC modelling, with the MUSIC parameters and assumptions outlined in an appendix to the WSUD Strategy. Parameters to be submitted include rainfall, source and treatment nodes.
- Integration with the urban design – Identify how the WSUD elements will integrate with the development layout.
- Costs – Identify capital and operation and maintenance procedures, resourcing and cost estimates of proposed treatment elements. Both typical annual maintenance costs and corrective maintenance or renewal/adaptation costs should be included.
- Checklist – outlining the details of the WSUD strategy and reference of the location of the information.

Table 3 outlines the detail required under each of the headings and provides links to supporting information and key resources and tools available to assist in the preparation of the WSUD Strategy. The supporting information is contained both within this document as well as in external documents which are available on the internet.

## 4.1 WSUD Strategy Development stage

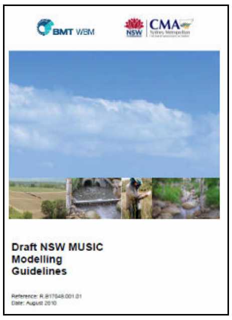
When preparing a Development Application a proponent is required to employ the services of appropriately qualified and experienced practitioners for the development of an appropriate WSUD strategy for their site. The following information should be referred to when developing that strategy.

1. MUSIC Model – MUSIC, the Model for Urban Stormwater Improvement Conceptualisation, derives default water quality parameters for a range of pollutants generated from various land use types. As presented in Australian Runoff Quality (Engineers Australia)[1] most verified and published Australian water quality research has been synthesised and incorporated into MUSIC. The latest version of MUSIC is Version 6 (2013), and is available for purchase at eWater.

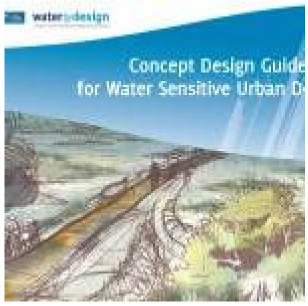
[1] Engineers Australia (2006), Australian Runoff Quality, Melbourne, Australia.

The MUSIC model includes a modelling guideline which should be referred to when using the MUSIC software.

2. MUSIC Modelling guide – the development of a MUSIC model requires specific inputs and parameters. For proposed developments in Liverpool City Council LGA key parameters for undertaking any MUSIC modelling are outlined in Section 5 of this document. Further information on MUSIC modelling is available in the *Draft NSW MUSIC Modelling Guideline*.



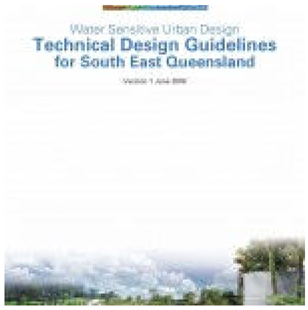

3. WSUD Conceptual Design Information – information on specific WSUD elements (such as rainwater tanks, bioretention and wetlands) and where they are appropriate is available in the South East Queensland's (SEQ) 'Water by Design' Program's Concept Design Guidelines for WSUD. This document provides an industry standard and seeks to assist multi-disciplinary teams conceptualise and develop design solutions that integrate best practice sustainable urban water management within the urban form. The Sydney Metropolitan Catchment Management Authority has produced an Interim Reference Guideline that replaces Queensland references with Sydney specific alternatives available.

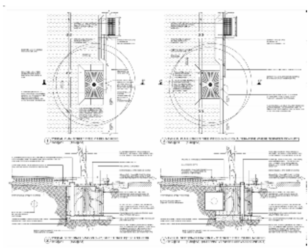


## 4.2 Further Information beyond the Development Application stage

The following resources outline further information which can be used by proponents when developing detailed design / construction drawings and undertaking construction.

4. Technical Design Manual – the 'Water by Design' Program's WSUD Technical Design Guidelines for South East Queensland describe appropriate methods for the detailed design of some common structural stormwater management measures.



5. Typical Drawings – the Sydney Metropolitan CMA has released typical drawings for a series of WSUD elements, including bioretention systems at steep or flat sites, in footpaths or roadways.

6. Construction and Establishment for Swales, Bioretention Systems and Wetlands – the South East Queensland 'Water by Design' Program has produced Construction and Establishment Guidelines, providing guidance on common construction and establishment issues associated with the delivery of vegetated WSUD elements, assisting practitioners to avoid common faults and potential failure at the delivery and design stage. The Sydney Metropolitan Catchment Management Authority has produced an Interim Reference Guideline that replaces Queensland references with Sydney specific alternatives.

**Table 3: Contents of a WSUD Strategy, and tools and resources available**

| Outline contents | Details to be provided in the WSUD Strategy | Supporting Information |
|---|---|---|
| **Proposed Development** | Summarise any background information available on the site, including previous studies, a description of the existing site conditions and details of the proposed development – layout, size, catchments, topography, landuse, roof areas, etc. | *Proponent's development layout* |
| **WSUD objectives** | This section should identify the WSUD objectives which apply to the development including water conservation and stormwater quality objectives. | *Liverpool City Council DCP* |
| **Water conservation** | Identify how water saving fittings, fixtures and appliances can be integrated into the development, or if the development is within a recycled water precinct and will be connected, to meet the water conservation targets. Water balance modelling (for harvesting and reuse systems) should include:<br>• Rainfall data<br>• Water demands<br>• Other parameters and assumptions | *Concept Design Guidelines for WSUD (external link Section 4.1)*<br>*Standard MUSIC parameters for Liverpool City Council (Section 5 of this document)* |
| **Stormwater quality**<br>Demonstrate how the stormwater quality targets will be met. Including:<br>• stormwater quality (MUSIC) modelling results<br>• Identify the location, size and configuration of stormwater treatment measures proposed for the development.<br>• Including details of which sub-catchments are | Establish a stormwater quality (MUSIC) model for the proposed development to predict expected stormwater pollutant loads generated from development and to develop a strategy to achieve the stormwater quality targets.<br><br>The information submitted with the WSUD Strategy should include:<br>• Location, size and configuration of stormwater treatment elements.<br>• Summary of MUSIC results demonstrating compliance with the targets<br>• Details of MUSIC modelling, with the MUSIC parameters and assumptions outlined in an appendix to the WSUD Strategy. Parameters to be reported include:<br>  ○ rainfall (rain station, time step and years of rainfall) and evapotranspiration | *MUSIC modelling software*<br><br>*Standard MUSIC parameters for Liverpool City Council (Section 5 of this document)*<br><br>*NSW MUSIC Modelling Guide* |

| | | |
|---|---|---|
| directed to which treatment measure. | ○ source nodes (catchment areas, impervious fractions, soil parameters and pollutant mean and standard deviation values), and<br>○ treatment nodes, with the following parameters reported:<br>▪ bioretention systems - hydraulic conductivity, extended detention depth and filter depth<br>▪ ponds and wetlands - inlet pond size, permanent pool depth, extended detention depth and notional detention time<br>▪ swales - slope and vegetation heights<br>▪ where treatment nodes vary from k-c*, values for all pollutants and rationale for non-standard pollutants<br>• Any variation from the recommended MUSIC parameters must be reported and justified. | *(external link Section 4.1)*<br><br>WSUD Conceptual Design Information *(Section 3 and external link Section 4.1)* |
| **Integration with the urban design**<br>The WSUD Strategy should outline how WSUD elements will integrate with other elements of the urban design. | This may include:<br>• Site plans (and cross-sections, where relevant) including WSUD elements<br>• List of plant species to be used in vegetated stormwater treatment measures<br>• Drawings to illustrate conceptual layout of WSUD elements within the context of other site features | *Concept Design Guidelines for WSUD (external link Section 4.1)* |
| **Costs**<br>Prepare capital and operation and maintenance cost estimates of proposed water cycle management measures. | Both typical annual maintenance costs and corrective maintenance or renewal/adaptation costs should be included.<br><br>Develop a maintenance plan. | *Concept Design Guidelines for WSUD (external link Section 4.1))* |
| **Checklist** | Checklist of the WSUD aspects of the development | *Section 10* |

# 5 MUSIC Modelling Parameters for Liverpool City Council

This section provides guidance on modelling parameters to be used when modelling WSUD elements in MUSIC. These guidelines are provided to ensure consultants, developers and Council have a consistent and uniform approach to stormwater quality and harvesting modelling within the Liverpool City Council LGA.

The parameters outlined in this section should be used at all times when developing a WSUD Strategy to meet the targets outlined in Liverpool City Council's DCP. Further information on MUSIC Modelling is available in the *Draft NSW MUSIC Modelling Guideline*. The information contained herein is an adaption of the Draft NSW MUSIC Modelling Guideline and should be read in conjunction with the eWater MUSIC User Guide which is provided with the MUSIC software (2013).

This guideline provides specific guidance on rainfall and evaporation inputs, source node parameters, rainfall runoff parameters, pollutant generation parameters and stormwater treatment nodes. Any MUSIC models that are not consistent with this guideline must justify the differences in parameters and/or assessment methods.

## 5.1 Rainfall & evaporation inputs

The rainfall data recommended for MUSIC modelling for Liverpool City Council is shown in Table 4.

Council requires all stormwater quality modelling to use the Liverpool (Whitlam Centre) 6-minute rainfall data. A modelling period of 1/1/1967 to 31/12/1976 is required, as this period is representative of the long-term average annual rainfall of Liverpool LGA, and includes a number of wet and dry years.

For hydrologic modelling used for stormwater harvesting analysis and stormwater storage design (including rainwater tank sizing), continuous simulation should be used at a daily time step for estimating supply reliability. Liverpool (Whitlam Centre) daily data from 1967-1976 is recommended as it is representative of the long-term average annual rainfall of the Liverpool LGA.

**Table 4: Recommended Rainfall Data for MUSIC modelling**

| Purpose | Time step required | Rainfall Station | Modelling Period |
|---|---|---|---|
| Water quality | 6 minutes | 067035 Liverpool (Whitlam Centre) | 1967-1976 |
| Water quantity (including rainwater tanks, stormwater storages) | Daily | 067035 Liverpool (Whitlam Centre) | 1967-1976 |

Average potential evapotranspiration (PET) data is not available for the Liverpool (Whitlam Centre) weather station. Following a comparison of nearby stations with PET data, Parramatta PET data was selected and is considered suitable for use in modelling water quality and hydrology. The average daily PET values are shown in Table 5.

**Table 5: Daily Average Evapotranspiration for Parramatta**

| Month | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PET (mm) | 5.57 | 4.58 | 3.74 | 2.52 | 1.62 | 1.28 | 1.24 | 1.79 | 2.5 | 3.87 | 4.85 | 4.97 |

## 5.2 Source node inputs

### 5.2.1 Rainfall runoff parameters

MUSIC rainfall-runoff parameters have been derived for NSW from model calibration studies. Table 6 outlines the soil properties recommended for adoption in MUSIC modelling for Liverpool City Council LGA. The steps for setting up the rainfall runoff parameters are described below:

Step 1: Divide site into sub-catchments based on topography and land use types – all subcatchments (to be designated as separate source nodes) should be classified as Roads, Roofs, and Other impervious and Pervious areas and entered into the model at appropriate locations.

Step 2: Estimate Fraction Impervious for each sub-catchment (source node) – A calculation of the impervious fraction for each sub-catchment (source node) should be made based on the proposed land-uses (eg road, roof, carpark, landscape area etc).

The total impervious area for the site should be consistent with Council's planning controls, including minimum landscaping area, maximum building envelopes, floor space ratios and road design guidelines.

Step 3: Set Soil Properties – For all source nodes, the soil characteristics shown in Table 6 should be adopted in MUSIC based on the location of the site in the soils map (Figure 1). These parameters have been derived based on typical soils found in the Liverpool City Council LGA. Use of different soil parameters must be justified.

### 5.2.2 Pollutant generation parameters

The development of the MUSIC software included a comprehensive review of stormwater quality in urban catchments, which forms the basis for the default values of event mean concentrations for total suspended solids (TSS), total phosphorous (TP) and total nitrogen (TN). Table 7 presents the recommended stormwater quality parameters for various land use categories in MUSIC. Note that for all simulations the MUSIC model must be run with pollutant export estimation method set to "stochastically generated" as opposed to the "mean" estimation method.

**Table 6: Soil properties for MUSIC Source Nodes**

| Parameter | Unit | Recommended values | | |
|---|---|---|---|---|
| **Impervious area parameters** | | | | |
| Rainfall Threshold (mm) | mm | 1.5 (for roads/paths etc.)<br>0.3 (for roofs) | | |
| **Pervious area parameters** | | | | |
| | | **Sand**<br>(fr, ri, sc) | **Sandy loam**<br>(ha, gy, lu, pn) | **Clay**<br>(bt, bp, fb, lh, xx) |
| Soil Capacity (mm) | mm | 350 | 195 | 187 |
| Initial Storage (%) | % | 30 | 30 | 30 |
| Field Capacity (mm) | mm | 144 | 135 | 127 |
| Infiltration Capacity Coefficient a | | 360 | 250 | 135 |
| Infiltration Capacity Coefficient b | | 0.5 | 1.3 | 4.0 |
| **Groundwater Properties** | | | | |
| Initial Depth (mm) | mm | 10 | 10 | 10 |
| Daily Recharge Rate (%) | % | 100 | 60 | 10 |
| Daily Baseflow Rate (%) | % | 50 | 45 | 10 |
| Deep Seepage (%) | % | 0 | 0 | 0 |

**Table 7: Stormwater 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** |
| **General urban** (incl. public open space)<br>**Residential**<br>**Industrial**<br>**Commercial** | Mean<br>Std Dev | 2.15<br>0.32 | 1.20<br>0.17 | -0.60<br>0.25 | -0.85<br>0.19 | 0.30<br>0.19 | 0.11<br>0.12 |
| **Road Areas** | Mean<br>Std Dev | 2.43<br>0.32 | ---*<br>---* | -0.30<br>0.25 | ---*<br>---* | 0.34<br>0.19 | ---*<br>---* |
| **Roof Areas** | Mean<br>Std Dev | 1.30<br>0.32 | ---*<br>---* | -0.89<br>0.25 | ---*<br>---* | 0.30<br>0.19 | ---*<br>---* |

* Base flows are only generated from pervious areas, therefore these parameters are not relevant to impervious areas

## 5.3 Treatment node inputs

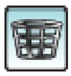
To meet the site's stormwater quality objectives the development will need to incorporate an appropriate stormwater treatment process for the development, dependent on site constraints and opportunities.

The default parameters in MUSIC for the first order decay k-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 Manual.

**Note**: The following devices are not to be modelled within the MUSIC program: Natural waterways, Natural wetlands, Naturalised channel systems, Environmental buffers and ornamental Lake/Pond systems.

In order to avoid any confusion relating to treatment node implementation Council provides the following advice for modelling stormwater quality treatment systems within the Liverpool City Council LGA.

**Table 8: Stormwater treatment parameters**

| Stormwater treatment measures | Selected key parameter values and design guidance |
|---|---|
| Bioretention systems (basins & swales)<br> | High flow bypass = generally 3-month ARI flow (to be calculated by consultant).<br>Extended detention depth (for basins or raingardens) = 0.0.1 - 0.3 m<br>Extended detention depth (for swales) = 0<br>Filter depth = 0.4-0.8 m (CoS standard drawing has 0.4m)<br>Saturated hydraulic conductivity = 50-200 mm/hr<br>Exfiltration rate = 0 mm/hr (if lined)<br>TN content of filter media = >600mg/kg<br>Orthophosphate content of filter media = >30mg/kg<br>Note that a submerged (saturated) zone requires a specially designed outlet pit configuration.<br>Bed slope = 0% for bioretention (bioretention systems need to be flat) systems can be built in cells to address level changes on a site. |
| Gross pollutant traps<br> | High flow bypass for the device = 3-month ARI peak flow.<br><br>Gross pollutant removal should be obtained for the specific GPT type proposed from the supplier – preferably independently verified.<br>Pollutant removal should be based on Appendix C of the MUSIC User Manual and the *Draft NSW MUSIC Modelling Guideline*. |
| Wetlands<br> | High flow bypass = 1 year ARI flow (to be calculated by consultant).<br>Inlet pond volume calculated using:<br>• Inlet pond surface area = 10% of macrophyte zone (storage surface) area<br>• Inlet pond depth = 2.0 m recommended<br>• Extended detention depth = 0.25 - 0.75 m based on outlet design<br>Notional detention time target = 72 hours. |
| Swales<br> | Bed slope = 1-5% (maximum)<br>Vegetation heights of 0.05-0.5 m are acceptable, however MUSIC assumes that swales are heavily vegetated when modelling their treatment performance. Mown grass swales should not be expected to provide significant stormwater treatment and should not be modelled in MUSIC. |
| Rainwater tanks<br> | Only roofs should be connected.<br>Given constraints due to gutter and downpipe arrangement, typically a maximum of 50% of the total roof area can be connected to one tank.<br>If using stored water for irrigation, insert annual irrigation demand (kL/yr) and provide other irrigation estimation details. For a daily demand (kL/day), make estimation based on proposed building design with calculations of proposed demands to be connected (e.g. toilet flushing and/or washing machines). |
| Infiltration systems<br> | Infiltration is not a stormwater treatment measure and stormwater treatment should be provided upstream of infiltration basins.<br><br>MUSIC pollutant removal parameters assume that the basin is vegetated and that stormwater is pre-treated to remove coarse sediment upstream of the retention/infiltration basin. If these assumptions are not true, then the basin should not be expected to meet the pollutant removal performance estimated in MUSIC. |

| **Stormwater treatment measures** | **Selected key parameter values and design guidance** |
|---|---|
| Water quality ponds   | Permanent pool = 1.0-2.0 m<br>Extended detention depth = 0.25-1.0 m.<br>Parameters within the MUSIC model assume that stormwater is pre-treated to remove coarse sediment upstream of the pond, therefore ponds should never be designed without pre-treatment (such as a swale or sedimentation basin). |
| Sedimentation basins   | Permanent pool volume based on 2 m depth (e.g. with a surface area of $50m^2$ the PPV would be $100m^3$)<br>Extended detention depth = 0.25-1.0 m |
| Detention basins   | *On site detention (OSD) basins are not to be modelled for water quality impacts.*<br>Refer to Council's DCP for details on OSD requirements. |
| Buffers   | Buffer strips are only applicable where runoff is distributed across the whole buffer strip and the buffer strip slope is ≤ 5% |
| Media filtration systems (e.g. sand filters)   | As per bioretention systems (without vegetation) |
| Generic   | For modelling a treatment device that is not a specific node within the program. This option should only be used is the user has sufficient data to model it effectively. Examples of applications include flow diversions, or sewer overflows. |
| Porous Paving | Whilst MUSIC does not include a treatment node specifically for porous paving, it can be modelled using an unvegetated bioretention treatment node. If using this method the void spaces in the paving area should be set as the 'filter area'. Refer to the *Draft NSW MUSIC Modelling Guideline* for details on modelling. |
| Permeable Pipes | Permeable pipes are to be modelled according to the manufacturer's recommendations. The flows treated by the permeable pipes must be according to the treatable flow rate for the proposed length of pipe and head achieved for infiltration. |
| ALL TREATMENT NODES | If infiltration is allowable based on a site specific investigation, seepage loss (exfiltration rate) should be as follows:<br>- 36 mm/hr for sandy sites (within soil landscape zone fr, ri, sc)<br>- 3.6 mm/hr for sandy clay loam (within soil landscape zones ha, gy, lu, pn)<br>If site specific hydraulic conductivity tests are carried out these can be used to set an alternative exfiltration rate.<br>Evaporative loss should normally range from 75% of PET for completely open water to 125% of PET for heavily vegetated water bodies. |
| ALL "ADVANCED PROPERTIES"<br>(k-C* values, orifice discharge and weir coefficients, void ratio, number of CSTR cells) | As per MUSIC default values |

# 6 Bioretention Systems as WSUD Treatment

Bioretention systems are commonly used in Sydney to meet stormwater quality targets, and are further described in this section. Bioretention systems are vegetated soil media filters, which treat stormwater by allowing it to pond on the vegetated surface, then slowly infiltrate through the soil media. Treated water is captured at the base of the system and discharged via outlet pipes. A typical cross-section of a bioretention system is shown in Figure 10.

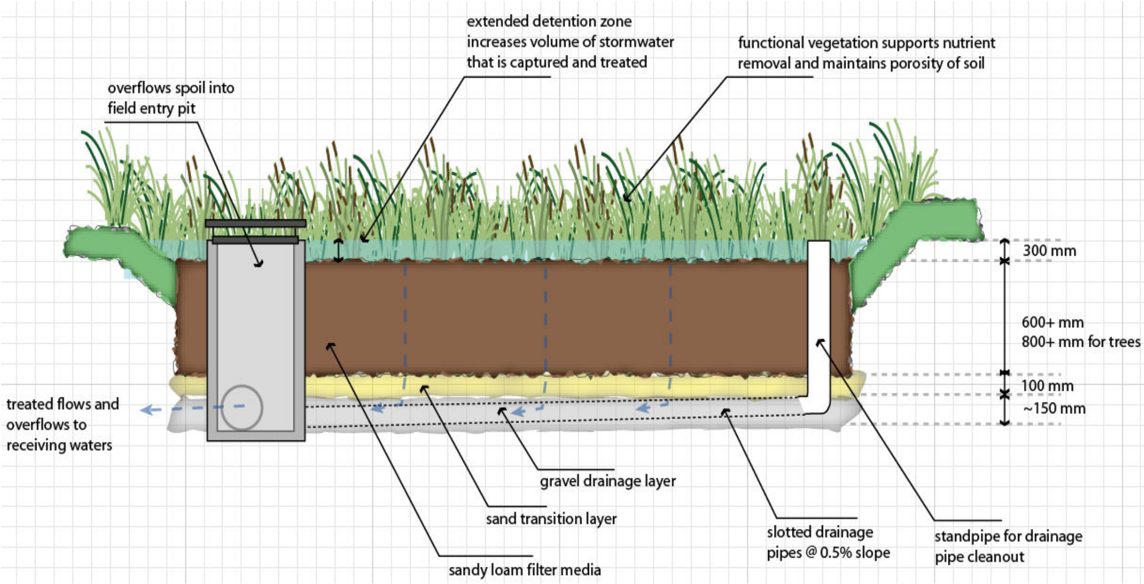



**Figure 10: Bioretention system typical arrangement (Water by Design 2009)**

Bioretention systems can be implemented in almost any size/shape in many different locations including street trees in the footpath, or road or traffic calming devices within streetscapes. It is important to have sufficient depth (normally at least 0.8 m) between the inlet and outlet of a bioretention system, therefore they may not be suitable at sites with shallow bedrock or other depth constraints, however they are otherwise a very flexible and effective treatment measure for both suspended and dissolved pollutants.

The surface layer of a bioretention systems needs to be flat to allow for equal ponding of water over the system, and minimise movement of sediment through the system. Bioretention systems can be built in cells to address level changes on a site.

As a general rule bioretention systems should not be greater than 1,000m$^2$. If a bioretention system larger than 1,000m$^2$ is proposed, then the system should be built in cells.

**Bioretention systems are able to meet the stormwater treatment targets identified in Council's DCP and are typically sized to have a filter area of approximately 1.5% of the catchment draining to the treatment element. This size will vary based on the imperviousness of the development and elements of the bioretention system such as extended detention depth and filter depth.**

## 6.1 Street trees

Street tree bioretention systems are small systems that are incorporated into street tree plantings. These systems can be integrated into high-density urban environments and can take on a variety of forms. The filter media should be at least 0.8 m deep to allow for root growth of the tree, therefore substantial depth is required between the inlet and outlet. Examples of street tree bioretention systems are shown in Figure 11.


**Figure 11: WSUD in Street Tree pits – Redfern St (left), Sydney University (centre) and Pirrama Park (right) (Photos: Alluvium).**

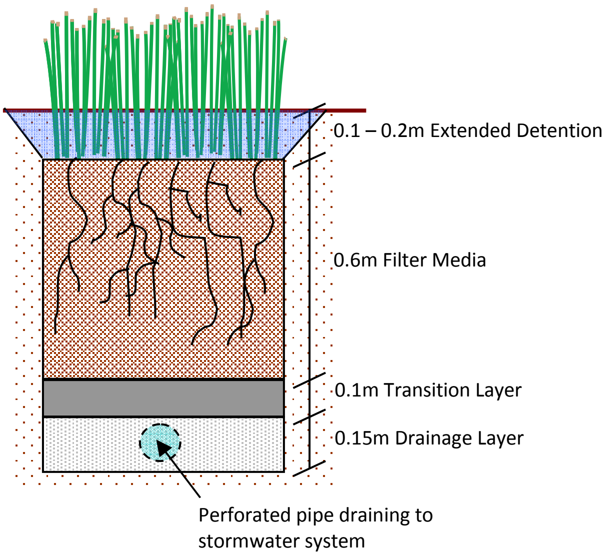
## 6.2 Bioretention Rain-gardens

Rain-gardens can be incorporated in a range of locations, as they can be any shape and size. They are essentially small bioretention basin systems, with typical locations including pocket parks, traffic calming measures and between parking bays. Examples of rain-gardens in Sydney are shown in Figure 11 and Figure 12.

**Figure 12: WSUD rain-gardens in Sydney – Telopea St, Redfern (left) and Pirrama Park, Pyrmont (right), (Photos: Alluvium).**

## 6.3 Elements of a bioretention system

A bioretention system includes the following components:

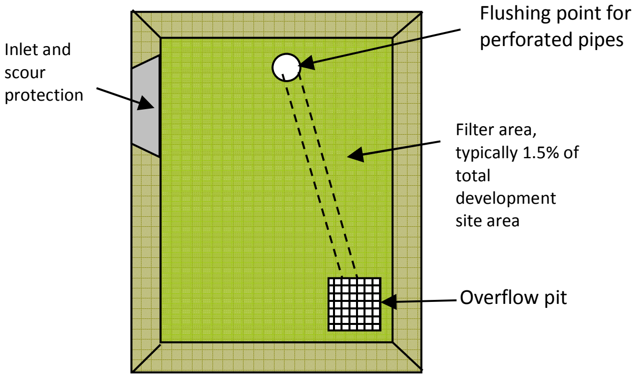



- **Vegetation** prevents surface clogging and assists in pollutant removal via biological processes. Some plant species that can be used include:
  - *Banksia robur*
  - *Correa alba*
  - *Dianella caerulea 'King Alfred'* (Blue flax-lily)
  - *Dichelachne micrantha*
  - *Doryanthes excels*
  - *Imperata cylindrical* (Blady Grass),
  - *Isolepsis nodosa*
  - *Lomandra hystrix*
  - *Lomandra longifolia* (Matrush)
  - *Melaleuca thymifolia*
  - *Westringia fruiticosa*
  - *Acmena smithii*
  - *Callistemon sp*

  A minimum of 8 plants per square metre is recommended, which may be planted from 'hiko' cells, provided that there is adequate irrigation and maintenance during the establishment period. Shrubs or trees may also be included.

- **Extended detention** (or ponding depth) stores stormwater temporarily on the surface to buffer flows so that a greater volume can be treated.
- The **filter media** is the principal treatment zone. As stormwater passes through the filter media, pollutants are removed by filtration, adsorption and biological processes. The filter media should normally be 0.6 m deep, and 0.3 m is the minimum acceptable depth where the site is constrained. The filter media should be a loamy sand (refer technical specification for details) with a permeability of 200-400 mm/hr after gentle compaction and should be clean and free of weeds. The filter media should contain some organic matter (less than 5%) but be low in nutrient content. No fertiliser is to be added.
- A **transition layer** of clean well graded sand/coarse sand prevents the filter media from washing out of the system
- The **drainage layer** of clean fine gravel (2-5 mm) collects treated water at the base of the system and contains 90-100 mm perforated pipes to convey treated water out of the system
- An **impervious liner** may be required to prevent infiltration into surrounding soils, particularly if the treatment system is immediately adjacent to roads or buildings where infiltration may cause structural issues. Note that geotextile filters should not be used within the bioretention system, as they are prone to clogging. If perforated pipes come with a geotextile sock, this should be discarded before installation.
- An **inlet** for stormwater runoff. The inlet should be designed to protect the surface of the bioretention system from scour and erosion

- An **overflow pit** (or other controlled overflow point) to allow high flows, beyond the capacity of the treatment system, to escape to the stormwater drainage system in a controlled manner
- A **flushing point** connected to the perforated pipes, so they can be cleaned in the event of blockage

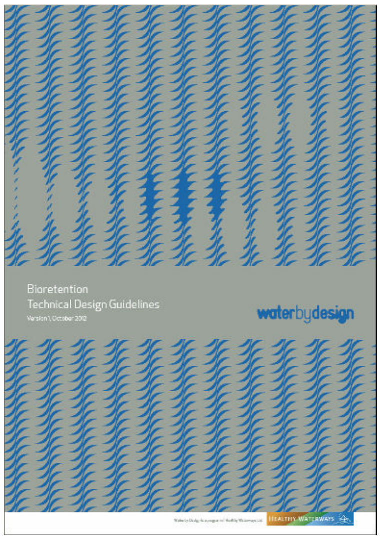



- **Edge treatment** (e.g. a raised kerb or series of bollards) may be required to protect the bioretention system from traffic
- **Pre-treatment** is recommended when sediment loads are likely to be high, or if there is a risk of spills. The simplest option is to incorporate a pit with a sump immediately upstream of the bioretention system.

# 7 Detailed design advice

## 7.1 Detailed Designs for Specific Sites

Design guidance in the form of typical drawings for bioretention systems at steep or flat sites, in footpaths or roadways, has been developed by the WSUD in Sydney program and is available at the following link - http://www.wsud.org/resources-examples/tools-resources/typical-drawings/smcma-wsud-standard-drawings-final/.




Further detailed design guidance can be found in the *Water By Design* 'Bioretention Technical Design Guidelines', available at: http://waterbydesign.com.au/techguide/

WSUD systems should be designed to ensure that they will require as minimal on-going maintenance as practical.

## 7.2 Construction and maintenance

It is essential that adequate construction supervision is provided and that all hold points are witnessed by an appropriately qualified person. The correct installation of drainage systems, media and planting are all crucial in making raingardens function properly and ensuring that they are visually appealing from early in their life.

During the construction phase, bioretention systems should be protected from high sediment loads associated with construction on site (erosion and sediment control measures should be in place to manage stormwater during this phase). The bioretention system should be connected at the end of the construction phase.

Regular maintenance is important to ensure the ongoing performance of bioretention systems. Maintenance requirements of bioretention systems include:

- Monitoring for scour and erosion, and sediment or litter build-up
- Weed removal and plant re-establishment
- Monitoring overflow pits for structural integrity and blockage

Further information is available in the Construction and Establishment for Swales, Bioretention Systems and Wetlands guidelines, is identified in Section 4.2. Further information on design checking tools and typical maintenance activities in contained in Sections 8 and 9 respectively.

# 8 Design Checking Tools

Design checklists have been adopted for the Liverpool City Council LGA for the following stormwater treatment elements:

- Bioretention systems
- Constructed wetlands

For sand filters and infiltration measures, the design checklists in the South East Queensland's Guidelines are appropriate for the Liverpool City Council LGA.

The checklists are provided on the following pages. The checklists present the key design features that are to be reviewed when assessing the design of stormwater treatment systems. These considerations include configuration, safety, maintenance and operational issues that need to be addressed during the design phase.

# BIORETENTION SYSTEM DESIGN ASSESSMENT CHECKLIST

| | | | | |
|---|---|---|---|---|
| **Asset I.D.** | | **DA No.** | | |
| **Basin Location:** | | | | |
| **Hydraulics:** | Minor Storm ($m^3/s$): | Major Storm ($m^3/s$): | | |
| **Area:** | Catchment Area (ha): | Bioretention Area ($m^2$): | | |
| **Treatment** | | | **Y** | **N** |
| Treatment performance verified from curves? | | | | |
| **Bioretention Media and Drainage Systems** | | | **Y** | **N** |
| Design documents bioretention area and extended detention depth as defined by treatment performance requirements? | | | | |
| Overall flow conveyance system sufficient for design flood event(s)? | | | | |
| Where required, bypass sufficient for conveyance of design flood event? | | | | |
| Where required scour protection provided at inflow point to bioretention? | | | | |
| Specifications for filter, transition and drainage layers consistent with FAWB bioretention media specifications? | | | | |
| Perforated pipe capacity > infiltration capacity of filter media? | | | | |
| Liner provided to prevent infiltration (if required)? | | | | |
| Will groundwater levels interact with bioretention system? | | | | |
| Collection pipes extended to surface to allow inspection and flushing? | | | | |
| *Overflow pit has set down of at least 50mm below kerb invert? (where conventional gully/lintel used downstream of bioretention then no overflow pit required) | | | | |
| **Surface Finishes** | | | **Y** | **N** |
| Bioretention area and extended detention depth documented to satisfy treatment requirements? | | | | |
| Extended detention level is min 50mm below inlet level | | | | |
| Overflow pit crest set at top of extended detention? | | | | |
| Maximum ponding depth will not impact on public safety? | | | | |
| Maintenance access provided to surface of bioretention system (for larger systems)? | | | | |
| Protection from coarse sediments provided (where required) with a sediment forebay? | | | | |
| Protection from gross pollutants provided (where required)? | | | | |
| **Landscape** | | | **Y** | **N** |
| Plant species selected can tolerate extended dry periods, periodic inundation and design velocities? | | | | |
| Provision for irrigation or water storage in saturated zone? | | | | |
| Bioretention design and plant species selected integrate with surrounding landscape or built environment design? | | | | |
| Planting design conforms to acceptable sight line and safety requirements? | | | | |
| **Comments** | | | | |

# WETLAND DESIGN ASSESSMENT CHECKLIST

| | | | | |
|---|---|---|---|---|
| **Asset I.D.** | | **DA No.** | | |
| **Wetland Location:** | | | | |
| **Hydraulics:** | Design operational flow ($m^3/s$): | Above design flow ($m^3/s$): | | |
| **Area:** | Catchment Area (ha): | Wetland Area (ha): | | |
| **Treatment** | | | **Y** | **N** |
| MUSIC modelling performed? | | | | |
| **Inlet Zone** | | | **Y** | **N** |
| Discharge pipe/structure to inlet zone sufficient for maximum design flow? | | | | |
| Scour protection provided at inlet for inflow velocities? | | | | |
| Configuration of inlet zone (aspect, depth and flows) allows settling of particles >125µm? | | | | |
| Bypass weir incorporated into inlet zone? | | | | |
| Bypass weir length sufficient to convey 'above design flow'? | | | | |
| Bypass weir crest at macrophyte zone top of extended detention depth? | | | | |
| Bypass channel has sufficient capacity to convey 'above design flow'? | | | | |
| Bypass channel has sufficient scour protection for design velocities? | | | | |
| Inlet zone connection to macrophyte zone overflow pit and connection pipe sized to convey the design operation flow? | | | | |
| Inlet zone connection to macrophyte zone allows energy dissipation? | | | | |
| Structure from inlet zone to macrophyte zone enables isolation of the macrophyte zone for maintenance? | | | | |
| Inlet zone normal water level above macrophyte normal water level? | | | | |
| Maintenance access allowed for into base of inlet zone? | | | | |
| Public safety design considerations included in inlet zone design? | | | | |
| Where required, gross pollutant protection measures provided on inlet structures (both inflows and to macrophyte zone) | | | | |
| **Macrophyte Zone** | | | **Y** | **N** |
| Extended detention depth >0.25m and <0.75m? | | | | |
| Vegetation bands perpendicular to flow path? | | | | |
| Appropriate depth and configuration of macrophyte zone to maximize water retention? | | | | |
| Will deep pools retain water year-round to support mosquito predators? | | | | |
| Vegetation appropriate to inundation regime in each section of the wetland? | | | | |
| Aspect ratio provides hydraulic efficiency =>0.5? | | | | |
| Velocities from inlet zone <0.05 m/s or scouring protection provided? | | | | |
| Public safety design considerations included in macrophyte zone? | | | | |
| Maintenance access provided into areas of the macrophyte zone (especially open water zones)? | | | | |
| Provision for overland flows? | | | | |
| Safety assessment of publicly accessible areas undertaken? | | | | |
| Freeboard provided above extended detention depth to define embankments? | | | | |
| **Outlet Structures** | | | **Y** | **N** |
| Riser outlet provided in macrophyte zone? | | | | |
| Notional detention time of 48-72 hours? | | | | |
| Orifice configuration allows for a linear storage-discharge relationship for full range of the extended detention depth? | | | | |
| Maintenance drain provided? | | | | |
| Discharge pipe has sufficient capacity to convey maximum of either the maintenance drain flows or riser pipe flows with scour protection? | | | | |
| Protection against clogging of orifice provided on outlet structure? | | | | |
| **Comments** | | | | |

# 9 Maintenance and Inspection Activities

A range of inspection and maintenance activities for bioretention systems are outlined in Table 9.

**Table 9: Bioretention System inspection and Maintenance Activities (after Melbourne Water 2013).**

| Item | Action | Maintenance Timelines |
|---|---|---|
| Filter Media | • Remove leaf litter and gross pollutants<br>• Check for biofilms (algal biofilms may develop on the surface of the filter media leading to clogging issues)<br>• Monitor ponding of water following rainfall events<br>• Check for permanently boggy/pooled areas | 3 monthly or after major rain events |
| | • Remove sediment (or scarify filter media surface if required) | Annually |
| | • Replace filter media | 25 years |
| Erosion | • Check for erosion/scouring<br>• Check for evidence of preferential flow paths<br>• Replace filter media in eroded areas<br>• Add rock protection around inlets (if required) | 3 monthly or after major rain events |
| Mulch | • Check depth and even distribution of mulch<br>• Check mulch is not touching plant stems<br>• Check for sediment/silt accumulation in mulch layer<br>• Replace mulch (if required)<br>• Retain mulch using jute mats or nets (if required) | 3 monthly or after major rain events |
| Vegetation | • Inspect plant health and cover<br>• Replace dead or diseased plants (maintain a consistent vegetation density of 6–10 plants per square metre across the raingarden filter media)<br>• Remove weeds (avoid use of herbicides)<br>• Prune plants (where applicable)<br>• Water plants (if required during establishment phase) | 6 weeks initially then dependent on system |
| Civil Components | • Check infrastructure for damage and repair as required<br>• Ensure inlet (including diversion, if applicable) and outlet points are clear of sediment, litter and debris, and are flowing freely | 3 monthly or after major rain events |
| | • Inspection opening for underdrain (slotted drainage pipe):<br>o Check that inspection opening caps are in place<br>o Check water level<br>o Check for sediment accumulation within underdrainage<br>o Flush the underdrain system (if required) | Annually |

# 10 Applicant Lodgement Checklist for WSUD Strategy

This lodgement checklist is to be used by Applicants who are required to complete a WSUD Strategy to meet the requirements of Liverpool City Council's WSUD DCP.

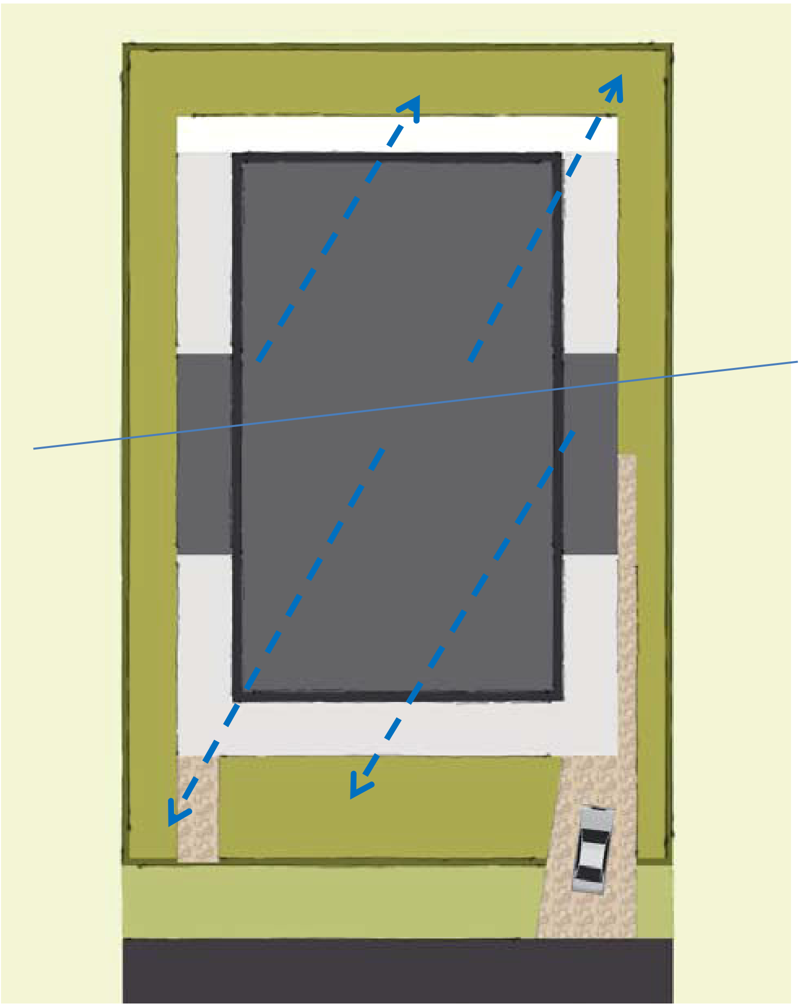
| Detail | Location of Information (eg Section 2 of WSUD Report, drawing3a.dwg) | Information Supplied Yes / No |
|---|---|---|
| **Proposed development –** Information on the development site, including existing site conditions, site boundaries, proposed land uses, densities, population, infrastructure, development staging. | | |
| **Stormwater quality -** demonstrate how the stormwater quality targets will be met. The WSUD Strategy should include stormwater quality modelling results and identify the location, size and configuration of stormwater treatment measures proposed for the development. | | |
| **Costs -** capital and operation and maintenance cost estimates of proposed WSUD measures. | | |
| **Maintenance Plan** – A maintenance plan should outline how the WSUD elements will be maintained. | | |
| **Appendix A –**<br>MUSIC Model, including:<br>• Sqn or Sqz model of catchment with treatment measures (to be supplied electronically, by email or CD)<br>• Sqn or Sqz model of catchment without treatment measures (to be supplied electronically, by email or CD)<br>• Electronic / hard copy of the catchment and subcatchment from MapInfo or other approved format.<br>Modelling Assumptions and inputs, including:<br>• Description of rainfall/ET data used<br>• Catchment details and a description of the approach taken.<br>• Description of how fraction impervious was calculated (what figures were used for different zonings).<br>• Description of and documentation for any departure from the "MUSIC Inputs" outlined in Section 5.<br>Modelling Results, including:<br>• Mean annual load reduction for TSS, TP and TN<br>• % reduction of each treatment system<br>• % reduction of total treatment system<br>• Description of the function and intent of the treatment system. | | |

# 11 Case Study – Industrial

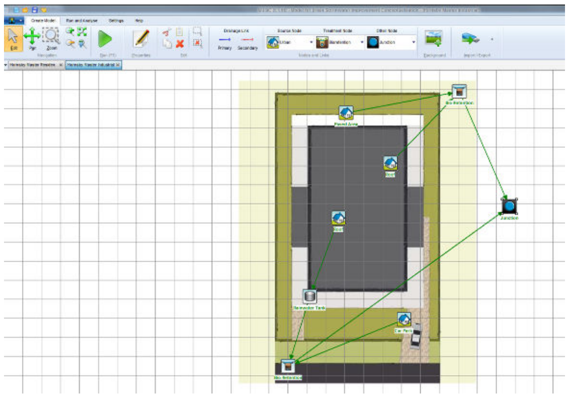
To demonstrate how WSUD can be applied to an industrial site the following case study has been developed. The case study presents a generic industrial development layout and highlights steps undertaken in identifying WSUD options for the site. The site is 45m x 60m and has the following dimensions:

- Total Area – 2700m$^2$
- Roof – 1,600m$^2$ (60% site)
- Car Park – 400m$^2$ (15%)
- Driveway – 360m$^2$ (14%)
- Front Veg – 250m$^2$ (9%)
- Back Veg – 45m$^2$ (2.5%)
- Back Paved – 45m$^2$ (2.5%)

The roof drains both to the front and the back of the property, with approximately 60% of the roof draining to the front, and 40% to the rear. The development is two storeys and includes a central toilet block in the middle of the building. The non-potable water usage for both toilet flushing and irrigation has been estimated at 1kL/day.



## 11.1 Sizing Stormwater Treatment Systems



A MUSIC model (v5) was developed to determine the size of the stormwater treatment measures to meet the water quality targets. As outlined above the development drains both to the front and the rear of the property. To ensure that the whole site is treated, two discrete catchments were modelled.

1. The roof and paved area draining the back of the property were treated in a bioretention system. The total area draining the back of the property is 685m$^2$ (roof 640m$^2$ and paved area 45m$^2$). An approximate size of the bioretention system would be 1.5% of the area, or 10m$^2$. A bioretention of 15m$^2$ was modelled and found to meet the pollution loads from the catchment.

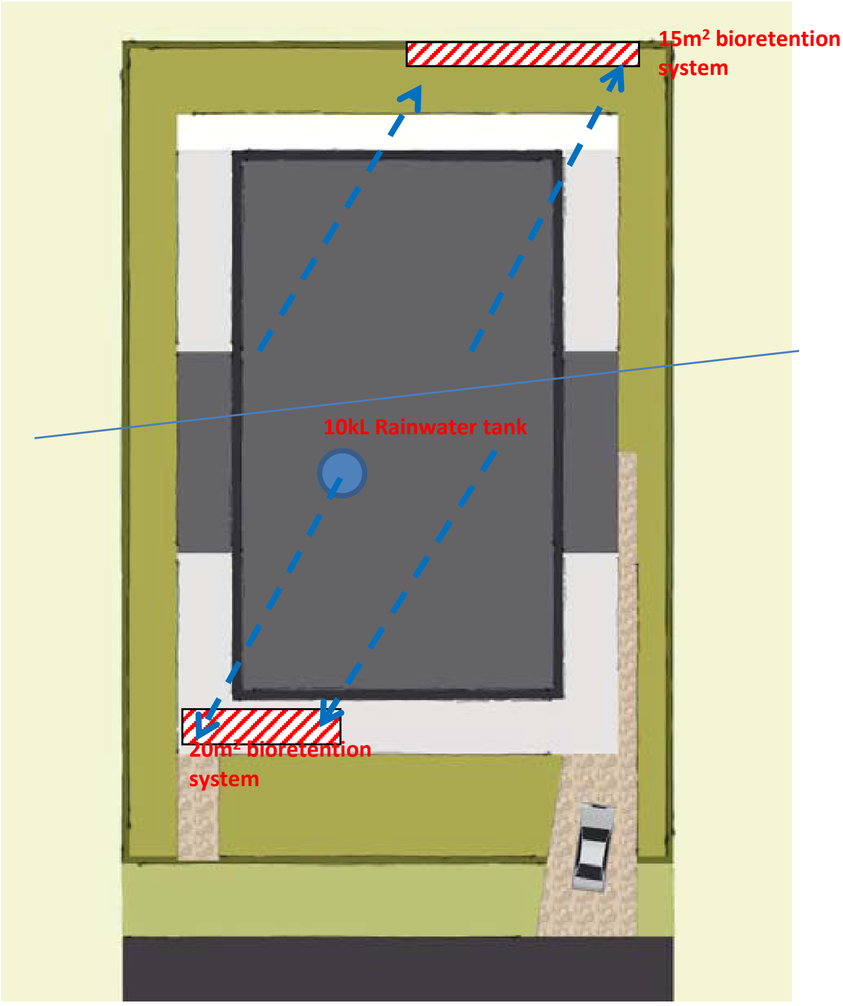
2. In the front of the property the roof drains to a 10kL tank which is used for internal uses (1kL/day), with the overflows and the carpark / driveways areas draining to a bioretention system. The areas to be treated by the bioretention system are 1,720m$^2$, including the roof overflows (960m$^2$), carpark and driveway (760m$^2$). An approximate size of the bioretention system would be 1.5% of the area, or 25m$^2$. A bioretention of 20m$^2$, coupled with reuse from the rainwater tank was found to meet the pollution loads from the catchment.

Both of the catchments attained the stormwater treatment targets as identified in Councils DCP, with the pollution reduction shown in the following table.

| Parameter | Inflow | Outflow | % Reduction | Target |
|---|---|---|---|---|
| Flow (ML/yr) | 1.0 | 0.8 | 20.3% | - |
| Total Suspended Solids (kg/yr) | 137.0 | 18.4 | 86.5% | 85% |
| Total Phosphorus (kg/yr) | 0.3 | 0.1 | 74.3% | 60% |
| Total Nitrogen (kg/yr) | 2.2 | 1.0 | 54.9% | 45% |
| Gross Pollutants (kg/yr) | 25.1 | 0.0 | 100.0% | 100% |

The MUSIC model used the default parameters identified in Section 5. The bioretention system has an extended detention depth of 0.2m and a filter depth of 0.6m.

The WSUD solution for the site is shown in the attached schematic with two bioretention systems and a rainwater tank. The bioretention systems can be integrated into the vegetated areas in both the front and back of the property.




## 11.2 Prepare Design Drawings of Stormwater Treatment Systems

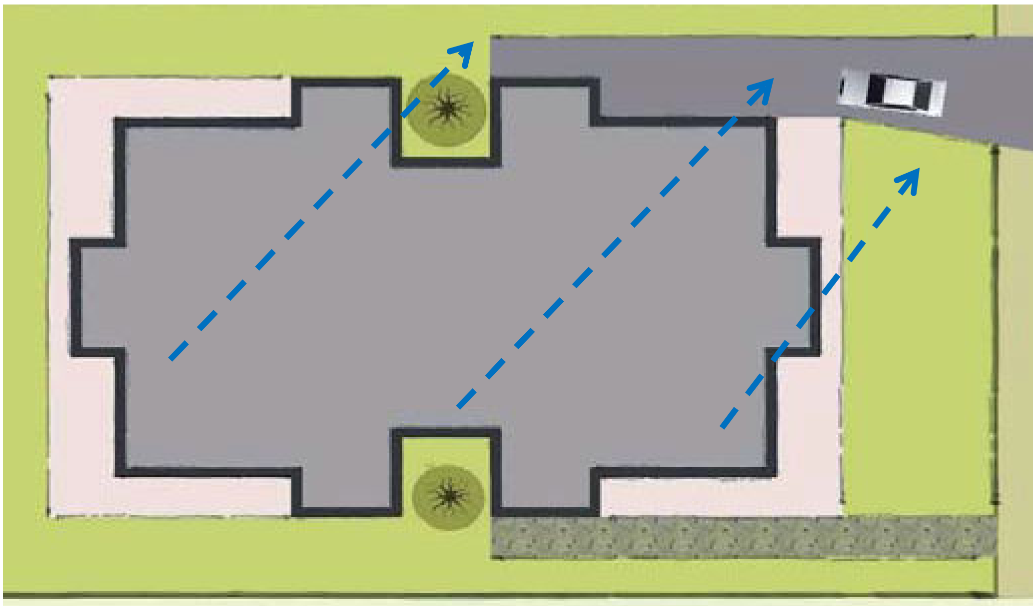
Design drawings of the bioretention system should be included in the proponents Development Application. Guidance in the form of standard drawings of WSUD elements is available from the WSUD.org website (see http://www.wsud.org/resources-examples/tools-resources/).

# 12 Case Study – High Density Residential

To demonstrate how WSUD can be applied to a residential site the following case study was developed. The case study presents a generic high density development and identifies WSUD options for the site. The site is 60m x 45 m and has the following area:

- Total – 2,400$m^2$
- Roof – 1,200$m^2$ (50% of site)
- Driveway – 180$m^2$ (7.5%)
- Landscape Areas – 640$m^2$ (27%)
- Internal Courtyard – 380$m^2$ (16%)

The site generally drains to the north-east, where it connects with Councils drainage system. The site has a main entrance / road to the west.



## 12.1 Water Conservation Measures

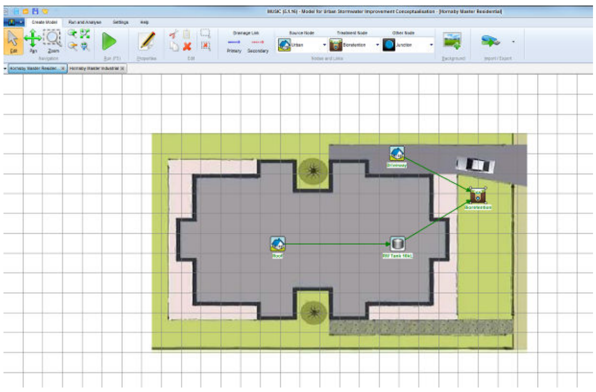
As this is a residential development, water conservation targets must meet the BASIX Scheme, which requires a 40% reduction in potable mains water consumption. More information is available at BASIX http://www.basix.nsw.gov.au. The BASIX Tool can be used to determine the size of a rainwater tank or other non-potable supply to meet the irrigation demands as required.

## 12.2 Sizing Stormwater Treatment Systems

A MUSIC model was developed to determine the size of the stormwater treatment measures to meet the water quality targets. As determined in the site assessment the development drains to one point and only one catchment was therefore modelled.

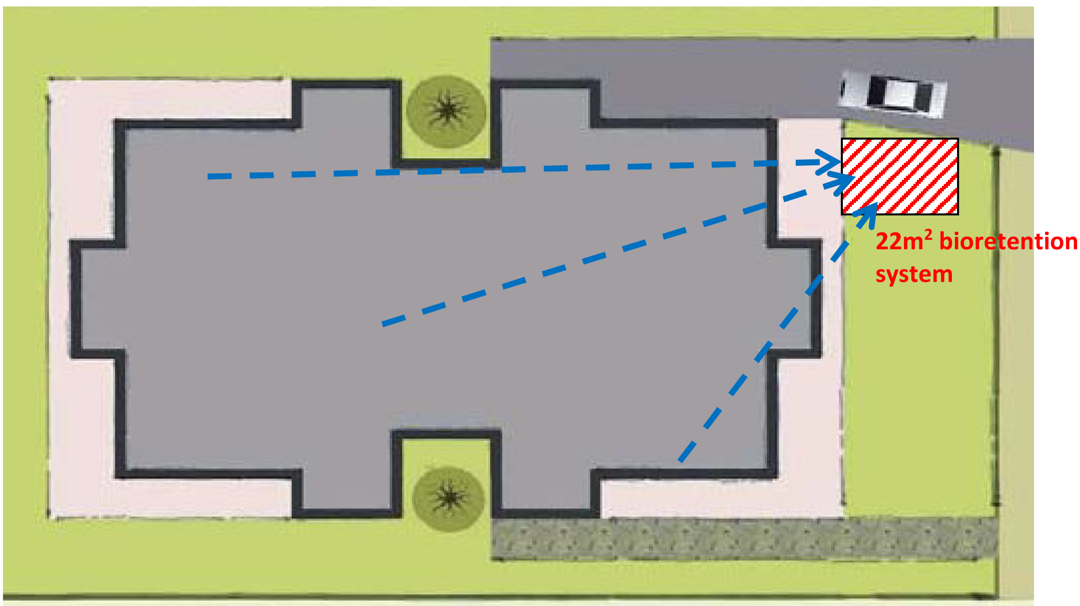
In this scenario the roof area drains to a rainwater tank. The demands were estimated through the Sydney Water 'Water Right' tool as 250kL/year. A 10kL tank was found to meet 82% of the reliability of the demand and is seen as the optimal size.

The model set-up is shown in the schematic and includes the roof draining to a 10kL tank irrigation, with the overflows and the driveway draining to the bioretention system. The areas to be treated by the bioretention system are 1,835$m^2$, including the roof overflows (1,700$m^2$) and driveway (135$m^2$). An approximate size of the bioretention system would be 1.5% of the area, or approximately 30$m^2$. A bioretention of 25$m^2$, coupled with reuse from the rainwater tank was found to meet the pollution loads from the catchment. The bioretention system has an extended detention depth of 0.2m and a filter depth of 0.6m. The MUSIC modelling results are shown in the following table.



| Parameter | Inflow | Outflow | % Reduction | Target |
|---|---|---|---|---|
| Flow (ML/yr) | 1.3 | 1.0 | 20.0% | - |
| Total Suspended Solids (kg/yr) | 87.6 | 10.0 | 88.6% | 85% |
| Total Phosphorus (kg/yr) | 0.3 | 0.1 | 53.6% | 60% |
| Total Nitrogen (kg/yr) | 2.8 | 1.1 | 62.0% | 45% |
| Gross Pollutants (kg/yr) | 32.4 | 0.0 | 100.0% | 100% |

The WSUD solution for the site is shown in the attached schematic with one bioretention system and the rainwater tank. The bioretention systems can be integrated into the vegetated areas at the front of the property.




## 12.3 Prepare Design Drawings of Stormwater Treatment Systems

Design drawings of the bioretention system should be included in the proponents Development Application. Guidance in the form of standard drawings of WSUD elements is available from the WSUD.org website (see http://www.wsud.org/resources-examples/tools-resources/).

## References


Bureau of Meteorology (2015) Climate Data Online; Available at http://www.bom.gov.au/climate/data/

Chapman, G.A. and Murphy, C.L. (1989) *Soil Landscapes of the Sydney 1:100 000 sheet*. Soil Conservation Service of N.S.W., Sydney.

Fletcher, T., Duncan, H., Poelsma, P., Lloyd, S (2004) "Stormwater Flow and Quality, and the Effectiveness of Non-Proprietary Stormwater Treatment Measures — A Review and Gap Analysis", Technical Report 04/8, December 2004, Cooperative Research Centre for Catchment Hydrology

Liverpool City Council (2008) Development Control Plan, available at http://www.liverpool.nsw.gov.au/planninganddevelopment/liverpools-planning-control/liverpool-dcp

Liverpool City Council (2008) Local Environmental Plan, available at http://www.legislation.nsw.gov.au/maintop/view/inforce/epi+403+2008+cd+0+N

Melbourne Water (2013). WSUD maintenance guidelines: Inspection and maintenance activities, Melbourne Water 2013.


**Full web addresses are provided for the weblinks throughout this document:**

Sydney CMA Typical WSUD Drawings
http://www.wsud.org/resources-examples/tools-resources/typical-drawings/

Sydney CMA Draft NSW MUSIC Modelling Guideline
http://www.wsud.org/resources-examples/tools-resources/tools/draft-music-modelling-guidelines-31-08-201011/

eWater – MUSIC software
http://www.ewater.com.au/products/ewater-toolkit/urban-tools/music/

South East Queensland's (SEQ) 'Water by Design' Program's WSUD Technical Design Guidelines for South East Queensland. http://waterbydesign.com.au/TechGuide/

South East Queensland's (SEQ) 'Water by Design' Program's Concept Design Guidelines for WSUD. http://waterbydesign.com.au/conceptguide/

Sydney Metropolitan CMA Concept Design Interim Reference Guideline.
http://www.wsud.org/resources-examples/tools-resources/reference-guidelines/wsud-reference-guidelines/

South East Queensland 'Water by Design' Program Construction and Establishment Guidelines, http://waterbydesign.com.au/CEguide/

Sydney Metropolitan CMA Construction and Establishment Interim Reference Guideline.
http://www.wsud.org/resources-examples/tools-resources/wsud-reference-guidelines/wsud-reference-guideline-construction-establishment-guidelines_final1/