Part 2
Getting WSUD On The Ground

Module 2.1
Starting the project

This module provides information and tools to help Councils evaluate the feasibility of a WSUD project at the concept design stage. Use this resource to gain support and make decisions.

Set the project objectives

One of the first stages in a WSUD project is to define the project objectives. This should capture what the project will achieve. WSUD projects need to consider:

- Water sensitive urban design principles
- Energy and climate impacts
- Social considerations
- Life cycle costs
- Technology selection.

Objectives should as much as possible:

- Reduce potable water demand
- Meet stormwater water quality or flow discharge objectives
- Maintain or enhance landscape amenity and ecosystem value
- Minimise changes to existing topography
- Preserve and maintain the natural drainage system
- Ensure adequate provision for access and maintenance to all services.

To secure internal support, it's important that the objectives of the WSUD project are also in line with the values of the Council.

Decision support tools

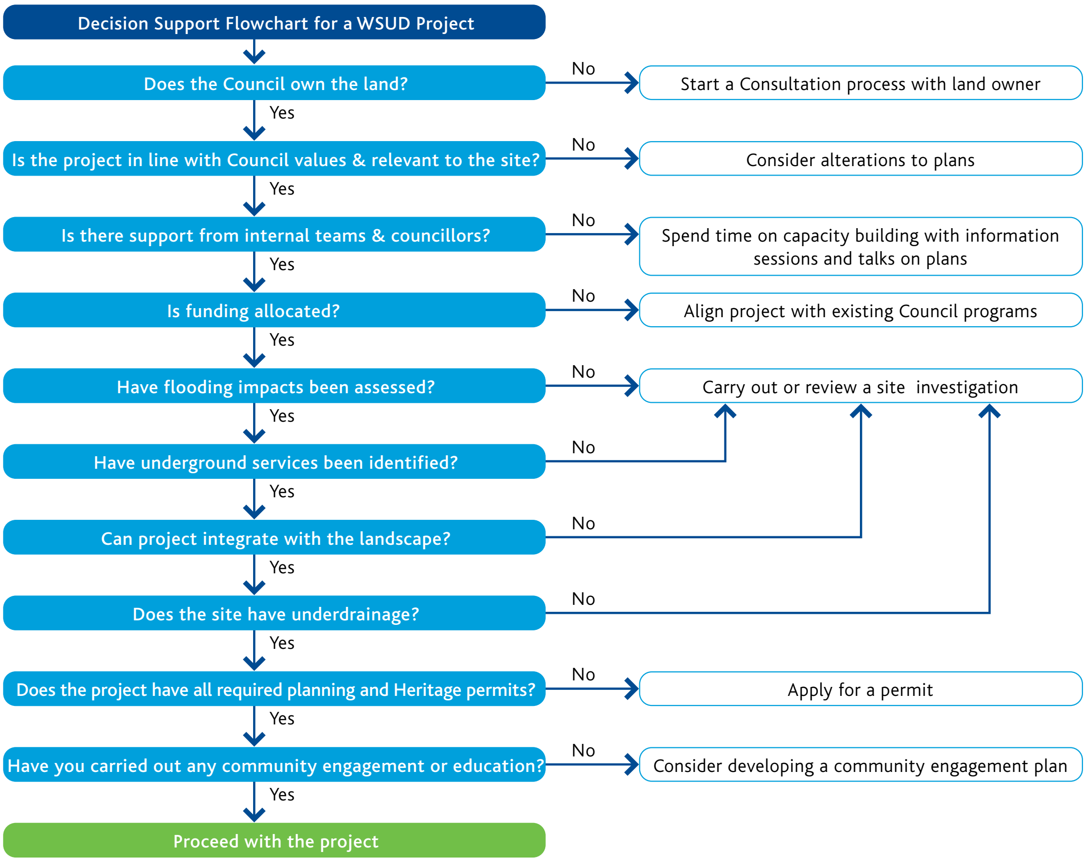
The City of Melbourne is committed to a triple bottom line approach to its decision making, incorporating consideration of:

- Environmental issues: water quality, stormwater harvesting integration and river health
- Social issues: community awareness, education potential, internal capacity and involvement across Council departments
- Economic issues: costs of a WSUD project, relative to an alternative project.

The Guidelines incorporate a WSUD project checklist and flow chart to help Council officers with the key steps to undertaking a WSUD project.

To make use of the information and tools in these guidelines:

Use the *WSUD Project Checklist* to record actions at the concept design stage.


Decision Support Flowchart for a WSUD Project
Does the Council own the land?
No
Start a Consultation process with land owner
Yes
Is the project in line with Council values & relevant to the site?
No
Consider alterations to plans
Yes
Is there support from internal teams & councillors?
No
Spend time on capacity building with information sessions and talks on plans
Yes
Is funding allocated?
No
Align project with existing Council programs
Yes
Have flooding impacts been assessed?
No
Carry out or review a site investigation
Yes
Have underground services been identified?
No
Yes
Can project integrate with the landscape?
No
Yes
Does the site have underdrainage?
No
Yes
Does the project have all required planning and Heritage permits?
No
Apply for a permit
Yes
Have you carried out any community engagement or education?
No
Consider developing a community engagement plan
Yes
Proceed with the project

Seek funding

Funding sources for WSUD projects can be internal (Council) or external (Federal or State Government)

Internal sources	External sources
Capital works	Melbourne Water stormwater funding
Asset renewal programs	DSE alternative water sources fund
Traffic management programs	Water retailers water saving funding
Parks	Federal funding e.g. Community Water grants

Gain support internally

As WSUD is relatively new, it's important to gain support and capacity building for WSUD projects internally. Hold short information sessions and presentations to colleagues and Councillors. Melbourne Water also provides capacity building support.

Understand the site

Understanding the location of a WSUD project is fundamental to its overall success. Gather a broad overview of the site and identify issues that may assist or delay the overall delivery. At this stage, this can be a desktop study.

For more detail on information to collect, refer to the WSUD Project Checklist.

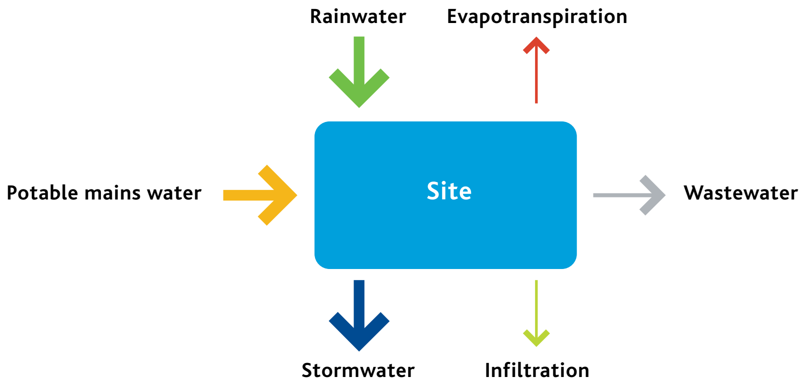
Collect background information

Table 1. Recommended site background information

Data/information to be collected	Source
Land ownership and management	Local plans, land register, land use zonings
Community issues	Complaints to the Council, site visit, known community groups
Terrain information	Aerial photography, contour maps, GIS systems
Catchment boundaries	Catchment planning records
Receiving environment	Catchment or sub-catchment plans
Flooding	Flooding records, EPA
Natural features	Catchment surveys, aerial photography, GIS systems
Heritage listings	Heritage overlays, Heritage Victoria database
Planning constraints	Planning scheme
Strategic catchment planning	Catchment or sub-catchment plans

Conduct a water balance

It's important to understand existing and potential water flows through a site. Construct a water balance which quantifies all water flows in and out of the site to capture this information. This will establish flow data (baseline data) and show how much water is needed for different uses such as toilets and gardens (end-use data).



Carry out a site visit

A site visit is useful for collecting further information and verifying underground services and drainage against GIS information gathered from Council databases.

Involve the community

Involving the community at this stage in a development is important as it helps identify potential issues and can influence the project design. The degree of community consultation will be directed by the scale of the project.

Community concerns could include:
- Visual aesthetics
- Safety
- Use of land
- Flooding concerns
- Ecosystem management.

Through consultation, the ideas, innovations and concerns of a community can be incorporated into the decision making process. Establish open communication early, and a design solution can be developed that has ownership within the community. Community consultation also increases public awareness of water-related issues and can result in positive behaviour change with improved environmental outcomes.

Performance evaluation

The following ready reckoner communication tool is available to help staff and developers with a general understanding of the potential water quality impacts of different WSUD projects.

WSUD Performance Ready Reckoner

To treat 260 sq. metres of road reserve catchment
1 sq. metre of WSUD treatment
=
1 small WSUD street tree pit
=
26 kgs of TSS removed annually
=
1 point

To treat 780 sq. metres of road reserve catchment
3 sq. metres of WSUD treatment
=
1 large WSUD street tree pit
=
78 kgs of TSS removed annually
=
3 points

To treat 2500 sq. metres of road reserve catchment
10 sq. metres of WSUD treatment
=
1 raingarden
=
260 kgs of TSS removed annually
=
10 points

To treat 1 ha of road reserve catchment
40 metres of WSUD treatment
=
1 swale
=
1290 kgs of TSS removed annually
=
50 points

To treat 2500 sq. metres of roof
1.3ML/year of roofwater reused
=
100kL rainwater tank
=
26 kgs of TSS removed annually
=
1 point

To treat 1000 sq. metres of road reserve catchment
30 sq. metre of WSUD treatment
=
porous pavers
=
100 kgs of TSS removed annually
=
4 points

To treat 5 ha of catchment
1000 sq. metres of WSUD treatment
=
1 small wetland
=
2600 kgs of TSS removed annually
=
100 points

To treat 5 ha of catchment
1 small wetland
(100 points)
+
7 ML/year stormwater reuse
= 400 KL storage
= 520 kg of TSS removed annually
= 20 points
In total 120 points

To treat 5 ha of catchment
Stormwater reuse 7ML/year
=
400 KL storage
=
2080 kg of TSS removed annually
=
80 points

Some new works will be constructed that will generate more stormwater and potentially lower stormwater quality. It's hoped that the number of these projects will reduce over time as awareness of water quality impact grows.

The following 'negative points' can be assigned to works that increase impermeable area.

1,000m^2 pervious open space
to
1,000m^2 impervious surface
=160 kg/yr TSS
= negative 6 points

1,000m^2 pervious open space
to
1,000m^2 porous paving
=30 kg/yr TSS
= negative 1 points

Establish internal systems to easily log pollutant loads and 'point' reductions. Once these are in place, these pollutant reductions can potentially be incorporated into Key Performance Indicators.

Costs of WSUD works

Initial analysis shows the following costs for works. Council staff can then budget the 'points' into their annual capital works planning.

Notes:

- Costs are based on the small number of projects done to date, and will be revised when additional data becomes available
- It's likely that the costs will decrease as works become standard procedure
- Changes in maintenance procedures will also carry a cost.

Model WSUD Project Checklist

Site Details	
Name of project	
Name of officer	
Date	
Address	
Short description of site Treatment technologies to be used Approx. catchment area Size of treatment	
Number and type of WSUD treatments Efficient fittings and appliances? Rainwater harvesting? Stormwater harvesting? Treepits? Raingardens? Swales? Wetlands? Water recycling? Other?	

Part 1: Essential requirements for WSUD project

Action	Issues to consider	Response	Further details
Set project objectives (Module 2.1)	Does the proposal incorporate the following objectives? If not, why not? Consider the objectives below and determine if they are relevant. Also insert any other relevant objectives to the right.		
	Reduce potable water demand?	☐ Yes ☐ No	
	Improve stormwater quality?	☐ Yes ☐ No	
	Maintain or enhance the landscape amenity value?	☐ Yes ☐ No	
	Maintain or enhance local ecology/habitat/biodiversity ?	☐ Yes ☐ No	
	Ensure adequate access and maintenance to all services.	☐ Yes ☐ No	
	Community engagement	☐ Yes ☐ No	
	Briefly, what are the main risks with this project? Public health? Safety? Costs? Carbon intensive? New technology? Other? (Divide into financial, environmental and human health risks)		
Seek funding (Module 2.1)	Internal (Council)		
	Has capital been allocated to the project?	☐ Yes ☐ No	
	If capital has been allocated, how much?		
	Is this project integrated into an existing rolling program for capital works or streetscape works etc?	☐ Yes ☐ No	
	If yes, which program?		
	Have you considered external funding and the timing requirements of these grants? If so, please specify.	☐ Yes ☐ No	
	Have you considered the changes in maintenance procedures, who will maintain the treatment and any likely cost impacts? (Module 2.8)	☐ Yes ☐ No	
Collect background information and carry out a site visit (Module 2.1)	**Land ownership and management**		
	Is land available?		
	Who is it owned by?		
	What are the neighbouring uses of the site? Are there any immediately upstream land uses that are contributing to stormwater pollution and will limit the effectiveness of the proposed WSUD works? Will the WSUD works form part of a treatment train for the downstream catchment?		
	Community issues		
	Are there any community issues that could affect the implementation of the project?		
	Are there any community activities that could benefit or link to the project?		
	Terrain information		
	Are there areas of high or low gradients?	☐ Yes ☐ No	
	Are there flatter areas which may allow larger WSUD measures such as wetlands?	☐ Yes ☐ No	
	Are there level areas which may present difficulties in terms of hydraulic head and high groundwater table?	☐ Yes ☐ No	

Action	Issues to consider	Response	Further details
Collect background information and carry out a site visit (Module 2.1)	**Catchment boundaries**		
	What is the catchment area? Identify the catchment boundaries.		
	Are there any proposed reuse schemes upstream or downstream that will affect, or be affected by, the proposal?		
	Receiving environment		
	Are there any waterways or drainage lines where discharge off site is likely to occur?		
	Flooding		
	Do you have access to information about flooding issues at the site?	☐ Yes ☐ No	
	If so, please specify.		
	Natural features		
	Are there any natural features that need to be assessed?		
	Creek lines?		
	Permanent water bodies?		
	Existing vegetation?		
	Existing infrastructure?	☐ Yes ☐ No	
	If so, please specify.		
	Heritage listing		
	Are there any Heritage considerations you need to take into account?	☐ Yes ☐ No	
	If so, please specify.		
	Planning constraints		
	Are there any planning constraints that would prevent the project going ahead?		
	Environmental corridors?		
	Waterway corridors?		
	Flood lines?		
	Open space or recreational nodes?	☐ Yes ☐ No	
	If so, please specify.		
	Strategic catchment planning		
	Are there any catchment or sub-catchment plans to identify any regional or catchment-scale strategies applicable to the site.	☐ Yes ☐ No	
	If so, please specify.		
	Water balance		
	Do you have enough information on flows to conduct a water balance?	☐ Yes ☐ No	
	Site visit		
	Have you undertaken a site visit?	☐ Yes ☐ No	
	Has an underground service check been carried out?	☐ Yes ☐ No	
	Is there under drainage in the site, with adequate depth? (a depth of approx. 700mm is desirable)	☐ Yes ☐ No	
	Involving the community		
	Have you carried out any form of community engagement or consultation? If so, please specify.	☐ Yes ☐ No	

Part 2: Designing for a WSUD project

Action	Issues to consider	Response	Further details
Integrate WSUD principals into the design (Module 2.2)	**Water conservation**		
	What water saving fittings and devices will be fitted: Tap aerators? Efficient showerheads? Dual flush? High star appliances? Other?		
	What are the water saving targets for the site?		
	Water reuse		
	Will you replace potable water with another water source?	☐ Yes ☐ No	
	If so how?		
	Will you be setting water reuse targets?	☐ Yes ☐ No	
	If yes what are they?		
	Is there potential for rainwater harvesting?	☐ Yes ☐ No	
	Is there potential for stormwater harvesting?	☐ Yes ☐ No	
	Is there potential to reuse greywater?	☐ Yes ☐ No	
	Is there potential to reuse blackwater (water / sewer mining)?	☐ Yes ☐ No	
	Water quality		
	Has a MUSIC Model been carried out for the project?	☐ Yes ☐ No	
	If yes, does the project meet best practice stormwater targets? (80:45:45)		
Assess environmental impacts (Module 2.3)	What are the potential impacts on the aquatic environment from this project?		
	Has a land capability assessment been carried out on the site?	☐ Yes ☐ No	
	What are the potential impacts on the land, primarily from irrigation?		
	What will be the extent of the production of biosolids and other wastes and odours?		
	How will these be managed?		
Assess the climate impacts (Module 2.4)	What are the estimated greenhouse gas emissions that will be generated from the project? (Emissions are from electricity use to run the system and the embodied energy in the materials)		
Assess economic impacts (Module 2.5)	Have you carried out a life cycle costing analysis on the project? If so, please specify.	☐ Yes ☐ No	

Action	Issues to consider	Response	Further details
Assess the risks (Module 2.6)	Have you carried out a risk assessment on the environmental risks on the site?	☐ Yes ☐ No	
	If so, provide details.		
	Have you carried out a risk assessment on the human health risks on the site?	☐ Yes ☐ No	
	If so, provide details.		
	Have you carried out a risk assessment in terms of public safety & access on the site?	☐ Yes ☐ No	
	If so, provide details.		
Design (Module 2.7)	Does the design of the project integrate with existing open space and conservation corridors?	☐ Yes ☐ No	
	Please provide details.		
	Does the design of the project integrate with road layouts and streetscaping?	☐ Yes ☐ No	
	Please provide details.		
	Does the design of the project integrate with lot layouts?	☐ Yes ☐ No	
	Please provide details.		
Operations and maintenance (Module 2.8)	Have you considered operational and maintenance requirements?	☐ Yes ☐ No	
	Have you included annual maintenance costs? If so, please specify.	☐ Yes ☐ No	

Part 3: Beneficial actions for a successful project

Action	Issues to consider	Response	Further details
Relevance of project	Is the project in line with Council contemporary values?	☐ Yes ☐ No	
	Is the project relevant to the site?	☐ Yes ☐ No	
Build internal capacity	Is there support from internal teams and councillors?	☐ Yes ☐ No	
	Have you carried out any awareness sessions with colleagues?	☐ Yes ☐ No	
	Please provide details.		
	Have Councillors been briefed?	☐ Yes ☐ No	
Community engagement	Have you carried out any community engagement or education? Please detail	☐ Yes ☐ No	
	Please provide details.		

Part 2

Module 2.2

Scoping the options

This module takes steps to help develop WSUD options. The steps are:

Step 1: Find ways to reduce water consumption
Step 2: Replace drinking water with an alternative source
Step 3: Treat stormwater before discharge into water bodies.

All three steps are necessary to find the best sustainable water solution using water sensitive urban design. Treating stormwater can be done as the second or third step as any treatment to remove pollutants from stormwater will help to improve the opportunity to reuse that water as an alternative source. Water saving also helps to improve stormwater quality by preventing some runoff (and its pollution) from entering waterways.

Step 1: Find ways to reduce water consumption

Water saving targets

The City of Melbourne aims to achieve the following water saving targets by 2020 (compared to water use in 2000):

- 40% reduction in water consumption per resident by 2020 from 2000 levels
- 50% reduction in water consumption per employee by 2020 from 2000 levels
- 90% reduction in total water consumption by Council by 2020 from 2000 levels.

Managing the demand for water

Households in the City of Melbourne were large water users per capita in 2000, with each person using an average of 296 litres per day, or 228 KL/year per average household. This was significantly higher than the average of 146 KL/year for high density living and only slightly less than the average of 240 KL/year for traditional suburban households[6]. Recent savings have been made by residents reducing the average to 179 litres per day used by each person. These water saving efforts need to be long term, as the number of residents in the city continues to grow.

Figure 1 below shows how a typical residence in the City of Melbourne uses water. The bathroom (27%) and toilet (25%) rate highest. Gardens in the City of Melbourne are generally smaller than in other suburbs, but they still account for approximately 20% of water use.

These results suggest that current use of mains drinking water could be significantly reduced by using alternative water sources for toilet flushing and gardens (up to 45% of total water use).

The kitchen accounts for only 12% of total household use. Here, the primary use would be human consumption, including drinking and food preparation. The kitchen is the obvious place for high quality potable mains water rather than alternative water sources.

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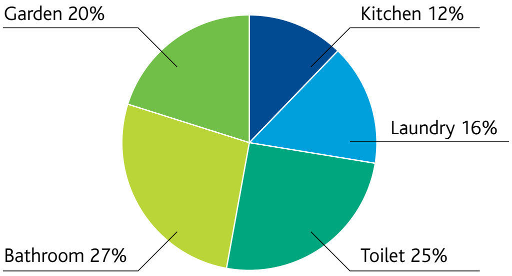
[6] Data source: Water resources strategy committee for the Melbourne Area (2001)

Figure 1. Typical residential water use breakdown[7]



Water use in business is harder to generalise as each business has very different water needs. Since 2000, water use per employee has dropped from 181 litres per person per day to 95 litres/person/day. Over seven years, this 38% reduction has reduced total water use in the commercial/industrial sector from 18,200 megalitres down to 11,430 megalitres.

Council's own water use has dropped by 29% due to water conservation efforts in our buildings and parks.

Until recently, there has been a culture of water being plentiful and cheap in the urban environment. As a result, water has been undervalued and overused. The increasing pressure on our water resources requires a change to this perception. Ideally, our everyday habits must change and our approach and behaviour must reflect the view that potable water is a valuable resource.

Permanent water restrictions such as limiting garden watering, prohibiting hosing hard surfaces, stipulating vehicle washing with buckets and permits for pool filling are now required.

Demand management is a relatively easy way to reduce water consumption. Water demand can be reduced through changing:

- Behaviour
- Regulation
- Technology
- Design.

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[7] Data source: Water resources strategy committee for the Melbourne Area (2001) Discussion Starter: Stage 1 in developing a water resources strategy for the Greater Melbourne area.

Demand for water in the home and business can be decreased by installing water efficient:

- Fittings (tap aerators, efficient showerheads, 6/3L dual flush toilets)
- Appliances (5A washing machines and 4A dishwashers).

Larger businesses can improve efficiency in fire sprinkler testing regimes and cooling towers. Food businesses can use waterless woks and more efficient steamers. Businesses with large gardens can use efficient irrigation technology and practices when water restrictions are not in place.

Step 2: Replace drinking water with an alternative source

Water recycling and reuse targets

The City of Melbourne has **alternative water use targets**, as follows:

- 30% of Council's water needs to be sourced from alternative water by 2020
- 9% of non-Council water needs to be sourced from alternative water by 2020
- 100% of Council's development projects to show consideration of alternative water sources by 2010
- 100% of non-Council development sites requiring approval for a 'legal point of discharge' to show consideration of sourcing alternative water.

Under the City as a Catchment approach, the alternative water use target is a stepping stone to achieve the adopted **wastewater reduction target**:

- 30% reduction of wastewater entering the sewerage system by 2020.

Alternative water source hierarchy

Drinking mains water is currently the primary water source for Melbourne. After efforts have been made to reduce demand for water, alternative sources must be considered to decrease the use of drinking mains water.

Using alternative water sources helps to deliver sustainable water outcomes by:

- Saving water (reduced reliance on potable water and the wider water catchment)
- Improving stormwater quality (less stormwater entering the waterways thereby reducing pollution and velocity)
- Reducing wastewater (less wastewater entering the sewer to free up capacity for population growth and to reduce energy and ecological pressures at metropolitan treatment centres).

The urban water cycle has identified a range of potential alternative water sources which can be used depending on the quality of water that is needed (this is known as 'fit-for- purpose' water use). Not all of these options are suitable in all areas due to various environmental, economic and social reasons, and as such the following general hierarchy is recommended.

Alternative Water Sources from within the Local Catchment

1. Consider rainwater harvesting

Smaller rainfall volumes are easy to harvest because the equipment required (such as tanks or storage pond) to hold this volume of runoff can be relatively small, yet able to help meet some of the residential and Council demands on mains water supply. Typically 90% of rainfall volume is attributed to frequent events smaller than the one in three month annual recurrence interval (ARI).

Rainwater harvesting also helps to reduce stormwater pollutants, most particularly nitrogen loads from atmospheric pollutants.

2. Consider stormwater harvesting

Stormwater harvesting allows for a much greater amount of rainwater to be harvested once it has landed on roads, footpaths, open space and other impermeable areas. Stormwater requires treatment therefore it needs more management, financing and energy than rainwater harvesting. Stormwater harvesting generally requires careful planning for large storage areas once the water has been captured and treated.

Stormwater harvesting provides the greatest reductions in stormwater pollutants compared to other alternative water sources. In particular, it reduces total suspended solids (grit, car and tyre residue etc).

3. Consider water recycling

This hierarchy is shaped by a commitment to minimising carbon, and lifecycle implications.

Each water recycling proposal, greywater and blackwater, has unique reliability, energy cost, environmental risk and economic profiles. It is necessary to consider the circumstances of every site to determine the best option for saving water, sourcing alternative water and reducing stormwater pollution.

Alternative Water Sources from beyond the Local Catchment

If the above hierarchy of sustainable water management solutions is not able to meet water conservation and water quality targets, then it is recommended that water sources generated from outside the municipality, but traversing the local region be considered to supplement supply. This includes:

4. *Wastewater conveyed along the Melbourne Water Sewerage Transfer Network.*

Sewer mining is an option for alternative water sourcing on sites that have limited space or other constraints. It does have significant energy implications that need to be managed, but has the benefit of a certainty of supply (unlike rain-dependent options) and much less storage requirements.

5. *Stormwater in the Yarra River, Maribyrnong River and Moonee Ponds Creek*

Drawing water from waterways requires full consideration of environmental flow requirements of that waterway. Drawing from upper reaches is not recommended because of the detrimental impacts resulting from reduced environmental flows in waterways.

Whilst the lower reaches do not have the great implications of environmental flows it is often limited by the water in these lower reaches being saline and requiring significant treatment and desalination.

6. *Groundwater*

Groundwater is a highly variable resource across Melbourne and localised circumstances need to be researched. The lower Yarra region does not provide a significant groundwater resource because of the shallow, saline water table across the Yarra Delta region[9]. If extracted, groundwater often needs to be desalinated.

Central Melbourne is located on unconsolidated quaternary alluvium deposits and therefore it is characterized by a very low storage potential for aquifer storage recharge.

Water quality considerations

Water quality and typical treatment required for urban water sources and the associated impacts on climate change and risks to human health are summarised in Table 2. Reused water (greywater and blackwater) has minimal risks if appropriately treated and used as discussed in Module 2.6.

Table 2. Summary of water quality for urban water streams

Water	Source	Quality	Treatment required	Use
Drinking mains water	Reticulated (piped) water distribution	High quality	None	General domestic uses
Roof runoff	Rainwater from roof	Reasonable quality	Low level – typically sedimentation occurs within a rainwater tank	Toilet flushing, garden irrigation, washing machine, hot water system
Stormwater runoff	Catchment runoff (includes impervious areas such as roads, pavements, etc)	Moderate quality	Reasonable treatment to remove litter and reduce sediment and nutrient loading	Toilet flushing, garden irrigation, washing machine, hot water system
Greywater	Shower, bath, bathroom basins, washing machine	Wastewater – variable organic loading and pathogens	Moderate to high treatment level required to reduce pathogens and organic content No treatment required if used within 24 hours and subsurface irrigation	Toilet flushing, garden irrigation, washing machine
Blackwater	Kitchen, toilet and bidet water from the sewer	Wastewater. Lowest quality – high levels of pathogens and organics	Advanced treatment and disinfection required	Toilet flushing, garden irrigation

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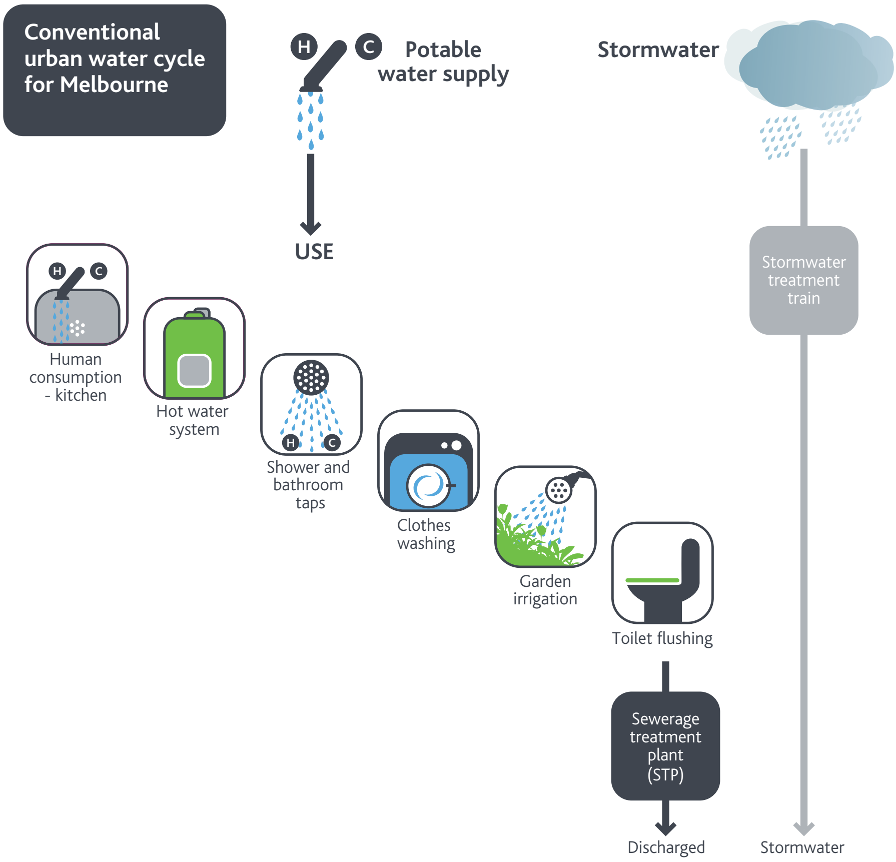
[9] Broad scale potential mapping exercise undertaken by Dudding et al (2006).

Conventional urban water cycle

Melbourne's conventional urban water cycle has a large scale centralised water supply and disposal system, as shown in Figure 2.

Water is collected from a large catchment area, treated and delivered via a pipe network to the customer. After use, the wastewater flows through a second set of pipes, the sewer, to Melbourne's sewage treatment plants. The treated water is then discarded to Port Phillip Bay. Stormwater is discharged to the bay via drainage pipes and the Yarra River.

Figure 2. Conventional urban water cycle for Melbourne



Rainwater harvesting

Rainwater covers water that is captured on roofs. It is an alternative water source for use within the City, as shown in Figure 3.

Rainwater can be used for:

- Toilet flushing
- Garden irrigation
- Washing machines
- Hot water systems.

Water storage tanks can be strategically incorporated into new or existing buildings and open space areas without impacting on the aesthetics of the building or streetscape. Tanks should be appropriately sized to maximise their reliability and usefulness. Details of tank sizing, installations and approvals can be found in the *Rainwater Tank Fact Sheets 2, 3 and 8*.

The capture and use of rainwater is an environmentally preferable option for sourcing alternative water supplies. Rainwater captured from a roof has a low level of pollution and this means that treatment is not always necessary. Because the water is reused on the same site, materials are minimised and less energy is needed to pump the water to its intended use. This reduces resource consumption and lowers greenhouse gas emissions.

The amount of pollutants entering the waterways is also reduced. Rainwater harvesting will primarily reduce the total nitrogen load, which has been picked up as airborne pollutants. A reduction in nitrogen means less algae and plant growth. This growth in waterways can inhibit invertebrate and fish diversity. A reduction in runoff to streams is another benefit for urban stream health and flood mitigation.

Stormwater harvesting

Stormwater harvesting provides an alternative water source that can be captured from roads, footpaths, car parks, open space and gardens for use within the City as shown in Figure 3.

Stormwater can be used for:

- Toilet flushing
- Garden irrigation
- Washing machines
- Hot water systems.

Water storage tanks are used for stormwater as well as rainwater harvesting. They can be incorporated into new or existing buildings and open space areas so that they do not impact on the aesthetics of the building or streetscape. Tanks should be appropriately sized to maximise their reliability and usefulness. Details of tank sizing, installations and approvals can be found in the *Rainwater Tank Fact Sheets 2, 3 and 8*.

Stormwater can also be stored at ground level including ponds and waterbodies in open space areas.

The onsite capture and use of stormwater requires more treatment than rainwater harvesting, but less treatment than many water recycling options. Capturing stormwater also helps to reduce the amount of pollutants entering the waterways. If stormwater is captured from:

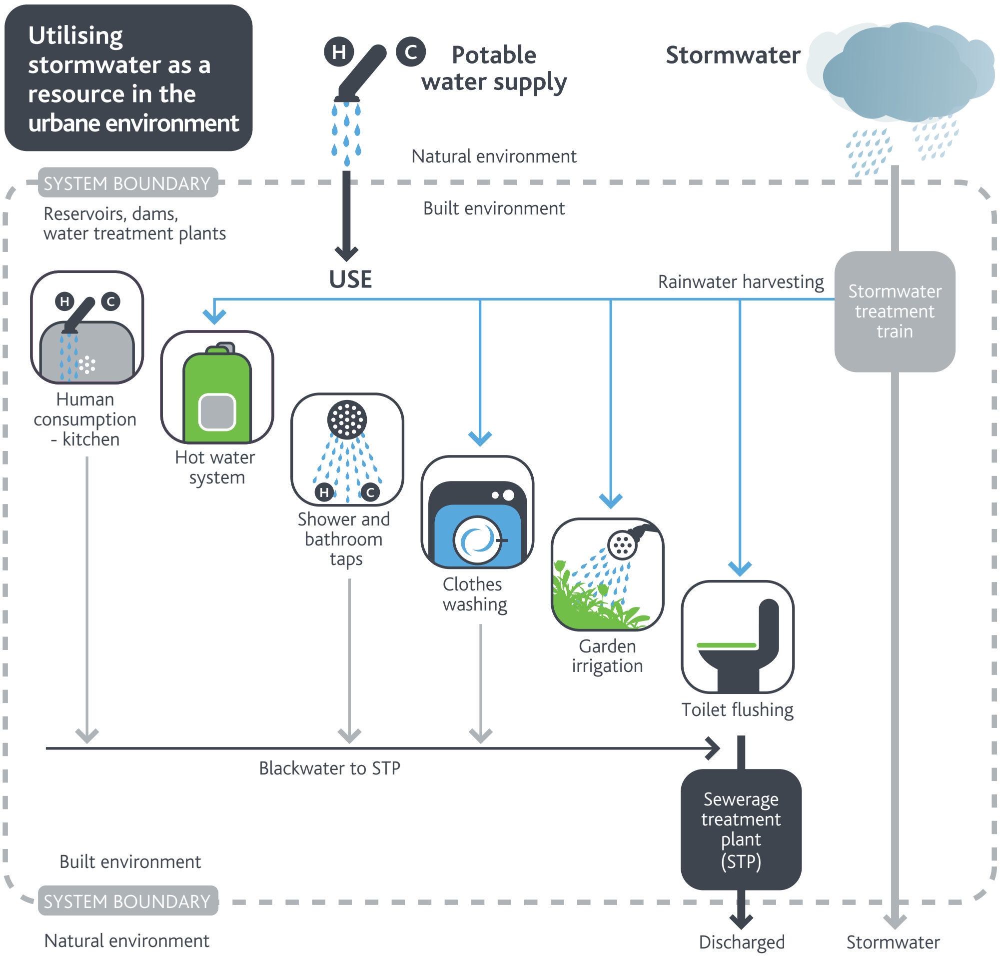
- Roads and carparks, it will primarily reduce the total suspended solid load, which includes the general grit and tyre/car residue
- Garden areas, it will primarily reduce the total nitrogen and total phosphorus loads from fertilisers.

Reducing these pollutants will help fish, invertebrates and macrophytes stay healthier.

Stormwater reuse will also aid in flood mitigation and urban stream health by reducing runoff .

Stormwater treatment is further described in Step 3: Managing stormwater before discharge into the environment

Figure 3. Utilising stormwater and rainwater as a resource in the urban environment



Greywater reuse

Greywater can save significant quantities of drinking water and reduce the amount of wastewater going to a sewerage treatment plant. It can require treatment, or can simply be diverted untreated.

Greywater varies in quality depending on the amount of organic loading it has in it, which is determined by its original use:

- Residential and commercial greywater includes water from the laundry, bathroom taps and shower
- Industrial greywater includes slightly polluted water reused in manufacturing.

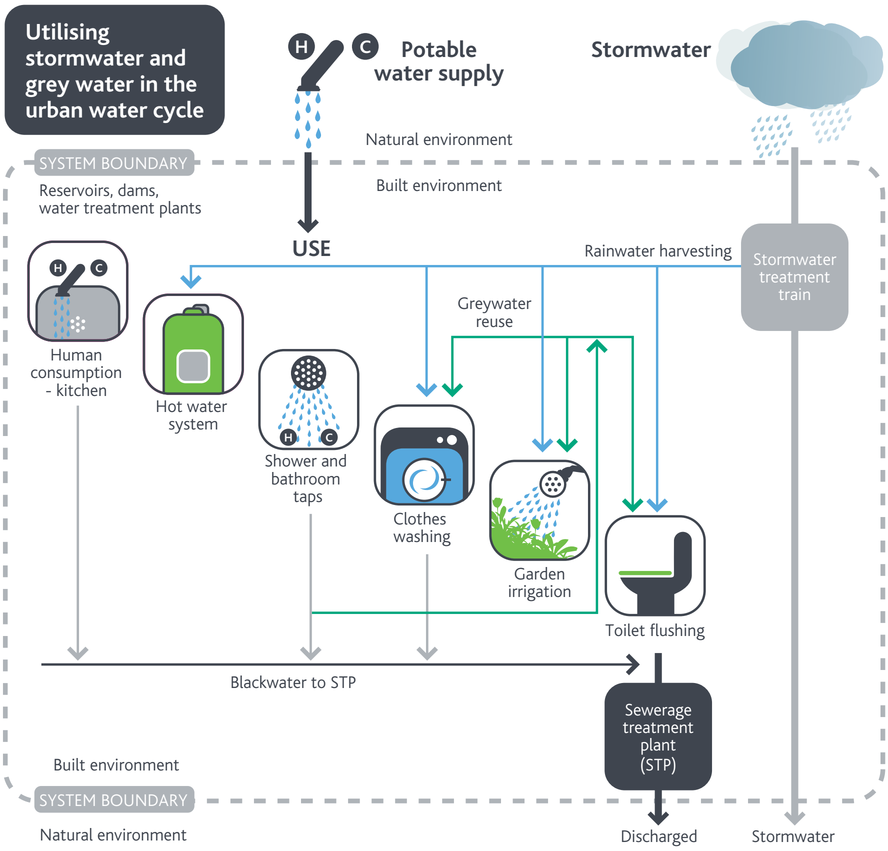
Greywater needs treatment as it contains contaminants made up of low levels of bacteria, faecal matter, organic matter, micro-organisms, salts and detergents. These are dangerous to human health and can degrade water colour and create odours.

The level of 'treatment' of greywater depends on its end use and exposure pathway (the extent to which humans will come into contact with it). Options include:

- Simple screening of pollutants using a mesh
- Settlement in a tank
- Chemical treatment
- Biological treatment.

Figure 4 shows how stormwater and greywater can be reused.

Figure 4. Utilising stormwater and grey water in the urban water cycle

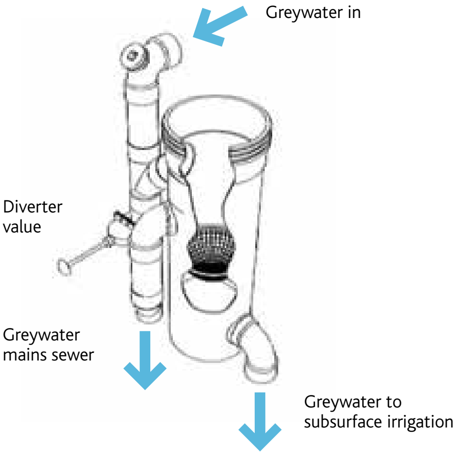


Small-scale greywater diversion

A simple greywater reuse system diverts greywater to the garden for irrigation. This means greywater can be used straight away, with little treatment and minimal human contact.

Figure 5 shows a typical system where greywater is redirected to the garden through a subsurface irrigation system using a diverter valve. The system can be retrofitted to existing buildings close to washing machines or sinks. Care must be taken to reduce the clogging and blockages of dispersion systems.

Figure 5. Greywater diverter (www.greywatersaver.com)



Managing risks associated with greywater

Human exposure to greywater should be limited. A closed system is best for collection, treatment and reuse. At the simplest level, the following principles should be followed to manage health risks[3]:

- Don't make cross connections between greywater and drinking water systems
- Direct excess greywater to the sewer
- Use a self-contained system
- Limit exposure to the greywater system
- Don't use greywater during wet weather
- Don't use greywater to irrigate vegetable gardens.

With simple greywater systems, there is no provision for storage in the system. Irrigation is subsurface, so human exposure is limited. In this situation, there is no direct contact between greywater and people, and public health risk is extremely small.

Currently there is no Victorian legislation specific to the use of untreated greywater. Simple greywater diversion systems do not require EPA or Council approval[4]. All plumbing should be completed by a licensed plumber in accordance to Australian Standards *(AS3500.1.2 Water Supply: Acceptable Solutions)*. Further advice is available from EPA Victoria and the Victorian Department of Human Services.

Temporary greywater storage

Greywater can be temporarily stored in an underground tank, to be reused at a later time. Garden irrigation is an appropriate use for this type of system. The Department of Human Services does not recommend the use of untreated greywater within the household[5]. Storing untreated greywater is hazardous, as it may lead to microbial growth and therefore produce odours and septic water. Greywater can be stored for up to 24 hours without treatment before it must be discarded to sewer. If greywater is to be stored for more than 24 hours it must be treated and disinfected.

Greywater treatment

Greywater from the shower, bath and basin in bathrooms requires treatment before it is reused. If it is to be used again, additional infrastructure is needed to install a reuse system, including underground tanks, pumps and an onsite disposal system. Figure 6 shows an overview of a greywater system.

Figure 6. Schematic of greywater reuse system

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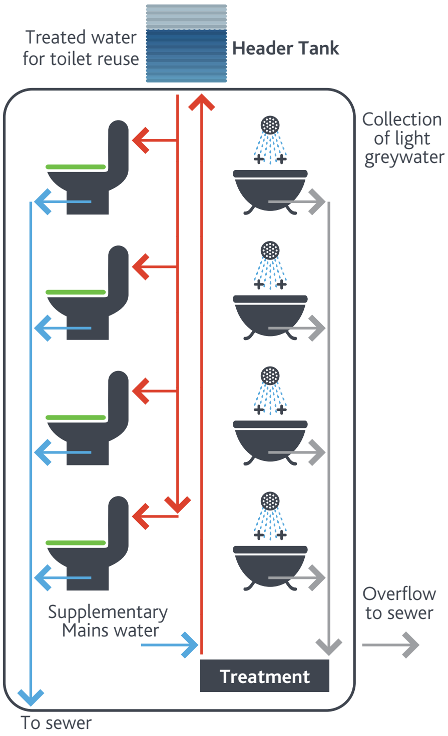
[3] NSW Health (2000) *Greywater reuse in sewered single domestic premises.*
[4] Refer Victoria EPA (2001) Reuse options for household wastewater – publication 812.
[5] Department of Human Services (2003) Appropriate reuse of greywater.

For a multi-storey residential development, a dedicated collection system is needed to collect the greywater and a separate system for treated water reuse (Figure 7). A header tank is typically installed to minimise fluctuations during the day.

Figure 7. Greywater system within a multi-storey residential development



Meeting water quality standards for greywater

Water quality requirements for greywater stored for over 24 hours depend on the final use. EPA Victoria has prepared guidelines for the use of reclaimed water. Similar water quality criteria are expected to apply for greywater reuse schemes. The water quality objectives are summarised in Table 3. The pH should be between 6 and 9 for all waters. Class D (agricultural use) is not applicable for inner Melbourne so is not included in this table. For more detailed information, refer to EPA Victoria's *Guidelines for Environmental Management: Use of Reclaimed Water* (Publication 464.2, 2003).

Table 3. Water quality objectives for reclaimed water treatment (Victoria EPA, Publication 464.2, Table 1)

Class	Water quality objectives	Range of uses (includes all lower class uses)
A	<10 E.coli org/100ml <10 mg/L BOD <5 mg/L SS Turbidity < 2 NTU Disinfection	Urban with uncontrolled public access e.g. toilet flushing, irrigation Industrial with open systems and worker exposure potential
B	<100 E.coli org/100ml <20 mg/L BOD <30 mg/L SS	Industrial – e.g. wash down water
C	<1000 E.coli org/100ml <20 mg/L BOD <30 mg/L SS	Urban with controlled public access e.g. subsurface irrigation or irrigation of areas where there is no public access

Larger-scale greywater treatment technologies

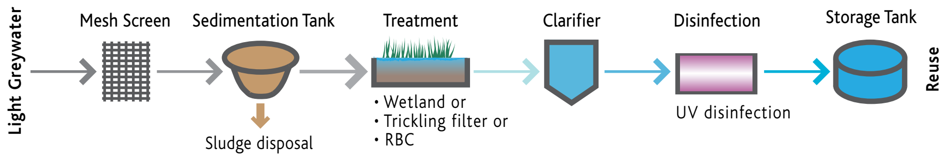
Typically, a greywater treatment system is a combination of treatment technologies that are sequentially placed to form a treatment train. Figure 8 illustrates the key components of a generic treatment train.

A treatment train should provide a graduated level of treatment from primary through to tertiary (advanced) treatment. Using only one measure will not adequately address the range of pollutants generated in a typical urban development. Therefore a series of individual treatment measures must be developed.

The treatment train should consider the optimal operating environment for each treatment measure, taking into account:

- Contributing catchment area
- Hydraulic and pollutant loading
- Treatment process employed
- Soil type and ground water
- Maintenance and public health issues.

Figure 8. Typical treatment train for a greywater reuse system



Mesh screen: The mesh screen physically traps and removes larger objects from the greywater reuse process.

Sedimentation tank: The sedimentation tank works as a surge tank to regulate inflow into the treatment system. The tank helps remove larger-sized pollutants through sedimentation (the natural settlement of solids).

Treatment: Treatment of greywater from a wetland through trickling filter or rotating biological contactor (RBC) reduces and/or dissolves organic matter.

Clarifier: The clarifier acts to stabilise flow and removes excess biomass by sedimentation.

Filtration (not shown): Filtration happens through either sand or a membrane to improve the level of the water quality. This is dependent on relevant health regulations.

Disinfection: If organic material is not removed, greywater may become anaerobic and give off odours. Disinfection kills micro-organisms including pathogens and bacteria to minimise public health risks and prevent biofouling in the system. Ultraviolet (UV) disinfection is preferable, although this can also be achieved by chlorination and ozonation (refer to Fact Sheet 22). DHS will often prefer an element of residual disinfection achieved only by chlorination.

Technologies available for large greywater systems

There are a range of technologies available for treatment of larger greywater reuse systems. These include:

- Subsurface flow wetlands *(Fact Sheet 16)*
- Suspended growth systems e.g. activated sludge systems *(Fact Sheet 17)*
- Fixed growth systems e.g. trickle filters, rotating biological contactors (RBC) *(Fact Sheet 18)*
- Recirculating media filters (fixed film bioreactor) *(Fact Sheet 19)*
- Sand and depth filtration *(Fact Sheet 20)*
- Membrane filtration (micro, ultra, nano filtration and reverse osmosis) *(Fact Sheet 21)*
- Membrane bioreactor *(Fact Sheet 17)*.

This technology list is only a guide and not exhaustive. It aims to capture the most common and applicable treatment systems available. Technology selection depends on a range of criteria including:

- Water use
- Water quality and quantity
- Available space
- Economic considerations
- Other environmental objectives, e.g. greenhouse gas emissions and land capability
- Climatic conditions
- Operating and maintenance.

Each treatment and technology should be evaluated on a case-by-case basis. An overview of pollutant removal is presented in Table 3, with more detailed information provided in the relevant Fact Sheets.

Table 4. Overview of treatment technologies and their pollutant removal abilities[6]

	Suspended solids (TSS)	Biodegradable organics (BOD removal)	Nutrients- nitrogen	Nutrients- phosphorous[7]	Salts	Pathogens
Subsurface flow wetland *(Fact Sheet 16)*	Yes	Yes	Yes	Yes	No	Good[8]
Biological processes – suspended growth systems *(Fact Sheet 17)*	Yes	Yes	Yes	Limited	No	Limited
Biological processes – fixed growth *(Fact Sheet 18)*	Yes	Yes	Yes	Limited	No	Limited
Recirculating media filter *(Fact Sheet 19)*	Yes	Yes	Yes	Limited	No	Limited
Depth Media Filtration *(Fact Sheet 20)*	Yes	Function of size	Limited	Limited	No	Limited
Membrane filtration *(Fact Sheet 21)*[9]	Yes	Function of size	Function of size	Function of size	Reverse osmosis only	Function of size
Disinfection *(Fact Sheet 22)*	No	No	No	No	No	Yes

As shown in Table 5, the scale of the site will influence which technology is selected:

- For single households, simple greywater reuse systems are preferable
- Larger systems are more appropriate for larger scale applications with associated management and maintenance.

Table 5. Suggested greywater treatment technologies for different scales

Scale	Treatment technologies
Small Household	Greywater diversion Temporary storage Subsurface flow wetland Disinfection
Medium High rise residential development Mixed use urban development Residential urban development / redevelopment	Subsurface flow wetland Biological processes – suspended growth systems Biological processes – fixed growth systems Recirculating media filter Depth filtration Disinfection
Large Commercial development Industrial development	Biological processes – suspended growth systems Biological processes – fixed growth systems Depth filtration Membrane filtration Disinfection

Blackwater reuse

Melbourne has an extensive city sewerage network that is presently designed to transport wastewater to large-scale treatment plants. This water could be used as a resource. The wastewater (blackwater) can be extracted from the sewerage system, treated and reused appropriately for irrigation purposes or for toilet flushing.

Blackwater reuse (or 'water mining') requires a higher level of treatment than greywater. The treatment train must include disinfection to reduce high pathogen levels.

Treatment can be energy intensive. When selecting a blackwater project, the broader ecologically sustainable development objectives must be considered, particularly the greenhouse gas emissions and a land capability assessment (LCA).

An LCA assesses the capability of the site to sustainably manage wastewater and looks at parameters such as the site drainage, rainfall and soil characteristics. For more information on LCAs, EPA Victoria has an information bulletin *Land capability assessment for onsite domestic wastewater management*, Publication 746.1.

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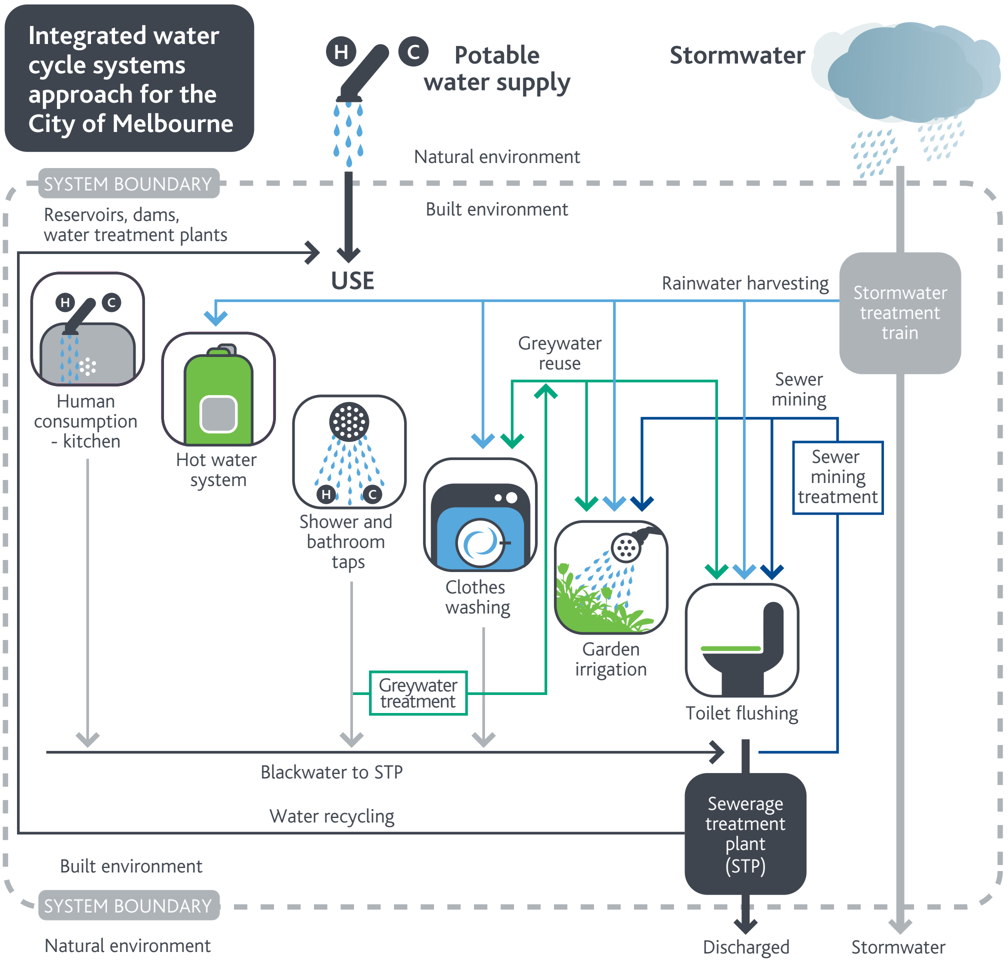
[6] Refer to Crites and Tchobanoglous (1998) Small and decentralised wastewater management systems, McGraw-Hill.
[7] Phosphorous removal is dependent on the reactor configuration and the scale of treatment system.
[8] Further pathogen removal, such as disinfection may be required to meet EPA Victoria requirements.
[9] Pollutant removal by membrane filtration is a physical separation process with pollutant removal dependent on the pore size, refer to Fact Sheet 21.

Figure 9. Integrated water cycle systems approach



In Melbourne, it's better to have smaller scale systems that extract and treat water as required. Small treatment plants produce water quality and quantity as required, which is an advantage.

Water mining (Sewer mining)

Water mining (also referred to as 'sewer mining') involves:

- Extracting wastewater from the sewerage (blackwater) system
- Treating and recycling the water
- Disposing of the remaining waste to the sewer for centralised treatment.

Typically the water is disinfected to Class A standard (10 E.Coli/100mL, 10 BOD mg/L and 5 mg/L SS)[16] (refer to *Fact Sheet 18*).

Water mining systems are typically a combination of technologies and can be purchased as 'package treatment plants'. These are compact, sometimes portable treatment stations available from proprietary companies. Often they are sized to fit inside a shipping container.

Sewer flow rates and quality

Effective water mining matches water demand with blackwater supply. The flow of a sewer changes with people's behaviour. Flows peak in the morning and evening. As the sewerage system becomes larger, so does the sewer catchment, so there is less variation in peak flows. The supply of water increases with a greater source and upstream network.

When a collection system is smaller, it's more sensitive to variations in flow. This limits the potential for continuous sewer extraction, and an onsite surge tank may be needed to meet periods of high demand.

The exact design of the surge tank will depend on the collection system and the sewer extraction point. A smaller upstream collection network means varying blackwater quality. Avoid potentially hazardous consumers such as industrial and other trade waste customers by carefully selecting sewer extraction points.

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[16] EPA Victoria's *Guidelines for Environmental Management: Use of Reclaimed Water* – Publication 464.2, 2003.

Water quality

Blackwater extraction from sewers is highly contaminated and of variable water quality. Domestic wastewater typically contains:

- High total suspended solids (120-370 mg/L)
- High biochemical oxygen demand (BOD) (120-380 mg/L)
- High levels of micro-organisms (faecal coliform bacteria 10^5-10^7)
- High nutrients - total nitrogen (20-705 mg/L) and total phosphorous (4 -12 mg/L)[17].

As with greywater, the level of 'treatment' of greywater depends on its end use and exposure pathway. Usually, water used for toilet flushing and uncontrolled public access irrigation must be high quality. EPA Victoria's guideline for the use of reclaimed water (publication 464.2) specifies the quality of reclaimed water needed for a particular end use.

Figure 10. Schematic overview of a sewer mining

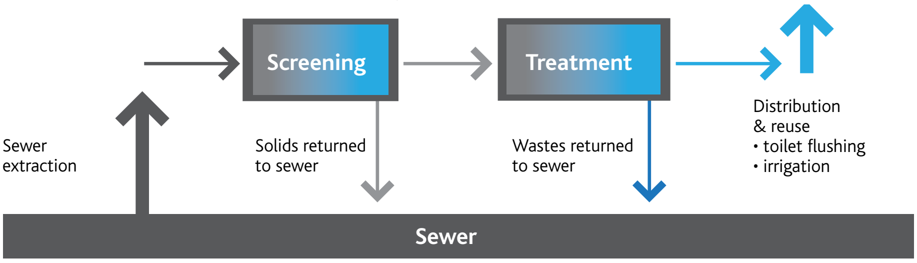

Figure 10 shows a typical water mining treatment systems, consisting of:

- Water extraction from the sewer
- Screening and treatment before reuse.

Extraction

Minimise solids extraction, and therefore treatment costs, through:

- Using a pumping system that transports blackwater from the sewer to the treatment system
- Positioning the extraction point closest to the surface within the sewer.

Screening and treatment

After extraction, a primary separation process commonly takes place to remove any remaining solids. Screening is the most common physical separation process used, and the screened solids are immediately returned to the sewer. Wastewater can be used to continually clean the screen, and preventing clogging. Alternatives to using screens before pre-treatment include:

- Hydro-cyclone separators
- Sedimentation
- Enhanced sedimentation
- Dissolved air flotation (DAF) devices.

All of these techniques separate solid matter from wastewater.

After treatment, most systems need disinfection to control the high pathogen concentrations. Disinfection methods are explored in *Fact Sheet 21*.

Water mining technologies

Water mining technologies are similar to those used for greywater systems. The main difference is in inflow wastewater quality. Water mining treatment must:

- Reduce the high organic and micro-organism concentrations
- Control pathogen levels.

The technology is designed to accommodate changes in water characteristics and pollutant loading. A range of treatment technologies can be used for water mining, including:

- Subsurface flow wetlands *(Fact Sheet 16)*
- Suspended growth systems, e.g. activated sludge systems *(Fact Sheet 17)*
- Fixed growth systems, e.g. trickle filters *(Fact Sheet 18)*
- Recirculating media filters (fixed film bioreactor) *(Fact Sheet 19)*
- Sand and depth filtration *(Fact Sheet 20)*
- Membrane filtration (micro, ultra, nano filtration and reverse osmosis) *(Fact Sheet 21)*
- Membrane bioreactor *(Fact Sheet 17)*.

The technologies listed above include both:

- Commercially available technologies
- New technologies expected to become commercially viable as competition increases in the water market.

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[17] Metcalf and Eddy (2003) *Wastewater Engineering – Treatment and Reuse, Fourth Edition*, McGraw-Hill, p.191.

Selecting a technology should be done on a case-by-case basis, with key considerations similar to greywater treatment. Importantly, the water use will determine required water quality, as recommended by EPA Victoria's *Guidelines for Environmental Management: Use of Reclaimed Water* (publication 464.2).

Table 6 shows how the scale of the site will influence the treatment technology. For single households, greywater reuse is preferable to blackwater treatment. Blackwater treatment and reuse is more appropriate for larger scale applications.

Table 6. Suggested blackwater treatment technology for different scales

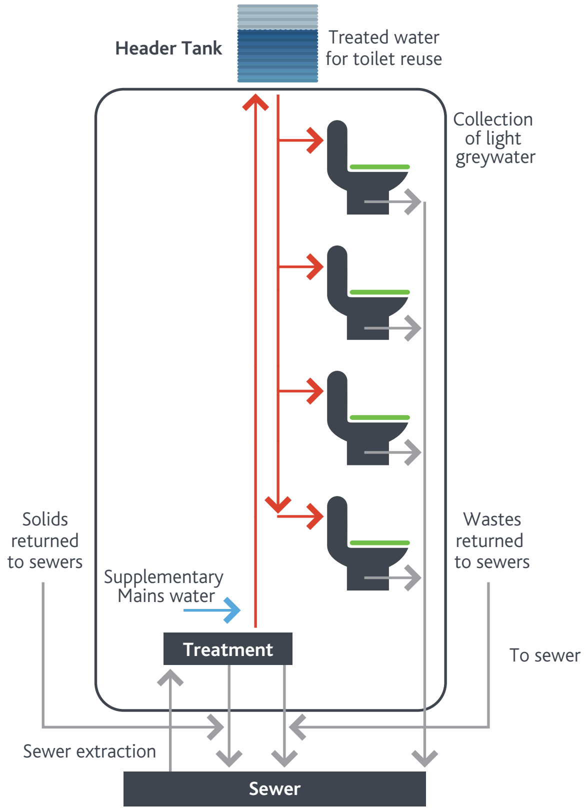
Scale	Treatment technologies
Small Household	Should be sent to centralised sewerage treatment plant (STP) via sewer. Onsite treatment biological treatment systems are available
Medium High rise residential development Mixed use urban development Residential urban development/redevelopment	Biological processes – suspended growth systems Biological processes – fixed growth systems Recirculating media filter Depth filtration Membrane filtration Disinfection
Large Commercial development Industrial development	Biological processes – suspended growth systems Biological processes – fixed growth systems Depth filtration Membrane filtration Disinfection

Recycled water use in buildings

Commercial high-rise developments offer opportunities for water mining, where other potential water sources such as rainwater harvesting are limited due to the size of the roof catchment. In a similar way, greywater production in commercial buildings is limited by lack of showers. Therefore the sewer provides a consistent water resource and water mining is the most appropriate treatment technology.

Toilet flushing is the main water consumer in commercial buildings. High quality drinking water is unnecessary for toilet flushing and treated blackwater is perfectly adequate. Consequently, water mining provides a good match between appropriate use and supply. Figure 11 shows a typical water mining plumbing schematic for a high-rise commercial development.

Figure 11. Typical plumbing requirements for sewer mining within high rise development



Water mining systems need a dedicated dual supply pipe to deliver the reclaimed water to toilets, cold washing machine tap and/or irrigation. Adequate provision of the pipe network is essential during the building's construction. Treatment technologies can be located in the basement of the building through 'package plants'.

Step 3: Treat stormwater before discharge into waterways

This section includes a methodology for setting stormwater quality targets.

Why is it useful to have a stormwater quality target?

The WSUD Guidelines are designed to encourage all projects to be measured, and their contribution to improving water quality logged as progress in meeting a water quality improvement target for that municipality. This will help in understanding the water quality impact of each WSUD initiative.

Melbourne Water has worked with Melbourne City Council to establish a simple stormwater target framework based on rigorous analysis of land use, rainfall and pollutant loads. Such a target is needed to meet the regulatory requirements of State Environment Protection Policy (Waters of Victoria).

Previously, Councils have been able to measure litter reduction progress through litter counts on the streets, in waterways and in litter traps.

Progress in understanding and implementing water sensitive urban design solutions is helping to move stormwater treatment closer to the source. That is, pollutants can be prevented from reaching the stormwater system in the first place and there is less reliance on catching the pollutants in the drains just before entering the waterways. This has the benefit of reducing maintenance on litter traps, and also increases capture of finer pollutants such as:

- Total suspended solids (grit, tyre and car residue)
- Nitrogen (airborne pollutants and fertilisers)
- Phosphorus (fertilisers and detergents).

Melbourne Water is providing support to all municipal councils to undertake municipal target setting.

What stormwater targets should each Council have?

Over the past few years, the stormwater industry has increasingly been encouraging and regulating for each development site to treat stormwater. These efforts aim to achieve:

- 80% reduction in total suspended solids (grit, tyre and car residues etc)
- 45% reduction in total phosphorus (fertiliser, detergent)
- 45% reduction in total nitrogen (airborne pollutants, fertiliser)
- 70% reduction in litter.

Council may set stormwater targets by choosing to use a single ‘indicator’ pollutant to report against. Total suspended solids is considered the appropriate indicator pollutant for built up inner areas.

Stormwater Target Setting: City of Melbourne

In the highly urbanised City of Melbourne, the most appropriate pollutant to measure is Total Suspended Solids (TSS) as there is a lot of grit from roads and hard surfaces including dirt and residue from tyres and cars. Heavy metals also attach to TSS, and these need to be managed as they are a significant environmental issue for Port Phillip Bay and the estuarine reaches of the waterways.

1,539,000 kg of TSS must be removed to achieve an 80% reduction in total suspended solids across the whole of City of Melbourne. Pollutants arising from Council-owned land totals 48% of all TSS generated, or 738,720 kg annually.

Council has shown it can reduce TSS loads by installing stormwater infrastructure that removes pollutants, such as raingardens and wetlands. In its first year of installing WSUD initiatives (2005), the City of Melbourne only removed 2,288 kg with its own projects. The installation of the Royal Park Wetlands removed an additional 20,100 kg, but this was a rare and specific opportunity and a level not expected from single projects into the future.

On this basis it has been modelled that Council can establish a program of removing 8,000 kg of TSS per year (in addition to the 22,388 kg already removed on an annual basis).

A point system has been developed to help communicate and measure TSS reductions. This is based on one point being equal to 26 kg of TSS removed. For more information, see the Ready Reckoner in Module 2.1.

Stormwater improvement targets for Council to achieve from its own works (from a 2005 base year) are:

- 2080 – TSS reduction of 80% or 590,976 kg TSS or 22,730 points
- 2020 – TSS reduction of 20% or 147,744 kg TSS or 5,682 points
- 2010 – TSS reduction of 8% or 59,098 kg TSS or 2,273 points.

Achievement of these targets is well underway with a 4% reduction achieved by June 2008. The application of a range of solutions including raingardens, swales, porous paving, wetlands, gross pollutant traps and others will continue to assist the City to achieve this target.

Pollutants arising from non Council-owned land total 52% of all TSS generated, or 799,800 kg annually. Developers on non Council-managed land are averaging very high levels of annual TSS reductions at around 15,000-25,000 kg per year. Some large projects are contributing to this figure and this early phase of WSUD implementation is producing highly variable results. In response to this variability, a conservative target of 8000 kg of TSS reductions per year was set for non Council-managed land. This will be reviewed in June 2010.

The stormwater improvement targets for the community to achieve on non Council-managed land have proved similar to those for Council land. For simplicity, community targets were therefore rounded to match Council targets. They are (from a 2005 base year):

- 2080 – TSS reduction of 80% or 639,840 kg TSS or 24,609 points
- 2020 – TSS reduction of 20% or 159,960 kg TSS or 6,152 points
- 2010 – TSS reduction of 8% or 63,984 kg TSS or 2,461 points.

Council will help the development community and the local community to meet these targets through incentives, education, training, partnerships and planning permits.

There will be separate measurements for:

- Reductions made by Council on Council land
- Reductions made on non-Council land (by developers, residents etc).

This reflects the different level of influence and responsibility that City of Melbourne has on its own land.

Stormwater treatment measures

Best practice urban stormwater management aims to meet multiple objectives including:

- Providing flood conveyance to reduce flow volumes and velocities (safe transport of floodwaters downstream that reduces risk to humans, riverine habitat and infrastructure)
- Removing contaminants to protect downstream aquatic ecosystems.
- Providing for infiltration to groundwater and baseflow
- Promoting WSUD elements as part of the urban form.

Infrastructure to avoid nuisance flooding and flood damage to public and private property is a fundamental requirement of a stormwater system. At the same time, a stormwater system should also provide on-site stormwater retention and detention. This protects downstream aquatic ecosystems from increased flow volumes and rates associated with urbanisation.

Typical urbanisation produces many contaminants that can be blown or washed into waterways and affect the health of streams and waterways. Best practice stormwater management makes sure that runoff is treated to remove water borne contaminants and protect or enhance the environmental, social and economic values of receiving waterways.

Stormwater can carry a wide range of pollutant types and sizes. No single treatment measure can effectively treat all pollutants carried by stormwater. A combination of treatments is therefore required to reduce the range of pollutants contained in stormwater.

Table 7. Site conditions and benefits of stormwater treatments

Treatment Measure	Potential benefits	Suitable site conditions	Unsuitable conditions
Gross pollutant traps *(Fact Sheet 9)*	Reduces litter and debris Can reduce sediment Pretreatment for other measures	Conventional drainage systems	Sites larger than 100 ha Natural channels
Sediment basins *(Fact Sheet 10)*	Coarse sediment capture Temporary installation Pretreatment for other measures	Need available land area	Proximity to airports because of bird presence
Rainwater tanks *(Fact Sheets 2, 3, 8)*	Storage for reuse Sediment removal in tank	Proximity to roof Suitable site for gravity feed Incorporate to urban design	Non-roof runoff treatment
Vegetated swales *(Fact Sheet 12)*	Medium and fine particulate removal Streetscape amenity Passive irrigation	Mild slopes (<4%)	Steep slopes
Buffer strips *(Fact Sheet 12)*	Pretreatment of runoff for sediment removal Streetscape amenity	Flat terrain	Steep terrain
Raingardens *(Fact Sheet 13, 14)*	Fine and soluble pollutants removal Streetscape amenity	Flat terrain	Steep terrain High groundwater table
Ponds *(Fact Sheet 11)*	Storage for reuse Fine sediment settling Flood retardation Community & wildlife asset	Steep terrain with confined valleys	Proximity to airports, landfill
Wetlands *(Fact Sheet 15)*	Community asset Medium to fine particulate and some soluble pollutant removal Storage for reuse Wildlife habitat	Flat terrain	Steep terrain High groundwater table Acid sulphate soils Proximity to airports because of bird presence
Retarding basins	Flood retardation Community asset	Available space	Limited available space Very flat terrain

Treatment train

A series of treatment measures that collectively address stormwater pollutants is called a 'treatment train'. The selection and order of treatments is a critical consideration. Treatment trains need to consider:

- Removal of coarser pollutants must be removed so that treatments that target fine pollutants can operate effectively
- Proximity of a treatment to its source
- Distribution of treatments throughout a catchment.

Table 6 outlines stormwater treatment measures that form a 'tool kit' from which individual measures can be selected to treat pollutants generated in an urban area.

An overriding management objective can help determine the most feasible stormwater treatment process. As a general rule, site conditions and the characteristics of the target pollutant(s) affect how treatment measures are chosen. Climate conditions, such as the frequency and intensity of storm events, affect the design of treatment systems and the overall effectiveness of pollutant removal.

Figure 12. Stormwater management issues, pollutants and likely treatment processes[19]

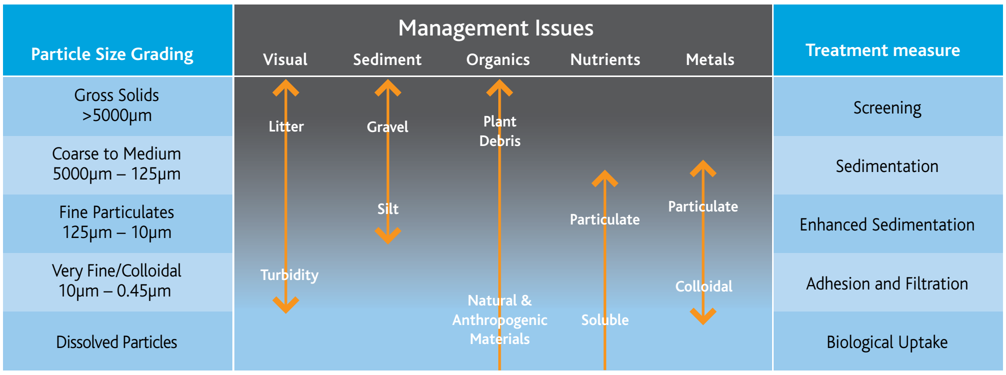


Figure 12 shows the relationship between:

- Management issues
- Likely pollutant sizes
- Appropriate treatment processes for those pollutants.

The horizontal lines through the arrows show the extent of the effectiveness of the treatment processes for each particle size. For example, if the management issue is to control the visual pollution caused by stormwater entering a watercourse, large particles such as litter can only be treated by screening and not by sedimentation or biological uptake. As the pollutant particle size reduces (e.g. for the treatment of soluble nutrients and metals), the nature of the treatment changes. Soil, gravel and vegetation can then provide treatment of soluble pollutants. These are called rain gardens. For more details these methods, refer to *Fact Sheets 13 and 14*.

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[19] Developed for Landcom's WSUD strategy (2003)

Figure 13. Pollutant size ranges for various stormwater treatment measures[20]

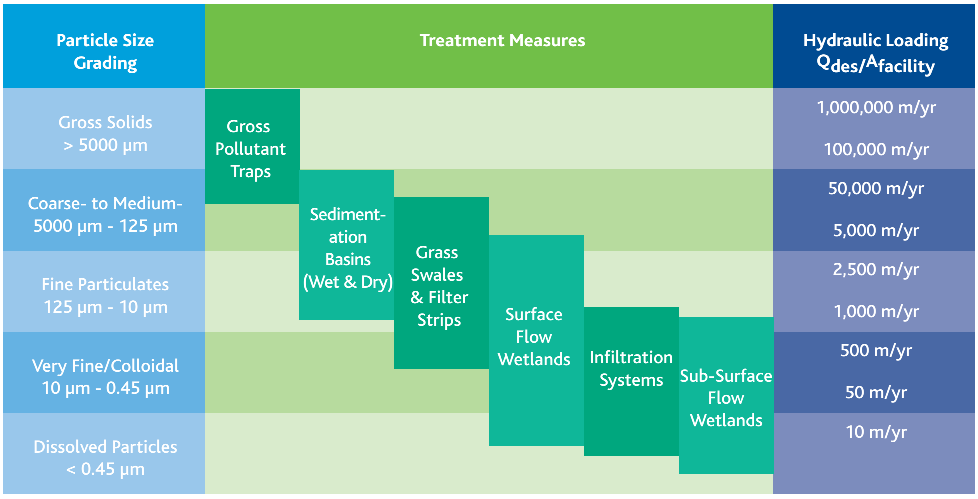

Figure 13 shows the inter-relationship between:

- Stormwater pollutant particle size
- Suitable types of treatment measures
- Appropriate hydraulic loading.

Hydraulic loading is the flow of stormwater through a treatment system. To allow the various pollutant removal processes to occur, treatments such as grass swales, vegetated buffer strips, surface wetlands and infiltration systems require the stormwater to flow through the system for a longer time than gross pollutant traps (GPTs).

GPTs collect litter and debris from stormwater systems through screening (refer to *Fact Sheet 9*). For a given size of unit, GPTs can treat higher flow rates than rain gardens. This means that they use a smaller proportion of land for treatment. The process of pollutant removal, either sedimentation or physical screening, reflects the smaller land size.

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[20] Developed for Landcom's WSUD strategy (2003)

Groundwater

Improving stormwater quality helps to protect our 'surface waters' including the Yarra River, Maribyrnong River, our creeks and Port Phillip Bay.

It is also important to protect our groundwater.

Groundwater in Melbourne is typically low in quality making groundwater extraction unfeasible without extensive treatment. Changes to the built or natural environment should always protect or enhance both groundwater quality and quantity.

Construction work can often disrupt groundwater requiring it to be extracted away from certain sites. Such works generally then require groundwater to be re-injected to prevent any land subsidence.

The management principles for groundwater are:

- Groundwater quantity – over the long term, there is to be no net change in the water quantity
- Groundwater quality – water injected is to be of equivalent or greater quality to the receiving groundwater.

Groundwater users have the responsibility to make sure the groundwater is appropriately managed and protected.

Part 2

Module 2.3

Considering the Environment

Interaction with the broader environment is a key consideration after the site has been assessed for suitability for a sustainable water project.

Recycled water can have several associated environmental risks, including:

- Impact on the aquatic environment
- Impact on the land, primarily from irrigation
- Production of greenhouse gases
- Production of biosolids and other wastes
- Odours.

These risks are site-specific and depend on the:

- Topography, geography and location associated with specific water treatment technology
- End use of the water.

Impact on the aquatic environment

WSUD can help to protect the aquatic environment by reducing:

- Impacts of stormwater outlets into waterways by slowing water velocity and reducing the amount of pollutants in the stormwater (this will in turn protect the natural ecosystem of the receiving waterway or bay)
- Demand for mains water, which in turn reduces the demand from upstream regional waterways that are sourced for Melbourne's water storages
- Local requirements to draw water directly from local waterways
- Inadequately treated wastewater discharging into the aquatic environment.

WSUD will also provide:

- Quality re-use water for additional environmental flows by ensuring there are no elevated nitrogen and phosphorus levels that would contribute to algal blooms
- Additional aquatic environments through WSUD works, including wetlands and ponds
- Water retention within the catchment to help with flood mitigation and reduce the rapid rise and fall of water levels in creeks and streams.

Further information and advice is available in environmental guidelines including:

- Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (2000) *National Water Quality Management Strategy – Paper No. 4 – Australian and New Zealand Guidelines for Fresh and Marine Water Quality*
- Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (2000) *National Water Quality Management Strategy – Paper No. 14 – Guidelines for Sewerage Systems – Use of Reclaimed Water.*
- Department of Environment and Conservation (NSW) (2004) Environmental Guidelines – *Use of Effluent by Irrigation*.

Algal management and water quality

The ability of a waterbody to provide a healthy ecosystem is largely determined by the levels and residence time of excess nutrients and (to a lesser extent) toxins, within both the waterbody itself and the inflowing water.

Excessive blue-green algal growth is a large threat to the health of a waterbody. The exponential rate of algal growth under unlimited conditions means that algal populations can rapidly reach levels where they become a risk to public health and fish and invertebrate growth. Some cyanobacterial (blue-green algae) blooms can be toxic to humans and other biota.

The rate of algal growth is a function of:

- Available nutrients
- Light
- Temperature
- Hydrologic conditions.

When there are enough nutrients, which only need to be in low concentrations, managing residence times becomes critical to managing the risks of algal blooms[21].

Nuisance algal growth and possible algal blooms develop under a combination of factors. Figure 1 summarises these factors in a generic algal growth end-point diagram.

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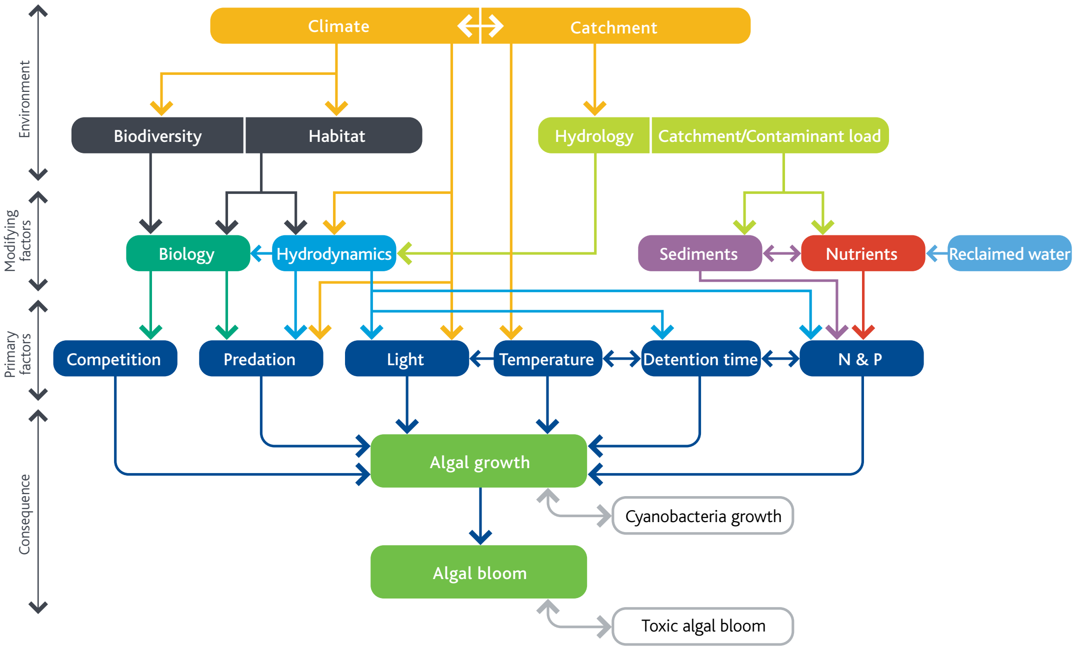
[21] See *WSUD Engineering Procedures: Stormwater*, Chapter 10 Ponds and Lakes (Melbourne Water, 2004) and Burge and Breen (Ecological Engineering, 2006) for more detail.

Figure 14. End-point diagram for algal growth



In summer, algal growth and bloom within waterbodies must be managed through the hydraulic residence time of the lake. 30 days is the maximum residence time for lakes in Melbourne to minimise the risk of cyanobacterial blooms.

Impact on the land primarily from irrigation

Recycled water in urban settings provides water for irrigation. Irrigation provides an appropriate use of recycled water and should not be simply seen as a way of disposing of water.

The suitability of recycled water for a particular environment depends on:
- Soil conditions
- Site topography
- Geology.

Risks associated with applying recycled water for land irrigation in urban and rural settings include:
- Elevated nutrient levels
- Elevated salinity levels
- Excessive sodicity.

Increased salinity from recycled water irrigation has the potential to impede plant growth and degrade soil conditions. The soil structure can also be degraded through soil sodicity due to the high presence of sodium ions relative to magnesium and calcium ions.

Increased nutrient levels will also be present in reused water. If the urban environment has an adjusted botanical landscape from pre-development conditions, it may benefit from the increased nutrient loading. To protect groundwater quality, proper management is needed to ensure minimal nutrients excretion to the groundwater.

Land Capability Assessment (LCA) for irrigation using recycled water

A land capability assessment (LCA) undertaken at the planning phase will be required to assess the suitability of land for irrigation by recycled water.

An LCA is a survey that assesses the capability of a site to sustainably manage the health and environmental impacts of external stressors such as recycled water use. It looks at:
- Soil conditions
- Site topography
- Geology.

For examples of land capability assessment approaches, look at:
- EPA Information Bulletin – Land Capability Assessment for Onsite Domestic Wastewater Management (March 2003) by EPA Victoria
- *Environmental Guidelines – Use of Effluent Irrigation* (2003), by NSW Department of Environment and Conservation (NSW).

An LCA for on-site management of domestic wastewater will help to:

- Identify land areas that are most and least capable for on-site wastewater programs
- Develop a management regime to suit the site, minimising impact of on-site wastewater management and ensuring long-term sustainability.

A four-stage process for assessing land capability for on-site wastewater management includes:

- Stage 1. Develop appropriate LCA criteria
- Stage 2. Gather and collate land inventory information
- Stage 3. Assess land capability
- Stage 4. Develop a management program.

EPA Victoria's approach is summarised in this module. For more detailed information, refer to EPA Victoria's published information on how to carry out an LCA[22].

Soil sodicity

Elevated salinity levels can lead to an increase sodicity level. This can lead to a degradation of the soil properties resulting in soil dispersion.

Sodicity is the complex interaction between soil physical and chemical properties. Sodicity is caused by a relative excess of sodium ions (Na+) in the soil compared to the divalent cations calcium (Ca^{2+}) and magnesium (Mg^{2+}).

When there is an excess of sodium cations, the majority of clay exchange sites in the soil are occupied by sodium ions. If other soluble salts are then leached, the positively charged clay particles repel each other. In particular, this happens during soil wetting, including irrigation.

The soil particles are then dispersed, causing the soil to swell and stopping the movement of air and water through the soil structure. Plants are damaged by sodic soils because swollen soils prevent root growth, leading to potential waterlogging and anoxia.

The application of irrigation water can produce sodic soils. Using water with a high proportion of sodium to calcium and magnesium can also produce sodicity. Clay soils, with a higher concentration of ionic charged surfaces, have a higher risk of developing sodic properties.

Sodic surface soils can be identified by the turbidity and clouliness they create in water.

For large irrigation areas, soil and moisture testing is recommended to secure the best environmental and financial management of this asset.

Production of biosolids

Wastewater contains solids, known as biosolids or sludge. These solids are wastes and require disposal. Disposal can happen through the conventional sewer system or by dedicated sludge processing facilities. The site boundary and surrounding infrastructure determine the options for sludge disposal.

Water reuse aims to extract water from the sewer. Sewer mining applications will dispose sludge and other waste directly into the sewer for centralised treatment. To make sure there is enough flow and avoid odour issues, minimum flows in the sewer must be maintained.

Localised water treatment systems, away from centralised facilities, must be self-contained. Therefore, sludge handling and processing will be required so there are no adverse environmental effects.

Odour control

Untreated wastewater must not be stored. Untreated wastewater not only releases odours, it is also a potential risk to public health.

Odour can be generated by the biological decomposition of wastewater. If untreated and stored, wastewater can turn septic. Treatment for reuse and safe disposal of wastewater is essential.

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[22] EPA Information Bulletin – *Land Capability Assessment for On-Site Domestic Wastewater Management* (Published March 2003) provides further information.

Part 2

Module 2.4
Being Carbon Sensitive

This module looks at the greenhouse gas emissions of different water sensitive urban design (WSUD) projects. It's based on the City of Melbourne's 'carbon sensitive' greenhouse gas framework for sustainable water schemes. It follows industry best practice and relevant government programs and regulation.

The 'carbon sensitive' framework measures, reduces and offsets the greenhouse gas emissions from the following aspects of a WSUD project:

- Energy use
- Biodegradation processes
- Embodied energy emissions.

When it's not possible to reduce all of the emissions associated with a WSUD project, offset the additional emissions from the main sources.

This module helps Councils to:

- Compare the greenhouse impacts from alternative water schemes
- Identify material sources of emissions and options for the purchase of greenhouse gas offsets.

The City of Melbourne is committed to:

- Neutralising its contribution to global warming through the Zero Net Emissions by 2020 Update 2008 Strategy
- Minimising, and where necessary offsetting, greenhouse gas emissions from WSUD treatments

Carbon Sensitive vs Carbon Neutral

The last few years have seen an increase in marketing that refers to climate change. Companies use phrases such as 'carbon neutral' to show their positive greenhouse gas actions. We must be clear with this type of language to make sure there is no misleading information about which, and if, emissions are neutralised.

In the WSUD Guidelines, the term 'carbon sensitive' means that the greenhouse gas emissions from energy use, biodegradation processes and embodied energy emissions of equipment have been measured, reduced and offset over the operation of a water saving scheme.

Although not all emissions associated with the water saving scheme have been eliminated, the additional emissions from the main sources have been reduced and offset.

Currently, there are no Australian or international standards for a carbon neutral statement. It's recommend that the Greenhouse Friendly™ program be used to assess carbon neutrality. This program provides a robust accreditation process:

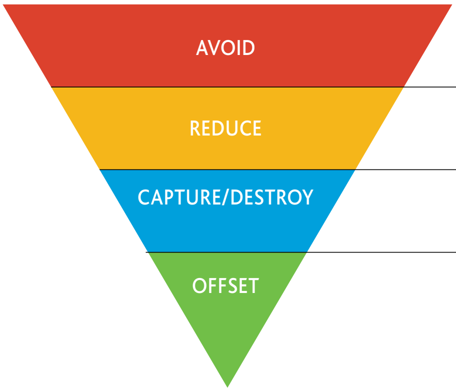
- Built on international assessment standards which are encoded in the ISO 14 040 series of standards
- Requiring the maintenance of accreditation to ensure the carbon neutrality during the operation of the product or service
- Forming the basis of early action abatement assessments under carbon trading in the future, which means it's likely to be the Australian benchmark in the future.

Applying for Greenhouse Friendly™ accreditation may not always be practical due of time and cost constraints. However the principals of carbon management from the Greenhouse Friendly™ process should be used.

Greenhouse gas management hierarchy

In order to be carbon sensitive, a greenhouse management system will need to be implemented reflecting the hierarchy of actions outlined below in Figure 15.

Figure 15. The greenhouse gas management hierachy



Avoid the activity (e.g. demand management measures, selection of drought tolerant plant species) or seek low emissions inputs such as recycled material or renewable energy

Reduce the emissions intensity of the activity through efficiency programs (e.g. efficient equipment) or fuel switching (e.g. electricity to natural gas)

Capture and store (e.g. tree planting) or destroy emissions (e.g. harvesting biogas)

Procure and retire carbon credits

First, strive to avoid or reduce emissions. This is a feature of the most effective greenhouse gas management systems. Reducing or avoiding emissions can often happen at low or zero net cost per tonnes of emissions abatement. Next, switch to greener fuel sources. Finally, consider the use of offsets.

Purchasing offsets alone is not a recommended option for greenhouse gas management systems, either economically and environmentally. Relying on purchased offsets (the last step in the hierarchy) does not prevent the greenhouse impacts in the first place, and increases exposure to financial risk, both through price volatility in offset markets and increases in energy costs.

Scale of greenhouse issue relevant to WSUD Treatment

As a general message, the greenhouse emissions from most WSUD treatments are minimal.
For example:

- to run the Royal Park Wetlands stormwater harvesting and reuse system for a year generating 134 ML for reuse is equivalent to same amount of greenhouse gases emitted by six average Victorian households;
- to harvest rainwater at Queen Victoria Markets and reuse in the public toilets for a year generating 5.2 ML for reuse is equivalent to the same amount of greenhouse gases emitted by one quarter of an average Victorian household.

The greenhouse emissions from desalination and other advanced technology such as reverse osmosis are much higher. For example:

- a membrane sewer mine used for a 9 storey office building emits the equivalent greenhouse emissions as 21 average Victorian households over the course of a year.

Hierarchy of WSUD treatment based solely on greenhouse impact

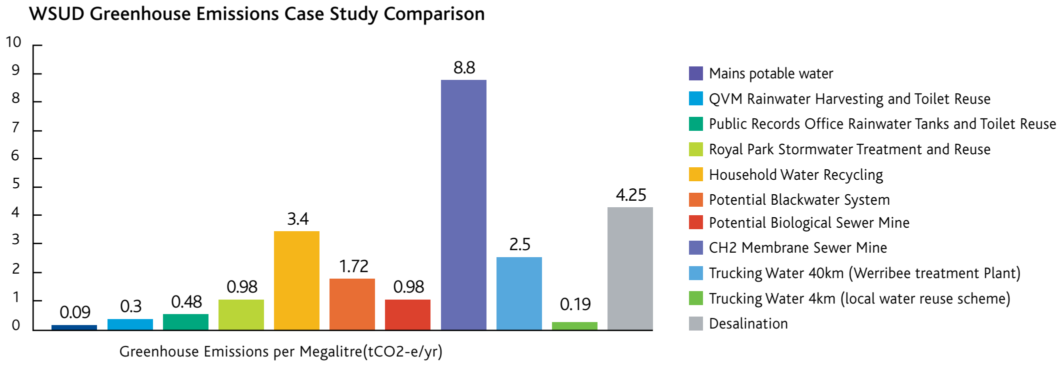
In summary, the greenhouse efficiency of different WSUD treatments (based on limited case study analysis and not including the treatment of wastewater) is set out in the following order:

1. **Potable mains water** – greenhouse efficiencies exist as one of the benefits of potable water being provided by a large, established, gravity fed centralised water supply system.
2. **Rainwater harvesting** – the limited need for treatment helps to reduce the greenhouse requirements for rainwater harvesting, and good design can also reduce the need for pumping to transport water on site.
3. **Stormwater harvesting** – energy needs for stormwater harvesting are primarily needed for distributing water, with less needed for treatment as this can happen through soil filtration. Efficiencies can be delivered through the large scale of stormwater harvesting systems.
4. **Biological sewer mining** – recent advances in sewer mining to draw on biological treatment has made this option more greenhouse efficient particularly as it can deliver large quantities of treated water.
5. **Blackwater recycling** – recent advances enable system operators to have more control over the quality of the blackwater that is being treated. This means that the level of filtration can be moderated to produce fit-for-purpose reuse water, saving on pumping and energy requirements.
6. **Trucking water** – is greenhouse intensive when delivered over large distances such as from the Werribee Treatment Farm. It is much more efficient if delivered from a local water reuse scheme, however would need to include emissions from the treatment itself to be a fair comparison.
7. **Household water recycling** – this is a greenhouse intensive way of delivering potable water savings because of the small amount of water that is delivered by the system.
8. **Desalination** – this is greenhouse intensive due to the technology used which includes either membrane processes such as reverse osmosis, or thermal distillation.
9. **Membrane sewer mining** – this is very greenhouse intensive due to the pumping required in removing pollutants through membrane filters.

It is important to remember that greenhouse emissions are only one factor in considering WSUD treatment options.

The following analysis of the greenhouse emissions of different WSUD treatments is based on limited data available, and it is hoped that future analysis will provide a more rigorous comparison of the greenhouse emissions of such treatments.

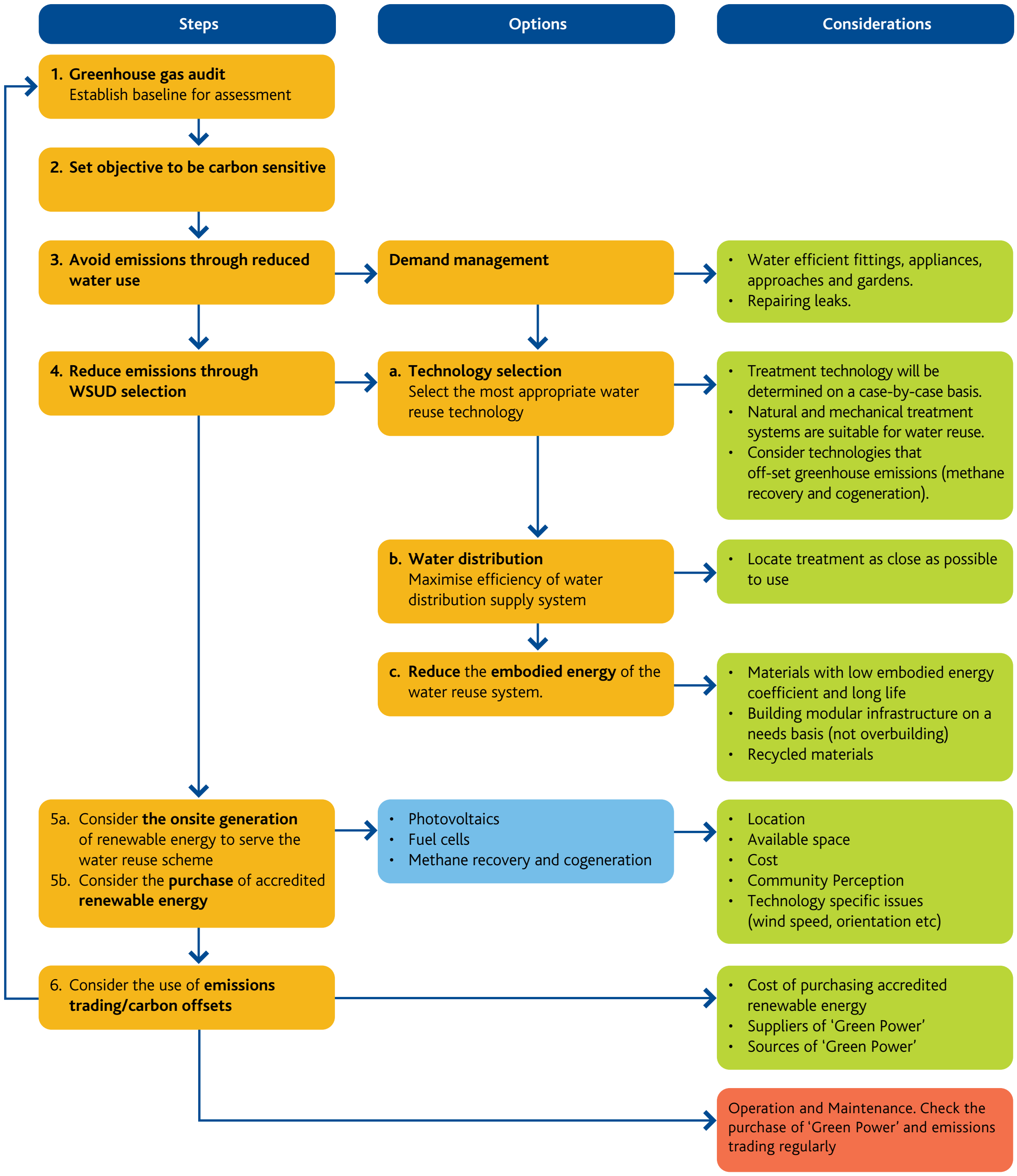
Figure 16. Case study comparison of greenhouse emissions from different WSUD treatments



Carbon sensitive WSUD project framework

Figure 17 shows a best practice greenhouse gas management system for a WSUD project. Using these steps, you can measure and reduce the greenhouse impacts of a WSUD project before planning the offset options that can take place on an annual basis as the project progresses.

Figure 17. Steps to a carbon sensitive WSUD project



1. **Greenhouse gas audit**
   Establish baseline for assessment

2. **Set objective to be carbon sensitive**

3. **Avoid emissions through reduced water use**

Demand management

- Water efficient fittings, appliances, approaches and gardens.
- Repairing leaks.

4. **Reduce emissions through WSUD selection**

a. **Technology selection**
   Select the most appropriate water reuse technology

- Treatment technology will be determined on a case-by-case basis.
- Natural and mechanical treatment systems are suitable for water reuse.
- Consider technologies that off-set greenhouse emissions (methane recovery and cogeneration).

b. **Water distribution**
   Maximise efficiency of water distribution supply system

- Locate treatment as close as possible to use

c. **Reduce** the **embodied energy** of the water reuse system.

- Materials with low embodied energy coefficient and long life
- Building modular infrastructure on a needs basis (not overbuilding)
- Recycled materials

5a. Consider **the onsite generation** of renewable energy to serve the water reuse scheme
5b. Consider the **purchase** of accredited **renewable energy**

- Photovoltaics
- Fuel cells
- Methane recovery and cogeneration

- Location
- Available space
- Cost
- Community Perception
- Technology specific issues (wind speed, orientation etc)

6. Consider the use of **emissions trading/carbon offsets**

- Cost of purchasing accredited renewable energy
- Suppliers of 'Green Power'
- Sources of 'Green Power'

Operation and Maintenance. Check the purchase of 'Green Power' and emissions trading regularly

Step-by-step: A carbon sensitive WSUD framework

Step 1 – Measure emissions

Preparation is needed to compare the level of greenhouse gas emissions from the current system with new, alternative WSUD projects. Full greenhouse gas inventories of the collection, treatment and transport of Melbourne's mains potable water and alternative WSUD options are required.

This applies to projects at a range of scales, from the household rainwater tank to larger water reuse projects. All emissions from electricity use should be included, as well as emissions from wastewater treatment.

Step 2 – Set objectives

Targets should be set for reducing greenhouse emissions based on an assessment of opportunities for reductions. The City of Melbourne's *Zero Net Emissions by 2020 Strategy Update 2008* sets greenhouse reduction targets and key opportunities for consideration as part of this step.

Step 3 – Reduce water use to avoid emissions

The most efficient way to avoid emissions from WSUD projects is to reduce water demand. Reducing water demand means that emissions from supplying water and subsequent wastewater treatment are reduced.

Step 4 – Reduce emissions through WSUD selection

Consider greenhouse emissions from WSUD options by accounting for emissions from:

- Operating the WSUD treatment
- Distributing water from the WSUD treatment
- Embodied energy within the WSUD treatment.

Step 5 – Consider the on-site renewable energy generation and accredited renewable energy

Consider:

- On-site renewable energy generation to power the WSUD projects – options include photovoltaics or cogeneration from biogas
- Purchase of renewable energy accredited to government standards – generally considered to have more greenhouse benefits than other offsets such as from methane flaring or energy efficiency, as it supports investment in energy infrastructure not reliant on fossil fuels.

Step 6 – Assess residual emissions and offset purchasing

For the remaining emissions that cannot be reduced by the above methods, purchase carbon offsets from the market.

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[17] The figures are an average for the entire distribution system for water supply and wastewater disposal including the greenhouse gas abatement strategies that are relevant to the supply of water to City West Water. They exclude greenhouse gas emissions from offices and company vehicles. No greenhouse gas were supplied from City West Water as they had a 'zero net greenhouse emissions', meaning that their emissions were offset or reduced through renewable energy purchases.

Step 1: Develop a greenhouse gas inventory

A full greenhouse gas inventory must be prepared for all emissions associated with the collection, treatment and transport of Melbourne's mains potable water. This includes current or 'business-as-usual' and alternative WSUD projects. Projects should cover a range of scales, from the household rainwater tank to larger water reuse projects.

By preparing both inventories, it's possible to quantify the additional greenhouse gas emissions generated from the new WSUD projects. This can then be compared to the 'business-as-usual' baseline. Use the same methodology for both project types.

Calculating greenhouse gas emissions

The greenhouse gas emissions from a water supply and treatment system or project are the sum of emissions from:

1. Electricity consumption from the water consumed and wastewater generated
2. Biological degradation of wastewater
3. Embodied energy from materials selection.

1.1 Electricity consumption from the water consumed and wastewater generated

Emissions are generated from the electricity consumed by all the processes associated with the transportation and treatment of potable water and wastewater. These are classed as 'indirect scope 2' emissions as they were emitted by the utility companies that produced the electricity. More information is available in the definition of emission sources (weblink to definition of emission sources).

To calculate greenhouse gas emissions, emission factors are applied to the energy consumed. The factors depend on:

- Where the electricity was generated (the state or territory)
- Fuel source used (for Victoria, this predominately from non-renewable, brown coal-fired power stations).

Water is typically used once and wastewater is generated. The wastewater is then transported long distances and more energy is used for treatment prior to discharge. These are 'indirect scope 3' emissions as they are emitted by the water utility company that has produced the water.

The water utilities produce figures for the greenhouse gas emissions for supplying potable water and treating wastewater. These are listed below in Table 1. A water balance is prepared for a WSUD project before the greenhouse gas inventory. This quantifies:

- Total water use
- Wastewater generation of the site.

Using baseline water consumption, greenhouse gas emissions can be calculated for a 'business-as-usual' case (i.e. without the water saving scheme). This is achieved by applying emission factors to the total consumption.

Table 8 shows greenhouse gas emissions for water and wastewater per mega litre supplied to Melbourne. Melbourne Water provided these figures for the 2006/2007 year[17], based on emission factors that are calculated annually. These figures will be updated annually on the Melbourne Water website using information provided by the water utilities companies.

Table 8. Greenhouse gas emissions for water and wastewater in Melbourne

Water	Equivalent CO_2 generated (CO_2t/ML)
Potable Water	0.09
Wastewater	0.74

1.2 Biological degradation of wastewater

Greenhouse gas emissions are produced by the biological treatment of wastewater. The organic loading that needs treatment mainly comes from faecal matter. Kitchen and laundry waste produces other organic matter. In Melbourne, greenhouse gas emissions are minimised by the capture and reuse of biogas to power the wastewater treatment process.

Further instructions for calculating biological degradation emissions are available in the WSUD Carbon Sensitive Framework Guidelines.

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[18] See Chapter 4: Setting Operational Boundaries (www.ghgprotocol.org/DocRoot/7e9ttsv1gVKekh7BFhqo/ghg-protocol-revised.pdf)

1.3 Embodied energy emissions from materials selection

It's also necessary to consider how much energy is used in the production of the water treatment system. This embodied energy is determined by a life cycle analysis. Table 4 in Step 4.3 shows the embodied energy of some common materials.

In general, the embodied energy of a product can be reduced by:

- Selecting appropriate materials with a low embodied energy coefficient and longer life expectancy
- Building modular infrastructure on a needs basis (not overbuilding)
- Using locally sourced materials where possible to minimise transport related carbon emissions
- Considering the use of recycled material (the embodied energy in recycled materials is generally less than new materials).

This is set out in greater detail in Step 4 of this WSUD Carbon Sensitive Framework Module.

Carbon calculator

The City of Melbourne has developed a carbon calculator to help measure baseline carbon emissions from WSUD projects, using the three emissions sources described previously. Using generic project templates, you can enter details about the size of the system and the material contents. Greenhouse gas emissions are then calculated based on the methodology above.

Definition of emission sources

A greenhouse gas inventory should identify:

- Direct emission sources from operations
- Indirect emission sources from the consumption of purchased energy, such as electricity.

The *Greenhouse Gas Protocol* (Revised Version, 2004)[18] is an internationally-recognised protocol that defines emissions as:

- Scope 1
- Scope 2
- Scope 3.

Scope 1 emissions are direct greenhouse gas emissions from sources that are owned or controlled by a company. For example:

- Emissions from combustion in boilers and vehicles (water tankers)
- Emissions from biodegradation of wastewater.

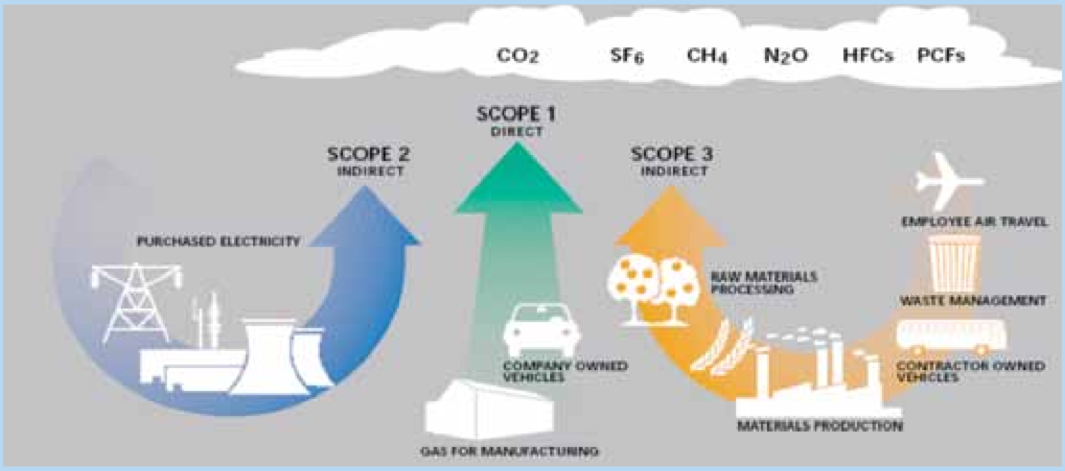
Emissions from combustion of biomass or those that are not covered by the Kyoto Protocol (CFCs etc.) are not included in scope 1.

Scope 2 emissions are indirect greenhouse gas emissions from the generation of electricity, steam and heating/cooling purchased or otherwise brought into the organisational boundary of the company, and consumed by the company. Scope 2 emissions physically occur at the facility where electricity or steam is generated.

Scope 3 emissions are all other indirect greenhouse gas emissions that are from sources not owned or controlled by the company, but occur because of the activities of the company. For example:

- Extraction and production of purchased materials
- Transportation of purchased fuels
- Use of sold products and services.

Figure 17. Emissions scope definition (Source: New Zealand Business Council for Sustainable Development)



Step 2: Set objectives

Targets can be established once the greenhouse gas inventories have been completed for the 'business-as-usual' option and the alternative WSUD projects. Targets set realistic goals and help assess opportunities for reducing emissions.

The City of Melbourne's *Zero Net Emissions by 2020* Strategy Update 2008 sets greenhouse reduction targets and key opportunities for consideration as part of this step.

The boundary definition for the Council water infrastructure is critical when establishing the objectives. Both direct (scope 1) and indirect (scope 2 and 3) emissions must be included within the boundary in a carbon sensitive scheme.

Figure 18. Boundaries for emissions for business-as-usual and for the WSUD project using City of Melbourne as an example

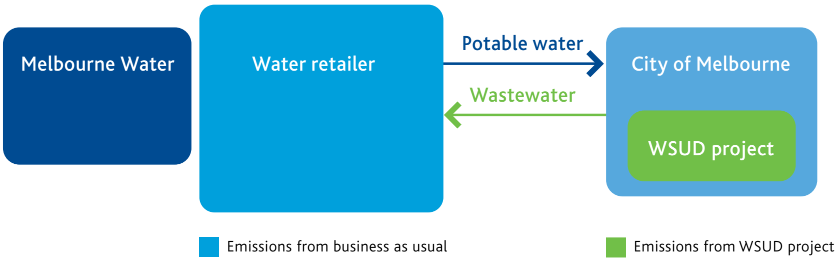


Figure 18 shows the boundaries for emissions from a business-as-usual case and from a WSUD project.

Business-as-usual

Council is supplied potable water from its water retailer, and sends wastewater back to the retailer for treatment by Melbourne Water. Therefore, under business-as-usual, the boundary for emissions includes:

- The water retailer(s)
- The portion of Melbourne Water services to these water retailer/s.

WSUD project

The WSUD project will be located within the Council area. Therefore, the boundary for its emissions is its physical boundary which includes:

- A single site (i.e. rainwater tank), or
- A series of activities (i.e. rainwater tank plus distribution system).

Assumptions are listed below.

Water sources for the WSUD project will either be from:

- Mains water supply, wastewater (greywater reuse, blackwater, water mining)
- Rainwater harvesting
- Stormwater harvesting.

Water leaving the water saving scheme will either be wastewater back to the mains or to the natural environment through seepage, evapotranspiration or stormwater.

There are no associated emissions with natural processes such as evapotranspiration. Therefore the emissions of water entering or leaving the water saving scheme will be from (where applicable) the emissions associated with the water retailer(s) and Melbourne Water Corporation.

Step 3: Avoid emissions – reduce water use

The most effective way of reducing greenhouse emissions is to reduce water use in the first place. Greenhouse gas emissions associated with water treatment can be minimised by:

- Reducing water consumption and wastewater generation
- Reducing organic material in wastewater (e.g. by educating commerce and industry about waste minimisation and cleaner production)
- Diverting organic waste from uncontrolled anaerobic conditions, such as leaf litter from rainwater tanks.

3.1 Reduce water consumption

Reducing demand also reduces the energy needed to move water across large distances. This includes transport to and from:

- Locations where water is stored for use
- Wastewater treatment plants where water is treated and disposed.

Importantly, less energy is also required to heat (for hot water), treat and transport water to and from the site.

Demand management measures include:

- AAAAA rated water efficient fittings (5A taps, 6/3L dual flush toilets, waterless urinals)
- AAAAA rated water efficient appliances (5A washing machines)
- Water efficient gardens (xeriscaping, hydrozoning, smart irrigation techniques)
- Flow reduction valves.

Demand management measures also encompass surface changes. As well as landscape and turf species changes water reduction can be achieved through synthetic surfaces although consideration needs to be given to other environmental factors such as embodied greenhouse emissions (see Step 4 of this *WSUD Carbon Sensitive Module*).

3.2 Reduce organic material in wastewater

Avoid disposing organic material, for example food scraps or vegetable peelings, into the wastewater system. Greenhouse gases are produced by the biological decomposition of organic matter. This is mostly human waste, but kitchen waste such as food scraps, oils and vegetable peelings also contribute to the overall loading which requires subsequent treatment.

In industrial applications, review operations and auditing processes to reduce organic loadings. Due to a wide range of activities and operations, individual strategies are appropriate in this context.

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[19] These comments are based on a small sample base with best available data to date.

[20] Inventory of Carbon and Energy Version 1.5 Beta, Prof. Geoff Hammond and Craig Jones, Department of Mechanical Engineering, University of Bath, UK

Step 4: Maximise the efficiency of the system

4.1 Treatment selection

Treatment is needed to upgrade water quality for the appropriate end use. Typically, water used within the city will be treated to a high standard due to the type of water reuse. A range of water sources are available for integrated water resource management as shown in Table 9.

Table 9. Water source and level and treatment

Water	Treatment
Rainwater	Minimal treatment required.
	Hotwater system (e.g. gas boosted system) can be integrated to provide thermal disinfection. Alternatively UV disinfection may be installed.
Stormwater	'Best practice' treatment required. Typically this is through the use of natural treatment systems such as bioretention systems or constructed wetlands.
	Mechanical systems, e.g. filtration systems, can also be used for stormwater treatment. Particularly for large scale systems where limited space is available for treatment.
Greywater	Diversion devices can be fitted to subsurface irrigation systems with no treatment required.
	Household greywater reuse treatment systems can be used for reusing water.
	Moderate treatment is required to ensure pathogens are removed from greywater for non-potable water reuse.
Blackwater/ sewer mining	High level of treatment is required to remove pathogens and biological components to ensure water is safe for reuse.
	Mechanical treatment systems are typically used in cities due to the limited space available.

4.2 Distribution and supply system

Maximise the efficiency of the water reuse systems through the distribution and supply system. WSUD identifies smaller, localised, modular treatment technologies, where the end use of the water is close to the treatment system. In contrast, centralised treatment means wastewater has to be transported to a treatment plant and then transported back to the consumer for reuse. This extensive transport is expensive and energy intensive due to the piping and pumping required.

Minimise energy requirements by:

- Locating treatment as close as possible to the end user and relying on gravity where possible – this minimises resource consumption (piping) and energy requirements (less need for pumping)
- Using header tanks for water supply – these can be fed by low flow trickle pumps
- Selecting energy efficient pumps and motors.

Trucking

In response to the current drought and water restrictions, there has been a significant rise in the amount of recycled water that is being transported throughout Melbourne and beyond by trucks. The trucking of water will reduce the use of potable water, but it is an energy intensive way of accessing water.

The greenhouse emissions associated with trucking water are primarily from fuel use. Most trucks currently use diesel fuel with emissions highly dependent on the load, distance travelled and the frequency of trips. The alternatives for fuel use in these trucks include biodiesel, LPG and petrol.

Trucks used for delivering water are generally categorised into two sizes. These are:

- Small (rigid truck) – 7,500 litres
- Large – 25,000 litres.

The emissions generated from one large truck travelling from Werribee Treatment Farm to central city (40km trip) to water a park with a demand of 50 ML/y will be 2.5 tCO_2e/y per megalitre of water. As with all alternative water sources this is much higher than the greenhouse emissions from mains water (at 0.09 tCO_2e/y per megalitre) and higher than local rainwater and stormwater harvesting schemes with reuse. The emissions for trucking water over this distance is often higher than the latest technology for blackwater recycling and sewer mining[19]. This comparison can be seen in Figure 16.

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[21] CSIRO Manufacturing and Infrastructure Technology

[22] City of Yarra (2008) The Environmental Impact of Synthetic Turf Relative to Natural Turf Playing Fields.

Trucking from within the local area (within 4 kms) reduces the emissions down to 0.19 tCO_2e/y per megalitre of water. This is significantly more greenhouse efficient in terms of vehicle emissions, but will always be combined with the emissions from the local recycled water source itself. For example if the water was sourced from the Royal Park Wetlands then it is necessary to include the emissions from this stormwater system which are measured at 0.98 tCO_2e/y per megalitre of water. Trucking this local source of alternate water emits about half of the greenhouse emissions than trucking it from the Werribee Treatment Plant.

4.3 Embodied emissions in materials selection

It's also necessary to consider how much energy is used in the production of the water treatment system. This embodied energy is determined by a life cycle analysis. Table 10 below shows the embodied energy of some common materials.

In general, the embodied energy of a product can be reduced by:

- Selecting appropriate materials with a low embodied energy coefficient and longer life expectancy
- Building modular infrastructure on a needs basis (not overbuilding)
- Using locally sourced materials where possible to minimise transport related carbon emissions
- Considering the use of recycled material (the embodied energy in recycled materials is generally less than new materials).

Table 10. Process energy requirement embodied energy of common materials[20]

Material	PER Embodied Energy (MJ/KG)
Hardboard	24.11
Cement	6.8
PVC	77.2
Glass	18.5
Aluminium	118.8
Copper	67.22
Galvanised steel	35.8

The type of material used in a pipe is an important factor for water reuse systems. Basic factors[21] that influence the embodied energy impact of a piping system include:

- Size – the bigger the pipe, the more embodied energy
- Amount of materials – the more materials used, the higher embodied energy
- Recycled material – pipes produced with significant recycled materials usually have a lower overall embodied energy
- Embodied energy coefficient – materials with a lower coefficient have a lower embodied energy
- Durability – piping systems with a longer life expectancy mean less repair and replacement, leading to lower embodied energy over the life cycle of the system.

Relative scale of embodied emissions

Generally the embodied energy emissions arising from WSUD treatments are small when compared to the emissions generated from operating the system.

Table 11 shows examples of the impact of embodied energy on the total carbon footprint for WSUD treatments.

[23] SEAV, 2004.
[24] AWEA, 2004
[25] Developed by the Wind Energy Research Unit of CSIRO Land and Water
[26] CH2M Hill (1997)
[27] www.ourgreenoffice.com

Table 11. Process energy requirement embodied energy of common materials

WSUD Treatment	Annual emissions from technology (tCO2-e/yr)	Annual emissions from distribution and supply system (tCO2-e/yr)	Emissions from embodied energy (tCO2-e/yr)	Total megalitres treated annually (ML)	Embodied energy contribution to total emissions	Annual emissions from embodied energy per ML treated (tCO2-e/ML)
Royal Park Wetlands Large Stormwater Harvesting and Reuse Scheme	0.0	71.3	0.044*	73	0.06%	0.0006
CH2 Sewer Mining Proposal for Office Building	225	26	1.59**	28.6	0.63%	0.056
QVM Large Underground Rainwater Harvesting and Reuse Scheme	0.0	2.25	0.82*	10.2	36%	0.08
Public Record Office Above Ground Office Rainwater Tanks	0.0	1.3	0.012*	2.7	0.9%	000.4

* using a conservative estimated design life of 10 years **using a 50 year design life

The greater embodied energy contribution will be seen from those WSUD treatments that require significant materials, reticulation and associated equipment. However, studies to date show that the range of WSUD treatments are all less than 0.1% of total emissions per ML treated over the life of the scheme.

Each WSUD treatment will be different and project designers should use the Carbon Calculator to calculate their own emissions.

Embodied energy of synthetic turf

The use of synthetic turf as a water saving measure also needs to consider embodied energy based on its production, installation and transport. Consideration also needs to be given to the disposal and/or recycling of these materials once they have reached the end of their useful life.

A study[22] has been undertaken in Canada to estimate these emissions. Calculated emissions would be higher when translated to Victoria due to the use of brown coal as the primary energy source (which comparatively emits more greenhouse emissions).

Benefits associated with synthetic turf include water conservation through reduced irrigation, and the ability to use the surface as a catchment to harvest stormwater for reuse. Synthetic turf does absorb sunlight and emit heat, and performs best when established with some trees and shading to diminish the possible heat island effect in a time of climate change.

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[28] Radcliffe, 2004

Step 5: Consider renewable energy

On-site generation of renewable energy

Generating renewable energy onsite helps to avoid greenhouse gases. After finishing a greenhouse gas inventory and improving system efficiency, greenhouse gases may still be produced. On-site generation of renewable energy can negate or offset these emissions.

Renewable energy uses natural resources that can be replaced or 'renewed'. These resources don't contribute to the greenhouse effect or global warming. Renewable energies include but are not limited to:

- Photovoltaics
- Wind
- Fuel cells
- Methane recovery and cogeneration.

Renewable energy prevents greenhouse gases in the first place and is therefore a better environmental solution than relying on purchasing offsets after emissions have been produced.

Ideally all energy use should come from renewable sources, however with current disproportional cost of renewable energy it is considered that requiring 20% of energy needs to come from renewable sources will help to mitigate emissions, grow the renewable energy market and help contribute to the Federal mandatory renewable energy target of sourcing 20% of energy needs from renewable sources by 2020.

Photovoltaics

Photovoltaic (PV) cells convert light energy from the sun directly into direct current (d.c.) electricity. An inverter converts this into alternating current (a.c.) electricity for use[23].

Currently, photovoltaics are expensive. The exception is specialist applications where connecting to the electricity grid would be comparatively expensive, for example in a large park. However photovoltaics will become a more attractive economic alternative as efficiencies increase and costs decrease.

Solar powered water pumps are commercially available and are an option for small to medium pumping applications that are not demand dependant.

Wind

A wind turbine generator consists of a:

- Foundation
- Tower
- Nacelle
- Rotor (blades on a central hub).

The rotor turns a generator, converting some of the wind's energy to electricity. As wind speed increases more energy is delivered to the rotor.

Within metropolitan Melbourne, there are a number of factors to consider when using wind power to fuel water recycling. These include:

- Location – wind farms are generally located where there is a good wind resource, local community support and plenty of open land available[24]
- Wind speed – an average annual wind speed of 5m/s for Melbourne has been modelled using the WindScape wind resource mapping tool[25], which is below the optimal wind speed for generating electricity (according to the Australian Wind Energy Association)
- Noise – wind generators in urban areas have turbines mounted on a tower and make some noise in operation (according to the Australian Greenhouse Office (AGO)).

Fuel cells

Fuel cells convert energy from chemical reactions directly into electrical energy. They are cleaner and more efficient than any carbon fuelled engine, however as yet they are not greenhouse neutral.

Fuel cells can be cost competitive with engine driven and turbine power plants. This was found by comparing molten carbonate fuel cells with three conventional approaches for recovered methane use (heat recovery, energy generator and natural gas production)[26].

Today fuel cells typically need hydrogen as a fuel source. Creating hydrogen usually needs energy, which can have greenhouse implications. However, there are some trials with fuel cells running on natural gas provided by the existing mains network. This system will create up to 90% of the building's hot water needs with close to zero greenhouse gas emissions[27].

Methane recovery & cogeneration

When biological systems are used, greenhouse gases can be generated from the water treatment process[28]. Biogas (predominately methane) can be collected in these situations and used to operate co-generation plants which provide energy to the treatment plant. Excess energy can be supplied to the electricity grid.

Methane is collected and used as an energy source at a number of wastewater treatment plants including those run by Melbourne Water. When methane is captured and reused as a fuel source, it:

- Prevents methane from being discharged into the atmosphere
- Reduces reliance on traditional energy sources including electricity and gas.

Biogas recovery systems improve efficiency of current practices. However there will still be a residual greenhouse impact associated with burning the methane to generate power. Carbon dioxide is released by the combustion of biogas (predominately methane) and this will need to be offset.

The WSUD Carbon Sensitive Framework Guidelines provide further explanation about these issues.

Consider the purchase of accredited renewable energy

If there are greenhouse gas emissions from the water saving process after you've taken the steps above, you must consider the purchase of Green Power™ from an accredited electricity supplier.

Council considers that purchasing renewable energy is a better environmental outcome than relying on carbon offsets to mitigate emissions once they have occurred. Unlike offsets, renewable energy prevents emissions from occurring in the first instance. It would be ideal to purchase all energy needs from renewable sources, however in acknowledgement of the current higher costs of renewable energy it is considered that a proportion of energy purchased from renewable sources is an adequate contribution.

In light of this, Council requires 20% of the electricity to be Green Power™. The 20% contribution is equal to the current mandatory renewable energy target set by the Federal Government.

Ask the energy retailer for proof that their product is currently an accredited Green Power™ product, or check that their product displays the Green Power Accreditation.

GreenPower™ (accredited renewable energy)

Electricity customers can purchase a specific amount of Green Power™ from electricity suppliers. The retailer then has to source an equivalent amount of energy from wholesale renewable energy generators such as wind, solar and hydro-power, instead of sourcing it from coal fired generators.

The National Green Power Program "aims to drive investment in renewable energy in Australia with a view to increase the sustainability of Australia's electricity supply. This will be achieved by raising awareness of, and ensuring consumer confidence in, accredited renewable energy products and increasing their uptake".

The Accreditation Program sets out technical criteria, marketing criteria and eligibility requirements for energy products to be included in the scheme. The retailer of the energy products must provide quarterly and annual information to ensure the criteria and requirements are being met.

The Green Power Scheme, including its accreditation process, is overseen by a national steering committee. This group has representatives from the lead State Government agency working in renewable energy issues in each state. Currently, this is the only scheme in Australia that has a:

- Clear framework to ensure consumer confidence
- Robust and transparent accounting process
- Mechanism which links consumer demand to stimulating growth of renewable energy infrastructure in Australia.

Visit www.greenpower.com.au for more information.

Step 6: Assess residual emissions and purchase offsets

Purchasing carbon offsets should be the last step to minimise greenhouse gas impacts. It's only appropriate after all other avenues, such as avoidance or reduction of emissions, have been used.

Carbon offsets are 'credits' for greenhouse gas abatements achieved by other organisations. For example, energy efficiency or renewable energy projects can generate carbon credits. Currently there are many providers of carbon credits that have been certified under numerous voluntary and government programs.

In general, each carbon credit is equal to the abatement of 1 tonne of carbon dioxide equivalent gases (tCO_2equivalent). However, there are many ways that carbon credits can be generated and/or accredited. It's up to the project manager to choose which carbon credit is most suitable.

Evaluation of greenhouse gas abatement

Use the following evaluation criteria to select options:

- Cost – measured in terms of $/tonne greenhouse gas abated
- Certainty of delivery – contractual certainty
- Adaptability to future policy and market environments – will the offsets be eligible under a future emissions trading scheme
- Management – complexity of implementation
- Transparency and verifiability of abatement
- Communications – how can abatement be articulated to stakeholders
- Environmental benefit – in terms of emissions reduced.

Part 2

Module 2.5

Considering Life Cycle Costs

Economic analysis of a water sensitive urban design (WSUD) project needs to consider the total costs to the community. A life cycle costing approach considers the total cost over the life of the project. This module defines what life cycle costing is and how it can be applied.

What is life cycle costing?

Life cycle costing (LCC) is a process used to determine the sum of all expenses associated with a product or project. It's a structured approach that looks at all of the elements of a project's cost.

The key components to a life cycle costing evaluation are:
- Capital expenditure
- Installation
- Operation
- Ongoing maintenance and labour costs
- Replacement costs and timing for significant expenditure
- Life span
- Decommissioning costs.

When should life cycle costing be used?

LCC allows you to compare total costs over the lifetime of a WSUD project with other options. It provides an important economic indicator for the selection of WSUD opportunities.

LCC can be used to produce a spend profile over the anticipated life span of a project. When there are several options to choose from, the results of an LCC analysis can help managers to make decisions.

The accuracy of LCC analysis diminishes as it projects further into the future, so it's most valuable as a comparative tool when long term assumptions apply to all the options and therefore have the same impact.

How is it calculated?

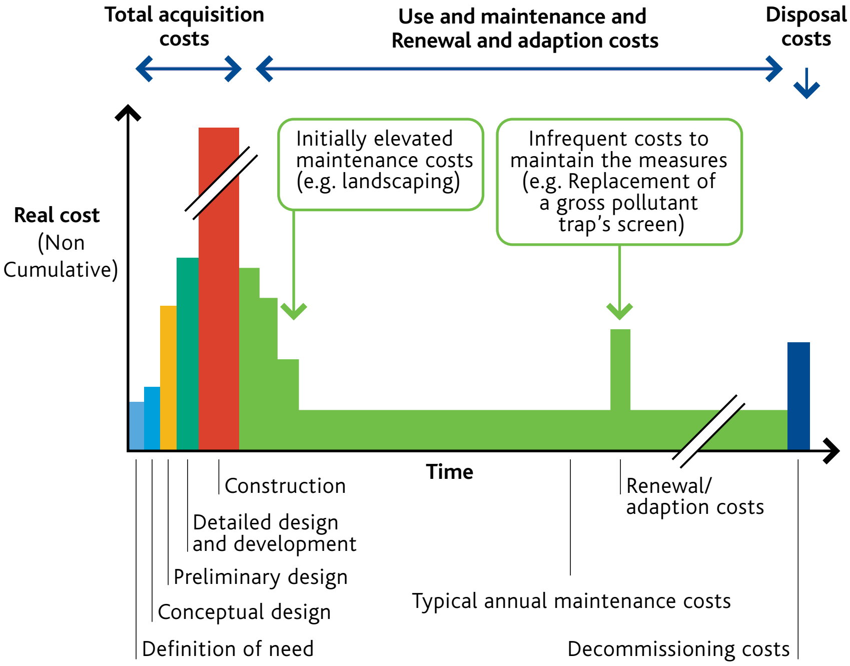
LCC is the sum of all 'discounted costs' over the life cycle of the project. It's expressed in dollars relevant to the 'base date', which is typically the current date. A typical life cycle cost is over a 50-year period.

All costs are discounted to the base date using an appropriate discount rate. A 'real discount rate' is used for discounting future costs that are expressed in real terms relative to a base date.

An LCC for a WSUD project should include all the indicative costs. This provides the base information for analysis. As water reuse technologies and their commercialisation are developing quickly, costs are expected to decrease.

Figure 19 shows the cost elements which are incorporated into life cycle costing.

Figure 19. Life cycle costing elements



Source: Gold Coast City Council; Land Development Guidelines, Section 13.2[29]

MUSIC modelling

MUSIC (Model for Urban Stormwater Improvement Conceptualisation) is a tool for simulating urban stormwater treatment trains to estimate their performance. MUSIC can also assist in estimating WSUD lifestyle costing by providing cost data for different stormwater treatment measures, based on lifecycle assumptions. The MUSIC User Guide provides further guidance on the lifestyle data costing. A lifecycle cost assessment customised to the particular system in question should be undertaken for a more reliable result.

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[29] Land Development Guidelines, Gold Coast City Council, Section 13.2 WSUD Conceptual Design: http://www.goldcoast.qld.gov.au/attachment/planningscheme/wsud_13_2_conceptdesign.pdf

Part 2

Module 2.6

Assessing the Risks

This module outlines a risk management framework to enable safe and sustainable water recycling schemes in metropolitan Melbourne. The information in this module is extracted from the *WSUD Risk Management Guidelines* which provide further detail and useful tools to support decision making.

This module provides a summary of risk management for WSUD projects.

Project managers should also use the detailed *WSUD Risk Management Guidelines* when implementing WSUD projects.

Protecting public health and the environment is paramount when alternative water sources are being used. Careful planning, construction and monitoring are required to make sure recycled water is safe.

The framework is designed to support straightforward risk management for simple projects, and a comprehensive approach for more complex projects and those that carry higher risks.

It can be used by Councils and by community, including developers and commercial and industrial businesses.

Tools for risk management at a household level are also included, so it's relevant to those with an interest in small scale domestic schemes.

Managing risks associated with water sensitive urban design

Water sensitive urban design schemes present public health, environmental and institutional risks. Identified risk exposures are detailed below. A more detailed outline of risks is provided in the *WSUD Risk Management Guidelines*.

People

Risks to human health can be caused by poor planning, design and maintenance of water schemes.

Environmental

Unauthorised discharge to the environment causing ecological risks to flora, fauna and soils can be triggered by poor planning, design and maintenance.

Financial and economic

Projects can become financially unfeasible due to poor design. This can lead to the abandonment of infrastructure and a particular initiative. In addition, management of peak flows (i.e. flood prevention) is necessary for safe conveyance of flows and protection of property.

Liability

The City is now playing a role in water treatment and supply and has compliance and due diligence requirements. Treatment failure and poor risk management processes can result in non-compliance and risk for public liability and contractual liability.

Reputation

The City is recognised as a leader in integrated water management. Any of the above risk exposures can impact on community trust.

Managing these risks is not purely achieved by regulation and managing assets and hazards. Ensuring communication and consultation between all stakeholders throughout the planning, design, implementation and management phases of a water recycling scheme is also critical.

Current risk management legislation and guidelines

A risk management approach specific to water schemes does not yet exist at the City of Melbourne. Risk Management Guidelines have been developed to support the City as it works towards a well defined approach.

The project examples discussed below provide significant lessons for the City, particularly, as the risk assessment and management processes adopted or lacking for each project is reviewed. A key part of this process will be to integrate a more participatory community consultation component into council requirements.

An overview of the City of Melbourne's current risk management approach for each water source follows.

Wastewater recycling

For wastewater recycling projects, the City of Melbourne applies the risk management framework set out in these WSUD Guidelines.

Wastewater has a high inbuilt risk which needs careful risk management. This is known as an 'inherent' risk. Water recycling is closely regulated under the Environment Protection Act and is subject to works approvals, licensing provisions and septic tank provisions. Victorian requirements for works approvals and licensing are outlined in the frameworks for using reclaimed water and recycled water. There is limited regulation of small water recycling systems.

Victorian Government requirements for project governance and environmental and health risk management within water recycling schemes are provided in:

- EPA Publication 464.2: *Guidelines for Environmental Management: Use of Reclaimed Water*
- EPA Publication 1015: *Guidelines for Environmental Management: Dual Pipe Water Recycling Schemes: Health and Environmental Risk Management*.

For the first time, the City has taken on responsibility for a water recycling project, through the water mining scheme at the City's offices at CH2. The key risk management approach for this scheme is based on EPA and DHS requirements, with all aspects of risk management managed inhouse. This will give the City first hand experience in documenting risk management processes – from selecting and installing treatment types to management and maintenance measures.

Stormwater recycling

For stormwater harvesting, the City of Melbourne applies the risk management framework set out in these *WSUD Guidelines*.

Stormwater can be harvested and reused at local catchments. Increasingly local governments and developments are reusing harvested stormwater for open space irrigation.

Stormwater has a highly variable water quality due to local catchment variations. Guidelines for stormwater reuse for irrigation have been released by the EPHC – *Australian Guidelines for Water Recycling – Stormwater Harvesting and Reuse*, July 2009. This document provides guidance for:

- Roofwater reuse for larger buildings (greater than residential dwelling)
- Stormwater reuse for small to medium scale open space irrigation.

All other stormwater harvesting and reuse applications should take a risk-based approach.
These non-potable uses include:

- Toilet flushing
- Washing machine use
- Dust suppression
- Waterscape features (e.g. water fountains)
- Commercial food crop irrigation
- Home grown food irrigation
- Fire fighting, street cleaning
- Dual reticulation
- Industrial use.

The Royal Park Wetlands stormwater treatment and reuse scheme presents environmental and public health risk management concerns but as stormwater is unregulated it's not subject to legislative requirements. Council undertook a risk assessment prior to operationalising the scheme, and has conducted considerable monitoring of its performance since then with the assistance of Monash University's Engineering department. The findings of this monitoring will give the City the opportunity to develop a risk management approach specific to current and emerging risks observed in scheme performance, and will assist in the development of an appropriate risk management framework for such schemes into the future.

Bioretention tree pits installed on Little Bourke St have provided additional learnings. In partnership with Melbourne Water, the City delivered a detailed engagement and knowledge building program with traders in the area. This resulted in increased 'ownership' by Council of the responsibilities associated with managing risks that require community acceptance and enhanced knowledge of the expectations of users of water reuse schemes.

Rainwater

For rainwater harvesting, the City of Melbourne applies the risk management framework set out in these *WSUD Guidelines*.

The first council rainwater harvesting project at Brens Pavilion did not incorporate a comprehensive risk management process due to its small scale nature and limited risks. However the newly operating scheme at Queen Victoria Market required significant risk management planning due to its ability to impact up to 10 million visitors a year. Water at Queen Victoria Market is harvested for toilet flushing, consequently the health risks associated with this use needed to be considered as part of this risk assessment.

Greywater

If managed carefully, domestic greywater used within the boundaries of a property where it is generated can become a low risk. It's important that appropriate treatment takes place, with:

- No cross connections
- Safe chemical management
- Appropriate end-uses such as underground garden and lawn watering, toilet flushing and clothes washing.

There are three types of greywater:

- Treated – where water is stored for more than 24 hours and requires treatment before reuse
- Diverted into plumbing – where water is diverted into plumbing fixtures for reuse within 24 hours
- Diverted with no plumbing – for example, running washing machine water directly onto gardens. No treatment or approvals are necessary for this diversion.

Treatment is required for uses that are medium risk:

- Laundry
- Surface irrigation
- Outdoor.

If multiple sites are generating greywater, the 'end use'-based ranking increases to medium and high, and requires treatment.

The collection and reuse of greywater is regulated. Schemes that discharge to the environment are subject to the works approval, licensing provisions and septic tank provisions of the Environment Protection Act 1970, depending on their flow rate.

Schemes that reuse treated or untreated greywater require water authority consent, typically to increase the level of backflow protection. A registered plumber must install this system. This is because legislation requires any changes to plumbing connections to have consent, not just water recycling proposals. For simple diversion devices, the reuse of untreated greywater is currently unregulated.

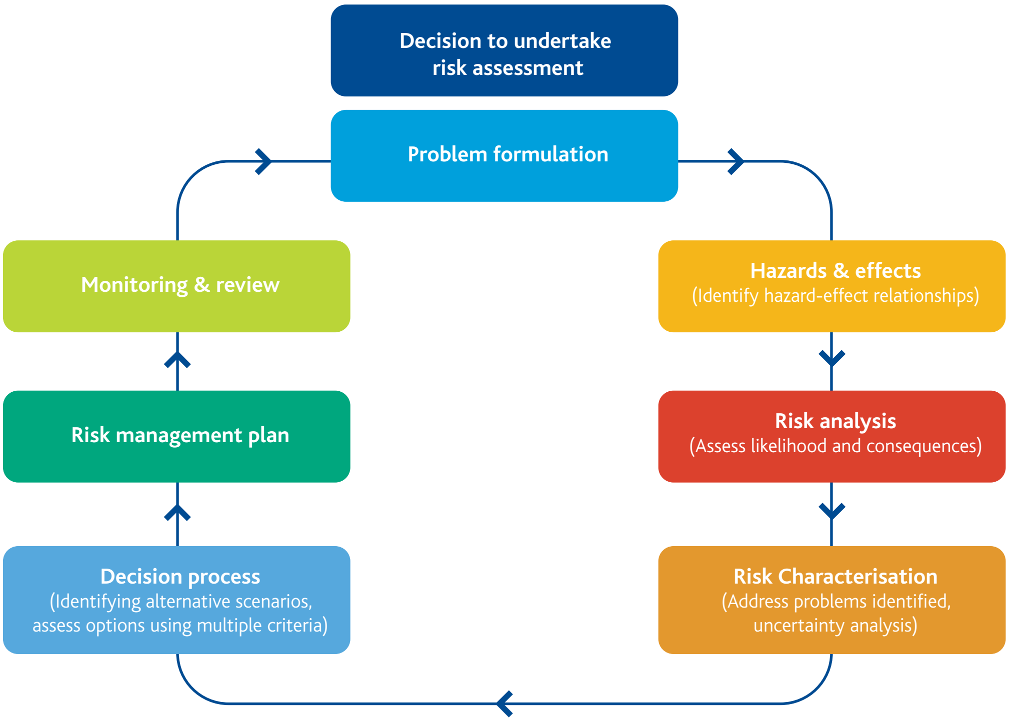
More information is provided in EPA Publication 812.2 – *Domestic Wastewater Management Series, Reuse Options for Household Wastewater.*

Risk management and governance procedures

Council recommends adopting the risk assessments framework shown in Figure 20 for any project. This assessment process is methodical and engages a range of stakeholders through a workshop format that can be separated into several key phases.

The model follows the PLAN, DO, CHECK, ACT model, supported by an Environmental Aspects and Impacts Register, standard risk assessment processes, and occupational health and safety requirements.

Figure 20. Risk analysis framework
(Hart, B. T. et al. (2005). Ecological Risk Management Framework for the Irrigation Industry, Water Studies Centre, Monash University, Melbourne, Australia, 55pp (www.wsc.monash.edu.au))



Risk assessments can range from a qualitative assessment to a quantitative analysis employing mathematical relationships. The level of complexity is determined by:

- Information available (or lack of)
- Resources assigned to each risk.

Each potential treatment option has different risks associated with:

- Technology
- Site constraints
- Potential identified uses.

These risks are based on the requirement that water reuse schemes achieve a 'fit-for-purpose' water quality standard.

Risk assessments are required for water recycling schemes. However there is no explicit requirement to cover an environmental or public health issue. You must identify any risk impacts and issues where there is a compliance requirement for Council works when submitting details of water recycling schemes for inclusion on Council's risk register.

Defining risk

The risk is defined as the likelihood (probability) of an adverse event multiplied by the consequence if that event occurs.

Risks can be categorised as either:

- Inherent – the risks associated with the project concept itself, or
- Residual – the risks associated with the project after risk management controls have been put in place.

Examples

- A dual pipe estate using reclaimed sewage can have high inherent risk but low residual risk due to the extensive risk management controls.
- In contrast, local greywater recycling may present a lower inherent risk, but due to the limited reliable end use controls, could represent unacceptable residual risks.

These guidelines focus on using good management to minimise inherent risk to an acceptable residual risk level. The guidelines don't relate to projects with very high inherent risks as Council believes such projects should not be considered.

Commitment to risk management

Council supports and promotes responsible implementation of water sensitive urban design projects.

It recognises the limitations of current legislation for alternative water use schemes and advocates management that meets the needs of all users and the environment.

In its role as scheme manager, scheme participant, approval authority and community leader, the Council will implement and promote the use of 'fit for purpose' water through:

- *Risk management*
- *Management procedures*
- *Communication*
- *Monitoring and reporting*.

Risk management includes:

- User-based, risk-oriented approach to the analysis of 'fit for purpose' water management options
- Preventative risk management approach and an appropriate water quality management system
- Contingency planning and incident response capability.

Management procedures include:

- Water quality management at relevant points along the delivery chain, from water source to point of application or recycled water user
- Processes and procedures to protect public and environmental health
- Planning processes that integrate the needs and expectations of water users, regulators, employees, other stakeholders and the environment
- Appropriate technical expertise in developing and managing water schemes
- Training to ensure all managers and employees involved in the supply of treated water can implement, maintain and continuously improve a recycled water scheme.

Communication includes:

- Partnerships with stakeholders involved in managing water recycling schemes
- Best practice community consultation, enabling participation in decision-making processes relating to the design, delivery and management of schemes.

Monitoring and reporting includes:

- Regular monitoring of control measures and water quality
- Effective reporting mechanisms to provide relevant and timely information
- Regular performance assessment to improve management practices and meet stakeholder expectations
- Mandatory reporting of non conformances with critical limits and routine reporting of operational data.

Risk Management Framework

This risk management process has been developed for all water recycling schemes operated by Council that collect and treat stormwater, rainwater, greywater and wastewater. Figure 21 shows the risk management framework for water recycling schemes in the IMAP area.

A range of fact sheets are proposed to help guide residents. However, the scope of this framework does not include water recycling schemes developed and managed by residents.

The framework has three key phases, each with defined tasks that must be completed. More detail about these key steps is provided below.

Phase 1: Assess project significance and level of risk (steps 1-2)

Phase 2: Conduct risk assessment (step 3)

Phase 3: Develop, apply and monitor risk management plan (steps 4-6).

Resources that will help develop a risk management approach to water recycling include fact sheets, a project management checklist and a risk management plan template (see Section 5 of the Risk Management Guidelines).

A risk management plan should cover:

- Regulatory requirements
- Scheme design
- Installation and operational procedures
- Monitoring
- Corrective action
- Communication and engagement protocols.

It should ensure multiple barrier controls are applied where necessary. For example:

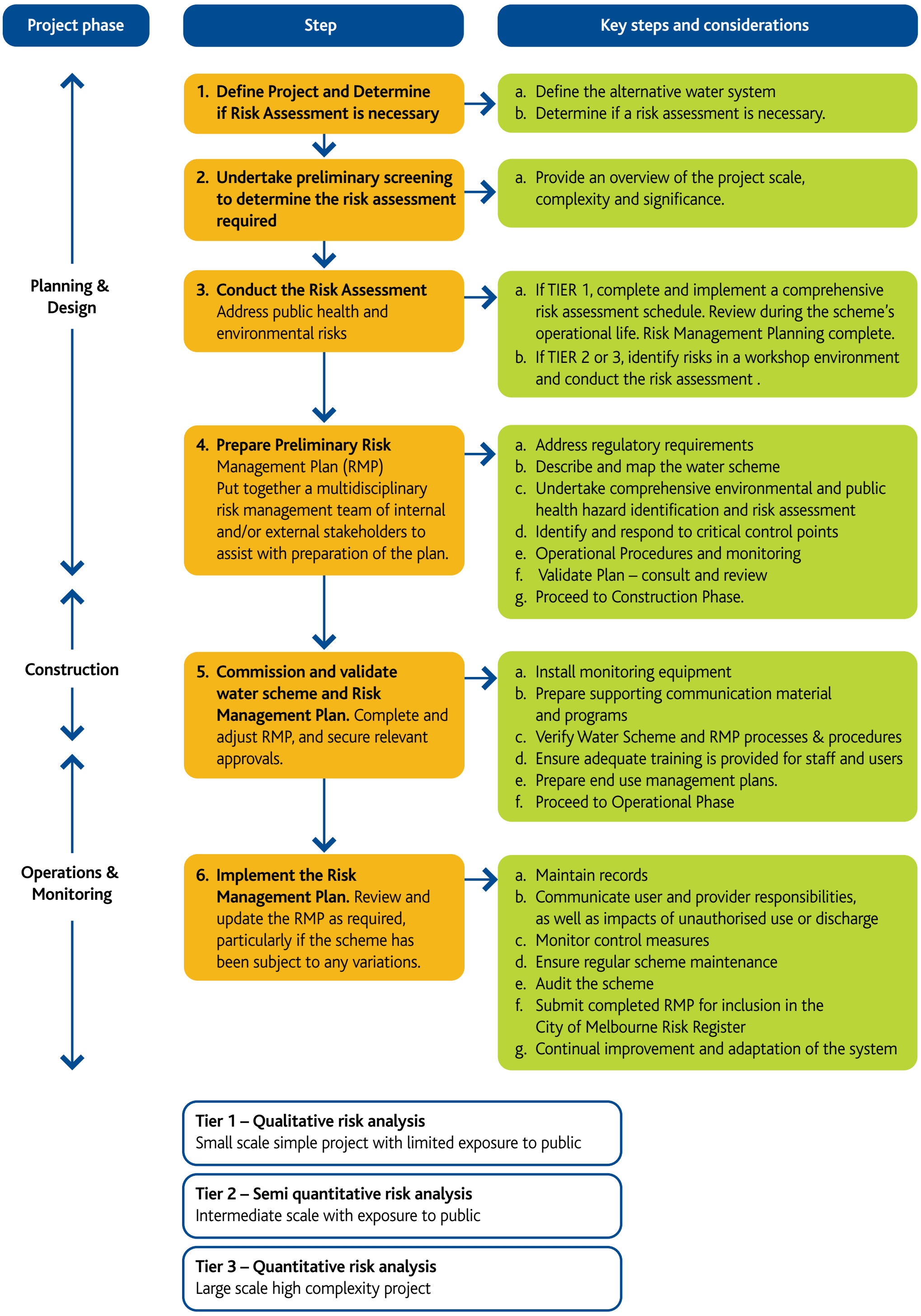
- Asset control mechanisms
- Education
- Technological barriers
- Plumbing and distribution controls
- Signage
- Operational procedures.

Corporate governance: compliance and liability management

The lack of an Environmental Management System (EMS) at some Councils limits the potential for appropriate water quality management within recycling schemes. Until an EMS is developed, risk management documentation must be integrated into each Council's corporate governance processes. At this stage, the most appropriate mechanism for legal compliance and liability management is to ensure a risk management plan is included on the relevant Council's risk register.

The best approach to managing potential liability issues is to design a system that minimises the risk of improper or unauthorised use of a treated (and untreated) product. Also consider product quality to address risks of improper use. Adhering to plumbing and other regulations, running awareness and education programs and ensuring an appropriate frequency of monitoring will help manage these issues.

Figure 21. Risk Management Framework for Water Recycling Schemes



Project phase	Step	Key steps and considerations
Planning & Design	1. **Define Project and Determine if Risk Assessment is necessary**	a. Define the alternative water system b. Determine if a risk assessment is necessary.
	2. **Undertake preliminary screening to determine the risk assessment required**	a. Provide an overview of the project scale, complexity and significance.
	3. **Conduct the Risk Assessment** Address public health and environmental risks	a. If TIER 1, complete and implement a comprehensive risk assessment schedule. Review during the scheme's operational life. Risk Management Planning complete. b. If TIER 2 or 3, identify risks in a workshop environment and conduct the risk assessment .
	4. **Prepare Preliminary Risk** Management Plan (RMP) Put together a multidisciplinary risk management team of internal and/or external stakeholders to assist with preparation of the plan.	a. Address regulatory requirements b. Describe and map the water scheme c. Undertake comprehensive environmental and public health hazard identification and risk assessment d. Identify and respond to critical control points e. Operational Procedures and monitoring f. Validate Plan – consult and review g. Proceed to Construction Phase.
Construction	5. **Commission and validate water scheme and Risk Management Plan.** Complete and adjust RMP, and secure relevant approvals.	a. Install monitoring equipment b. Prepare supporting communication material and programs c. Verify Water Scheme and RMP processes & procedures d. Ensure adequate training is provided for staff and users e. Prepare end use management plans. f. Proceed to Operational Phase
Operations & Monitoring	6. **Implement the Risk Management Plan.** Review and update the RMP as required, particularly if the scheme has been subject to any variations.	a. Maintain records b. Communicate user and provider responsibilities, as well as impacts of unauthorised use or discharge c. Monitor control measures d. Ensure regular scheme maintenance e. Audit the scheme f. Submit completed RMP for inclusion in the City of Melbourne Risk Register g. Continual improvement and adaptation of the system

Tier 1 – Qualitative risk analysis
Small scale simple project with limited exposure to public

Tier 2 – Semi quantitative risk analysis
Intermediate scale with exposure to public

Tier 3 – Quantitative risk analysis
Large scale high complexity project

Part 2

Module 2.7

Site Design and Approvals

This module covers how water sensitive urban design (WSUD) can be integrated into the design and construction of different urban development sites, taking into account approvals and compliance issues. For technical design and construction issues, refer to the *WSUD Engineers Procedures: Stormwater Manual*[30].

Incorporating WSUD into urban layouts

Open space layout

There are many opportunities to use WSUD to improve open space, conservation corridors and recreational facilities. For example, stormwater could be treated as it flows through landscape features such as grassed swales and wetlands.

When locating open space areas, consider the following principles:

- Align open space along natural drainage lines
- Protect and enhance areas containing natural water features and other environmental values, such as the Yarra River and Victoria Harbour
- Use open space to link public and private areas and community activity nodes, especially in new developments.

Road layouts and streetscaping

Roads can significantly change the way water is transported because they create large areas of impervious hard surfaces in a typical urban development. When using WSUD stormwater harvesting techniques, roads are a great source of water.

Roads also generate waterborne stormwater contaminants that can damage the health of the receiving waterway. These include fine sediments, metals and hydrocarbons. Consequently, it's important to carefully plan road alignments and streetscapes to lessen the impact of stormwater runoff from road surfaces.

The continual upgrade of roads and streets provides opportunity to incorporate stormwater elements by diverting the flow from the road to a treatment system such as a raingarden or vegetated swale. To do this, traditional road features such as medians, traffic calming bays, street trees and car parking nodes must be slightly lowered below the road level to collect runoff from the road. Other features such as kerb and channel can be replaced with grass swales. Street trees can be retrofitted into stormwater treatment planter boxes.

Figure 22 shows how stormwater is filtered through a loamy sand before it's released to the stormwater systems.

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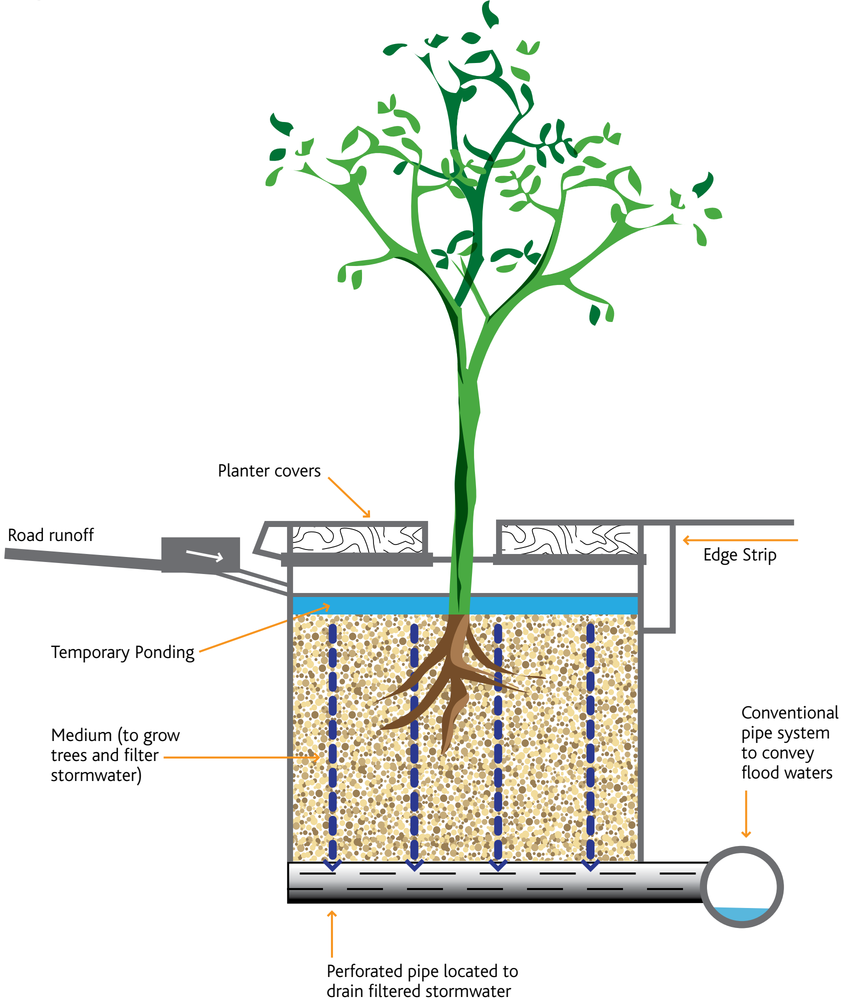
[30] WSUD Engineering Procedures: Stormwater, CISRO 2005

Figure 22. Tree planter schematic



Bioretention tree pits can be installed when street trees are planted. This means that trees are watered by the road runoff which is then filtered through sand before it's released into the stormwater systems. Figure 23 shows a series of street trees –bioretention & conventional.

Figure 23. Street planter boxes showing the construction of a planter, a modified tree planter and a traditional planter box.

Construction of a planter tree **Modified tree planter** **Traditional street tree**

Traffic medians, traffic treatment beds and roadways can be retrofitted to become raingarden systems. Examples include Little Bourke St, Melbourne and Cremorne St, Richmond where an urbanised street was retrofitted with raingardens.

Figure 24 below shows how the vegetated area (on the left) can be retrofitted to include a stormwater entrance. Stormwater overflow in high flow events is diverted directly to the side entry pit. The low flow, which is the majority of rainfall in Melbourne, and initial runoff (first flush) during storm events are treated by the raingarden. The majority of contaminants are contained in the low flow runoff and initial runoff in storm events.

Figure 24. Medians and vegetated road verges can be retrofitted to accept stormwater for treatment.

Lot layouts

The development of new lots has limited application to the inner areas of Melbourne. When it does apply, it's useful to integrate open space with WSUD elements.

WSUD promotes smaller, more compact housing lots adjacent to open space areas that typically have high amenity value. This allows greater community access to open space and WSUD elements. For example, natural and landscaped water features can form part of the local stormwater drainage and treatment system. Natural landscape features such as significant remnant vegetation and natural waterways should be incorporated into open space with housing lots wherever practical.

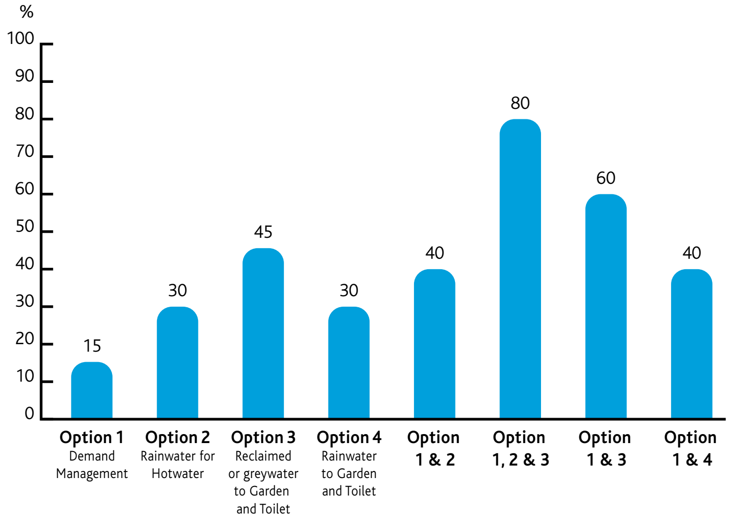
Application to development scales

Applying the three-step approach to selecting WSUD options (in Module 2.2), users have:

- Firstly, reduced demand for water
- Secondly, sourced alternate water for uses that do not require potable water (fit-for-purpose approach to water management)
- Thirdly, ensure stormwater is treated prior to it entering water bodies.

The potable water savings that can be achieved for different WSUD applications are outlined in Figure 25.

Figure 25. Expected potable mains savings from demand management and reuse options



The summaries below show how WSUD options can be used within different development scales.

Low density residential

Low density households can combine water efficiencies, rainwater harvesting and in some cases greywater technologies to reduce mains water demand. For typical suburban residential households, the expected potable mains water savings through demand management and water reuse options is shown in Figure 25.

The greatest potable mains water saving (80%) can be achieved through a combination of:

- Demand management (option 1)
- Rainwater for hot water (option 2)
- Recycled water or greywater for toilet flushing and garden irrigation (option 3).

In the absence of recycled water (e.g. water mining or greywater systems), a 40% saving can be achieved through a combination of:

- Demand management (option 1)
- Rainwater used for toilet flushing and garden watering (option 4).

A case-by-case approach to achieving water demand reductions will take into account:

- Development scale
- Layout
- Proximity to wastewater treatment facilities
- Local climate
- Willingness to manage any recycled water systems.

High rise residential development

High rise urban development is typical of present and future residential growth within inner Melbourne. In high rise apartments, residential water demand is similar to a typical household with the exclusion of garden irrigation. The base buildings require the efficiencies of centralised hot water systems. Stormwater capture from the roof (and possible carpark/plaza/garden area) will reduce stormwater pollution. However the relatively small ratio of surface area to water demand (i.e. number of people) limits this as alternative water source.

Therefore the preferred combination for high rise residential development is:

- Demand management (option 1)
- Reclaimed or greywater for toilet use (option 3).

Commercial office development

Toilet flushing is typically the main use of water in office buildings. Relatively small demand exists for drinking water, bathrooms and garden irrigation. Shower use is low, so little greywater generation can be expected. Stormwater capture from the roof (and possible carpark/plaza/garden area) will reduce stormwater pollution. However the relatively small ratio of surface area to water demand (i.e. number of people) limits this as alternative water source.

Therefore the preferred combination for commercial office development is:

- Demand management (option 1)
- Reclaimed water for toilet flushing (variation of option 3 involving sewer mining).

Demand management will result in significant savings in water bills for the office buildings. However installing sewer mining systems is costly, so ideally this facility should be shared amongst adjacent buildings.

Events and institutions development

The commercial sector also includes schools, universities, hospitals, markets and event venues. These venues can reduce water demand through efficient toilets, showers, appliances and fittings including fire sprinkler systems and cooling towers (option 1).

Buildings with large catchment areas (e.g. roof areas) can harvest rainwater and use for toilet flushing and irrigation (option 2) as such venues often have large gardens (option 3). Stormwater can also be harvested from large car park and garden areas to provide water quality improvement.

Mixed use urban development

Residential and commercial uses are typically combined in a mixed use development. Building height, density, landscape area and use will determine the WSUD strategy.

The feasibility of rainwater harvesting will be determined by the ratio of stormwater roof runoff to the number of residents. Similarly, the amount of stormwater harvesting will be determined by the ratio of plaza, carpark and open space area. Greywater can usually be collected to provide an alternative water source.

Therefore the preferred combination for mixed use urban development is:

- Demand management (option 1)
- Recycled water or greywater for toilet flushing and garden irrigation (option 3).

Industrial development

Industrial water use is dependent on the specific industry and site. Usage ranges from cooling water for industrial equipment to very high purity water for technology companies. Industry should use ‘fit-for-purpose’ water and be able to demonstrate best water management and practice.

Industrial sites often have large roof spaces and car parks, offering valuable opportunities for rainwater and stormwater harvesting. For example:

- Multiple uses of water within a manufacturing site
- Reclaimed water for process cooling applications
- Stormwater harvesting for onsite use.

As industrial developments and their water use are varied throughout the City of Melbourne, approaches should be developed on a case-by-case basis.

The combination of appropriate water sensitive urban designs are further developed in the Case Studies in Part 3 of these guidelines.

Modelling stormwater performance

Stormwater quality improvement systems in urban areas are predominantly driven by climatic factors such as the occurrences of storm events and dry weather conditions. These factors are highly variable in terms of the seasonality of the occurrences of storm events, their magnitudes and durations.

The performance of an urban stormwater quality improvement strategy is determined over a continuous period of typical climatic conditions, rather than an individual storm event. Monitoring and water quality sampling of a small number of storm events are normally not sufficient to define system performance.

Using well-established computer models of urban stormwater management systems is a recognised method to determine long-term performance. Modelling involves the use of historical or synthesized long-term rainfall data that can simulate the performance of stormwater treatment measures to determine stormwater pollution control outcomes.

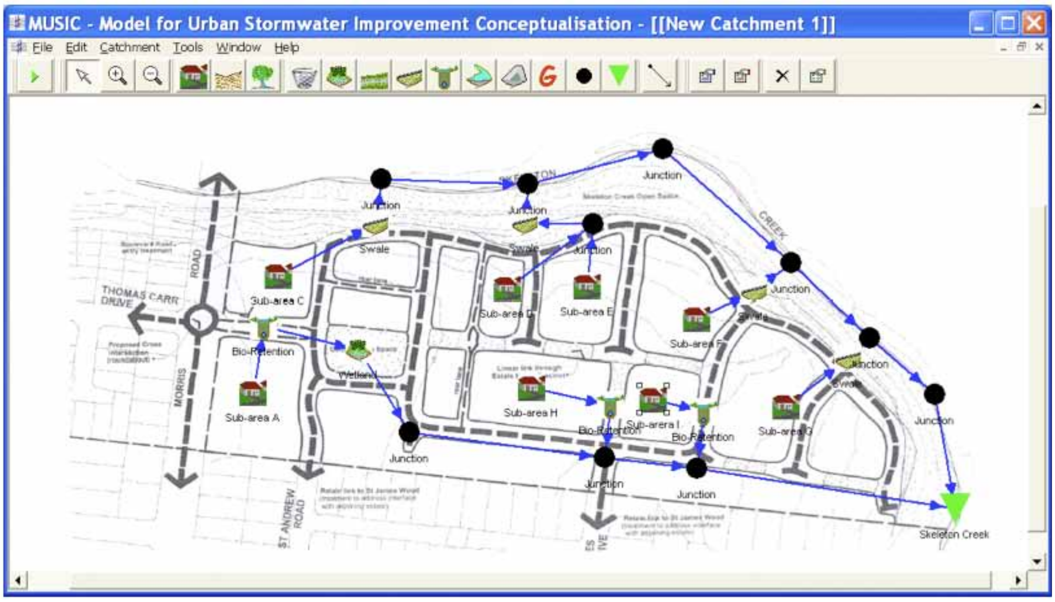
Modelling is required for WSUD solutions on sites larger than single households.

MUSIC modelling

The Cooperative Research Centre for Catchment Hydrology (now eWater) has developed stormwater management evaluation software called MUSIC[31].

The software provides a planning and decision support system. Through an easy-to-use tool, it presents the most current knowledge of the performance of a range of stormwater treatment measures. MUSIC is designed to operate at a range of temporal and spatial scales, suitable for modelling stormwater quality treatment systems from individual lots up to regional scales.

Figure 26. The structure of a MUSIC model to evaluate stormwater treatments using rain gardens in a typical residential development



Using MUSIC, you can make a first estimate on the expected pollutant load from catchments following development, in the absence of any stormwater treatment initiatives. This sets a baseline condition which can then be used to compare alternative stormwater treatment strategies for compliance with state and local government stormwater quality objectives.

Figure 26 shows an example of a MUSIC model, representing the evaluation of stormwater treatments for a typical residential development.

STORM modelling tool

The STORM tool is a simple modelling tool for small scale development. It's based on achieving best practice for a particular site. This is a simplified version of the MUSIC tool to be used for non-complex developments.

The STORM tool is available from Melbourne Water's website and is easily accessible for local governments, households and developers (www.storm.melbournewater.com.au).

Other modelling approaches

There are other computer models that allow a user to model the performance of a group of treatments or an individual treatment measure.

Phillips and Thompson (2002) describe an application of XP-AQUALM in the development of a management strategy for drainage and stormwater, as part of an overall Water Cycle Management Strategy for Sydney's Olympic Games Village. Currently, MUSIC and XP-AQUALM are the two most widely used tools for modelling urban stormwater quality improvement systems.

The application of computer models to predict the performance of individual or a group of stormwater treatment measures is not a simple exercise and requires a level of modelling expertise.

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[31] For more details – www.catchment.crc.org.au

Approvals and compliance

Stormwater

Stormwater treatment works can take various forms in the urban environment. Some treatment works will involve:

- Infrastructure upgrades
- Streetscape layout changes
- Piping reconfigurations
- Storage tanks
- Laying of different paving and other such variations.

In many of these cases, planning approval will be necessary.

Applications for planning approval are required where there will be changes to land use and/or development works that impact the local environment. Meet with the statutory planning department of Council as soon as possible to determine whether a permit is needed for your proposed work. Also seek advice about the information that needs to be submitted and the likely timing of the approval.

Heritage provisions apply to most of the City of Melbourne and therefore a heritage permit may also be needed.

Clause 56 for residential sub-divisions

Clause 56 of the State Planning Policy was modified in October 2006 which requires all new residential subdivisions to incorporate integrated water management. The urban run-off management objectives 56.07-4 address urban stormwater.

Like these *WSUD Guidelines*, the standards to be met under Clause 56 include performance objectives set out in the *Urban Stormwater Best Practice Environmental Management Guidelines* (BPEMs), published by CSIRO in 1999, as amended.

Incorporating water sensitive urban design (WSUD) elements as part of the drainage system is one of the main ways to meet these standards. The development industry and local government officers therefore need to understand:

- What are the principles behind WSUD?
- What are the various technologies that can be used?
- What is the best technology or device for a particular situation?
- How to use industry design and assessment tools to determine whether a particular suite of technologies will meet the BPEM objectives

New site management provisions are set out in the Site Management Objectives 56.08-1. These provisions require that subdivision applications describe how the site will be managed to minimise environmental impacts.

Greywater

Simple greywater diversion systems that do not store greywater for more than 24 hours do not require approval.

EPA Victoria approval is required for greywater treatment systems that treat more than 5000L/day. Contact EPA Victoria directly for more information about the approval process.

Water quality is expected to be similar to the EPA Victoria's guidelines for reclaimed water, requiring water to be treated to Class A standard (10 E.Coli/100mL, 10 BOD mg/L and 5 mg/L SS[32]) for toilet flushing and unrestricted irrigation. Class B (100 E.Coli/100mL, 20 BOD mg/L and 30 mg/L SS) and Class C (1000 E.Coli/100mL, 20 BOD mg/L and 30 mg/L SS) quality water is appropriate for restricted access irrigation.

For systems treating less than 5000L/day, EPA Victoria has provided a list of approved greywater treatment systems. EPA approval is not required for a closed system, that is, when no water is released to the environment. The City of Melbourne can issue permits for EPA-approved systems.

- EPA Victoria's website (www.epa.vic.gov.au) lists approved greywater devices
- EPA publication 812 provides further advice for greywater reuse.

All installations must conform to Australian Standards, with reference to *AS3500.1.2 Water Supply: Acceptable Solutions*, wastewater treatment (AS1546) and wastewater effluent management (AS1547), and plumbing requirements.

A licensed plumber is required to install the system. The Green Plumbers (www.greenplumbers.com.au) and the Plumbing Industry Commission (www.pic.vic.gov.au) websites have additional information.

The Department of Human Services has also prepared guidelines for greywater reuse, available from their website (www.health.vic.gov.au/environment/).

[32] EPA Victoria's *Guidelines for Environmental Management: Use of Reclaimed Water* – Publication 464.2, 2003

Blackwater

EPA Victoria approval is required for water treatment systems treat more than 5000L/day. Contact EPA Victoria directly for more information about the approval process.

EPA Victoria has guidelines for the use of reclaimed water from sewage treatment plants (refer to publication 464.2). Use these guidelines to assess requirements for large scale water treatment.

Water quality is expected to be similar to the EPA Victoria's guidelines for reclaimed water, requiring water to be treated to Class A standard (10 E.Coli/100mL, 10 BOD mg/L and 5 mg/L SS) for toilet flushing and unrestricted irrigation. Class B (100 E.Coli/100mL, 20 BOD mg/L and 30 mg/L SS) and class C (1000 E.Coli/100mL, 20 BOD mg/L and 30 mg/L SS) quality water is appropriate for restricted access irrigation[33].

For blackwater systems treating less than 5000L/day, EPA Victoria considers the treatment to be a sceptic system. EPA Victoria has guidelines for onsite wastewater treatment (refer to Publication 451: *Code of Practice – Septic Tanks*). The City of Melbourne is the approval authority for the system and can issue a permit. The approved treatments are listed on the EPA Victoria's website (www.epa.vic.gov.au).

All installations must conform to Australian Standards, with reference to *AS3500.1.2 Water Supply: Acceptable Solutions*, wastewater treatment (AS1546) and wastewater effluent management (AS1547), and plumbing requirements.

A licensed plumber is required to install the system. The Green Plumbers (*www.greenplumbers.com.au*) and the Plumbing Industry Commission (*www.pic.vic.gov.au*) websites have additional information.

The Department of Human Services has responsibility for approving large scale reclaimed water systems where there is a potential for 'high exposure' from Class A water applications. High exposure examples include the use of reclaimed water for toilet flushing in a residential building or irrigating an unrestricted area. The Department should be contacted directly for approval (*www.health.vic.gov.au/environment/*).

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[33] EPA Victoria's *Guidelines for Environmental Management: Use of Reclaimed Water* – Publication 464.2, 2003

Part 2

Module 2.8

Maintaining WSUD Assets

This module summarises the issues relating to the operation and maintenance of water sensitive urban design (WSUD) projects[34].

Key aspects of maintenance

The condition of the civil works and the landscape will impact on maintenance needs of a WSUD system. Civil works generally require minimal maintenance apart from checks to ensure drainage function[34]. Landscape areas require ongoing maintenance to maintain vegetation and plant health, control weeds, remove litter and sediment and maintain design levels and the efficiency of the treatment system in removing pollutants.

Maintenance activities need to ensure officer safety and should not require direct contact with pollutants and other trapped materials. Common maintenance activities across many WSUD systems include:

- Horticultural (weed control and pruning) activities to maintain health of plantings
- Removing litter and debris
- Replanting vegetation (if garden bed style system)
- Mowing grass if turf present (typically in swales)
- Managing algae
- Preventing root growth into drainage pipes
- Draining to avoid blockages, ponding or unnecessary bypassing from sediment build up
- Cleaning and renewing the filter media surface to maintain treatment efficiency
- Visual checks after rainfall to check infiltration is at optimum efficiency
- Disposing of solid wastes
- Maintaining pumps.

Appendices 2 - 8 detail the specific maintenance requirements for different WSUD systems.

Maintenance over the life of a project

Across the life of a project, the level of maintenance varies. In the two years immediately following construction (the establishment period), more maintenance takes place. During this period, weed removal and replanting may be needed, in particular for catchments with poor building controls. Monitoring should be more frequent when construction is occurring in the catchment, as sedimentation may also be a problem and can affect the functioning of WSUD systems.

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[34] Information sources include:
- Somes and Crosby (2006) report [34] (rain gardens)
- WSUD Engineering Procedures: Stormwater manual[34] (other WSUD systems)
- Water Sensitive Urban Design Technical Design Guidelines for South East Queensland[34] (other WSUD systems).

Maintenance plans

All maintenance activities must be specified in a maintenance plan and associated maintenance inspection forms. These are developed as part of the design process. Maintenance personnel and asset managers use this plan to make sure that the WSUD system continues to function as it was designed.

Maintenance plans and forms must address the following:

- Inspection frequency
- Maintenance task frequency
- Data collection/ storage requirements (i.e. during inspections)
- Detailed cleanout procedures (main element of the plans) including:
  - equipment needs
  - maintenance techniques
  - occupational health and safety
  - public safety
  - environmental management considerations
  - disposal requirements (of material removed)
  - access issues
  - stakeholder notification requirements
  - data collection requirements (if any)
- Design details, including a description and sketch of how the system operates.

Use maintenance checklists whenever an inspection is conducted and keep them as a record on the asset condition and quantity of removed pollutants over time. Generally, inspection frequencies are every three to six months for Victoria. Appendices 2 - 8 contain examples of WSUD maintenance checklists.

Rain gardens maintenance

The information in the Somes and Crosby (2006) case study is based on a recent review of 22 water sensitive urban design (WSUD) street scale projects.

Post construction maintenance

Immediately after a rain garden is built, there is an important period where the landscape system is established. During this time, a range of works are needed, including:

- Watering – as required
- Control of weeds – a monthly visit
- Removal of litter and sediment – as required
- Replacement of plant losses – typically 10% to 15% of initial plantings.

These costs are typically the responsibility of the contractor. They will be between 10% and 25% of the soft landscape (planting and mulching works) construction cost per annum. Small sites often involve significant mobilisation, therefore higher establishment costs.

A two year post construction maintenance period is generally recommended before handing assets over to Council on large projects. For smaller projects, a shorter maintenance period may be appropriate if Council has the resources to undertake maintenance.

The cost of maintenance is less if Council takes over the site after an initial six month maintenance period, as the landscape can be maintained using local resources with no additional travel costs. Commercial landscapers also have to make assumptions about the proportion of re-plants, watering and weed control. Therefore cost estimates provided by contractors for maintenance during the establishment phase generally include contingencies, as contractors need to recover costs for all works undertaken.

Long term maintenance

To ensure the ongoing aesthetics and function of rain gardens, long term maintenance is needed. Maintenance activities are divided into the following key areas:

- Aesthetics
- Horticulture
- Damage
- Inspections.

Maintenance frequencies for rain gardens

Use the different maintenance categories in Table 12 to gain an understanding of the estimated maintenance cost for rain garden sites. The ranges in frequency of maintenance reflect the site review findings for typical urban and industrial areas. It's important to note that in some cases a significantly higher frequency of visits will be needed due to the nature of the site, i.e. a high visitation local park.

Table 12. Recommended maintenance actions and frequencies for rain gardens
(adapted from Somes and Crosby 2006)

Action	Frequency
Aesthetics	
Litter and organics removal	As required. Typical range 12-18 visits per year.
Sediment removal	As required. Only expected if there was a new sediment source present in catchment, e.g. construction works.
Vegetation	
Weed control	6 to 12 visits per year.
Replanting	5% per year after the first two years of maintenance.
Mulching	Top up annually if required.
Damage	Repair accidental and deliberate damage as required.
Inspections	
Functional elements	Every 5 to 10 years an inspection of drainage elements is undertaken.
Landscape	Every 5 to 10 years an inspection of the landscape is undertaken.
Infiltration	Every 5 to 10 years an in situ infiltration test should be undertaken.

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[35] EPA (2008) *Maintaining water sensitive urban design elements*, publication 1226

A well functioning rain garden has similar maintenance needs as other gardens beds. Therefore many new rain garden areas have been assimilated into Councils' maintenance regimes across Melbourne. It's recommended that any estimate of future landscape maintenance cost be based on current maintenance costs for similar landscapes within the municipality[35].

Issues identified from metropolitan Melbourne site inspections

In metropolitan Melbourne, civil works and maintenance (weed and litter control) for WSUD projects are generally implemented well[35]. However some maintenance issues were identified, including the use of inappropriate mulches and loss of extended detention storage due to overfilling of filters.

Poor filter function was the most common issue identified in site inspections. Many filters had infiltration rates below that specified in the design. The results indicated that most WSUD measures had infiltration rates of less than 80 mm/hr, when the rate should be 100 - 300 mm/hr. Systems with low infiltration rates achieve lower than intended pollutant removal rates as systems bypass more frequently.

The low hydraulic conductivity of the filters was due to inappropriate selection of filter materials, in particular topsoil material was used in many rain gardens. Topsoil has a proportion of fine grade materials that is too high for this application. The fine materials clog soil pores and reduce the infiltrative capacity of the soil. Instead, turf sand (loamy sand) should be used as per Melbourne Water and FAWB specifications.

Plant growth was variable across the sites. Whilst poor plant growth due to waterlogged soils is not an ideal outcome, it does at least help staff to identify a potential filter function problem. Terrestrial plants (e.g. Dianella species) are better at showing low infiltration rates than semi-aquatic plants that can remain healthy in waterlogged soils. Where possible, use plants which prefer well drained conditions as they will indicate poor filter function.

No plants were found to be suffering stress from a lack of water despite the drought conditions during the study. This indicates that stormwater runoff to rain gardens contributes to their long term health.

Maintenance costs

Actual costs incurred by operators of WSUD systems have only recently become available and are listed in Appendix 1. These were collected by EPA Victoria[36] and generated from information available around Australia. Data is very limited for some measures such as buffer strips, rain gardens and infiltration systems.

The WSUD datasets are small and there is a large variation between systems. Therefore the figures should only be used as a useful check at the design stage.

Maintenance issues for water recycling systems

Rainwater and stormwater tanks

When the design has carefully considered the quality of the water entering the system, rainwater and stormwater tanks only need minimal maintenance. Harvested water must be as free as possible of debris, litter and sediment. For rainwater tanks this can be as simple as gutter guards, leaf diverter and/or first flush diverters. Maintenance tasks include the following:

- Inspect gutter guards, leaf diverter and/or first flush diverters every six months and clean if necessary
- Monitor sediment build-up within the tank every one to two years
- De-sludge every five years, if necessary.

Stormwater harvesting from roads and paved surfaces will need greater screening and treatment. These treatment measures may involve rain gardens, swales or gross pollutant traps. As most stormwater harvesting systems are large, they are often underground and therefore cleaning measures are limited. Pre-treatment is therefore more important than in systems which only use roof run-off (rainwater).

Greywater systems

Each greywater treatment will have its own maintenance requirements. Manufacturers and suppliers can provide relevant maintenance regimes. For example, a subsurface wetland will require minimal maintenance if adequate prefiltering and settling occurs before the filter bed. To ensure consistent flow, regularly clean and remove solids from the filters and screens.

Factor in adequate provision for downtime, such as scheduled maintenance. Therefore, connect the greywater plumbing to the mains and the sewer to:

- Enable immediate diversion and greywater disposal
- Provide for potable mains water to be temporarily used for toilet flushing.

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[36] EPA (2008) *Maintaining water sensitive urban design elements*, publication 1226

Blackwater systems

All water mining systems need regular maintenance. Technology selection will determine the maintenance management schedule. For example, membrane filtration processes will require regular membrane cleaning either chemically or physically with eventual membrane replacement.

Variable wastewater quality can affect operation and potentially harm the system, for example a peak caustic load in the sewer from an industrial customer. Regulatory approaches have minimised these occurrences, using license agreements to stipulate pollutant loading and advanced approaches to track ‘rogue’ customers.

Maintaining pumps

Undertake maintenance on pumps for the storage and distribution of water and wastewater in WSUD systems as part of a scheduled maintenance program.

Most pump maintenance activities centre on:

- Checking packing and mechanical seals for leakage
- Peforming preventive or predictive maintenance activities on bearings
- Assuring proper alignment
- Validating proper motor condition and function.

Table 13 below shows a generic pump maintenance checklist. However it’s always good practice to check with manufacturers and suppliers for the relevant maintenance regimes.

Table 13: Generic pump maintenance checklist

		Maintenance frequency		
Description	**Action**	**Every 3 mths**	**Every 6 mths**	**Annually**
Pump use and sequencing	Turn off or sequence unnecessary motors.	•		
Overall visual inspection	Complete overall visual inspection to check all equipment is operating and safety systems are in place.	•		
Check lubrication	Make sure that all bearings are lubricated per the manufacturer’s recommendation.		•	
Check packing	Check packing for wear and repack as necessary.		•	
	Consider replacing packing with mechanical seals.		•	
Motor and pump alignment	Align the pump/motor coupling to allow for efficient torque transfer to the pump.		•	
Check mountings	Check and secure all pump mountings.		•	
Check bearings	Inspect bearings and drive belts for wear.			•
	Adjust, repair or replace as necessary.			•
Motor condition	Check the condition of the motor through temperature or vibration analysis to assure long life.			•

(Adapted from U.S. Department of Energy - Energy Efficiency and Renewable Energy Federal Energy Management Program)
www1.eere.energy.gov/femp/operations_maintenance

Appendix 1 – Maintenance costs for rain gardens and other treatment devices

Rain garden street-scale works to date have shown that maintenance costs average between $3.80 and $20 per square metre of landscape per annum[36]. The range of costs reflects the profile of the site to be maintained, with higher profile sites requiring greater maintenance intervention.

Table 14 shows a typical maintenance regime. Two maintenance regimes were developed and costed, reflecting the profile of various sites. Annual costs are:

- $8.76/m^2 for low maintenance levels
- $13.25/m^2 for high maintenance levels.

Annual inspections and litter pick up take up a large proportion of the maintenance costs. If you want to reduce maintenance inputs, make savings in these areas, rather than reducing weed control or replanting. Coordinate maintenance of rain gardens with adjacent landscapes to reduce the costs.

Table 14. Estimated annual maintenance costs per square meter of rain garden

Activities	Lower cost	Upper cost
Aesthetics	$ 4.80	$ 7.20
Vegetation	$ 3.00	$ 4.13
Damage	$ 0.96	$ 1.92
Total annual cost	**$ 8.76**	**$ 13.25**

Source: Somes and Crosby 20061

Table 15. Typical maintenance costs for various WSUD systems, EPA 2008

Treatment devices	Typical annual maintenance cost (TAM)	Correlation
Constructed wetlands	TAM ($2004) = 6.831 x (A) 0.6435	R2= 0.76; p< 0.01; n= 21
Vegetated swales	TAM ($2004) = 48.87 x (TAC) 0.4407	R2= 0.94; p= 0.03; n= 4
Buffer strips	TAM ($2004) = 48.87 x (TAC) 0.4410	R2= 0.94; p= 0.03; n= 4
Rain gardens	TAM ($2004) = 48.87 x (TAC) 0.4410	R2= 0.94; p= 0.03; n= 4
Ponds and sediment basins	TAM ($2004) = 185.4 x (A) 0.4780	R2= 0.92; p= 0.04; n= 4
Infiltration systems	TAM ($2004) = 30.15 x (TAC) 0.4741	R2= 0.80; p= 0.04; n= 5

Source: EPA Maintaining water sensitive urban design elements, publication 1226

Notes

The size/cost relationships for TAM, TAC and RC are derived from a combined data set involving vegetated swales, buffer strips and rain gardens. There is insufficient data to analyse swales on their own.

A = surface area of treatment zone/ basin/ infiltration system in m^2.

TAC = total acquisition cost.

R2 = explanation of variance

p = significance

n = number of samples p is derived from.

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[36] Somes and Crosby (2006) report

Appendix 2 – Maintenance requirements for swales (incorporating buffer strips)

Swale treatment relies upon good establishment of vegetation. Therefore ensuring adequate vegetation growth is the key maintenance objective. Swales also have a flood conveyance role that needs to be maintained to protect local properties from flood.

The plant establishment period, during the first two years, is the most intensive period of maintenance. This is when:

- Weeds may need to be removed
- Replanting may be required
- Large loads of sediments may impact on plant growth, particularly in developing catchments with an inadequate level of erosion and sediment control.

Carefully monitor the potential for rilling and erosion along a swale, particularly during establishment stages of the system. The inlet points (if the system does not have distributed inflows) and surcharge pits will also need careful consideration. The inlets can be prone to scour and build up of litter and sediment.

Swale field inlet pits also require routine inspections to check structural integrity and blockages with debris.

Debris removal is an ongoing maintenance requirement. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of debris should be done regularly.

Typical maintenance of swale elements will involve:

- Routinely inspecting the swale profile to identify any:
  - areas of obvious increased sediment deposition
  - scouring of the swale invert from storm flows
  - rill erosion of the swale batters from lateral inflows
  - damage to the swale profile from vehicles
- Routinely inspecting inlet points (if the swale does not have distributed inflows), surcharge pits and field inlet pits to identify any:
  - areas of scour
  - litter build up
  - blockages
- Removing sediment where it is impeding the conveyance of the swale and/ or smothering the swale vegetation and if necessary reprofiling of the swale and revegetating to original design specification
- Repairing damage to the swale profile resulting from:
  - scour
  - rill erosion
  - vehicle damage
- Clearing blockages to inlet or outlets
- Regular watering/ irrigation of vegetation until plants are established and actively growing
- Mowing turf or slashing vegetation (if required) to preserve the optimal design height for the vegetation
- Removing and managing invasive weeds
- Removing plants that have died (from any cause) and replacement with plants of equivalent size and species as detailed in the plant schedule
- Pruning to remove dead or diseased vegetation material and stimulate new growth
- Removing litter and debris
- Monitoring and controlling vegetation pests.

Swale and Buffer Maintenance Checklist

Asset I.D.:			
Inspection frequency	3-6 monthly	**Date of visit:**	
Location:			
Description:			
Site visit by:			

Inspection Items	**Yes/No**	**Action required (details)**
Sediment accumulation at inflow points?		
Litter within swale?		
Erosion at inlet or other key structures (e.g. crossovers)?		
Traffic damage present?		
Evidence of dumping (e.g. building waste)?		
Vegetation condition satisfactory (density, weeds etc.)?		
Replanting required?		
Mowing required?		
Sediment accumulation at outlets?		
Clogging of drainage points (sediment or debris)?		
Evidence of ponding?		
Set down from kerb still present?		
Soil additives or amendments required?		
Pruning and/ or removal of dead or diseased vegetation required?		

Comments

Appendix 3 – Maintenance requirements for bioretention swales

The flood conveyance role of bioretention swales must be maintained to ensure adequate flood protection for local properties. Vegetation plays a key role in maintaining the porosity of the sand of the bioretention system. Strong healthy growth of vegetation is critical to its performance.

The plant establishment period, during the first two years, is the most intensive period of maintenance. This is when:

- Weeds may need to be removed
- Replanting may be required
- Large loads of sediments may impact on plant growth, particularly in developing catchments with an inadequate level of erosion and sediment control.

Carefully monitor the potential for rilling and erosion along a swale, particularly during establishment stages of the system. The inlet points (if the system does not have distributed inflows) and surcharge pits will also need careful consideration. The inlets can be prone to scour and build up of litter and sediment.

Bioretention swale field inlet pits also require routine inspections to check structural integrity and blockages with debris.

Debris removal is an ongoing maintenance requirement. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of debris should be done regularly.

Typical maintenance of bioretention swale elements will involve:

- Routinely inspecting the swale profile to identify any:
  – areas of obvious increased sediment deposition
  – scouring of the swale invert from storm flows
  – rill erosion of the swale batters from lateral inflows
  – damage to the swale profile from vehicles
  – clogging of the bioretention trench (evident by a 'boggy' swale invert)
- Routinely inspecting inlet points (if the swale does not have distributed inflows), surcharge pits and field inlet pits to identify any:
  – areas of scour
  – litter build up
  – blockages
- Removing sediment where it's impeding the conveyance of the swale and/ or smothering the swale vegetation, and if necessary, reprofiling of the swale and revegetating to original design specification
- Repairing damage to the swale profile resulting from:
  – scour
  – rill erosion
  – vehicle damage
- Tilling the bioretention trench surface if there is evidence of clogging
- Clearing blockages to inlet or outlets
- Regular watering/ irrigation of vegetation until plants are established and actively growing
- Mowing turf or slashing vegetation (if required) to preserve the optimal design height for the vegetation
- Removing and managing of invasive weeds
- Removing plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule
- Pruning to remove dead or diseased vegetation material and to stimulate new growth
- Removing litter and debris
- Monitoring and controlling vegetation pests.

Resetting, or complete reconstruction, of bioretention elements will be required if the:

- Available flow area of the overlying swale is reduced by 25% (due to accumulation of sediment)
- Bioretention trench fails to drain adequately after tilling of the surface.

Inspections are also recommended following large storm events to check for scour.

Bioretention Swales Maintenance Checklist

Asset I.D.:			
Inspection frequency	3-6 monthly	**Date of visit:**	
Location:			
Description:			
Site visit by:			

Inspection Items	**Yes/No**	**Action required (details)**
Sediment accumulation at inflow points?		
Litter within swale?		
Erosion at inlet or other key structures (e.g. crossovers)?		
Traffic damage present?		
Evidence of dumping (e.g. building waste)?		
Vegetation condition satisfactory (density, weeds etc.)?		
Replanting required?		
Mowing required?		
Clogging of drainage points (sediment or debris)?		
Evidence of ponding?		
Set down from kerb still present?		
Damage/vandalism to structures present?		
Surface clogging visible?		
Drainage system inspected?		
Remulching of trees and shrubs required?		
Soil additives or amendments required?		
Pruning and/ or removal of dead or diseased vegetation required?		
Resetting of system required?		

Comments

Appendix 4 – Maintenance requirements for sediment basins

Sediment basins treat runoff by slowing flow velocities and promoting settlement of coarse to medium sized sediments. Maintenance revolves around:

- Ensuring inlet erosion protection is operating as designed
- Monitoring sediment accumulation
- Ensuring that the outlet is not blocked with debris.

Outlets from sedimentation basins should be designed so that access to the outlet does not require a water vessel. Maintenance of the littoral vegetation including watering and weeding is also required, particularly during the first two years or the plant establishment period.

Inspect the inlet configuration following storm events soon after construction to check for erosion. Regular checks of sediment build up will also be needed as sediment loads from developing catchments vary significantly. The basins must be cleaned out if they are more than half full of accumulated sediment.

Debris removal is an ongoing maintenance requirement. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of debris should be done regularly.

Typical maintenance of sedimentation basins will involve:

- Routinely inspecting the sedimentation basin to identify:
  - depth of sediment accumulation
  - damage to vegetation
  - scouring or litter
  - debris build up (after first 3 significant storm events and then at least every 6 months)
- Routinely inspecting inlet and outlet points to identify any:
  - areas of scour
  - litter build up
  - blockages
- Removing litter and debris
- Removing and managing invasive weeds (both terrestrial and aquatic)
- Periodic draining and desilting (usually every 5 years) – this will require excavation and dewatering of removed sediment and disposal to an approved location
- Regular watering of littoral vegetation during plant establishment
- Replacing plants that have died (from any cause) with plants of equivalent size and species as detailed in the planting schedule.

Sediment Basins Maintenance Checklist

Asset I.D.:			
Inspection frequency	3-6 monthly	**Date of visit:**	
Location:			
Description:			
Site visit by:			

Inspection Items	**Yes/No**	**Action required (details)**
Litter accumulation?		
Sediment accumulation at inflow points?		
Sediment requires removal (record depth, remove if >50%)?		
All structures in satisfactory condition (pits, pipes, ramps etc.)?		
Evidence of dumping (building waste, oils etc.)?		
Littoral vegetation condition satisfactory (density, weeds etc.)?		
Replanting required?		
Weeds require removal from within basin?		
Settling or erosion of bunds/batters present?		
Damage/vandalism to structures present?		
Outlet structure free of debris?		
Maintenance drain operational (check)?		
Resetting of system required?		

Comments

Appendix 5 – Maintenance requirements for bioretention basins, rain gardens and WSUD treepits

Vegetation plays a key role in maintaining the porosity of the filter media of a bioretention system. A strong healthy growth of vegetation is critical to its performance.

The plant establishment period, during the first two years, is the most intensive period of maintenance. This is when:

- Weeds may need to be removed
- Replanting may be required
- Watering may be required.

Inflow systems and overflow pits require careful monitoring, as these can be prone to scour and litter build up. Where sediment forebays are adopted, regular inspection of the forebay is required. Remove accumulated sediment as required.

Debris removal is an ongoing maintenance requirement. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of debris should be done regularly.

For larger bioretention basins, it’s essential to design and maintain a maintenance access point in the bioretention basin. The design will be guided by the size and complexity of the system and may involve provision of a reinforced concrete ramp/ pad for truck or machinery access.

Routinely inspect the bioretention basin profile to identify any:

- Areas of obvious increased sediment deposition
- Scouring from storm flows
- Rill erosion of the batters from lateral inflows
- Damage to the profile from vehicles
- Clogging of the bioretention basin (evident by a ‘boggy’ filter media surface).

Typical maintenance will involve:

- Routinely inspecting inflows systems, overflow pits and under-drains to identify and clean any:
  - areas of scour
  - litter build up
  - blockages
- Removing sediment where it is smothering vegetation
- Removing accumulated sediment where a sediment forebay is adopted
- Repairing any damage to the profile resulting from scour, rill erosion or vehicle damage by replacement of appropriate fill (to match the design media) and revegetating
- Tilling of the surface, or removal of the surface layer, if there is evidence of clogging
- Regular watering/irrigation of vegetation until plants are established and actively growing
- Removing and managing invasive weeds (herbicides should not be used)
- Removing plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule
- Pruning to remove dead or diseased vegetation material and to stimulate growth
- Monitoring and controlling vegetation pests.

Resetting (i.e. complete reconstruction) of the bioretention system will be required if it fails to drain adequately after tilling of the surface.

Maintenance should only occur after a reasonably rain free period when the soil in the bioretention system is dry. Inspections are also recommended following large storm events to check for scour and other damage.

Bioretention Systems Maintenance Checklist

Asset I.D.:			
Inspection frequency	3-6 monthly	**Date of visit:**	
Location:			
Description:			
Site visit by:			

Inspection Items	Yes/No	Action required (details)
Sediment accumulation at inflow points?		
Litter within system?		
Erosion at inlet or other key structures?		
Traffic damage present?		
Evidence of dumping (e.g. building waste)?		
Vegetation condition satisfactory (density, weeds etc.)?		
Watering of vegetation required?		
Replanting required?		
Mowing/slashing required?		
Clogging of drainage points (sediment or debris)?		
Evidence of ponding?		
Damage/vandalism to structures present?		
Surface clogging visible?		
Drainage system inspected?		
Resetting of system required?		

Comments

Appendix 6 – Maintenance requirements for constructed wetlands

Wetlands treat runoff by filtering it through vegetation and providing extended detention to allow sedimentation to occur. In addition, they have a flow management role that needs to be maintained to ensure adequate flood protection for local properties and protection of the wetland ecosystem.

Maintaining healthy vegetation and adequate flow conditions in a wetland are the key maintenance considerations. The main tasks are:

- Weeding
- Planting
- Mowing
- Removing debris.

The inlet zone needs to be maintained in the same way as sedimentation basins. Routine maintenance of wetlands should be carried out once a month.

The plant establishment period, during the first two years, is the most intensive period of maintenance. This is when:

- Weeds may need to be removed
- Replanting may be required
- Large loads of sediments could impact on plant growth, particularly in developing catchments with poor building controls.

Debris removal is an ongoing maintenance requirement. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of debris should be done regularly.

Typical maintenance of constructed wetlands will involve:

- Desilting the inlet zone following the construction/ building period
- Routinely inspecting the wetland to identify any damage to vegetation, scouring, formation of isolated pools, litter and debris build up
- Routinely inspecting the inlet and outlet points to identify any areas of scour, litter build up and blockages
- Removing litter and debris
- Removing and managing invasive weeds
- Repairing the wetland profile to prevent the formation of isolated pools periodicly (usually every 5 years)
- Draining and desilting of the inlet pond every 2 to 5 years
- Regular watering of littoral vegetation during plant establishment
- Controlling the water level during plant establishment
- Replacing plants that have died (from any cause) with plants of equivalent size and species as detailed in the planting schedule
- Monitoring and controlling vegetation pests.

Inspections are recommended following large storm events to check for scour and damage.

Bioretention Basins Maintenance Checklist

Asset I.D.:			
Inspection frequency	3-6 monthly	**Date of visit:**	
Location:			
Description:			
Site visit by:			

Inspection Items	**Yes/No**	**Action required (details)**
Sediment accumulation at inflow points?		
Litter within inlet or macrophyte zones?		
Sediment within inlet zone requires removal (record depth, remove if >50%)?		
Overflow structure integrity satisfactory?		
Evidence of dumping (building waste, oils etc.)?		
Terrestrial vegetation condition satisfactory (density, weeds etc.)?		
Aquatic vegetation condition satisfactory (density, weeds etc.)?		
Replanting required?		
Settling or erosion of bunds/batters present?		
Evidence of isolated shallow ponding?		
Damage/vandalism to structures present?		
Outlet structure free of debris?		
Maintenance drain operational (check)?		
Resetting of system required?		

Comments

Appendix 7 – Maintenance requirements for infiltration

Maintenance for infiltration measures aims to:

- Stop the system clogging with sediments
- Keep the appropriate infiltration rate.

The most important consideration during maintenance is to ensure the pre-treatment elements are operating as designed to:

- Avoid blockage of the infiltration measure
- Prevent groundwater contamination.

The infiltration zone should be inspected every 3-6 months (or after each major rainfall event) to ensure the system is operating as designed. Frequency will depend on the size and complexity of the system.

Typical maintenance of infiltration systems will involve:

- Routinely inspecting the system to identify any surface ponding after the design infiltration period, which would indicate clogging/blockage of the underlying aggregate or the base of the trench
- Routinely inspecting inlet points to identify any areas of scour, litter build up, sediment accumulation or blockages
- Removing of accumulated sediment and clearing of blockages to inlets
- Tilling of the infiltration surface, or removing the surface layer (if there is evidence of clogging)
- Maintaining the surface vegetation (if present).

Infiltration Maintenance Checklist

Asset I.D.:			
Inspection frequency	3-6 monthly	**Date of visit:**	
Location:			
Description:			
Site visit by:			

Inspection Items	**Yes/No**	**Action required (details)**
Sediment accumulation in pre-treatment zone?		
Erosion at inlet or other key structures?		
Evidence of dumping (e.g. building waste)?		
Evidence of extended ponding times (e.g. algal growth)?		
Evidence of silt and clogging within 'detention volume'?		
Clogging of flow management systems (sediment or debris)?		
Damage/vandalism to structures present?		
Drainage system inspected?		
Resetting of system required?		

Comments

Appendix 8 – Maintenance requirements for sand filters

Sand filter maintenance mainly concerns:

- Regular inspections (3-6 monthly) to inspect the sedimentation chamber and the sand filter media surface, in particular immediately after construction
- Checking for blockage and clogging
- Removal of accumulated sediments, litter and debris from the sedimentation chamber
- Checking to ensure the weep holes (if provided) and overflow weirs aren't blocked.

To maintain the flow through a sand filter, it's essential to inspect regularly and remove the top layer of accumulated sediment. Inspections should be conducted after the first few significant rainfall events following installation and then at least every six months. Inspections will help to determine the long term cleaning frequency for the sedimentation chamber and the surface of the sand media.

Removing fine sediment from the surface of the sand media can typically be done with a flat bottomed shovel. Tilling below this surface layer can also maintain infiltration rates. The complete surface area of the sand filter must be accessible. This is a key consideration during the design stage.

Sediment accumulation in the sedimentation chamber must be monitored. Sediment deposition can overwhelm the chamber and reduce flow capacities, depending on catchment activities (e.g. building phase).

Debris removal is an ongoing maintenance function. Debris can block inlets or outlets, and be unsightly if located in a visible location. Inspection and removal of debris/ litter should be carried out regularly.

Sand Filters Maintenance Checklist

Asset I.D.:			
Inspection frequency	3-6 monthly	**Date of visit:**	
Location:			
Description:			
Site visit by:			

Inspection Items	**Yes/No**	**Action required (details)**
Litter within filter area?		
Scour present within sediment chamber or filter?		
Removal of fine sediment required?		
All structures in satisfactory condition (pits, pipes etc.)?		
Sediment requires removal from sedimentation chamber (record depth, remove if >50%)?		
Traffic damage evident?		
Evidence of dumping (e.g. building waste)?		
Clogging of drainage weep holes or outlet?		
Evidence of ponding (in sedimentation chamber or sand filter)?		
Damage/vandalism to structures present?		
Surface clogging visible?		
Drainage system inspected?		

Comments