ACT Planning & Land Authority

Waterways
Water Sensitive Urban Design
General Code

Table of contents

Foreword

As Canberra expands and grows, the water cycle undergoes a transformation from its natural regime. This transformation poses a significant risk to our environment as a result of:

- a growing demand for mains water that requires an increased abstraction of water from either our existing water supply catchments or from new catchments;
- increasing volumes of wastewater that require treatment prior to discharge into the Murrumbidgee River;
- increases in the rate and volume of stormwater runoff which can erode our waterways and destroy ecological habitats; and
- increased mobilisation of pollutants such as nutrients, sediment and litter into local waterways, ponds and lakes.

The costs of these impacts are not limited to the environment. They include significant social and economic costs as well. Some of these costs include:

- loss of amenity in our public places - our waterways and lakes become unattractive and can be closed to recreational use due to potential health risks; and
- loss of biodiversity - changed flow regimes and water quality in our creeks can no longer support species we value in our environment.

It is our continuing commitment to sustainability that has highlighted the need to embrace new techniques and an integrated view of the water cycle in our urban environment.

Waterways is part of the ACT Government's broader strategy of responsible water resource management to ensure the future sustainability of our community. The code incorporates the principles of water sensitive urban design (WSUD) which aims to integrate the management of the total water cycle into the urban development process. Initially focused on reducing the impacts of urban development and redevelopment on stormwater runoff, the definition of WSUD has been broadened to encompass management of the total urban water cycle. The implementation of WSUD involves the application of a broad range of measures aimed at:

- reducing the reliance on the town water supply system;
- optimising the opportunities for the use of stormwater and reuse of wastewater (both treated effluent and greywater); and
- reducing the export of stormwater runoff and associated pollutants to pre-development levels.

Andrew Barr MLA
Minister for Planning

Note

Water Ways was released by ACT Minister for Planning Andrew Barr MLA on 6 July, 2007. Water Ways is to be implemented in conjunction with the ACT's new planning legislation and the new Territory Plan.

This document is referred to as a 'General Code' throughout, however it should be noted that its status as a General Code will only come into effect when the new Territory Plan does.

In the interim, users of Water Ways are encouraged to incorporate the principles of water sensitive urban design as part of their planning and building processes.

1. Introduction

Water sensitive urban design (WSUD) is an approach to urban planning and design that aims to integrate the management of the urban water cycle into the urban development process. The ACT Government is committed to the introduction of WSUD as part of a broader strategy of responsible water resources management.

On 5 June 2002 (World Environment Day), the ACT Legislative Assembly passed a motion about water management. It was agreed that:

- as far as possible, the building of further water supply dams in the ACT should be avoided;
- the water leaving the ACT via the Murrumbidgee River should be of no less quality than the water flowing into the ACT; and
- adequate flows should be maintained in the ACT waterways to maintain their environmental values.

The ACT Government released ***think water, act water – a strategy for sustainable water resource management*** in April 2004. This strategy commits the ACT to world-class responsible urban water management. One of the six objectives of the strategy is to "facilitate the incorporation of water sensitive urban design principles into the urban, commercial and industrial development". The specific Canberra-wide targets identified in the strategy are:

- a 12 percent reduction in mains water usage per capita by 2013, and a 25 per cent reduction by 2023 (compared with 2003), achieved through water efficiency, sustainable water recycling and use of stormwater;
- an increase in the use of treated wastewater (reclaimed water) from 5% to 20% by 2013;
- the level of nutrients and sediments entering ACT waterways is no greater than from a well-managed rural landscape; and
- a reduction in the intensity and volume of urban stormwater flows so that the runoff event that occurs on average once every 3 months, is no larger than it was prior to development.

There are a number of key principles which underpin the implementation of WSUD. These are:

- the principles of integrated catchment management;
- protecting ecological and hydrological integrity;
- integration of good science and community values in decision making;
- management of stormwater as close to source as possible; and
- equitable cost sharing.

WSUD provides many benefits to both the community and the environment. WSUD can be employed in a cost-effective manner in new developments, and in many cases, through retrofitting. Moreover, improved land use and urban development planning through greater integration of the natural water cycle can generate long-term social, economic and environmental benefits for the ACT. WSUD provides a paradigm shift from the traditional approach of planning water supply, wastewater and stormwater management systems as separate services. It provides an integrated approach to the provision of these services, to achieve effective management of the urban water cycle.

However, WSUD alone cannot fully achieve our objectives for sustainable water resource management. There is also a need for us all to change our habits and attitudes to the use of water, recognising it as a valuable resource. The ACT Government is pursuing a range of other water-related initiatives, such as a water efficiency program assisting existing householders to improve their water efficiency. There is also a need for households and individuals to play their part, to change our behaviour in how we use water. For example, we should consider taking shorter and less frequent showers and only use the washing machine when we have a full load. It is only by taking a holistic approach to water conservation that we can truly optimise our use of this valuable natural resource.

This code provides mandatory targets for reduction in mains water consumption and stormwater quality and quantity management. The target for mains water consumption reduction is 40%, compared to pre-2003 consumption levels. This target must be achieved in all new developments and redevelopments, whether that developments are single residential, multi-unit residential, estate, commercial, industrial or institutional. The stormwater management targets are to be achieved on estates and larger multi-unit sites, as well and commercial, industrial and institutional developments.

1.1. What is water sensitive urban design?

When we build and expand our cities and towns, we significantly modify the natural water cycle. There is a dramatic increase in stormwater runoff and associated pollutants, causing serious degradation of our natural river systems. Water is imported from water supply catchments and wastewater is discharged through the sewerage system back into local rivers and streams.

There is now much attention on how to better manage water in urban areas. This approach is known as water sensitive urban design. WSUD seeks to provide a more sustainable approach to the management of the total water cycle within the urban environment. This is achieved by a range of measures that can be applied at a broad range of scales, from large public open space areas to individual blocks, aimed at:

- minimising disruption to natural drainage pathways (eg. retention of native vegetation, mulched pervious areas, dispersed overland flow paths, vegetated natural waterways, wetlands and floodplains);
- minimising impervious areas and enhancing the permeability of remaining pervious areas (eg. mulching, protection from vehicle compaction);
- reducing the hydraulic connectivity of the stormwater system by the use of swales, vegetated waterways, wetlands and ponds rather than pipes and lined channels;
- offsetting the impacts of development by incorporating retention capacity (eg. infiltration, rainwater tanks, swales, wetlands, ponds and retarding basins);
- minimising water requirements and reducing stormwater runoff by adopting landscaping strategies (eg. mulching, reduce lawn areas, water efficient lawns, ponds and gardens);
- conserving water by installing water efficient fixtures and appliances;
- harvesting rainwater with storage in rainwater tanks (or other storage devices) for internal (eg. toilet flushing, washing machines) and external (garden irrigation) use; and
- use of greywater and treated effluent for non-potable purposes.

1.2. Why a WSUD Code is necessary

The purpose of this code is to provide a methodology for the implementation of water sensitive urban design (WSUD) in the ACT to assist in achieving the specific targets set out in *think water, act water – a strategy for sustainable water resource management*. This code applies:

- development of new residential neighbourhoods and estates;
- re-development or in-fill development within the existing built environment; and
- institutional, commercial and industrial developments.

As such, this code signifies the ACT Government's commitment to incorporating WSUD into its own planning and development processes, as well as requirements placed on private developers, builders and homeowners. It is this commitment by the Government that will ensure that metropolitan-wide targets are met as well as targets for individual developments.

Low water use garden

Bio-swale drainage system

Rainwater collection system

Examples of WSUD measures Sources: A I Lawrence & Enviro Links Design

This code provides mandatory targets for mains water use reduction and for stormwater quality and quantity management. These targets must be met for all new developments and redevelopments. The code describes a broad range of measures that can be utilised to achieve these targets and identify a number of assessment tools that can be used to demonstrate that the targets are being met. They also provide a range of acceptable solutions to assist with meeting the targets on less complex developments.

1.3. Who should use the code

- **Government agencies and utilities** – To achieve sustainable water cycle management, Government agencies and utilities, with responsibilities for various aspects of water management, need to be aware of the interaction between the various aspects and to integrate their activities in order to achieve the specific targets set out in *think water, act water*.

  Government agencies and utilities include the ACT Planning and Land Authority, the Land Development Agency, Department of Territory and Municipal Services, ACTEW and ActewAGL.

- **Land developers** – Land developers, both public and private sectors, will use this code in the planning and design of all new urban developments and redevelopments. To achieve the specific targets set out in *think water act water*, there is a need to ensure that all new developments fully integrate the requirements of WSUD. As well as meeting sustainability objectives, the integration of WSUD can improve the visual appeal of an area and significantly enhance the value of properties within the development. In some instances, particularly with re-development projects it may be difficult to meet all necessary WSUD requirements. In such cases it may be possible, with the approval of the Authority, for the developer to consider a contribution to the construction of off-site measures as a means of offset.

- **Commercial developers** – Developers of commercial, industrial and institutional facilities will use this code to ensure their developments comply with the relevant targets and objectives. There are commercial benefits, as well as environmental benefits, to be gained by the integration of WSUD principles into these developments.
- **Planners and consultants** – Planners and consultants should use this code firstly to understand the concepts behind current best management practices and also for specific information on the planning and design of WSUD measures for new projects.
- **Builders and homeowners** –All new dwellings, as well as extensions and alterations that increase the floor area by more than 50%, are required to comply with this code. Many of the measures identified in the code can also be implemented in and around existing homes. "Achieving Sustainable Residential Development", published by the Authority, provides additional information on measures which can be applied to both private and public housing.

1.4. Legislative and policy context

A range of legislation requires ACT Government agencies to responsibly manage the water cycle. It is important to understand the legislative and administrative framework related to the Authority and application of the ACT water sensitive urban design code, and their relation to other legislative and administrative requirements and approval processes.

The relevant legislative and policy framework is outlined in the following sections.

1.4.1 People place prosperity

The ACT Government's approach to sustainability, outlined in People, Place, Prosperity describes the sustainability principles that the ACT Government will incorporate into its systems and operations. It commits the ACT Government to:

- embedding sustainability within its decision-making processes;
- promoting sustainability to the wider community;
- developing partnerships for sustainability with the ACT community; and
- developing indicators and reporting regularly on progress.

Water is an environmental resource that we value in all its forms. It provides for the well being of our citizens and our environment. It underpins many aspects of our economy and it is one of the features that define the character of Canberra. The sustainable management of water is a key activity if we are to protect the values of people, place and prosperity. Water sensitive urban design is a key aspect of the sustainable management of water in the ACT.

1.4.2 *think water act water*

think water, act water – a strategy for sustainable water resource management was launched by the Chief Minister in April 2004. It provides long-term guidance for the management of ACT water resources. One of the key objectives of the strategy is the introduction of WSUD.

The Water Resources Act 1998 provides for the management of the water resources in the ACT. The Act requires a Water Resources Management Plan to be prepared. *think water, act water* has been tabled in the Legislative Assembly as the Water Resources Management Plan under the Water Resources Act.

1.4.3 National Capital Plan

Planning with the Territory is guided by the Commonwealth through the National Capital Plan, administered by the National Capital Authority (NCA), and through the Territory Plan, administered through the ACT Planning and Land Authority. The National Capital Plan provides a general policy framework for land use and planning in the Territory, and more specifically guides the planning, design and development of areas of the Territory that have been identified as having national capital importance (Designated Areas). Any significant departure from the metropolitan structure for the Territory contained in the National Capital Plan requires the Commonwealth's agreement to amend the National Capital Plan. Any such amendment would include consideration of matters of national significance. Included in these objectives is ***the development of a city which both respects environmental values and reflects concerns with the sustainability of Australia's urban areas***. The WSUD code addresses this and other objectives of the National Capital Plan.

1.4.4 Territory Plan

The ACT's planning legislation sets out the provisions for permitting, maintaining or changing land use in the Territory and prescribes the object of the Territory Plan, which guides planning at a Territory level. It currently states that:

> *The object of the Territory Plan is to ensure, in a manner not inconsistent with the National Capital Plan, the planning and development of the ACT provide the people of the ACT with an attractive, safe and efficient environment in which to live, work and have their recreation.*

The Territory Plan provides a strategic framework for the management of development and land use change in the ACT. The Plan sets out broad principles which will guide development and manage change over the next 10-15 years. It sets out strategies in respect to sustainable development, integrated land and water based planning, and environment and high quality design.

The Territory Plan includes planning controls for development.

1.4.5 Canberra Spatial Plan

The Canberra Spatial Plan was released by the ACT Government in March 2004 and provides strategic directions for the development of Canberra over the next 30 years and beyond. It is the Territory's key strategic planning document for directing and managing urban growth and change. It puts in place a framework that encourages and facilitates population growth and seeks to ensure that we can sustainably provide for this community of the future.

The Spatial Plan includes the objective to "create and establish a built form and city layout that minimises resource consumption, including water and energy use".

1.4.6 Environment Protection Act

The Environment Protection Act 1997 (the Act) provides for the protection of the environment. The Water Quality Standards detailed in the Act and the *Environment Protection Regulation 2005* list the necessary water quality to support the water uses referred to in the Territory Plan. The Territory Plan sets the permitted uses for waters in the ACT and their catchments according to the predominant water use or environmental value. The three types of water use are:

- conservation;
- water supply; and
- drainage and open space.

Each category has a water use policy which sets specific objectives and environmental values in the water use and catchment policies of the Territory Plan.

1.4.7 Water Resources Act

Control of all water use in the Territory is vested with the Territory. This means that a licence to take water is required to use groundwater, water from streams, rivers and dams. However, there are some exceptions, so if a component of WSUD involves the taking of water from a pond/wetland/dam, there is a need to check the requirement for a licence.

1.5. Planning processes

This code applies to all stages of planning for new developments and redevelopments, as outlined below.

1.5.1 Metropolitan land use planning

The Territory Plan, administered by the ACT Planning and Land Authority, is the key statutory planning document in the ACT, providing the policy framework for the administration of planning in the ACT. The purpose of the Territory Plan is to control land use change and development in a manner consistent with strategic directions set by the ACT Government, Legislative Assembly and the community. It must not be inconsistent with the National Capital Plan. The Territory Plan includes broad principles and policies that guide development, through land use specific objectives and policies.

The Territory Plan consists of the Territory Plan Map and the Written Statement, and is updated on a regular basis through a process of variations to the Territory Plan.

1.5.2 Structure and concept plans

Structure and concept planning for new developments is undertaken by the Authority. These are prepared in conjunction with other Government agencies and through a process of public consultation. Concept plans are developed for new estates, consistent with the framework of the Territory Plan and Spatial Plan. Once a concept plan is finalised, it is deemed to be a Precinct Code in the Territory Plan and used for development assessment.

1.5.3 Estate development

The planning and design for a new estate involves the preparation of an Estate Development Plan, which is subject to the approval of the Authority and other government agencies.

1.5.4 Development and building approvals

Development applications and building approvals are required to be submitted for new developments. The various assessment codes in the Territory Plan provide the rules criteria that must be met in relation to WSUD and demonstrate that the relevant targets will be achieved.

1.5.5 Capital works

The ACT Government's capital works projects are subjected to the development assessment process, the same as any other development proposal. All capital works projects are required to incorporate the principles of WSUD. Approval of capital works projects will be subject to the satisfactory inclusion of appropriate WSUD measures. The actual measures to be incorporated in each project will depend on both the nature and the location of the works involved.

1.6. Using the code

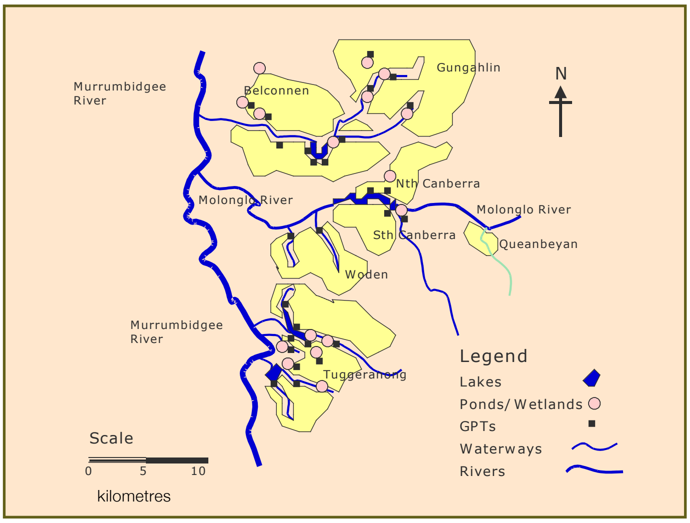
A suggested process for the design of WSUD measures is provided below. The process shown generally applies to larger-scale developments, but can also be used as a guide for smaller developments.

Step 1	Select the WSUD criteria applicable to the development type and scale
Step 2	Identify the available measures or sequence of measures
Step 3	Assess the ability and effectiveness of these measures to meet the targets
Step 4	Undertake the sizing and design for each WSUD measure
Step 5	Document the WSUD measures, complete the checklists and confirm the WSUD targets are met

1.6.1 Stages of the planning and development process

WSUD is to be incorporated into all levels of the planning and development process, as outlined below. This includes the broader scale planning activities undertaken by the ACT Government, as well as those activities undertaken by developers, builders and homeowners.

Metropolitan land use planning



Metropolitan scale stormwater planning

Metropolitan land use planning provides the framework for development within Canberra. It is at this scale that key features and strategies are set. This includes identification of major natural features (eg. rivers and other water features) to be protected, enhanced and incorporated into the urban structure. It also involves identification of key infrastructure elements, such as major urban lakes and ponds to be introduced into the urban structure.

Structure and concept planning

Structure and concept planning provides further details on land use planning. This includes the identification of specific strategies (eg. effluent reuse,) and identification of major WSUD measures (eg. ponds, wetlands and major GPTs).

North Gungahlin structure plan

Typical concept plan

Estate planning and design

Estate planning and design identifies the specific measures required to achieve WSUD outcomes (eg. neighbourhood ponds & wetlands, minor GPTs, swale drains, the need for broad application of on-block measures associated with an estate release).

Example of estate development plan

Block and section development

There are many opportunities to implement WSUD measures at the block level, whether it be a single detached dwelling, a multi-unit or apartment development or a commercial or industrial development. Whilst it is easier to implement these measures in new buildings, it is also possible to implement many of them in existing buildings and premises. For example, in many cases the installation of a rainwater tank or greywater system can be implemented easily.

Mains water use can be reduced significantly by initiatives such as water-efficient landscaping, installation of rainwater tanks and greywater systems and the use of water-efficient fixtures, fittings and appliances.

Rainwater tanks can also assist in managing stormwater runoff. Other measures to assist with stormwater runoff management include redirecting of downpipes, indirect drainage of impervious areas and on-site retention systems. Care needs to be taken when utilising such measures to ensure that the structural integrity of building footings is not compromised and that flooding does not become a nuisance.

In some instances, a neighbourhood water feature may be installed with a reliance on roof water runoff to maintain adequate inflow. In such cases, the developer will need to indicate that roof runoff should be allowed to flow directly to the stormwater system.

1.6.2 Scope of application

WSUD is to be implemented for all developments in the ACT, including greenfield and redevelopment projects and, as opportunities arise, in established urban areas.

Greenfield developments

New greenfield developments offer significant opportunities for the implementation of WSUD. They provide the opportunity to integrate WSUD measures into the development process at an early stage, without the constraints often encountered in retrofitting measures in existing urban areas. A WSUD focus can also enhance the attractiveness and appeal of a new development.

Redevelopment projects

It is anticipated that there will be an increasing number of redevelopment projects in the ACT. In particular, there will be continuing growth of inner city and town centre residential redevelopments. Redevelopment projects in existing neighbourhoods also offer significant opportunities to implement WSUD. These opportunities are generally more constrained than for in new estates and will generally be limited to block scale measures.

There are opportunities to capture and use rainwater for garden irrigation, toilet flushing, laundries and, in larger buildings, even in air-cooling towers. Greywater use systems can generally be easily installed in single residential developments, but may be more complex to implement in multi-unit developments because of the need to adequately address public health issues.

Neighbourhood wetland at the city edge re-development, O'Connor

Source: Enviro Links Design

Established urban areas

To meet the objectives of reducing mains water demand, increasing the use of treated sewage effluent and reducing stormwater runoff and improving its quality, it will be necessary to implement WSUD measures in established urban areas, both in public open space and at the block level.

The ACT Planning and Land Authority's publication "Achieving Sustainable Residential Development" provides advice on WSUD measures that can be implemented in and around the home.

The design of WSUD measures continues to evolve based on the monitoring of the performance of built measures and, as experience grows, with the on-going maintenance of the various measures.

New references and information will become available over time and designers are encouraged to use new and updated methodologies as they emerge. If a method which is not included in this code, or a new technology is available that can be appropriately applied to the specific development under consideration, then a design submission can be made using these methods in lieu of the methods identified in this document.

1.6.3 Innovation

Given the rate of innovation in WSUD measures and the frequency at which new information is available, the implementation of innovative WSUD solutions is strongly encouraged. When implementing innovative solutions, the following issues need to be considered:

Design considerations

A discussion and summary of the technical performance of the proposed WSUD measure should be included in any design submission, including appropriate references. Any other method or measure should be referenced to enable verification of the stated performance.

Intent

A description of the intent of the WSUD measure should be included in a development application submission.

Merit

New approaches or methods will be assessed on merit on the basis of incorporating amenity, protecting local ecosystems and natural processes, displaying local opportunities, whole of lifecycle costing and maintenance needs. A description of how the proposed WSUD measure reflects these values should be provided in the design submission.

Treatment trains

A discussion of how the proposed WSUD measure integrates with existing and other proposed measures into a treatment train should be discussed in the design submission. WSUD treatment trains must be designed to ensure that damage or nuisance to public and private assets is avoided.

Maintenance

The ongoing maintenance requirements, including any special equipment or expertise that will be needed, should be discussed in the design submission. Where large new WSUD measures are proposed, a management plan is to be prepared for these measures to protect them from damage during the construction and building activity stages of development, as this is when damage is most likely to occur.

1.7. Implementation

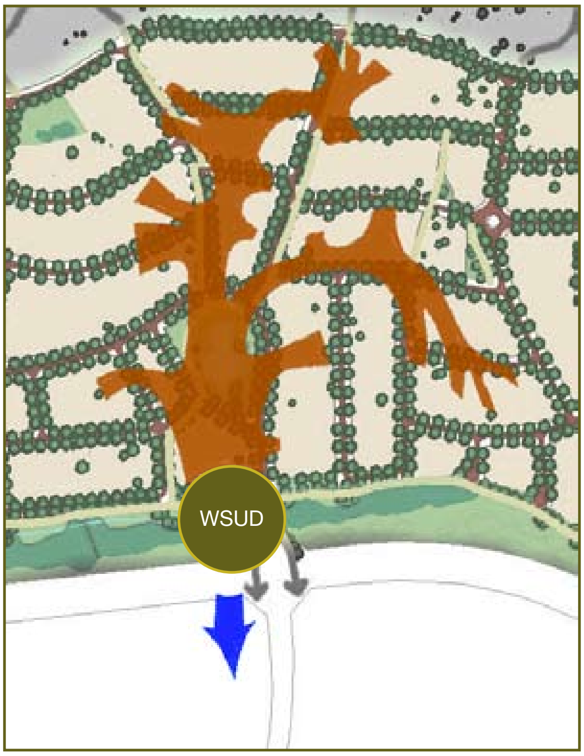
A range of WSUD measures can be implemented depending on the nature of the development and local conditions. All developments on individual blocks, regardless of whether they are residential, commercial, industrial or institutional, are required to comply with the mains water use reduction target. Any addition or alteration to a residential property, which will increase the floor area by greater than 50%, is also required to comply with the mains water reduction target for the whole property. The stormwater quality and quantity targets apply to all new residential estates, all residential developments with 3 or more residential units and any non-residential development where the total site is greater than 5,000 m^2. Without any WSUD measures in place, runoff and stormwater pollutant loads will progressively increase through the development before discharging from the development site.

Many opportunities exist to implement WSUD in new developments. By contrast, opportunities in existing developed areas are often constrained by available open space and existing uses of the open space, particularly landscaping. Options for implementation of actions and measures include:

- **Mains water use reduction**
  - Water efficient irrigation systems for playing fields and open space
  - Use of stormwater to replace mains water for irrigation
  - Water efficient landscaping, both on public open space and within leases
  - Rainwater tanks for garden watering and internal uses, such as toilet flushing
  - Use of greywater for irrigation and toilet flushing on individual dwellings
  - Wastewater treatment and reticulation to commercial or industrial users who do not require water of a mains water standard
- **Stormwater management**
  - Wetlands and ponds
  - Retarding basins integrated into public open space
  - Extended detention in major dry basins or in major wetlands, ponds or lakes
  - Filter strips, swales and bio-swales in lieu of piped drainage systems
  - Downpipes and impervious surfaces not directly connected to the stormwater system; direct runoff across lawns and gardens
  - Minimising impervious surfaces
  - Installing on-site detention storage, particularly in multi-dwelling sites (which may be increased in size to allow for water harvesting)
  - Creating extended detention volume in ornamental ponds or landscaped depressions
  - Direct connection of downpipes to a separate collection system to discharge to ornamental ponds to maintain water quality
- **Wastewater reuse**
  - Use of large-scale treated sewage effluent schemes
  - Use of domestic greywater, treated or untreated

The following examples illustrate a number of options for installing WSUD stormwater measures in a new estate. The diagrams indicate in each case the extent of untreated stormwater (shown in brown) and “treated” stormwater (shown in blue) that can be achieved.

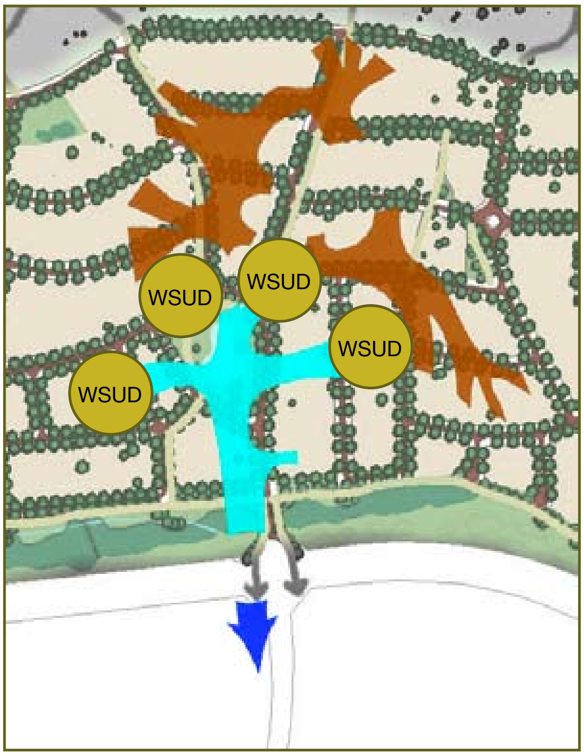
Single measure at estate outlet



An appropriately sized and designed single WSUD stormwater measure at the downstream end of an estate can satisfy water quality requirements downstream of the development, but will provide no water quality benefits within the development itself. Such a measure would normally be an appropriately sized pond or wetland.

Reliance on a single measure alone is not the preferred approach and should only be used where a system of more distributed measures is not practical. As well as placing a high level of reliance on the single WSUD measure, it also loses the opportunity to enhance the urban environment by the inclusion of WSUD measures into the local landscape.

Distributed neighbourhood measures



A more distributed system of WSUD measures will lessen the reliance on a single measure, improve water quality within a development and enhance both the aesthetic and environmental qualities of a development.

Measures could include additional ponds and wetlands, vegetated waterways, swales and bio-retention systems. Water quality improvement will be achieved downstream of each pond, reducing the areas of polluted stormwater runoff to the waterways above the ponds.

On-block measures only

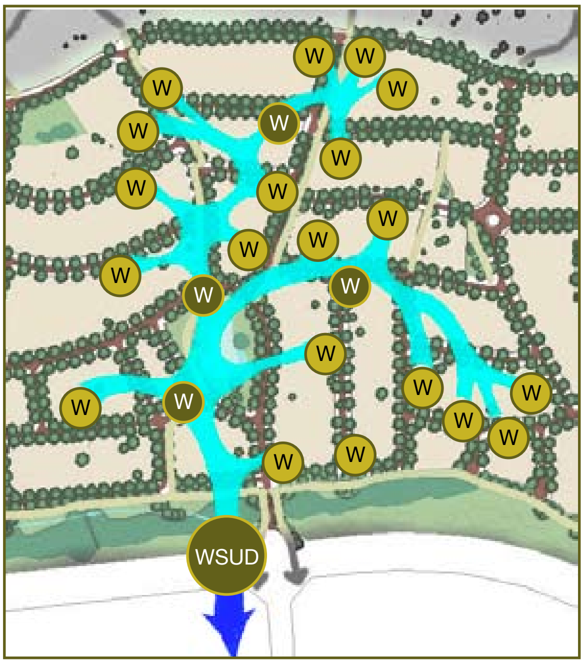
Measures can be implemented on-block to address the impact of development at its source and to add to both the aesthetic and environmental qualities of a development.

Measures for block scale implementation include:

- **Mains water use reduction**
  - Water efficient landscaping
  - Water efficient appliances and fixtures
  - Rainwater tanks for garden watering and internal uses (eg toilet flushing, laundry cold water)
  - Recycling of laundry and/or bath water (greywater)
- **Stormwater management**
  - Downpipes and other impervious surfaces not directly connected to the stormwater system
  - Distributing hard surface runoff onto permeable surfaces (lawns and gardens), with care not to direct flow to adjacent blocks
  - Installation of a small pond or wetland, particularly on multi-unit sites
- **Wastewater reuse**
  - Direct use of untreated greywater on gardens
  - Installation of a greywater treatment system, for use in toilets, laundries and gardens

On-block WSUD measures are encouraged in all new developments to promote more responsible water management. Such measures will contribute significantly to achieving WSUD targets, particularly in reducing mains water consumption.

Fully integrated solution



The preferred implementation of WSUD stormwater management is in a fully integrated solution, which includes on-block measures and measures in public space distributed throughout the development. This approach lessens the reliance on individual measures and provides opportunity to enhance the urban environment by the inclusion of these measures into the local landscape.

2. Mains water use reduction

Think water, act water sets the target of a 12 per cent reduction in mains water usage per capita by 2013, and a 25 per cent reduction by 2023 (compared with 2003), achieved through water efficiency, sustainable water recycling and use of stormwater and rainwater. The application of WSUD in new developments and redevelopments will play a significant role in achieving these targets. As there are more opportunities to reduce water consumption in new developments than in existing developed areas, these developments will need to bear a higher proportion of water use reduction.

The first priority should be to implement measures that reduce total per capita water consumption, such as low water-use landscapes and water-efficient fixtures and appliances. Consideration should also be given a "fit for purpose" approach - using alternative sources of water, based on their suitability for specific applications. Significant reductions in mains water use can be achieved when a "fit for purpose" approach is taken, although there is no reduction in total water usage. The following table indicates the opportunities for the application of a "fit for purpose" approach.

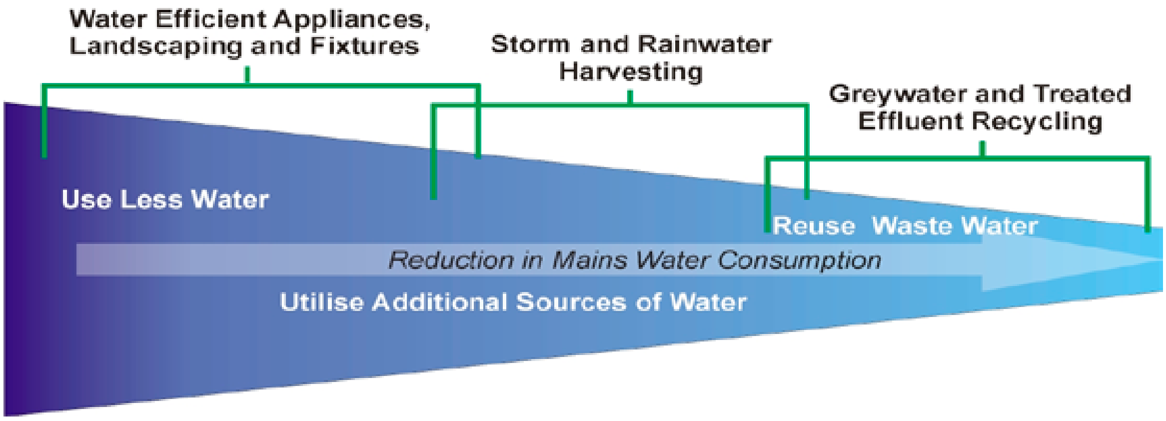
"Fit for purpose" water use

	Irrigation	Kitchen		Laundry		Toilet	Bathroom	
SOURCE		**Cold**	**Hot**	**Cold**	**Hot**		**Cold**	**Hot**
Mains water	3	1	2	1	2	3	1	2
Wastewater								
• Treated effluent	2	4	4	4	4	2	4	4
• Greywater	1	4	4	4	4	1	4	4
Stormwater								
• Roof water	2	2	1	1	1	2	2	1
• Non-roof water	2	4	4	4	4	2	4	4

1=Preferred use, 2=Compatible use, 3=Non-preferred use, 4=Not compatible

Source: Landcom WSUD best planning and management practices (2004)

The range of measures to reduce mains water usage is presented schematically below. The preferred order of implementation is from left to right based on effectiveness, cost and social acceptability.



2.1 Intent

The intent is to provide better management of our water resources, by:

- providing reduction in the use of mains water through increased water use efficiency;
- developing the resource potential of stormwater and wastewater to supply a range of water uses presently met by the mains water supply; and
- developing the resource potential of stormwater and wastewater to reduce the cost of drainage, wastewater and potable water infrastructure.

2.2 Performance targets

Based on individual development targets and demographic predictions for the various types of development in the ACT, it is estimated that the overall mains water consumption in the ACT would reduce from the current 57 GL/year to 54 GL/year in 2013 and to 50 GL/year in 2023.

The target for mains water use reduction is 40% (compared with 2003 water usage levels) in all new developments and redevelopments, including:

- single residential dwellings;
- residential estates (including on-block measures);
- multi-unit developments; and
- commercial, institutional and industrial developments.

The intent may be achieved where:

- on site and neighbourhood stormwater use systems are effective in collecting, storing stormwater for use;
- stormwater and wastewater re-use systems provide the community with opportunities to reduce mains water use;
- landscaping in public open space and in domestic gardens minimises irrigation requirements; and
- water efficient fixtures are fitted to all commercial, industrial and residential buildings.

2.3 Guidance

2.3.1 Assessment tools

The ACT Planning and Land Authority has developed an on-line tool to assess the performance of the measures proposed for residential properties. Other tools are also available, and they are detailed in Appendix B, with a brief summary of each tool given below.

BASIX

Introduced as part of the NSW planning system, BASIX (the Building Sustainability Index), is a web-based planning tool that measures the potential performance of new residential dwellings against sustainability indices.

BASIX ensures each dwelling design meets the NSW Government's targets of:

- up to 40% reduction in water consumption; and
- 25% reduction in greenhouse gas emissions, compared with the average home.

BASIX can be used to assess whether a new dwelling design meets the desired target reduction in water consumption compared with the average home. Compliance with this target is demonstrated through the completion of a BASIX assessment and the issuing of a BASIX Certificate.

Provision of a BASIX certificate (using Queanbeyan location data) for single and multi-unit residential developments in the ACT will be considered acceptable evidence that the WSUD requirement for mains water use reduction will be achieved.

Green Star

Green Star is a suite of rating tools developed by the Green Building Council Of Australia. It is a national voluntary system that evaluates the environmental performance of buildings. Rating tools are being developed for a range of building types and phases, with an initial focus on commercial office buildings.

Effectiveness of measures

	Residential blocks	Multi-unit residential	Estate development works	Commercial, industrial & institutional developments	Capital works (roads, ponds, earthworks, public areas)
Water efficient fittings and fixtures	High	High	N/A	High(1)	N/A
Water efficient mechanical plant	N/A	N/A	N/A	High(2)	N/A
Water efficient landscaping	High	Med	Med	High	Med
Rainwater storage and use	High	High	Med(3)	Med	N/A
Use of greywater	Med	Low(4)	N/A	Low(4)	N/A
Use of treated effluent (if available)	High	High	N/A	High	N/A

(1) May include items such as waterless urinals and infrared sensor taps

(2) May include closed circuit evaporative coolers and capture and reuse of roof water in cooling towers

(3) In some instances, there may be opportunities for neighbourhood-level rainwater storage to irrigate public areas

(4) Cost of managing health issues may preclude use of greywater in these cases

2.3.2 Rainwater storage

Typical household rainwater tank

Outline

Rainwater tanks and other storage devices are used to capture and store rainwater from a roof catchment. This stored water is then utilised in place of mains water for commercial, industrial or domestic uses that do not require a potable standard of water. On a residential block, stored rainwater can be used for garden watering, toilet flushing and laundry use. Use of rainwater for hot water systems is also a possibility and is currently under review in many jurisdictions.

Purpose

Rainwater tanks are a versatile WSUD measure. They can offset mains water demand and decrease stormwater peak flows and volumes, which can improve water quality downstream.

Design considerations

Roof size

The size of the roof that is drained to a rainwater tank is one of the main factors that govern the amount of water that can be harvested and reused. It is generally more effective to increase the contributing area of roof draining to a tank than to increase the tank size. Other key factors include the size of the tank and the amount and pattern of use of the stored rainwater.

Tank size

Tanks come in a wide range of shapes and sizes. The typical size of rainwater tanks installed on residential properties within urban areas (that are connected to mains water) is between 1 kL and 10 kL.

Demands

The use of stored rainwater for toilet flushing, laundry and lawn/ garden watering will reduce water levels in the rainwater tank and make available airspace to capture further water during the next storm. Increasing the demands on a rainwater tank by attaching more internal and external uses saves more mains water. There are particular advantages of attaching regular demands, such as toilet flushing or laundry use, to a rainwater tank, as the mains water savings are achieved continuously and the yield from the tank is significantly increased.

First flush devices and downpipe screens

A first flush device captures and diverts the initial runoff from a roof during a storm. Typically, the first flush runoff from a roof contains the most polluted water. First flush devices safeguard the quality of water captured in a rainwater tank. Downpipe screens prevent leaf litter and other larger items entering the downpipe and tanks.

Inverted siphon systems

Inverted siphon systems allow for rainwater to be collected from all downpipes on a house. These systems increase the supply of rainwater available for use.

Mains water buffer

During a prolonged dry period, all the water stored in a rainwater tank may be used. If the stored rainwater is for any internal use, then either a mains water buffer is required to maintain a minimum volume of water (preferably 10-20% of the total volume) in the tank or a system of valves to automatically connect the mains water to the internal plumbing if the tank runs dry.

Embodied energy and greenhouse gas impact

Energy and materials impact of rainwater tank manufacture and operation are substantially higher, in percentage terms, than the energy equivalent for reticulated water supply, especially when a pump is used with the tank. However, the absolute impact of rainwater tanks is not large in proportion to other impacts. In terms of greenhouse gas emissions, the overall additional impact of a rainwater tank and pump is equivalent to 50 to 100 kilometres per year of car travel. Water use is generally considered the most significant environmental indicator with respect to rainwater tanks. In respect to greenhouse gas emissions, steel tanks have the lowest impact, followed by concrete, with plastic tanks having the highest impact.

Design guideline

Guidance on the sizing and design of rainwater tanks for existing dwellings in the ACT is given in the following guideline:

ACT Government (2004) ***Rainwater tanks: Guidelines for residential properties in Canberra***, Published cooperatively by ActewAGL, Environment ACT and ACT Planning and Land Authority, February 2004. (This guide includes a number of graphs to assist in selecting an appropriately sized tank for a range of contributing roof areas and likely uses.)

2.3.3 Landscaping

Outline

Canberra households use almost half their mains water for gardens. Playing fields and parks are generally irrigated using mains water, rather than alternative sources, such as ponds and lakes. We can change the way we use water and the need for water in the landscapes we design, in both private and public realms, to achieve water conservation targets. Key landscape elements that relate to WSUD are outlined below with suggested performance measures.

Soils

Canberra soils are generally clay-based and therefore do not absorb water quickly. Runoff can occur before saturation. They have fine particle size, so are easily eroded. At all scales of development, measures should be taken to achieve:

- soil stability to prevent erosion and sedimentation;
- stormwater free of sediment;
- ground water recharge;
- enhanced water penetration through soil improvement; and
- retention of upper soil moisture.

Plants

Canberra's microclimates can sustain a wide variety of plants from grasses to large trees, both native and exotic, evergreen and deciduous. Plants that are deep rooting and tolerant of drought, heat, cold (frost) and wind will perform well once established, and may not require significant supplementary water.

At all scales of development plants used should be grouped according to water requirements:

- Zero or low water use for irrigation (xeriscape); or
- High water use (eg exotic grass/lawns), though kept to a minimum area.

Water sources

To achieve water conservation targets, measures should be taken at all scales of development, in both private and public open space, to:

- reduce use of mains water;
- make better use of rainwater, either directly or by storage for later use; and
- reuse wastewater, where appropriate.

Design considerations

Public open spaces

The quality and quantity of designed landscapes in neighbourhoods need to be sustainable as well as provide the necessary amenity. Where possible, parks and local playing fields should be located and designed to better harvest and use stormwater and treated effluent.

Private gardens

Private outdoor spaces (gardens) should be designed to provide household amenity in a sustainable manner, while contributing to the streetscape and neighbourhood. Irrigation systems can be manual or automatic. The method of delivery of the water is most important. Sub-surface watering systems (drip irrigation) lose less water to evaporation and wind drift than spray or micro-jet irrigation. Gardens should be designed:

- with low water use plants and mulched surfaces to minimise water loss;
- to minimise watered lawns to areas of high use;
- to co-locate areas of high water use plants (eg vegetables and annuals);
- to utilise water sources other than mains water;
- to maximise rainfall soaking into areas that need it;
- to allow space for storage of roof runoff (rainwater) in tanks or other storage devices; and
- with effective watering systems.

2.4. Acceptable solutions

Each individual block must demonstrate compliance with the mains water use reduction target of 40%. For multi-unit residential, commercial, industrial and institutional developments, calculations need to demonstrate this target is being achieved. For **single residential blocks**, the following tables indicate solutions which will be accepted as "deemed to comply" with this target. If one of these options is selected, there is no requirement to further demonstrate that the target is being met.

For blocks less than 300m^2, the inclusion of water-efficient plumbing fittings will be accepted as meeting the 40% target. The use of water-efficient plumbing fixtures is already mandatory for all new dwellings in the ACT.

Option 1: Rainwater Tank

Block size 300 to 500 m^2

Minimum tank size (litres)	Minimum roof area connected to tank	Tank connected to at least:
2,000	50% or 75m^2	Toilet, laundry cold water, all external uses

Block size 500 to 800 m^2

Tank size (litres)	Minimum roof area connected to tank	Tank connected to at least:
4,000	50% or 100m^2	Toilet, laundry cold water, all external uses

Block size greater than 800 m^2

Tank size (litres)	Minimum roof area connected to tank	Tank connected to at least:
10,000	50% or 125m^2	Toilet, laundry cold water, all external uses

Option 2: Greywater system

If this option is adopted, all bathroom and laundry greywater is to be captured and treated, with greywater connected to laundry cold water, all toilet flushing and all lawn and garden irrigation. The greywater system must treat water to a Class A standard.

For non-residential developments, and for residential developments not utilising the solutions in the above tables, calculations demonstrating the required reduction in mains water consumption are to be provided in summary form as part of a development application. The reductions should be based on what mains water consumption will be for the proposed development compared to what a typical similar development would have consumed prior to 2003. In these calculations it can be assumed that for pre-2003 developments all appliances and fittings would have been A rated and that dual flush toilets of 6L/3L flushes would have been used. These calculations can be undertaken using:

- the on-line spreadsheet calculator available on the ACT Planning and Land Authority website;
- the BASIX tool as used in NSW (using Queanbeyan as the climate zone);

- the Green Star tool for commercial developments; or
- spreadsheets incorporating the required comparison.

Consideration of landscaping proposals will not be accepted as part of the assessment of meeting the 40% target.

As a guide, the average household consumption in the ACT (from 1998 to 2002) was 330 kL/year (or 120 kL/person per year based on a household occupancy of 2.74) while the average consumption for units in the ACT was 214 kL/year (89 kL/person per year based on a unit occupancy of 2.41).

Measures that can be considered for meeting these targets include:

- mandatory ★★★ rated (or better) plumbing fixtures;
- use of rainwater tanks for garden watering, toilet flushing and laundry uses; and
- on-site greywater recycling.

Where a rainwater tank or greywater treatment system is installed, it should be connected to laundry cold water, all toilet flushing and all external taps.

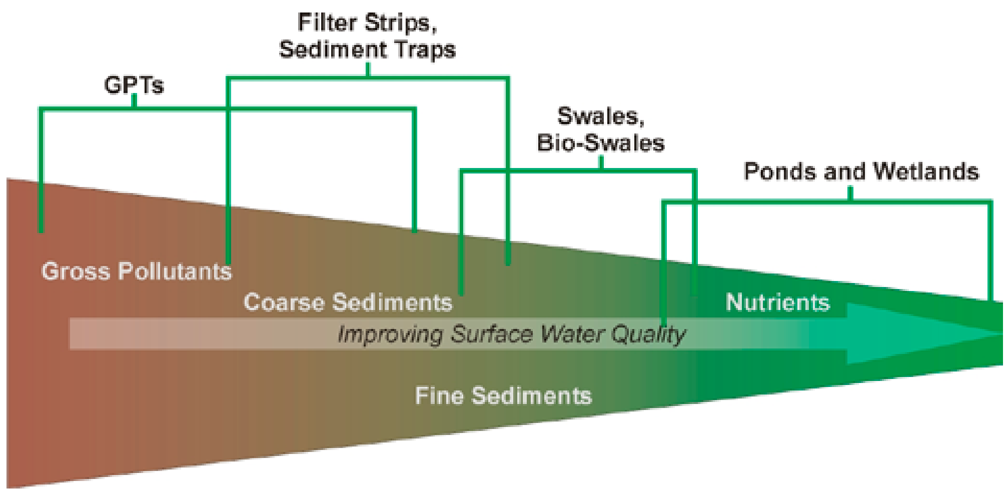
Use of groundwater from building basement pump-out systems would also be an acceptable substitution for potable water use, particularly for apartment and commercial buildings with deep basements.

The use of untreated greywater is permitted for direct use on gardens only and not through spray irrigation systems. Untreated greywater must not be stored for more than 24 hours. Direct use of untreated greywater does not meet the requirements of option 2 above, but is nonetheless an effective way of reducing mains water consumption.

3. Stormwater quality

The existing system of urban ponds and lakes in the ACT provides for significant capture of sediments and nutrients. A number of measures can be put in place that will supplement these. Other measures which will assist in reducing the export of nutrients and sediments include the use of swales, bio-swales and other bio-filtration systems (trenches, basins), use of buffer strips and better erosion and sediment control on building sites. The design philosophy of immediate collection and piping of stormwater is no longer preferred and stormwater should be utilised, slowed and treated prior to entering the piped system.

The reduction in the export of sediments and nutrients from a development requires the implementation of a strategy that progressively captures coarse, medium and fine sediments as well as attached nutrients. The strategy depicted below is based on progressively trapping finer fractions of sediments and nutrients.



3.1 Intent

To provide water quality management systems which ensure that disturbance to natural stream systems is minimised, and stormwater discharge to surface and underground receiving waters, both during construction and in developed catchments, does not degrade the quality of water in the receiving domains.

3.2 Performance targets

The objectives for stormwater quality management will be achieved by the combination of works undertaken by the Government, through its development and capital works program, and by private sector works undertaken in new developments and redevelopments.

The responsibility for meeting targets on development or redevelopment sites lies with the developer or builder, while responsibility for meeting the regional or catchment-wide targets lies with Government. The Government will continue to develop, prioritise and implement larger-scale WSUD stormwater measures, such as lakes, ponds and wetlands, to ensure that the catchment-wide targets are achieved. These targets are shown in the table below. They refer to reduction in pollutant export compared to an urban catchment with no water quality management controls. These targets must be met for all developments greater than 2000 m^2.

Targets for stormwater quality management

	Development or redevelopment sites	Regional or catchment-wide
Reduction in average annual suspended solids (SS) export load	60%	85%
Reduction in average annual total phosphorus (TP) export load	45%	70%
Reduction in average annual total nitrogen (TN) export load	40%	60%

The intent may be achieved where:

- adequate provision is made for measures during construction to ensure that the landform is stabilised and erosion is controlled;
- the system design maximises the interception, retention and removal of water-borne pollutants prior to their discharge to receiving waters;
- the system design minimises the environmental impact of urban run-off on surface receiving water quality and on other aspects of the natural environment, such as creek configuration and existing vegetation, by employing all possible techniques that are technically appropriate and effective in reducing run-off and pollution travel in the catchment;
- the system design ensures the continuation, in healthy condition, of a wide diversity of wetland environments (including ephemeral wetlands) in the urban landscape; and
- point sources of pollution in the catchment are identified and their impact minimised until they can be eliminated.

3.3 Guidance

3.3.1 Assessment tools

Development proposals in the ACT for sites greater than 2000m^2 must demonstrate that the required water quality criteria will be achieved. Use of the MUSIC model to demonstrate compliance will be accepted. Other models may be used with the agreement of the ACT Planning and Land Authority.

MUSIC

MUSIC is the "Model for Urban Stormwater Improvement Conceptualisation", developed by the Cooperative Research Centre for Catchment Hydrology. MUSIC has been widely adopted by government agencies, councils and consultants throughout Australia for the assessment of stormwater quality impact and the performance of stormwater quality treatment trains. It provides the ability to simulate both quantity and quality of runoff from catchments ranging from a single house block up to many square kilometres. It can test the impact of a wide range of treatment facilities on the quantity and quality of runoff downstream.

Recommended parameters for the application of MUSIC under ACT conditions are summarised in Appendix B.

XP-AQUALM, PURRS, Aquacycle and others

There are a range of other existing and emerging programs that can be used to assess the effectiveness of WSUD measures in meeting targets and objectives. The selection of a program for an assessment will be guided by the complexity of the scheme of measures to be analysed and the measures that can be modelled by each program.

As a general guide, the following table outlines the effectiveness of stormwater quality measures for different types of development.

Effectiveness of measures

	Residential blocks	Multi-unit residential	Estate development works	Commercial, industrial & institutional developments	Capital works (roads, ponds, earthworks, public areas)
Ponds and wetlands	Low	Med	High	Med	Med
Gross pollutant traps	N/A	N/A	High	Med	Med
Constructed waterways	N/A	N/A	High	Low	High
Filter strips, swales & bio-swales	Low	Med	High	Med	High

3.3.2 Ponds and wetlands

A neighbourhood pond retrofitted into an existing urban area in the Sullivans Creek Catchment

Outline

Ponds and wetlands are permanent water features that can achieve significant improvements in water quality, retard storm flows, provide a habitat for native plants and animals, a venue of passive recreation and enhance the urban landscape. The existing system of urban ponds and lakes in the ACT captures significant amounts of sediment and nutrients. The ACT Government is committed to the continuation of this strategy, including finding opportunities to retrofit ponds and lakes into existing urban areas where such measures do not already exist.

Purpose

Wetland ponds in the ACT urban areas are to be constructed to achieve three underlying objectives:

- Management of water quality and flows for environmental enhancement/protection and for public safety;
- Urban amenity and recreational use; and
- Habitat creation and enhanced biodiversity of the waterway.

While the primary role of a wetland or pond is to improve water quality, the quantity of water discharged downstream in frequent storms can also be managed by incorporating extended detention into the facility.

Urban runoff can also be harvested from ponds and re-used for irrigation of open space, thereby reducing the demand for mains water. Ponds and wetlands can also make significant improvements to the local landscape and amenity with consequent increases in property values. As such, consideration should be given to retrofitting ponds and wetlands on existing lined stormwater channels.

Design considerations

Some key design issues that need to be considered include:

Off-line or on-line system

Ponds and wetlands can be constructed either:

- on-line, ie. on the main drainage line, with all flows passing through the pond or wetland; or
- off-line, with a diversion of low flows from the drainage line into the pond or wetland.

Off-line ponds and wetlands allow high flows to bypass the ponds or wetlands thereby reducing the likelihood of re-mobilising captured pollutants and saving the cost of constructing major spillways.

Where one development is downstream of another, the upstream developer is responsible for meeting the water quality target for discharge from this estate, and the downstream developer is responsible for meeting the targets for the additional flow from this estate. However, the developers may combine their water quality measures, provided the water quality targets are met for the developments in total.

Sizing of pond or wetland

The sizing of a pond or wetland needs to take into account the reduction in pollutant loads achieved by upstream measures and the remaining capture of pollutants that is required to achieve the overall stormwater quality targets.

Pre-treatment of inflows

Ponds or wetlands should be protected by installing GPTs or other measures upstream of the inlet, and preferably a sedimentation pool at the inlet to capture coarse sediments.

Extended detention

Where possible, a pond or wetland should include extended detention storage where a small outlet is provided for part of the storage, thus allowing for capture and treatment of small storm runoff up to the 3 months ARI. This extended detention storage can vary between 0.1m and 0.5m of the pond or wetland depth.

Water circulation

To maximise pollutant capture, the design aim is to achieve an even distributed flow through the wetland or pond and to avoid short-circuiting of flows from an inlet to an outlet. Islands, peninsulas, submerged weirs and walls can be used to modify water circulation patterns in a pond or wetland.

Public safety

A combination of edge treatments can facilitate public access and recreational opportunities while maintaining a safe and ecologically rich environment. Formal (paved) edges, beaches or boardwalks where the public can gain all weather access to the water edge should be considered for sections of larger wetland ponds or those near high activity areas.

Generally, the edges of ponds and wetlands should be graded at between 1(V):6(H) to 1(V):10(H) above and below the water line to provide for safe access and egress.

The extensive planting of macrophytes along the water edge is recommended where it is desired to prevent people from entering the wetland or pond.

Appropriate warning signs should be erected informing the public of the purpose and hazards of the pond and indicating no swimming is allowed.

Habitat creation

Planting schedules should aim to achieve a mix of species with the majority of plants being local to the ACT. Species that could potentially cause problems in downstream environments, e.g. weed (pest) species should be excluded.

Protected habitats can also be created by constructing islands within ponds or wetlands that are not accessible to people and domestic pets.

It is important to provide habitats that will, with time, attract a variety of native birds and aquatic species.

Design guidelines

Current practice or the detailed design of wetlands and ponds is given in the following guidelines:

ACT Department of Urban Services, ***Design Standards for Urban Infrastructure, Section 16 Urban Wetlands, Lakes and Ponds,*** (www.roads.act.gov.au/documents/index.html)

Breen, P. and Lawrence, A.I (1998), ***Design Guidelines for Stormwater Pollution Control Ponds and Wetlands,*** Cooperative Research Centre for Freshwater Ecology (CRCFE).

Wong, T, Breen, P, Somes, N, Lloyd, S (1998***), Managing Urban Stormwater using Constructed Wetlands***, Cooperative Research Centre for Catchment Hydrology.

NSW Department of Land and Water Conservation (1998), ***The Constructed Wetland Manual,*** Volumes 1 & 2.

Melbourne Water (2004), ***WSUD Engineering Procedures: Stormwater***, prepared by Ecological Engineering, WBM, Parsons Brinkerhoff, June. (www.wsud.melbournewater.com.au)

Engineers Australia (2006***), Australian Runoff Quality, A Guide to Water Sensitive Urban Design***, Ed THF Wong, Canberra, April.

(This General Code provides an overview of current knowledge and best practices for wetlands and ponds.)

3.3.3 Gross pollutant traps

A proprietary GPT unit: (i) full of urban litter, and (ii) after cleaning

Outline

Gross pollutant traps (GPTs) were first developed in Australia in the ACT in the late 1970s and 1980s. A GPT treats catchment runoff prior to its discharge to a waterway, pond, wetland or urban lake by removing litter, debris and coarse sediment. The most commonly used types of GPT in Canberra to date have been the 'Minor DUS GPT' and the 'Major DUS GPT', as defined in the Department of Territory and Municipal Services design standards. These GPTs consist of a concrete sediment basin with a fixed trash rack at the downstream end of the basin. In recent years there have been numerous proprietary devices developed for trapping gross pollutants that may be suitable for use in Canberra.

Purpose

GPTs are desirable at the discharge point of sites likely to generate high sediment and pollutant loads and are required at the downstream end of pipelines and engineered floodways that discharge into urban ponds, lakes and receiving waters.

GPTs provide initial water pollution control for urban lakes and ponds by removing litter, debris and coarse sediment from stormwater. Most GPTs will also provide some reduction in other pollutants. For example, trapping coarse sediment may also provide:

- removal of particulate nutrients;
- removal of trace metals, oil and grease;
- reduction in bacteria; and
- reduction in dissolved oxygen demanding substances.

All of these substances can be partly bound to sediments and will be removed along with the trapped sediment.

Design considerations

Some key design issues that need to be considered include:

Sizing criteria

GPTs within the public stormwater system are to be designed to retain trash and debris and a percentage of coarse sediment transported by dry weather base-flow events up to and including 1 year ARI.

Public GPTs are to be sized in accordance with the methods outlined in the ACT Government design standards. The surface area of the sediment trap is to be sized to retain 70% of grain sizes equal to or greater than 0.04 mm. The trap volume is to be based on an average cleaning frequency of 6 months.

Approved proprietary traps are to be sized in accordance with the trap manufacturer's specifications. All proposed proprietary GPTs are to be submitted to the Department of Territory and Municipal Services for approval.

Maintenance

GPTs must be designed to facilitate maintenance, especially in respect to removal of silt and debris. Designs must be based on cleaning operations being undertaken with conventional plant and equipment. A poorly maintained GPT may not only perform badly, it may become a flood hazard or a source of pollution itself.

Design guidelines

Current practice for the selection and detailed design of GPTs is given in the following guidelines:

ACT Department of Urban Services ***Design Standards for Urban Infrastructure, Section 1 Stormwater***, Edition 1, Revision 0, (www.roads.act.gov.au/documents/index.html)

(This document describes the current requirements for selection and design of public GPTs in the ACT.)

Engineers Australia (2006)***, Australian Runoff Quality, A Guide to Water Sensitive Urban Design***, Ed THF Wong, Canberra, April.

(This General Code provides an overview of current knowledge and practices for selection and design of GPTs.)

3.3.4 Filter strips, swales and bio-swales

A car park bio-swale

Source: Enviro Links Design

Outline

Filter strips, swales and bio-swales are measures that primarily treat runoff through filtering of deposition of sediments. The simplest of these three measures is the filter strip, which is a vegetated zone that filters overland flow prior to its collection in a swale or drain. Swales are vegetated, shallow open channels that convey stormwater with minimal infiltration, while bio-swales are swales with the addition of a subsurface gravel or sand filled trench with a small pervious (slotted) collector pipe. The intent of bio-swales is that low intensity frequent flows infiltrate through the gravel or sand medium providing both physical and biological treatment while higher flows are carried within the swale. These measures convey runoff and improve runoff quality to formalised drainage systems and/or natural waterways.

Purpose

The primary purpose of filter strips, swales and bio-swales is to capture sediment and attached pollutants. Sediments and bound nutrients are primarily removed through the physical process of sedimentation while a proportion of dissolved nutrients are removed by the bacteria that grow on the surfaces of the plant roots and the soil media. As the flow in swales is channelised, the potential for pollutant removal through the filtering action of grass or precipitation of particulate matter is lower than in filter strips. The benefits of a grassed swale can include the partial infiltration of runoff as well as providing an aesthetically pleasing alternative to concrete channels or conventional kerb-and-gutter streetscapes.

Bio-swales can be particularly effective due to the considerable surface area of the filter media and contact time for stormwater that infiltrates into the trench. This results in a higher level of pollutant removal than can be achieved in a swale alone.

Design considerations

Some key design issues that need to be considered include:

Vegetation

The selection of appropriate grasses, ground covers and/or other plants for filter strips, swales and bio-swales is the key consideration in the design of these measures.

The use of appropriate drought-tolerant species of grasses and ground covers is important to maintaining the effectiveness and survival of filter strips and/or swales. The selection of plants needs to consider the moisture regimes experienced in a filter strip, swale and the drainage characteristics of the adopted filter media in a bio-swale. Filter strips, swales and bio-swales may require watering during extended dry periods to ensure vegetation fulfils its intended role during subsequent wet periods.

Hydraulic conductivity

In clay soils, like most soils encountered in the ACT, Argue, 2004 (pp 187) recommends the installation of a subsurface trench filled with single–sized gravel and coarse sand underlain with a non-woven geotextile fabric. A small quantity of loam can assist with plant propagation. The installation of a small, perforated drainage pipe at the base of the sand/gavel layer will help ensure that excess water can be discharged to a natural watercourse or the formal drainage system.

Slope

The recommended range of slopes for filter strips, swales and bio-swales is 1% - 5%.

Slopes less then 1% can lead to ponding and boggy soil, while slopes greater than 5% are less effective in removing pollutants and are susceptible to erosion.

Maintenance

To maintain the effectiveness of filter strips, swales and bio-swales, it is necessary to undertake regular inspections and regular maintenance of the filter area. This can include mowing, removal of woody weeds, reinstatement of dead vegetation and repairing of erosion. A management and protection plan is to be prepared for these measures to protect them from damage during the construction and building activity stages of development and redevelopment.

Design guidelines

Current practice for the detailed design of swales, bio-swales and filters strips is given in the following guidelines:

Melbourne Water (2004) ***WSUD Engineering Procedures: Stormwater***, prepared by Ecological Engineering, WBM, Parsons Brinkerhoff, June. (www.wsud.melbournewater.com.au)

Argue J (2004) ***WSUD: Basic Procedures for 'Source Control' of Stormwater: A Handbook for Australian Practice***, Ed JR Argue, 1st Edition, prepared by the Urban Water Resources Centre, University of South Australia in collaboration with the SIA and AWA, November, 246 pp + Apps.

(Detailed guidance is given on the design and construction of filter strips, swales and bio-swales. Specific guidance is given on implementing these measures in low permeability soils).

Engineers Australia (2006*), **Australian Runoff Quality, A Guide to Water Sensitive Urban Design***, Ed THF Wong, Canberra, April.

(This General Code provides an overview of current knowledge and best practices for buffer strips, swales and bio-swales).

3.3.5 Constructed waterways

A small constructed waterway

Source: Enviro Links Design

Outline

The terms ‘constructed waterways’ or ‘restored natural waterways’ have been adopted to convey an approach that is much wider than the hydraulic drainage function (Engineers Australia, 2006).

Since the 1980s, there has been a greater retention of natural streams in urban areas. In some areas in the ACT, constructed waterways have been installed with dense vegetation to slow runoff and protect the bed and banks against erosion.

Constructed waterway corridors can range from main channels with major flow capacity, to terraced cross sections with the upper terrace accommodating major flows and, on occasions, the use of levies to contain major flows and enhance floodway capacity (Engineers Australia, 2006).

Purpose

Constructed (engineered) or modified waterways in ACT urban areas are designed to achieve four objectives, namely (i) the management of flows and water quality for environmental enhancement/protection; (ii) flood protection and public safety; (iii) urban amenity and recreational use; and (iv) the creation of habitat with enhanced biodiversity.

Design considerations

Design capacity

Watercourses in urban areas must have a flow capacity sufficient to safely convey flows up to the 100 year ARI event. A higher capacity may be required downstream of major water retaining structures (dams, walls and embankments) to allow for the consequences of failure in accordance with ANCOLD requirements.

Grades

Waterways should be constructed with sufficient grade to avoid ponding and/or unwanted deposition of sediment. The minimum waterways grade should be 0.2%-0.5%.

Waterways also need to be designed with grades that minimise the occurrence of hydraulic jumps or erosion. This is generally achieved by limiting 100 yr ARI flow velocities to 2 m/s. Drop structures should be used to reduce grades, where necessary.

Low flow provision

A constructed waterway should include provision for low flows in the form of either a pipe of low flow invert.

The invert design should allow for trickle flows such that the invert is not eroded. This may require the provision of a stabilised or lined invert but does not exclude the use of vegetation only, provided grades and flow velocities are low enough.

Piped low flow provision should have a minimum capacity of 1 month ARI flow or minimum pipe size of 450mm.

Erosion and scour protection

Erosion and scour protection measures should be used where required to prevent soil erosion or damage to floodway vegetation for storms up to the 20 year ARI and damage to floodway structures for storms up to the 100 year ARI.

Public safety

ACT standard floodway warning signs should be erected along waterways warning the public of any danger during major storms. Details of signs can be found in the TAMS design standards.

Urban amenity

Existing natural stream sections should be preserved where possible. Existing vegetation and fauna are generally hard to re-establish in constructed waterways and may have aesthetic qualities worthy of retention.

The audibility of waterways and the wildlife inhabiting them (birds and frogs) can also create an attractive and unique aspect to an urban area. Maintaining water on the surface and providing pool and riffle sequences can add to this dimension.

Varying the invert and bank treatments to suit the location and waterway gradient can also create visual interest. The use of meanders in the invert of the waterway and variations to the side slopes will reduce the "engineered" appearance of a waterway.

Drop structures can also add interest as well as serving a hydraulic purpose. These should be aesthetically pleasing and mimic natural cascades using local rocks and boulders as much as possible. High use public areas or areas with more formal landscaping may dictate a more formal design of drop structures.

Habitat creation

Planting schemes should aim to achieve a mix of species with the majority of plants being local to the ACT. Species that could potentially cause problems in downstream environments, e.g. weed (pest) species should be excluded.

Concrete lined inverts, although necessary in some locations, do not allow for the creation of viable habitats for aquatic and semi aquatic species. These inverts should be avoided where possible. The use of coarse materials or finishes such as stone pitching or rake finishing concrete surfaces can assist the establishment of biofilms and create macro-invertebrate habitat.

Design guidelines

Current practice for the detailed design of constructed watercourses is given in the following guidelines:

ACT Department of Urban Services, ***Design Standards for Urban Infrastructure, Section 1 Stormwater***, (www.roads.act.gov.au/documents/index.html)

ACT Department of Urban Services (1995), ***ACT Floodplain Protection Guidelines.***

Engineers Australia (2006***), Australian Runoff Quality, A Guide to Water Sensitive Urban Design***, Ed THF Wong, Canberra, April.

Melbourne Water (2004), ***WSUD Engineering Procedures: Stormwater***, prepared by Ecological Engineering, WBM, Parsons Brinkerhoff, June. (www.wsud.melbournewater.com.au)

3.4 Acceptable solutions

For larger developments, such as residential estates and larger commercial or institutional developments, it is expected that qualified consultants familiar with stormwater management issues would be engaged to assess ways of meeting the stormwater management targets based on current technologies and methodologies. Programs such as MUSIC (Model for Urban Stormwater Improvement Conceptualisation – CRCCH), Aqualm, Aquacycle, PURRS and others may be applicable.

For developments where modelling tools may not have been developed as yet or for smaller residential developments, the following calculation procedures are regarded as "acceptable solutions".

Reduction in suspended solids, nutrients and low flows

Reduce the peak flow of small storm runoff such that the 3 month ARI runoff volume is captured and released at a controlled rate over a 1 to 3 day period. For all areas of the ACT, the rainfall depth applicable for this calculation is 28mm. Assuming a runoff coefficient for pre-urban areas of 0.4 and a runoff coefficient of 0.9 for impervious areas, the quantity of increased runoff per 100 m^2 of impervious area would be 1.4 kL for the 3 month ARI storm.

Rainwater tanks, plumbed into toilets and laundry areas, and having the top portion as active storage for slow (trickle) release are supported. On-site detention (OSD) for major storm flow regulation on leases in new estates is not required but would be encouraged as a voluntary measure. The need for OSD on redevelopment sites will depend on the existing impervious proportion of the site compared to the proposed impervious portio, the location of the site and the capacity of the downstream stormwater system.

Greenfield sites (public and private land development)

1.4 kL detention storage per 100 m^2 of impervious area to be provided within or downstream of the estate development, preferably on public land (either through capital works, off-site works by developer or within the public realm of the estate). For a typical residential development, this would equate to 0.7 kL of storage per 100 m^2 of development area (assuming 50% impervious surfaces).

For residential land development, it is expected that the requirements for stormwater quality will be met at the estate development scale through the use of ponds, wetlands and other measures. As an example, a 100-hectare residential development with 50 % impervious surfaces would have a stormwater retention requirement of 7000 kL. This could be met by providing a pond with a 7000 kL extended detention component above the normal water level. This component of the total pond volume would capture flows from the one in 3 months ARI storm and releasing it over a 1 to 3 day period.

Rainwater tanks plumbed into toilets and laundries and used for garden watering can be considered to count for part of the stormwater retention requirement. In this case, 50% of the tank volume would be counted as forming part of the stormwater retention requirement. In this case, the above 100 hectare residential development could meet its stormwater quality requirement by providing a pond with a 4000 kL extended detention component above the normal water level and providing 6000 kL of rainwater tank storage within the development, counting as 3000kL of stormwater retention. Assuming 1300 blocks of land, each block would have a tank with 4.6 kL of storage, 2.3 kL of which counts as extended detention storage.

For details on the sizing of tanks and other associated details, refer to the on-line tool and the rainwater tanks guideline for the ACT at www.actpla.act.gov.au.

Requirements for the use of rainwater tanks include that at least 50% of the total roof area drains to the tank and that the water is used (plumbed in) for toilet flushing, garden watering and preferably laundry cold water use. Connection of 100% of roof area is now easily achievable using 'inverted siphon' downpipe systems.

The volumetric storage requirements above could also be met by using other measures, including bioretention trenches and basins and depression storages. If pervious or permeable paving is used, 50% of the surface area of this paving can be considered as pervious.

Redevelopment sites and infill sites (including new leases for single blocks)

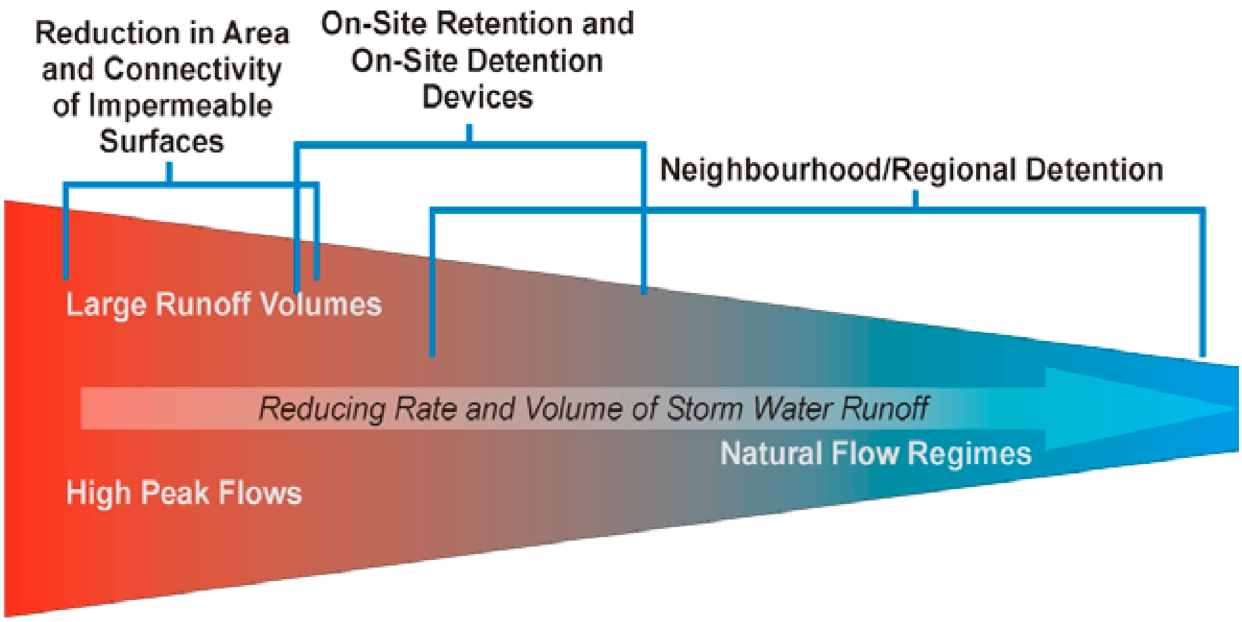
1.4 kL per 100 m2 of impervious area in excess of 50% of the site for commercial or industrial areas and in excess of 35% of the site for other areas, including residential areas.

This requirement recognises the difficulty of making stormwater retention and detention requirements retrospective for sites within existing urban areas and that commercial and industrial areas were previously expected to have a higher impervious proportion. The criteria will require developers and builders to either reduce site coverage / impervious area (building footprint and paved area) of the development and/or provide sufficient stormwater retention and possible reuse of this water. The greater the proportion of impervious surfaces, the more storage will be required.

Appropriate measures for such sites will vary depending on the nature of the site but could include those options listed as for greenfield development.

4. Stormwater quantity

Urban development increases both the frequency and quantity of stormwater runoff. This results from the introduction of large impervious areas, such as building rooves and road surfaces. Existing vegetation and soils are replaced with impervious surfaces connected to gutters, stormwater pipes and concrete channels. The opportunities for reducing runoff begin on the block with simple measures to disconnect direct connections and disperse, infiltrate, store and harvest runoff. At neighbourhood or subcatchment scales, measures to retain or detain runoff can reduce the volume and rate of runoff. A number of these measures can be combined with stormwater quality measures. The treatment train depicted below outlines the opportunities to implement measures at a range of scales designed to emulate natural flow patterns.



4.1 Intent

To provide minor and major drainage systems which:

- adequately protect people and the natural and built environments at an acceptable level of risk and in a cost-effective manner, in terms of initial cost and maintenance; and
- contribute positively to environmental enhancement of catchment areas.

4.2 Performance targets

Performance targets for stormwater quantity are indicated in the following table:

Performance targets for stormwater quantity

Reduction of runoff peak flow to no more than the pre-development levels and release captured flow over a period of 1 to 3 days	3 month ARI
Reduction of peak flows to pre-development levels	5 year to 100 year ARI

For redevelopment and infill sites, the impervious area calculations can exclude the first 35% of the site for residential areas and the first 50% of the site for commercial and industrial areas, as shown on the Territory Plan.

Opportunities should be sought to utilise stormwater as a substitution for mains water, particularly for the irrigation of sportsgrounds and public open space. Where this is proposed, there is a requirement to comply with environmental flow guidelines.

The intent may be achieved where:

- the stormwater system is designed to have capacity to control flows up to the relevant design flood;
- the capacity of downstream stormwater systems is not exceeded;
- downstream natural waterways are protected against erosion;
- design of the stormwater system is undertaken by qualified personnel, using recognised and locally accepted hydrological and hydraulic parameters and design methodology; and
- the design and construction of the stormwater system are in accordance with the requirements of the relevant authorities.

4.3 Guidance

4.3.1 Assessment tools

The ACT Government has previously assessed the suitability of four rainfall/runoff programs for the assessment of the impacts of development on peak flows and volumes of runoff due to storm events. These programs include XP-RAFTS, DRAINS (ILSAX), RORB and WBNM.

The recommended parameters and procedures to be used for the ACT are summarised in Appendix B and are also contained in the TAMS publication titled “Design Standards for Urban Infrastructure, 1 Stormwater” downloadable from www.roads.act.gov.au/documents/index.html#stormwater

Guidance on the requirement to reduce the peak flow for the 3 months ARI to the pre-urban level can be found in Section 3.4.

Effectiveness of measures

	Residential blocks	Multi-unit residential	Estate development works	Commercial, industrial & institutional developments	Capital works (roads, ponds, earthworks, public areas)
Porous and permeable pavements	Med	Med	Med	Med	Med
On-site retention	Med	Med	High	High	High
On-site detention	Med	Med	N/A	Med	N/A
Retarding basins	N/A	Med	High	High	High
Disconnected drainage	Med	Med	Med	Med	Med

4.3.2 Retarding basins

Flow retardation can be incorporated into other infrastructure, such as urban lakes

Outline

Retarding basins temporarily store runoff and release it at a controlled rate to reduce the peak flow in the downstream drainage system. Retarding basins have been combined with recreation or environmental facilities, eg. playing fields, ponds and wetlands.

Retarding basins reduce downstream drainage infrastructure costs as the size of pipes and channels is reduced with the decreased peak flow.

Ponds and wetlands can also incorporate a flow retardation capability and can thus contribute to both stormwater quantity and quality objectives.

Purpose

The primary function of retarding basins is to capture and temporarily store runoff during major (infrequent) storm events and to then discharge stormwater to the drainage system at a reduced rate over a longer period of time, usually within a few hours.

Design considerations

Discharge targets

In the past, retarding basins have been sized to reduce peak discharges only in major floods eg. 100 year ARI events. Increasingly, multiple discharge targets for storms of different ARIs are being set and a staged outlet is often required to achieve these multiple targets. The standard planning requirement is that downstream flow rates do not exceed pre-development levels for both minor and major design ARI flows, eg. 5 to 100 year ARI events.

Multi-purpose uses

Where possible, basins should be designed for a range of uses, including stormwater management, active (playing fields) and/or passive recreation. These structures should be designed to enhance the visual amenity or landscape value of an area.

Inundation frequency

The frequency of inundation should be designed to be compatible with the land use of an area. For example, playing fields and areas used for footpaths and cycle paths, the frequency of inundation should be no greater than an average of once every two years.

The TAMS guidelines require that a minimum low flow bypass of 1 month ARI needs to be incorporated in a retarding basin in the ACT. The bed of the basin also needs to be graded to the outlet at a minimum slope of 1(V):50(H) to prevent waterlogging.

Public safety

Public safety is a key design consideration for detention basins [and other facilities eg floodways, ponds, etc]. Basin side slopes should be preferably 1(V) in 6 (H) and no steeper than 1(V):4(H). The maximum depth of ponding should also be discussed with the TAMS during the design process.

Design guidelines

Current best practice for the design of retarding basins is given in the following guideline:

ACT Department of Urban Services, ***Design Standards for Urban Infrastructure, Section 1 Stormwater***, Edition 1, Revision 0, (www.roads.act.gov.au/documents/index.html)

4.3.3 On-site detention

Outline

On-site detention (OSD) is the temporary storage and controlled release of stormwater runoff generated within a block and is generally required on redevelopment sites to ensure the capacity of the municipal stormwater system is not exceeded. The outflow from the storage to the existing municipal stormwater system is limited to a predetermined flow rate, which is usually the flow rate before redevelopment. Storages can be either underground (typically tanks) or surface storage, such as landscaped areas, car parks or other paved areas.

OSD is generally required for redevelopment involving commercial, industrial or multi-unit residential premises where there is insufficient capacity in the downstream municipal stormwater system to cater for the increased runoff resulting from the development.

Purpose

The primary function of on-site detention is to capture and temporarily store runoff during storm events and to discharge stormwater to the drainage system at a reduced rate over a longer period of time.

Design considerations

Discharge targets

Where OSD is required, the standard planning requirement is that the released peak flow rate does not exceed pre-development peak flow rate for all storms between the 1 in 2 year and 1 in 100 year ARI. Runoff from storms smaller that the 1 in 2 years ARI is not required to be stored.

Minimising nuisance

OSD storages should be designed so that runoff is stored where inconvenience is minimised. To avoid water damage to vehicles parked within an OSD storage, depths should not exceed 200mm under design conditions. Surface grades within areas used to store stormwater should not be less than 1 in 100 year ARI, to ensure satisfactory free drainage following storms. Ponding depths in private landscaped areas should not exceed 500mm.

Floor levels

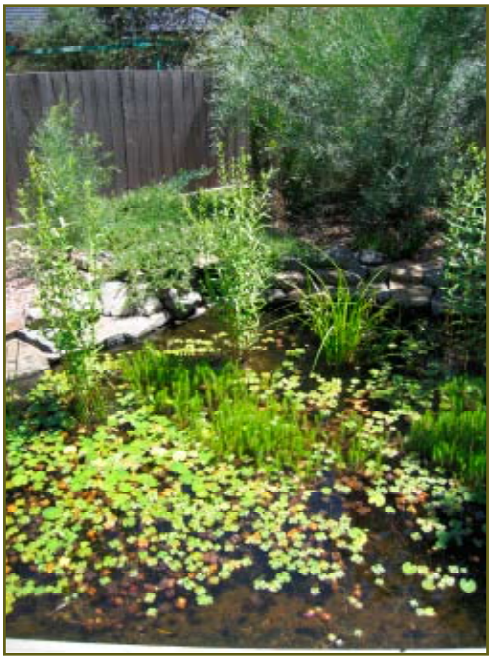
The internal stormwater drainage system for the site must ensure that all habitable floor areas are a minimum of 150mm and garage floor levels a minimum of 100mm, above the maximum design water surface level of the OSD storage for both new and existing dwellings.

Surcharge provision

Surcharge from an OSD storage should cause flooding in a noticeable location, so that malfunctions are likely to be investigated and remedied.

For storms in excess of the OSD storage design capacity, the additional surcharge should not be concentrated beyond that reasonably expected of the landform into neighbouring or public land where it would cause property damage or public safety issues.

4.3.4 On-site retention



A small pond in a residential property providing on-site retention

Outline

On-site retention (OSR) holds stormwater on a site with runoff typically draining at low flow rates into soils or away from the site over a period of one day or longer. This allows a significant portion of runoff to dissipate through natural processes such as infiltration, evaporation and transpiration. However, the natural clay soils in the ACT are not conducive to infiltration. Consequently, a small outlet is often installed in storages to slowly discharge stored water into the local drainage system.

Examples of OSR include a shallow basin that is dry between storm events or a small wetland or pond with storage capacity above the normal water level. Rainwater tanks are also a form of OSR that capture roof runoff in frequent storms and reduce the rate and volume of stormwater runoff from a site.

Purpose

The purpose of OSR is to capture and temporarily retain runoff on a site. Ideally, an OSR facility should be sized to reduce the intensity and volume of runoff so that the peak flow from a runoff event that occurs on average once every 3 months is no more than pre-development level.

Design considerations

Location

Infiltration is undesirable next to building footings where the shrinking and swelling of some clays may cause structural damage. A minimum clearance of 5 metres from footings should be maintained or an impermeable lining should be used in these areas.

Outlet

In the ACT, the natural clays are not well suited to infiltration. Preferably, a small outlet at the base of the OSR facility should be sized to drain stored water over one to three days.

Pre-filtration

If a subsurface OSR facility (typically an underground tank) is installed, then runoff directed to the facility should be pre-filtered through a vegetated buffer strip or equivalent measure. A removable filter screen should be also incorporated into the device to allow easy maintenance. The outlet to an OSR facility should also incorporate a screen to prevent clogging of the outlet by leaf litter and other debris.

Design guidelines

Argue J (2004) ***WSUD: Basic Procedures for 'Source Control' of Stormwater: A Handbook for Australian Practice***, Ed JR Argue, 1st Edition, prepared by the Urban Water Resources Centre, University of South Australia in collaboration with the SIA and AWA, November, 246 pp + Apps

4.3.5 Porous paving

Porous & permeable pavements installed at Holt shops

Outline

Porous and permeable pavements come in many different forms from brick paving where water infiltrates between the cracks to paving material designed so that water can move through the blocks. The intent is to create a paved surface where water can infiltrate into the underlying soils. In the ACT, soils are predominately clay and hence porous paving usually requires a drainage sub-layer of material to transport excess water laterally to the drainage system. These pavements fall into two categories:

- Porous pavements, which comprise a layer of highly porous material; and
- Permeable pavements, which comprise a layer of paving blocks, typically impervious, specially shaped to allow the ingress of water by way of vertical "slots" or gravel-filled "tubes".

Standard pavers have a limited degree of permeability, allowing some water to infiltrate through the gaps between individual pavers.

Purpose

Porous and permeable pavements reduce runoff from paved surfaces and also provide some treatment of stormwater pollutants. However, these pavements can be sensitive to clogging from fine sediments. Any decision to install these pavements should consider nearby sources of sediments. After the pavement has been installed, it should be protected from short-term sources of sediments (a load of landscaping material for a garden for instance or development work such as new house construction). Technologies and procedures currently exist for cleaning permeable pavers, however, these are generally expensive operations.

Design considerations

Site evaluation

Porous and permeable pavements show a decline in permeability with exposure to sediment and organic matter through their lifetime. To ensure adequate performance of these pavements, it may be necessary to protect these systems by pre-filtering runoff through buffer strips, avoid areas with high sediment loads and design the pavements to utilise only a portion of their 'as new' capacity. An assessment of site conditions is necessary to identify what additional measures, if any, are required to ensure that the porus or permeable pavements will perform for their entire lifetime.

Infiltration

The rate at which water can flow through the surface is a key design measure of porous and permeable pavements. This information is available from the pavement manufacturers and is essential in ensuring that the paved area is appropriately sized to cater for design flows.

Sub-grade stability

Many clay soils become weak when moist and move under loading. Porous and permeable pavements may not be suitable where there is a heavy loading due to such traffic as commercial vehicles, particularly where there are clay soils.

Reservoir/Drainage layer

A gravel and/or sand filled sub-layer provides both detention and treatment within the pore spaces. Drainage outlets should be constructed to allow excess water to drain to the drainage system or receiving waterway.

Low permeability liner

In some locations, infiltration to clay is undesirable, for example next to footings where the shrinking and swelling of some clays can cause structural damage. A minimum clearance of 5 meters from footings or impermeable lining should be used in these areas.

Design guidelines

Current best practice on the detailed design of permeable pavers/pavement is given in the following guidelines:

Argue J (2004) ***WSUD: Basic Procedures for 'Source Control' of Stormwater: A Handbook for Australian Practice***, Ed JR Argue, 1st Edition, prepared by the Urban Water Resources Centre, University of South Australia in collaboration with the SIA and AWA, November, 246 pp + Apps.

Upper Parramatta River Catchment Trust (2004) ***Water Sensitive Urban Design Guidelines for Western Sydney***, prepared by URS Australia Pty Ltd, (refer Design Specification DS5).

4.4 Acceptable solutions

The design and construction of the major storm drainage system are in accordance with the detailed standards contained in:

- Section 3.4 of this code for management of the 3 months ARI flood;
- Australian Rainfall & Runoff (IE Aust, 1997) or its successor;
- Design Standards for Urban Infrastructure (DUS, 2002) or its successor;
- Stormwater Pollution Control Ponds and Wetlands (CRCFE, 1998) or its successor; and
- Use of assessment tools as described in Appendix B.

5.0 Wastewater

5.1 Intent

Where infrastructure is available, the opportunity is to be taken, where practical, to reuse treated effluent for appropriate uses to replace mains water use. Initiatives, such as extensions to the North Canberra Effluent Reuse Scheme, will make effluent reuse available to a wider area. Large greenfield development, such as that proposed for the Molonglo Valley, also provides opportunities for large-scale effluent reuse. In order to achieve the wastewater reuse target in *Think water, act water*, effluent reuse will need to be implemented wherever reasonably possible.

5.2 Performance targets

Where an effluent reuse scheme is available, this should be used in preference to mains water for the irrigation of sportsgrounds and public open space. In addition, consideration should be given to the use of treated effluent, as a substitute for mains water in industrial applications, toilet flushing and garden watering.

There is an opportunity for the use of greywater at a domestic level. Use of greywater on individual residences can be easily undertaken, with systems ranging from simple direct diversions to more sophisticated treatment and storage systems. Management of health issues and associated costs make use of greywater less attractive in multi-dwelling developments and in many industrial and commercial developments.

5.3 Guidance

5.3.1 Treated sewage effluent

Opportunities for the reuse of treated sewage effluent will depend on the location and type of development. Use of treated sewage effluent in place of mains water should be considered in new developments, but will depend on whether:

- such a scheme is operating in the locality of the development; or
- a sewage treatment plant is in reasonable proximity that could be used as a source of treated effluent; or
- the development is of sufficient size to justify the installation of a “sewer mining” system, to provide a source of treated effluent; or
- a scheme can be provided that is economically viable.

Where an effluent reuse scheme is to be used, consideration should be given to all irrigated open space being connected to the scheme, at a minimum. Opportunities for addition applications of effluent reuse should also be investigated.

5.3.2 Use of greywater

Outline

Greywater is the wastewater discharged from the hand basin, shower, bath, spa bath, washing machine and laundry basin. There are opportunities for the direct use of this greywater for watering lawns or gardens. Storing untreated greywater for more than 24 hours is not recommended because of the rapid growth of bacteria.

Use of greywater in single residential developments can be simple and low in cost. Use of greywater in multi-unit and commercial developments is likely to be more difficult and high in cost because of the need to appropriately manage the inherent public health issues.

Greywater can be used either directly, without treatment, or can be treated and stored for later use. Untreated greywater should not be stored for more than 24 hours.

Purpose

The intent of greywater recycling is to reduce the amount of mains water consumed and reduce the amount of wastewater discharged to the sewerage system. It has the advantage in that it is a regular daily source of water in comparison with runoff from storms that occur at irregular intervals and can be of widely varying magnitudes.

5.3.3 Design guidelines

Current practice in the ACT for the design of greywater recycling systems is given in the following guidelines:

ACT Government (2004, ***Greywater use: Guidelines for residential properties in Canberra,*** Published cooperatively by ACT Health, The ACT Planning and Land Authority Environment ACT and ACTEW Corporation, October.

ACT Government (1995), ***ACT Wastewater Reuse for Irrigation – Environment Protection Policy***, Environment ACT, July.

National Health and Medical Research Council (2000), ***Guidelines for Sewerage Systems, Use of Reclaimed Water, National Water Quality Strategy***.

Natural Resource Management Ministerial Council, (2005), ***National Guidelines for Water Recycling – Managing Health and Environmental Risks***, Environment Protection and Heritage Council, October.

5.4 Acceptable solutions

Use of treated effluent and domestic greywater, as substitutes for mains water, are both effective methods to contribute to the achievement of the mains water use reduction target. Section 2.4, which details acceptable solutions for meeting the mains water use reduction includes the option of a greywater treatment system, treating water to class A standard. This option requires all bathroom and laundry greywater to be captured, with treated greywater being used for all toilet flushing and garden and lawn irrigation. If a greywater treatment system is not installed, use of untreated greywater should be considered to reduce mains water use. The on-line tool available on the ACT Planning and Land Authority website can be used to assess the effect of the use of untreated greywater.

6. Abbreviations and glossary

Abbreviations

ARI	Average recurrence interval
CRCCH	Cooperative Research Centre for Catchment Hydrology
CRCFE	Cooperative Research Centre for Freshwater Ecology
DA	Development application
DUS	(Former) ACT Department of Urban Services
ESD	Ecologically sustainable development
GPT	Gross pollutant trap
OSD	On-site detention
OSR	On-site retention
TAMS	Department of Territory and Municipal Services
WSUD	Water sensitive urban design

Glossary

Average recurrence interval	The long-term average period between the occurrences an event of a specific size.
Blackwater	Water which is contaminated with human waste, such as toilet water.
Demand management	An approach that is used to reduce the consumption of water (also called water conservation).
Environmental flow	The streamflow needed to protect appropriate environmental values in a waterway.
Greywater	Wastewater, typically from the laundry, bathroom and kitchen, that does not contain faecal matter.
Nutrient	Any substance that provides essential nourishment for the maintenance of life. Typically, the limiting nutrients in urban water pollution are nitrogen and phosphorus. Nutrients have the potential to generate toxic and non-toxic algal blooms in aquatic ecosystems.
Reclaimed water	Effluent that has passed through a treatment process and has been reticulated to users, or domestic greywater used for garden irrigation or other purposes.
Runoff	That part of precipitation (rainfall) that flows from a catchment area.
Sediment	Small-grained material (such as sand, silt and clay) that is carried by water and is deposited on the surface of the land. Sediment is capable of choking and destroying natural aquatic ecosystems.
Sewage	The waterborne wastes from residential, commercial and industrial premises.
Sewerage system	The infrastructure used for the collection, removal and treatment of sewage.
Stormwater harvesting	Collection of runoff that is stored and re-used.
Treatment train	A combination of measures that work in series to improve the quality of water.
Urban stormwater	Runoff from urban areas as a result of rainfall.
Water conservation	See demand management.
Water use efficiency	A measure of whether activities are being undertaken with the minimum amount of water needed and/or whether the water used is more pristine for the purpose than needed.
Water sensitive urban design	The practise of utilising sustainable measures to reduce the impact of development on the natural water cycle.

7. References

ACT Department of Urban Services *Design Standards for Urban Infrastructure, Section 1 Stormwater*, (www.roads.act.gov.au/documents/index.html).

ACT Department of Urban Services *Design Standards for Urban Infrastructure, Section 16 Urban Wetlands, Lakes and Ponds*, (www.roads.act.gov.au/documents/index.html).

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Water and Rivers Commission *(1998) A Manual for Managing Urban Stormwater Quality in Western Australia*, August.

Appendix A – Development checklists

Water sensitive urban design
Single residential development checklist

DA No. ……………………………. Block ……….. Section ………….. Suburb ……………..

Street Address ………………………………………………………………………………………….

Applicant Name ………………………………………………………….

Lessee (Owner) Name ………………………………………………….

Estate Name (if applicable) ……………………………………………

Block Size: __________________m^2

Refer Section 2.4 of this code to complete the table below.

<table>
<tr><td>Block size < 300 m^2</td><td>Block size 300 - 500 m^2</td><td>Block size 500 – 800 m^2</td><td>Block size > 800 m^2</td></tr>
<tr><td rowspan="3">★★★ plumbing only</td><td>☐ ★★★ plumbing plus 2,000 litre tank, minimum roof area connected = 50% or 75m^2</td><td>☐ ★★★ plumbing plus 4,000 litre tank, minimum roof area connected = 50% or 100m^2</td><td>☐ ★★★ plumbing plus 10,000 litre tank, minimum roof area connected = 50% or 125m^2</td></tr>
<tr><td colspan="3">Tank must be connected to laundry cold water, all toilet flushing and all external taps</td></tr>
<tr><td colspan="3">☐ Greywater treatment system, treating to Class A water. All laundry, bathroom and ensuite greywater to be captured and treated. Greywater to be connected to laundry cold water, all toilet flushing and all external taps.</td></tr>
</table>

☐ **Other**

(Achievement of the 40% target will need to be demonstrated to the satisfaction of ACT Planning and Land Authority)

Plumbing fitting	**Rating (★★★ min)**	**Appliances (optional)**	**Rating**
Taps		Washing machine	
Shower heads		Dishwasher	
Toilets			
Other …………………..			

Rainwater reuse storage and use proposed	Y / N
Uses for stored water Garden use Toilet flushing Laundry use Other	 Y / N Y / N Y / N Y / N

Estimated mains water use reduction using the WSUD On-line calculator, BASIX or other assessment tool/ spreadsheet: ………………… % (Attach copy of calculations or model output)

Rainwater reuse storage proposed	Y / N
Type of storage (above ground tank, buried tank, gutter storage, wall storage, other)	
Volume of storage (m^3 or kL)	………………………..m^3 (= kL)

Wastewater reuse (optional)

Wastewater reuse proposed?	Y / N
Type of reuse Untreated greywater (direct use on garden only) Treated greywater Community reuse facility (if available)	 Y / N Y / N Y / N
Uses for wastewater Garden use Toilet flushing Laundry use Other	 Y / N Y / N Y / N Y / N
Estimated annual reuse	……………..m^3 (= kL)

Summary of WSUD Targets and Achievements

	Target	Achieved
Mains water use reduction	40%	………..%
Wastewater reuse	Optional	…………. KL/yr

Water sensitive urban design
Multi-unit residential development checklist

DA No. ……………………………. Block ……….. Section ………….. Suburb ……………..
Street Address ………………………………………………………………………………………….
Applicant Name ……………………………………….. Company …………………………………….
Lessee (Owner) Name …………………………………………………….
Estate Name (if applicable) …………………………………………….

WSUD Concept Plan required as 1:200 scale. Plan No …………………………

Mains water use

Plumbing fitting	**Rating (★★★min)**	**Appliances (optional)**	**Rating**
Taps		Washing machine	
Shower heads		Dishwasher	
Toilets			
Other …………………..			

Landscaping	
Area of irrigated lawn	………………………..m²
Area of irrigated garden beds	………………………..m²
Total irrigated area	………………………..m²
Area of non-irrigated lawn (eg dryland grass)	………………………..m²
Area of non-irrigated garden beds (eg native plants with low water requirements in low maintenance mulched garden beds)	………………………..m² ………………………..m²
Total non-irrigated area	………………………..m²

Rainwater storage and use proposed	Y / N
Uses for stored water	
Garden use	Y / N
Toilet flushing	Y / N
Laundry use	Y / N
Other. ………………………	Y / N

Estimated mains water use reduction using online assessment tool, BASIX or other assessment tool/ spreadsheet: ………………… %

Stormwater management

Development area	………………………..m²
Impervious area – Roof area	
Roof connected to rainwater storage	………………………..m²
Roof area not connected to storage	………………………..m²
Total	………………………..m²
Impervious area - Paved areas	
Hard paved areas	………………………..m²
Permeable / porous paving area times 50%	………………………..m²
Total	………………………..m²
Total impervious areas	………………………..m²

A WSUD plan or a more detailed roof plan will need to be submitted that demonstrates the capture of water to enable an assessing officer to check.

The landscape plan will need to nominate all permeable and non-permeable surfaces for an assessing officer to check.

Stormwater site storage = (TIA – 35% of block area) x 1.4 KL / 100 where TIA = total impervious area If the project is in a **commercial** or **industrial** zoned area, then the stormwater site storage requirement = (TIA – 50% of block area) x 1.4 KL /100 ***Note**: This requirement may have been met partly or fully in the development works of the residential estate you are located within and hence this requirement may be omitted or reduced.	……………………….m^3 ……………………….m^3
Paved areas shedding runoff to garden beds and/or lawns	……………………….m^2

Rainwater reuse storage proposed	Y / N
Type of storage (above ground tank, buried tank, gutter storage, wall storage, other)	…………………………………………….
Volume of storage (m^3 or kL)	……………………….m^3 (= kL)
Extended detention storage	Y / N
Type of storage (tank, mini-pond / wetland, landscape depression, gravel-filled trench, other)	
Volume of storage (m^3 or kL)	……………………….m^3 (= kL)
Stormwater site storage achieved (= 50% of rainwater reuse storage plus 100% of extended detention storage)	……………………….m^3 (= kL)

Alternatively, modelling of water quality and quantity may be undertaken as for Estate Development – see separate checklist.

On-site detention (OSD)** - if required	Required / Not required
Type of storage (in-ground tank, above ground storage, landscape depression, other)	…………………………………………….
Volume of storage (m^3 or kL)	……………………….m^3 (= kL)

** Separate submission required for OSD - refer to Dept of Territory and Municipal Services requirements.

Wastewater reuse (optional)

Wastewater reuse proposed?	Y / N
Type of reuse Untreated greywater (direct use on garden only) Treated greywater Community reuse facility (if available)	 Y / N Y / N Y / N
Uses for wastewater Garden use Toilet flushing Laundry use Other	 Y / N Y / N Y / N Y / N
Estimated annual reuse	………………………..m^3 (= kL)

Summary of WSUD targets and achievements

	Target	Achieved
Mains water use reduction	40%	………..%
Stormwater site storage (if applicable)	………….. m^3 (= kL)	………….. m^3 (= kL)
On-Site Detention (OSD) storage (if applicable)	………….. m^3 (= kL)	………….. m^3 (= kL)
Wastewater reuse	Optional	………….. KL/yr

Water sensitive urban design Commercial, industrial and institutional development checklist

DA No. ……………………………. Block ……….. Section ………….. Suburb ……………..
Street Address ………………………………………………………………………………………….
Applicant Name ……………………………………….. Company …………………………………….
Lessee (Owner) Name ………………………………………………….
Development Name ……………………………………………..

WSUD Concept Plan required as 1:200 scale. Plan No …………………………..

Mains water use

Plumbing fitting	Rating (★★★ min)	Appliances (optional)	Rating
Taps		Washing machine	
Shower heads		Dishwasher	
Toilets			
Other …………………..			

Landscaping	
Area of irrigated lawn	……………………….m²
Area of irrigated garden beds	……………………….m²
Total irrigated area	……………………….m²
Area of non-irrigated lawn	……………………….m²
Area of non-irrigated garden beds	……………………….m²
Total non-irrigated area	……………………….m²

Rainwater storage and use proposed	Y / N
Uses for stored water	
Garden use	Y / N
Toilet flushing	Y / N
Laundry use	Y / N
Other ………………………..	Y / N

Estimated mains water use reduction using the on-line assessment tool or other assessment tool/ spreadsheet: ………………… %

Stormwater management

Development area	……………………….m²
Impervious area – Roof area	
Roof connected to rainwater storage	……………………….m²
Roof area not connected to storage	……………………….m²
Total	……………………….m²
Impervious area - Paved areas	
Hard paved areas	……………………….m²
Permeable / porous paving times 50%	……………………….m²
Total	……………………….m²
Total impervious areas	……………………….m²

Stormwater site storage requirements (= total impervious area above minus 50% of block area divided by 100 and multiplied by 1.4 kL). If the project is in an area zoned other than 'commercial' or 'industrial' as per the Territory Plan, then the stormwater site storage requirement is total impervious area above minus 35% of the block area divided by 100 and multiplied by 1.4 kL. **Note**: This requirement may have been met partially or fully in the development works of the estate you are located within and hence this requirement may be omitted or reduced.	……………………..m^3 ……………………..m^3
Paved areas shedding runoff to garden beds and/or lawns	……………………..m^2

Rainwater reuse storage proposed	Y / N
Type of storage (above ground tank, buried tank, gutter storage, wall storage, other)	
Volume of storage (m^3 or kL)	……………………..m^3 (= kL)
Extended detention storage	Y / N
Type of storage (tank, mini-pond / wetland, landscape depression, gravel-filled trench, other)	
Volume of storage (m^3 or kL)	……………………..m^3 (= kL)
Stormwater site storage achieved (= 50% of rainwater storage plus 100% of extended detention storage)	……………………..m^3 (= kL)

Alternatively, modelling of water quality and quantity may be undertaken as for residential and mixed use developments – see separate checklist.

On-site detention (OSD)**	Required / Not Required
Type of storage (in-ground tank, above ground storage, landscape depression, other)	……………………………………………
Volume of storage (m^3 or kL)	……………………..m^3 (= kL)

** Separate submission required for OSD - refer to Dept of Territory and Municipal Services requirements.

Wastewater reuse (optional)

Wastewater reuse proposed?	Y / N
Type of reuse Untreated greywater (direct use on garden only) Treated greywater Community reuse facility (if available)	 Y / N Y / N Y / N
Uses for wastewater Garden use Toilet flushing Laundry use Other	 Y / N Y / N Y / N Y / N
Estimated annual reuse	……………………..m^3 (= kL)

Summary of WSUD targets and achievements

	Target	Achieved
Mains water use reduction	40%	………..%
Stormwater site storage (if applicable)	………… m^3 (= kL)	………… m^3 (= kL)
On-site detention (OSD) storage (if applicable)	………… m^3 (= kL)	………… m^3 (= kL)
Wastewater reuse	Optional	………… kL/yr

Water sensitive urban design estate development checklist

Note:	This checklist may be completed for each stage of development as well as for the total development area.

DA No. ……………………………. Estate Name ………………………………………...…..

Stage …………..Suburb/District………………………Nearest Streets …………………………..

Applicant Name ……………………………………... Company …………………………………….

Developer Name …………………………………………………….

WSUD Concept Plan required as 1:1000 scale. Plan No …………………………..

Mains water use

Mandatory provisions for rating plumbing fittings and appliances for individual dwellings, such as in Lease and Development Conditions? Y / N

Estimated mains water use reduction using the Design Response Report, BASIX, Green Star or other assessment tool/spreadsheet: ………….. %

Mains water savings proposed in the design of the public realm? Y / N

Description: …………………………………………………………………………….

Stormwater management

Development area	……………………….m^2
Impervious areas – Roof areas Roof connected to rainwater storage Roof area not connected to storage Total	 ……………………….m^2 ……………………….m^2 ……………………….m^2
Impervious areas - Paved areas Hard paved areas Permeable / porous paving Total	 ……………………….m^2 ……………………….m^2 ……………………….m^2
Total impervious areas (with a 50% reduction applied to permeable/porous paving areas)	……………………….m^2

Analysis / modelling results for sediment, nutrient and runoff volumes

	Existing conditions	Development with no WSUD measures	Development with WSUD measures	% Reduction with WSUD measures
Suspended solids export (kg/yr)				
Phosphorus export (kg/yr)				
Nitrogen export (kg/yr)				
Peak flow for 3 months ARI storm (m^3/s)				
Peak flow for 5 years ARI storm (m^3/s)				
Peak flow for 100 years ARI storm (m^3/s)				

Pond / Wetland proposals

The following details are to be completed for all proposed pond / wetland designs to allow for the basic elements to be checked for sizing and adequacy.

	RL	Surface area	Volume
Pond invert		0	0
NWL(1)			
TWL(2) – 3 months ARI storm			
TWL(2) – 100 years ARI storm			

(1) NWL = Normal water level prior to storms

(2) TWL = Top water level

	Inflow	Outflow
1 year ARI flow		
5 years ARI flow		
100 years ARI flow		

Catchment area to pond for small storms up to 3 months ARI = …………..Ha

Catchment area to pond for large storms up to 100 years ARI = …………..Ha

Percentage urbanised = ……………..%   Percentage impervious = ………….. %

Extended detention = Volume at TWL (target 3 months ARI flow) – Volume at NWL

= ………………… m^3

Retardation storage = Volume at TWL (100 years ARI flow) – Volume at TWL (3 months ARI flow)

= ………………… m^3

Macrophyte zone area (less than 600 mm depth at NWL) = ……………………..%

Plant species proposed (list and include % of total planting area):

Wastewater reuse (optional)

Wastewater reuse proposed?	Y / N
Type of reuse Untreated greywater (direct use on garden only) Treated greywater Community reuse facility (if available)	 Y / N Y / N Y / N
Uses for wastewater Garden use Toilet flushing Laundry use Other	 Y / N Y / N Y / N Y / N
Estimated annual reuse	……………………….m^3 (= kL)

Summary of WSUD targets and achievements

	Target	Achieved
Mains water use reduction	40%	………..%
Reduction in suspended solids	60%	
Reduction in total phosphorus	45%	
Reduction in total nitrogen	40%	
Effluent reuse	Optional	………….. kL/yr

Appendix B - Assessment tools

B.1 Mains water

The ACT Government is currently reviewing a number of alternative tools to assess the achievement of mains water reduction targets. In the interim, it is proposed to use either the NSW BASIX toolkit or the ACT Planning and Land Authority on-line tools to determine how to meet mains water reduction targets for residential properties.

ACT Planning and Land Authority on-line tool

The ACT Planning and Land Authority has developed an on-line tool for assessing the reduction in mains water use of a range of measures. The tool can be used for single residential, multi-unit residential and commercial developments. The tool assesses whether a proposed development will meet the target of 40% mains water reduction. It requires information about the proposed development such as block area, roof area, landscaped areas (both lawn and garden areas). It enables measures such as rainwater tanks and greywater systems to be assessed in terms of meeting the water use reduction target.

BASIX

Introduced as part of the NSW planning system, BASIX (the Building Sustainability Index), is a web-based planning tool that measures the potential performance of new residential dwellings against a range of sustainability indices, including water, stormwater and landscape. By reducing the environmental impact of these features, new homes are more comfortable and cheaper to run than most existing homes.

BASIX ensures each dwelling design meets the **NSW Government's targets** of:

- up to 40% reduction in water consumption and
- 25% reduction in greenhouse gas emissions, compared with the average home.

BASIX can be used to assess whether a new dwelling design meets the desired target reduction in water consumption compared with the average home. Compliance with this target is demonstrated through the completion of a BASIX assessment and the issuing of a BASIX Certificate.

The BASIX on-line assessment requires information about the proposed development, such as site location, dwelling size, floor area, landscaped area and services. BASIX compares the proposal to average existing homes. The proposal is scored according to its potential to consume less mains water than an average existing home.

BASIX can be accessed at www.basix.nsw.gov.au/basix_home.jsp. Data for the Queanbeyan LGA should be used for assessing proposed developments in the ACT.

B.2 Stormwater quality

To support the consistent assessment of stormwater pollutant exports and stormwater treatment trains, calibration of the rainfall/runoff and pollutant export parameters for the MUSIC and XP-AQUALM models were undertaken. The calibration process is outlined below and the resulting recommended model parameters are given.

MUSIC

The CRC for Catchment Hydrology (CRCCH) has developed a Model for Urban Stormwater Improvement Conceptualisation (MUSIC), which packages the results of many research activities undertaken at the CRCCH and other organisations into a user-friendly stormwater management tool.

MUSIC enables urban catchment managers to (a) determine the likely water quality emanating from specific catchments, (b) predict the performance of specific stormwater treatment measures in protecting receiving water quality, (c) design an integrated stormwater management plan for a catchment, (d) evaluate the success of a treatment node or treatment train against a range of water quality standards, and (e) analyse the lifecycle costs of a treatment node or treatment train.

Rainfall/Runoff calibration

The rainfall/runoff parameters for MUSIC were calibrated against observed runoff from the Gungahlin (112 ha) gauged rural catchment and the Giralang (91 ha), Mawson (413 ha), Long Gully (495 ha) and Curtin (2,701 ha) gauged urban catchments. It was found that the initial calibrated parameters for the Gungahlin and Giralang catchments did not perform well for the Mawson, Long Gully and Curtin catchments.

The calibration approach that evolved was to:

- run models of the Gungahlin and Giralang catchments for the period 1981 – 1985 using pluviograph data available for each catchment; and
- run models of the Mawson, Long Gully and Curtin catchments for the period 1992-1998 using daily rainfall data for each catchment (initially it was intended to use pluviograph data from Canberra Airport but a comparison of the annual rainfall recorded daily and at 6 minute intervals raised concerns regarding the accuracy of the pluviograph data for this period). A start date of 1992 was adopted to give some certainty in the assessed degree of urbanisation of Long Gully.

A comparison of the gauged and predicted average annual runoff for each gauged catchment gave the following level of agreement: Gungahlin (+8.7%), Giralang (-9.6%), Mawson (-1.1%), Long Gully (-2.4%) and Curtin (+2.0%).

The final adopted rainfall/runoff parameters represent a trade-off between the calibration achieved for the Gungahlin and Giralang catchments and the Mawson, Long Gully and Curtin catchments.

Pollutant exports

An issue of concern when running MUSIC with stochastic Event Mean Concentrations (EMCs) (ie. specifying both a mean EMC and a standard deviation) is that re-running the same model without changing any parameters gives calculated annual export rates that vary. This provides a challenge when the aim is to reduce pollutant exports after development to pre-development levels and the pre-development “benchmark” can vary from run to run. To overcome this problem it is recommended that constant EMCs only be used to ensure the reproducibility of results.

Mean EMCs and standard deviations were identified based on a review of:

- available water quality data from the paired catchment study (Gungahlin and Giralang);
- EMCs reported in the draft Australian Runoff Quality Guidelines, 2003; and
- default values given in MUSIC.

The MUSIC model was run using stochastically generated and constant EMCs. It was found that using constant EMCs set equal to the mean gave lower export rates than the stochastically generated EMCs particularly for SS. Constant EMCs that gave similar results to the stochastically generated results were determined by adjusting the input constant EMC and comparing calculated export rates with the rates generated using stochastic EMCs.

The adopted constant EMCs were based on the following:

	Baseflow	Stormflow
Pasture		
SS	Mean	Mean + 0.25 * Std Dev
TN	Mean	Mean + 0.25 * Std Dev
TP	Mean	Mean + 0.25 * Std Dev
Urban		
SS	Mean	Mean + 0.5 * Std Dev
TN	Mean	Mean + 0.25 * Std Dev
TP	Mean	Mean + 0.25 * Std Dev

Rainfall

To allow the consistent assessment of stormwater pollutant exports and stormwater treatment trains across Canberra pluviograph data from the Canberra Airport for the period 1968 to 1977 shall be used for assessment purposes. This period of rainfall has an average annual rainfall of 655.3 mm.

MUSIC parameters

The recommended MUSIC parameters are summarised as follows:

Parameter	Pasture	Urban
Rainfall Runoff Parameters		
Impervious Area Properties		
Rainfall Threshold (mm/day)	0	0
Pervious Area Properties		
Soil Storage Capacity (mm)	40	40
Soil Initial Storage (% of Capacity)	20	20
Field Capacity (mm)	25	25
Infiltration Capacity coefficient - a	200	200
Infiltration Capacity exponent – b	1	1
Groundwater Properties		
Initial Depth (mm)	1	1
Daily Recharge Rate (%)	25	25
Daily Baseflow Rate (%)	1	1
Daily Deep Seepage Rate (%)	15	15
Stormwater Quality Parameters		
Baseflow TSS Mean (log mg/L)	1.400	1.100
Baseflow TSS Standard Deviation (log mg/L)	0	0
Baseflow TSS Estimation Method	Mean	Mean
Stormflow TSS Mean (log mg/L)	**2.041**	**2.19**
Stormflow TSS Standard Deviation (log mg/L)	0	0
Stormflow TSS Estimation Method	Mean	Mean
Baseflow TP Mean (log mg/L)	-0.880	-0.820
Baseflow TP Standard Deviation (log mg/L)	0	0
Baseflow TP Estimation Method	Mean	Mean
Stormflow TP Mean (log mg/L)	**-0.6615**	**-0.6497**
Stormflow TP Standard Deviation (log mg/L)	0	0
Stormflow TP Estimation Method	Mean	Mean
Baseflow TN Mean (log mg/L)	0.074	0.320
Baseflow TN Standard Deviation (log mg/L)	0	0
Baseflow TN Estimation Method	Mean	Mean
Stormflow TN Mean (log mg/L)	**0.3138**	**0.4265**
Stormflow TN Standard Deviation (log mg/L)	0	0
Stormflow TN Estimation Method	Mean	Mean

XP-AQUALM

XP-AQUALM is a water resources quality modelling package with components for generating surface and subsurface runoff, non-point source and point source pollutant export and pollutant transport and routing. It is aimed at enabling environmental planners and engineers to analyse and cost the effects of planned land use changes and catchment management practices. It also aims to allow the planner or engineer to analyse and optimise a range of catchment management options in a networked environment.

Rainfall/Runoff calibration

The rainfall/runoff parameters for XP-AQUALM were also calibrated against observed runoff from the Gungahlin gauged rural catchment and the Giralang, Mawson, Long Gully and Curtin gauged urban catchments using the same approach as adopted for the calibration of MUSIC model parameters.

Rainfall/runoff parameter values were determined to match the runoff from each catchment predicted by the MUSIC model. This approach was adopted to ensure that consistent results would be obtained from both models. The calibrated parameters are summarised as follows:

Parameter	**Pasture**	**Urban**
a	0.0927	Varies (see below)
b	-0.2	-0.2
Cp_{max} (Initial Value)	2 (0)	2 (0)
Dr_{max} (Initial Value)	40 (0)	40 (0)
Kt	0.05	0.05
g	0.0002	0.0002
Us_{max} (Initial Value)	115 (70)	115 (70)
d	0.7	0.7
e	0.0004	0.0004
f	0.0	0.0

Catchment Imperviousness	Coefficient a
0%	0.0927
31%	0.42
40%	0.51
50%	0.61
60%	0.71
70%	0.80
80%	0.92

Coefficient “a” can be also calculated using the following relation:

$$a = 0.010292 \times I\ (\%) + 0.0927$$

Rainfall

To allow the consistent assessment of stormwater pollutant exports and stormwater treatment trains across Canberra pluviograph data from the Canberra Airport for the period 1968 to 1977 shall be used for assessment purposes. This period of rainfall has an average annual rainfall of 655.3 mm.

Pollutant exports

Until recently the most widely adopted approach for daily estimation of pollutant exports using XP-AQUALM has been to adopt a load relationship of the form:

$$\text{Load (kg/ha)} = a\ \text{RO}^{b}$$

where RO = daily runoff (mm)

a = calibrated coefficient

b = calibrated exponent

A review of the daily pollutant concentrations calculated using these simple load based pollutant export relations concluded that the calculated daily concentrations can give misleading agreement when compared with 10 percentile, 50 percentile and 90 percentile observed pollutant concentrations (Phillips & Thompson, 2002).

This has led to the recommendation that non-point source pollutant loads be estimated using load relationships of the form:

$$\text{Load (kg/ha)} = c\ \text{SR} + d\ \text{TF}$$

where SR = total surface runoff (mm)

TF = total throughflow (mm)

c = calibrated coefficient for surface runoff

d = calibrated coefficient for throughflow

Based on the adopted EMCs for the MUSIC the following pollutant coefficients are recommended for XP-AQUALM.

Pollutant	**Pasture**		Pollutant	**Urban**	
Coefficient	(c)	(d)	Coefficient	(c)	(d)
SS	1.41	0.25	SS	1.55	0.13
TN	0.0246	0.01186	TN	0.0267	0.02089
TP	0.00257	0.00132	TP	0.00224	0.00151

The average annual unit pollutant exports calculated using the recommended MUSIC and XP-AQUALM parameters were compared. The pollutant exports for SS, TN and TP for Urban land use (with imperviousness varying from 40% to 80%) were in agreement with a maximum difference between estimates of up to 1.5%.

These recommended coefficients for XP-AQUALM supersede the guidance given in Table 16.1 of the Design Standards for Urban Infrastructure, Part 16 Urban Wetlands, Lakes and Ponds issued by the Department of Territory and Municipal Services.

Pollutant retention curves

Where catchment runoff is directed through ponds or wetlands the pollutant retention curves for SS, TN and TP based on curves reported in the publications entitled ***Urban Stormwater Standard Engineering Practices, Edition 1*** released by the ACT Government and ***Managing Urban Stormwater - Treatment Techniques*** released by NSW EPA are recommended. The recommended retention curves are tabulated as follows:

Retention Time (days)	**Suspended Solids**		**Total Nitrogen**		**Total Phosphorus**	
	Sedimentation Regime	Macrophytic Regime	Sedimentation Regime	Macrophytic Regime	Sedimentation Regime	Macrophytic Regime
0	0	0	0	0	0	0
0.4	17	28	3	15		
1	30	44	10	25	11	19
2	40	55	15	30	20	32
3	45	62	19	35	25	39
4	50	67	23	39	29	44
5	53	70	25	41	32	48
7	58	76	28	45	36	54
10	63	82	31	50	40	60
14	67	85	35	52	45	66
21	73	87	40	57	49	74
28	77	88	45	61	53	79
35	80	89	47	64	56	83
49	83	91	50	66	60	85
Source:	*ACT, 1994 Guidelines*		*DLWC, 1998*		*ACT, 1994 Guidelines*	

B.3 Stormwater quantity

The ACT Government has previously assessed the suitability of four rainfall/runoff programs for the assessment of the impacts of development on peak flows and volumes of runoff due to storm events. These programs include XP-RAFTS, DRAINS (ILSAX), RORB and WBNM.

The ACT Government has previously determined appropriate parameters for these rainfall/runoff computer programs from the calibration of predicted peak flows against gauged flood frequency curves for urban catchments in Giralang, Mawson and Curtin. The calibrations determined appropriate parameters applicable to individual programs as follows:

- design rainfall loss rate estimation parameters;
- surface runoff routing parameters for pervious and impervious areas; and
- design storm event modelling procedures.

The recommended parameters and procedures to be used instead of values and procedures recommended in program documentation and related reports are given in the ACT Department of Urban Services publication ***Design Standards for Urban Infrastructure, 1 Stormwater*** downloadable from www.roads.act.gov.au/documents/index.html#stormwater

XP-RAFTS

The XP-RAFTS rainfall/runoff program has been recently used to explicitly model the rainfall runoff process on an individual block and the adjoining strip of roadway, then combine countless individual single block models to simulate flood behaviour at the neighbourhood, sub-catchment and catchment scales. It has also been used to assess the interaction of rainwater tanks and OSD tanks and the reduction in OSD tank sizes due to either dedicated airspace and/or dynamic airspace in a rainwater tank.

Rainfall loss rates

The XP-RAFTS program offers a choice between two approaches to rainfall loss estimation. They are the initial/continuing loss model and the infiltration/water balance procedure that utilises the Australian Representative Basins Model (ARBM). The use of the ARBM loss model shall be used in preference to the initial/continuing loss model due to the ability of ARBM to model a range of ARI events with a single set of model parameters.

The values for the ARBM loss model to be adopted are as follows.

Parameter	Adopted Value	Initial Value
Storage Capacities		
Impervious (IMP)	0.50	0.0
Interception (ISC)	1.00	0.0
Depression (DSC)	1.00	0.0
Upper soil (USC)	25.00	20.00
Lower soil (LSC)	50.00	40.00
Infiltration		
Dry soil sorptivity (SO)	3.00	
Hydraulic conductivity (K0)	0.33	
Lower soil drainage factor (LDF)	0.05	
Groundwater recession;		
constant rate (KG)	0.94	
variable rate (GN)	1.00	
Evapo-Transpiration		
Proportion of rainfall intercepted by vegetation (IAR)	0.70	
Max potential evapo-transpiration (EV);		
upper soil (UH)	10.00	
lower soil (LH)	10.00	
Proportion of EV from upper soil zone (ER)	0.70	
Ratio of potential evaporation to A class pan (ECOR)	0.90	

Surface runoff routing

The following surface runoff routing parameters shall be adopted.

Parameter	Value
Impervious surface roughness	0.015
Pervious surface roughness	0.040
Non-linearity coefficient (default) (1)	0.285

Peak flow estimation

As part of a recent assessment of the effectiveness of WSUD water quality storages for On-Site Detention (Cardno Willing, 2005) an XP-RAFTS model of the Curtin gauged urban catchment was assembled using the ARBM rainfall loss parameters given in ACTUS. Runs were undertaken for a Benchmark Urban condition (based on 31% imperviousness for urban areas) and a Pasture condition. 100 year ARI, 5 year ARI and 3 month ARI storm bursts were run.

It was found when the 3 month ARI storm for the Pasture case was run that no runoff was generated. Consequently the subcatchment "baseflow" calculation was "turned on". It was found that turning on the baseflow has a significant effect in the estimated peak flows during 3 month ARI events. The impact on peak flows in the 5 year ARI and 100 year ARI events was minimal (no more than 2-3%).

A check on the benchmark urban 3 month ARI estimates was undertaken. Estimates of the peak 3 month ARI flow were obtained for the Mawson gauge and Curtin gauge from "Design Peak Discharges for ARIs less than One Year", Report HWR 92/679 dated February 1993. The comparison disclosed excellent agreement between the two estimates.

It was found however that the hydrographs for the 3 month ARI pasture results (with baseflow "turned on") exhibit a constant outflow after the cessation of rainfall. This is attributed to the soil stores draining. Consequently it was not possible to estimate runoff volumes for the 3 month ARI events under Pasture conditions.

It is recommended that when assessing the impact of development and/or stormwater quantity measures that:

- The subcatchment "Use Baseflow" option be activated;
- "Calculate Baseflow using ARBM" be selected; and the
- "Baseflow multiplier" = 1.

On-site detention

A recent assessment of the effectiveness of WSUD water quality storages for on-site detention was undertaken for ACT Roads in 2004/2005. The application of XP-RAFTS for the assessment of the impacts of on-site detention and/or rainwater tanks on peak flows in 3 month ARI, 5 year ARI and 100 year ARI events is outlined in Cardno Willing, 2005. This report provides a guide to the application of XP-RAFTS to similar assessments of OSD for new developments or re-developments.

DRAINS (ILSAX)

Rainfall loss rates

The DRAINS (ILSAX) program incorporates the Horton's infiltration equation to determine rainfall losses occurring on pervious surfaces. DRAINS (ILSAX) also requires that the catchment soil type and antecedent moisture condition be specified. The rainfall loss parameter values given below shall be adopted.

Parameter	Value
Impervious (paved) depression storage	1 mm
Pervious (grassed) depression storage	5 mm
Soil type	3.0
AMC	3.2

Time of concentration

The procedure to calculate the time of concentration for sub-catchment pervious runoff shall be as follows:

The minimum time of concentration to be considered shall be 5 minutes.

The following relations shall be used for determining the overland flow travel time component (*t*) of the total surface flow time of concentration (t_c) for catchments in the ACT.

$T_0 = 107\ n\ L^{0.333}\ S^{-0.2}$ for $L \leq 200$ m

$T_0 = 0.058\ L\ A^{-0.1}\ S^{-0.2}$ for $L > 200$ m

where:
A = catchment area (hectares)
T_0 = overland flow travel time (minutes)
L = flow path length (m)
S = slope of surface (%)
N = Horton's roughness value for the surface (refer below

Surface Type	Horton roughness value
Paved surface	0.015
Bare soil surface	0.028
Poorly grassed surface	0.035
Average grassed surface	0.045
Densely grassed surface	0.060

The time of concentration for all impervious areas should be set at 6 minutes.

RORB

The RORB model utilises a constant loss rate for impervious areas and an initial loss followed by a runoff coefficient or constant (continuing) proportional loss rate for pervious areas. The rainfall loss parameters in the following table shall be adopted for pervious areas.

Parameter	Value
Initial loss	10 mm
Runoff coefficient	45%

The RORB runoff routing method is based on the storage-discharge relationship:

$$S = 3600\ k\ Q^{m}$$

The dimensionless coefficient, m, is a measure of catchment non-linearity with a value of 1.0 implying a linear catchment. The dimensionless empirical coefficient, k, is the product of two factors, k_c and k_r.

The factor k_r is a dimensionless ratio called the relative delay time applicable to an individual reach storage and k_c is an empirical coefficient applicable to the entire catchment and stream network. The runoff routing parameters in the following table shall be adopted.

Parameter		Value
m	(adopt default)	0.8
k_c	(adopt default equation)	$2.2A^{0.5}$ (1)

(1) A = catchment area (km^2)

Water Bounded Network Model (WBNM)

The WBNM program offers a choice between two approached to rainfall loss estimation. They are the initial/continuing loss model and the initial/proportional loss model. Due to a lack of information on proportional losses in Canberra, the initial/continuing loss model shall be used for both urban and rural catchments in the ACT with the recommended values given in the following table.

Catchment	Initial Loss (mm)	ARI (years) 2	5	10	20	>50
		Continuing Loss (mm)				
Rural	0	3.6	3.3	2.8	1.7	1.0
Urban (30% urbanised)	0	2.5	2.3	1.9	1.2	0.7

Other methods and models

The use of other propriety hydrological methods or models will not be permitted without prior approval from the operating Authority.

To obtain approval, the designer must demonstrate, to the satisfaction of the operating authority, that a particular method or model is appropriate for ACT conditions. One of the following procedures shall be used to calibrate the method or model and determine appropriate assumptions and parameter values for the estimation of major and minor system design flow;

- calibration to the current flood frequency rating curves for the Giralang, Mawson, and Curtin catchments; or
- comparison with the Rational Method or one of the rainfall/runoff models described herein.

Flood frequency curves and calibrated model data sets for the Giralang, Mawson, and Curtin catchments may be obtained from the operating authority.

The designer shall submit a report to the operating authority giving full details of the method or model to be used including all assumptions made, recommended parameter values, and tabulated flow comparisons for major and minor system ARIs.