# Chapter 5

# Water Sensitive Urban Design

**Key references**

Department of Planning, 1993, *Better Drainage: Guidelines for the Multiple Use of Drainage Systems*.

National Capital Planning Authority, 1993, *Designing Subdivisions to Save and Manage Water.*

Whelans, Halpern Glick Maunsell, Thompson Palmer and Institute for Science and Technology Policy, Murdoch University, 1993, *Water Sensitive Urban (Residential) Design Guidelines for the Perth Metropolitan Region: Discussion Paper.*

## 5.1 Introduction

Water sensitive urban design offers an alternative to the traditional conveyance approach to stormwater management. It seeks to minimise the extent of impervious surfaces and mitigate changes to the natural water balance, through on-site reuse of the water as well as through temporary storage.

By integrating major and minor flow paths in the landscape and adopting a range of water sensitive design techniques, the size of the structural stormwater system required can be reduced. These techniques include detention and retention basins to lower peak flows, and grassed swales and vegetation to facilitate water infiltration and pollutant filtration.

An *integrated approach* to stormwater management is the key to water sensitive urban design. This integrated approach regards stormwater as a resource rather than a burden and considers all aspects of run-off within a development, including environmental, social and cultural issues.

A *multi-purpose corridor* is an important design element in many integrated stormwater management systems, and it may include water features, habitat protection and recreation. These provide many benefits including:

- protection of environmental values and supporting wildlife habitats;

- filtration of stormwater (via well vegetated areas);
- recreational opportunities; and
- protection of the residential development from flooding.

Managing urban run-off in a water sensitive manner not only resolves problems associated with stormwater, but it enhances the social and environmental amenity of the urban landscape. Reducing peak flows and maintaining a more natural stormwater system can also potentially reduce capital and maintenance costs of drainage infrastructure.

The objectives of water sensitive urban design are summarised in Figure 5.1. This section presents techniques for water sensitive urban design to be incorporated into: site planning, residential design, commercial and industrial design and construction site management.

1 *Protect natural systems*
Protect and enhance natural water systems within urban developments.

2 *Integrate stormwater treatment into the landscape*
Use stormwater in the landscape by incorporating multiple use corridors that maximise the visual and recreational amenity of developments.

3 *Protect water quality*
Protect the quality of water draining from urban development.

4 *Reduce run-off and peak flows*
Reduce peak flows from urban development by local detention measures and minimising impervious areas.

5 *Add value while minimising development costs*
Minimise the drainage infrastructure cost of development.

**Figure. 5.1**

## 5.2 Benefits of water sensitive urban design

Water sensitive urban design emphasises the benefit of stormwater and waterways as a resource and an asset, rather than the conventional view of stormwater merely as a nuisance. It provides many opportunities to integrate water features in urban design and to enhance the social and environmental amenity of urban developments.

Tables 5.1 and 5.2 provide a summary of the economic, environmental and social benefits and constraints associated with water sensitive urban design.

| Economic opportunities | Economic constraints/limitations |
|---|---|
| *Capital cost savings*: reduces capital costs (pipework and drains). | *Market limitations*: the market may be sensitive to new urban forms. |
| *Construction cost savings*: reduces construction costs (e.g. grading, tree clearing). | *Maintenance/operation costs*: can potentially increase maintenance and operation costs. |
| *Water quality cost savings*: potentially reduces the costs of water quality improvement, by retaining existing waterways. | *Limited developable lots*: potential loss of profits through the reduction in the number of developable lots. This occurs in areas that traditionally have been made available through the piping of water courses. |
| *Developer cost savings*: reduces developer contributions for downstream drainage capacities. | *Storm events and steep terrain*: there may be a possible need to supplement water sensitive treatments (such as swales) with pipes, to accommodate minor storm events and steep terrain. |
| *Improved market value*: incorporating water features, water frontages, networked public open space and preserving and enhancing ecological systems tends to make developments more desirable and marketable. | *Land acquisition difficulties*: fragmented land ownership may limit the opportunity to implement water sensitive initiatives. |
| *Improved resource utilisation*: offers cost benefits where areas are unsuitable for residential development, but are suitable for passive recreation and contribute to required public open space allocation. | *Open space requirements*: the benefits may be reduced where potentially attractive residential areas must be reserved as open space. |

**Table 5.1 Summary of economic benefits and constraints associated with water sensitive urban design.**

| Environmental and social opportunities | Environmental and social constraints/limitations |
|---|---|
| *Hydrological balance*: maintains the hydrological balance by using natural processes of storage, infiltration and evaporation. | *Water table depth*: opportunities are limited in areas with high water tables. |
| *Sensitive area protection*: protects environmentally sensitive areas from urban development. | *Topography and erosion*: opportunities are limited in areas of deeply dissected terrain and high slope. |
| *Waterways restoration*: restores and enhances urban waterways. | *Ground conditions*: opportunities are limited in areas of poor soil (high slaking or highly dispersive) and shallow depth to bedrock. |
| *Impact reduction*: minimises the impact on the environment of urban development. | *Safety perceptions*: perceived safety risks. |
| *Natural habitats enhancement*: can increase the diversity of natural habitats and suburban landscapes. | *Acceptance*: may experience some public resistance to new forms in urban landscape. |
| *Groundwater recharge.* | |
| *Amenable urban and residential landscapes.* | |
| *High visual amenity.* | |
| *Linking*: opportunities to link community nodes through public open space. | |

**Table 5.2 Summary of environmental and social benefits and constraints associated with water sensitive urban design.**

# 5.3 Site planning

The process used to lay out a development is fundamental to achieving the principles of water sensitive urban design and good environmental management of stormwater. The following describes three key areas where developers can incorporate these principles at the site planning stage.

## 5.3.1 Site analysis

The purpose of a site analysis is to identify and explain graphically the natural features of the area that need to be taken into consideration during planning and design. These include the area's topography, drainage patterns, soils, geology, ground cover and sensitive regions, along with significant natural attributes such as wetlands, waterways, remnant vegetation and wildlife corridors.

There should also be an assessment of the area's stormwater and drainage requirements and constraints. This should include flood control (for example the 100-year ARI flood limit), the potential maintenance of natural waterway corridors, and the provision of stormwater management structures and treatment measures.

As part of the drainage strategy required by the responsible drainage authority, developers need to demonstrate either that the proposed development will not affect the downstream systems, or that the proposed stormwater treatment measures will sufficiently mitigate potential water quality and quantity impacts.

## 5.3.2 Land capability assessment

Land capability assessment analyses the physical ability of the land to sustain specific uses. It determines the scale and arrangement of development that is most consistent with water sensitive urban design principles, based on the local site features identified in the site analysis.

## 5.3.3 Land-use plans

Land-use plans determine the scale and arrangement of development that is most consistent with water sensitive urban design principles for managing the drainage system.

Using the site analysis and land capability assessment, which identify and protect those areas of environmental significance, the areas of developable land can then be identified. Water sensitive land-use plans determine where development should occur within the site to produce the least impact on the ecosystem.

These plans should ensure there is adequate land area in appropriate locations designated for the purpose of stormwater management. The assessment of potential areas for development should consider the site locations of stormwater treatment measures such as wetlands, sediment traps and infiltration/retention basins.

At this stage, it is appropriate to determine recommendations and details of cost-effectiveness for practices that:

- are most appropriate for retaining or detaining stormwater locally, given the particular conditions of soil, geology and topography involved and the anticipated land-use;
- are needed to ensure that pollution mobilisation and conveyance within and from the site are minimised; and
- increase public amenity through landscaping and the provision of wetlands and wildlife habitats where possible and appropriate.

## 5.4 Residential design tools: index



### Residential design tool No. 1: Local public open space networks

*Description*

Water sensitive urban design often incorporates multi-purpose drainage corridors in residential developments. These integrate public open space with conservation corridors, stormwater management systems and recreation facilities. This has both social and economic benefits. Consequently, open space becomes more useable because of the opportunity to link and share space for multiple activities. Vegetated drainage corridors can also provide buffer strip protection for natural water features within the development.

The development of active recreation areas next to drainage facilities can introduce some elements of public safety and health risk. This requires consideration during the design phase and can often be addressed using techniques such as safety signs and barriers.

*Advantages*

A networked public open space system incorporating water sensitive urban design provides many opportunities including:

- integration of public open space, habitat and stormwater corridors;

- protection of natural water features with vegetated buffer strips;
- improvement of visual amenity, public access and passive recreational activities;
- incorporation of water features in public open space;
- creation of landscaped links between public and private areas;
- incorporation of pathways between community activity nodes;
- treatment of pollution and encouragement of detention and filtration of stormwater;
- possible use of stored stormwater for irrigation purposes; and
- enhanced property values.

*Limitations*

- networked area may be physically unsuitable for recreational activities;
- networked open space may be unevenly distributed and remote from some areas of the development; and
- development of active recreation areas next to drainage facilities needs to be carefully planned and managed.

**Public open space: suggested measures**

- *Buffer strips*: incorporate buffer strips and grass swales that contain passive recreation elements such as walking trails along natural water features.
- *Filtration/retention basins*: integrate filtration/retention basins in public open spaces.
- *Networked public open spaces*: join public open spaces between community nodes.
- *Drainage corridor*s: use drainage corridors to direct run-off to local treatment ponds.
- *Natural drainage*: maintain natural drainage lines.

Figures 5.2 and 5.3 compare the conventional design with a water sensitive design of a neighbourhood incorporating public open space.

### Residential design tool No. 2: Housing layout

*Description*

A water sensitive housing layout integrates residential blocks with the surrounding drainage function and public open space. Such housing layouts often include a more compact form of development, which reduces impervious surfaces and helps protect the water quality and health of urban waterways.

*Advantages*

- provides the opportunity to incorporate mixed density and use, a pedestrian focus, quality design and a distinct local identity and character;

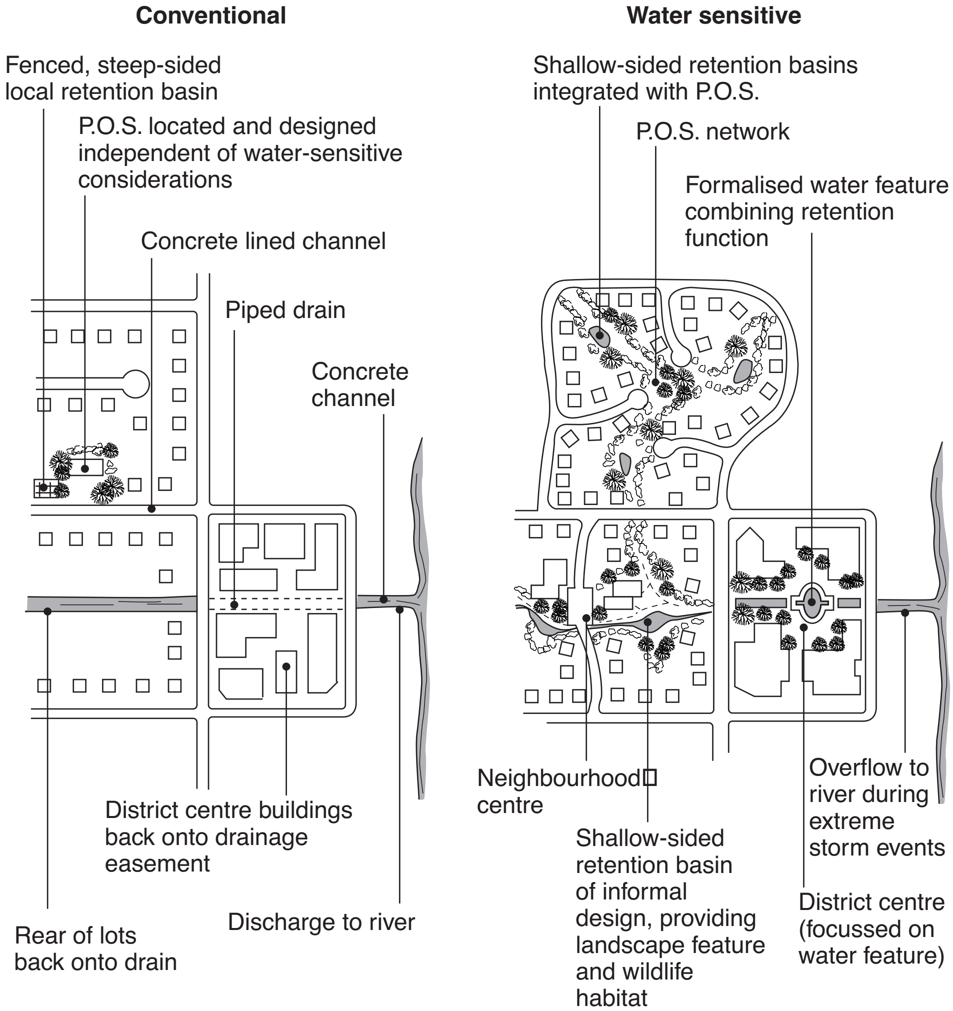


**Figure 5.2 Networked public open space incorporated in development.**

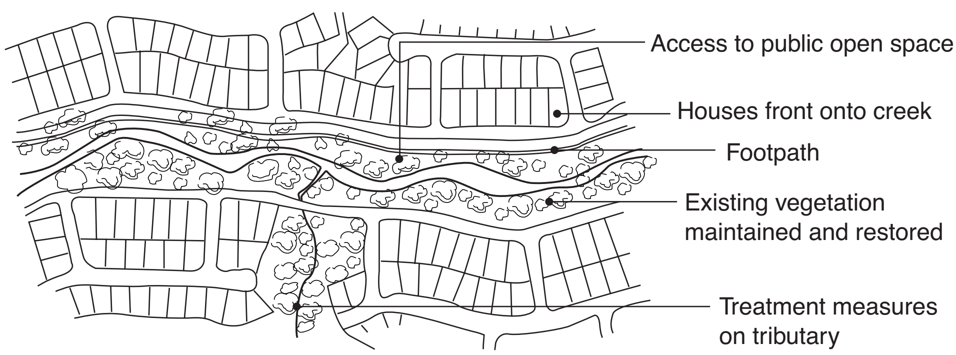


**Figure 5.3 Integration of housing with waterway corridor.**

- reduces capital and maintenance costs per household for municipal infrastructure;
- provides a greater area of public open space within the development; and
- provides the opportunity to direct run-off from housing layouts, such as cluster developments, to water features located in public open space.

*Limitations*

- compact forms of development may not be as attractive to developers and the community.

## Housing layout: suggested measures

- *Increase public open space*: encourage a reduction of private open space and an increase in public open spaces, particularly in areas adjacent to existing public open space. Introduce a flexible minimum lot size.
- *Setbacks*: setbacks from waterways should be determined according to topography, waterway flooding characteristics, vegetation and visual quality.
- *Buffer zones*: incorporate buffer zones beside creeks and retain existing remnant vegetation.
- *Orientation*: orientate residential living areas to public open space.
- *Reduced paving*: minimise the extent of paving and impervious surfaces by introducing
  - shorter residential driveways; and
  - reduced and varied building setbacks and frontages.
- *Lot geometry*: introduce a flexible lot minimum size. Where appropriate, adopt zero lot-lines,† especially for carports.
- *Housing run-off*: where possible, direct run-off from housing to a treatment point within the development site. This is best achieved within more compact developments, such as cluster developments.

† *Zero lot-line*: the location of a structure on a lot in such a manner that one or more sides of the structure rests directly on a lot-line.

### Residential design tool No. 3: Road layout

*Description*

A water sensitive road layout incorporates the natural features and topography of the site. It implements the practice of locating roads beside public open spaces wherever possible—this enhances visual and recreational amenity, temporary storage, infiltration at or close to source, and water quality. It also aims to minimise the extent of impervious road surfaces. As with all road design, road safety should not be compromised.

Figures 5.4, 5.5 and 5.6 illustrate the application of water sensitive design in road layout.

*Advantages*

- in new subdivisions, the road drainage system can be incorporated within the open space network or adjacent to private landscaped areas;
- reduced cost, by minimising the required capacity of the piped network; and
- offers aesthetic benefits, particularly where roads and associated open spaces are incorporated and landscaped with local spaces.

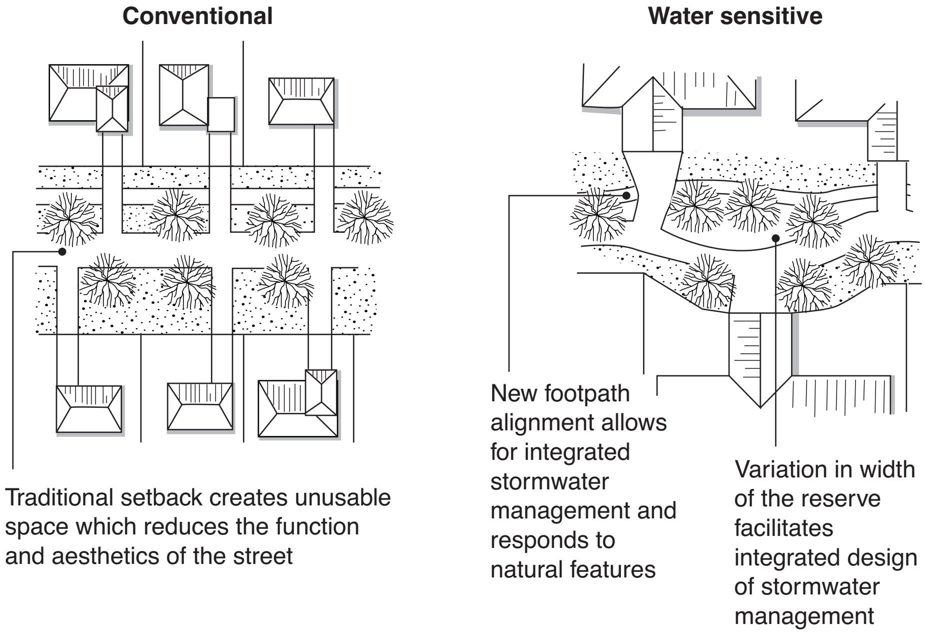


**Figure 5.4 Conventional versus water sensitive road layout.**

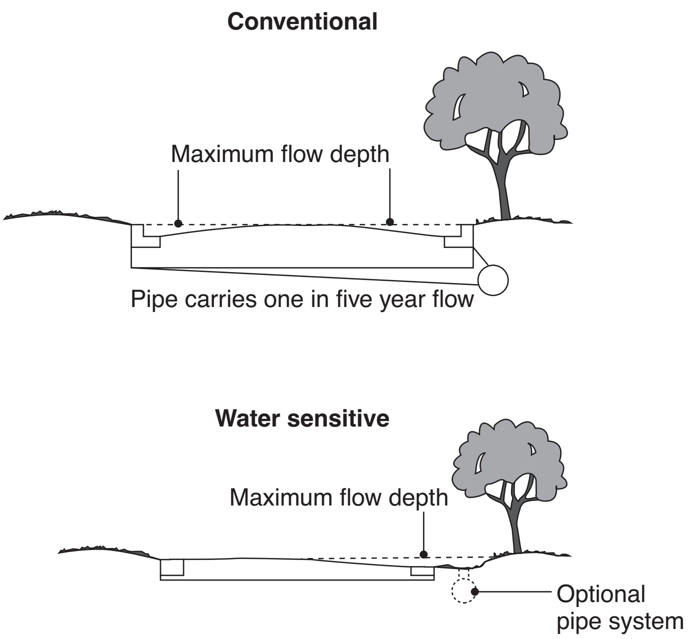


**Figure 5.5 Cross-section of a road.**

### *Limitations*

- existing road layout or irregular terrain may conflict with the drainage function;
- requires a suitable area within a roadway or nature strip to locate infiltration systems;
- infiltration may be limited by soils of low permeability and steep road gradients;
- potential conflict with standard public utility alignments;
- swales and detention in minor streets may not be readily accepted by the public; and
- incorporation of crossovers to properties may prove difficult.

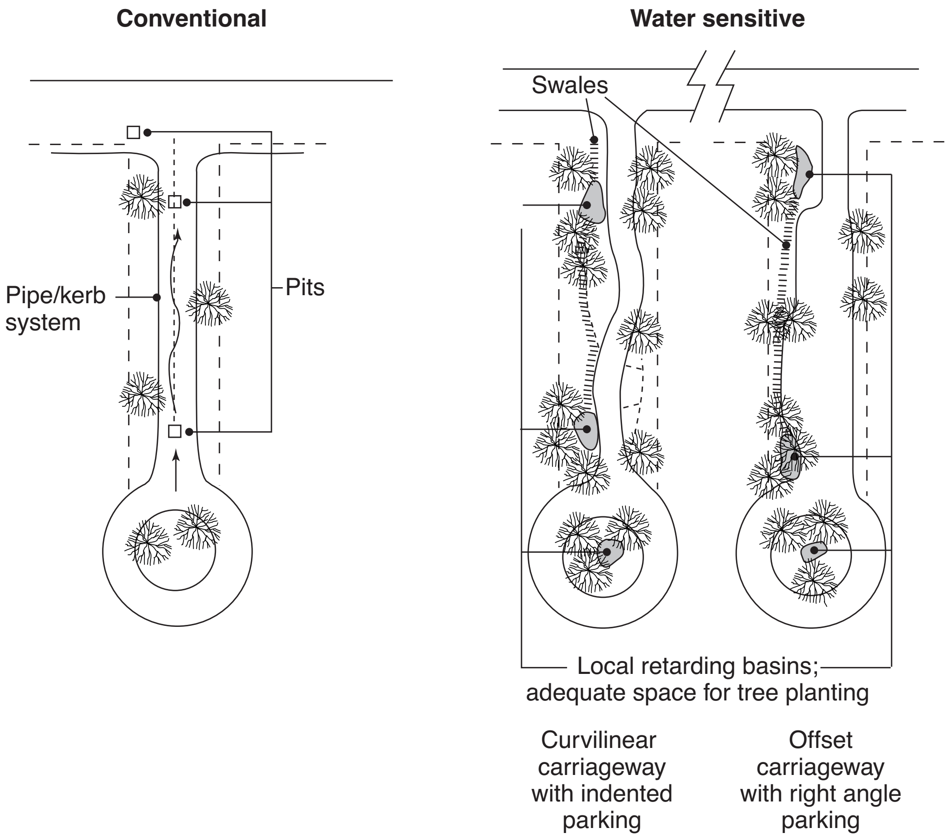


**Figure 5.6 Road verge design and management.**

## Road layout: suggested measures

- *Road alignment*: ensure that local collector roads run parallel to contours.
- *Access places and ways*: ensure short access places and access ways are perpendicular to the contours. Design access places and road cross falls to direct run-off to local collection/detention measures.
- *Reduce impervious surfaces*: reduce the area of impervious surfaces through
  - decreasing the length and width of low traffic local roads;
  - designing a shorter road network; and
  - using cul-de-sacs with reduced road surface areas (smaller radius, T-shaped).
- *Roadside detention*: design roadways and parking to incorporate detention basins and filtering by vegetation. Provide areas for stormwater detention and filtration along road verges where direct vehicular access is restricted or limited. Locate small detention basins, leach drains and swales in ‘pockets’ created by curved alignments.
- *Road location*: locate public open spaces on local collectors at the head or base of cul-de-sac to accommodate local run-off overflow (this is restricted by the gradient of the land).
- *Minor and major flows*: incorporate swales to carry minor flows along collector roads, while roads carry major storm event flows.

## Residential design tool No. 4: Streetscape layout and design

*Description*

A water sensitive streetscape integrates the road layout and vehicular and pedestrian requirements with stormwater management needs. It uses design measures such as reduced frontages, zero lot-lines, local detention of stormwater in road reserves and managed landscaping.

Figures 5.7 and 5.8 illustrate the application of water sensitive design to streetscape layout and design.

*Advantages*

- incorporates water into the streetscape, using surface exposed systems in preference to underground;
- more aesthetically pleasing, with an emphasis on verge treatment by vegetation rather than road pavement;

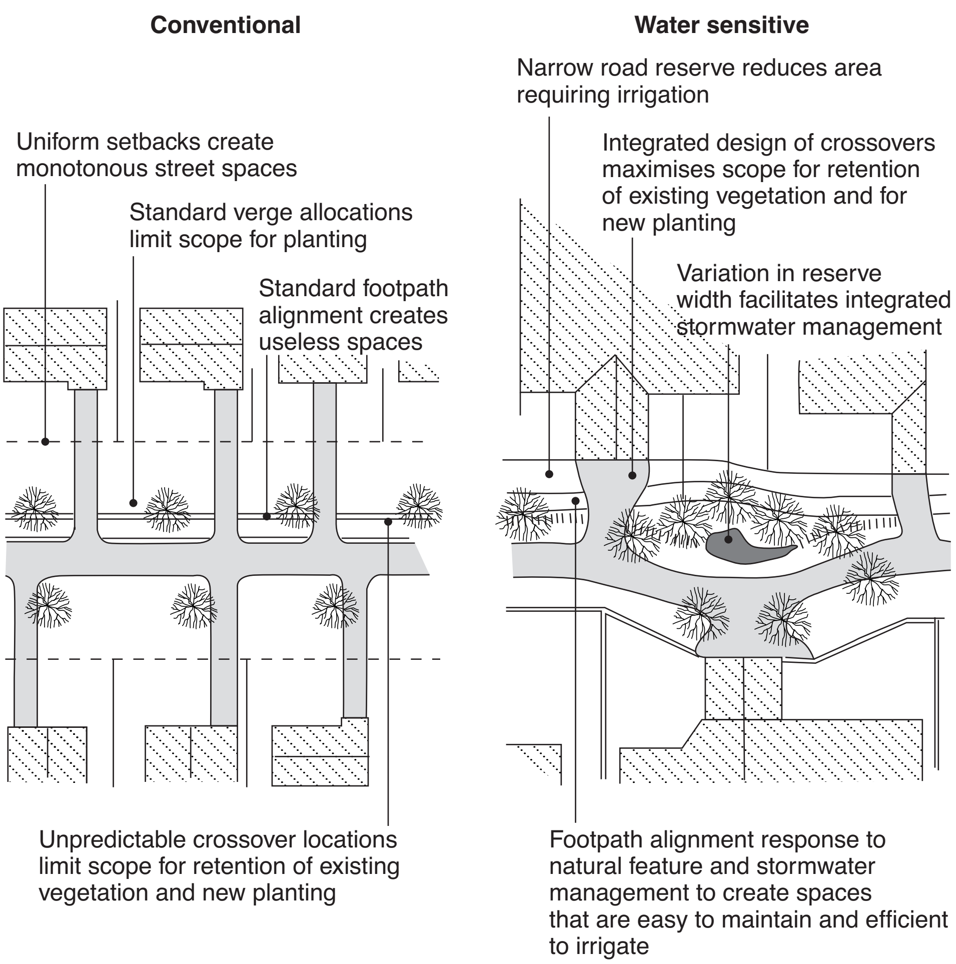


**Figure 5.7 Building/street interface**

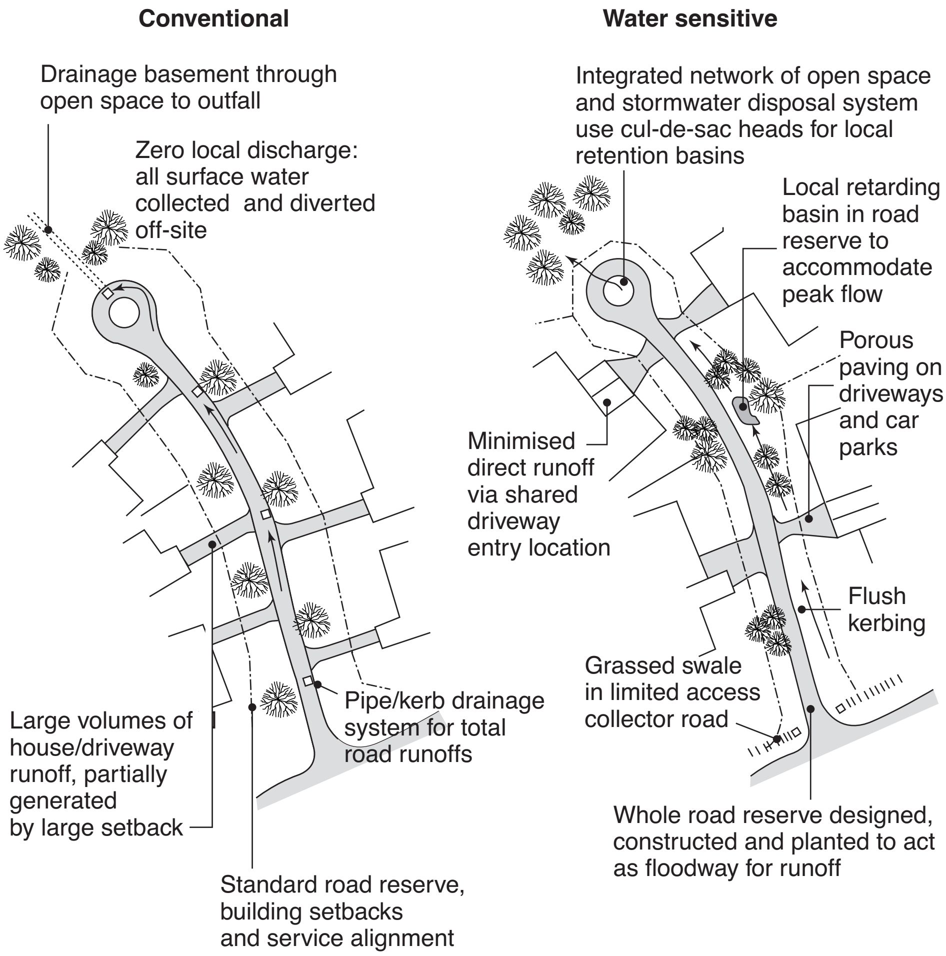


**Figure 5.8 Cul-de-sac streetscapes.**

- local detention or infiltration is encouraged by the use of agricultural type drains and gravel filter beds within drainage channels;
- often incorporates indigenous vegetation;
- provides enhanced public open space; and
- the variation in road reserve width enhances landscape possibilities and streetscape amenity.

*Limitations*

- local site conditions may limit application;
- application in established areas may be limited;
- potential conflict with standard utility alignments; and
- difficult to implement a total managed landscaping program in areas embracing a range of subdivisions or developments.

### Streetscape layout: suggested measures

- *Reduce paved areas*: reduce paved areas by
  - reducing the pavement width;
  - using smaller parking stalls;
  - incorporating footpath on one side of street only;
  - using shared driveway/entry locations.
- *Localised filtration/detention*: use localised leach drains, filtration trenches and pits to detain and filter run-off and contain peak storm events. Use cul-de-sac heads for local retention basins. Use grass swales in limited access collector roads. Incorporate site techniques such as soak wells and porous pavement.
- *Underground services*: incorporate underground power and telecommunications services to increase landscaping options.
- *Setbacks*: incorporate variable building setbacks to increase landscaping and road and drainage design options. Determine setbacks according to pavement width, servicing and landscape requirement.
- *Landscaping*: use landscaping to create interest and variety in the streetscape.
- *Crossovers*: integrate the design of crossovers with vegetation swales and local detention basins.
- *Stormwater recycling*: use stormwater to irrigate local vegetation.

## 5.5 Commercial and industrial design tools: index



### Commercial/industrial design tool No. 1: Parking area storage

*Description*

Parking areas can be a large generator of run-off and polluted stormwater, particularly from shopping areas. Creative design options are needed to minimise the extent of impervious surfaces of parking lots and the subsequent impacts on downstream waterways.

Gently sloping grassed areas or recessed basins can be incorporated into car parks. These may be used to pond water to allow for filtration and the deposition of sediment. This is usually accomplished by incorporating specifically designed or modified inlet structures that permit the temporary storage of stormwater. Figure 5.9 is an illustration of a landscaped car park that contains long recessed areas that store and encourage the detention and treatment of stormwater.

Car park storage is best achieved on sites that are flat to gently sloping, with suitable soils. It is essential that overflow paths for major storms are defined and that these conform with established standards. It is desirable to incorporate other stormwater treatment train processes in the design of car park storage systems.

*Advantages*

The opportunities associated with parking lot storage include:

- integration with car park landscaping proposals and steep slope stabilisation;
- improved car park aesthetics, with an emphasis on local detention and treatment; and
- the possibility of incorporating indigenous vegetation.

*Limitations*

- parking lot size, topography and soil conditions plus its proximity to structures and traffic routes may limit suitability;
- depth of water acceptable in detention zones may be limited; and
- requires regular maintenance as accumulated debris and sediment must be removed, along with periodic inspection of discharge control structures.

**Parking areas: suggested measures**

- *Porous pavement*: 'overflow' of infrequently used parking areas could be constructed with porous pavement.
- *Car park storage and detention*: incorporate gently sloping grassed areas or recessed basins into car parks to encourage detention and treatment of run-off.
- *Infiltration*: use infiltration trenches where appropriate to minimise run-off from the site.
- *Retain natural drainage paths*.
- *Landscape*: incorporate vegetation to improve amenity and water use.

### Commercial/industrial design tool No. 2: On-site detention for large sites

*Description*

Large commercial and industrial sites tend to have extensive impervious surfaces. On-site detention stores stormwater in underground tanks, driveways or landscaped depressions. If designed and used correctly, as shown in Figure 5.10, these can reduce peak discharges and reduce impacts on the downstream receiving environment.

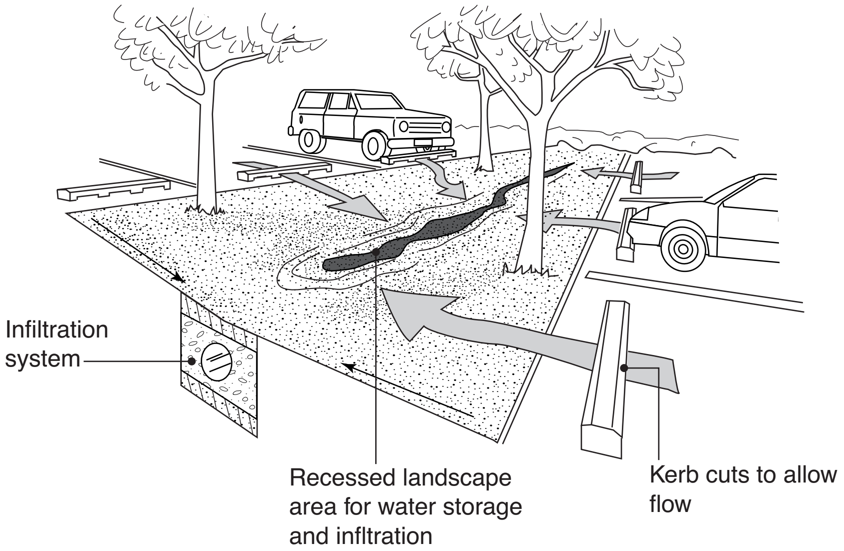


**Figure 5.9 Gently sloping grassed area in parking area.**

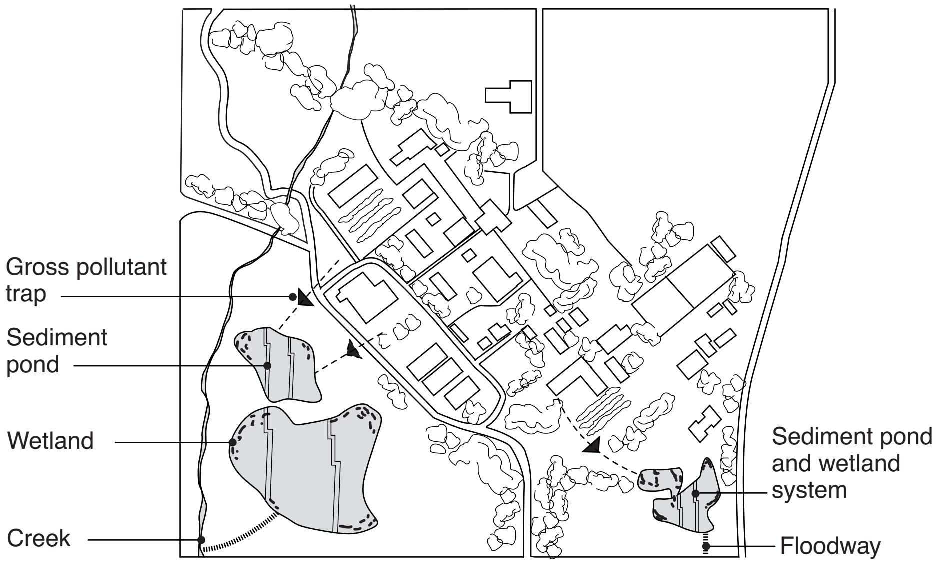


**Figure 5.10 On-site detention for large sites.**

### *Advantages*

The opportunities associated with on-site detention include:

- reduced flooding risk and peak discharges downstream;
- integration with site landscaping proposals and steep site stabilisation;
- improved site aesthetics;
- the possibility of incorporating indigenous vegetation; and
- the possibility of using collected run-off for local irrigation or commercial/industrial purposes.

*Limitations*

- site size, topography and soil conditions plus its proximity to structures and traffic may limit suitability;
- depth of water acceptable in detention zones may be limited; and
- on-site detention outlets may become blocked with debris if regular inspection and maintenance is not carried out—potentially resulting in overflow and uncontrolled discharge.

## 5.6 Site construction management practices

Eroded soils and litter are major pollutant sources during construction activity. Water sensitive urban design principles are fundamental to reducing erosion during construction.

Significant reductions in pollutants can be achieved by using a combination of improved construction practices, structural and vegetation measures and soil stabilisation techniques. An overall site management plan should be prepared, incorporating a range of control measures.

Further information on these techniques is included in Chapter 6 of these Guidelines.