# WATER SENSITIVE URBAN DESIGN

# SITE ASSESSMENT GUIDE

# FINAL

Prepared for the Northern Territory Department of Planning and Infrastructure
GPO Box 2520
Darwin NT 0801

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# 1 INTRODUCTION

Site assessment is required to:

- Understand the nature of the site and the proposed development
- Provide information on physical constraints that will guide the concept and detailed design of WSUD measures such as stormwater treatment devices.
- Provide key information to guide the conceptualisation of water conservation and stormwater quality treatment options

Site assessment will involve some fieldwork and desktop investigation. Important considerations to be addressed in a site assessment are outlined in Table 1.

**Table 1: Site assessment checklist**

| Main considerations | Specific issues | Sources of information |
|---|---|---|
| Climate | - Rainfall (daily and pluviograph)<br>- Evapotranspiration | - Bureau of Meteorology – www.bom.gov.au |
| Natural capital | - Native vegetation<br>- Important habitat/fauna<br>- Waterways – environmental values<br>- Cultural assets | - Ecological assessment<br>- Heritage assessment |
| Ecology | - Aquatic ecosystems requiring protection from urban development<br>- Potential for stream rehabilitation<br>- Vegetation template | - Ecological assessment (including geomorphology input) |
| Landscape attributes | - Adjacent development<br>- Views<br>- Pedestrian links | - Landscape assessment |
| Physical infrastructure | - Regional infrastructure including water supply, wastewater treatment, water recycling, etc. | - Consultation with service authorities |
| Development imperatives | - Population and demographic<br>- Land use and density<br>- Staging and timing<br>- Initial development layout | - Collaboration with urban planners, engineers, etc |
| Topography and drainage | - Catchments and drainage<br>- Slope<br>- Proposed cut and fill | - Detailed site survey |
| Geology, soils and groundwater | - Shallow bedrock<br>- Soil permeability<br>- Acid sulfate soils (ASS)<br>- Salinity<br>- Shallow groundwater | - Geotechnical assessment<br>- ASS risk maps are available from NRETA |
| Existing development | - Existing development on the site to be retained or removed<br>- Underground and overhead services | - Services survey |

This document is organised into the following sections:

- **Section 2** discusses the **Site Context**, which includes those attributes of the site and its surroundings that have a bearing on the WSUD Strategy. Attributes of the site context include climate, natural capital, ecology, landscape, physical infrastructure and development imperatives.

- **Section 3** discusses the **Physical Setting**, which includes the attributes of the site which have a bearing on the location and design of stormwater treatment measures. Attributes of the physical setting include the topography and drainage, geology, soils and groundwater, and existing development.

- **Section 4** discusses **Site Analysis**, which is the process of bringing together information on the site context and physical setting to compile a catchment analysis, water balance and a summary of site constraints and opportunities.

# 2 SITE CONTEXT

In order to formulate a WSUD Strategy for a new subdivision, the site needs to be seen within the context of the broader region. Understanding the site context can help to determine:

- Appropriate types of WSUD solutions for the site
- Locations where stormwater treatment measures could be integrated into the development masterplan

This section discusses how to compile relevant information on a site's natural capital, landscape attributes, physical infrastructure and development imperatives.

## 2.1 Climate

The climate of Darwin region is highly seasonal and, as elsewhere in the wet/dry tropics, is dominated by an extreme wet season between December and March and an extreme dry season between April and October-November. The average rainfall at Darwin is 1700 mm/year and as illustrated in Figure 1, essentially all this rain falls in a three to four month period. The average evaporation at Darwin is approximately 2,590 mm/year, ranging from 165 mm in February to 260 mm in October.

The seasonal nature of the climate dictates all elements of the natural and urban water cycle. During the wet season vegetation is lush, soils become waterlogged, groundwater recharge fills local aquifers, local waterways/streams flow permanently and there is no need to irrigate landscapes. During the dry season, the site becomes parched with only very hardy vegetation present, local streams cease to flow, groundwater levels drop within aquifers and extensive irrigation is required to sustain landscapes.

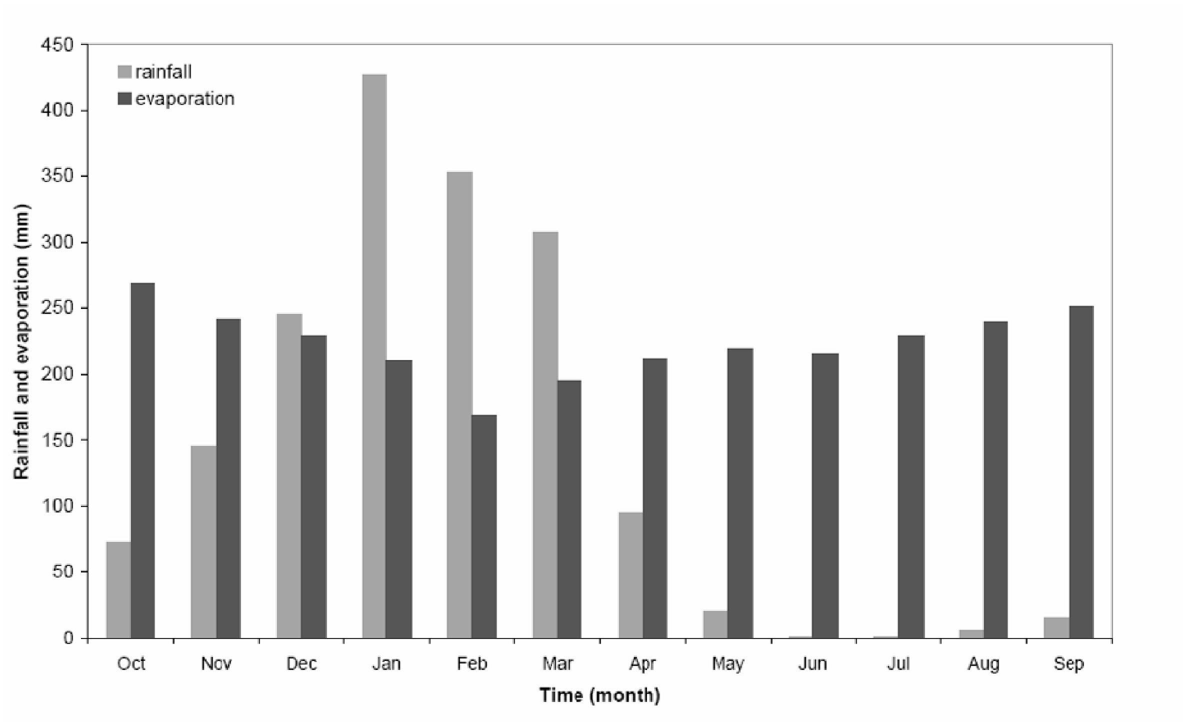


**Figure 1: Summary rainfall and evaporation characteristics for Darwin**

The climate impacts on the design of WSUD measures. Some key considerations are:

- Rainfall and stormwater runoff occurs predominantly from October to April, and stormwater treatment devices will receive almost no inflows from May to September. In some years the dry period may extend to 6 or 7 months.

- Water demands are unevenly distributed throughout the year, with the majority of outdoor water demands occurring in the dry season.

Rainfall data is available from the Bureau of Meteorology at selected weather stations as follows:

- Daily rainfall data is available at most weather stations. Daily rainfall data is used for analysis of runoff quantities, rainwater supply and water demands (e.g. for sizing rainwater tanks).

- Pluviograph (6-minute) data is available from Darwin Airport. Pluviograph rainfall data is used for analysis of stormwater quality and the performance of stormwater treatment devices.

Monthly average evapotranspiration data is available within the MUSIC model. Evapotranspiration data is used to model losses from stormwater treatment and storage systems. Further information on rainfall and evapotranspiration data for setting up a water quality model is available in the "Stormwater Quality Modelling Guide".

### 2.1.1 Climate Change

Global climate change will lead to changes in Darwin's local climate (temperature, rainfall, etc) as well as increasing sea levels.

In the Darwin region, the effects on the local climate are likely to be increased temperatures and increased intensity of tropical cyclones, however after the release of the 2007 "Climate Change in Australia" Report, NRETA said that changes to rainfall remain ambiguous for the Top End. In light of this ambiguity, rather than designing WSUD solutions for any specific future rainfall scenario, it is recommended that the design approach should build in resilience and adaptability.

A WSUD approach is inherently more resilient to climate change than traditional urban water management, as it encourages reduced water demands, a greater diversity of water supplies and reduced dependence on external catchments to provide water to the urban environment.

Vegetated stormwater treatment systems can also be designed to be resilient to the impacts of climate change. It is recommended that when modelling stormwater treatment systems, as well as looking at average long-term conditions, particularly wet and dry years should also be examined. Stormwater treatment systems should be able to function over a wide range of seasonal rainfall conditions.

Potential sea level rise should be considered when assessing the site's physical setting. If WSUD systems are to be located in low-lying areas, they may be inundated by high tides in the future.

## 2.2 Natural Capital

Natural capital refers to a site's natural features that are worth protection and the ecosystem services they provide, for example:

- Native vegetation

- Important habitat/fauna

- Waterways

- Cultural assets

When evaluating a site, consideration must be given to avoiding areas which are to be protected and isolating protected areas from any disturbances resulting from the construction or function of stormwater treatment devices.

An ecological site assessment would identify the key areas of native vegetation, important habitat and waterways that need to be protected. In addition, some sites may contain cultural assets, which would be identified through a heritage assessment.

## 2.3 Ecology

An ecological assessment should identify:

- A site's natural assets, discussed above
- Aquatic ecosystems, both within and downstream of the site, requiring protection from urban development
- The potential for rehabilitation of any degraded streams on site
- A vegetation template suitable for both stormwater treatment measures and landscaped areas on the site
- Potential links to create biodiversity corridors

The ecological assessment should therefore look beyond the site itself to understand its context within the catchment/region.

Darwin Harbour is the ultimate receiving environment for all stormwater runoff within its catchment. The Darwin Harbour Regional Plan of Management and the Draft Management Strategy for the Darwin Harbour Catchment establishes the initial elements of a framework for managing these water quality impacts. In terms of managing stormwater and wastewater entering Darwin Harbour the following objectives were established as part of the Draft Stormwater Management Strategy for the Darwin Harbour Catchment:

- Maintain the declared Beneficial Uses and Environmental Values of the Darwin Harbour through Integrated Catchment Management planning.
- Maintain water quality through improved practice.
- Promote opportunities for, and benefits of, pollution reduction in stormwater.
- Generate knowledge and certainty of stormwater management, for all relevant stakeholders, in the Darwin Harbour Catchment.

## 2.4 Landscape Attributes

Key landscape features of a site may include existing adjacent development, views, pedestrian links, etc. A landscape assessment will identify landscape attributes and help to design stormwater treatment measures so that they are integrated within the overall landscape strategy for a site.

Figure 2 shows an example illustration from the Bellamack landscape analysis.

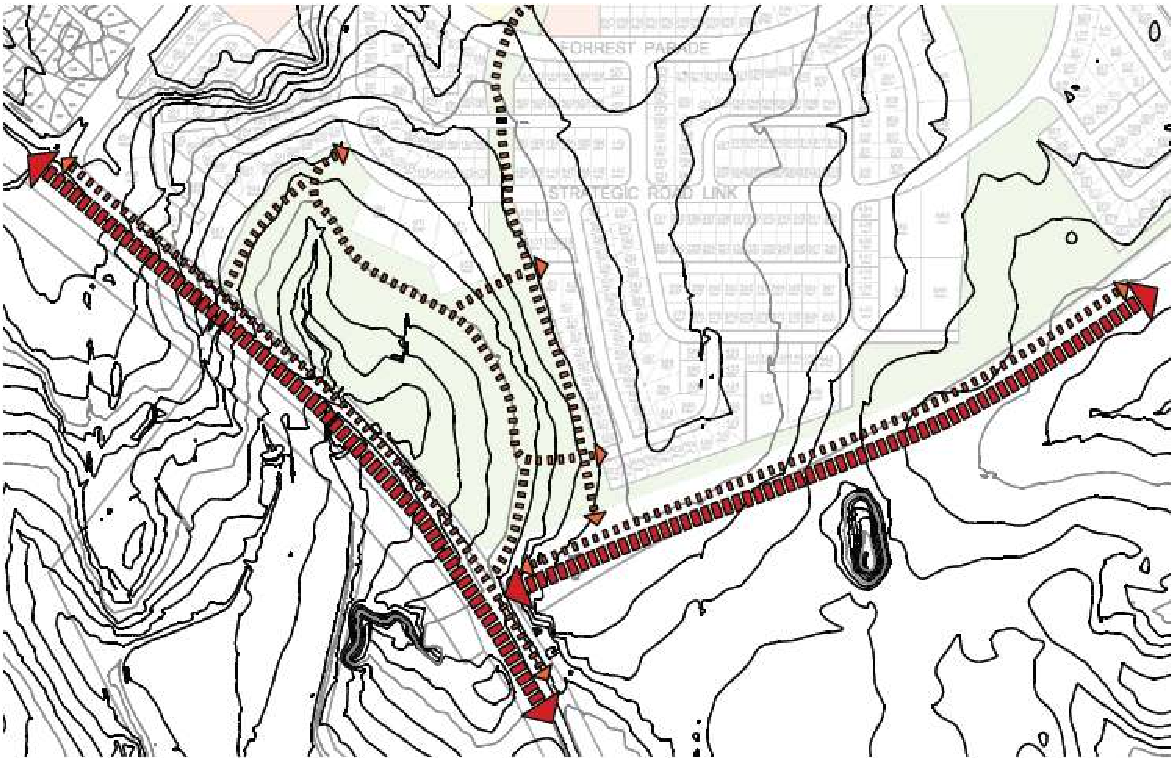


**Figure 2: Analysis of vehicular and pedestrian access routes around the Elrundie wetland at Bellamack**

## 2.5 Physical Infrastructure

Regional infrastructure of interest in preparing a WSUD Strategy includes:

- Water supply
- Wastewater collection and treatment
- Water recycling
- Major stormwater drainage works

Water and wastewater infrastructure can be identified through consultation with Power and Water. Stormwater infrastructure is normally managed by the local council.

Information on the regional infrastructure is important for understanding current and future opportunities for wastewater recycling and/or stormwater harvesting and reuse, including regional schemes.

## 2.6 Development Imperatives

Key attributes of the development which are important to the WSUD Strategy are:

- Population and demographic
- Land use and density
- Staging and timing
- Initial development layout

This information will assist with estimation of water demands, wastewater volumes and stormwater runoff quality and quantity. It will also allow identification of initial sites for stormwater treatment measures.

# 3 PHYSICAL SETTING

In this Site Assessment Guide, "physical setting" refers to the attributes of specific locations where stormwater treatment measures will be located. It is helpful to understand the physical setting early in the conceptual design of stormwater treatment measures, as the physical setting may dictate the type of treatment measures that are feasible and it may exclude certain locations from consideration.

All stormwater treatment devices can be subject to site-specific constraints. Stormwater treatment devices should be first selected based on matching the pollutant removal capability of a device with target pollutants in the stormwater. The physical constraints of the site (e.g. slope, soils, groundwater, etc) then need to be incorporated into the design of the selected device. Table 2 has been reproduced from the *WSUD Technical Design Guidelines for South East Queensland* (Moreton Bay Waterways and Catchments Partnership, 2006), summarising key physical constraints that may affect the use of specific WSUD measures.

**Table 2: Summary of physical constraints affecting WSUD measures**

| WSUD Measure | Steep site | Shallow bedrock | Acid Sulfate Soils | Low permeability soil (eg. Clay) | High permeability soil (eg. sand) | High water table | High sediment input | Land availability |
|---|---|---|---|---|---|---|---|---|
| Swales and buffer strips | C | D | D | ✓ | ✓ | D | D | C |
| Bioretention Swales | C | C | C | ✓ | ✓ | C | D | C |
| Sedimentation basins | C | ✓ | ✓ | ✓ | ✓ | D | ✓ | C |
| Bioretention basins | C | D | D | ✓ | ✓ | C | C | C |
| Constructed wetlands | C | D | C | ✓ | D | D | D | C |
| Infiltration measures | C | C | C | C | ✓ | C | C | C |
| Sand filters | D | ✓ | ✓ | ✓ | ✓ | D | C | ✓ |
| Aquifer storage and recovery | C | C | C | C | ✓ | C | C | C |

C – Constraint may preclude use; D – Constraint may be overcome through appropriate design;
✓ - Generally not a constraint

Table 2 provides a useful summary, however it needs to be supplemented by site-specific investigation and technical design information for a more complete feasibility assessment in each case.

Many physical constraints can be overcome by appropriate design. When assessing the natural attributes of the site with a view to incorporating WSUD, the issues to be considered are discussed in the following sections:

1. Topography – slope is a key consideration
2. Geology, Soils and Groundwater – key considerations are depth to bedrock, soil permeability, acid sulfate soils, salinity and groundwater
3. Existing development – existing infrastructure may form a constraint to the design of stormwater treatment measures

## 3.1 Topography and Drainage

The site assessment needs to identify the major subcatchments and drainage lines on the site, as well as any catchments which drain into the site. This will help inform the catchment analysis, discussed in Section 4.1.

Topography can be a constraint to the location of WSUD measures; in particular the slope is important. Many stormwater treatment devices will not work effectively on steep slopes, and are best located in the flatter areas of the landscape. Slopes of 1-5% are ideal. Bioretention systems can be designed for steeper sites, whereas wetlands are more easily integrated into flatter sites. Swales can be designed for steep sites if check dams and/or drop structures are incorporated at regular intervals.

Future development may change the landform substantially, and this will affect the siting of WSUD measures.

Figure 3 shows an example of the topography and drainage assessment done for Bellamack (EDAW, 2007). This identified the major subcatchments and low lying seasonally waterlogged areas on site.

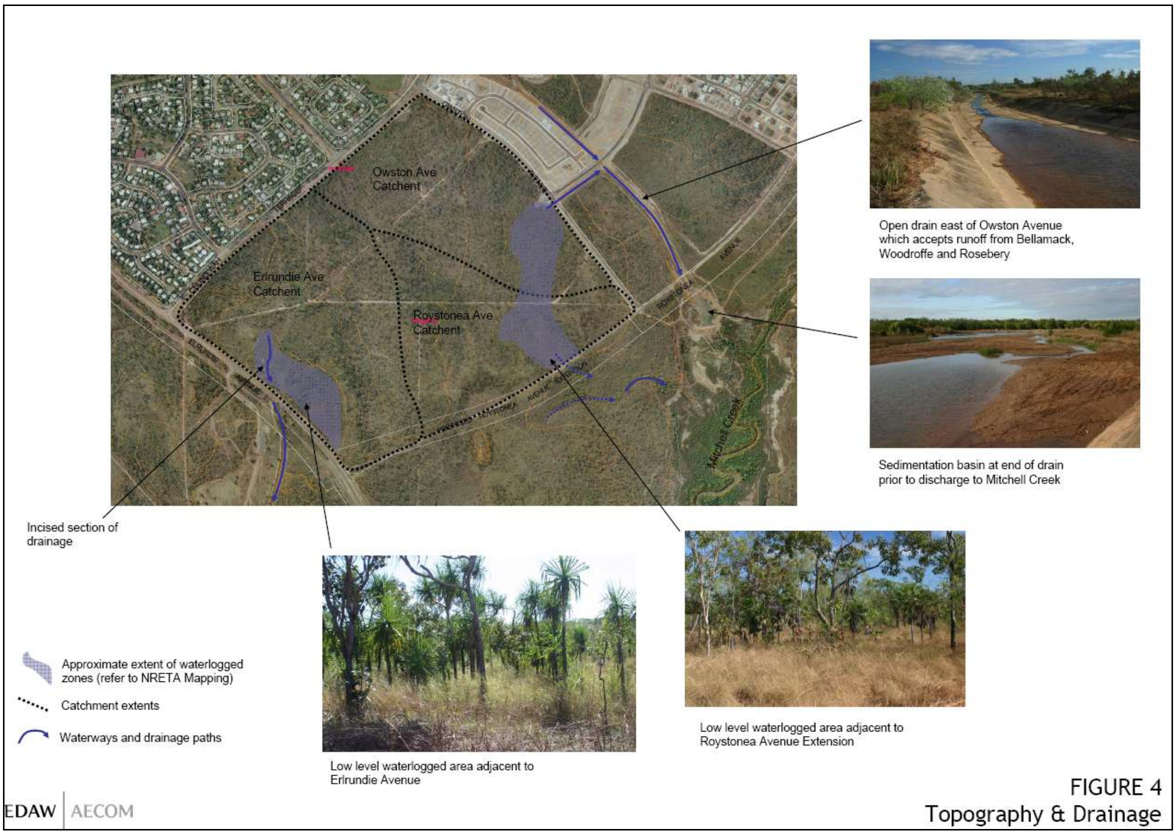


**Figure 3: Example topography and drainage assessment for Bellamack**

The site assessment should identify locations where stormwater flows exit the site and ensure that stormwater management measures are installed upstream of these locations. Where flows leave the site as dispersed sheet flow, it may be necessary to preserve this characteristic, in order to protect the downstream environment from channelling and erosion.

## 3.2 Geology, Soils and Groundwater

A geotechnical site assessment can identify key attributes of the geology, soils and groundwater that are important to the design of WSUD measures:

- Depth to bedrock

- Soil permeability
- Groundwater table level (and seasonal variation)
- Management risks, including acid sulfate soils and salinity

Some of this information is available from NRETA. Mapping data and technical reports are available via the “NRETA maps” website (http://www.nt.gov.au/nreta/nretamaps/).

### 3.2.1 Soil permeability

High permeability soils can be a constraint to devices designed to hold permanent water, as it can be difficult to ensure that they will hold water in such an environment. It is difficult to ensure that an impervious liner is completely effective in a high permeability environment.

Low permeability soils do not pose a constraint to most stormwater treatment measures; the exception is infiltration, which relies on high permeability.

### 3.2.2 Groundwater

The impact of a stormwater treatment device on groundwater, and vice versa should be carefully considered. If water tables are shallow (i.e., near the surface), devices such as wetlands or bioretention systems may need to be carefully designed to avoid interacting with groundwater. In these circumstances, advice should be sought from soil/groundwater and WSUD specialists.

### 3.2.3 Acid Sulfate Soils

Acid sulphate soils can cause damage to concrete structures and other infrastructure. Acid Sulfate Soil Risk Maps define the risk of encountering acid sulfate soils. An acid sulfate soil mapping project is currently being conducted by NRETA. The mapping project is due for completion in mid-2008. Further information is available from NRETA’s website.

If there is a risk of acid sulfate soils on the site, soil sampling and analysis can determine the presence and extent of acid sulfate soils. Stormwater treatment measures can be constructed in areas of acid sulfate soils, providing that the soils are managed appropriately during the construction stage.

### 3.2.4 Salinity

Unmanaged development in saline soils can result in costly degradation of urban infrastructure, vegetation and soils. Where saline soils are likely to occur, tests of soil and groundwater may need to be conducted prior to any construction taking place. Construction techniques may need to be altered when working near saline soils. Important factors to consider are:

- Construction should avoid disturbing the saline soils, and when disturbed the saline soils should be appropriately treated
- If groundwater is saline, any impacts of the site developments on the groundwater must be evaluated
- To prevent impacts on groundwater, exfiltration of stormwater from stormwater treatment devices to the native soils, should be avoided

## 3.3 Existing Development

Existing development may include:

- Development associated with the previous land use (for example, farm dams)
- Development adjacent to, upstream or downstream of the site (for example, boundary roads)

- Underground and overhead services (for example, transmission lines)

Most existing development can be understood through a site walk over. A heritage assessment would also identify particular heritage constraints associated with existing development. A services search may also be undertaken to identify potential underground services (such as water, sewer, gas) at the site. During the design stages, more detailed survey of existing development can be conducted as required.

Development associated with previous landuses may either facilitate WSUD (for example, an old farm dam could be converted to a sediment basin or other type of stormwater treatment system) or could form a constraint to WSUD (e.g. there may be a need to preserve heritage items on site, meaning that some areas can't be utilised for stormwater treatment systems).

Similarly, adjacent development may either form an opportunity (e.g. some non-potable water demands within existing development could be met with excess stormwater from the proposed development) or it could present a constraint (e.g. uncontrolled stormwater flows may enter the site from adjacent development).

Underground services can be a significant constraint to the location of stormwater treatment systems and should be considered early in the design stages.

# 4 SITE ANALYSIS

Having gathered information on the site context and physical setting, site analysis can be conducted. Three key activities are described here:

1. Catchment analysis
2. Water balance
3. Analysis of constraints and opportunities

## 4.1 Catchment Analysis

Stormwater treatment measures need to be considered for each subcatchment within a new development, and normally this will require catchment analysis to be undertaken in a water quality model such as MUSIC. The "Stormwater Quality Modelling Guide" includes more information.

Understanding the topography and drainage allows the site subcatchments to be delineated on a plan. Knowledge of the proposed land use allows the impervious fraction to be estimated for each subcatchment, and then stormwater runoff characteristics can be estimated using water quality and quantity models.

Figure 4 and Table 3 show a summary of the catchment analysis undertaken for Bellamack (EDAW, 2007).

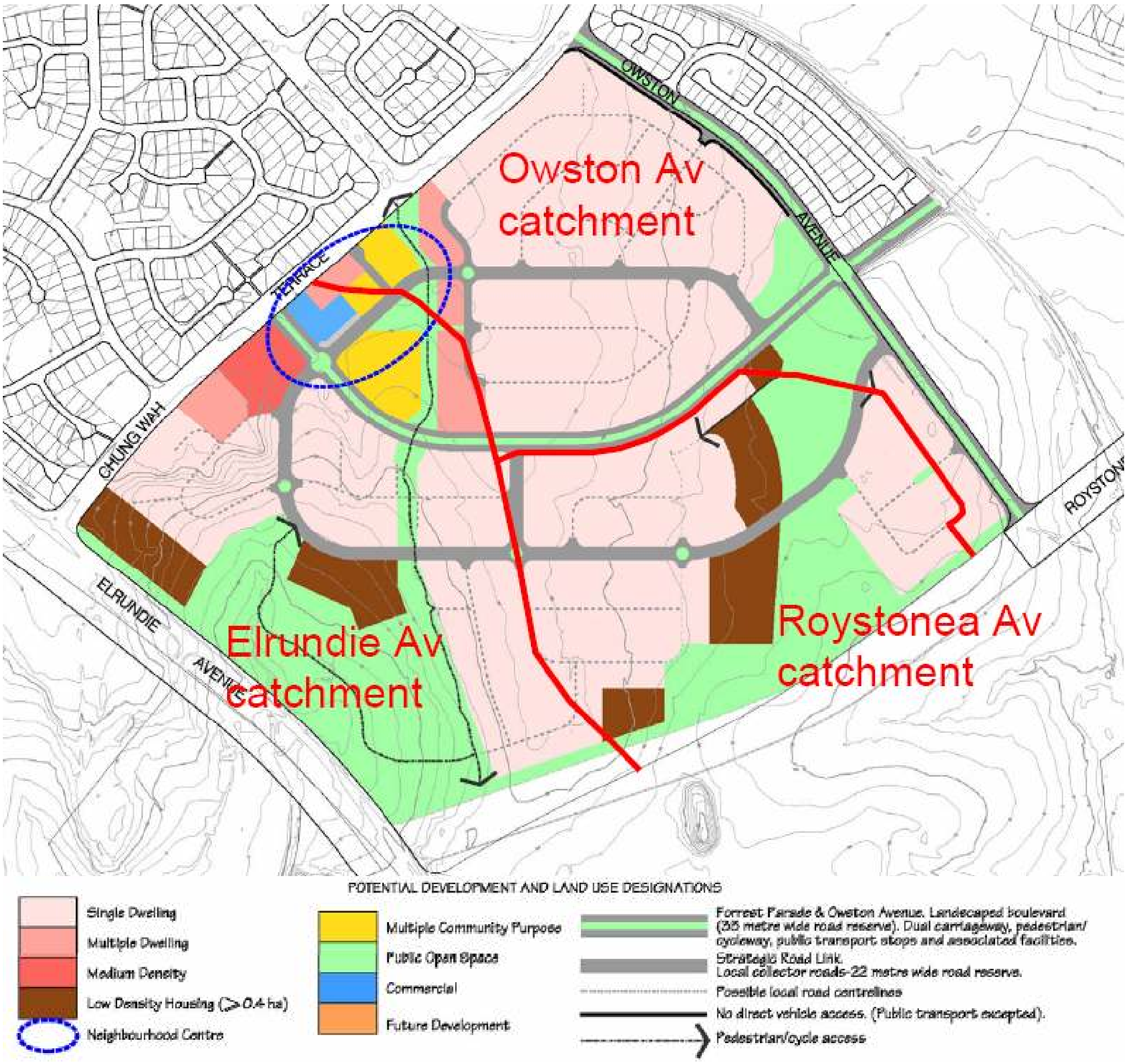

Figure 4: Bellamack catchment analysis

Table 3: Catchment areas and land use at proposed Belllamack development

| Catchment | Owston Avenue | Roystonea Avenue | Elrundie Avenue |
|---|---|---|---|
| Total area, ha | **42.2** | **34.1** | **46.5** |
| Estimated area of roofs, ha | 13.6 | 8.4 | 11.5 |
| Estimated area of roads, ha | 5.1 | 3.1 | 4.3 |
| Estimated total paved areas, ha | 25.1 | 15.5 | 21.2 |
| Overall impervious fraction, % | 60% | 45% | 45% |

## 4.2 Water Balance

A water balance can be a helpful way to summarise water demands, wastewater volumes and stormwater runoff quantities. It can assist in identifying opportunities for potable water substitution, and can help quantify water savings associated with different options.

An example of the water balance prepared for Bellamack is shown in Figure 5 (EDAW, 2007).

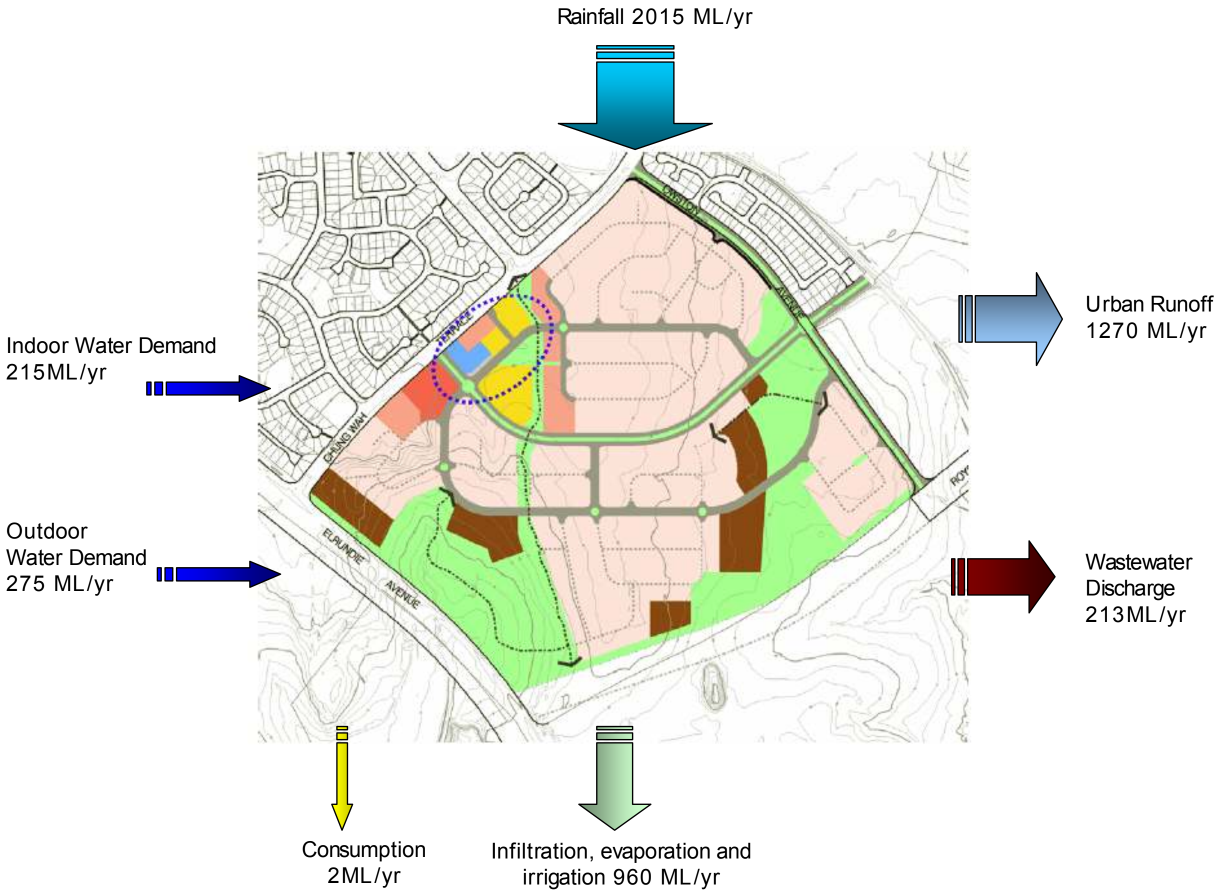


**Figure 5: Bellamack Water Balance (traditional water servicing)**

Further information on quantifying each of the components in the water balance is included in the "WSUD Practice Guide".

## 4.3 Constraints and opportunities

All of the information from the site assessment contributes to identifying site constraints and opportunities for WSUD. A number of different WSUD options may become apparent, or in some cases the site assessment may indicate clear advantages of a particular strategy.

The site assessment will be revisited throughout the WSUD planning and design process, therefore it is helpful if the information from the site assessment can be compiled in a format that is easy to review. GIS mapping is an ideal tool for this task.

# 5 REFERENCES

EDAW 2007 "Water Sensitive Urban Design Strategy for Bellamack" prepared for the Northern Territory Department of Planning and Infrastructure, December 2007.

Moreton Bay Waterways and Catchments Partnership 2006 *WSUD Technical Design Guidelines for South East Queensland* Version 1 June 2006.
Online: http://www.healthywaterways.org/FileLibrary/wsud_tech_guidelines.pdf