Water Sensitive Urban Design

DESIGN REQUIREMENTS FOR WSUD TECHNOLOGIES IN THE COASTAL DRY TROPICS

Purpose of this fact sheet:

This fact sheet provides advice to the development industry on applying Water Sensitive Urban Design Technologies in the Coastal Dry Tropics.

Key principles of WSUD in a dry tropics climate

- *Protection of natural resources* – Protect and enhance natural water systems in the urban environment
- *Flow Frequency* - Capture and manage stormwater runoff from post development impervious surfaces during the dry season (May to October) such that the frequency of surface runoff is the same as pre-development conditions.
- *Stormwater quality* - Stormwater discharged from development areas to be treated in accordance with best practice:

  >80% reduction in the mean annual load of Total Suspended Solids (TSS)

  >65% reduction in the mean annual load of Total Phosphorus (TP)

  >40% reduction in the mean annual load of Total Nitrogen (TN)

  >90% reduction in the mean annual load of Gross Pollutants

- *Integration of stormwater treatment into the landscape* – enhance urban design, visual, social, cultural and ecological values.

Royal Gardens wetland, VIC

Benefits of WSUD

- Protect ecologically and economically valuable freshwater, estuarine and marine aquatic ecosystems, including the Great Barrier Reef
- Reduce potable water demand
- Protect existing natural features and ecological processes.
- Protect water quality of surface and ground waters.
- Maintain natural hydrologic behaviour of catchments.
- Minimise demand for potable water.
- Minimise wastewater generation and discharge to the natural environment.

KEY POINTS OF THIS FACT SHEET

This fact sheet provides advice to professionals in the development industry with

- An overview of the techniques and principles of WSUD in the Dry Tropics
- The benefits of applying WSUD to the environment.
- An explanation of how constructed wetlands and bioretention systems can be applied in the Dry Tropics to achieve best practice stormwater treatment

City of Townsville

Adapting to the dry tropics climate

The Dry Tropics has a unique seasonal climate with hot and humid summer months with "build-up" thunderstorms starting in late October or November and the highest rainfall occurring from late December through early April (Figure 1). The average annual rainfall is 1143mm, occurring on average over 91 days per year. In the dry tropics the majority of the rain falls in the six month "wet season", however, as shown in Figure 1, winter showers do occur sporadically from May through September.

Due to the strong seasonal rainfall pattern resulting in high runoff during the wet season and then long periods of 'dry' weather in the Dry Tropics, special design considerations have to be made to successfully implement WSUD:

Sustaining functional vegetation

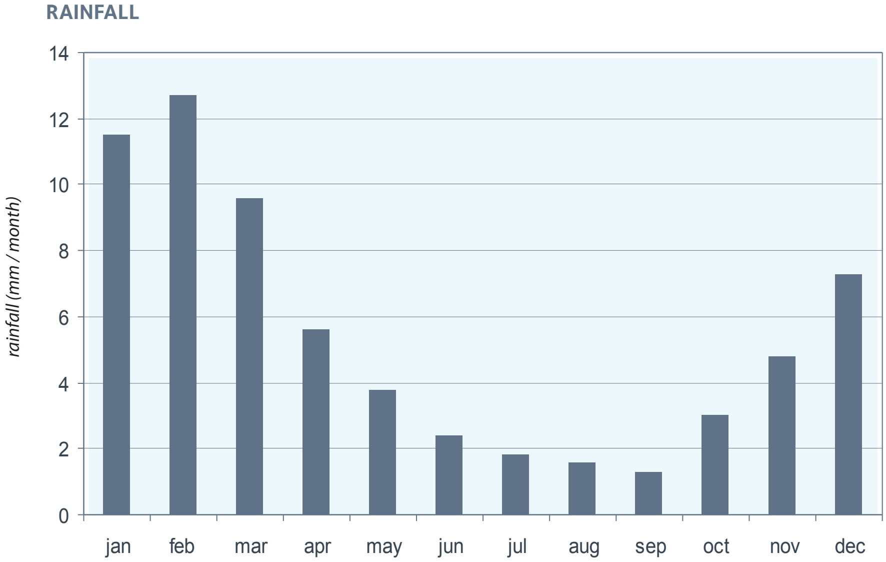
Sustaining vegetation within vegetated WSUD systems (such as bioretention and constructed wetlands) is important in order to enhance the ability of these systems to treat pollutant loads from the first rain events at the beginning of the wet season. Dense, perennial vegetation maintains treatment capacity and function over the lifetime of the system. Vegetation also reduces the risk of wind blown erosion and greatly enhances the landscaping and aesthetic value of these areas.

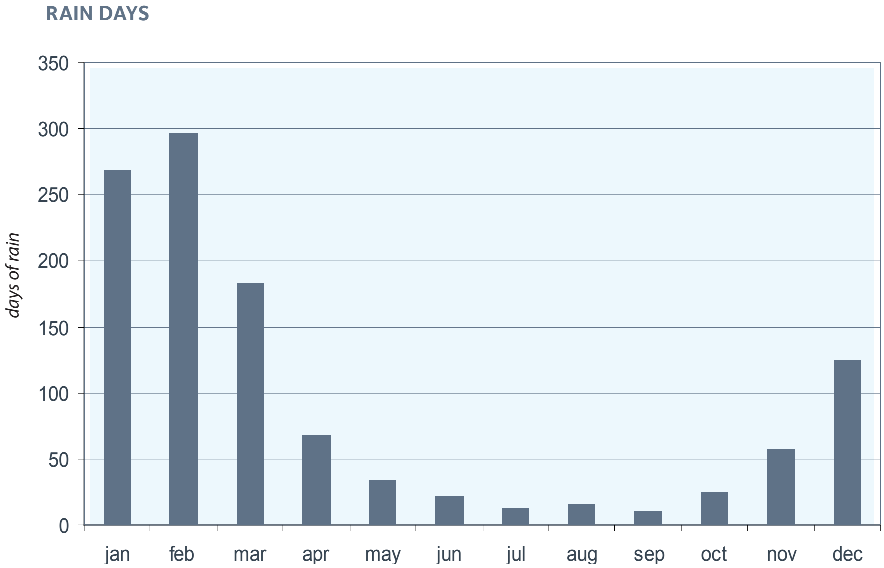
Protecting against high flows

In order to protect wetland and bioretention systems from vegetation scour and erosion, high flow bypass channels or outfalls are installed.

Managing aesthetics and public perception

The public perceives most constructed wetlands and bioretention systems by their overall aesthetic look and feel. Areas that are perceived to be problematic for reasons such as pests or vector management will have difficulty gaining community support; therefore, it is essential to address such issues starting at conceptual design and continuing through implementation and long-term maintenance.





Rainfall data was sourced from the Bureau of Meteorology gauging station at Townsville

Dry Tropics WSUD systems

WSUD technologies that employ physical screening and/or sedimentation in their primary treatment processes will work equally well in the Dry Tropics as they do in the southern climatic conditions. Technologies that employ enhanced sedimentation (via vegetation) and biological treatment processes such as bioretention systems and constructed wetlands rely on sustaining a functional vegetation community throughout the year. Accordingly, these systems require careful design consideration to ensure their treatment efficiency throughout the year. The information below describes the specific design requirements for constructed wetlands and bioretention systems in the dry tropics.

Freshwater Wetland Design

- Wetlands should include deep and shallow water zones that provide adequate water quality treatment during the wet season, while supporting water levels in deep pools and vegetation throughout the dry season.
- It should include a densely vegetated deep marsh zone that will be seasonally inundated and that should be designed to dry out periodically.
- Dry season low flows will provide critical wetting periods ensuring that the deep marsh zones do not dry out for overly extended periods (not greater than 60 days at a time).

In order to respond to the key design issues, such as vegetation resilience and aesthetics, high flows, and overall public perception and acceptance, freshwater wetland design must:

- support dense, perennial wetland plants that can tolerate large water level variations and periodic dry periods;
- provide peripheral terrestrial vegetation (e.g. native shrubs and trees) that are adapted to the climatic conditions;
- reduce mosquito larvae habitat by avoiding small isolated pools and by providing refugia pools for mosquito predators such as fish and large macroinvertebrates
- manage high flow events by providing sufficient wetland bypass and/or backwater protection thereby reducing risk of vegetation scour and erosion;
- size constructed wetlands appropriately to achieve best practice treatment targets;
- provide coarse sediment basins or forebays to manage early storm and associated sediment loading.

KEY DESIGN REQUIREMENTS

Wetland Configuration

Normal "wet season" water level in macrophyte zone: 0.5 to 0.7m. This should ensure that dry periods will typically be no more than 60 to 70 days at a time. This will allow perennial emergent macrophytes to occupy the wetland footprint thus managing colonisation of the wetland by invasive weed species.

Extended detention: This zone is commonly ~0.5 m (max)

Wetland sizing: 5% of the contributing urban catchment

Managing high flows: provision for bypass of flows up to the 50 year ARI. Where this is not practical, high flow velocities through the wetland should not exceed 2m/sec.

Supplemental Irrigation

Maintaining the planting on the littoral edge of the wetland will be important to manage invasive weeds colonising the wetland macrophyte zone from the littoral edge. It may be necessary during extended dry periods to irrigate the littoral edge plantings to ensure that they maintain their planting density and plant health.

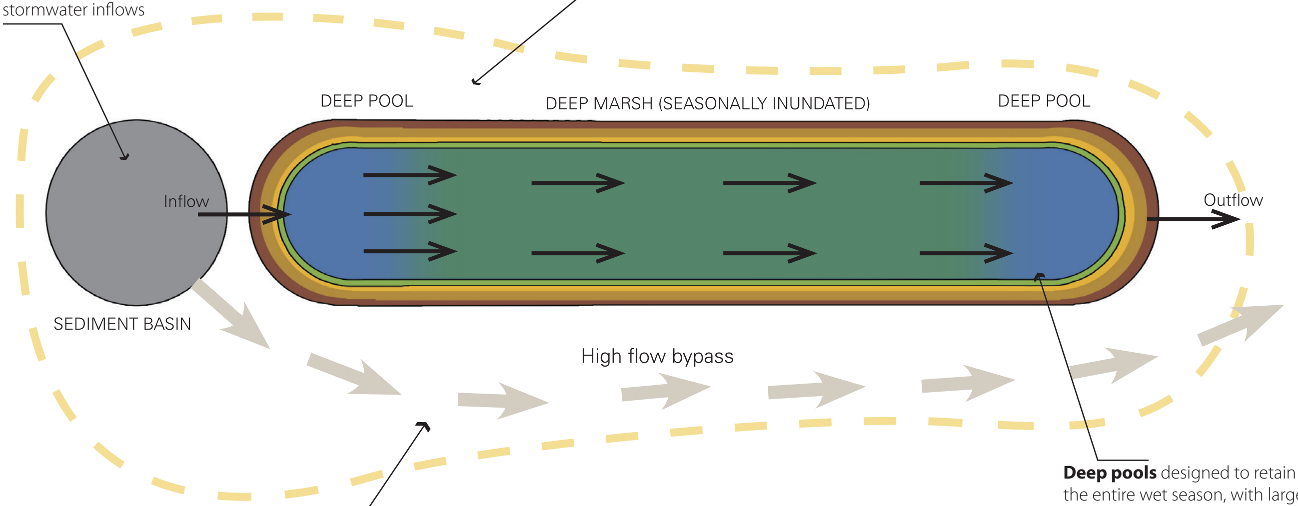
Mosquitoes Management (best management practices):

- creating deep water refugia pools that can support mosquito predators – e.g. small native freshwater fish;
- creating buffer zones around wetland areas;
- planting vegetation with thin vertical upright stems maximizing predation throughout the wetland area;
- minimizing isolated ponding within the deep marsh zone through careful construction oversight that reduces micro-pockets of standing water.

TYPICAL CONSTRUCTED WETLAND DESIGN STRATEGY

Terrestrial landscaping provides a visual buffer and framework for the wetland system within the community and native habitat. Native trees can encourage recreational elements such as walking and bird watching. These recreational elements as well as education in the form of descriptive panels and signs can increase acceptance of these systems within the community.

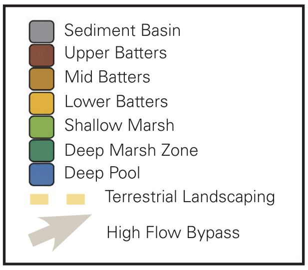
Sediment basin functions as a sediment trap as well as control for stormwater inflows



Deep pools designed to retain water for the entire wet season, with large sections of open water:

- create a habitat for mosquito larvae predators;
- improve landscape aesthetics, and provide habitat and refuge zones for submerged aquatic plants and emergent macrophytes during the dry,
- assisting in wet season colonisation of the ephemeral zone.

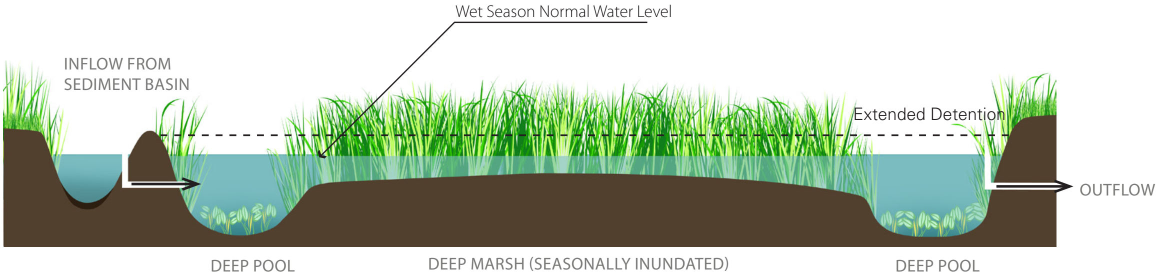
High flow bypass is designed to allow large flows to bypass the wetland thereby protecting the macrophyte zone from the risk of scour and vegetation damage.



Not to Scale

TYPICAL CONSTRUCTED WETLAND DESIGN STRATEGY

The deep marsh zone is the main treatment area in the wetland. Contact with the emergent macrophytes growing in this seasonally inundated area provides important stormwater treatment. This area is designed to dry out periodically, but not more than 60-70 days



Wet Season Condition

Dry Season Condition

Not to Scale

Bioretention System Design

The bioretention solution for the Dry Tropics is focused on sustaining vegetation through the dry season, managing early storms and coarse sediment as well as overall aesthetics and public perception.

Large bioretention system, Wakerley QLD

Biorentention system, SA Museum forecourt

KEY DESIGN REQUIREMENTS

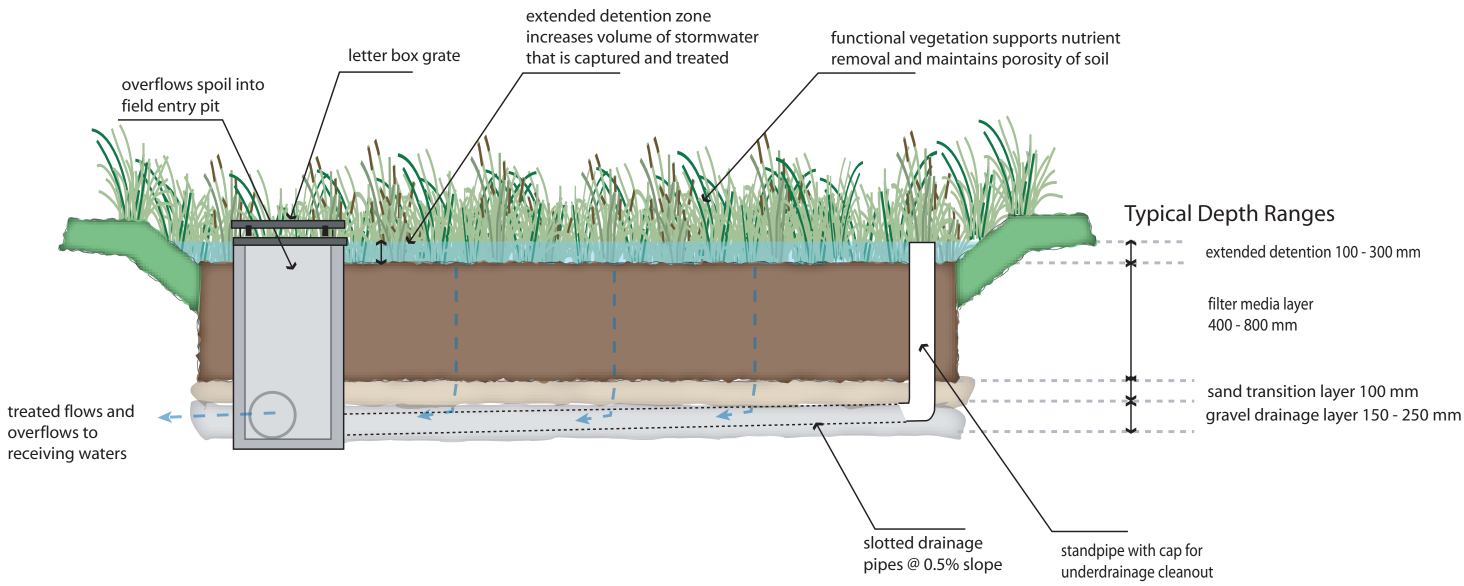
Submerged saturated zone bioretention systems:
a simple modification of the typical system can help sustain vegetation by providing a saturated zone (can stay saturated for 2 to 3 months) to help retain soil moisture. This submerged layer also provides additional nitrogen removal through denitrification.

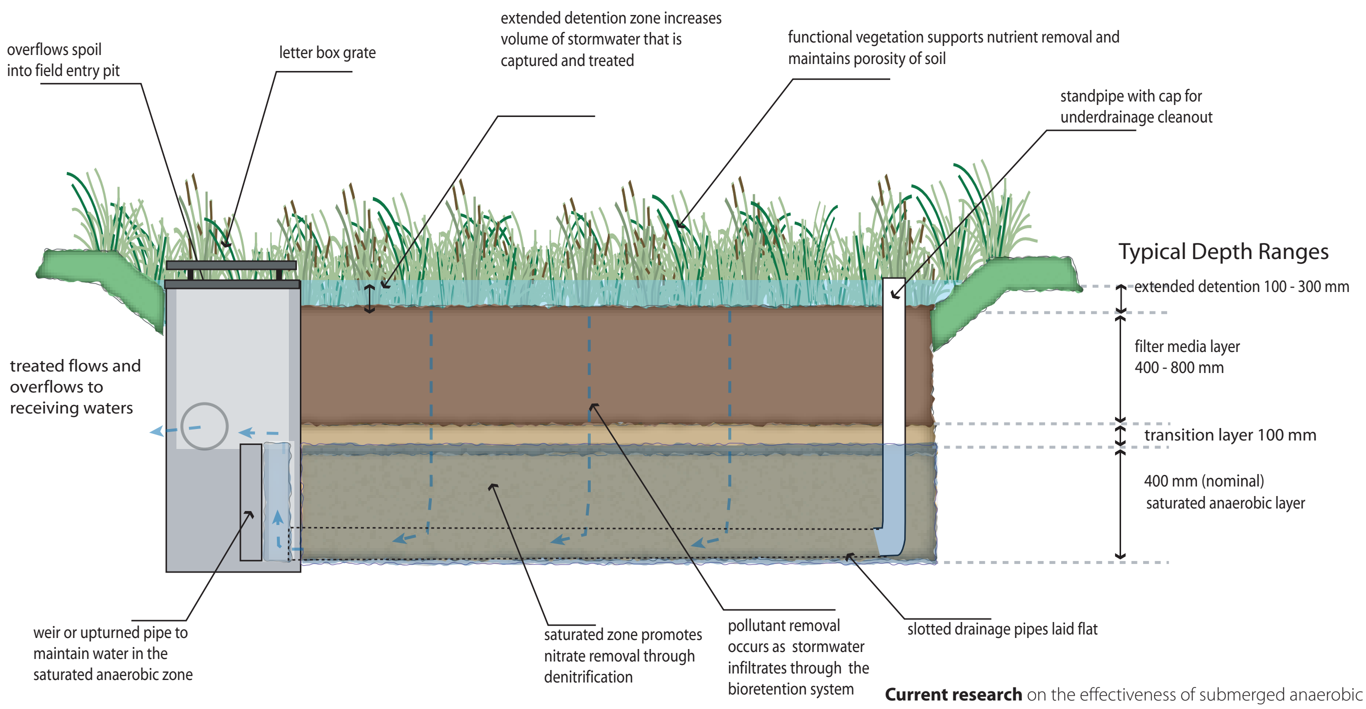
Coarse sediment management:
coarse sediment forebays are to be used to capture the higher coarse sediment load likely to be carried in the first wet season storm events due to build up in the catchment. These forebays are designed:

- to remove particles that are 1 mm or greater in diameter from the 3 month ARI storm event and
- with large rocks placed at inflow locations to provide energy dissipation that will be underlain by filter material to promote drainage following a storm event.

Supplemental irrigation:
Vegetation will need to be sustained throughout the dry to be able to effectively treat the first storm events at the beginning of the wet season. Some additional irrigation with a non-potable source (excluding wastewater) may be required depending on the location of the system and whether it has a saturated submerged zone (top-up watering of saturated zone) or not (surface irrigation).

Supplemental watering is best done by 'topping up' the saturated zone via the subsurface drainage pipe. The raised standpipe which is connected to the subsurface drainage pipe can be used to fill this subsurface layer which will provide moisture up into the soil column through capillary action. For bioretention systems located within the public realm, such as biopods within the streetscape or lacking a saturated zone, vegetation can be sustained during the dry season through surface irrigation.





A saturated zone can be formed at the base of a bioretention system by using a riser pipe with the outlet level higher than the drainage layer or by incorporating a weir within the outlet pit (see Figure 9 below). The saturated zone would hold water rather than draining freely, and would therefore provide a source of water to the plants during dry periods. The water in the saturated zone would be gradually drawn down via evapotranspiration.

Current research on the effectiveness of submerged anaerobic zones on nitrogen removal conducted at the Facility for Advancement of Water Biofiltration (FAWB) indicate the potential removal rates of 70% compared with 45% in bioretention systems with no saturated zone. The additional layer should be medium to coarse sand and should contain a long term carbon source (such as hardwood woodchips) to promote denitrification. Denitrifying bacteria occur in a small anoxic layer around the surface of the carbon source, and the stormwater passing through the system does not become anoxic itself. It should be noted that anaerobic zones can be a source of pathogens, therefore if bioretention systems are to be used with stormwater harvesting, anaerobic zones should be avoided.

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