WATER SENSITIVE URBAN DESIGN

CONSTRUCTED WETLANDS IN THE NT - GUIDELINES TO PREVENT MOSQUITO BREEDING

FINAL

Prepared for the Northern Territory Department of Planning and Infrastructure
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1 INTRODUCTION

To facilitate the adoption of WSUD, the DPI (Department of Planning and Infrastructure) in conjunction with NRETAS (Department of Natural Resources, Environment, the Arts and Sport) have secured a grant from the Australian Government to develop a WSUD Strategy for Darwin Harbour. The WSUD Strategy will create an enabling environment to ensure commitment to urban water cycle and stormwater management through a WSUD framework for Darwin. The WSUD framework will link policy to locally relevant technical design guidelines, manuals and industry tools. Development of the Strategy represents a substantial project as defined by the Workplan provided in Table 1 below.

In 2008 the Medical Entomology Unit of the NT Department of Health and Families developed "Constructed Wetlands in the Northern Territory - Guidelines to Prevent Mosquito Breeding" (hereafter referred to as 'the guidelines'). The guidelines were written to assist developers and land managers in planning and designing appropriate WSUD treatment measures without creating mosquito breeding sites. The guidelines will become part of the broader framework of design guidelines and technical tools available to implement WSUD in the Darwin region.

The guidelines include important information about design and management options which can be adopted to minimise mosquito breeding. Specifically the guidelines discuss mosquito species that are likely to breed in WSUD treatment measures in the Darwin Region, the role of constructed wetlands on mosquito breeding, design considerations for WSUD treatment systems, mosquito monitoring, risk management requirements, and control of mosquitoes.

1.1 Purpose of this Document

A review of the guidelines has been undertaken as part of Task 19 (Stage 7) of the WSUD Strategy Workplan. The Workplan is shown in Table 1. The review has been undertaken to:

- ensure that the guidelines are consistent with the overall WSUD Strategy including consistency in terminology
- understand and discuss the implications of the guidelines on WSUD strategies
- provide a technical review of the content particularly in relation to the functioning of various treatment systems
- provide a review of the structure of the document and its useability for WSUD design practitioners

This document builds on previous work undertaken as part of the WSUD Strategy project. In particular this review should be read in conjunction with:

- WSUD Planning Guide
- WSUD Site Assessment Guide
- WSUD Technical Design Guidelines
- Functional design reports for Bellamack WSUD elements

1.2 Outline of this Document

This document is organised into the following sections:

- Section 2 reviews content of the individual sections of the guidelines
- Section 3 discusses the overall structure of the guidelines

Table 1: WSUD Strategy for Darwin Harbour - Workplan

STAGE	TASK #	Activity
1	1	Refine workplan
	2	Establish project working group.
2	3	Develop WSUD Strategies for case studies in suitable format for communication and identify case studies for sub-catchment scale application of WSUD treatment train.
	4	Identify potential WSUD objectives for Darwin
	5	Critical Analysis of WSUD/Stormwater Treatment Options for Darwin
3	6	Prepare a stakeholder communication and consultation strategy (including establish website, fact sheets, presentations).
	7	Prepare and communicate a definition of WSUD within Darwin
	8	Review and report on policy, programme, technical and decision-support systems for WSUD in Australia (including any barriers to uptake of WSUD and respective jurisdictional responses).
	9	Identify potential barriers to uptake of WSUD in the NT. Develop strategy to address barriers.
4	10	Develop WSUD Strategies for case studies in suitable format for communication and identify case studies for sub-catchment scale application of WSUD treatment train.
	11	Prepare detailed workplan for development of NT WSUD policy, objectives, design manual, performance standards and decision-support tools.
5	12	Prepare draft NT WSUD policy and objectives for Darwin including understanding existing legislation, workshops etc.
	13	Assess application of WSUD objectives and management practice options across a range of development situations and/or catchment-scale treatment-train & confirm set of objectives.
	14	Undertake consultation of draft WSUD policy and WSUD objectives to stakeholders and barriers to WSUD.
6	15	Define requirements of WSUD Guidelines and Tools (workshop to define design needs in detail and assess whether exiting guidelines satisfy this need)
	16	Document Draft WSUD Guidelines and Tools in including High Level and Conceptual Design Guideline, Technical Design Guideline and Design Tools (MUSIC Guidelines, Deemed to Comply Solutions, Standard Drawings etc.)
	17	Prepare Draft WSUD decision support tools for Darwin Harbour, consistent with WQPP, linking policy, objectives and guidelines
7	18	Undertake stakeholder consultation of WSUD Policy, WSUD design manual and performance standards, and decision support Tools and seek approval.
	19	**Finalise WSUD design manual, decision support tools and performance standards**
8	20	Seek NT Government approval for WSUD Policy, WSUD design manual and performance standards and decision support tools.
	21	Develop and publish stormwater management plans for key subcatchment in Darwin to illustrate application of WSUD Policy/Framework, design manual and decision support tools.
9	22	Develop an implementation strategy for incorporating policies and provisions for WSUD within NT planning policies, strategic plans and development approval processes as well as local government instruments
	23	Ongoing communication and website management
	24	Capacity Building and Training including government, local authorities, developers and industry practitioners
10	25	Incorporate policies and provisions for WSD into NT government planning policies, strategic plans and development approval processes, as well as relevant local government instruments. Implement agreed strategy to address barriers to uptake of WSD.

2 REVIEW OF THE CONTENT OF THE GUIDELINES

This section reviews the content of the guidelines providing a review of each individual section of the guidelines as well as a general review of the content

2.1 General Review

It is recommended to provide consistent terminology of the guidelines with the WSUD Strategy. This is to reduce confusion between terms. A summary of recommended terminology changes are shown in Table 2.

Table 2: Recommended terminology

Terms in current guideline document	Recommended terms, consistent with WSUD Strategy documents
Semi aquatic	Ephemeral
Lake	Pond
Wetlands with detention vegetation zones	Bioretention systems
Wetlands with retention vegetation zones	Constructed Wetlands
Silt traps	Sediment Basins
Emergency drainage	Water level control/Maintenance drain

It is generally recommended to specify required outcomes in terms of functional or performance-based measures rather than specific design measures. Specifying design measures limits innovation and does not allow for alternate designs which provide an improved ecological outcome. Examples where this is important are as follows:

- Sections discussing aeration recommend providing mechanical aeration rather than functionally prescribing well oxygenated water.
- Removal of sediment is required upstream of wetlands. Silt traps (or sediment basins) are one potential method of removing sediment, but not the only option
- Discussion of swale design should refer to the performance criteria of having no standing or ponding water rather than specifying that a concrete invert drain is required.
- In the landscaping section it is suggested that the guidelines should recommend that the landscape be well drained and should not create localised ponding rather than specifying how this is to be achieved (through grading).

The role of natural water level fluctuation has not been discussed in the design criteria. Artificial manipulation of water levels in the form of emergency drainage has been discussed however natural water level fluctuation can also be beneficial in disrupting mosquito breeding. It may be beneficial to include a section in the guidelines on the role that natural water level fluctuations have on the breeding of mosquito species.

Research undertaken in subtropical and tropical Queensland[1] examined four constructed wetlands for the potential to create mosquito breeding sites. The study was based on ladle samples and detection of mosquito larvae. The study also assessed what parameters were most likely to influence breeding characteristics.

[1] Greenway, M. Dale P., Chapman H, 2003, "An assessment of mosquito breeding and control in 4 surface flow wetlands in tropical-subtropical Australia", *Water Science and Technology*, vol 48 (5), pp 249-256,

Overall the study found that the constructed wetland with the greatest biodiversity of plants and macro-invertebrates (important as predators) had the least number of mosquito larvae (<1% of all dips). Furthermore the study found that few pupae stages were detected suggesting the completion of the mosquito life cycle was being disrupted by predators. The study included wetlands that had large areas of shallow emergent vegetation.

Some of the key findings of this study included:

- Diverse macrophyte populations are important for macroinvertebrate diversity. The study found that there was a strong correlation between diversity of macrophytes and low mosquito larvae suggesting the control of mosquito larvae by predator populations.
- The wetlands with the largest numbers of mosquito larvae had low diversity with typically on dominant plant forming stands with accumulation of submerged dead steams suitable for mosquito breeding
- Good water quality, particularly high dissolved oxygen, was important in maintaining low mosquito larval numbers
- Maintaining open water of at least 30% of the wetland area was important

2.2 Introduction (Section 1)

Within the introduction and the title of the document the guidelines refer to "constructed wetlands". However it is clear from the introduction (and Section 5 of the guidelines) that the guidelines refer to a range of different stormwater treatment systems. For this reason it is suggested that the introduction (and the title) of the document should refer to stormwater treatment systems rather than just constructed wetlands.

The final paragraph of the introduction section of the guidelines includes the following statement: "The purpose of this guideline is to assist developers and land managers in deciding on an appropriate wetland design". It is recommended to include the range of the target audience to also include:

- engineers, planners and landscape architects involved in the development process and
- development approval authorities

2.3 Mosquito species and constructed wetlands (Section 2)

It is recommended that this section include periods during which each key mosquito species is active. For example the University of Sydney Department of Medical Entomology reports that *Culex annulirostris* is active during the mid-Spring to late Autumn period.

It is recommended to include a summary table at the end of Section 2. A suggestion for list of table headings is included in Table 3.

Table 3: Suggested structure for table in Section 2 of the guidelines

Species	Preferred Habitat	Typical Range	Vector Status	Active Months	Risk
Culex annulirostris	Vegetated margins of permanent and semi-permanent water bodies	Up to 15km	MVE KUNV RRV BFV	….	High
….	….	….	….	….	….

2.4 Constructed wetlands and the potential for mosquito breeding (Section 3)

As discussed in Section 2.2 above it is suggested this section should refer to stormwater treatment systems in general rather than just constructed wetlands. It is recommended to refer to a range of stormwater treatment systems. It is suggested that this include the stormwater treatment systems identified in the WSUD Practice Guide (available at http://equatica.com.au/Darwin/reports-pdfs/04%20Guidelines%20and%20Tools/WSUD%20Practice%20Guide%20FINAL%20DRAFT%20_Oct08_.pdf)

To provide further guidance to the industry it is recommended to provide further definition of terms such as "shallow vegetated wetlands" which are used in this section.

2.5 Risk Assessment (Section 4)

It is recommended to move this section to after the maintenance session.

In general it would be beneficial to the broader industry to provide more guidance on the risk assessment that is to be undertaken. For example a pro-forma risk assessment and risk hazard could be developed which provides hazard ratings to determine the risk. An example for illustrative purposes is shown in Table 4.

Table 4: Example format for risk assessment pro-forma

Variable	Value	Risk Rating
Distance from urban housing	Less than 1 km Less than 2 km Greater than 2 km	High Medium Low
Depth of water	< 0.4m > 0.4 0 but <0.75 >0.75	High Medium Low
….	….	……

In the final paragraph of this section it states "For example in Brisbane, it is suggested 72 hours is a preferable period of detention in the macrophyte (vegetation) zone of a constructed wetland to allow removal of contaminants. Therefore in some situations there may be no need to retain water for periods greater than 3 days in a heavily vegetated shallow area."

In standard wetland design in the eastern states of Australia 72 hours (3 days) is used for the *extended detention* zone. The extended detention zone is provided as temporary detention above a permanent pool. During and after a rainfall event the extended detention zone is filled with water which slowly drains out over 72 hours. However water is retained in the permanent pool year round.

It is recommended to remove the example to remove the potential for any confusion in relation to standard wetland design. The paragraph would then read like this:

"For each constructed wetland, the time for significant levels of contaminants to settle out of the water would need to be determined, with design and management measures tailored to suit these calculations. In some situations there may be no need to retain water for periods greater than 3 days in a heavily vegetated area….."

2.6 Design Considerations (Section 5)

This section currently includes a combination of design considerations and also different treatment types. It is recommended to separate out the treatment measures (Sections 5.5 to 5.9) from the design measures (Sections 5.1 to 5.4 and 5.10 to 5.11). This is discussed further in Section 3 of this review.

In Section 5.1 third line – it is suggested that the word “preferably” be inserted between “should be”

In Section 3 discussing aquatic vegetation, the guidelines present a key design constraint on constructed wetlands. Wetlands which have only sparse or fringe vegetation provide little benefit in terms of stormwater treatment. It would be helpful to provide more information on particular vegetation types and the characteristics which tend to encourage or discourage mosquito breeding. For example:

- Is there vegetation which is more likely to allow predator access? Previously discussions with freshwater ecologists have suggested that vegetation which has an upright, non-clumping form is more likely to allow access for predators

- Do submerged (*Najas* and *Hydrilla*) and floating vegetation (lilies) present similar mosquito breeding issues or is it predominantly emergent vegetation which is the key issue?

In Section 5.4 it is recommended to provide a performance-based requirement for well oxygenated water (high dissolved oxygen, DO) particularly during the late dry season, rather than proscribe one particular method of providing high DO levels. Mechanical aeration can be discussed as one method of increasing DO.

In Section 5.5 discussing lakes it is recommended to remove the second sentence. This repeats information that has been discussed elsewhere in the guidelines.

In Section 5.5 it is recommended that the two design criteria raised in this section are discussed as separate sub-sections. These two design criteria are:

- Edge details (hard edges are preferred to maximise wave action) and

- Batter slopes (steep sides are preferred)

In Section 5.6.1 this section describes wetlands which retain water for 2 to 3 days. However based on Darwin rainfall patterns, during the wet season it will be difficult to design systems that retain water for 2 to 3 days but which also empty between rainfall events.

In Section 5.6.2 the second paragraph discusses monitoring requirements for these treatment systems in detail. It is recommended to include this detailed description in the Monitoring section (Section 7) and refer to this section.

In Section 5.6.2 in the third paragraph it is suggested to change all references to ”emergency drainage” to ”water level control”

In Section 5.7 it is recommended to change the title to “Tidal areas”. This design issue is relevant to all stormwater treatment systems.

In Section 5.8 it should be noted that high sediment removal rates can also be provided by gross pollutant traps.

In Section 5.9 it is recommended that the function of free standing water be specified rather than a concrete invert.

In general it is recommended to provide a summary table showing the key requirements for each system. An illustrative example is shown in Table 5.

Table 5: Example format for a summary table on each treatment system

Treatment System	Design Notes	Maintenance Plan	Monitoring
Silt Trap/Sed Basin	- Steep sides - Concrete base	Y	N
Wetland	- Water level controller	Y	Y

	- Refuge pools ….		
….	….	….	….

A number of small spelling errors include:

- Section 5.2 second line there should be a space between “theyear”.
- Section 5.3, last line of the third paragraph space between “bevery”
- Section 5.6 line 1, “marcophyte” should be “macrophyte”
- Section 5.6.2 third paragraph second line replace “could an” with “could be an”
- Section 5.11 replace “lake of the sea” with “lake or the sea”

2.7 Monitoring (Section 7)

It is unclear within the monitoring section how long monitoring would need to be undertaken. If it is established over a suitable time frame that the wetland is not having an impact on mosquito numbers, would monitoring still be required?

Also it is unclear whether the monitoring station should be compared to background levels prior to the construction of any stormwater treatment system. Monitoring of background levels is suggested. This will be useful to determine if the stormwater treatment system is increasing local mosquito numbers. For example even in the case of high mosquito numbers, it may be the case that the stormwater treatment system is not causing a major increase in mosquito numbers (due for example to the presence of existing natural mosquito breeding sites).

3 REVIEW OF THE STRUCTURE OF THE GUIDELINES

It is suggested that the structure of the document be modified to better convey the information contained within the guidelines.

In general it is suggested to expand the title and function of the guidelines to include all stormwater treatment systems. This would ensure that the guidelines address the complete WSUD Strategy and would allow the guidelines to be included as part of the WSUD Strategy guidelines and tools. It would also ensure wider readership and adoption, as many practitioners on perusing the title may not realise that the guidelines actually provide important guidance for a range of different treatment systems, not just constructed wetlands.

It is suggested that Section 3 be included as part of the introduction. This section sets the scene for the guidelines and provides both a historical introduction as well as the general justification for the guidelines.

It is suggested that Section 5 be divided into two sub-sections. Currently Section 5 provides guidance on design criteria which are common to all treatment systems as well as providing design criteria specific to particular stormwater treatment systems.

It would be beneficial for designers to separate out design criteria which are generally relevant to most or all treatment systems. For example the landscaping section recommends appropriate grading on surrounding landscapes to ensure good drainage. This section is relevant to all treatment systems.

The section on treatment systems would focus on specific issues relating to the individual treatment system to be discussed. For example within the guidelines it is recommended that silt traps are to drain dry during the dry season and that sediment is to be removed annually. This information is generally specific to silt traps (sediment basins) and thus should be included in this section.

Providing separate sections in this manner provides streamlined guidance for designers of WSUD systems. It also provides a clear structure for design practitioners, development assessment, and asset owners who are dealing with a particular stormwater treatment system or a particular design feature.

It is suggested to separate Section 5 of the guidelines into two sections. A suggested outline for these two sections is as follows:

- The first section relates to different design criteria including:
    - siting (Section 5.1),
    - hydrology (Section 5.2),
    - aquatic vegetation (Section 5.3),
    - water quality (Section 5.4),
    - landscaping (Section 5.10),
    - tidal areas (Section 5.6.2) and
    - end point of discharge (Section 5.11)
    - edges (a suggested additional topic)
    - batter slopes (a suggested additional topic)
- The second section includes the stormwater treatment systems including
    - lakes/ponds (Section 5.5),

- constructed wetlands (Section 5.6),
- bioretention systems (Section 5.5.6.1),
- silt traps/sediment basins (Section 5.1)
- stormwater drains and swales (Section 5.9)

It is suggested that the diagram in Appendix 1 could be moved into the main body of the text. The diagram is a good summary of the design criteria and their relation to different treatment systems and thus would be suited in the Summary section of the guidelines.

It is suggested that the section on risk management be moved after the two sections discussed above.