WATER SENSITIVE URBAN DESIGN

WATER QUALITY DATA and ADOPTION IN WATER QUALITY MODELS

FINAL

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

Urban development in the Darwin Region is occurring without appropriate consideration of its impact on the health of the region's waterways. In order to manage the impacts of new development on Darwin Harbour, the Territory Government is seeking to implement Water Sensitive Urban Design (WSUD) within all new development

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's Coastal Catchments Initiative (CCI) program 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.

1.1 Purpose of this Document

This document has been developed as part of Task 17 (Stage 6) of the Workplan. This report on the assessment of existing water quality data assists in the linking the WSUD Strategy for Darwin Harbour with the Water Quality Protection Plan (WQPP) developed by the Department of Natural Resources, Environment, the Arts and Sport (NRETAS).

NRETAS have developed a receiving water quality model to quantify the impacts of various land use on the water quality of Darwin Harbour (Skinner, Townsend and Fortune, 2008). This model has identified urban stormwater as a key contributor to pollutant loads entering Darwin Harbour. Furthermore NRETAS have identified that WSUD on new developments is an important scenario that could help to mitigate impacts of pollutant loads, from new development, on water quality in Darwin Harbour. Ensuring that water quality models developed to assess the impact of new development reflect and are compatible with pollutant loads used in NRETAS receiving water model is a key step in linking the WQPP and the WSUD Strategy for Darwin Harbour.

This document

- assesses the pollutant loads from different land uses that have been adopted in the receiving water and
- analyses the underlying literature that was used to develop the pollutant loading rates for different land uses.
- discusses the adoption of pollutant concentrations and pollutant loads for various land uses and their incorporation into stormwater quality modelling tools.
- Compares loads adopted by the WQPP receiving water model and values adopted nationally and in other receiving waters around Australia.

This document builds on previous work undertaken as part of the WSUD Strategy project. In particular this report builds on the following reports:

- WSUD Stormwater Treatment Options Discussion Paper
- Stormwater Quality Modelling Guide
- WSUD Design Objectives Discussion Paper

1.2 Outline of this Document

This document discusses the pollutant loads from various land uses to Darwin Harbour and the incorporation of this into water quality models with appropriate local parameters for Darwin. The outline of the document is as follows:

- Section 2 summarises the pollutant loads adopted by the NRETAS receiving water model developed as part of the WQPP for Darwin Harbour
- Section 3 discusses the background monitoring reports that were used in developing the pollutant loads
- Section 4 discusses the incorporation of these pollutant loads into stormwater quality models with locally relevant parameters

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. • *WSUD Showcase - Bellamack residential sub-division conceptual WSUD Strategy is complete* • *Design development of Bellamack WSUD Strategy is about to commence (see Task below)*
	4	Identify potential WSUD objectives for Darwin • *Stakeholder workshop held on 14th and 15th June 2007* • *WSUD Objectives for Darwin - Discussion Paper (EDAW, Oct 2007)*
	5	Critical Analysis of WSUD/Stormwater Treatment Options for Darwin • *Stakeholder workshop held on 14th and 15th June 2007* • *Water Sensitive Urban Design Stormwater Treatment Options For Darwin - Discussion Paper (EDAW, Oct 2007)*
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.

STAGE	TASK #	Activity
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. *WSUD Showcase - Complete design development of the Bellamack WSUD Strategy* *Identify and scope work associated with "retrofit" WSUD case study*
	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 RECEIVING WATER QUALITY

The Department of Natural Resources, the Environment, the Arts and Sport (NRETAS) developed a water quality model of Darwin Harbour as part of a Darwin Harbour Water Quality Protection Plan (WQPP). The water quality tool is a decision support tool that assists decision makers in designing management plans to protect the existing water quality of Darwin Harbour. The water quality model is a key tool that can be used to predict the impact of management scenarios on the reduction of pollutants entering Darwin Harbour.

A range of variables are included in the receiving water model which need to be as consistent as possible with water quality modelling undertaken on a subcatchment scale and when determining the impacts of structural measures to reduce pollutant loads. The variables used in the receiving water are discussed in further detail below based on the report The Impact of Urban Land Use on Totla Pollutant Loads Entering Darwin Harbour (Skinner, Townsend and Fortune, 2008). While this report discussed urban and non-urban pollutant loads the focus of this report is on urban water quality parameters as the focus of the WSUD Strategy for Darwin Harbour is on ameliorating the impact of new developments.

2.1 Runoff Coefficients

The receiving water model based runoff coefficients based on monitoring of two urban subcatchments Moil and Karama (discussed in detail in section 3). The documentation for the WQPP noted that

- Runoff coefficients vary between wet seasons depending on rainfall
- Urban runoff coefficients are typically double those of rural and undisturbed catchments
- Averaged 0.78 for Moil
- Averaged 0.5 for Karama

2.2 Pollutant Export Rates

As part of the WQPP monitoring was undertaken during the 2006/7 wet season, including monitoring in the urban area of Moil, as well as rural and undisturbed catchments. The results from this study for flow weighted mean concentrations (FWMC) are shown in Table 2 and for wet season export loading rates are shown in

Table 3.

Table 2: Flow weighted mean concentrations Moil (Urban) 2006/7 wet season

Parameter	Urban
TN (mg/L)	0.82
TP (mg/L)	0.09
TSS (mg/L)	56.1

Table 3: Wet Season Export Coefficients

Parameter	Undisturbed	Rural	Urban
TN (kg/Ha)	4.7	2.6	14
TP (kg/Ha)	0.058	0.075	1.5
TSS (kg/Ha)	85	73	930

This report also came to the following key conclusions:

- Previous Winnellie data was unreliable due to an inaccurate rating curve
- Export loading rates were strongly dependent on rainfall
- There was little difference between rural and undisturbed catchments and thus these catchments were lumped together as one. This was partly a function of the nature of the rural catchments monitored which had large areas of undisturbed land use as well as rural land use within the catchment`

Based on the finding that the export loading rates are strongly dependent on rainfall, an export loading rate parameterised by rainfall was used, and is shown in Table 4. This value will be used as the basis of comparison of loading rates for local subcatchment models and this is discussed further in Section 4.

Table 4: Average Wet Season Export Coefficients (non parameterised in brackets)

Parameter	Non-urban	Urban
TN (kg/Ha/m)	1.65 (3.2)	5.5 (9.9)
TP (kg/Ha/m)	0.06 (0.12)	0.59 (1)
TSS (kg/Ha)	58 (110)	444 (730)

Based on these export loading rates, and land use assessment of Darwin Harbour, the total pollutant loads entering Darwin Harbour were calculated in the report.

2.3 Nutrient fractionation

Monitoring of nutrient fractionation was undertaken in 2006/07 in the Moil Drain (urban catchment) and compared to previous monitoring undertaken for Winnellie (light industrial). This monitoring found that:

- Solube P is 60% of total P compared to 45% at Winnellie
- Dissolved N is 55% of total N (the majority of which is nitrate) compared to 80% at Winnellie

3 PREVIOUS WATER QUALITY STUDIES AND REPORTS

Over the last two decades a range of water quality monitoring studies have been undertaken in Darwin by NRETAS and Power and Water Corporation. A summary of these studies are discussed here and their relevance to the values adopted in Section 2 are discussed. The focus in this report is on TSS, TP and TN which are the key indicators for treatment performance and which are also aligned to the objectives of the WSUD Strategy for Darwin Harbour. It should be noted that the reports outlined below include considerable other data, especially on heavy metals.

3.1 The amount of sediment, nutrients and metals that enter the Harbour each year, Water Monitoring Branch, 2005

This study is a summary of pollutant data previously collected. The study reported export coefficients as 'median' values which are considered typical values and are shown in Table 5. These values are different to those adopted in Section 2. The main differences between the two sets of data are that this study

- included data for the industrial area of Winnellie which was later determined unreliable data and
- did not parameterise the export coefficient for rainfall

Table 5: Wet Season Export Coefficients

Parameter	Undisturbed and Rural	Urban/Industrial
TN (kg/Ha)	2.4	9.4
TP (kg/Ha)	0.08	1.9
TSS (kg/Ha)	81	590

3.2 Providing a scientific basis to managing the region's development, Darwin Harbour Advisory Committee Ecosystem Research Group, 2005

This report was a compilation report of previous studies undertaken at the time of the report. This report presented no new monitoring data. The report lumped all urban areas into one urban parameter and the loads. These values are shown in Table 6. The values are similar to the values adopted in section 2 however the values do not taken into account the impact of rainfall on export loads.

Table 6: Loads from Urban Area Adopted

Parameter	Urban
TN (kg/Ha/y)	9.4 +/- 4.9
TP (kg/Ha/y)	1.9 +/- 0.4
TSS (kg/Ha/y /y)	590 +/- 190

3.3 Nutrient concentrations in four Darwin region streams, Schult, 2004

This study was undertaken to understand fractionation of nutrients in the Darwin Harbour catchment. The nature of the previous sampling techniques did not allow fractionation to be undertaken. This study took fortnightly grab samples rather than composite samples; hence the values are not flow weighted mean concentrations unlike values for TSS, TN and TP stated throughout the report. Hence this data can only be used as an indication of the fractionation, not the actual loads of fractionated species.

The only urban catchment analysed was Winnellie, however as the study took grab samples it is not affected by the unreliable rating curve. The study found that the

- overwhelming majority of TN was dissolved N (80%) predominately in the form of nitrates.
- TP was split evenly between dissolved and particulate P

The results of the study are summarised in

Table 7. It should be noted that the mean values for the grab samples for TN and TP were similar to composite samples indicating confidence in the representativeness of the samples.

Table 7: Grab samples – Winnellie Drain

Parameter	Mean	Range	N
TN (mg/L)	1.03	0.16-1.43	14
TP (mg/L)	0.09	0.01-0.7	14
TSS (mg/L)	28	0-70	11

3.4 An understanding of the groundwater and surface water hydrology of the Darwin Harbour Plan of Management, Haig and Townsend, 2003

This study is a summary report of monitoring undertaken at the time of the study and included further information based on data mining of existing monitoring. This report included some important information on runoff coefficients in the Darwin Harbour catchment including

- As a result of waterlogging up to 80% of rainfall during wet season months can contribute to surface runoff
- In the rural area wet season runoff coefficients average 33% and in wetter years increase to 48%
- In undisturbed catchments runoff coefficients likely to be similar to Kakadu National Park – 6 to 28%
- In urban catchment of Karama 78% runoff coefficient for a wet season in the early 1990s

This report also has some useful information about soil parameters, which can be correlated to the soil store parameters used by MUSIC. This included the following information:

- The soil deficit at the end of the dry season is approximately 150mm to 165 mm
- The long term recharge of rainfall to groundwater is approximately 200mm `

3.5 The water quality of wetland and streams in the Darwin Harbour catchment, Armando Padovan, 2003

This study is a summary report of monitoring undertaken at the time of the study and does not present new monitoring data. The summary results of this study show FWMC in

Table 8 and export loading coefficients in Table 9. This report also noted that stream flow data is the most uncertain variable due to the reliability of rating curves over time. It should be noted that in this report wet season monitoring years are not stated, therefore it is difficult to use data in this report

The urban residential FWMCs values presented here are very similar to those discussed in section 2. However some data for this study was later discounted including

- Data for the industrial area of Winnellie which was later determined unreliable data and
- Export loadings because they did not parameterise the export coefficient for rainfall

Table 8: Flow weighted mean concentrations

Parameter	Undisturbed (Celia Ck)	Rural (Elizabeth Rr)	Urban (Karama and Moil)	Industrial (Winnellie)
TN (mg/L)	0.5	0.3	0.7	0.8
TP (mg/L)	0.03	0.01	0.07	0.21
TSS (mg/L)	24	14	63	44

Table 9: Wet Season Export Coefficients

Parameter	Undisturbed (Celia Ck)	Rural (Elizabeth Rr)	Urban (Karama and Moil)	Industrial (Winnellie)
TN (kg/Ha)	4	2	11	30
TP (kg/Ha)	0.3	0.1	1.3	7.3
TSS (kg/Ha)	168	96	775	1305

3.6 Assessment of the ecological condition of freshwater streams in the Darwin region: evidence from a survey of macroinvertebrate communities and water quality in the early dry season 2001, Dostine, 2002

This study sought to address the lack of data on in-stream ecological health indicators. This study monitored macroinvertebrates and water quality and samples were taken at 14 sites during the 2001 early dry season. Two of the 14 sites are affected by urbanisation, Rapid Creek and Mitchell Creek. The water results of this study are shown in Table 10. As these water quality results are 14 grab samples and not FWMCs it is not possible to use this data. However it is noted that the in stream water quality is significantly better than urban land use runoff, particularly for TSS.

Table 10: Early Dry Season Creek WQ – 14 Samples

Parameter	Rapid	Mitchell
TN (mg/L)	0.05	0.06
TP (mg/L)	0.003	0.003
TSS (mg/L)	1.4	1.3

3.7 Catchment Load Monitoring During the 2000/01 wet season (Berry Creek and Winnellie Drain stations), Padovan, 2001

This study undertook water quality modelling for FWMCs and calculated export loadings for an industrial area , Winnellie. This study also compiled all previous monitored data and the results are shown in Table 11 and Table 12.

The data for Winnellie is not reliable due to the inaccurate rating table, discussed in Section 2.

Table 11: Flow Weighted Mean Concentrations

	Undisturbed			Rural					Urban				Industrial			
	95	96	96	90	95	96	99	00	90	91	95	96	95	96	99	00
TN (mg/L)	0.3	0.6	0.5	0.4	0.3	0.4	0.1	0.2	0.6	0.8	0.7	0.7	0.9	1.2	0.5	0.6
TP (mg/L)	0.02	0.04	0.03	0.01	0.01	0.02	0.01	0.01	0.04	0.06	0.1	0.09	0.27	0.25	0.16	0.16
TSS (mg/L)	23	25	16	9	13	14	10	16	34	149	39	31	85	30	29	33

Table 12: Wet Season Export Coefficients

	Undisturbed			Rural					Urban				Industrial			
	95	96	96	90	95	96	99	00	90	91	95	96	95	96	99	00
TN (kg/Ha)	0.7	6.6	4.4	2.4	1.5	5.2	2.2	1.0	11	5	12.6	16.9	18.9	71.9	16.5	12.4
TP (kg/Ha)	0.04	0.5	0.3	0.05	0.04	0.3	0.08	0.05	0.7	0.4	2.0	2.3	5.7	14.9	5.1	3.5
TSS (kg/Ha)	48	288	154	57	60	204	70	79	610	956	714	820	1802	1798	923	697

3.8 The quality of runoff and contaminant loads to Darwin Harbour, Padovan, 2001

This report is a summary report of total loads to Darwin Harbour and includes loadings from sewage treatment plants as well as stormwater runoff. This report has one of the most complete records of individual events sampled for the gauging stations which are useful for separate data mining. The report contains the same data as shown in Table 11 and Table 12.

Table 13: Flow Weighted Mean Concentrations

Parameter	Karama (90/91)	Karama (91/92)
TN (mg/L)	0.6	0.83
TP (mg/L)	0.037	0.062
TSS (mg/L)	34	154
AVRC	78%	62%

Table 14: Wet Season Export Coefficients

Parameter	Karama (90/91)	Karama (91/92)
TN (kg/Ha)	11	5
TP (kg/Ha)	0.7	0.4
TSS (kg/Ha)	610	956

3.9 Runoff water quality from an urban catchment (Karama, Darwin), Kernohan and Townsend, 2000

This study included a detailed statistical analysis of monitoring data on the urban catchment area of Karama, undertaken in 1991/92. This analysis included data showing individual storm event sampling results (as compared to composites for all other reports) as well statistical regression analysis for various parameters such as length of storm duration, length of wet season (with relatively weak results for all parameters). The study also attempted to separate out baseflow and stormflow loads.

This study reported a 62% runoff coefficient for Karama for the wet season of 1991/92.

3.10 The Quality of Runoff to Darwin Harbour, Padovan, 1997

During 1995/96 wet season water quality concentrations and flow were measured in an industrial area (Winnellie), an urban area (Moil) and a rural catchment (Elizabeth River) and an undisturbed catchment (Celia Creek). The results of this are shown in Table 15. The data for Winnellie is not reliable due to the inaccurate rating table, discussed in Section 2. The data for Moil was used and combined with other urban runoff water quality studies to determine average FWMCs and export loadings.

Table 15: Flow Weighted Mean Concentrations

Parameter	Undisturbed	Rural	Urban	Industrial
TN (mg/L)	0.3	0.3	0.7	0.9
TP (mg/L)	0.02	0.01	0.1	0.3
TSS (mg/L)	24	13	39	85

3.11 Nutrient, Suspended Solid and Metal inputs from point and non-point sources into Darwin Harbour, Nov 90-Oct 91 , Townsend, 1992

Townsend conducted one of the first comprehensive studies on urban land use runoff water quality. Water quality was monitored at an undisturbed catchment and an urban residential catchment (Karama) during the wet season and dry season in 1990/91. the results are shown in The data from this study of Karama was used and combined with other urban runoff water quality studies to determine average FWMCs and export loadings as discussed in section 2.

Table 16 and Table 17. It should be noted that dry season samples were taken by grab sampling as flows were two low for autosampling. The study also reported runoff coefficient for Karama as 0.78. The data from this study of Karama was used and combined with other urban runoff water quality studies to determine average FWMCs and export loadings as discussed in section 2.

Table 16: Flow Weighted Mean Concentrations

Parameter	Undisturbed	Urban
TN (mg/L)	0.4	0.6
TP (mg/L)	0.01	0.04
TSS (mg/L)	9	34

Table 17: Wet Season Export Coefficients

Parameter	Undisturbed	Urban
TN (kg/Ha)	2.4	0.0511
TP (kg/Ha)	0.05	0.7
TSS (kg/Ha)	57	610

4 MUSIC MODEL CALIBRATION

Ideally parameters used in the broader lumped Darwin Harbour receiving water model and the local subcatchment models, such as those developed for Bellamack, should be identical. A range of default values have been derived based on data for the southern and eastern states of Australia and reported in the overarching national guide for WSUD - Australian Runoff Quality: A Guide to Water Sensitive Urban Design (Engineers Australia, 2005). These values have been adopted as the default values for stormwater quality modelling packages such as MUSIC.

This section compares the national guidelines values and the values from local monitoring in Darwin, discussed in section 2 and 3. It should be noted that the focus is on urban runoff parameters as the focus of the WSUD Strategy for Darwin is ameliorating the impact of urbanisation on aquatic ecosystems. Despite the significant amount of local monitoring data on industrial areas, this data cannot be used due to the inaccuracy of the rating table that was used to generate the data. Thus only one type of land use has been assessed due to the availability of data – urban residential.

4.1 Runoff Volumes

Runoff volumes are generated in MUSIC using a rainfall runoff model that determines pervious runoff and impervious runoff separately. For pervious areas MUSIC uses a series of storages, soil moisture and groundwater storages, which fill or deplete with infiltration, recharge and/or evapotranspiration. For impervious areas a daily threshold (typically 1mm) is required before runoff is generated from rainfall.

An assessment of impervious areas in the catchment of Karama and Moil was undertaken and an example is shown in Figure 1. The impervious areas in the catchment were generated from an analysis of aerial photo for the subcatchment. An estimate of the roof area, ground levels and road impervious area was estimated by tracing around the appropriate areas for a representative portion of the residential portion of the catchment. Large pervious areas (such as parks) and large impervious areas (such as carparks) were delineated separately. Based on this method the estimated impervious area for Moil was 42% and 37% for Karama. It should be noted that this process was undertaken using recent aerial photos rather than aerial photos taken at the time of monitoring. The error induced by this is considered to be small as there appears to be little evidence of increasing impervious areas within the urban areas, which are well established suburbs of Darwin undergoing little redevelopment or urban regeneration.

For the soil pervious store, Appendix A of the MUSIC manual (CRCCH, 2005) gives local parameters for Darwin based on calibrations undertaken by the CRCCH. These values were then adopted in a MUSIC model to determine the annual volumetric runoff coefficient (AVRC) and compare it to AVRC recorded in the field. The MUSIC model developed for Moil is shown in Figure 2. Based on these models a long term AVRC for ten years was found to be 55% to 60%. This value was found to compare reasonably with the average value found from field monitoring of 50% to 78%. Thus it was concluded that the flow volumes generation methods adopted by this method were considered locally relevant to Darwin.

Figure 1 Land Use Analysis of Moil Catchment

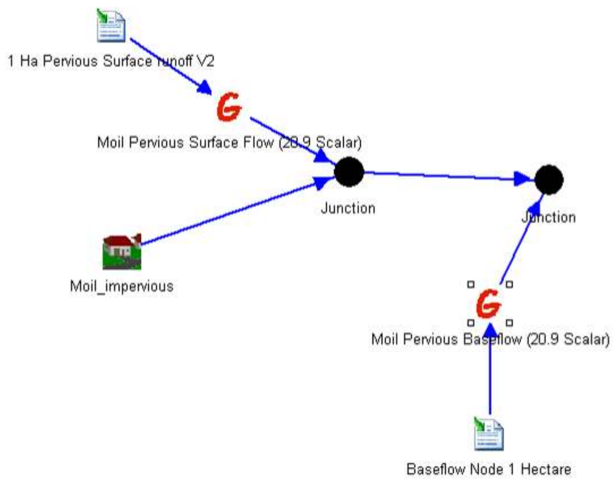

Figure 2 MUSIC model developed for Moil Catchment

4.2 Pollutant Loads

Default MUSIC pollutant parameters have been developed based on a wide ranging assessment of national and international pollutant flow weighted mean concentrations (Engineers Australia, 2005). MUSIC recommends using these values when there are no locally relevant parameters. Due to the comprehensive data analysis the values are fairly robust and found to generally represent water quality in the southern and eastern states of Australia. For example in south-east Queensland the recommended values are identical to the MUSIC defaults except for the local FWMC of TN (1.8 mg/L) which is lower than the default (2.6 mg/L).

As discussed in section 3 local water quality data has been collected in Darwin for almost two decades for two urban subcatchments in Darwin. Thus a reasonable data set exists for flow weighted mean concentrations for local water quality in urban areas. This data set has also been used in the Darwin Harbour receiving water model.

A comparison of the MUSIC default water quality concentrations and the monitored data in Darwin shows that the MUSIC defaults are consistently higher than values from local monitoring data. This is shown in Table 18. MUSIC concentrations are two to three times higher than local data measured in the field in Darwin.

Table 18: Comparison of flow weighted mean concentrations

Parameter	Darwin Urban (Karama and Moil)	MUSIC Defaults
TN (mg/L)	0.7	2.6
TP (mg/L)	0.1	0.35
TSS (mg/L)	63	158

Due to this significant difference in concentrations, modelling was undertaken to determine the difference in export loads when using MUSIC defaults compared to local Darwin monitoring data. The local Darwin export loads were based on the rates shown in Table 4, and multiplied by the average rainfall (1699mm) over the 10 year period, from 1987 to 1996, for which the model was run. The results, shown in Table 19, indicate that the MUSIC defaults generate significantly more pollutant loads than those monitored in the field. Estimates based on local Darwin flow weighted mean concentrations compare well with the loads derived from monitored data in Karama and Moil.

Table 19: Comparison of Export Loads

Parameter	Monitored data for Darwin Urban (Karama and Moil)	MUSIC – using default national concentrations	MUSIC – Using local monitored concentrations
TN (kg/Ha/y)	9.35	27.8	7.6
TP (kg/Ha/y)	1	3.8	1.3
TSS (kg/Ha/y)	755	1780	744

Thus based on an assessment of local water quality data it appears that the MUSIC default pollutant parameters are not suited to Darwin conditions. Utilising the MUSIC defaults results in estimates of pollutant loads which are two to three times high than the monitored loads from urban catchments in Darwin. Utilising the flow weighted mean concentrations determined from local monitoring data with MUSIC generated flows estimates loads very similar to those measured in the field. However adopting local concentration data for pollutant loads requires changes to other parameters within MUSIC, particularly treatment system parameters, and this is further discussed in section 4.3.

Build-up of pollutants on a catchment surface occurs during periods of no or low rainfall. Pollutants are deposited on the surface which are generally not mobilised until they are washed off by rainfall or other flows (such as street sweeping, hosing). There is some speculation that due to the long period of build up in the dry season in the wet dry tropics, that large pollutant loads could be washed off in the first few storms of the wet season. However pollutant monitoring undertaken shows that this is clearly not the case and that, generally pollutant loads are proportional to flow volumes. This is shown in Figure 3.

While there is a generally linear relationship between cumulative discharge and cumulative pollutant loads, pollutant concentrations are consistently higher in the early part of the wet season. This is shown, for example, for TSS from data from the urban catchment of Moil for one wet season. For the first 10 to 20% of the wet season flows concentration are noticeably higher than concentrations for the remainder of the wet season. This partly explains why loads are likely to be slightly proportionally higher at the beginning of the wet season than later in the wet season. However the impact on total loads is not strong, and thus it is assumed that for modelling purposes it is assumed that pollutant data is consistent throughout the wet season.

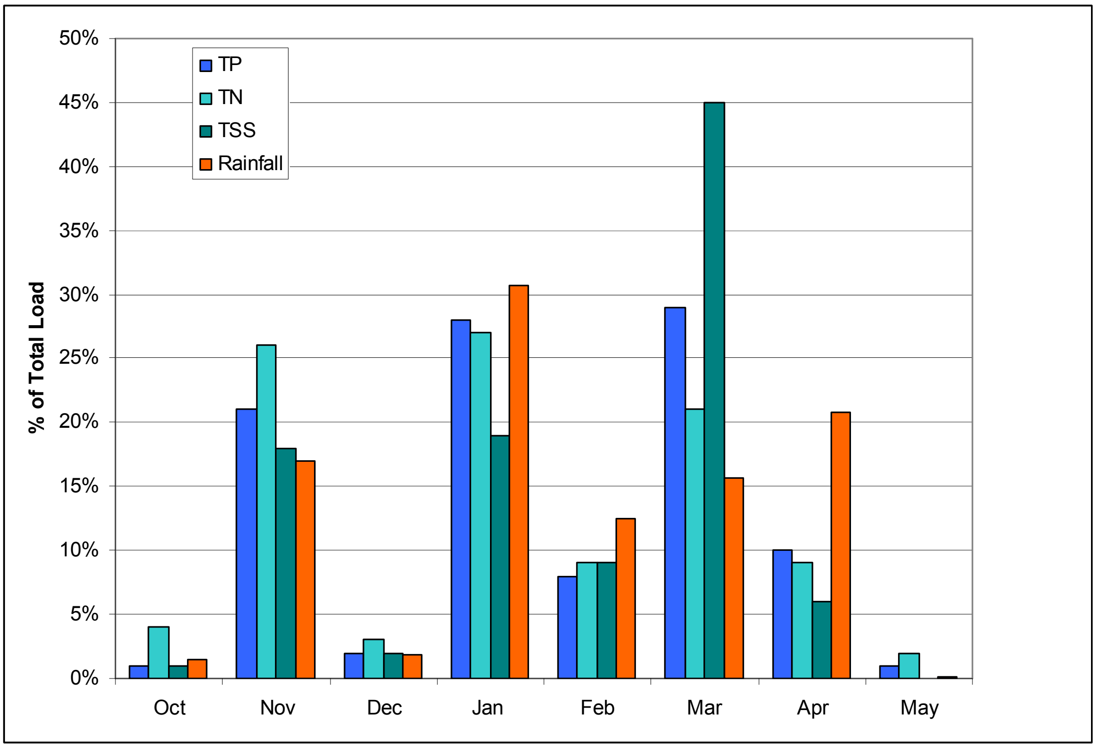

Figure 3 Pollutant Loads and Rainfall during the Wet Season (Based on Kernohan and Townsend, 2000)

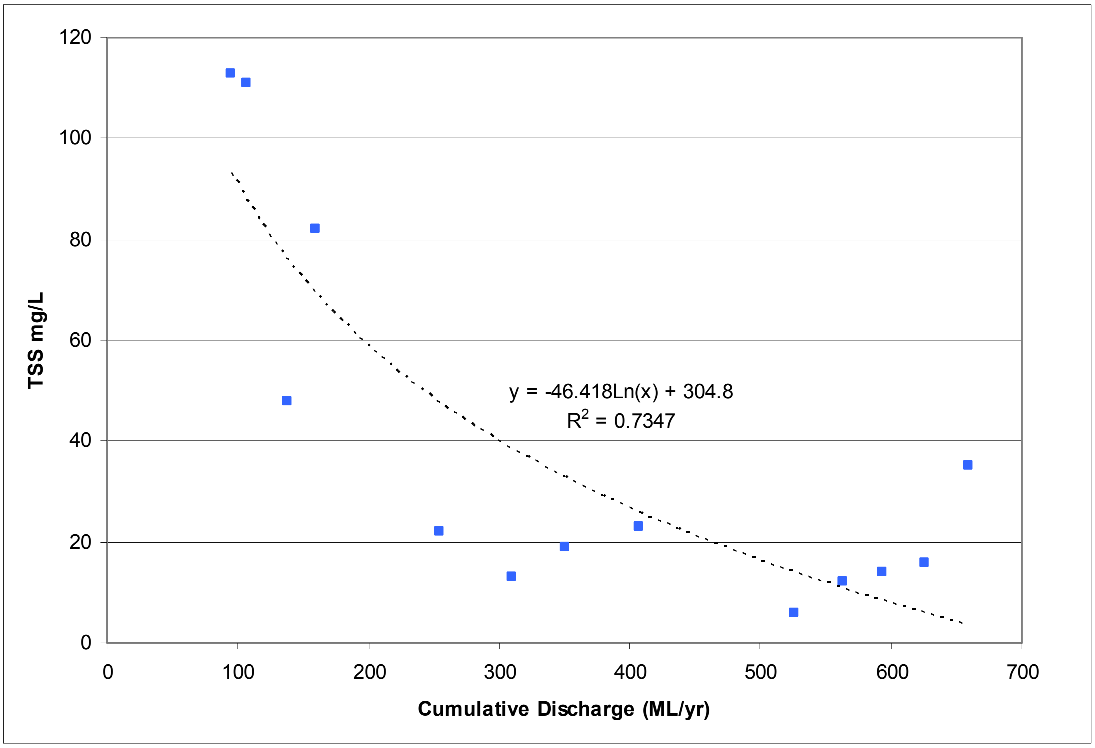

Figure 4 TSS vs Cumulative Discharge for the wet season of 1995/96

4.3 Treatment Parameters

MUSIC treatment systems are based on a continuous stirred tank reactor (CSTR) model. This model assumes that pollutants within the CSTR are

- well mixed
- removed based on a decay rate constant, k in m/year and
- removed based on a constant, C*, a background concentration in the treatment system, below which the outlet concentration will not drop.

These constants are interdependent on each other (CRCCH, 2005). The recommended range of C* values are shown in Table 20 for a range of treatment systems.

Table 20: Recommended C* values (CRCCH, 2005)

Parameter	Wetlands	Swales	Ponds
TN (mg/L)	0.7-1.3	1.1-1.7	0.7-1.3
TP (mg/L)	0.03-0.09	0.08-0.18	0.05-0.13
TSS (mg/L)	5-6	10-30	12-15

This table shows that

- The *minimum* total nitrogen C* values are above the incoming pollutant concentration of local Darwin data (see Table 18)

- The *average* total phosphorous C* values are typically above the incoming pollutant concentration for local Darwin data (see Table 18)

Thus to estimate the performance of the treatment systems in Darwin, particularly for nitrogen requires setting the TN C* constant *below* the current recommended range. These recommended ranges have been based on pollutant data and treatment systems developed in temperate climates. Currently the recommended ranges are not readily transferrable to Darwin local conditions. This is a significant technical gap in the current application of MUSIC and other water quality models to the wet –dry tropics and the Darwin region in particular.

MUSIC modelling undertaken with the Darwin pollutant concentration and the lowest recommended k-C* values found that while TP and TSS provided results relatively consistent with south and eastern states, TN removal was significantly lower (by a factor of ten).

Local monitoring of natural wetlands and lagoons in the Darwin region has been undertaken (see for example Lloyd, 1999). These results are shown in Figure 5.

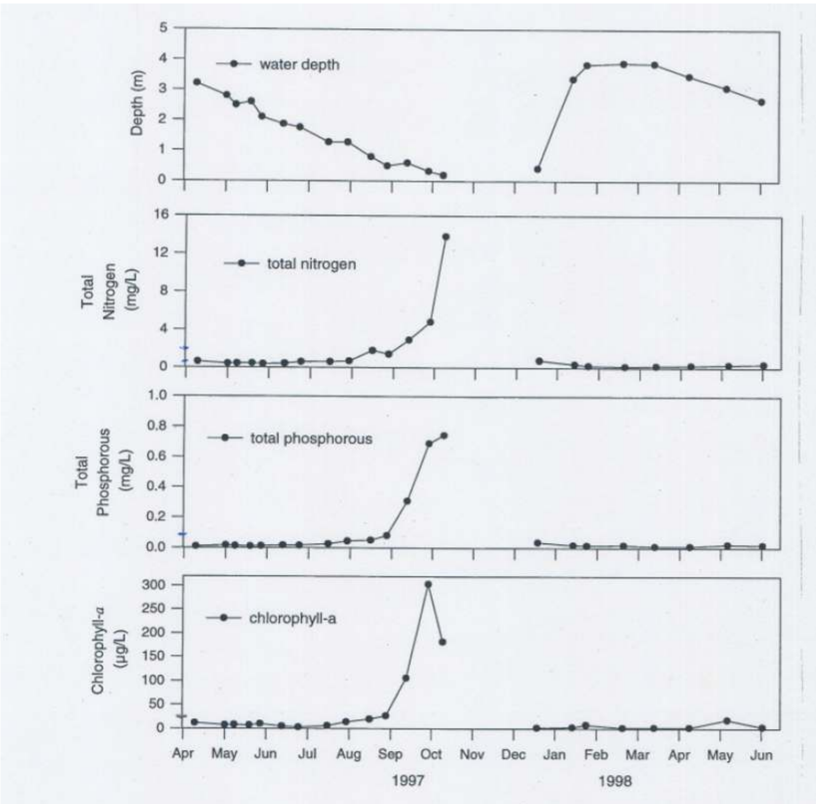

Figure 5 Nutrient Levels over time in a Darwin Lagoon (Lloyd, 1999)

This monitoring of natural lagoons and wetlands found that

- background TN concentrations were much lower than 0.7 mg/L, typically less than 0.3 to 0.4 mg/L

- background TP concentration were much lower than 0.1 mg/L

While it is not necessarily possible to directly correlate the background concentration in natural systems to constructed systems, it is an indication that lower background concentrations for constructed treatment systems may be more relevant than the current recommended minimums in MUSIC.

To address this key technical gap, monitoring of local treatment systems is an important requirement. A comprehensive monitoring strategy for the treatment systems which are to be constructed as part of the WSUD showcase of Bellamack has been developed which will address this gap (Equatica, 2009).

Until locally relevant treatment performance data is available, the interim strategy is to use default MUSIC pollutant concentrations with local Darwin soil store parameters.

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