



Urban Wetland Monitoring Program

FOR THE CITY OF ROCKINGHAM

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Urban Wetlands Monitoring Program – City of Rockingham

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Table of Contents

Urban Wetlands Monitoring Program - City of Rockingham

Summary	1
1.0 Introduction.....	1
1.1 Background.....	1
1.1.1 Water Quality.....	1
1.2 Project Objectives.....	2
1.3 Study Area	3
2.0 Method.....	4
2.1 Monitoring of Wetlands	4
2.1.1 Study sites	4
2.1.2 Monitoring and Analysis	5
3.0 Results	6
3.1 Water Quality Field Results	6
3.2 Water Sample Analysis	21
3.2.1 Field Parameters	22
3.2.2 Water Quality Analysis Results.....	24
4.0 Discussion and Conclusions	26
4.1 Field Parameters.....	26
4.2 Field Observations	26
4.3 Water Quality Parameters.....	27
4.4 Conclusions	28
References.....	29
Appendix One: Site Maps.....	30
Appendix Two: ANZECC Guidelines	32
Appendix Three: Raw Data	33

LIST OF TABLES

Table 1. Urban Wetland sites to be tested for water quality parameters and their locations.	4
Table 2. Summary of Field observations	20
Table 3. Summer Field results.....	22
Table 4. Summer Water Quality Results.	25
Table 3A. Raw data for field results	33
Table 3B. Average values for field results.....	34
Table 3C. Summary of findings from Urban Wetland and Drainage Swale Study, 2006.	34

LIST OF FIGURES

Figure 1: pH, DO and temperature readings from all sites.	23
Figure 2: Salinity measures from all sites.	23

LIST OF PLATES

Plate 1: Rotary Park.....	6
Plate 2: Rotary Park showing surface aerators.	7
Plate 3: City Park showing surface aerator and rubbish build-up in the reeds at the waters edge.	7
Plate 4: City Park.	8
Plate 5: City Park Drain.	8
Plate 6: June Road.....	9
Plate 7: Centenary Park.....	9
Plate 8: Don Cuthbertson showing aerating fountain and build-up of vegetation and rubbish along waters edge.	10
Plate 9: Don Cuthbertson showing congested edge of the wetland.	10
Plate 10: Monmarte showing birdlife in the middle of the lake and aerating fountain.....	11
Plate 11: Bayeux showing island in the middle of lake and fountain similar to Monmarte....	11
Plate 12: Sovereign Ave PK6A.....	12
Plate 13: Sovereign Ave Drain 1.....	12
Plate 14: Sovereign Ave Drain 2.....	13
Plate 15: Sovereign Ave Drain 3.....	13
Plate 16: Sunlight Park.	14
Plate 17: Baltimore.	14
Plate 18: Eighty Road.	15
Plate 19: Rivergum Boulevard.....	15
Plate 20: Tuart Grove.....	16
Plate 21: Hidden Swamp.....	16
Plate 22: Upper-layer of the lake at Hidden Swamp.	17
Plate 23: Hidden Swamp showing pooling water and rubbish around the edge of the upper- layer of the lake.	17
Plate 24: Proper John urban wetland.	18
Plate 25: Proper John Drain.	18
Plate 26: Dress Circle Basin showing rubbish dumping and suspended matter.....	19
Plate 27: Lark Hill Sporting Complex.....	19

Summary

Urban Wetlands Monitoring Program - City of Rockingham

Following the results of the *City of Rockingham Urban Wetlands and Drainage Swale Study, 2006* and its review in 2008 (*City of Rockingham*) the City of Rockingham has requested biannual monitoring of problem wetlands for water quality parameters.

The Project objectives were to:

- undertake a biannual monitoring program on problem wetlands to test water quality parameters and comment on the presence or potential of midge and mosquito presence
- provide the City of Rockingham with a summary report of findings and a discussion on trends and observations.

The findings of the summer sampling and analyses were:

- some wetlands need aerators
- some wetlands gave off odours
- Rotary Park was saline
- Don Cuthbertson had plant matter build up and reduced flow
- Dress Circle contained suspected macroalgae
- Hidden Swamp had little or no movement or aeration of water on its upper level, potential for midge and mosquito problems.

1.0 Introduction

Urban Wetlands Monitoring Program - City of Rockingham

1.1 Background

1.1.1 Water Quality

Australia faces critical salinity and water quality problems, which are expected to become more severe over the coming decades (Environment Australia 2002). Our water resources are under increasing pressure from water shortages, drought, pollution and over-extraction, all of which necessitates that we change the way we manage and use water (EA 2002).

Poor water quality affects us all, directly and indirectly. The causes of many water quality problems are broad-scale in origin (EA 2002) and may require remediation on multiple levels. The City of Rockingham has previously experienced, but was not limited to the following water quality issues.

Odour problems

Anoxic conditions may occur during both summer and winter but they are generally more pronounced in summer. Insufficient circulation/aeration and excessive biological oxygen demand (BOD) and ammonia loadings create anoxic conditions (City of Rockingham 2008).

Algal blooms

Important primary components of the ecosystem are algae, or phytoplankton. Suspended in the water, these small free floating plants often grow rapidly in spring when high levels of nutrients are available, which is referred to as a “bloom” (Brunson, Lutz et al. 1994). Like all green plants, phytoplankton produces oxygen during the daylight hours as a bi-product of photosynthesis. This is a major source of oxygen to the ecosystem (City of Rockingham 2008).

Mosquitoes

There are some mosquitoes closely associated with urban environments. These mosquitoes can breed in a range of habitats, from small water holding containers through to highly polluted ponds and other wetlands. The Domestic Mosquito, *Ochlerotatus notoscriptus*, is often found breeding in old pot plant saucers, bird baths, blocked gutters, used tyres, etc. It does not travel far but as it is closely associated with urban areas, it can be serious pest.

Midges

Non-biting midges are small flies that have an aquatic life stage. As juveniles, the larvae are located in rivers and wetlands. Not all species cause nuisance problems and those that do often occur in great abundance and are associated with degraded aquatic systems (WCA 2008).

1.2 Project Objectives

The City of Rockingham has previously experienced management problems with regard to their constructed wetlands including excessive algal growth, odour problems and bird deaths as well as mosquito and midge problems. A major contributor to these ongoing issues result from inadequate design of drainage features as well as high nutrient concentrations from stormwater drainage catchments (City of Rockingham 2008).

The City of Rockingham has undertaken a study into the health of constructed wetlands and drainage swales within its locality (City of Rockingham 2008). Part of the recommendations of the study was to undertake a bi-annual monitoring program to test problem wetlands for water quality parameters.

These wetlands were surveyed and selected for having combinations of the following water quality issues (**Appendix 3**):

- drying out
- algae
- non-native fish species
- bird deaths
- standing water in drain
- odour
- rubbish.

The City of Rockingham required sampling across the selected wetlands to test water quality parameters and requested that observations be made relating to the quality of the wetlands and their surrounds.

The Project objectives were to:

- undertake a biannual monitoring program on problem wetlands to test water quality parameters including water samples for analysis and in situ readings
- make opportunistic observations on other wetland characteristics such as presence of midge and mosquito, rubbish, odours, water colour, aeration, fauna and hydrology
- provide the City of Rockingham with a summary report of findings and a discussion on trends and observations.

1.3 Study Area

The City of Rockingham is located 47km southwest of Perth CBD and covers an area of 261km². Many wetlands exist in the City including natural wetlands, man-made lakes, ponds and drains.

The area has warm to hot summers and cool, wet winters. The minimum temperatures are in July and August (8.6°C) and the maximum in February (29.5°C). Rainfall in the area ranges from 9.6mm (January) to 189.7mm (June) (BOM 2008).

There were 20 sites from within 17 urban wetlands surveyed from between Patterson Rd, south to the end of Warnbro Sound Ave, bordered by the Indian Ocean to the west and the Kwinana Freeway and Ennis Ave to the east (**Map 1, Appendix 1**).

2.0 Method

Urban Wetlands Monitoring Program - City of Rockingham

2.1 Monitoring of Wetlands

2.1.1 Study sites

The *City of Rockingham Urban Wetlands and Drainage Swale Study Review, 2008* identified multiple management issues relevant to the wetlands monitored. The parameters measured during the study included pH, salinity, dissolved oxygen (DO) and total dissolved solids. These 20 urban wetlands and drains within the City of Rockingham were sampled in March, 2009 (**Table 1, Map 1**) as they were previously identified by the *City of Rockingham, 2008* as having one or more of the water quality issues listed in Section 1.2.

The drains PK6A, PK6B, PK6C and the drain at Proper John and Fisher St were dry and therefore these sites were not sampled (the main wetland at Proper John was sampled).

Table 1. Urban Wetland sites to be tested for water quality parameters and their locations.

Site Name	Location
Rotary Park	R1
Proper John	A6
June Road	SB1
Centenary Park	SB7
City Park	R41
Don Cuthbertson	C2
Rivergum Boulevard	B9
Eighty Rd	B1
Dress Circle Basin	WO4B
Bayeux	PK3
Monmarte*	PK2
Sovereign Ave	PK6A
	PK6B
	PK6C
	PK6D
Sunlight Park	PK13
Baltimore	PK16
Lark Hill	-
Tuart Grove	SH3
Hidden Swamp	SH4

*Water bodies feed into Lark Hill Lakes

2.1.2 Monitoring and Analysis

Water Quality Parameters

In late March two qualified Ecoscape environmental scientists undertook a survey of the selected water bodies. Each site was surveyed on foot to observe signs of water quality (i.e. colour of water, signs of pollutants, animal life) and evidence of overabundant mosquito and midge populations.

Water samples and in situ water quality readings were taken from one location at each of the wetlands and were marked by GPS waypoint and photographed. Where wetlands were large or potentially variable a second in situ reading was taken and a new GPS waypoint recorded. During field visits the wetlands were tested for the following parameters:

- pH
- Dissolved Oxygen (DO)
- temperature
- salinity and conductivity.

Water samples were collected and stored for transport to the requirements of SGS who completed all analysis. All samples were kept at low temperatures before being analysed for the following water quality parameters:

- total Dissolved Solids (TDS)
- total Nitrogen (TN)
- total Kjeldahl Nitrogen (TKN)
- nitrate and Nitrite (NO_x)
- ammonium (NH₄)
- total Phosphorus (TP)
- filterable Reactive Phosphorus (FRP)
- chlorophyll a.

3.0 Results

Urban Wetlands Monitoring Program - City of Rockingham

3.1 Water Quality Field Results

All wetlands were clean and well-drained. Most sites had bird life and aquatic fauna (vertebrate and invertebrate) and appeared in good health. Fourteen of the wetlands had surface aerators. Below are observations made at each of the wetlands and a summary has been provided in **Table 2**.

Rotary Park

Rotary Park was sampled at two locations, both of which were clean and healthy. Gambusia fish (*Gambusia affinis affinis*) were present in the water and there was bird life observed predominantly Cormorants (*Phalacrocorax varius*), Eurasian Coots (*Fulica atra*) and Silver Gulls (*Larus novaehollandiae*) (**Plate 1 and 2**).



Plate 1: Rotary Park.



Plate 2: Rotary Park showing surface aerators.

City Park

City Park was clean and well-drained although it was noted that rubbish had built up along the edges of the water and was trapped in the vegetation (**Plate 3 & 4**). This wetland had three surface aerators.

The long drain that ran into the wetland was clean although rubbish was observed within the drain (**Plate 5**).



Plate 3: City Park showing surface aerator and rubbish build-up in the reeds at the waters edge.



Plate 4: City Park.



Plate 5: City Park Drain.

June Road

The site appeared in good health although the water gave off a strong odour. This wetland was aerated (**Plate 6**).



Plate 6: June Road.

Centenary Park

Centenary Park was clean and flowing with two surface aerators and a large number of bird species including Pied Cormorants (*Phalacrocorax varius*), Eurasian Coots (*Fulica atra*), Purple Swamphens (*Porphyrio porphyrio*) and the Pacific Black Duck (*Anas superciliosa*) (Plate 7).



Plate 7: Centenary Park.

Don Cuthbertson

This wetland had swans (*Cygnus atratus*) and other birdlife. Large Koi fish (*Cyprinus carpio*) were also observed. It was well-drained and clean, although floating vegetation was seen congregating along the edge of the water reducing water flow. The single aerator in the main pond of the wetland was not creating adequate movement of water across the whole wetland (**Plate 8**). The build up of vegetation floating in the water is evidence of this restricted flow (**Plate 9**). Any stagnant water and build-up of nutrients presents a potential breeding ground for both mosquitoes and midges.



Plate 8: Don Cuthbertson showing aerating fountain and build-up of vegetation and rubbish along waters edge.



Plate 9: Don Cuthbertson showing congested edge of the wetland.

Monmarte

Monmarte was a clean site in good health with two surface aerators (**Plate 10**).



Plate 10: Monmarte showing birdlife in the middle of the lake and aerating fountain.

Bayeux

This site had two surface aerators, good drainage, was clean and contained birdlife (swans (*Cygnus atratus*)). There was a green colouration observed in water clarity which may indicate early stages of algae production or possible chemical application (**Plate 11**).



Plate 11: Bayeux showing island in the middle of lake and fountain similar to Monmarte.

Sovereign Ave

Sovereign Ave consisted of PK6A, PK6B, PK6C and PK6D. PK6A was the main wetland. Three other drains (PK6B, PK6C and PK6D) were located at various points around the park. The wetland was in good health but was slightly green in colour (**Plate 12**). All three drains were found to be dry during the site visit (**Plates 13-15**).



Plate 12: Sovereign Ave PK6A.



Plate 13: Sovereign Ave Drain 1.



Plate 14: Sovereign Ave Drain 2.



Plate 15: Sovereign Ave Drain 3.

Sunlight Park

Sunlight Park was clean and in good health, birdlife such as swans (*Cygnus atratus*) were observed. It had one surface aerator which created water movement (**Plate 16**).



Plate 16: Sunlight Park.

Baltimore

The water at Baltimore had an abnormal blue-green colour to it. It also let off a strong sulfur odour, when the sediment was disturbed; this is typical of anoxic (low oxygen) conditions (**Plate 17**). No birdlife was observed during the visit.



Plate 17: Baltimore.

Eighty Rd

Eighty Road had dense vegetation to one side. An algae layer across parts of the water was observed (**Plate 18**). There was almost no movement of water which can present an ideal breeding site for mosquitoes and midges. Gambusia (*G. affinis affinis*) was abundant.



Plate 18: Eighty Road.

Rivergum Boulevard

Rivergum was one of the larger wetlands and was in good health. It consisted of one surface aerator and a variety of birdlife were observed (**Plate 19**).



Plate 19: Rivergum Boulevard.

Tuart Grove

Tuart Grove was aerated with a small man-made waterfall. However, the water was green to aqua in colour (**Plate 20**), further monitoring is suggested as the discolouration was not typical of algal blooms and is not supported by the chlorophyll a counts from the water analysis.



Plate 20: Tuart Grove.

Hidden Swamp

The largest part of Hidden Swamp had no surface aeration (**Plate 21**). It was relatively clean and well-drained. Native vegetation provided sufficient habitat for the birdlife present. The elevation of the top-part of the wetland created a small drop into the lower-level although it did not appear to sufficiently aerate the water or create any movement. There was a salt crusted algal mat along the waters edge of the lower-level (Waypoint 27 and 28). The upper-level of the wetland was found to be very still and the thick vegetation had created water pooling around it (**Plate 22 & 23**). This could create potential mosquito and midge breeding sites. No *Gambusia (G. affinis affinis)* was seen.



Plate 21: Hidden Swamp.



Plate 22: Upper-layer of the lake at Hidden Swamp.



Plate 23: Hidden Swamp showing pooling water and rubbish around the edge of the upper-layer of the lake.

Proper John

The Proper John site consisted of a small round wetland (**Plate 24**) and a large drain (**Plate 25**). During the site visit the drain was completely dry. The entire area was clean (including the wetland itself) and well-drained.



Plate 24: Proper John urban wetland.



Plate 25: Proper John Drain.

Dress Circle Basin

This was the smallest of the sampled wetlands. It had a layer of suspected macroalgae, which is algae that can be seen by the unaided eye and can form through the aggregation of cells (colonies) (Water and Rivers Commission 1998) (**Plate 26**). However, a sample was not taken to confirm this and further investigation is recommended. It is used as a dumping ground for various items (e.g. a trampoline and a phone). It has a small fountain which created limited movement of the water and as such (as a standing body of water) will provide a breeding site for midges and mosquitoes. It also gave off a faint odour.



Plate 26: Dress Circle Basin showing rubbish dumping and suspended matter.

Lark Hill

Lark Hill, a rounded wetland at the far end of the Lark Hill Sporting Complex was clean with good water flow and a variety of birdlife (**Plate 27**).



Plate 27: Lark Hill Sporting Complex.

Table 2. Summary of Field observations

Wetland	Sample Location (GPS Co ordinate)		Colour (only noted if abnormal)	Birdlife observed	Number of Aerators	Non-native fish species	Mosquito/Midge risk	Dry	Algae	Odour	Rubbish	Stagnant water
	Easting	Northing										
Rotary Park	378966	6428180	-	✓	3	x	x	x	x	x	x	x
City Park	381785	6427415	-	✓	3	x	x	x	x	x	✓	x
June Road	379576	6425465	-	✓	1	x	x	x	x	✓	x	x
Centenary Park	381716	6424395	-	✓	2	x	x	x	x	x	x	x
Don Cuthbertson	383922	6426405	-	✓	1	✓	✓	x	x	x	✓	✓
Montmarte*	382714	6419892	-	✓	2	x	x	x	x	x	x	x
Bayeux	382153	6419752	Murky Green	✓	2	x	x	x	x	x	x	x
Sovereign Ave PK6A	383423	6419804	Murky Green	x	0	x	x	x	x	x	x	x
Sovereign Ave PK6B	383420	6419659	-	-	-	x	-	✓	-	-	-	-
Sovereign Ave PK6C	383420	6419761	-	-	-	x	-	✓	-	-	-	-
Sovereign Ave PK6D	383197	6419443	-	-	-	x	-	✓	-	-	-	-
Sunlight Park	383150	6418394	-	✓	1	x	x	x	x	x	✓	x
Baltimore	382125	6417584	Blue/Green	x	1	x	x	x	x	✓	✓	x
Eighty Rd	386654	6421572	-	x	0	✓	✓	x	✓	x	✓	✓
Rivergum Boulevard	389249	6421728	-	✓	1	x	x	x	x	x	x	x
Tuart Grove	384188	6413740	Aqua	✓	1	x	x	x	x	x	x	x
Hidden Swamp	381977	6414121	-	✓	0	✓	✓	x	✓	x	✓	✓
Proper John	379844	6427345	Green	x	0	x	x	x**	x	x	x	x
Dress Circle Basin	383513	6421973	-	x	*	x	✓	x	✓	✓	✓	✓
Lark Hill	384058	6416672	-	✓	1	x	x	x	x	x	x	x

*small fountain, not aerator.

**nearby drain was dry.

3.2 Water Sample Analysis

In situ readings were taken at multiple locations for some wetlands to assess variability. The time of day was recorded for the dissolved oxygen (DO) measurements as temperature can have an effect on DO levels and DO concentrations may change considerably over a daily (or diurnal) period due to aquatic plants producing oxygen during the day, however when they respire (breakdown carbohydrates, fats and proteins and expel CO²) at night their effect on oxygen production is minimal (Australia and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand 2000).

3.2.1 Field Parameters

The field results are as follows:

Table 3. Summer Field results

Wetland name	Site No.	Location	GPS Location		Waypoint	Field Parameters				Time
						pH	DO (ppm)	Temp (°C)	Salinity & EC (ppm)	
Rotary Park	1	R1	378978	6428181	1	-		-	-	-
			378966	6428180	2	8.7	8.7	20.3	2220	9:02AM
			378886	6428127	3					-
			378886	6428127	4	8.8	8.6	20.6	2230	9:20AM
Proper John	2	A6	379841	6427345	5	-	-	-	-	-
			379844	6427345	6	8.9	8.4	21.2	4420	9:50AM
June Road	3	SB1	379576	6425465	7	8.9	9	21.8	644	10:15AM
Centenary Park	4	SB7	381681	6424404	8	-	-	-	-	-
			381716	6424395	9	9.1	8.8	21.5	562	10:30AM
City Park	5	R41	381785	6427415	10	8.8	11.8	22.1	597	11:15AM
			381887	6427370	11	8.7	10.2	22.1	594	11:20AM
Don Cuthbertson	6	C2	383922	6426405	12	8.5	8	22.8	434	11:40AM
			383947	6426359	13	8.5	8.8	22.1	425	11:55AM
Rivergum Boulevard	7	B9	389249	6421728	14	7	8.4	22.5	491	12:20PM
Eighty Rd	8	B1	386654	6421572	15	8.8	18.7	24	307	12:30PM
Dress Circle Basin	9	WO4B	383513	6421973	16	9.4	9.7	23.2	432	12:47PM
Bayeux	10	PK3	382153	6419752	17	9.3	13.9	24	295	1:30PM
Monmarte	11	PK2	382714	6419892	18	8.6	9.5	23.2	419	1:44PM
Sovereign Ave	12	PK6A	383420	6419659	19	8.2	8.7	24	536	2:15PM
		PK6B	383420	6419761	20	-	-	-	-	-
		PK6C	383197	6419443	21	-	-	-	-	-
		PK6D	383423	6419804	22	-	-	-	-	-
Sunlight Park	13	PK13	383150	6418394	23	8.5	8.7	24	251	2:20PM
Baltimore	14	PK16	382125	6417584	24	8.9	11	24.7	450	2:35PM
			382123	6417593	25	-	-	-	-	-
Lark Hill	15		384058	6416672	26	8.3	9.2	22.8	485	2:55PM
Tuart Grove	16	SH3	384188	6413740	27	8.6	8.6	25.5	550	3:30PM
Hidden Swamp	17	SH4	381977	6414121	28	8.8	11.5	21.8	625	2:15PM
			382070	6413925	29	8.8	11.6	21.1	655	2:20PM
			382143	6413866	30	8.82	9.8	20.5	679	2:35PM

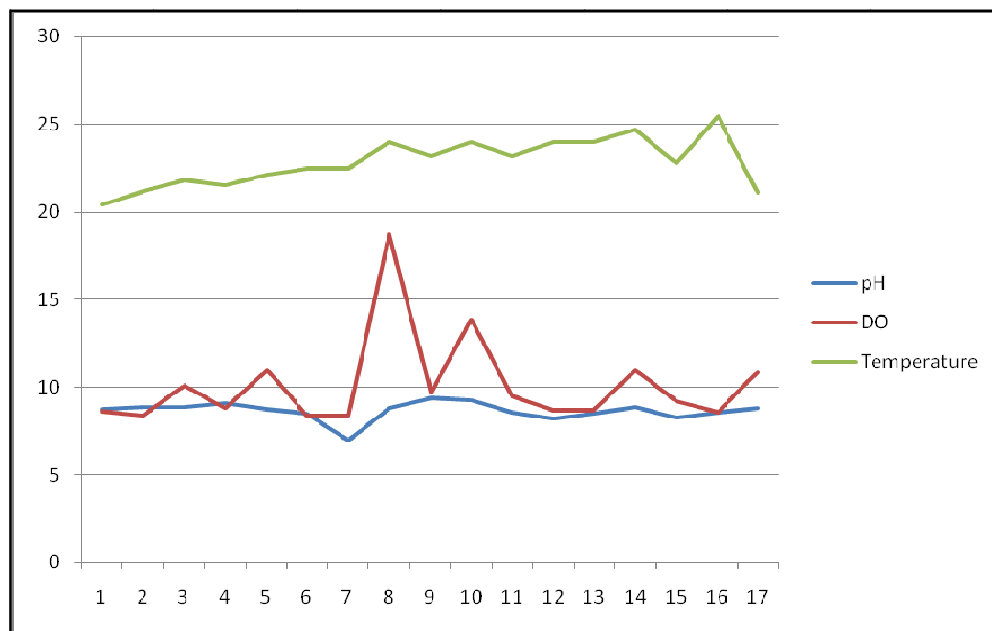


Figure 1: pH, DO and temperature readings from all sites.

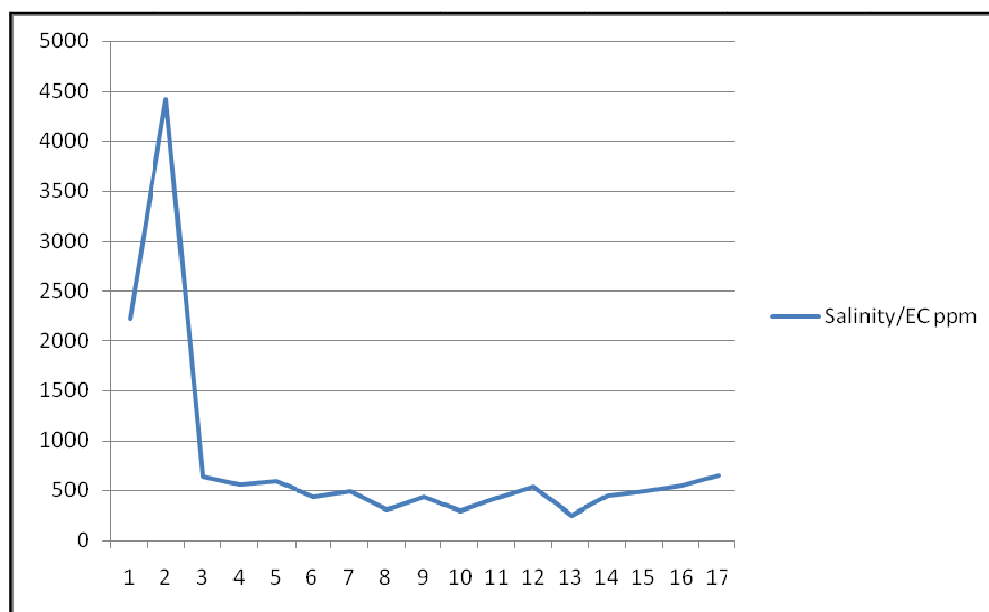


Figure 2: Salinity measures from all sites.

Mosquito and Midge Risk

The selected water bodies did not exhibit any midge or mosquito problems except for Hidden Swamp, Eighty Rd, Dress Circle Basin and Don Cuthbertson, which were assessed as minimal risk. As most sites were found to be clean, well-drained and either with aeration or flow of some kind, they were not considered risk areas.

Hidden Swamp however, was found to have pooling water around the upper-level of the lake. This combined with lack of movement or flow (stagnant) created a prime breeding location for both midges and mosquitoes. This was also true for Dress Circle and Eighty Road.

Don Cuthbertson was found to have a build-up of plant material along its edges and areas of stagnant water. Although this presents an issue for midge and mosquito populations the wetland was also home to many bird species (including Eurasian Coots (*Fulica atra*), Purple Swamphens (*Porphyrio porphyrio*) and Pacific Black Duck (*Anas superciliosa*)) and Koi. No Mosquito Fish (*Gambusia*) were seen during the site visit however the presence of this predator in particular in addition to the presence of birds and Koi should help alleviate the risk of these pests occurring.

3.2.2 Water Quality Analysis Results

The water samples collected at each wetland were analysed by SGS Environmental Services. The results of water analyses are shown in **Table 3**.

Table 4. Summer Water Quality Results.

	Conductivity @25oC	Total Dissolved Solids @ 180oC	Total Nitrogen	Kjeldahl Nitrogen (calculated)	NOx-N	Ammonia Nitrogen NH3-N	Total Phosphorus	Ortho Phosphorus, PO4-P	Chlorophyll a
	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Rotary Park	3,700	2,300	1.2	1.2	<0.005	<0.1	<0.01	<0.003	0.0096
City Park	1,000	640	0.92	0.85	0.073	<0.1	0.02	<0.003	0.019
June Road	1,100	720	1.8	1.8	<0.005	<0.1	0.04	<0.003	0.096
Centenary	970	490	0.95	0.95	<0.005	<0.1	0.03	<0.003	0.014
Don Cuthbertson	770	440	0.97	0.97	<0.005	<0.1	0.06	<0.003	0.019
Montmarte*	750	470	1.6	1.6	<0.005	<0.1	0.06	<0.003	0.048
Bayeux	520	320	3.1	3.1	<0.005	<0.1	0.10	<0.003	0.048
Sovereign Ave	920	560	1.1	1.1	<0.005	<0.1	0.07	<0.003	0.043
Sunlight Park	440	250	0.84	0.84	<0.005	<0.1	0.03	<0.003	0.0048
Baltimore	790	470	1.1	1.1	<0.005	<0.1	0.03	<0.003	0.014
Eighty Road	550	330	1.9	1.9	<0.005	<0.1	0.18	<0.003	0.014
Rivergum Boulevard	880	530	1.2	1.2	<0.005	<0.1	0.11	0.007	0.10
Tuart Grove	980	580	1.6	1.6	<0.005	<0.1	0.04	<0.003	0.024
Proper John	760	440	0.88	0.88	<0.005	<0.1	0.03	<0.003	0.014
Hidden Swamp	1300	660	0.91	0.87	0.037	<0.1	0.03	<0.003	0.0048
Dress Circle Basin	770	420	0.53	0.53	<0.005	<0.1	0.02	<0.003	0.0048
Lark Hill	860	470	0.92	0.79	0.13	0.4	0.02	<0.003	0.0048

*Wetland feeds into Lark Hill Lakes

All water quality results fall within the ANZECC guidelines for aquatic ecosystems (**See Appendix 2**). There were no unexpected or abnormal values to imply there were any water quality issues.

Rotary Park samples showed a high saline result. However, with the sites close proximity to the ocean this result is expected.

4.0 Discussion and Conclusions

Urban Wetlands Monitoring Program - City of Rockingham

4.1 Field Parameters

Field results showed that the wetlands were all within the ANZECC guidelines (**Table 3**) for environmental water quality of aquatic ecosystems except for the salinity at Rotary Park which was not thought to be unusual due to its close proximity to the ocean (**Appendix 3A, 3B & 3C**). Some of the pH measurements were also above the preferred range specified by the ANZECC guidelines (**Appendix 2**) however these differences were minimal.

Sites had acceptable DO levels as they are not intended to support aquatic life. DO measured in a water body reflects the equilibrium between oxygen consuming processes (respiration) and oxygen releasing processes (photosynthesis) and is highly dependant on temperature, salinity, biological activity and rate of transfer from the atmosphere. The oxygen presence would mainly have been produced through turbulent conditions (e.g. wind action or aeration devices). Eighty Road had the highest DO levels, and also had the highest TDS levels suggesting a better photosynthesis rate and physical transfer of oxygen from the atmosphere to the wetland.

4.2 Field Observations

No dead birds were seen during the field survey.

Some drains were completely dry but this was expected during summer sampling.

Bayeux, Sovereign Ave, Baltimore, Tuart Grove and Proper John showed signs of irregular discolouration. The laboratory results did not show an excessive chlorophyll *a* level which is a measurement of phytoplankton numbers and related to algal blooms which could explain this discolouration, therefore further investigation will be required.

Hidden Swamp and Dress Circle Basin showed evidence of macroalgae. However, from the low chlorophyll *a* results the presence of phytoplankton was not overabundant although some sites were unnaturally coloured (i.e. Sovereign Ave PK6A, Baltimore PK16, Bayeux PK3 and Tuart Grove SH3). This may have been due to larvicides or artificial colouring, further investigation into the treatment programs for these wetlands would be beneficial.

Various sites were seen to have non-native fish species such as *Gambusia* (Rotary Park and Eighty Rd) and Koi (Don Cuthbertson).

Some sites had rubbish scattered around the wetland or floating in the water. Dress Circle Basin, City Park, Hidden Swamp and Don Cuthbertson were noted for presence of rubbish.

Don Cuthbertson and parts of Hidden swamp did not appear to be aerated sufficiently as stagnant water and build-up of floating plant material was seen. There were no aerators at Eighty Rd or Dress Circle Basin. Flowing water generally has higher DO levels than stagnant water because of increased oxygen transfer. Maintaining DO concentrations within constructed lakes and urban wetlands prevents issues such as anoxic conditions (Strehlow et al. 2005), algal blooms (Hambright, Bar-Ilan & Eckert 1998), odour problems (Reeder & Berg 1977) and/or nuisance midge/mosquito (Mercer, Sheeley & Brown 2005) populations (as sighted in City of Rockingham 2008).

Odours were recorded at June Road, Baltimore and Dress Circle Basin. This may be a sign of insufficient circulation/aeration and excessive biological oxygen demand (BOD) and ammonia loadings (GHD 2008). Reducing the organic and nitrogen loadings can assist in preventing the occurrence of these odours. Aeration is widely practiced in water bodies to overcome problems associated with odours during periods of anoxia (Mackay, Miller et al. 2003). However, the *City of Rockingham Urban Wetlands and Drainage Swale Study Review, 2008* warned that initially, mechanical aeration can generate serious odour problems through stripping of volatile compounds such as hydrogen sulphide (EPA 2000).

4.3 Water Quality Parameters

Laboratory results confirmed the in situ data for Rotary Park as it was the only site with Electrical Conductivity (EC) and Total Dissolved Solid (TDS) levels above the ANZECC guidelines for aquatic ecosystems (**Appendix 2**). This urban wetland was found to exceed the recommended range with a value almost twice the recommended upper limit. The *City of Rockingham Urban Wetlands and Drainage Swale Study Review, 2008* also suggested that due to its close proximity to Cockburn Sound there was likely some seawater intrusion at the site attributing to the high salinity value (GHD 2008).

Total Nitrogen and Total Phosphorus levels were all well below the guidelines which is also reflected in the low chlorophyll a levels. From these levels the wetlands can be classified as oligotrophic, which means there is a very low phytoplankton count which results in a more aesthetically pleasing wetland (ANZECC 2000). The presence of macroalgae at Hidden Swamp and Dress Circle Basin needs further investigation since nutrient levels are low, the reasons behind its presence is unknown.

4.4 Conclusions

The following was observed during summer sampling:

- generally clean, well drained and aerated wetlands and surrounding areas
- no dead birds
- slightly higher than normal pH levels at some sites, although not significant
- surface aerators at Don Cuthbertson and Hidden swamp were not adequate to aerate and move water within the wetland
- there were no aerators at Eighty Road and an insufficient aeration at Dress Circle Basin
- June Road, Baltimore and Dress Circle Basin had a distinct odour
- minimal or no risk of mosquito or midge problems associated with the wetlands
- drains were dry
- Dress Circle Basin, City Park, Hidden Swamp and Don Cuthbertson had rubbish in or near the water
- Mosquito fish (*Gambusia affinis affinis*) found in Rotary Park and Eighty Road
- the feral fish Koi (*Cyprinus carpio*) was found in Don Cuthbertson
- presence of abundant microalgae (phytoplankton) was not confirmed during the survey, but the presence of macroalgae colonies were observed at Hidden Swamp and Dress Circle Basin
- discolouration of some wetlands observed (Baltimore, Bayeux, Sovereign Ave PK6A and Tuart Grove) could be due to chemical treatment of the water
- Rotary Park was saline and had a higher than normal TDS
- normal values in field parameters for all sites except Rotary Park
- normal values in water quality parameters for all sites except Rotary Park

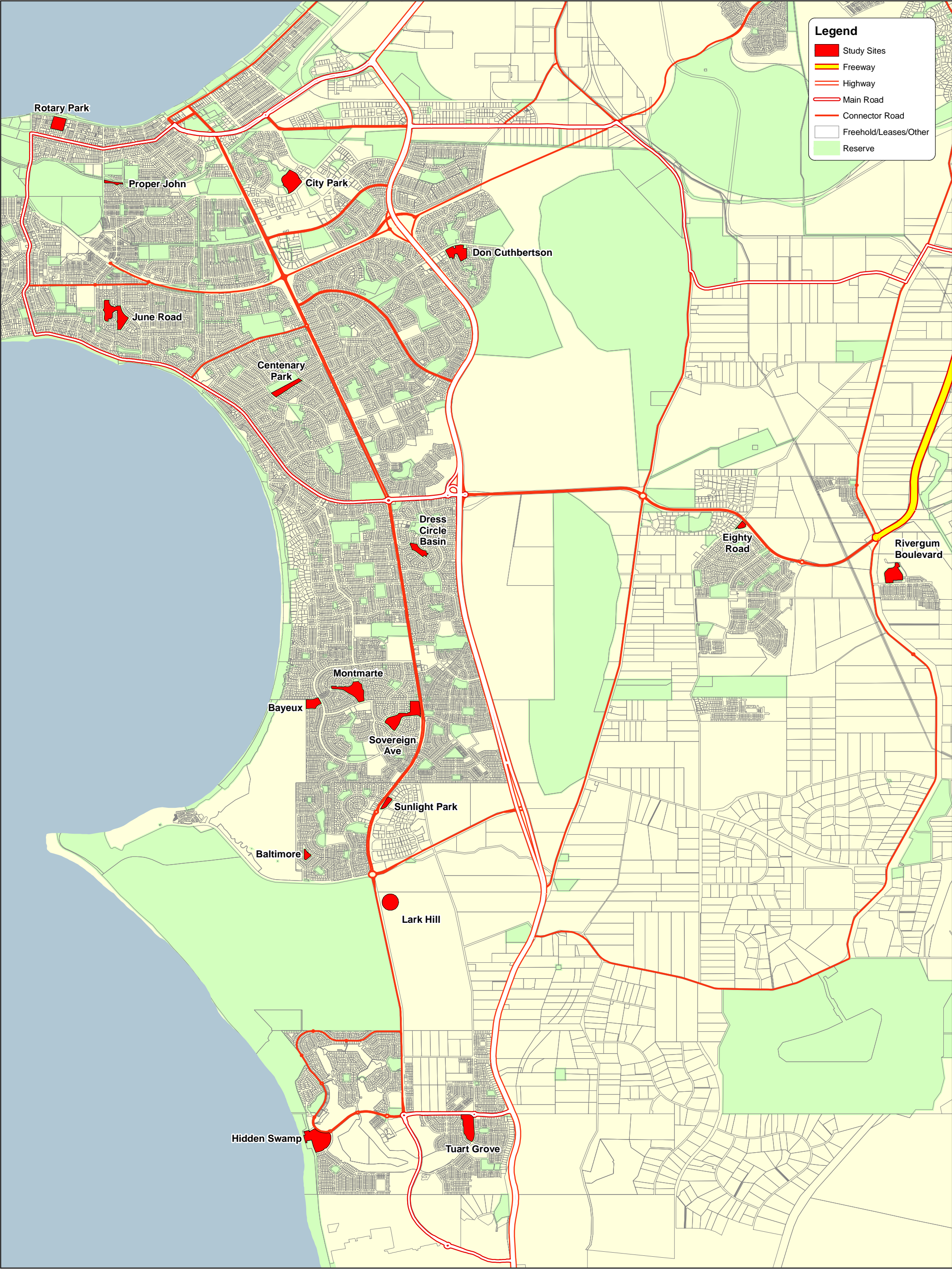
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Appendix One: Site Maps

Urban Wetlands Monitoring Program – City of Rockingham



Appendix Two: ANZECC Guidelines

Urban Wetlands Monitoring Program – City of Rockingham

Default trigger values for physical and chemical stressors for south-west Australia for slightly disturbed ecosystems. Trigger values are used to assess risk of adverse effects due to nutrients, biodegradable organic matter and pH in various ecosystem types. Data derived from trigger values supplied by Western Australia. Chl *a* = chlorophyll *a*, TP = total phosphorus, FRP = filterable reactive phosphate, TN = total nitrogen, NO_x = oxides of nitrogen, NH₄ + = ammonium, DO = dissolved oxygen.

Ecosystem type	Chl <i>a</i> (µg L ⁻¹)	TP (µg P L ⁻¹)	FRP (µg P L ⁻¹)	TN (µg N L ⁻¹)	NO _x (µg N L ⁻¹)	NH ₄ + (µg N L ⁻¹)	DO (% saturation) ⁱ		pH	
							Lower limit	Upper limit	Lower limit	Upper limit
Upland river ^f	na	20	10	450	200	60	90	na	6.5	8.0
Lowland river ^f	3–5	65	40	1200	150	80	80	120	6.5	8.0
Freshwater lakes & reservoirs	3–5	10	5	350	10	10	90	no data	6.5	8.0
Wetlands ^d	30	60	30	1500	100	40	90	120	7.0e	8.5e
Estuaries	3	30	5	750	45	40	90	110	7.5	8.5
Marine ^{g,h} Inshore ^c	0.7	20b	5b	230	5	5	90	na	8.0	8.4
Offshore	0.3b	20b	5	230	5	5	90	na	8.2	8.2

na = not applicable

a = monitoring of periphyton and not phytoplankton biomass is recommended in upland rivers — values for periphyton biomass (mg Chl *a* m⁻²) to be developed;

b = summer (low rainfall) values, values higher in winter for Chl *a* (1.0 µg L⁻¹), TP (40 µg P L⁻¹), FRP (10 µg P L⁻¹);

c = inshore waters defined as coastal lagoons (excluding estuaries) and embayments and waters less than 20 metres depth;

d = elevated nutrient concentrations in highly coloured wetlands (gilven >52 g440m⁻¹) do not appear to stimulate algal growth;

e = in highly coloured wetlands (gilven >52 g440m⁻¹) pH typically ranges 4.5–6.5;

f = all values derived during base river flow conditions not storm events;

g = nutrient concentrations alone are poor indicators of marine trophic status;

h = these trigger values are generic and therefore do not necessarily apply in all circumstances e.g. for some unprotected coastlines, such as Albany and Geographe Bay, it may be more appropriate to use offshore values for inshore waters;

i = dissolved oxygen values were derived from daytime measurements. Dissolved oxygen concentrations may vary diurnally and with depth. Monitoring programs should assess this potential variability (see Section 3.3.3.2).

Appendix Three: Raw Data

Urban Wetlands Monitoring Program – City of Rockingham

Table 3A. Raw data for field results

Wetland name	Site Number	Waypoint	Photo number	pH	DO	Temp	Salinity & EC (ppm)
Rotary Park	1	1	1,2,3,4	-	8.7	-	-
	1	2	-	8.7	-	20.3	2220
	1	3	5	8.8	8.6	20.6	2230
Proper John	2	4	6,7,8	-	-	-	-
	2	5	9	8.9	8.4	21.2	4420
June Road	3	6	10,11	8.9	11.2	21.8	640
	3	7	-	8.9	9	21.8	644
Centenary Park	4	8	12, 13	-	-	-	-
	4	9	14, 15, 16	9.1	8.8	21.5	562
City Park	5	10	17,18	8.8	11.8	22.1	597
	5	11	19	8.7	10.2	22.1	594
Don Cuthbertson	6	12	20	8.5	8	22.8	434
	6	13	21, 22,23	8.5	8.8	22.1	425
Rivergum Boulevard	7	14	-	7	8.4	22.5	491
Eighty Rd	8	15	26,27	8.8	18.7	24	307
Dress Circle Basin	9	16	28,29	9.4	9.7	23.2	432
Bayeux	10	17	30	9.3	13.9	24	295
Monmarte	11	18	31, 32	8.6	9.5	23.2	419
Sovereign Ave	12	19	33	8.2	8.7	24	536
	12	20	34	-	-	-	-
	12	21	35	-	-	-	-
	12	22	36	-	-	-	-
Sunlight Park	13	23	37	8.5	8.7	24	251
Baltimore	14	24	38, 39	8.9	11ppm	24.7	450
Lark Hill	15	25	40	8.3	9.2ppm	22.8	485
	15	-	41	-	-	-	-
Tuart Grove	16	26	42	8.6	8.6ppm	25.5	550
Hidden Swamp	17	27	45	8.8	11.5ppm	21.8	625
	17	28	46	8.8	11.6ppm	21.1	655
	17	29	47,48,49	8.82	9.8	20.5	679

Table 3B. Average values for field results.

Site	Averages				Time
	pH	DO	Temperature	Salinity/EC ppm	
Rotary Park	8.75	8.65	20.4	2225	9:02
Proper John	8.9	8.4	21.2	4420	9:50
June Road	8.9	10.1	21.8	642	10
Centenary Park	9.1	8.8	21.5	562	10:15
City Park	8.75	11	22.1	595.5	11:20
Don Cuthbertson	8.5	8.4	22.45	429.5	11:40
Rivergum Boulevard	7	8.4	22.5	491	11:55
Eighty Rd	8.8	18.7	24	307	12:30
Dress Circle Basin	9.4	9.7	23.2	432	12:47
Bayeux	9.3	13.9	24	295	1:30
Monmarte	8.6	9.5	23.2	419	1:44
Sovereign Ave	8.2	8.7	24	536	2:15
Sunlight Park	8.5	8.7	24	251	2:20
Baltimore	8.9	11	24.7	450	2:35
Lark Hill	8.3	9.2	22.8	485	2:55
Tuart Grove	8.6	8.6	25.5	550	3:30
Hidden Swamp	8.8	10.9	21.13	653	2:20

Table 3C. Summary of findings from Urban Wetland and Drainage Swale Study, 2006.

Site Name	Location Code	Management Issues Identified
Rotary Park	R1	Drying out, algae and non-native fish
City Park	R4 1	algae and non-native fish
June Road	SB1	Bird deaths, standing water, algae and non-native fish
Centenary Park	SB7	algae and non-native fish
Don Cuthbertson	C2	algae
Montmarte	PK2	non-native fish
Bayeux	PK3	-
Sovereign Ave	PKA	-
Sovereign Ave	B	algae
Sovereign Ave	C	-
Sovereign Ave	D	-
Sunlight Park	PK 13	algae
Baltimore	PK 16	Odour, non-native fish and rubbish
Eighty Rd	B1	algae and non-native fish
Rivergum Boulevard	B9	algae and non-native fish
Tuart Grove	SH3	algae
Hidden Swamp	SH4	algae
Proper John	A6	Standing water, algae and odour
Dress Circle Basin	WO4B	-