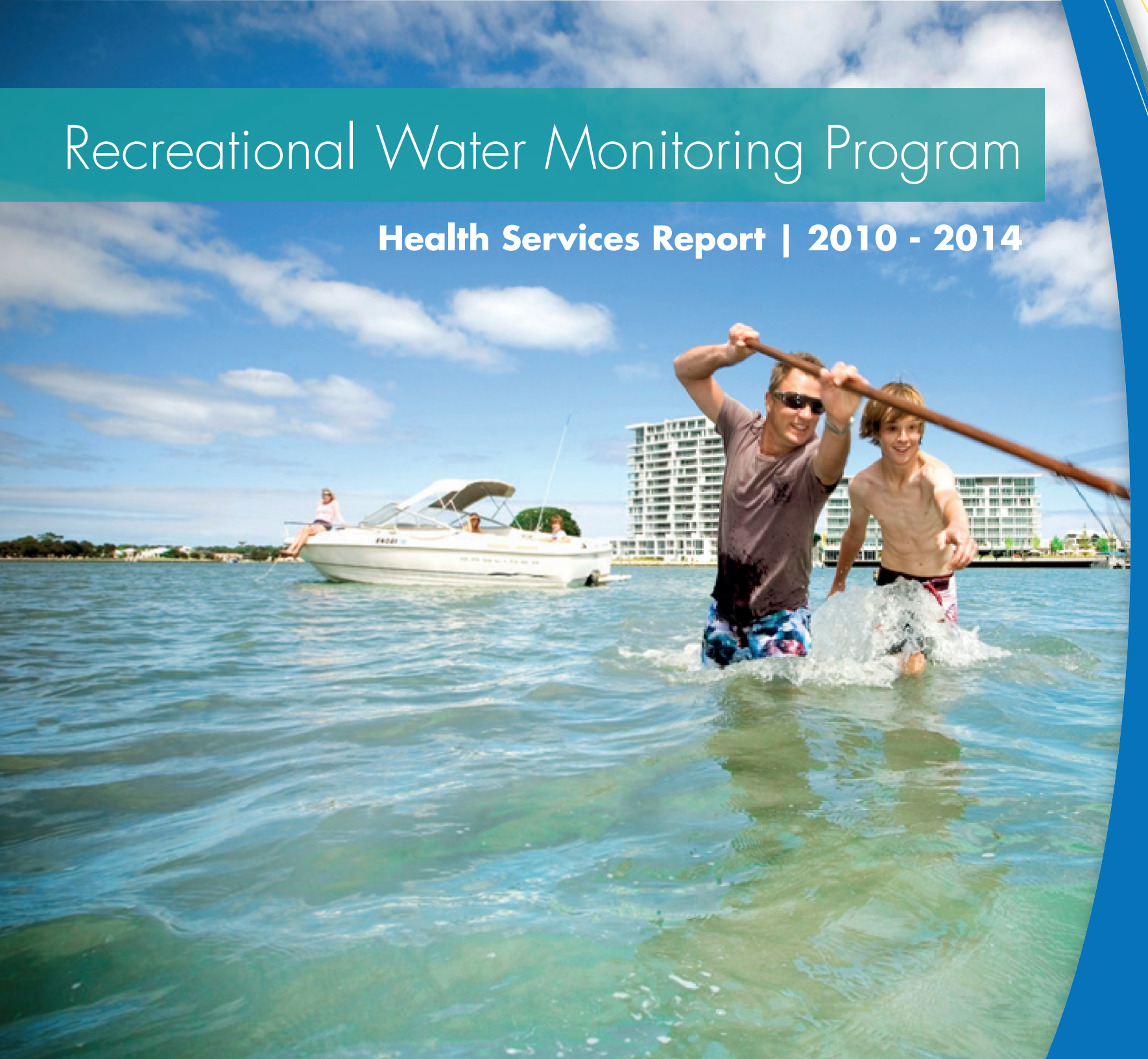
Recreational Water Monitoring Program

Health Services Report | 2010 - 2014



City of MANDURAH

Contents

1. Executive Summary

The City of Mandurah's Health Services monitors the quality of its recreational waters at designated sampling sites; along its 50 km coastline, canal waterways, Harvey Estuary and the Peel Inlet.

The aim of this monitoring program is to determine the suitability of the City's recreational waters for activities such as boating and swimming.

The population of Mandurah has been growing rapidly over the past 50 years (CoM, 2013). A forecast of 2% annual population growth means that its population, which is currently around 77,000, will be just over 93,000 by 2020 (Forecast id, 2012). In addition there are an increasing number of tourists visiting Mandurah every year, especially since the new train line commenced operating in 2007. This means there will be a significant increase in the number of people engaging in water-based recreational activities in Mandurah in years to come. It is therefore important that the City has a robust program for monitoring its recreational water quality to protect the public as well as to monitor anthropogenic impacts on its inland waterways and coastline.

There are currently 13 designated monitoring sites along the coastline of Mandurah from Madora Bay to Pyramids Beach along with 13 designated monitoring sites within the canals, Peel Inlet and the estuary.

A total of 1124 water samples were collected from the monitoring sites as part of this program from July 2010 to May 2014.

All of the designated sampling sites met the median microbiological guidelines provided by the 'Australian and New Zealand Environment and Conservation Council 1992' (ANZECC 2000). 99% of samples individually met the ANZECC 2000 microbiological guidelines.

The yearly average pH and Dissolved Oxygen measured in the inland waterways met the national recreational water quality guidelines between July 2010 and December 2013.

The nutrients (Total Nitrogen, Filterable Reactive Phosphorus and Total Phosphorus) in the inland waterways generally met the national guidelines for aquatic ecosystems during dry spells; however, samples taken during or post heavy rains generally exceeded the nutrient guidelines recommended for aquatic ecosystems in South West Australia.

Whilst all of the designated sites monitored as part of this water sampling program indicate high water quality for the purpose of recreation, it would be advisable for the public not to undertake any primary contact water based activities (such as swimming and surfing) for at least one day after heavy rain at ocean beaches and for three days at estuarine swimming areas.

With a continuous increase in the number of people living and visiting Mandurah, it is essential that the program is reviewed regularly to ensure that it meets the needs of its stakeholders.

This report provides:

- An introduction to the City of Mandurah's Recreational Water Monitoring Program.
- Methods used for monitoring recreational water quality by the City.
- A summary and discussion of the findings from the monitoring program from July 2010 to May 2014.
- Recommendations for the future of the program.

Set on the shores of beautiful Mandjar Bay, this one-time small fishing village has been transformed into a modern seaside hub.

The blue-green waters of the estuary are criss-crossed by pleasure boats and jet skis. Take a swim or paddle a kayak in the sheltered bay. Cruise the waters on a dolphin watching tour and spot water birds along the way. Try your hand at crabbing (in season) or catch yourself some king prawns for the barbecue.

Head for the coast and you'll find a string of sensational beaches offering more family fun, great surfing and windsurfing. Or follow the meandering waterways inland to discover the fresh flavours and fascinating heritage of the Peel wine region and country towns.

(Western Australia Tourism, 2013)

2. Introduction

2.1 Purpose of a recreational water monitoring program in Mandurah

An aerial map of Mandurah on Google, as shown, indicates how much water there is in and around Mandurah. On Mandurah's western side, there is a 50 km coastline and on its eastern side the Peel Inlet and Harvey Estuary.

Once a small fishing village that boomed during holiday periods, the City of Mandurah now has a thriving population of around 77,000. It is also a popular day-trip destination, and more so since the Mandurah train service began in late 2007, the City is also a gateway to the State's South West Region (CoM, 2013) and therefore attracts large numbers of tourists, both local and international. Mandurah is renowned for its magnificent waterways that are ideal for crabbing, boating, dolphin watching and kayaking. Its white sandy beaches offer great access for paddling, surfing, swimming and other water based activities.

The City of Mandurah's Health Services have designed and implemented a recreational water monitoring program for about 10 years. The main aim is to protect the health of its residents and visitors engaging in water-based recreational activities in Mandurah. The monitoring of water quality helps to identify if the rapid growth of the City is occurring with minimal impact on the estuarine and marine environment.

2.2 The recreational water monitoring program

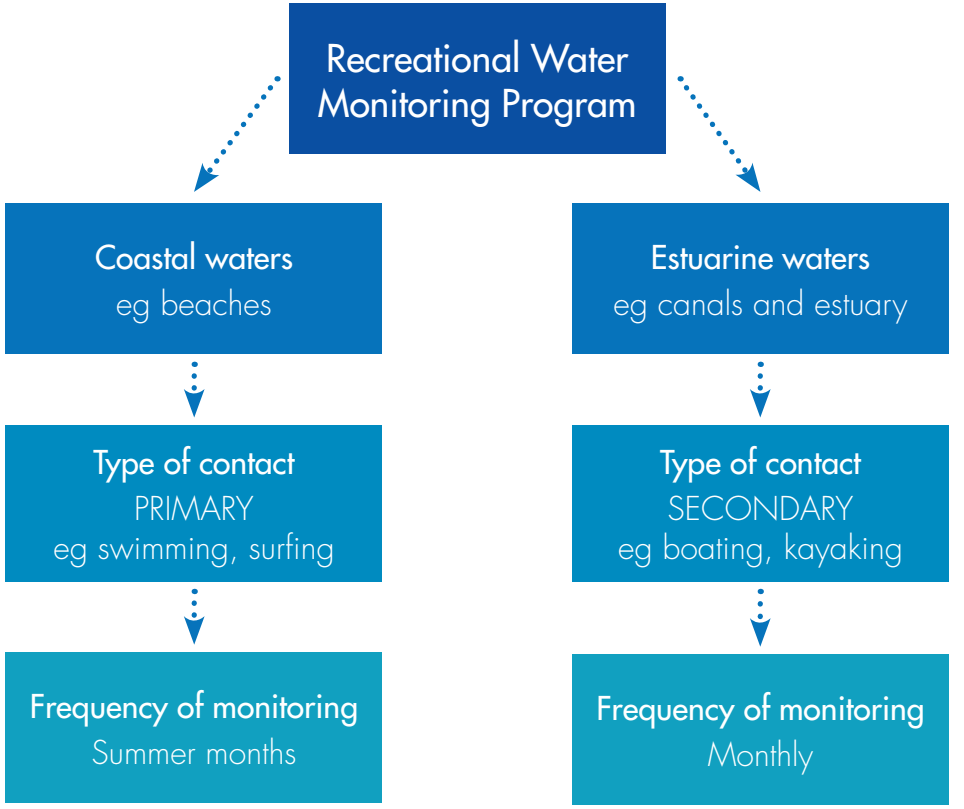
The recreational water monitoring program is divided into two parts:

1. Coastal waters, where the public comes into frequent direct contact with water, either as part of the activity; for example, swimming or surfing (primary contact); and
2. Estuarine waters, where the public generally have less-frequent body contact with the water; for example, boating or fishing (secondary contact).

The coastal water/primary contact sites are currently monitored only during the summer months (or the bathing season) when the likelihood of direct contact with water is at its peak.

The estuarine water/secondary contact sites are monitored on a monthly basis as boating and kayaking are common throughout the year.

The diagram below illustrates how the recreational water monitoring program is divided into two parts.



2.3 Indicators used to determine water quality

2.3.1 Microbiological characteristics

A vital part of the program is to monitor disease-causing micro-organisms (pathogens). Pathogens can cause a wide variety of infections, such as gastrointestinal, skin, ear, respiratory, eye, neurologic and wound infections.

Enterococci are indicator micro-organisms used to assess health risks associated with pathogens or disease-causing micro-organisms in recreational waters (ANZECC 2000). The presence of these organisms is usually associated with faecal contamination by sewage spills, bather shedding, failing septic system, domestic animals (e.g. dogs) and wildlife.

ANZECC 2000 provides guidelines for two categories of sporting activity:

1. sports in which the user comes into frequent direct contact with water, either as part of the activity or accidently; for example, swimming or surfing (primary contact);
2. sports that generally have less-frequent body contact with the water; for example, boating or fishing (secondary contact).

Table 2.1 shows the guidelines for recreational water quality and aesthetics for enterococci for the two categories of water-based sporting activity.

Table 2.1 Guidelines for recreational water quality and aesthetic guidelines for enterococci

Type of contact	Median (Enterococci organisms/100ml)	Maximum number in any one sample (Enterococci organisms/100ml)
Primary contact (swimming, surfing)	35	60 - 100
Secondary contact (kayaking, boating)	230	450 - 700

2.2.1 pH

Both alkaline and acidic waters may cause eye and skin irritation and may affect the taste of water. The National Health and Medical Research Council (NHMRC 2008) recommends that waters used for primary recreation should be in the pH range of 6.5 – 8.5. If the water has a very low buffering capacity, then the pH range may be extended to 5.0 – 9.0. ANZECC 2000 recommends a pH range of 5.0 – 9.0.

Table 2.2 shows the NHMRC and ANZECC guidelines for pH.

Table 2.2 pH Guidelines

Indicator	Guidelines	Range
pH	NHMRC 2008	6.5 - 8.5 (Primary contact) 5.0 - 9.0 (if water has low buffering capacity)
	ANZECC 2000	5.0 - 9.0

2.2.2 Dissolved Oxygen

Dissolved oxygen analysis measures the amount of gaseous oxygen dissolved in water. Monitoring oxygen levels helps to assess whether estuarine and coastal waters are receiving excess nutrients which may affect cyanobacterial growth. Cyanobacteria are of public health concerns because some types produce toxins that can have harmful effects to humans. Low levels of oxygen concentrations allow the growth of nuisance organisms, causing taste and odour problems, including the formation of hydrogen sulphide. Oxygen concentrations greater than 80% saturation should prevent such problems (NHMRC 2008). The recommended guidelines are summarised below:

Table 2.3

Indicator	NHMRC Guidelines
Dissolved oxygen	80%

2.2.3 Nutrients

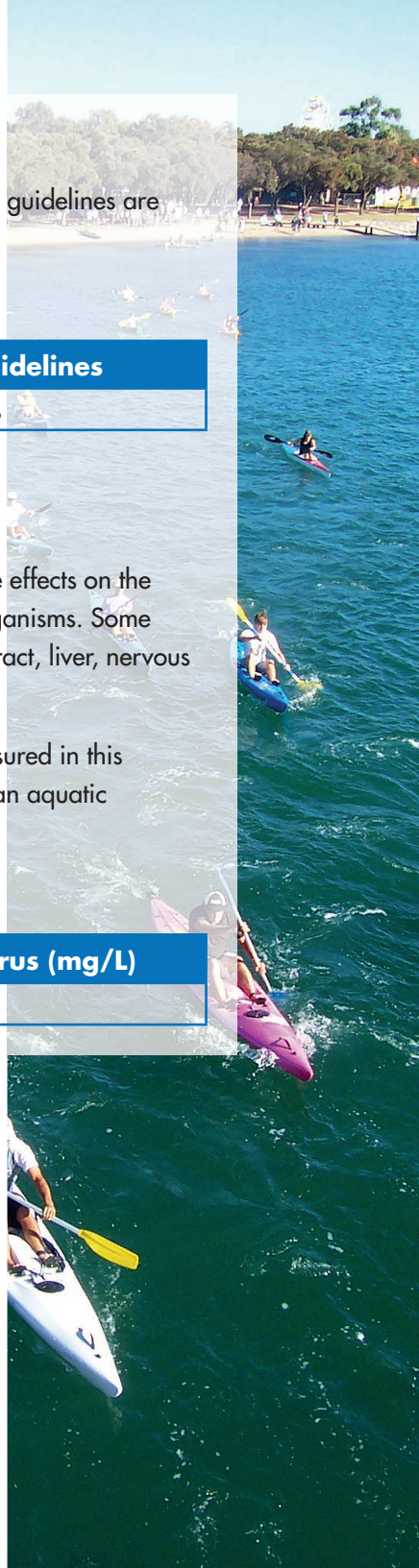
Nitrogen and phosphorus (also referred to as nutrients) are natural elements in the environment that are essential for plant and animal growth, maintenance and reproduction. The contamination of water by too much nitrogen and phosphorus can have an adverse effect on our recreational waters such as toxic algal blooms. Excess nutrients enter waterways by runoff from agricultural areas (e.g. fertilizers), urban storm water drains, eroded soils and aquaculture.

Algal blooms occur when algae increase to such large number that they colour the water and form visible thick scum. Algal blooms have negative effects on the aesthetic of a water body, dissolved oxygen and other aquatic organisms. Some algae produce toxins that can affect mammalian gastrointestinal tract, liver, nervous system and skin.

Table 2.4 shows the trigger values for the nutrient indicators, measured in this program. These values are recommended for South West Australian aquatic ecosystems (ANZECC 2000)

Table 2.4

	Total Nitrogen (mg/L)	Reactive Phosphorous (mg/L)	Total Phosphorus (mg/L)
Estuaries	0.75	0.005	0.03



3. Methodology

3.1 Sampling Sites

3.1.1 Coastal Waters

During the period of July 2010 to April 2014, there were 16 monitoring sites along the coastline of Mandurah, from Madora Bay to Tims Thicket; as indicated by arrows on the map in Figure 3.1.

These sites were divided into two categories based on their frequency of use by the public for water-based recreational activities during the bathing season:

- Ocean Sites with high user frequency level
- Ocean Sites with low user frequency level

Table 3.1 below lists ocean sites monitored in this program and their categories.

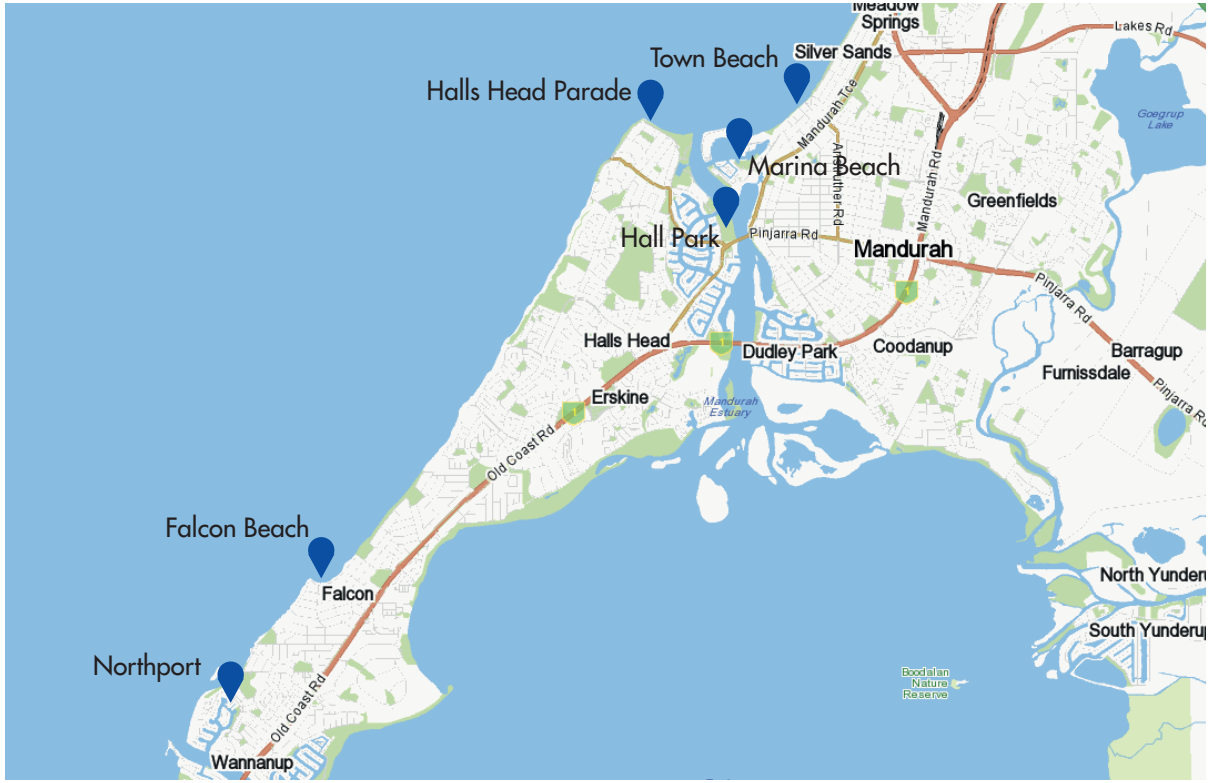
Figure 3.1 Mandurah Map showing location of Madora Bay and Tims Thicket

Table 3.1

Beach/Ocean sampling sites	
Town Beach	Ocean sites with high user frequency
Marina Beach	
Hall Park (swimming enclosure)	
Halls Head Parade	
Falcon Beach	
North Port	

Beach/Ocean sampling sites		
Tims Thicket	Blue Bay	Ocean sites with low user frequency
Melros Boat Ramp	Orion Road	
Pyramids Beach	Eros Place, San Remo	
Westview Parade	Madora Beach	
Gretel Road		
Janis Street		

Figure 3.2 Ocean sites with higher user frequency



Figures 3.3 and 3.4 show the locations of the ocean sites monitored in the northern and southern part of Mandurah. There are significantly less people visiting these sites during the bathing season compared to the sites in Figure 3.2.

Figure 3.3 Ocean sites with lower user frequency (North of Mandurah)

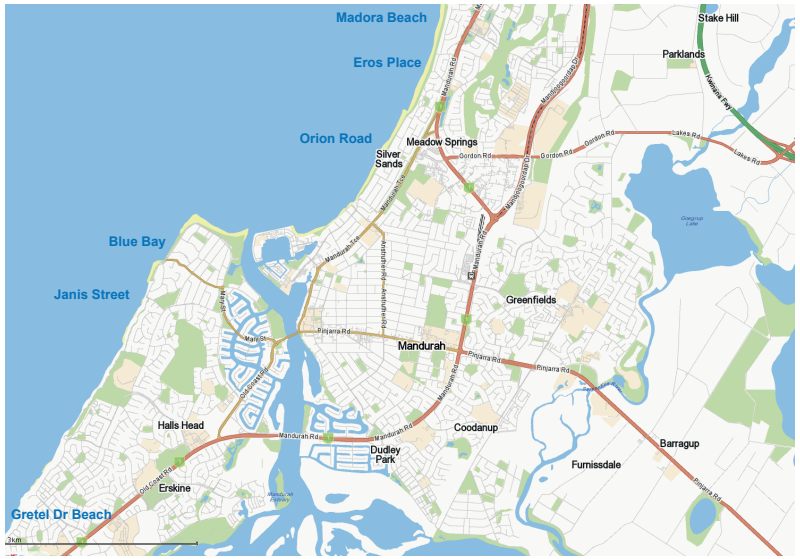


Figure 3.4 Ocean sites with lower user frequency (South of Mandurah)

Following a review of the sites in November 2013, it was decided that some of the sites would be removed from the list of designated sites. These sites were either used so infrequently or very unlikely to be affected by faecal contamination or dangerous to access for sampling.

Similarly, an additional site was added to the list of designated site due to the increase in frequency of its use for recreational purposes. This site was the Eastern Foreshore, due to the increasing number of events at this location, especially during the summer months. There are a number of stormwater drains close to this newly added designated site.

Since November 2013, there have been 13 beach/ocean sites sampled during the summer months.

Table 3.1 (a) shows the number of sites added and removed.

Table 3.1 (a) Beach/Ocean sampling sites

Beach/Ocean sampling sites	
Town Beach	Ocean sites with high user frequency
Marina Beach	
Hall Park	
Halls Head Parade	
Falcon Beach	
North Port	
Eastern Foreshore (new site)	

Beach/Ocean sampling sites		
~~Tims Thicket~~ (no longer monitored)	Blue Bay	Ocean sites with low user frequency
~~Melros Boat Ramp~~ (no longer monitored)	Orion Road	
Pyramids Beach	Eros Place, San Remo	
Westview Parade	Madora Beach	
~~Gretel Road~~ (no longer monitored)		
~~Janis Street~~ (no longer monitored)		

3.1.2 Estuarine Waters

There are 13 monitoring sites in the inland waterways in Mandurah.

Table 3.2 Estuary sampling sites

Estuary sampling sites	
Eastport (boat ramp)	Mandurah (South)
Eastport	
Southport	
Northport	

Estuary sampling sites		
Mandurah Quay	Monterey Bay	Mandurah (North)
Mariners Cove A	Mary Street Lagoon	
Mariners Cove B	Henry Sutton Grove	
Lesley Street (boat ramp)	Mandurah Ocean Marina	
Aztec Island		

The maps below (Figures 3.5 and 3.6) show the locations of the estuary sites in the northern and southern part of Mandurah.

Figure 3.5 Estuary sites (North of Mandurah)

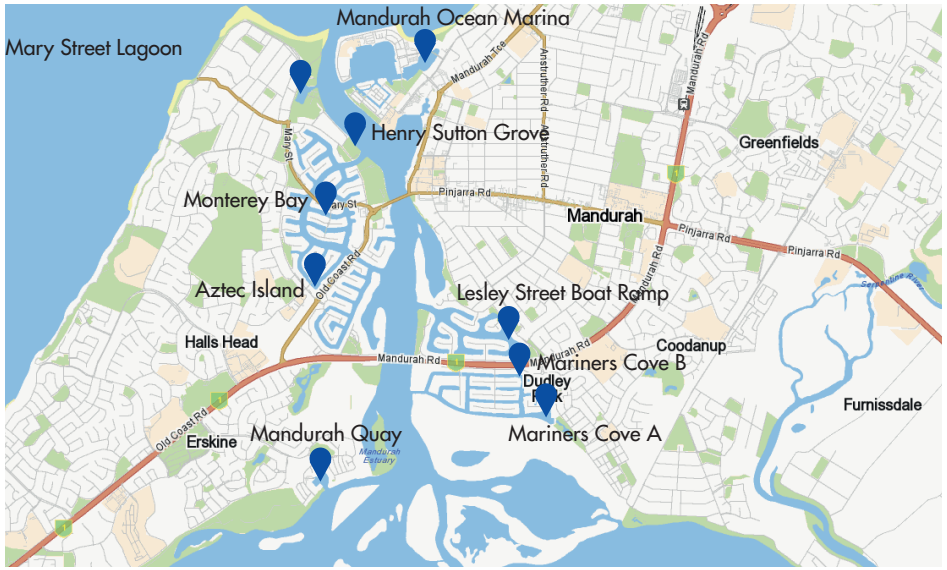
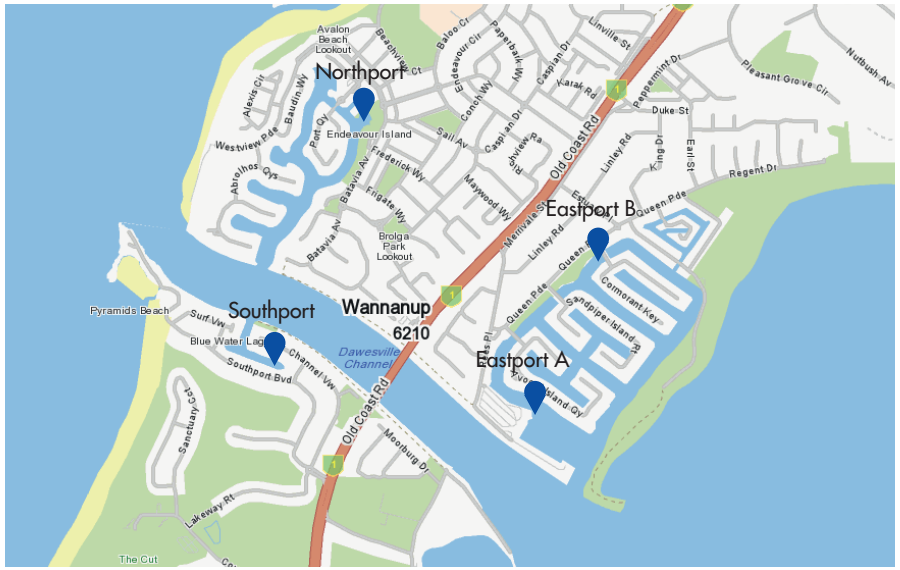


Figure 3.6 Estuary sites (South of Mandurah)



3.2 Sampling Frequency and Indicators Measured

Table 3.3 Sampling frequency and indicators measured at designated monitoring sites in Mandurah

Sampling Sites	Estuary Sites	Ocean Sites (High user level)	Ocean Sites (Low user level)
Time of the year	Throughout	Summer	Summer
Frequency	Monthly	Weekly	Monthly
Indicators	Enterococci, pH, dissolved oxygen and nutrient levels	Enterococci	Enterococci

3.3 Assessing water quality indicators

3.3.1 Enterococci/ Microbiological Characteristics

To assess microbiological indicators, water samples are collected in 250 ml bottles provided by Pathwest Laboratory at the designated sampling sites. They are stored and transported, in cool boxes with ice bricks to Pathwest Water Examination Laboratory. The samples are then analysed by water scientists at Pathwest. The results are sent to the City's Health Services by email. These results are then recorded on a database.

If the enterococci level at any particular site is unusually elevated, the City then follows the NHMRC 2008 guidelines for site specific trigger levels. These guidelines are reproduced below.

ACTION 1

When a value of 200 enterococci/100mL is exceeded after one sampling occasion, the City:

- Reviews field observation notes recorded on the day of sampling to determine a cause for the elevated enterococci count;
- Re-samples the recreational water body on a daily basis where no obvious source of faecal pollution is identified and;
- Undertakes a sanitary inspection to establish a possible source of faecal pollution.

ACTION 2

When a value of 400 enterococci/100mL is exceeded after two consecutive (within 24 hours) sampling events the City:

- Reviews field observation notes recorded on the day of sampling to determine a cause for the elevated enterococci count;
- Re-samples the recreational water body on a daily basis where no obvious source of faecal pollution is identified;
- Undertakes a sanitary inspection to establish a possible source of faecal pollution;
- Erects health warning/advisory signage and;
- Informs the public through the media that a public health problem may exist.

NOTE: Trigger levels should not be used as a measure of suitability for recreation when a known exceptional event such as a sewage overflow (discussed in section 5) has occurred. Such exceptional events may increase waterborne pathogens present in the water and increase the public health risk. Pathogen concentrations may not be directly correlated with bacterial indicator numbers (NHMRC 2008).

3.3.2 pH and Dissolved Oxygen

The City's Health Services hires a handheld unit which is designed to carry out basic water quality parameter spot measurements (Temperature, Dissolved Oxygen, Conductivity, pH, ORP (Redox), Depth, and Turbidity). The unit measures water quality through sensor technology. A probe connected to the meter is lowered into the water column and the readings in the handheld display (see Figure 3.7) are then recorded on a sampling form.

Figure 3.7 Mandurah Ocean Marina Site: handheld water quality metre, sampling bottle and clipboard

3.3.3 Nutrients

Water samples are collected in 250 ml bottles provided by the Analytical Reference Laboratory (ARL) at the designated sampling sites. They are stored and transported, in cool boxes with ice bricks, to the laboratory. The samples are then analysed by water scientists and submitted to the City's Health Services by email. These results are then recorded on a database.

4. Results and Discussion

4.1 Coastal Waters

The microbiological results of the coastal water samples collected between July 2010 and May 2014 have been analysed and are discussed in this section. A total of 661 samples were collected from the designated coastal and primary contact monitoring sites in Mandurah (Table 4.1).

Table 4.1 Total number of samples collected for enterococci analysis during the summer months or bathing seasons from July 2010 to May 2014

	Total number of samples July 2010 to May 2014
Coastal sites (high user level)	460
Coastal sites (low user level)	201
Total number of samples	661

Appendix 2 and 3 summarise the water quality results obtained during this period.

From July 2010 to May 2014, based on the median bacterial values, all coastal monitoring sites in Mandurah met the ANZECC 2000 water quality guidelines for primary contact.

Eleven of the 661 coastal water samples (i.e. 2% of the samples) exceeded the maximum recommended number of enterococci organisms as per the ANZECC 2000 guidelines. Therefore, 98% of the total number of coastal water samples collected during this time period met the recreational microbiological water quality guidelines.

These 11 instances are discussed as follows.

Melros Beach (Site category: User Level – Low)

Appendix 2 shows that 6% of the samples (or 1 in 18 samples) collected at Melros Beach exceeded the maximum recommended number of enterococci organisms.

This sample was taken on 19 April 2011 and the number of enterococci found in the sample was 300 organisms per 100 ml. Higher than normal densities of seaweed wrack were noted at the sampling site and this may have had a localised effect on the concentrations of enterococci in the water column that day.

Subsequent results have been within the guidelines.

Hall Park (Site category: User Level – High)

The table in Appendix 3 shows that 5% of the samples (or 4 in 75 samples) collected at Hall Park exceeded the maximum recommended number of enterococci organisms. These occurrences are listed in Table 4.2.

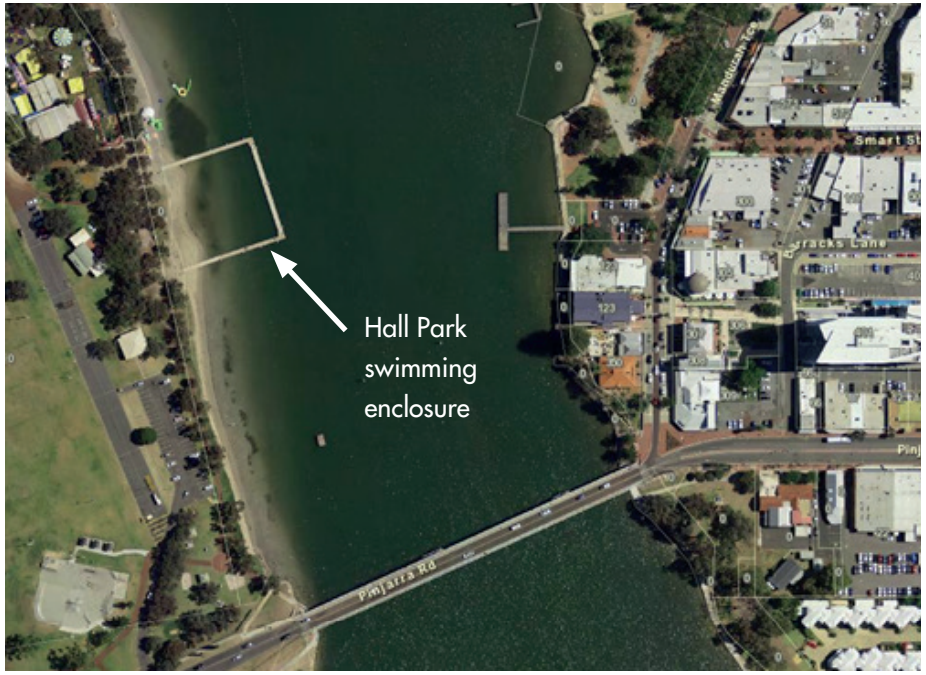
Table 4.2 Hall Park samples that exceeded recommended concentrations of Enterococci

Dates (guideline levels exceeded)	No. of Enterococci/100mL
3/11/2011	180
5/04/2012	300
11/12/2012	560
20/12/2012	300

This site is located within an enclosure and is a very popular site for school water-based activities such as kayaking, swimming etc. It is situated in the estuary between the Eastern and the Western Foreshore in the centre of Mandurah. The enclosure consists of floating walkway as shown in Figure 4.1.

There was no obvious source of faecal contamination identified as the potential. There was no further incident of high numbers of enterococci in samples collected between 20 December 2012 and the end of sampling season for beach/ocean sampling in 2014. However, the site will continue to be monitored at the next sampling season.

Figure 4.1 Hall Park swimming enclosure, Western Foreshore



Halls Head Parade

The table in Appendix 3 shows that 3% of the samples (or 2 in 75 samples) collected at Halls Head Parade Beach exceeded the maximum recommended number of enterococci. These are shown in Table 4.3. Halls Head Parade is a very popular site for school water-based activities such as swimming and kayaking. This site is located to the left of where the estuary meets the sea.

Table 4.3 Halls Head Parade samples that exceeded recommended concentrations of Enterococci

Dates (guideline levels exceeded)	No. of Enterococci/100mL
20/12/2012	300
10/04/2013	130

On 20 December 2012, the number of enterococci organisms per 100 mL was the same as a sample taken on the same day at the Hall Park site (300 enterococci organisms/ 100 mL). The Halls Head Parade site is located downstream from the Hall Park site so these two events may have been linked.

High reading was recorded on the 10 April 2013; kayakers and swimmers were in the water at the time of sampling. There were no prior rain events.

There was no obvious cause of faecal contamination to explain these high numbers.

There were no further incidents of high numbers of enterococci in samples collected between 10 April 2013 and the end of the beach/ocean sampling season in 2014.

Town Beach

The table in Appendix 3 shows that 3% of the samples (or 2 in 75 samples) taken at Town Beach exceeded the maximum recommended number of enterococci.

A sample collected on 20 October 2011 contained 330 enterococci units per 100ml. In this case the most probable cause was a broken stormwater drain next to the sampling site. A water sample collected from a point close to the broken drain contained 340 enterococci units per 100ml. Once the drain was fixed, subsequent results met the recommended guidelines until 5 December 2012 when another incident of high numbers of enterococci was recorded at this site. The same potential source of contamination was identified, which was a broken drain near the sampling site. Once the broken drain was fixed, further monitoring indicated no further high numbers in the samples collected.

Table 4.3(a) Town Beach samples that exceeded recommended concentrations of Enterococci

Dates (guideline levels exceeded)	No. of Enterococci/ 100mL
20/10/2011	330
5/12/2013	310

Eastern Foreshore

The table in Appendix 3 shows that 20% of samples collected at the Eastern Foreshore (i.e. 2 out of 10 samples) exceeded the recreational water guidelines for primary contact.

Table 4.3(b) Eastern Foreshore samples that exceeded recommended concentrations of Enterococci

Dates (guideline levels exceeded)	No. of Enterococci/ 100mL
26/2/2014	470
26/3/2014	180

There was no rainfall prior to or during the sample collected on 26 February 2014. According to the sampling notes, there were high numbers of birds in the immediate vicinity of the sampling site noted. A subsequent sample showed the numbers to be below 10 enterococci /100 ml. In regards to the sample collected on the 26 March 2014, there were no potential sources identified such as rain or birds. There were no further samples collected at this site after this incident. Further monitoring will be carried out at the next sampling season to identify any potential source of contamination that may need to be managed.

4.2 Estuarine Waters

4.2.1 Microbiological water quality

Appendix 1 shows the enterococci results for all the estuarine sites from July 2010 to May 2014. The median enterococci value for each site in this category met the recommended guidelines. Only one of the 463 estuarine water samples (i.e. 0.22% of the samples) failed to meet the recreational water guidelines recommended for secondary contact (such as boating and kayaking).

The one sample that exceeded the ANZECC 2000 recreational water guidelines for secondary contact was collected at Leslie Street Boat Ramp. The level recorded was 3300 enterococci/100 ml. The date of sampling was 7 August 2013. Bureau of Meteorology rainfall data indicate heavy rainfall the day prior to sampling. 12.6 mm rainfall was recorded on 6 August 2013 and on 7 August 2013, 5.4 mm rainfall was recorded. In this case, one very likely source of contamination would be from the stormwater drains and urban run-offs. Subsequent samples complied with the recreational water guidelines.

Other canal samples collected on the same day, at other sites, indicated a slight increase in numbers but did not exceed the recreational water guidelines for secondary contact.

4.2.2 pH

Appendix 4 shows yearly averages of the pH levels recorded at the estuarine monitoring sites in Mandurah from 2011 to 2013. The yearly average pH levels at all the sites were within the recommended range in both the ANZECC and NHMRC guidelines.

4.2.3 Dissolved Oxygen

The NHMRC 2008 guidelines recommend that recreational waters should have greater than 80% of dissolved oxygen (DO). Appendix 5 illustrates the average DO % from 2011 to 2013. The dotted line indicates the 80% Dissolved Oxygen, which is recommended for waters used for recreational purposes. According to the graph, the average DO % is either close to or above the recommended level in the guidelines.

4.2.4 Nutrients

This report analyses nutrient sampling results between July 2010 and July 2013.

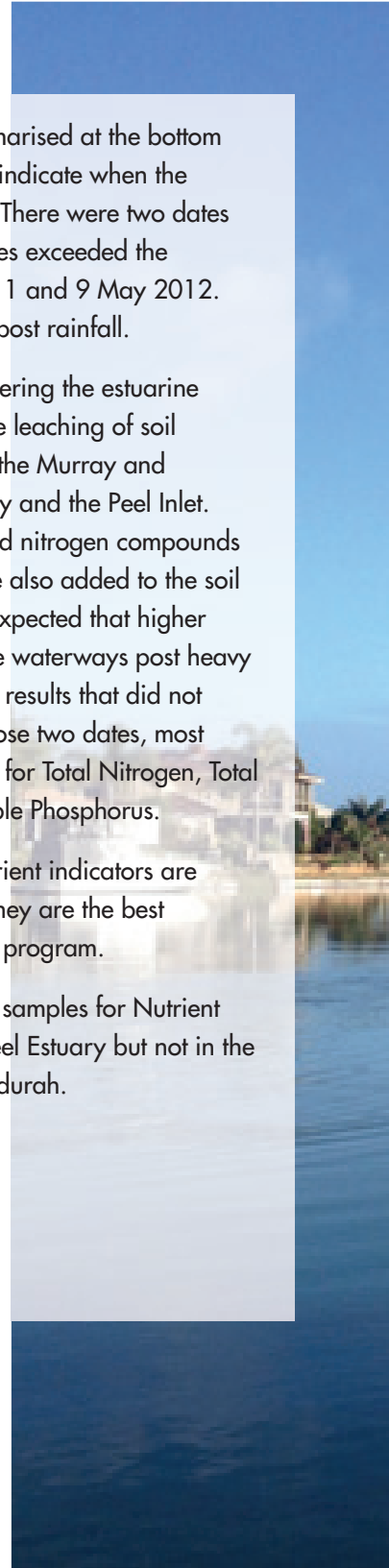
Tables in Appendix 6, 7 and 8 illustrate Total Nitrogen, Filterable Reactive Phosphorus and Total Phosphorus, respectively. ANZECC guidelines used to assess water quality based on nutrient levels are for the protection of fresh water and marine aquatic ecosystems in the South West of Australia rather than for the protection of human health. High levels of nutrients in the water may have a negative impact on human health by causing toxic algal blooms.

The relevant guidelines are summarised at the bottom of each table. The figures in red indicate when the guidelines have been exceeded. There were two dates when samples from almost all sites exceeded the guidelines, on 14 December 2011 and 9 May 2012. Both sets of samples were taken post rainfall.

The main sources of nutrients entering the estuarine waters in Mandurah are from the leaching of soil nutrients from areas adjacent to the Murray and Serpentine Rivers, Harvey Estuary and the Peel Inlet. Nutrients such as phosphorus and nitrogen compounds occur naturally in the soil but are also added to the soil for fertilisation. Thus, it is to be expected that higher levels of nutrients would enter the waterways post heavy rains. Although there were some results that did not meet the guidelines outside of those two dates, most other samples met the guidelines for Total Nitrogen, Total Phosphorus and Reactive Filterable Phosphorus.

It is recommended that these nutrient indicators are reviewed to determine whether they are the best indicators for the purpose of this program.

The Department of Water collect samples for Nutrient Analysis every fortnight in the Peel Estuary but not in the canal systems in the City of Mandurah.



5. Conclusion

From July 2011 to May 2014, a total of 1124 water samples were collected from the designated recreational water monitoring sites in Mandurah.

Based on the median values for enterococci numbers/100 ml, all sites met the microbiological guidelines provided by the Australian and New Zealand Environment and Conservation Council (ANZECC 2000).

There were 11 beach/ocean samples that exceeded the maximum recommended number of enterococci organisms in any one sample. A sample from Melros Beach exceeded the guidelines on only one occasion. A damaged stormwater drain at the Town Beach site was the most likely cause to the high numbers of enterococci within two separate samples (one collected in 2011 and the other in 2013). Hall Park and Halls Head Parade are beaches where there were recurring incidents of high levels of enterococci in the water in 2011, 2012 and 2013 but not during the last sampling season 2013/2014. Two samples collected at the new site at the Eastern Foreshore exceeded the maximum number of enterococci per samples. One sample could have been contaminated by high numbers of birds at the site during the sampling and there was no potential source identified for the other.

One canal/estuary sample from Leslie Street Boat Ramp exceeded the recreational water guidelines for secondary contact. The most likely source could have been heavy rainfall on the day prior to sampling.

The yearly average values for pH and Dissolved Oxygen, at the estuarine sites, were within the ranges provided both in the ANZECC 2000 and NHMRC 2008 guidelines.

During the sampling period 2010 to 2013, nutrient levels were high at most sites post rainfall; otherwise, they largely complied with the recommended guidelines for aquatic ecosystems. There were some samples where the trigger values in the guidelines were exceeded but they were one-off cases and the reason for these is unknown. It will be worthwhile reviewing the nutrient indicators used as part of this program and also the frequency of sampling.

Whilst all of the designated sites monitored as part of this water sampling program indicate high water quality for the purpose of recreation, it would be advisable for the public not to undertake any primary contact water based activities (such as swimming and surfing) for at least one day after heavy rain at ocean beaches and for three days at estuarine swimming areas.

6. Recommendations

Mandurah is surrounded by water with a 50 km coastline on the west side and the estuary on its east side. Local residents and visitors engage in water-based sporting activities all year round. These activities can involve frequent direct contact (primary contact) such as swimming or surfing or less frequent body contact such as boating and fishing (secondary contact). It is therefore essential that these waters are monitored to ensure that they meet recreational water quality guidelines.

The following recommendations have been made for the recreational water monitoring program in Mandurah:

- To continuously review sites that may need to be added or removed to the list of designated sites by September 2014.
- To review the aim and purpose of the canal and estuary sampling with the Marina Office by September 2014.
- To ensure that the City has all sampling equipment needed for water monitoring to prevent any disruptions to the program by September 2014.
- To publish the reports of the sampling program on the City's Website.
- To continuously work with other stakeholders such as the Marina Office, Works and Services, Peel Harvey Catchment Council and the Department of Water.

7. References

ANZECC/ARMCANZ (Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand). (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. National Water Quality Management Strategy. ANZECC/ARMCANZ, Canberra.

CoM Website (2013), viewed 30July 2013, http://www.mandurah.wa.gov.au/history.htm

Forecast.id (2013), viewed 30 July 2013, http://forecast2.id.com.au/default.aspx?id=260&pg=5000

NHMRC (National Health and Medical Research Council) (2008). Guidelines for Managing Risks in Recreational Water. NHMRC, Australian Government Publishing Service, Canberra.

Western Australia Tourism (2013), viewed 31 July 2013, http://www.westernaustralia.com/au/Pages/Destination.aspx?n=Mandurah&pid=9009632

WHO (World Health Organization) (2003). Guidelines for Safe Recreational Water Environments. Volume 1. Coastal and Fresh Waters. WHO, Geneva.

Appendix 1

July 2010 to May 2014

Estuarine sites	No. of samples	No. of samples that exceeded the maximum number of enterococci in any one sample (450-700 organisms/100mL)	% No. of samples exceeding max no. in any one sample	Median (230 enterococci organisms/100mL)
Aztec Island	36	0	0%	0
Eastport A	36	0	0%	0
Eastport B	36	0	0%	10
Henry Sutton Grove	36	0	0%	0
Leslie Street Boat Ramp	36	1	3%	0
Mandurah Ocean Marina	31	0	0%	0
Mariners Cove A	36	0	0%	10
Mariners Cove B	36	0	0%	0
Mary Street Lagoon	36	0	0%	0
Monterey Bay	36	0	0%	0
Mandurah Quay Marina	36	0	0%	0
Northport	36	0	0%	0
Southport	36	0	0%	0
Total no. of samples	**463**			

ANZECC 2000 guidelines for recreational water quality and aesthetics

Type of contact	Median (Enterococci units/100ml)	Maximum number in any one sample (Enterococci units/100ml)
Secondary Contact (Kayaking, boating)	230	450 - 700

Appendix 2

July 2010 to May 2014

Coastal sites (User level - low)	**No. of samples**	**No. of samples that exceeded the maximum number of enterococci in any one sample** (60-100 organisms/100mL)	**% No. of samples exceeding max no. in any one sample**	**Median** (35 enterococci organisms/100mL)
Blue Bay	22	0	0%	0
Eros Place	22	0	0%	0
Gretel Road	17	0	0%	0
Janis Street	17	0	0%	0
Madora Beach	22	0	0%	0
Melros Boat Ramp	18	1	6%	0
Orion Road	22	0	0%	0
Pyramids Beach	22	0	0%	0
Tims Thicket	17	0	0%	10
Westview Parade	22	0	0%	0
Total no. of samples	**201**			

ANZECC 2000 guidelines for recreational water quality and aesthetics

Type of contact	**Median** (Enterococci units/100ml)	**Maximum number in any one sample** (Enterococci units/100ml)
Primary Contact (swimming, surfing)	35	60 - 100

Appendix 3

July 2010 to May 2014

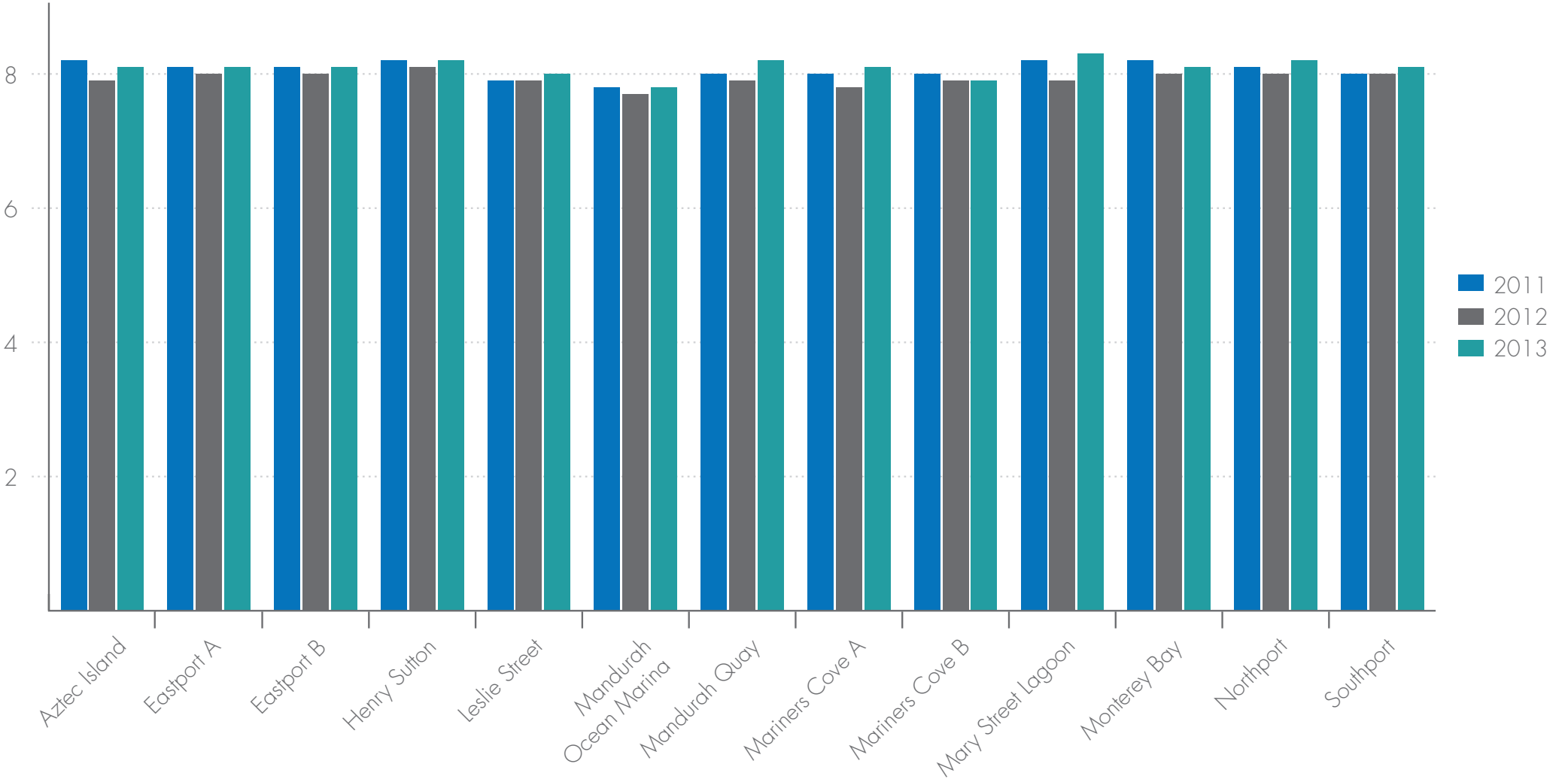
Coastal sites (User level - high)	**No. of samples**	**No. of samples that exceeded the maximum number of enterococci in any one sample** (60-100 organisms/100mL)	**% No. of samples exceeding max no. in any one sample**	**Median** (35 enterococci organisms/100mL)
Falcon Beach	75	0	0%	0
Hall Park	75	4	5%	0
Halls Head Parade	75	2	3%	0
Marina Beach	75	0	0%	0
Northport	75	0	0%	0
Town Beach	75	2	3%	0
Eastern Foreshore	10	2	20%	0
Total no. of samples	**460**			

ANZECC 2000 guidelines for recreational water quality and aesthetics

Type of contact	**Median** (Enterococci units/100ml)	**Maximum number in any one sample** (Enterococci units/100ml)
Primary Contact (swimming, surfing)	35	60 - 100

Appendix 4

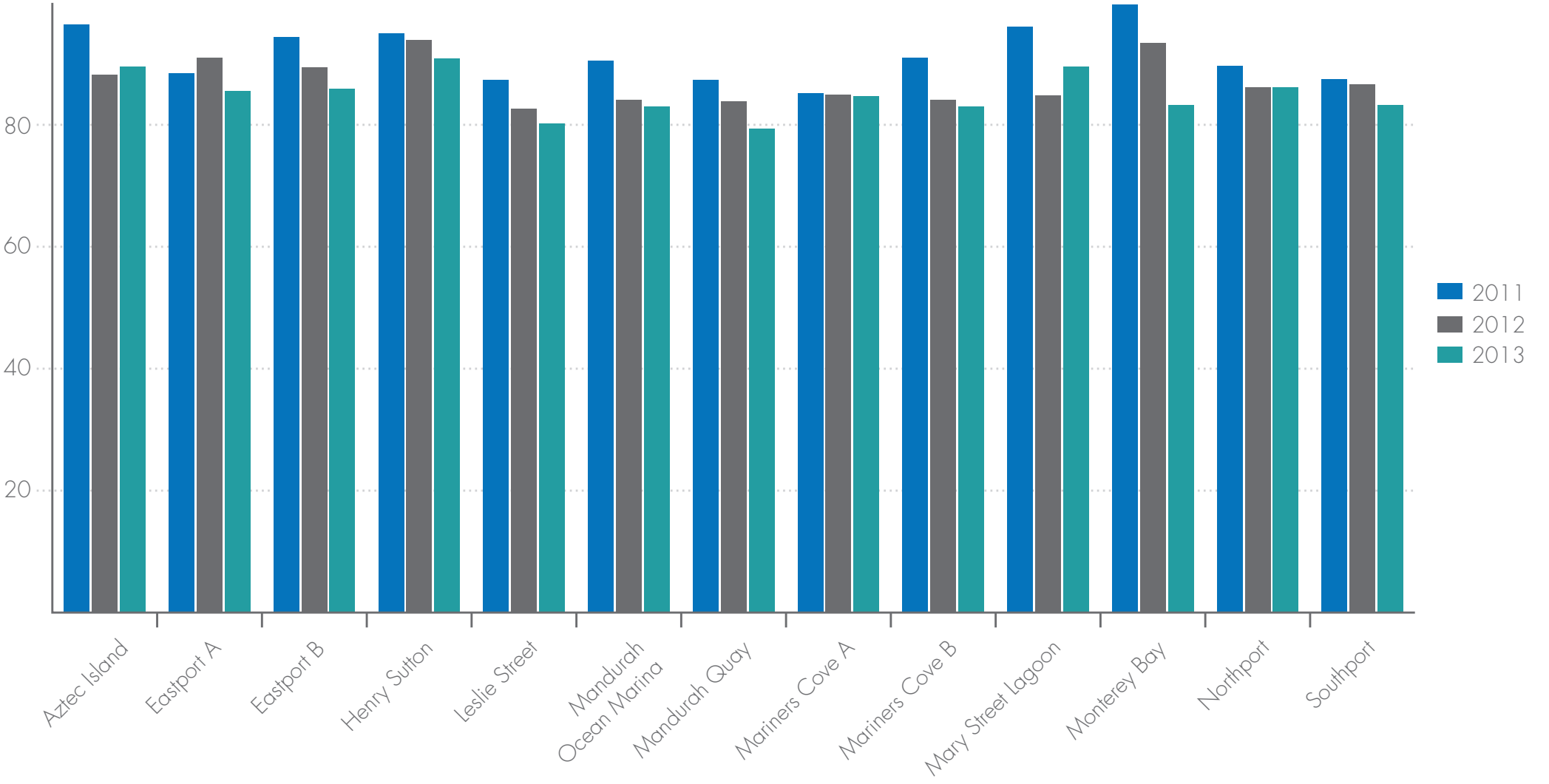
July 2010 to December 2013 - Average pH Values



Indicator	NHMRC 2008 Guidelines	ANZECC 2000 Guidelines
pH	6.5 - 8.5	5.0 - 9.0

Appendix 5

July 2010 to December 2013 - Average Dissolved Oxygen Values



Indicator	NHMRC 2008 Guidelines
Dissolved Oxygen	80%

Appendix 6

July 2010 to June 2013 - Total Nitrogen

Canals Total Nitrogen 2010 - 2013 (mg/L)

Trigger Level = 0.75 (mg/L)

Sample No. Date of Sampling	**1** 1/07/2010	**2** 11/10/2010	**3** 11/03/2011	**4*** 23/06/2011	**5** 14/12/2011	**6** 9/05/2012	**7** 20/06/2012	**8** 21/02/2012	**9** 31/05/2013
Aztec Island	<0.01	<0.01	<0.01	<0.01	0.5	1.6	<0.2	<0.2	<0.2
Eastport A	<0.01	<0.01	<0.01	<0.01	0.2	1.7	<0.2	<0.2	<0.2
Eastport B	<0.01	<0.01	<0.01	<0.01	0.9	1.9	<0.2	<0.2	<0.2
Henry Sutton	<0.01	<0.01	<0.01	<0.01	0.9	1.7	<0.2	<0.2	<0.2
Leslie Street	<0.01	<0.01	<0.01	<0.01	1	2.2	<0.2	<0.2	0.4
Mandurah Ocean Marina	<0.01	<0.01	<0.01	0.32*	0.6	2	<0.2	<0.2	0.8
Mandurah Quay	<0.01	<0.01	<0.01	0.06*	0.7	1.6	<0.2	<0.2	0.2
Mariners Cove A	<0.01	<0.01	<0.01	0.01	0.8	5.7	<0.2	<0.2	<0.2
Mariners Cove B	<0.01	<0.01	<0.01	<0.01	0.8	1.9	<0.2	<0.2	<0.2
Mary Street Lagoon	<0.01	<0.01	<0.01	0.01	0.9	1.8	<0.2	<0.2	<0.2
Monterey Bay	<0.01	<0.01	<0.01	<0.01	0.7	1.7	<0.2	<0.2	<0.2
Northport	<0.01	<0.01	<0.01	<0.01	0.6	2.2	<0.2	<0.2	0.4
Southport	<0.01	<0.01	<0.01	<0.01	0.5	1.5	<0.2	<0.2	<0.2

Values in red indicate ANZECC trigger values for Aquatic Ecosystems South West Australia was reached/exceeded

*Only Nitrate (NOx) levels obtained from ARL analysis for that date; Trigger values for NOx for SW Australia = 0.045 mg/L

ANZECC 2000 Guidelines	**Total Nitrogen (mg/L)**
Estuaries	0.75

Appendix 7

July 2010 to June 2013 - Filterable Reactive Phosphorus

Canals Filterable Reactive Phosphorus 2010 - 2013 (mg/L)

Trigger Level = 0.05 (mg/L)

Sample No. Date of Sampling	**1** 1/07/2010	**2** 11/10/2010	**3** 11/03/2011	**4*** 23/06/2011	**5** 14/12/2011	**6** 9/05/2012	**7** 20/06/2012	**8** 21/02/2012	**9** 31/05/2013
Aztec Island	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Eastport A	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Eastport B	<0.01	<0.01	<0.01	0.27	<0.01	<0.01	<0.01	<0.01	<0.01
Henry Sutton	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Leslie Street	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mandurah Ocean Marina	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Mandurah Quay	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mariners Cove A	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mariners Cove B	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mary Street Lagoon	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Monterey Bay	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Northport	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Southport	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Values in red indicate ANZECC trigger values for Aquatic Ecosystems South West Australia was reached/exceeded

ANZECC 2000 Guidelines	**Total Filterable Reactive Phosphorus (mg/L)**
Estuaries	0.005

Appendix 8

July 2010 to June 2013 - Total Phosphorus

Canals Total Phosphorus 2010 - 2013 (mg/L)

Trigger Level = 0.03 (mg/L)

Sample No. Date of Sampling	**1** 1/07/2010	**2** 11/10/2010	**3** 11/03/2011	**4*** 23/06/2011	**5** 14/12/2011	**6** 9/05/2012	**7** 20/06/2012	**8** 21/02/2012	**9** 31/05/2013
Aztec Island	0.02	0.08	<0.01	<0.01	<0.01	0.13	0.04	<0.01	<0.01
Eastport A	0.01	<0.01	<0.01	<0.01	<0.01	0.08	0.02	<0.01	<0.01
Eastport B	<0.01	0.03	<0.01	0.61	<0.01	0.05	0.03	<0.01	<0.01
Henry Sutton	0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.02	<0.01	<0.01
Leslie Street	0.02	0.02	<0.01	<0.01	0.02	0.05	0.09	0.02	<0.01
Mandurah Ocean Marina	0.01	<0.01	<0.01	<0.01	<0.01	0.06	0.04	<0.01	0.01
Mandurah Quay	0.01	<0.01	<0.01	<0.01	<0.01	0.07	0.04	<0.01	<0.01
Mariners Cove A	0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.04	<0.01	<0.01
Mariners Cove B	0.01	<0.01	<0.01	<0.01	<0.01	0.07	0.04	0.05	<0.01
Mary Street Lagoon	0.01	0.02	<0.01	<0.01	<0.01	0.08	0.02	<0.01	0.01
Monterey Bay	0.01	<0.01	<0.01	<0.01	<0.01	0.1	0.04	<0.01	<0.01
Northport	0.01	0.02	<0.01	<0.01	<0.01	0.02	0.03	<0.01	<0.01
Southport	0.02	0.02	0.02	<0.01	<0.01	0.05	0.06	0.01	<0.01

Values in red indicate ANZECC trigger values for Aquatic Ecosystems South West Australia was reached/exceeded

ANZECC 2000 Guidelines	**Total Phosphorus (mg/L)**
Estuaries	0.03

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