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Darwin Harbour Region
Report Cards 2010

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Website: www.nt.gov.au/nreta/water/aquatic/index.html

This report can be cited as: Drewry, J., Dostine, P.L., Fortune, J., Majid, M., Schult, J., Lamche, G. 2010. Darwin Harbour Region Report Cards 2010. Department of Natural Resources, Environment, The Arts and Sport. Report No 25/2010D. Palmerston, NT, Australia.

Annual publication

ISSN 1838-4625 (Print)

ISSN 1838-4633 (Online)

Report No 25/2010D

Front cover photos

The Indo-Pacific humpback dolphin (*Sousa chinensis*) is commonly found in Darwin Harbour. Photo: Carol Palmer.

Beach stone-curlew (*Esacus neglectus*). A shy resident of reefs, beaches and coastal mudflats of northern and eastern Australia. Photo: Mat and Cathy Gilfedder.

An undescribed sponge species of the genus *Haliclona*. It is restricted to the intertidal area. Found only at East Point, Channel Island and Cullen Bay. Photo: Belinda Glasby.

Northern trout gudgeon (*Mogurnda mogurnda*) occurs in Rapid Creek. Photo: Dave Wilson.

Back cover photos

This species of the sponge genus *Petrosia*, is common in the area of Elizabeth River estuary. Photo: Belinda Glasby.

Sunset at Nightcliff, Darwin. Photo: Nolan Caldwell.

Rapid Creek is the largest freshwater stream in the Darwin area.

Acknowledgements

The project was supported by the Darwin Harbour Advisory Committee. We thank many people who contributed photographs. Information was kindly supplied by Belinda Glasby (sponges) and Richard Willan (cyanobacteria and algae). We thank Larrakia Nation. Data in this report were obtained from projects funded by the Northern Territory Government and the Australian Government.

Symbols are courtesy of the Integration and Application Network (ian.umces.edu/symbols/), University of Maryland Center for Environmental Science, USA. Several conceptual diagrams were adapted from base diagrams from the Integration and Application Network.

Message from the Chair of the Darwin Harbour Advisory Committee

The Darwin Harbour Advisory Committee (DHAC), in partnership with the Aquatic Health Unit of the Department of Natural Resources, Environment, The Arts and Sport, is very pleased to present the second annual Darwin Harbour Region Report Cards 2010.

This annual snapshot of the Harbour's health is critical to assess the condition of the Harbour and highlight any changes, potential impacts and cumulative effects of development at an early stage. In future years there will be increased pressure on the Harbour environment from increasing population and increasing development and industry. We are fortunate that monitoring is well underway and baseline data of areas that have been relatively unimpacted by human activity are being collected. This provides an important foundation for future decision making about the use of the region. The new report card for the West Arm region on the Cox Peninsula is an excellent addition for this purpose.

As the Chair of DHAC I look forward to, and encourage, continual improvement of these Report Cards and this year is no exception.

I wish to acknowledge the hard work and commitment of the Aquatic Health Unit, Department of Natural Resources, Environment, The Arts and Sport in presenting their data in a transparent and user friendly way to meet the significant public interest in our beautiful Harbour.

The Darwin Harbour Strategy prepared by DHAC and endorsed by the Northern Territory Government in June this year is a comprehensive guide for the responsible stewardship and sustainable development of the Darwin Harbour region.

The Darwin Harbour Region Report Cards are an important component of the Darwin Harbour Strategy in a practical way which provides government and the public with an annual snapshot of the state of the Harbour.

Bill Stuchbery
Chair
Darwin Harbour Advisory Committee

View across Darwin CBD and city. The Charles Darwin National Park, and the East Arm Port are in the background. Photo: Tourism NT

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The Indo-Pacific humpback dolphin (*Sousa chinensis*) is known as a coastal or near-shore dolphin and is typically found in small populations inhabiting shallow coastal and estuarine waters, usually within about 10 km of land, in water less than 15 m deep and within about 20 km from the nearest river mouth.

This dolphin is vulnerable to habitat degradation, boat strikes, pollution and increased shipping traffic. Estimates of population size in local areas along the Queensland coast indicate that populations are notably small making them particularly vulnerable to human-induced disturbances on coastal ecosystems.

The Coastal Dolphin Research Project is currently undertaking baseline research on this species in Darwin Harbour along with the two other species of coastal dolphins: the endemic Australian snubfin (*Orcaella heinsohni*) and the Indo-Pacific bottlenose (*Tursiops aduncus*). This photo of the Indo-Pacific humpback dolphin was taken in the Howard River area. Photo: Carol Palmer

Darwin Harbour region

Aerial view of creek. Photo: Jeremy Freeman

Mindil Beach

Nymphaea violacea in Korebum Lagoon. *Nymphaea* is known as dambilinggwa to Larrakia people. Photo: Gisela Lamche

Summary

Water quality results

The Report Cards provide a snapshot of stream water quality from sites monitored in 2009, and water quality of estuarine sites monitored quarterly in late 2008 and 2009. Water quality at Darwin beaches was monitored in 2010. Water quality in outer Darwin Harbour, Elizabeth River, Darwin-Palmerston regions and outer Shoal Bay is in excellent condition. However, water quality at Buffalo Creek sites is in very poor condition. Water quality at the Myrmidon Creek monitoring site is in poor condition.

Water quality in the freshwater streams within the Harbour's catchments was assessed as being in good to excellent condition at the sites monitored. The water-bug community at the catchment biological monitoring sites is mostly unimpaired or equivalent to reference condition.

Differences in 'A to E' water quality ratings between years may not always reflect a real change in condition. Differences may arise from natural variability within short-term monitoring periods, and changes in methodology or sites.

Beach water quality monitoring

Results from monitoring of beaches, tidal creeks and sewage treatment plant mixing zone monitoring areas in 2010 are summarised in the Darwin Harbour Beaches Report Card.

Between June and September 2010 bacterial counts above guideline levels and presence of nuisance blooms led to beach closures. Investigations into all of the sources of the high bacterial counts are ongoing. Microbiological monitoring of beach waters and waterbodies like Little Mindil Creek, Mindil Creek, Rapid Creek and Vesteys Creek is continuing.

A bloom of maiden's tresses (*Lyngbya majuscula*) occurred in Darwin Harbour in May–June 2010, as in other years. *Lyngbya majuscula* can cause skin irritation in humans. Beaches were closed to assure public safety. Maiden's tresses and other cyanobacteria and algae can be observed as masses or slicks washed up on Darwin's beaches in the dry season. Examples of maiden's tresses, sea sawdust and sargassum seaweed are shown in the supplement to the Report Cards, *Other Projects and Monitoring*.

Monitoring and Report Cards

There is high community interest in water quality issues in Darwin Harbour, particularly given several beach closures and pollution incidents in 2010. The Darwin Harbour Integrated Monitoring and Research Plan is a comprehensive monitoring plan that is being progressed to assess the health of the Harbour. Monitoring at quarterly intervals at an additional seven estuarine sites has commenced in mid 2010 and the further development and implementation of the Darwin Harbour Integrated Monitoring and Research Plan will improve and expand on monitoring efforts.

The indicators 'total suspended sediment' and 'dissolved oxygen (%)' are under revision and new water quality objective values (local 'guidelines') will be based on a larger dataset than that from which they were developed. These Reports Cards therefore exclude total suspended sediment and dissolved oxygen (%) from the compliance and the 'A to E' water quality ratings for marine waters.

Other projects and monitoring

A snapshot of a few of the species that depend on the Harbour's waters is presented in the supplement to these Report Cards. A summary of selected research and monitoring activities in the Darwin Harbour region is also presented in the supplement to these Report Cards.

The Report Cards

This set of Darwin Harbour Region Report Cards describes the health of aquatic ecosystems across the Harbour and its catchment. They have been produced by the Aquatic Health Unit of the Department of Natural Resources, Environment, The Arts and Sport in conjunction with the Darwin Harbour Advisory Committee. Monitoring, laboratory analyses and data interpretation occur over time, so the Report Cards present data for late 2008–2009 for physical and chemical indicators. Water quality at Darwin beaches was monitored in mid 2010 and these results for microbiological monitoring are presented in the Darwin Harbour Beaches Report Card.

The Report Cards are aligned with the Darwin Harbour Strategy and the Territory 2030 Strategy. The Report Cards contribute to the strategies by providing knowledge to ensure we are maintaining a healthy environment for marine and freshwaters, to foster community awareness of water-related environmental issues, and therefore manage natural resources.

Our harbour, our life, our future

Life in Darwin and the Top End means being able to live among a variety of unspoilt environments and wildlife. How many other cities can boast of having green turtles (doedlirra to Larrakia people), dugong (damaldanggala, Larrakia), barramundi (damabila, Larrakia), sea eagles (garngarn, Wadjigin name), magpie geese (gakkingga, Larrakia), brahminy kites (butumba, Larrakia), mud crabs (madla, Larrakia) and agile wallabies (milula, Larrakia) in the Harbour and the suburbs?

Compared to other Australian ports and tropical ports around the world, the Darwin Harbour region is only partially modified. The Darwin region faces increasing population and industrial growth in the near future. This growth will intensify pressure on the Harbour environment and the wildlife it supports.

A bloom of maiden's tresses (*Lyngbya majuscula*) occurred in the Harbour in May–June 2010, as in other years. Maiden's tresses washed onto several beaches. Beaches were closed to assure public safety. Further investigation and monitoring to determine possible linkages between the bloom and bacteria levels is continuing. This photo was taken at a tidal creek at Vesteys Beach in June 2010. Photo: Julia Fortune

Water resources in the region support a diverse range of aquatic ecosystems and species which are significant cultural and recreational assets. However, the discovery of the aquatic freshwater weed cabomba (*Cabomba caroliniana*) in Darwin River in 2004, reminds us of the vulnerability of the environment to exotic species. Water resources in the region include perennial and seasonally flowing waterways, lagoons, floodplains, springs and estuaries. To protect these important natural resources, land and sea managers need to understand them as completely as possible.

The Darwin Harbour region stretches from Gunn Point in the north, to south of the Darwin River Dam. The region has a population of over 120,000 people within the cities of Darwin and Palmerston, and the Litchfield and Cox Peninsula shire areas. Catchments draining to the Harbour include the Elizabeth River, Blackmore River, Shoal Bay catchments and several smaller urban and rural ones. The area covers over 3,200 km^2 – 65% of which is terrestrial and 35% coastal and marine. Much of the region is undeveloped, with about 20% of the catchment being urban or rural land use.

Culture – land and sea country

Larrakia Nation 2010

It is traditional for Larrakia people to share our culture in the ‘first person’. Darwin Harbour, has been home to the Gulumoerrgin (Larrakia people), for thousands of years. For the Larrakia, the region’s environments are ‘cultural landscapes’ that are vital to our well being.

Larrakia ‘country’ consists of both land (gwalwa) and sea (gunumitjanda). There are tidal mudflats and mangrove (moerroerrlma) lined waterways, lagoons, floodplains, freshwater creeks and woodland (matboerrma). The sea itself comprises a variety of plant (mayoema) and animal (majawa) resources, which are managed, harvested, hunted and fished by the Larrakia People. Larrakia people have oral traditions and written documentation of our unbroken relationship to our land, our sacred sites, stories and resources. Larrakia people like to refer to ourselves as ‘saltwater people’ and consider the species that are not hunted including saltwater crocodiles, dolphins and whales an important part of our ancestry.

The Aquatic Health Unit

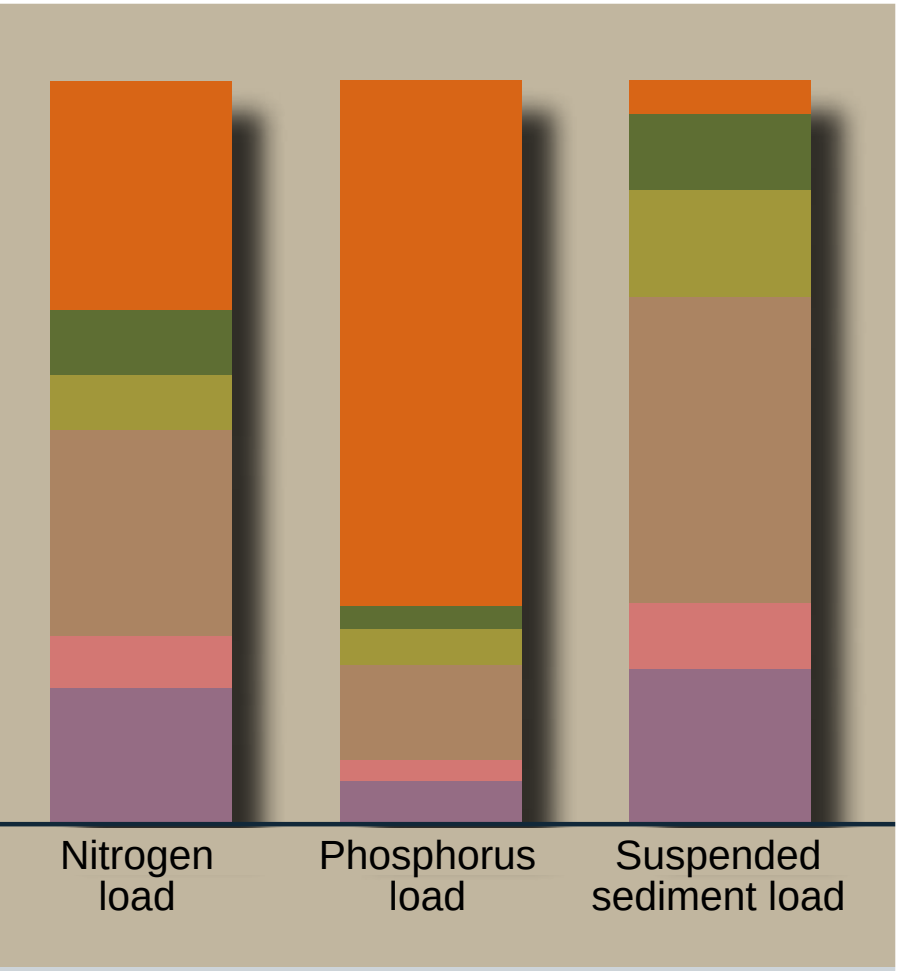
The Northern Territory Government’s Department of Natural Resources, Environment, The Arts and Sport (NRETAS) has an Aquatic Health Unit. The Northern Territory Government has an established record in monitoring and collaborative research in fresh, marine and estuarine water quality including biological health projects in the Darwin Harbour region and selected catchments in the Top End of the Northern Territory.

The NRETAS Aquatic Health Unit has expertise in aquatic ecology, limnology, estuarine science, catchment water quality modelling and water quality evaluation. Research and projects undertaken by the Northern Territory Government and its collaborators include:

- development of a Water Quality Protection Plan for Darwin Harbour
- ecological health assessment of aquatic habitats
- urban and rural catchment event-based pollutant load assessment
- assessment of nutrient and sediment budgets

Understanding water quality and pollution sources

Lightning and storm off Casuarina Beach. Wet season storm flows can affect catchment and estuarine water quality. Photo: Nolan Caldwell



Average annual pollutant loads to Darwin Harbour. Orange represents the percentage of total load from sewage treatment plants. Other colours represent the percentage of total load from diffuse sources for urban and rural catchments. Loads are measured using gauge station data.

Water quality samples and flow data are collected at a gauge station.

Introduction

This section presents some principles of water quality and pollution sources. Key water quality indicators and why they are used are explained.

Pollutant sources

The main pollutants to the waterways of the Darwin Harbour region are fine sediment, nutrients and, to a lesser degree, heavy metals and other chemical compounds.

Pollutants from land originate from both ‘point’ and ‘diffuse’ sources. Point sources include discharges from sewage treatment plants, aquaculture and other licensed operations. Point source discharges can occur throughout the year, including the dry season, and can have a substantial effect on water quality despite their often relatively small volume. Sewage treatment plants, for instance, are an important source of nutrients to the Harbour.

Diffuse, or non-point, sources such as urban and rural stormwater, leaching through soil, river bank erosion, and roads mainly enter our waterways during the wet season. The NRETAS Aquatic Health Unit monitors pollutant loads from these diffuse sources during the wet season at several stream gauges.

Some of the sources and effects on water quality in the Darwin Harbour region are shown in the diagrams on the following pages.

Estuary processes in the wet and dry seasons

In the estuaries, the main processes influencing water quality are seasonal changes and tidal flow. They affect water quality, salinity gradients, light, nutrient inflows and ecological processes in the upper, mid and outer parts of the estuary. Details are explained in the cross-section diagram on the following pages.

Key indicators for estuarine and freshwater quality

The key indicators used in the Report Cards are explained later in this section. The diagrams on the following pages show water quality indicators and some impacts such as changes in turbidity, oxygen and phytoplankton growth.

Other pollutants

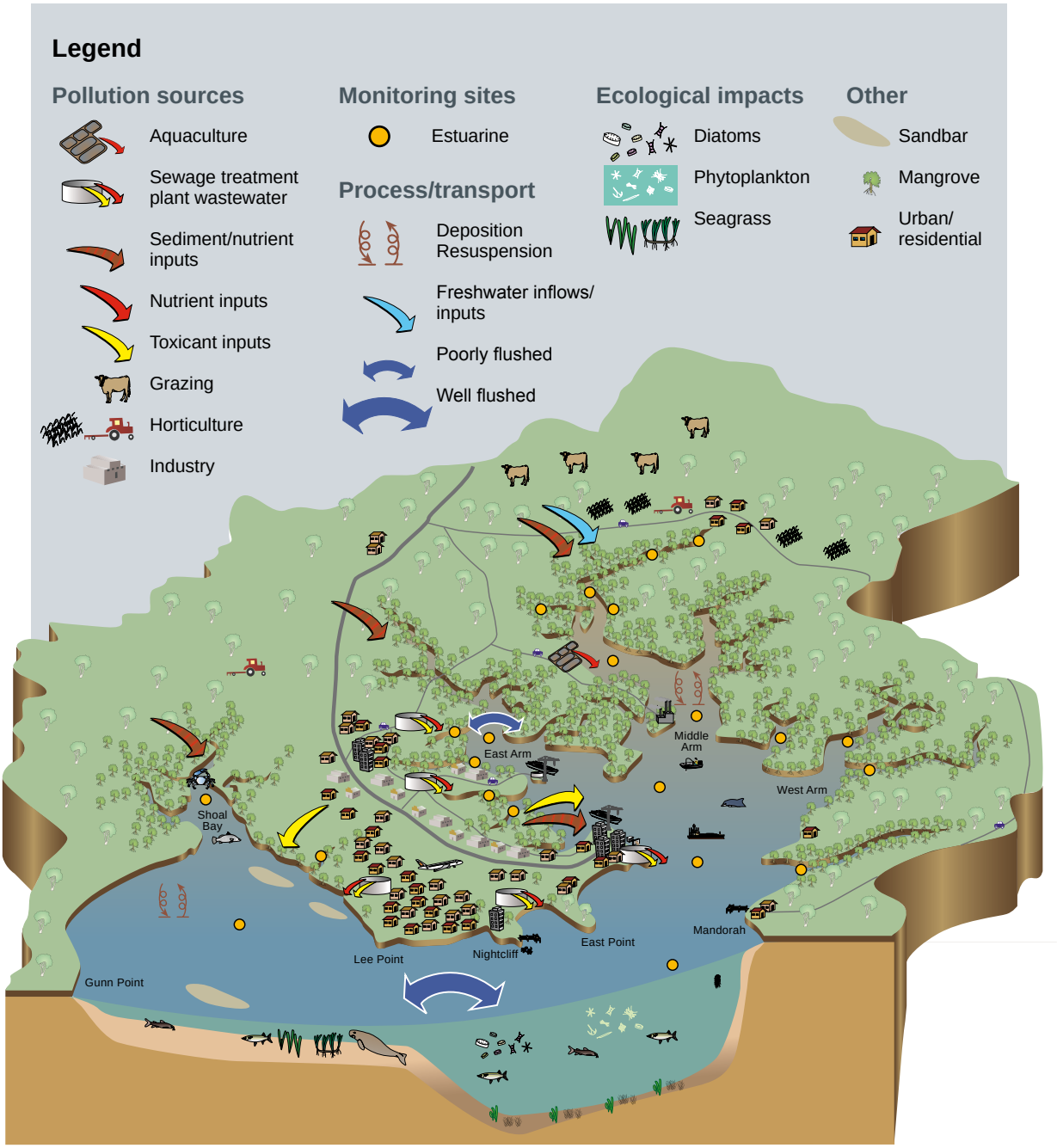
For some pollution indicators limited data are currently available for Darwin Harbour. Examples include human-related compounds (pharmaceuticals, petroleum compounds and chemicals) contained in stormwater, sewage and other licensed discharges, pollutants in leachate from landfills, and pesticides from urban and rural catchments.

Remember that what we put down the household drain or apply to our backyards and properties could in some form end up in Darwin Harbour and our food chain!

Estuarine monitoring sites, pollution sources, and ecology of Darwin Harbour

The diagram shows the Darwin Harbour catchment, pollutant sources and transport pathways. Sediment and nutrient sources to waterways (shown by arrows) include natural bushland, agriculture, and urban areas. Sewage treatment plants are a major source of nutrients and toxicants. Landfills, residential and industrial areas are a source of toxicants and nutrients. The upper parts of the Harbour estuary have deposition and resuspension of sediment, and are poorly flushed by tidal flow. Northern Territory Government monitoring sites are also shown.

Mangroves are an important feature – they are the “lungs” of the Harbour. There are 36 species of mangroves in this region. Sediments generate an important food supply for diverse organisms from microscopic bacteria to leaf-eating crabs. Mangroves also provide an effective natural barrier against waves, storms, and cyclones for coastal stabilisation.



Estuary processes in the wet and dry seasons

Estuary processes and water quality varies between the wet and dry seasons. Some of these effects are described below and in the diagram.

Tidal flow and water quality

- Many nutrients for plant and algae growth arise from resuspension of sediment and detritus from large tidal flow.
- Although the water in the Harbour can appear cloudy from tidal mixing, the water quality is high.
- High energy tides in Harbour areas scour the bottom so this area is not as productive. Rocky areas are rich in corals, algae and aquatic fauna.

Salinity

- The diagram shows that water quality in the estuary differs between the wet and dry seasons. During the dry season the salinity is quite uniform and the estuary well mixed. This contrasts with wet season conditions where the salinity is met in the upper estuary by a buoyant plume of freshwater (from the catchment).
- A strong salinity gradient can persist during and after rainfall events in the upper reaches of the estuary and the tidal creeks.

Nutrient inflows

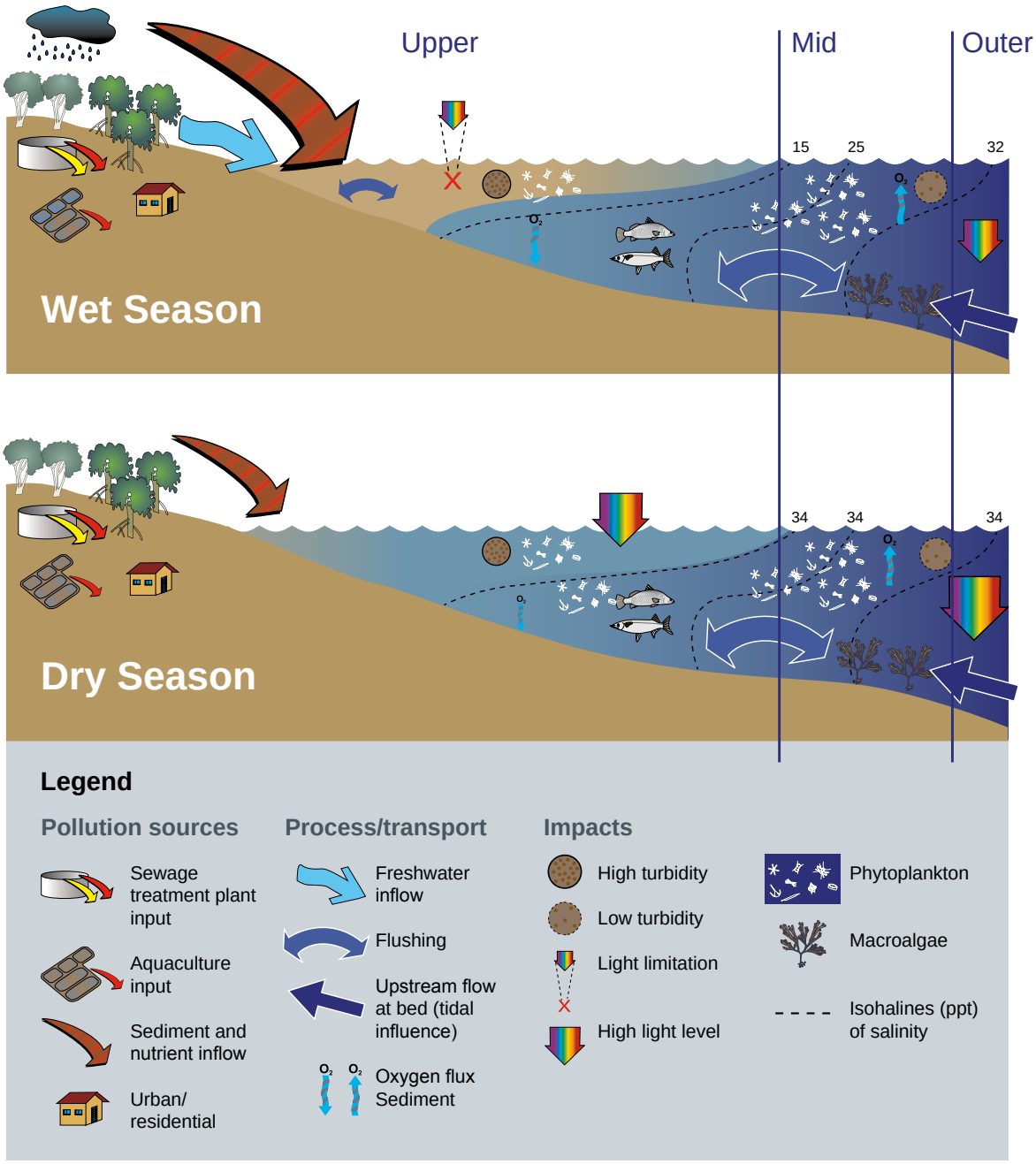
- Runoff entering the estuary from the urban and rural area increases available nutrients such as nitrate which can result in increased algal growth.

Turbidity, dissolved oxygen and phytoplankton

- Turbidity is at its highest in the wet season. Rainfall events result in the first flush of more turbid freshwater into the estuary influencing water clarity, light attenuation, productivity and oxygen demand. During these periods it is not unusual for dissolved oxygen to decrease dramatically.
- After the wet season flows become negligible. This results in reduced sediment loads and turbidity and good light attenuation through the water column. The resulting phytoplankton community is typically more diverse in species.

Shell Island looking towards East Arm. Photo: George Maly

This diagram shows how the wet and dry seasons affect salinity, nutrient inflows, turbidity, dissolved oxygen and phytoplankton in the estuary.

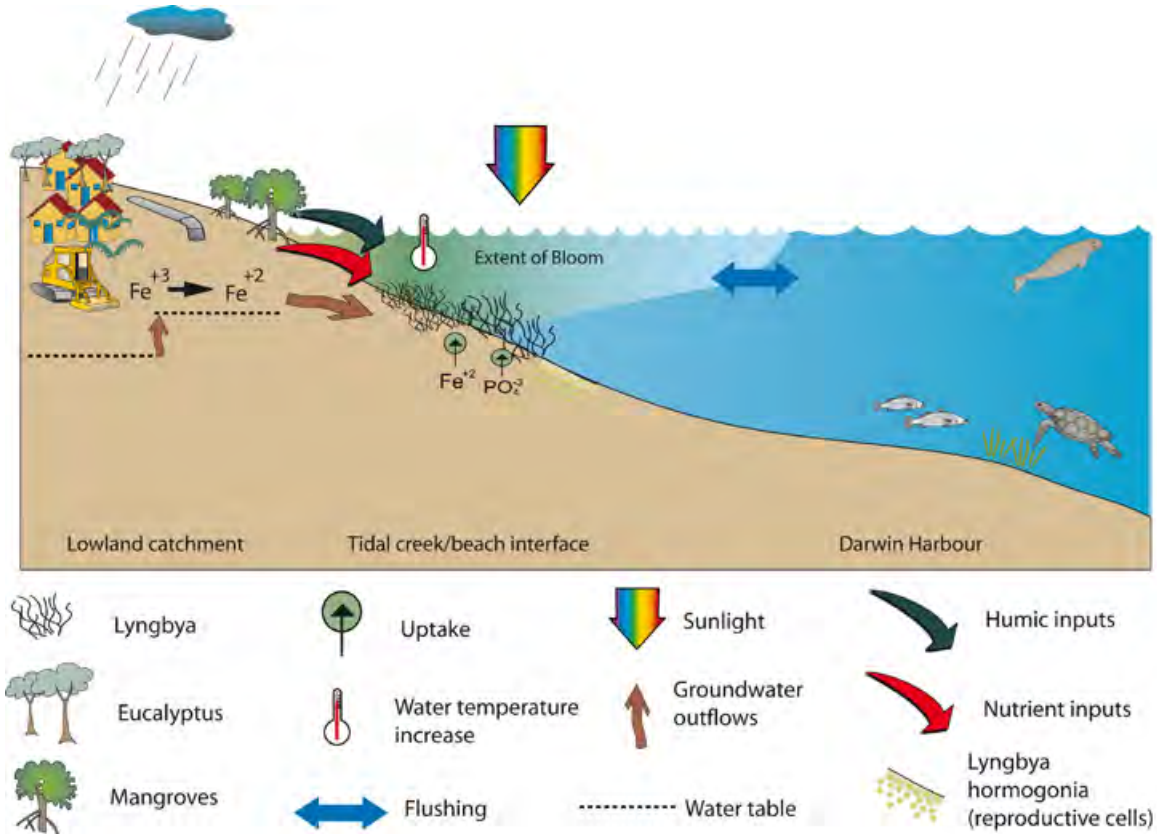


Formation of cyanobacteria blooms in Darwin Harbour and beach areas

The formation of cyanobacteria blooms (sometimes called algal blooms or 'red tides') in Darwin Harbour and beach areas occurs naturally during most dry seasons. Some of the processes for a common cyanobacteria bloom, maiden's tresses (*Lyngbya majuscula*) that occurred along the Fannie Bay foreshore in mid 2010 are described below and in the diagram.

- At the start of the dry season the Fannie Bay tidal creeks provided an ideal environment for a bloom where water was warm, shallow, clear and calm with nutrients delivered by runoff from late rainfall.
- The bottom dwelling cyanobacteria was observed to grow in tidal creeks along Fannie Bay, breaking off with outgoing tides and washing onto the beaches.
- Research suggests that *Lyngbya majuscula* is responsive to bio-available iron, phosphate and organic substances from runoff.

This diagram shows the processes leading to the formation and delivery of bio-available iron and phosphate initiating the *Lyngbya majuscula* bloom at Darwin beaches and nearby tidal creeks.

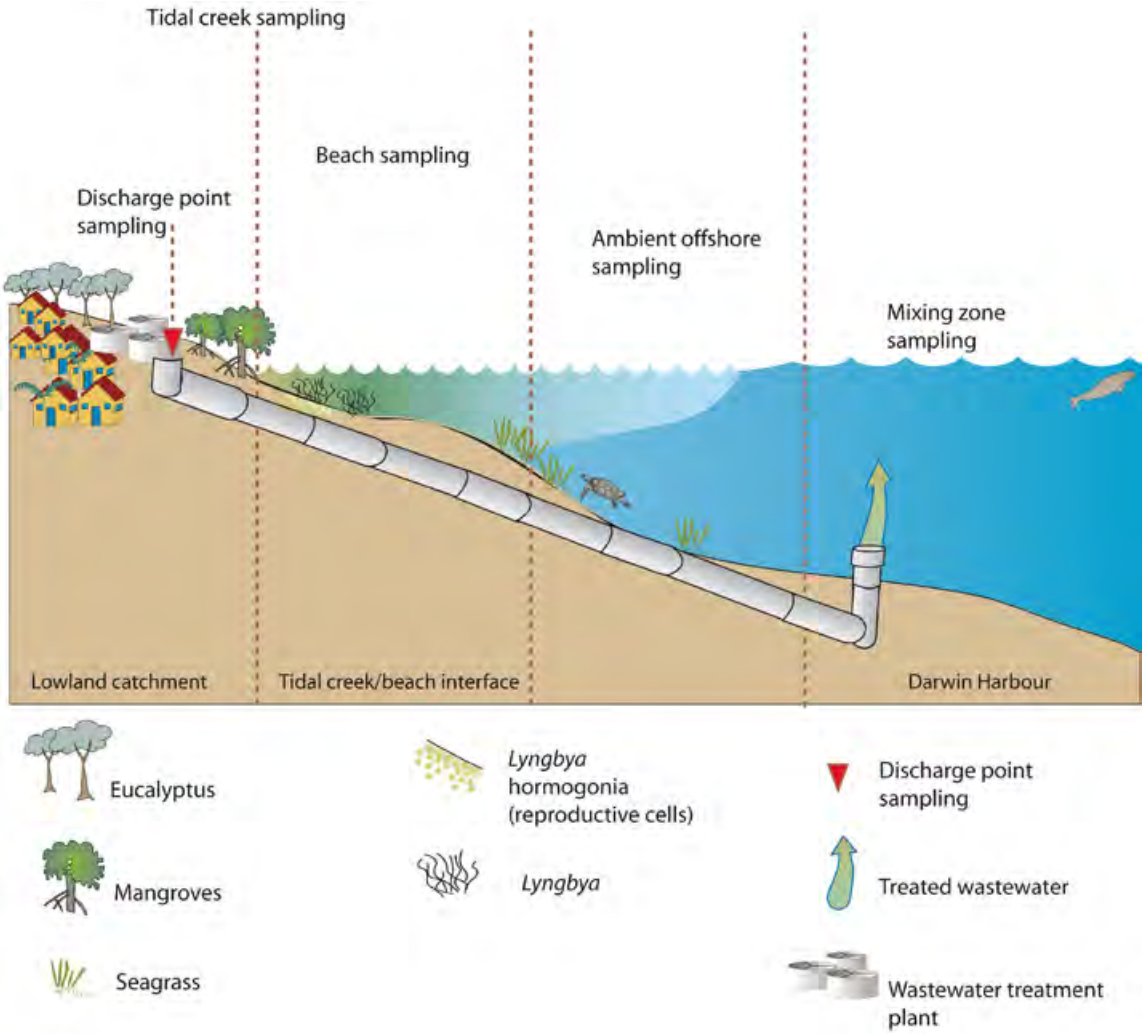


Monitoring sites for beach areas, tidal creeks and mixing zone areas

These conceptual diagrams show dry season monitoring sites for *Escherichia coli* (*E. coli*) and enterococci and other water quality indicators. The diagram below includes monitoring at Darwin's beaches, tidal creeks flowing to beach areas, offshore monitoring and treatment plant mixing zone areas at East Point and Larrakeyah.

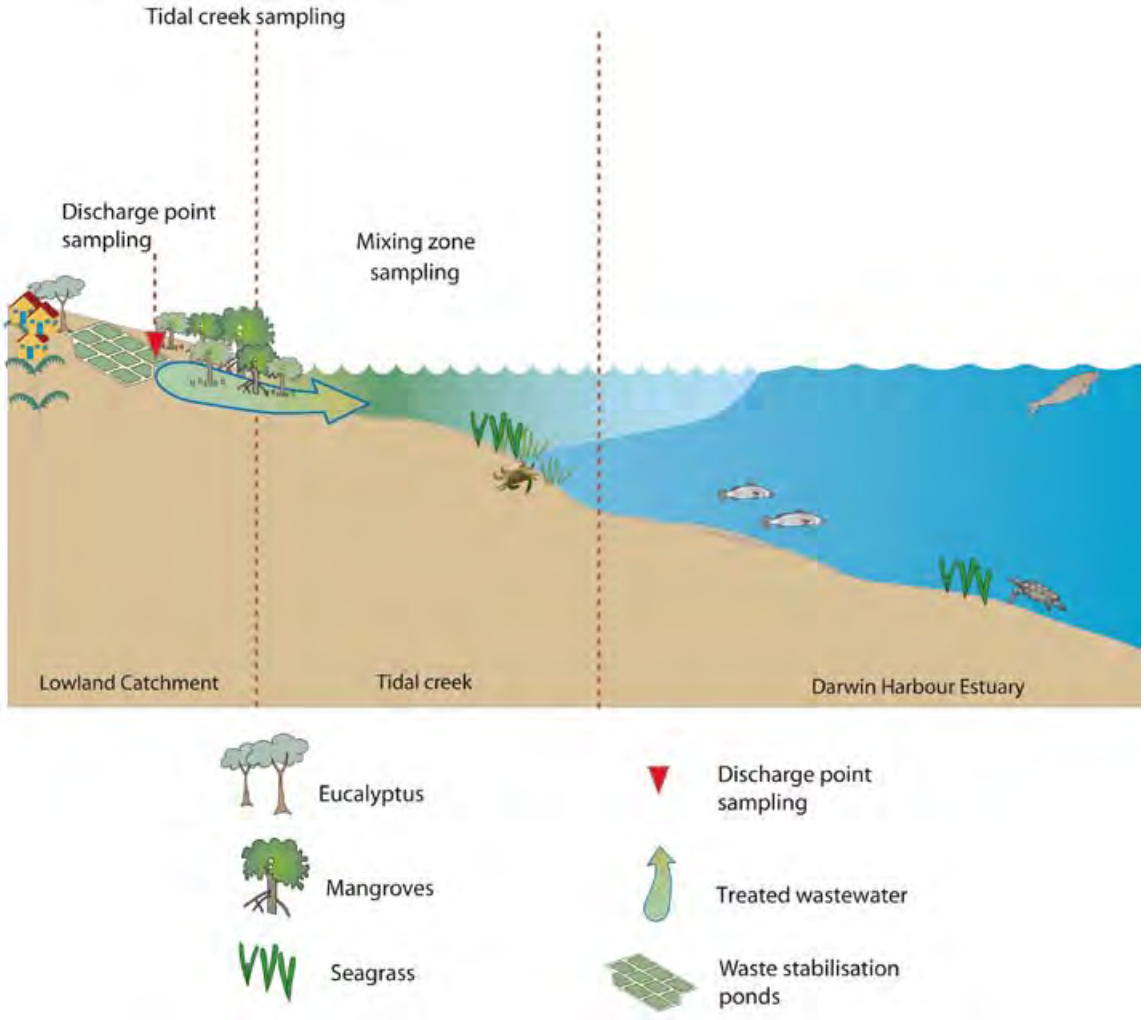
The tidal creek sites include Little Mindil Creek, Mindil Creek, Rapid Creek, and Vesteys Creek which are monitored weekly. The treatment plant mixing zone areas at East Point and Larrakeyah are independently monitored by the Aquatic Health Unit at fortnightly intervals. Up to six sites per mixing zone are monitored. Additional monitoring is undertaken by the Power and Water Corporation during alternate intervals. Data for beach swimming areas are collected weekly by the Department of Health and Families.

For further details and maps of individual monitoring sites see the NRETAS website.



The diagram below includes monitoring at tidal creeks and the treatment plant mixing zone areas at Buffalo Creek, Bleesers Creek and Myrmidon Creek.

The treatment plant mixing zone areas at Buffalo Creek, Bleesers Creek and Myrmidon Creek are independently monitored by the Aquatic Health Unit at fortnightly intervals. Up to six sites per mixing zone are monitored. Additional monitoring is undertaken by Power and Water Corporation during alternate intervals.



Darwin Harbour water classifications

Parts of Darwin Harbour are poorly flushed. Several classifications have been developed with the aid of a hydrodynamic model developed for Darwin Harbour. The level of tidal flushing affects water quality.

Upper estuary areas are poorly flushed with water residence times >32 days.

Mid estuary areas have a residence time of 14–32 days. Mid estuary areas cover the majority of the length of Darwin Harbour. The middle estuary has a moderate amount of water movement and salt and freshwater mixing. Shoal Bay was classified as mid-estuarine.

Outer estuary waters are subject to some mixing with inflowing water from the ocean. The water residence time for this area is <14 days.

Key indicators for estuarine and freshwater quality

Indicator	What it represents	Why it is used as an indicator
Electrical conductivity	A measure of electrical conductivity (dissolved solids, usually salts).	Inhibits plant and animal growth if too high.
Turbidity	Cloudiness in water.	A measure of the light scattering by material suspended in water. This affects the amount of light available for photosynthesis.
pH	Indicator of how alkaline or acidic the water is.	Important to biological processes.
Dissolved oxygen % saturation	A measure of the amount of oxygen in the water. Varies with physical and chemical conditions.	Critical for aquatic organisms to survive. Low dissolved oxygen is the major cause of freshwater fish kills.
Total suspended solids	Unconsolidated particulate material in the water column.	Indicator of eroded material such as sediment. Travels in water.
Chlorophyll *a*	The green component of plants used in photosynthesis.	Is used as an index of the amount (biomass) of algae.
NO_x	Nitrate + nitrite (dissolved) forms of nitrogen.	Nitrate stimulates plant growth. Travels with water in solution.
Ammonia	Total ammonia is the sum of un-ionised ammonia and the ammonium forms of nitrogen.	Readily used by aquatic plants. Decomposition and excretion product. Ammonia can be toxic to biota.
Total nitrogen	Nitrogen.	Nitrogen is essential for living organisms. Includes all forms of nitrogen.
Total phosphorus	Phosphorus.	Phosphorus is essential for living organisms. Travels mainly with sediment in water.
Filterable reactive phosphorus	Fraction of phosphorus that passes through a fine filter.	Stimulates aquatic plant growth. Travels with water in solution.
E. coli	*Escherichia coli* is a rod-shaped bacterium commonly found in the lower intestine of warm-blooded animals, including humans.	A common indicator for faecal contamination.
Enterococci	A group of faecal bacteria common to the faecal matter of warm-blooded animals, including humans (NHMRC 2008).	Enterococci generally survive longer than *E. coli* in marine waters. Increasingly used as the preferred indicator.

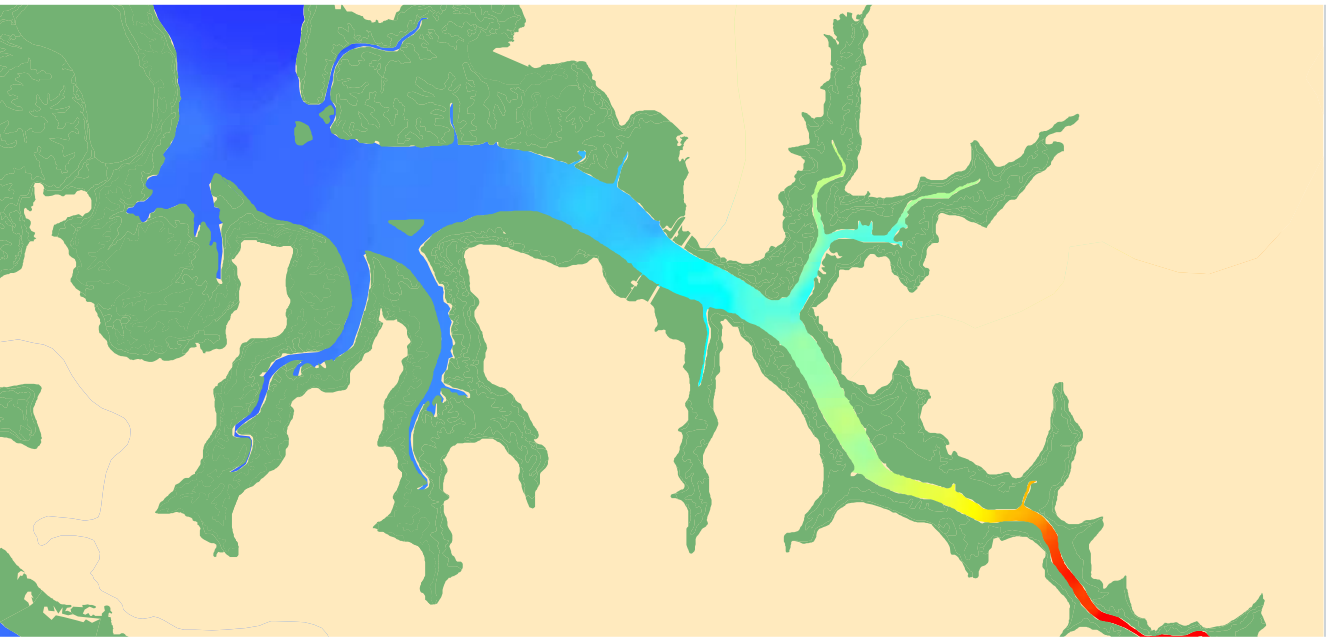
Units of measure

The Report Cards commonly express nutrient and chlorophyll indicators as concentrations in micrograms per litre. One microgram is one millionth of a gram. Total suspended solids are measured in milligrams per litre. One milligram is one thousandth of a gram. Turbidity is measured in nephelometric turbidity units. Electrical conductivity is measured in microsiemens per centimetre.

E. coli are measured in *E. coli* per 100 mL, or *E. coli* per 100 mL MPN. Enterococci are measured in enterococci per 100 mL, or enterococci per 100 mL MPN. MPN is most probable number. Units depend on the methodology of different laboratories.

Interpreting the Report Cards

A fluorometer is used to gather data for chlorophyll *a* mapping.



Distribution of conductivity in Elizabeth River estuary.

Laboratory equipment used to filter chlorophyll *a* water samples.

Introduction

This section contains information to help interpret the Report Cards.

Water quality

Darwin Harbour water quality (referred to as estuarine), catchment freshwater quality (ambient or low flow conditions) and interpretation methods are presented.

Information on the assessment of water quality using water quality objectives, and the assessment of the current condition of waterways is provided. These techniques are widely used in other regions of Australia. State and regional-scale water quality guidelines, such as water quality objectives, are considered more appropriate than national guidelines. The methods used have been established under a process developed by the National Water Quality Management Strategy. Further details are available in Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines and related publications.

Biological indicators

The interpretation of biological indicators using an assessment system common in Australia is described in this section. The Northern Territory Government has monitored biological health at current freshwater sites since 2001.

Microbiological indicators

The interpretation of microbiological indicators uses guidelines from the Northern Territory Recreational Microbiological Water Quality Guidelines (2007).

A Hydrolab datasonde is used to measure water quality indicators.

Interpreting the Report Cards

Ambient estuarine water quality

Water quality objectives: Water quality objectives act as a local guideline level. Water quality objectives describe the water quality needed to protect human uses and aquatic ecosystem values identified by the community (Beneficial Uses). These water quality criteria act as guideline levels and/or reference levels to help guide planning and water management to achieve and protect each of the values over time. Water quality objectives may change over time as more monitoring data become available.

Water quality objectives for nutrients, total suspended solids, and chlorophyll *a*, were calculated from the 80th percentile of ambient water sampling from reference sites in the region. Water quality objectives for dissolved oxygen (% saturation) and pH were calculated using the 20th to 80th percentile range of ambient water sampling from reference sites in the region. Separate water quality objectives for the outer, mid and upper estuarine regions of Darwin Harbour will apply.

Water quality objectives have been formally declared under the Northern Territory legislation (*Water Act* part 7).

Current condition: The current condition for nutrients, total suspended solids, turbidity, chlorophyll *a* and electrical conductivity were calculated from the median concentration of local ambient water quality data from recent years, as shown on the Report Cards. Dissolved oxygen (% saturation) and pH were calculated using the 20th to 80th percentile range.

Compliance: A tick indicates the current water quality condition for the indicator is equal to or better than specified by the water quality objective. A cross indicates the current condition for the indicator is outside the water quality objective.

Sampling for macroinvertebrates (water-bugs) to assess biological health of streams in the Darwin Harbour region. Photo: Matt Majid

Ambient freshwater quality

Water quality objectives: The water quality objectives for nutrients, total suspended solids, turbidity, chlorophyll *a*, and electrical conductivity were calculated from the 80th percentile of ambient (low flow) water sampling data from reference sites in the region. Water quality objectives for dissolved oxygen (% saturation) and pH were calculated using the 20th to 80th percentile range of ambient water sampling data from reference sites in the region.

Current condition: The current condition for nutrients, total suspended solids, turbidity, chlorophyll *a* and electrical conductivity were calculated from the median concentration of local ambient water quality sampling. Dissolved oxygen (% saturation) and pH were calculated using the 20th to 80th percentile range. The period of sampling is indicated in the Report Cards. The current condition is for ambient (low flow) conditions. Aquatic Health Unit monitoring sites are shown on the maps.

Compliance: A tick indicates the current condition for the indicator is equal to or better than specified by the water quality objective. A cross indicates the current condition for the indicator is worse than the water quality objective.

Catchment disturbance index

The catchment disturbance index (CDI) is an assessment of catchment-scale human impacts. It uses information on the area of different land uses, and weightings which reflect the relative impact of different land uses on stream water quality. Land use mapping is based on the Australian Land Use and Management (ALUM) classification which groups land uses with similar impacts into six classes. The weightings applied to each class were developed using expert opinion.

Land use class	ALUM classification	Weighting
1	Conservation and natural environments	0
2	Production from grazing natural vegetation	0.35
3	Production from dryland agriculture and plantations	0.53
4	Production from irrigated agriculture and plantations	0.70
5	Intensive uses	0.68
6	Water	0

The catchment disturbance index (CDI) is calculated using the fractional area of each land use within a catchment and its weighting to give a value between 0 and 1.
A low CDI value reflects a high level of catchment disturbance. The CDI for most subcatchments in the Darwin Harbour area is relatively high, reflecting the remaining large areas of natural vegetation present.

Biological indicators

Organisms living in streams and rivers can tell us about the condition or "health" of waterways. Diverse communities of macroinvertebrates (or water-bugs) indicate a stream in good condition, while simple communities of few water-bug types indicate a damaged or degraded stream. Water scientists regularly monitor the health of streams in the Darwin area using an assessment system known as AUSRIVAS. This stands for Australian River Assessment System, and works by comparing the water-bugs present in a stream with those expected to be present in reference streams of a similar type. AUSRIVAS produces a score based on the number of types found in a sample relative to the number of types expected. To simplify interpretation of these scores a banding system has been developed. Band X is more biologically diverse than reference. Band A means streams are equivalent to unimpacted reference streams; bands B, C, or D indicate that the stream is not equivalent to reference condition and is degraded to varying degrees. These Report Cards present data from a genus-level model based on 192 taxa and 114 reference sites within the Darwin-Daly region.

The table explains how to interpret bands from AUSRIVAS.

Band	Description	What it represents
X	More biologically diverse than reference	More types found than expected. Potential biodiversity "hot-spot" or mild organic enrichment.
A	Similar to reference	O/E scores range found at 80% of the reference sites, or equivalent to reference condition.
B	Significantly impaired	Potential impact either on water and/or habitat quality resulting in a loss of types.
C	Severely impaired	Many fewer types than expected. Loss of water and/or habitat quality.
D	Extremely impaired	Few of the expected types and only the hardy, pollution tolerant families remain.

Microbiological indicators

The interpretation of microbiological indicators uses guidelines from the Northern Territory Recreational Microbiological Water Quality Guidelines (2007). Several guidelines are summarised in the table. For full details and protocols refer to the guidelines, as not all compliance details are presented here. The table summarises some of the Northern Territory Recreational Microbiological Water Quality Guidelines.

Mode	Enterococci sample criteria		*E. coli* single sample criteria
Green: Surveillance / Open for Swimming	All samples to be less than or equal to 50 enterococci /100 mL	or	All samples to be less than or equal to 200 *E. coli* /100 mL
Amber: Alert / Open for Swimming	All samples between 51 and 200 enterococci /100 mL	or	Single sample greater than 200 *E. coli* /100 mL
Red: Closed for Swimming	Two consecutive samples within 24 hours greater than 201 enterococci /100mL	or	Single sample greater than 500 *E. coli* /100mL

Water quality rating

A ‘water quality rating’ was developed as an instantly recognisable assessment. Rating A is ‘excellent water quality’, through to E being ‘very poor water quality’.

The water quality rating was calculated from the percentage of compliance values for available water quality objectives listed for ambient fresh and marine waters. This rating method may change when catchment and water quality assessment schemes are further developed.

For these Report Cards, the total suspended sediment and dissolved oxygen (%) data are excluded from the marine water compliance and water quality ratings. These two indicators are under revision and new water quality objective values will be based on a larger dataset than the current water quality objective values.

Water quality rating	What the rating means	Compliance and method
	**Excellent water quality**	100% of indicators comply with water quality objectives
	**Very good water quality**	85% to <100% of indicators comply with water quality objectives
	**Good or moderate water quality**	50% to <85% of indicators comply with water quality objectives
	**Poor water quality**	30% to <50% of indicators comply with water quality objectives
	**Very poor water quality**	<30% of indicators comply with water quality objectives

Darwin Harbour Beaches

Summary

Several of Darwin Harbour beaches were closed in the dry season due to levels of microbiological water quality indicators being greater than guidelines.

Nature of system

- Estuarine system likely to be well mixed via tidal inflows and outflows
- Many stormwater drains enter tidal creeks directly onto beachfront areas
- Mangrove habitat and inter-tidal mudflats in some parts
- A large proportion of the catchment has been urbanised
- Cyanobacteria blooms (e.g., maiden's tresses and sea sawdust) typically occur as a natural event in most years in the dry season and can wash ashore

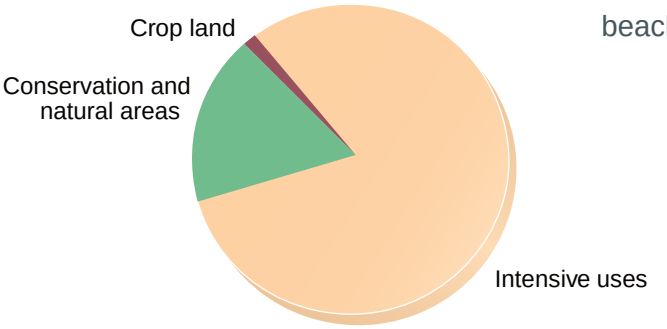
Sources of pollution

- Sediment, nutrient, bacteria, commercial and other human-related pollutants in stormwater runoff from rural, urban (e.g., residential, recreational facilities and areas, commercial areas) from diffuse sources in the catchment
- Sediment, nutrient, bacteria, and other pollutants from point sources (e.g., wastewater discharges, stormwater drains, recreational facilities and areas, commercial areas) to waterways
- Sewage treatment plant wastewater discharges at East Point and Larrakeyah between Darwin wharf and Lee Point

Mindil Beach is a popular recreation area in Darwin. Mindil Beach *E. coli* levels were above the NT water quality guidelines on 8 out of 25 sampling occasions from June to September 2010 (data supplied by Department of Health and Families).

Darwin Harbour beaches area catchment showing rivers and monitoring sites

Land use in the catchment



Catchment disturbance index

The CDI for the Darwin Harbour beaches catchment is 0.44.

Water quality issues in the catchment

In the dry season of 2010, bacterial counts above recreational water quality guideline levels and presence of nuisance algae led to closures of several of Darwin's beaches. Investigations into all of the sources of the high bacterial counts are ongoing.

Maiden's tresses (*Lyngbya majuscula*) is a naturally occurring cyanobacteria (previously called 'blue-green algae') that has recently been observed in large masses on Darwin's beaches. Blooms occur naturally, as in other years. *Lyngbya majuscula* can cause skin irritation in humans. Beaches were closed to assure public safety. This photo was taken on Casuarina Beach in June 2010.
Photo: Julia Fortune

Slicks of sea sawdust (*Trichodesmium* cf. *erythraeum*), a nitrogen-fixing cyanobacteria (previously called 'blue-green algae') appear on the sea's surface. The blooms are also commonly known as 'red tides'. These blooms are natural occurrences in Darwin Harbour and typically occur every year between September and November. Slicks caused by sea sawdust can have a strong, rank smell and form dark green scums when they wash ashore, but they are not iridescent like oil slicks. This photo was taken 1 km west of East Point in Darwin Harbour on 8 November 2008. Photo: Neil Wright.

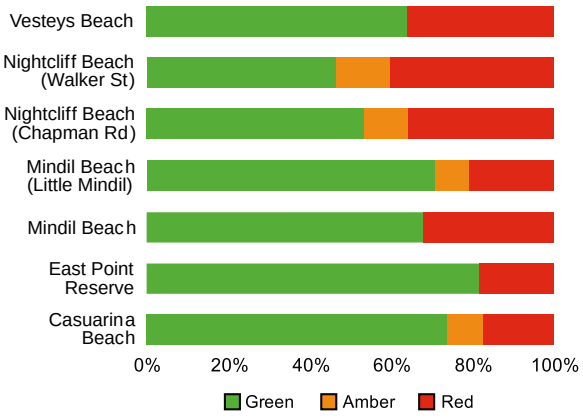
Sewage treatment plant wastewater discharges can contribute to nutrient, bacteria and other human-related pollutants. This photo was taken while water quality samples were collected at the East Point mixing zone monitoring area on 16 June 2010. Photo: John Drewry

Darwin Harbour beaches area marine ambient water quality

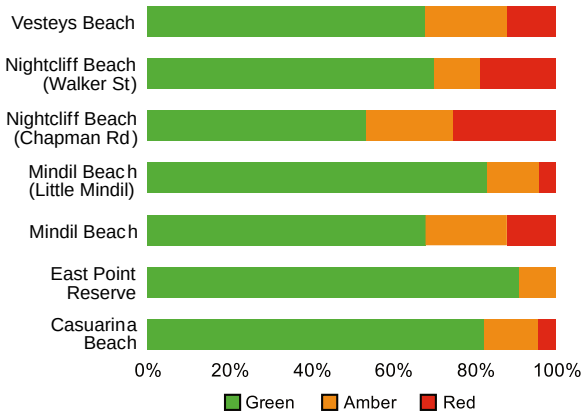
This section shows green (beach open), amber (alert-open) or red (beach closed) mode compliance for Darwin beaches monitored from 7 June to 13 September 2010. Criteria for each mode are described in the 'Interpreting the Report Cards' section. Data are *E. coli* and enterococci data collected by the Department of Health and Families. In line with national guidelines for recreational marine waters, the Department is transitioning to enterococci as the preferred indicator for 2011.

Sample numbers ranged from 15 to 28.

The graphs show the percentage of samples monitored that were in green, amber or red mode. For example, Casuarina Beach had 74% of *E. coli* samples in green (beach open) mode, 9% of samples in amber (beach open), and 17% of samples in red (beach closed) mode.



E. coli data for beaches
7 June to 13 September 2010.

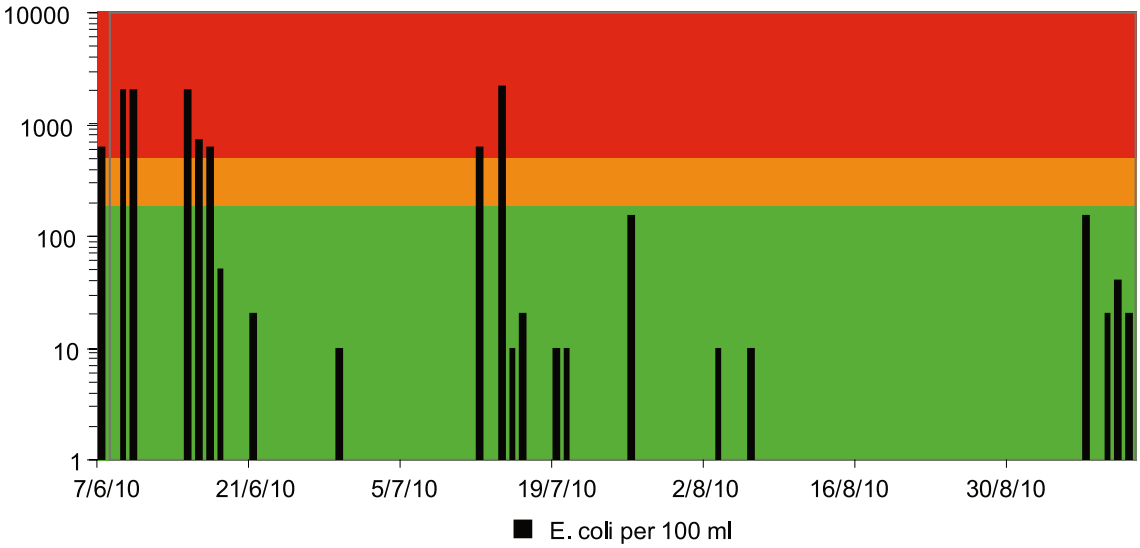


Enterococci data for beaches
7 June to 13 September 2010

Mindil Beach area marine ambient water quality

Levels of *E. coli* for Mindil Beach monitored from 7 June to 13 September 2010 are presented here. Data were collected by the Department of Health and Families. For 111 days from 1 June to 19 September 2010 there were only three days (6 July, 4-5 September) with rainfall recorded at Darwin airport.

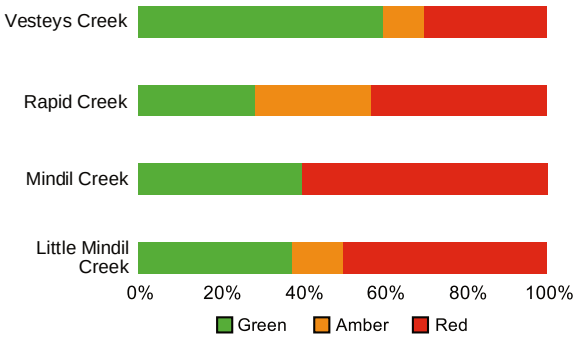
Note the logarithmic scale (useful for showing small and very large values) where each major division is 10 times greater than the previous division. Colours are green (beach open), amber (alert-open) or red (beach closed).



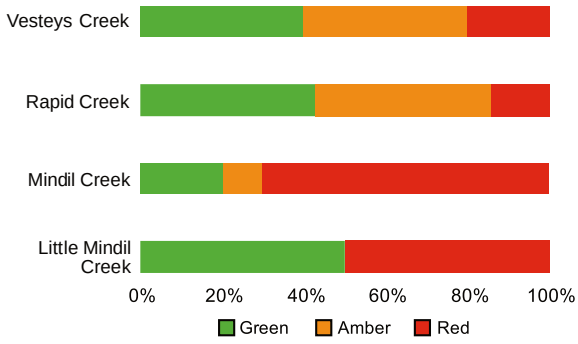
Darwin Harbour beaches area tidal creeks marine ambient water quality

This section shows green (beach open), amber (alert-open) or red (beach closed) mode indicative compliance based on *E. coli* or enterococci data for four tidal creeks monitored weekly from 24 June to 14 September 2010. Sample number: Little Mindil Creek (8), Mindil Creek (10), Rapid Creek (7), Vesteys Creek (10).

Note that beach closures are *not* determined from these tidal creek monitoring data. The graphs show the percentage of samples that were in green, amber or red indicative mode.



E. coli data for 4 tidal creeks



Enterococci data for 4 tidal creeks

Treatment plant mixing zone marine ambient water quality

This table shows preliminary results for the percentage of samples that are greater than or below the red (beach closed) trigger value for *E. coli* and enterococci levels at or near the East Point and Larrakeyah mixing zone monitoring areas. For these methods and conditions at the time of sampling, and the limited number of samplings, most samples contained fewer, or much fewer, *E. coli* and enterococci than the 'beach closed' trigger values. The source of the elevated bacteria levels at beach monitoring sites is unclear and investigation is continuing.

The East Point mixing zone was sampled at five nearby sites in August and September 2010. The Larrakeyah mixing zone was sampled at six nearby sites in August and September 2010. Trigger values are from NT recreational water quality guidelines. Note that these guidelines may not apply within a mixing zone. The complete extent of mixing zones have not yet been fully determined.

STP mixing zone	Date	Percentage of samples <500 *E. coli* /100 ml	Percentage of samples >500 *E. coli* /100 ml	Percentage of samples <200 enterococci /100 ml	Percentage of samples >200 enterococci /100 ml
East Point	6/08/2010	80	20	100	0
East Point	24/08/2010	80	20	100	0
East Point	7/09/2010	100	0	100	0
East Point	21/09/2010	100	0	100	0
Larrakeyah	9/08/2010	100	0	100	0
Larrakeyah	24/08/2010	100	0	100	0
Larrakeyah	7/09/2010	100	0	100	0
Larrakeyah	20/09/2010	83	17	83	17

Fannie Bay, tidal creeks, East Point and Larrakeyah mixing zone areas marine ambient water quality

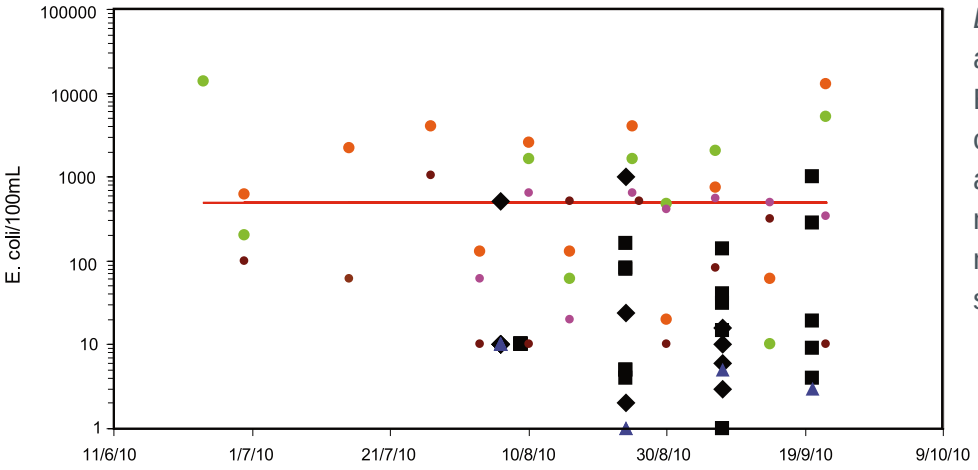
These graphs show *E. coli* and enterococci monitored at Fannie Bay, four tidal creeks, East Point STP and Larrakeyah STP mixing zone monitoring areas. Darwin airport rainfall is shown.

Little Mindil Creek, Mindil Creek, Rapid Creek, and Vesteys Creek were monitored weekly. The East Point mixing zone was sampled at five nearby sites. The Larrakeyah mixing zone was sampled at six nearby sites. The 'beach closed' guidelines are the trigger values from NT recreational water quality guidelines (2007). Note that the guidelines may not apply within a mixing zone.

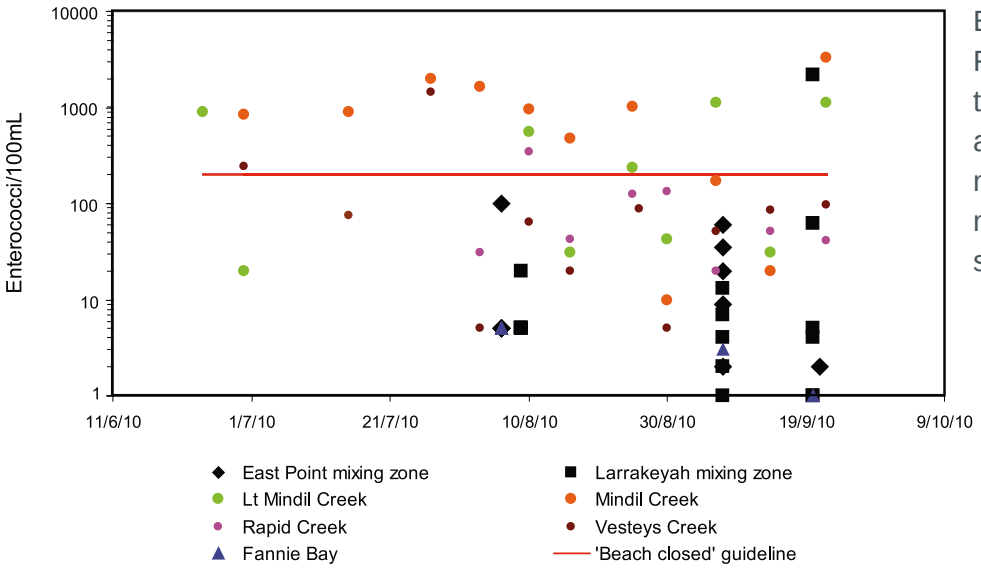
For the methods used and conditions at the time of sampling, most (but not all) samples near STP mixing zone sampling areas contained fewer *E. coli* and enterococci than the 'beach closed' trigger values. Tidal creeks varied above and below the 'beach closed' trigger values.

Note the logarithmic scale (useful for showing small and very large values) where each major division is 10 times greater than the previous division. Fannie Bay and mixing zone data are *E. coli* and enterococci per 100 mL. Tidal creek data are *E. coli* and enterococci per 100 mL MPN.

Rainfall



E. coli data at Fannie Bay, tidal creeks and STP mixing zone monitoring sites



Enterococci at Fannie Bay, tidal creeks and STP mixing zone monitoring sites

A Parks and Wildlife ranger overlooks a turtle release at Casuarina Coastal Reserve. The flatback turtle (*Natator depressus*) nests on Darwin's beaches including those within the Casuarina Coastal Reserve. Parks and Wildlife has an ongoing program to assist with the success of this nesting.

This program aims to improve the nesting success by actively monitoring each nest, and to allow the public to observe turtles emerging from their nest. Parks and Wildlife hold very popular public release viewings with accompanying talks during the dry season. Attendance is by booking only on (business hours) 08 8999 4555.

Darwin is the only capital city in the world that has flatback turtles nesting on its beaches.

Darwin Harbour

Summary

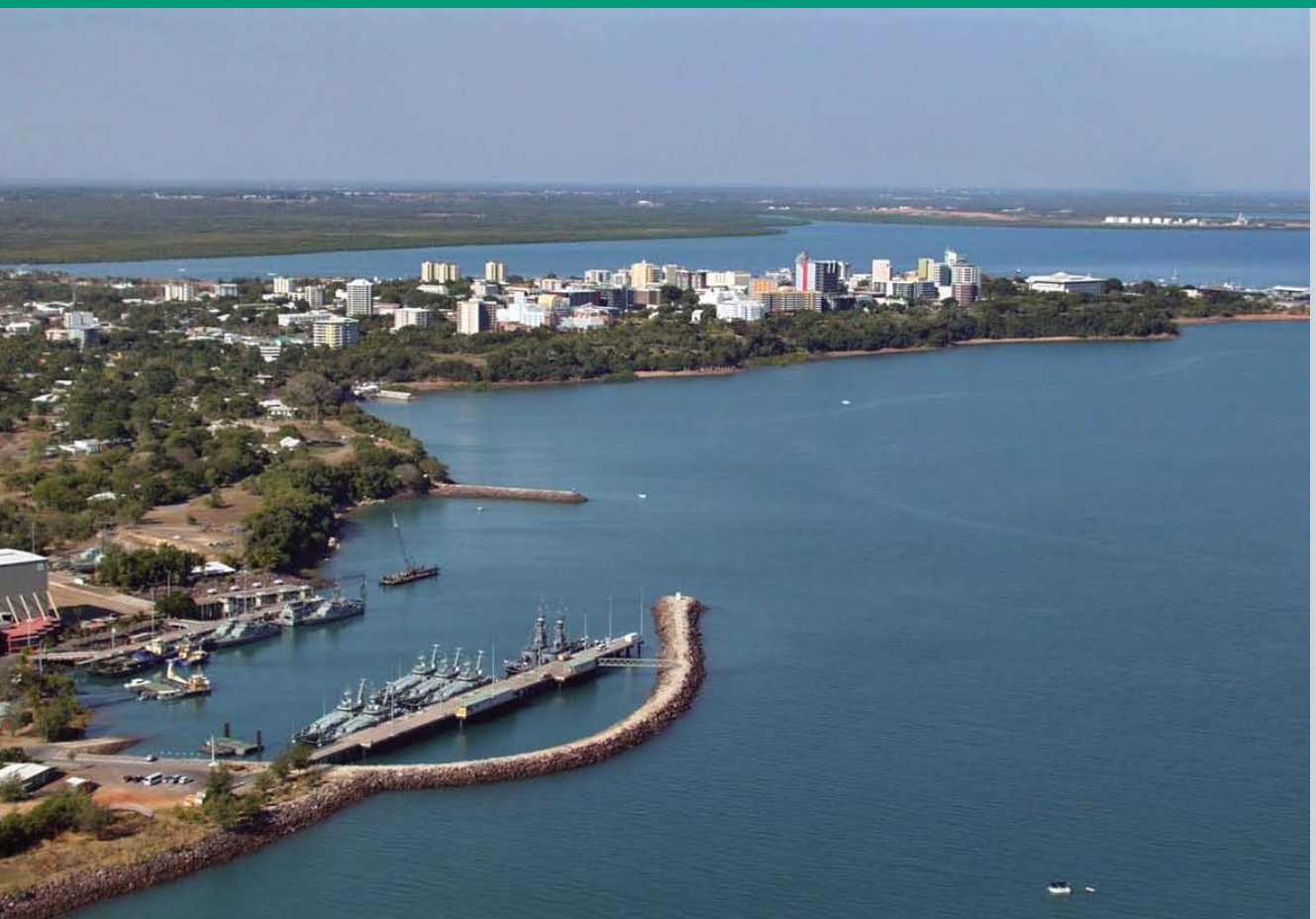
Water quality at the outer Harbour monitoring sites is in excellent condition.
Water quality at the mid Harbour monitoring sites is in very good condition.

Nature of system

- Estuarine system with outer estuary well mixed via tidal inflows and outflows
- Upper estuary and tidal creeks have long water residence times and are poorly flushed so are likely to be most prone to effects of pollution
- Maximum tidal height variation of nearly 8 m
- Perennial freshwater inflows from Howard River and Darwin River
- Extensive mangrove habitat and inter-tidal mudflats

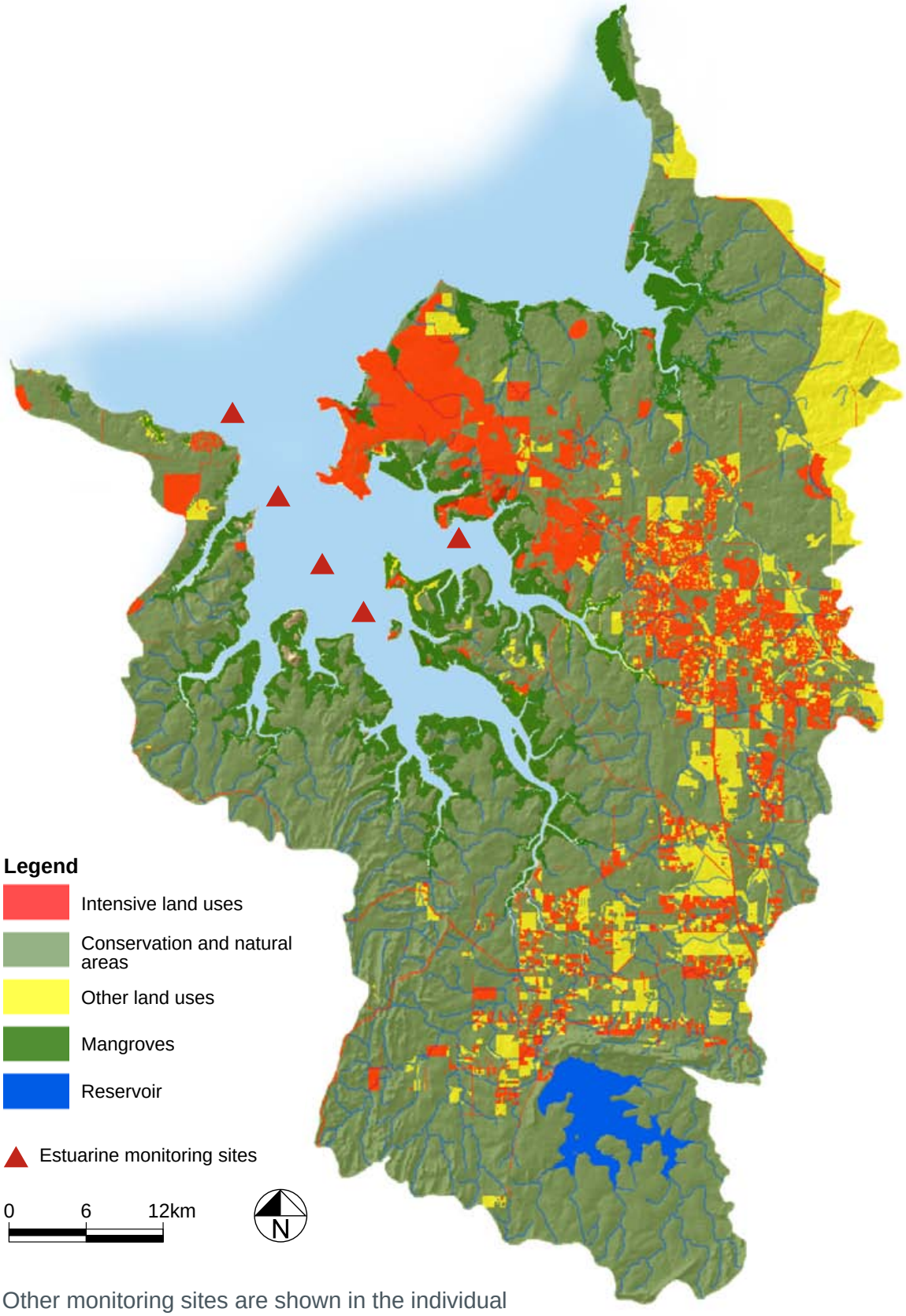
Sources of pollution

- High sediment, nutrient, industrial and other human-related pollutant loads during the wet season
- Sewage treatment plant wastewater discharges at several points in the Harbour
- Other licensed wastewater discharges at several points in the Harbour
- Sediment and nutrient loads in stormwater runoff from rural, urban and industrial catchment diffuse sources during the wet season



The view across Darwin CBD and city with part of the Charles Darwin National Park in the background. Photo: Tourism NT

Darwin Harbour catchment showing rivers and land use



Other monitoring sites are shown in the individual Report Cards. Seven new estuarine sites were added in mid 2010 (not shown), including Darwin's beaches, East Point and Elizabeth River.

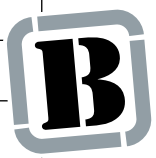
Darwin Harbour outer area marine ambient water quality

Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	NA	54200	7	
Turbidity (NTU)	NA	3.1	7	
pH	7.0–8.5	7.9–8.3	7	✓
Dissolved oxygen (%)	80–100	70–77	4	*
Total suspended solids (mg/L)	<10	22	7	*
Chlorophyll a (µg/L)	<1	0.5	7	✓
NOx (µg N/L)	<10	8	7	✓
Ammonia (µg N/L)	<20	6	7	✓
Total nitrogen (µg N/L)	<440	200	7	✓
Total phosphorus (µg P/L)	<20	10	7	✓
Filterable reactive phosphorus (µg P/L)	<10	5	7	✓

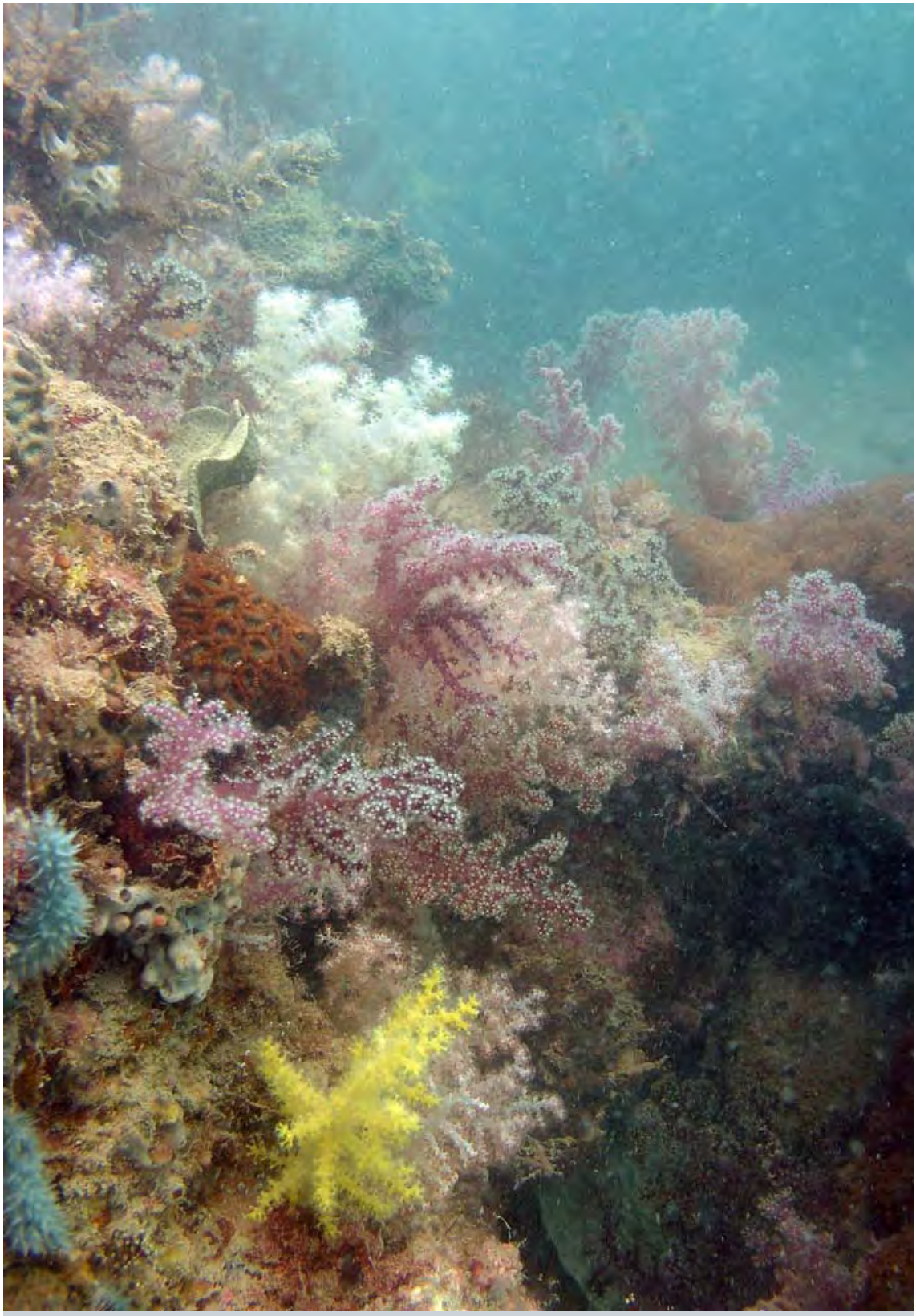
Period sampled for current condition is Sep 2008 to Dec 2009. NA Not available. * WQO currently under revision

Darwin Harbour mid estuary area marine ambient water quality

Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	NA	54350	28	
Turbidity (NTU)	NA	2.3	28	
pH	7.0–8.5	7.9–8.2	28	✓
Dissolved oxygen (%)	80–100	65–76	21	*
Total suspended solids (mg/L)	<10	20	28	*
Chlorophyll a (µg/L)	<2	0.8	28	✓
NOx (µg N/L)	<20	5	28	✓
Ammonia (µg N/L)	<20	5	28	✓
Total nitrogen (µg N/L)	<270	200	28	✓
Total phosphorus (µg P/L)	<20	10	28	✓
Filterable reactive phosphorus (µg P/L)	<5	6	28	✗



Period sampled for current condition is Sep 2008 to Dec 2009. NA Not available. * WQO currently under revision



This photo shows predominantly soft corals found in Darwin Harbour. Hard corals are well represented in the Darwin Harbour region - over 120 species are known. This is surprising given the environmental conditions - species composition reflects the harbour's turbid nature and coral reefs are restricted to hard substrates with strong currents.

Coastal development and human activities can affect coral communities through increased sediment and pollution entering the Harbour. Pollution can include oil and chemical spills, and contaminants entering waterways from stormwater. Stormwater can increase nutrient, sediment and contaminant levels which in turn can reduce biodiversity.

Sewage loads can increase algal growth, which can reduce water quality and biodiversity.

NRETAS' Biodiversity Group has been involved in Darwin Harbour and Northern Territory projects such as marine biodiversity surveys, habitat mapping, ecological studies and conservation planning. Photo: Tony Ayling

Darwin-Palmerston and Estuary

Summary

Water quality at the Darwin-Palmerston upper estuary monitoring sites is in excellent condition. Water quality at the Myrmidon Creek estuary monitoring site is in poor condition. Many water quality indicators at the Myrmidon Creek estuary monitoring site do not comply with water quality objectives. The water-bug community at the biological monitoring sites is assessed as equivalent to reference at one site and significantly impaired at the second site.

Nature of system

- Long residence time and poor flushing in the tidal creeks
- Light limitation during the wet season
- A large proportion of the catchment has been urbanised

Sources of pollution

- Several sewage treatment plants with wastewater discharge from Darwin at Bleesers Creek and Palmerston at Myrmidon Creek
- High sediment, nutrient, industrial and other human-related pollutant loads during the wet season

Mitchell Creek is the natural drainage system for the Palmerston escarpment, and residential suburbs in the east of the City of Palmerston.

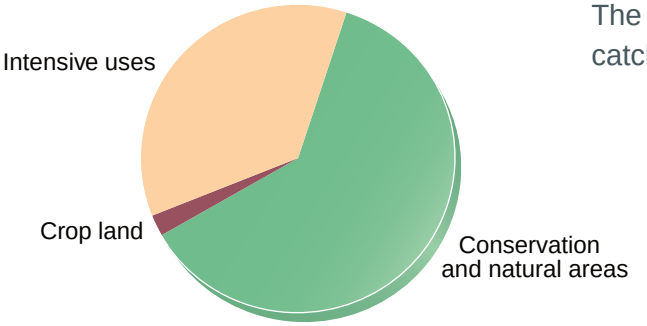
It is the only creek system in Palmerston with residential development, such as the proposed suburb of Johnston.

The Northern Territory Government has monitored water quality and water-bugs in Mitchell Creek since 2001.

Photo: Gisela Lamche

Darwin-Palmerston area catchment showing rivers and monitoring sites

Land use in the catchment



Catchment disturbance index

The CDI for the Darwin-Palmerston catchment is 0.74.

Water quality issues in the catchment

‘Water sensitive urban design’ (WSUD) features that are being planned in Johnston and Bellamack will help improve stormwater quality draining from new urban areas to Mitchell Creek.

Increased population and housing can contribute to increased pollutant loads to waterways.

Darwin City Council has installed raingardens to treat road runoff from Mitchell St. Water flows into the street raingarden and slowly filters through the soil. Photo: Equatica.

Darwin-Palmerston catchment ambient freshwater water quality

Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	<200	83	5	✓
Turbidity (NTU)	<20	8.1	5	✓
pH	6.0–7.5	6.3–7.0	5	✓
Dissolved oxygen (%)	50–100	58–78	5	✓
Total suspended solids (mg/L)	<5	NA	NA	
Chlorophyll a (µg/L)	<2	<1	4	✓
NOx (µg N/L)	<8	2	4	✓
Ammonia (µg N/L)	NA	8	4	
Total nitrogen (µg N/L)	<230	125	4	✓
Total phosphorus (µg P/L)	<10	8	4	✓
Filterable reactive phosphorus (µg P/L)	<5	2	4	✓

Period sampled for current condition is 2009. NA Not available

Biological health using the AUSRIVAS score

Site	2003	2009	Change
DW23	B	A	Change
DW41	B	B	No change

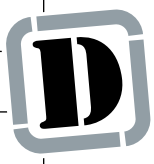
Darwin-Palmerston area marine ambient water quality

Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	NA	52500	30	
Turbidity (NTU)	NA	6.2	30	
pH	6–8.5	7.7–8.0	30	✓
Dissolved oxygen (%)	80–100	58–71	30	*
Total suspended solids (mg/L)	<10	24	30	*
Chlorophyll a (µg/L)	<4	2	30	✓
NOx (µg N/L)	<20	2	30	✓
Ammonia (µg N/L)	<20	8	30	✓
Total nitrogen (µg N/L)	<300	245	30	✓
Total phosphorus (µg P/L)	<30	13	30	✓
Filterable reactive phosphorus (µg P/L)	<10	3	30	✓

Period sampled for current condition is Sep 2008 to Dec 2009. NA Not available. * WQO currently under revision

Myrmidon Creek marine ambient water quality

Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	NA	53100	6	
Turbidity (NTU)	NA	5.4	6	
pH	6–8.5	7.8–7.9	6	✓
Dissolved oxygen (%)	80–100	58–71	6	*
Total suspended solids (mg/L)	<10	14	6	*
Chlorophyll a (µg/L)	<4	4.3	6	✗
NOx (µg N/L)	<20	11	6	✓
Ammonia (µg N/L)	<20	21	6	✗
Total nitrogen (µg N/L)	<300	350	6	✗
Total phosphorus (µg P/L)	<30	25	6	✓
Filterable reactive phosphorus (µg P/L)	<10	19	6	✗



Period sampled for current condition is Sep 2008 to Dec 2009. NA Not available. * WQO currently under revision

Indo-Pacific humpback dolphins (*Sousa chinensis*) are residents of Darwin Harbour and estuaries – important areas for foraging, calving and raising young. Indo-Pacific humpback dolphins can be identified by their distinctive triangular dorsal fin, and long slender nose. The dorsal fin usually has distinctive pink to white pigmentation. This dolphin surfaces with a characteristic roll. The dolphin is vulnerable to habitat degradation, boat strikes, pollution and increased shipping traffic. The Coastal Dolphin Research Project is undertaking research on this species in Darwin Harbour. Further information on identifying dolphins in Darwin Harbour and the Northern Territory, and the project can be found at http://www.nt.gov.au/nreta/wildlife/programs/dolphin/index.html Photo: Catherine Orme

Elizabeth River and Estuary

Summary

Water quality at the upper estuary monitoring site is in excellent condition. Water quality at the ambient freshwater monitoring sites is in excellent condition and complies with water quality objectives. The water-bug community at most biological monitoring sites is equivalent to reference condition.

Nature of system

- Long residence time and poor flushing in the upper estuary
- Saltwater ‘wedge’ formation during the wet season – increasing freshwater flows to the estuary form a buoyant plume of freshwater which results in partially ‘stratified’ conditions
- Phytoplankton biodiversity typically greater in dry season
- Higher salinities in upper estuary during the dry season with no freshwater inputs
- Light limitation during the wet season

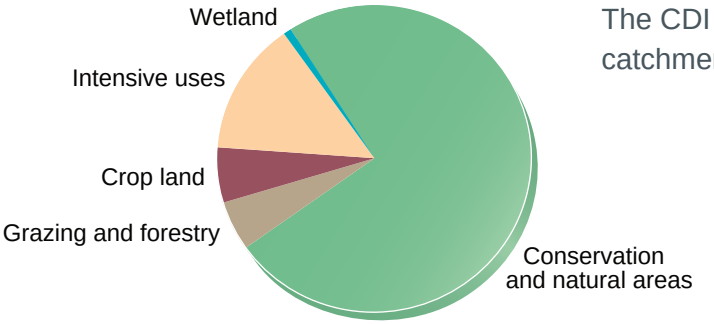
Sources of pollution

- High sediment and nutrient loads during the wet season from diffuse sources

View of lower Elizabeth River estuary looking towards Blaydin Point and Hudson Creek

Elizabeth River catchment showing rivers and monitoring sites

Land use in the catchment



Catchment disturbance index

The CDI for the Elizabeth River catchment is 0.84.

Water quality issues in the catchment

Mangroves help protect erosion of land surrounding the estuary.
Photo: George Maly

Construction in urban areas can contribute to increased pollutant loads to waterways. The city of Weddell is proposed in the Elizabeth River catchment.

Horticulture is an important industry but can be a source of pollutants such as nutrients and pesticides to waterways.

Elizabeth River catchment ambient freshwater water quality

Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	<200	32	11	✓
Turbidity (NTU)	<20	6.5	12	✓
pH	6.0–7.5	6.0–6.8	12	✓
Dissolved oxygen (%)	50–100	70–82	11	✓
Total suspended solids (mg/L)	<5	NA	NA	
Chlorophyll a (µg/L)	<2	<1	12	✓
NOx (µg N/L)	<8	4	9	✓
Ammonia (µg N/L)	NA	13	9	
Total nitrogen (µg N/L)	<230	170	9	✓
Total phosphorus (µg P/L)	<10	10	9	✓
Filterable reactive phosphorus (µg P/L)	<5	3	9	✓

Period sampled for current condition is 2009. NA Not available

Biological health using the AUSRIVAS score

Site	2003	2009	Change
DW26	A	A	No change
DW39	A	B	Change
DW40	A	A	No change
DW44	A	A	No change
DW52	B	A	Change
DW53	A	A	No change
DW71		A	
DW72		A	

Elizabeth estuary ambient marine water quality

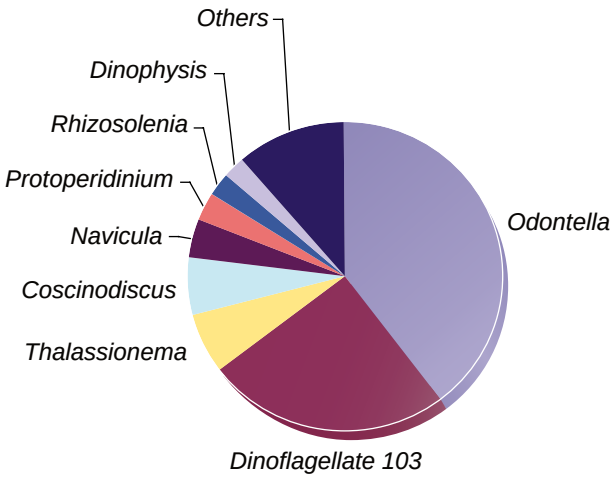
Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	NA	54250	6	
Turbidity (NTU)	NA	3.6	6	
pH	6–8.5	7.6–7.8	6	✓
Dissolved oxygen (%)	80–100	58–65	6	*
Total suspended solids (mg/L)	<10	17	6	*
Chlorophyll a (µg/L)	<4	2	6	✓
NOx (µg N/L)	<20	4	6	✓
Ammonia (µg N/L)	<20	11	6	✓
Total nitrogen (µg N/L)	<300	255	6	✓
Total phosphorus (µg P/L)	<30	13	6	✓
Filterable reactive phosphorus (µg P/L)	<10	4	6	✓

Period sampled for current condition is Sep 2008 to Dec 2009. NA Not available. * WQO currently under revision

Other monitoring

Phytoplankton

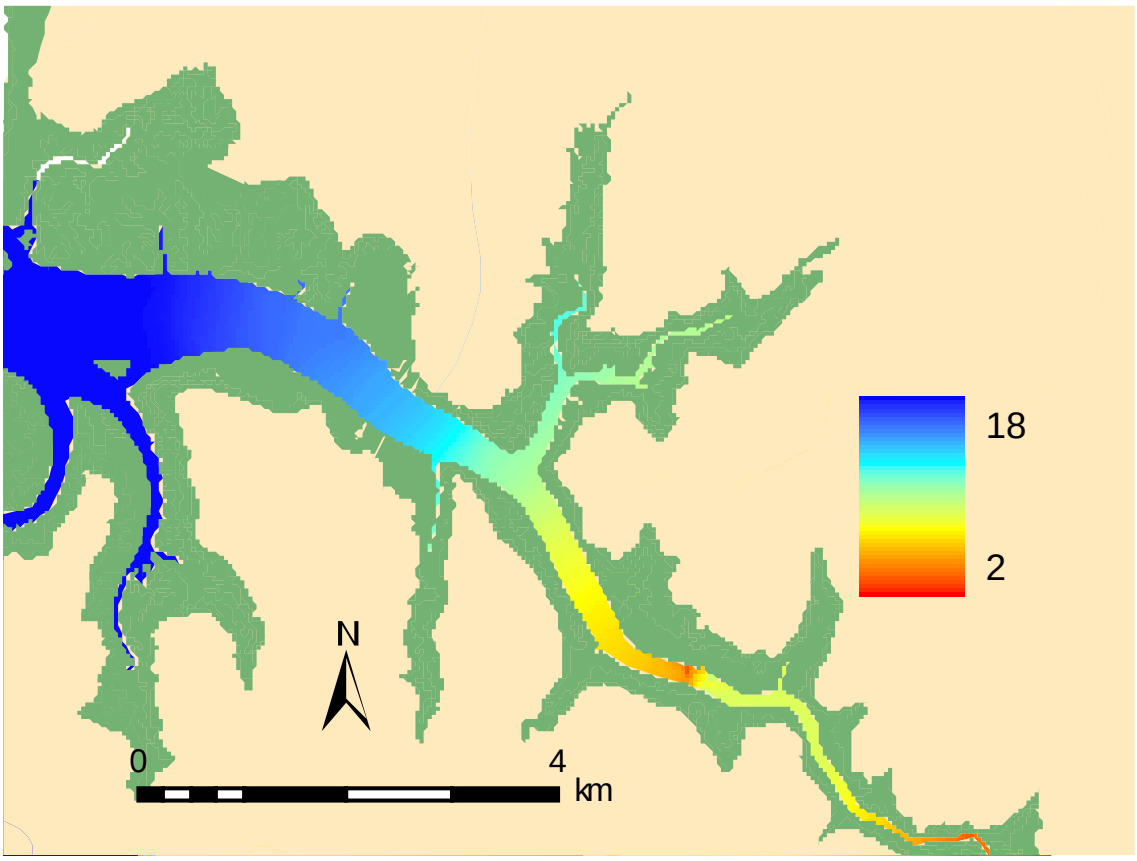
Phytoplankton (microscopic aquatic plants) community diversity has been studied in the Elizabeth River estuary. One hundred and sixteen phytoplankton taxa were identified in 29 samples from four sites in the 2006/07 wet season. These included 44 taxa of diatoms (Bacillariophyceae), 66 taxa of dinoflagellates (Dinophyceae) and small numbers of taxa of Chlorophyceae (1), Euglenophyceae (1), Cryptophyceae (2) and Cyanobacteria (2). Two taxa (the diatom *Odontella* and Dinoflagellate 103) comprised 65% of the total number of estimated cells. Monitoring studies in the dry and wet seasons of 2010/11 will examine spatial and temporal variation in phytoplankton communities in Darwin Harbour waters.



Water quality monitoring in a flood plume

Catchment runoff from storm events transports sediment, nutrients and pollutants to waterways. A flood plume was monitored in the Elizabeth River estuary on 3–4 March 2010 after 258 mm of rainfall during the previous nine days.

Flood plumes lower the salinity of receiving estuary waters. Normal marine water has a salinity of about 35 ppt. Salinity values ranged from 2–18 ppt during the plume. The outer estuary values of 18 ppt show strong influence of freshwater. Low salinity values in the upper estuary indicate mainly freshwater. Three weeks after the rainfall, salinity was 24–32 ppt showing that there was still some freshwater influence in the upper to mid estuary. These results show that the estuary is poorly flushed and has long water residence times.



Distribution of salinity (ppt) in Elizabeth River estuary, 3 March 2010. Red shading indicates low salinity values and is a natural occurrence after heavy rainfall.

Blackmore River and Estuary

Summary

Water quality at the upper estuary monitoring sites is in very good condition. Water quality at the freshwater monitoring sites is in good condition. The water-bug community at six out of seven biological monitoring sites is equivalent to reference condition.

Nature of system

- Long residence time and poor flushing in the upper estuary
- Light limitation during the wet season
- Minor freshwater flows are maintained by Darwin River Dam during the dry season
- Minor freshwater flows are maintained by natural groundwater sources from Berry Creek during the dry season
- Phytoplankton biodiversity typically greater in dry season

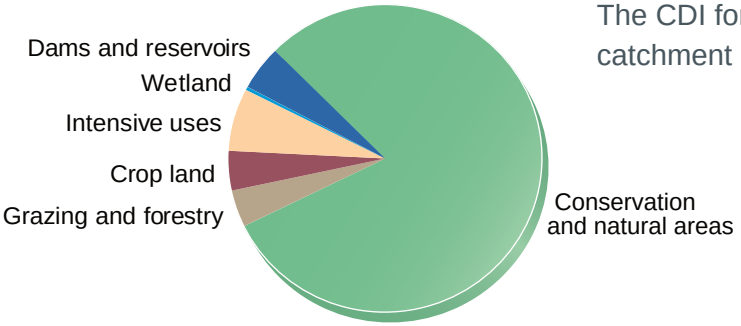
Sources of pollution

- Several licensed aquaculture operations are located in the catchment and discharge into the Blackmore estuary
- High sediment and nutrient loads during the wet season from diffuse sources

Darwin River Dam was constructed in 1972 and is designed to supply 200,000 people. Photo: John Drewry

Blackmore River catchment showing rivers and monitoring sites

Land use in the catchment



Catchment disturbance index

The CDI for the Blackmore River catchment is 0.91.

Water quality issues in the catchment

Cabomba is a declared weed in the NT but is present in Darwin River. The Northern Territory Government has an eradication program in place.

Darwin River Dam is the main drinking water supply for Darwin and surrounding area. Darwin people use up to three times more water per capita than in other Australian capital cities.

Horticulture is an important industry but can be a source of pollutants such as nutrients and pesticides to waterways.

Aerial view of an aquaculture operation in the Blackmore River catchment. Barramundi (*Lates calcarifer*), is a common aquaculture fish in the region. Photo: Jeremy Freeman

Blackmore River catchment ambient freshwater quality

Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	<200	69	9	✓
Turbidity (NTU)	<20	5.4	10	✓
pH	6.0–7.5	6.2–6.7	10	✓
Dissolved oxygen (%)	50–100	48–66	9	✗
Total suspended solids (mg/L)	<5	NA	NA	
Chlorophyll a (µg/L)	<2	2	10	✓
NOx (µg N/L)	<8	6	10	✓
Ammonia (µg N/L)	NA	21	10	
Total nitrogen (µg N/L)	<230	235	10	✗
Total phosphorus (µg P/L)	<10	15	10	✗
Filterable reactive phosphorus (µg P/L)	<5	4	10	✓

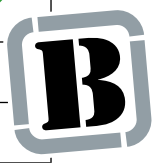
Period sampled for current condition is 2009. NA Not available

Biological health using the AUSRIVAS score

Site	2003	2009	Change
DW31	X	A	Change
DW36	B	A	Change
DW37	A	A	No change
DW46	A	A	No change
DW47	A	B	Change
DW73		A	
DW75		A	

Blackmore estuary marine ambient water quality

Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	NA	52700	59	
Turbidity (NTU)	NA	7	59	
pH	6–8.5	7.5–7.9	59	✓
Dissolved oxygen (%)	80–100	52–69	40	*
Total suspended solids (mg/L)	<10	19	59	*
Chlorophyll a (µg/L)	<4	2.5	59	✓
NOx (µg N/L)	<20	3	58	✓
Ammonia (µg N/L)	<20	9	55	✓
Total nitrogen (µg N/L)	<300	310	59	✗
Total phosphorus (µg P/L)	<30	15	59	✓
Filterable reactive phosphorus (µg P/L)	<10	8	58	✓



Period sampled for current condition is Sep 2008 to Dec 2009. NA Not available. * WQO currently under revision

Other monitoring

Cabomba

Cabomba caroliniana (cabomba) is a submerged aquatic plant native to South America. Cabomba is declared as a Class A weed (to be eradicated) and Class C weed (not to be introduced to the NT). Typical impacts of cabomba include significant reductions in biodiversity and a reduction in water quality. Cabomba was reported at Darwin River in 2004 within an 11 km stretch of the river. The Northern Territory Government has an eradication program in place.

The eradication program has reduced and contained the cabomba population to less than 1% of the level found in 2004. The program has prevented the re-establishment of infestations, production of flowers and seeds at all sites and also further spread and establishment. A monitoring program monitors water quality and macroinvertebrates. No off-target impacts within the project area or at downstream monitoring sites have been detected.

In the eradication program, herbicide is mixed with diatomaceous earth and applied directly onto submerged plants to minimise herbicide use and risk of off-target impacts.

Shoal Bay and Buffalo Creek

Summary

Water quality in outer Shoal Bay is in excellent condition. Several water quality indicators at some Shoal Bay upper estuary monitoring sites do not comply with water quality objectives, but water quality is in good condition. Water quality at the freshwater monitoring sites is in very good condition. The water-bug community is equivalent to reference condition at three out of four biological monitoring sites.

Estuarine water quality at monitoring sites in Buffalo Creek is in very poor condition. For some water quality indicators, water quality objectives are greatly exceeded. Of the sites monitored, the Buffalo Creek sites have the most degraded water quality in the Darwin Harbour region.

Nature of system

- Shallow embayment
- Series of sandbars changing with tides
- Light limitation during the wet season
- Perennial freshwater inflows from Howard River, typically most years in the wet and the dry seasons

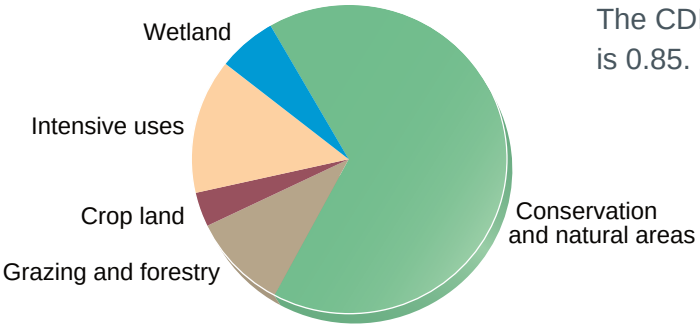
Sources of pollution

- Wet season diffuse source loads are received from the Howard and Shoal Bay sub-catchments
- Sediment and nutrient loads are high with runoff during the wet season
- Sewage treatment plant wastewater discharge at Buffalo Creek

Migratory shorebirds feeding between Lee Point and Buffalo Creek. Dogs are not permitted in this section of the beach to prevent disturbance to shorebirds as they provision for their northward journey. Photo: Brian Thistleton

Shoal Bay and Buffalo Creek catchment showing rivers and monitoring sites

Land use in the catchment

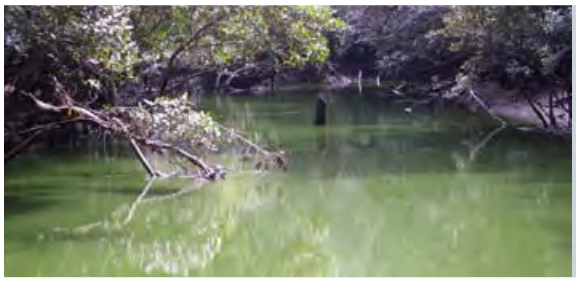


Catchment disturbance index

The CDI for the Shoal Bay catchment is 0.85.

Water quality issues in the catchment

Sampling sediment for assessing pollutant content near the Leanyer-Sanderson sewage treatment plant outfall.



Buffalo Creek receives treated wastewater discharge from the Leanyer-Sanderson sewage treatment plant. Water quality is poor.

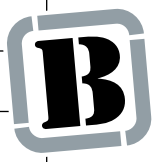
Lower Buffalo Creek is a popular recreation area, but subject to pollution from a sewage treatment plant.

Salvinia molesta is a free-floating aquatic fern that forms mats over water surfaces. Infestations can lead to degradation of water quality and reduced habitat quality for aquatic organisms. It occurs in the lower Howard River.

A grass swale (a water sensitive urban design feature), located in the centre of the road, is treating road runoff at Lyons residential development in Darwin before it discharges to Darwin Harbour.
Photo: Equatica

Shoal Bay catchment ambient freshwater quality

Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	<200	39	8	✓
Turbidity (NTU)	<20	4.7	8	✓
pH	6.0–7.5	6.1–6.5	8	✓
Dissolved oxygen (%)	50–100	74–84	8	✓
Total suspended solids (mg/L)	<5	NA	NA	
Chlorophyll a (µg/L)	<2	<1	8	✓
NOx (µg N/L)	<8	3	8	✓
Ammonia (µg N/L)	NA	11	8	
Total nitrogen (µg N/L)	<230	260	8	✗
Total phosphorus (µg P/L)	<10	10	8	✓
Filterable reactive phosphorus (µg P/L)	<5	2	8	✓



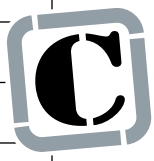
Period sampled for current condition is 2009. NA Not available

Biological health using the AUSRIVAS score

Site	2003	2009	Change
DW42	A	A	No change
DW43	B	B	No change
DW45	A	A	No change
DW70		A	

Shoal Bay upper area marine ambient water quality

Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	NA	55000	10	
Turbidity (NTU)	NA	19	10	
pH	6–8.5	7.7–8.0	10	✓
Dissolved oxygen (%)	80–100	65–77	10	*
Total suspended solids (mg/L)	<10	38	10	*
Chlorophyll a (µg/L)	<4	7	10	✗
NOx (µg N/L)	<20	2	10	✓
Ammonia (µg N/L)	<20	15	10	✓
Total nitrogen (µg N/L)	<300	360	10	✗
Total phosphorus (µg P/L)	<30	28	10	✓
Filterable reactive phosphorus (µg P/L)	<10	10	10	✓



Period sampled for current condition is Sep 2008 to Dec 2009. NA Not available. * WQO currently under revision

Outer Shoal Bay area marine ambient water quality

Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	NA	53400	10	
Turbidity (NTU)	NA	3.4	10	
pH	7.0–8.5	8.0–8.3	10	✓
Dissolved oxygen (%)	80–100	71–78	10	*
Total suspended solids (mg/L)	<10	18	10	*
Chlorophyll a (µg/L)	<2	0.5	10	✓
NOx (µg N/L)	<20	1	10	✓
Ammonia (µg N/L)	<20	6	10	✓
Total nitrogen (µg N/L)	<270	180	10	✓
Total phosphorus (µg P/L)	<20	5	10	✓
Filterable reactive phosphorus (µg P/L)	<5	4	10	✓

Period sampled for current condition is Sep 2008 to Dec 2009. NA Not available. * WQO currently under revision

Buffalo Creek marine ambient water quality

Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	NA	49800	9	
Turbidity (NTU)	NA	17	9	
pH	6–8.5	7.3–8.0	9	✓
Dissolved oxygen (%)	80–100	38–66	9	*
Total suspended solids (mg/L)	<10	28	9	*
Chlorophyll a (µg/L)	<4	29	9	✗
NOx (µg N/L)	<20	76	9	✗
Ammonia (µg N/L)	<20	533	9	✗
Total nitrogen (µg N/L)	<300	1510	9	✗
Total phosphorus (µg P/L)	<30	375	9	✗
Filterable reactive phosphorus (µg P/L)	<10	318	9	✗

Period sampled for current condition is Sep 2008 to Dec 2009. NA Not available. * WQO currently under revision

The Buffalo Creek monitoring site in the estuary is influenced by the treated wastewater discharged from the Leanyer-Sanderson sewage treatment plant outfall. The treatment plant is subject to a Waste Discharge Licence. In 2009, four additional sites were also monitored. All sites were between the outfall and upstream of the boat ramp. The licensed mixing zone is yet to be fully determined. It is possible that the Buffalo Creek monitoring site is located within the discharge mixing zone, and that the water quality objectives may not apply to this site.

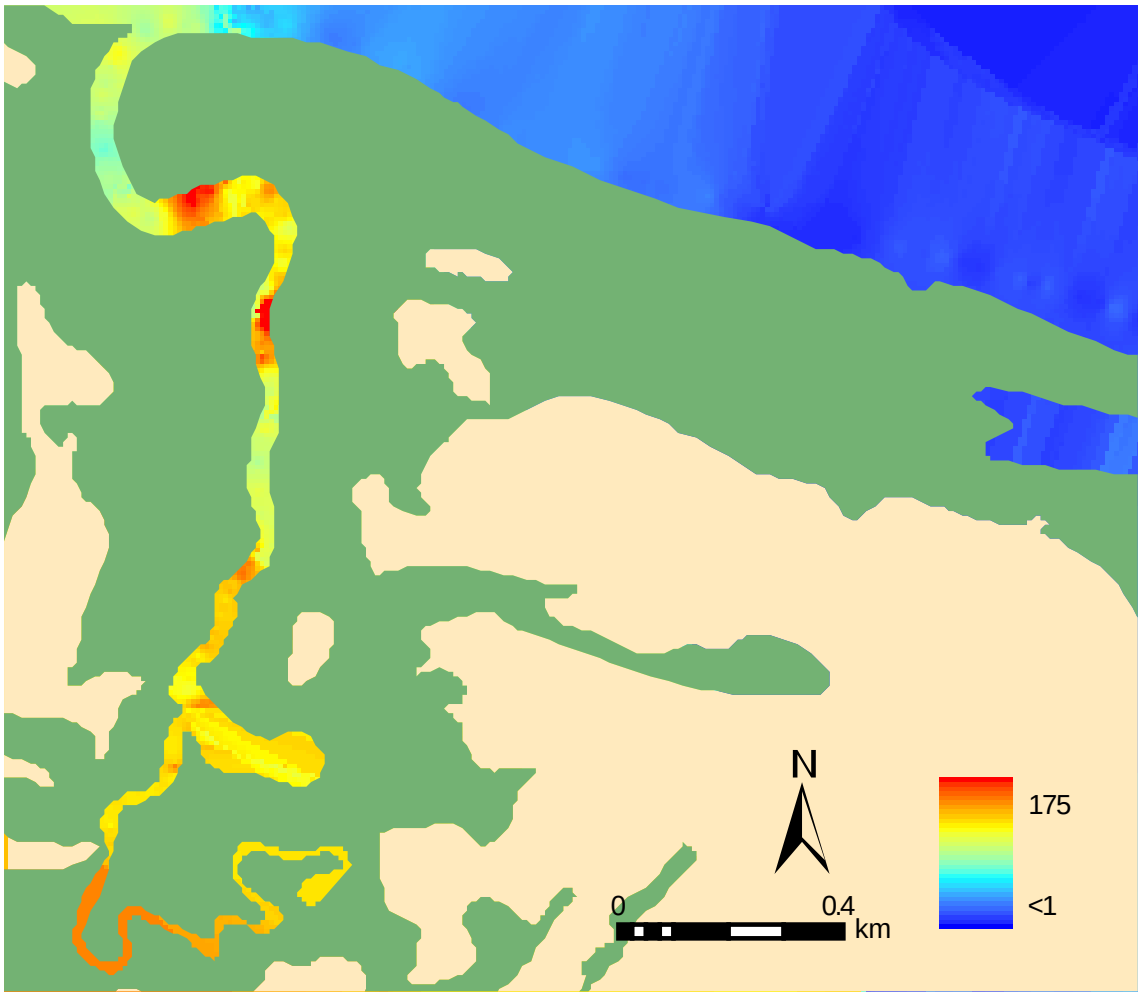
The Leanyer-Sanderson wastewater treatment plant uses a treatment system in waste stabilisation lagoons utilising a combination of sunlight, micro-organisms and algae to break down the raw wastewater. The presence of elevated concentrations of chlorophyll in Buffalo Creek may be largely due to the algae present in the treated wastewater discharge.

Other monitoring

Chlorophyll *a* mapping in Buffalo Creek

Chlorophyll *a* concentration in Buffalo Creek was mapped during the dry season in 2009 and wet season in 2010. In July 2009 chlorophyll *a* values were very high (>200 μg/L) in the upper estuary, with values <10 μg/L further downstream near a popular boat ramp.

In March 2010, chlorophyll *a* values were high (>80 μg/L) in the upper navigable part of the estuary. Greater chlorophyll *a* values (100–170 μg/L) were observed in parts of the mid estuary. Chlorophyll *a* values were approximately 60–75 μg/L near the boat ramp in the lower estuary, and <1 μg/L in Shoal Bay. The Darwin Harbour water quality objective for chlorophyll *a* is <4 μg/L for upper estuaries. These results show water quality in many parts of the estuary is in very poor condition.



Distribution of chlorophyll *a* (μg/L) in Buffalo Creek in March 2010.

Water quality sampling in Buffalo Creek. Buffalo Creek receives treated wastewater discharge from the Leanyer-Sanderson sewage treatment plant. Water quality is poor, with very high chlorophyll levels – hence the noticeable green colour of the water during this sampling. Photo: Julia Fortune

West Arm and Woods Inlet

Summary

Water quality at the West Arm and Woods Inlet upper estuary monitoring sites is in excellent condition. No freshwater or biological sites are routinely monitored in this region because the freshwater section of the streams is very short and flows for only a very brief part of the year.

Nature of system:

- Stream and riparian areas intact
- Large areas dry on spring tides in West Arm
- Extensive mangrove habitat and inter-tidal mudflats
- Minimal development in this region
- Most remote from development impacts within the Harbour, hence reference area

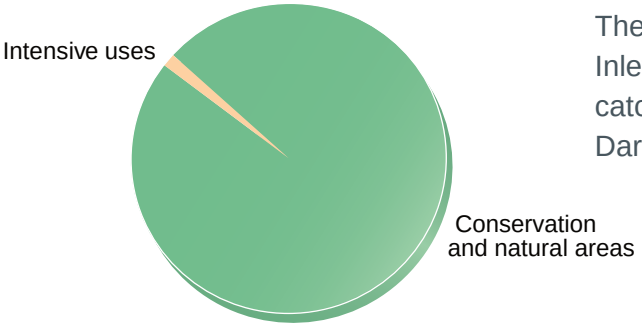
Sources of pollution:

- Considered to have minimal pollution
- Sediment and nutrient from catchment diffuse sources during the wet season
- West Arm region commonly considered as ‘reference’ condition to compare with other areas of Darwin Harbour

Sampling oysters (*Saccostrea cucullata*) for assessing micropollutant levels at a reef in West Arm. This area is commonly considered to be a “reference” area with minimal human impacts.

West Arm and Woods Inlet catchment showing rivers and monitoring sites

Land use in the catchment



Catchment disturbance index

The CDI for the West Arm/Woods Inlet catchment is 0.99. The West Arm catchment is the least disturbed in the Darwin Harbour region.

Water quality issues in the catchment

Sampling oysters (*Saccostrea cucullata*) for assessing micropollutant levels in a "reference" area in West Arm.

West Arm and Woods Inlet marine ambient water quality

Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	NA	54200	27	
Turbidity (NTU)	NA	3.4	27	
pH	6–8.5	7.9–8.2	27	✓
Dissolved oxygen (%)	80–100	65–74	27	*
Total suspended solids (mg/L)	<10	18	20	*
Chlorophyll a (µg/L)	<4	1	27	✓
NOx (µg N/L)	<20	3	27	✓
Ammonia (µg N/L)	<20	5	27	✓
Total nitrogen (µg N/L)	<300	220	27	✓
Total phosphorus (µg P/L)	<30	10	27	✓
Filterable reactive phosphorus (µg P/L)	<10	4	27	✓

Period sampled for current condition is Sep 2008 to Dec 2009. NA Not available. * WQO currently under revision

The Australian Institute of Marine Science research vessel “Solander” has been used in a collaborative project to assess micropollutant levels in molluscs in impacted areas of Darwin Harbour and unimpacted areas such as West Arm.

The blue-spotted fantail ray (*Taeniura lymma*) is a predator of molluscs on rocky reefs. Photo: Neil Wright

Rapid Creek

Summary

Water quality was monitored at one site in 2009. There were insufficient data to determine compliance with water quality objectives. Other monitoring data were not available for this report card. The water-bug community at the biological monitoring site is significantly impaired.

Nature of system

- Rapid Creek is the largest freshwater system within the Darwin city area
- A large proportion of the catchment has been cleared
- Stream corridor and riparian area remains relatively intact

Sources of pollution

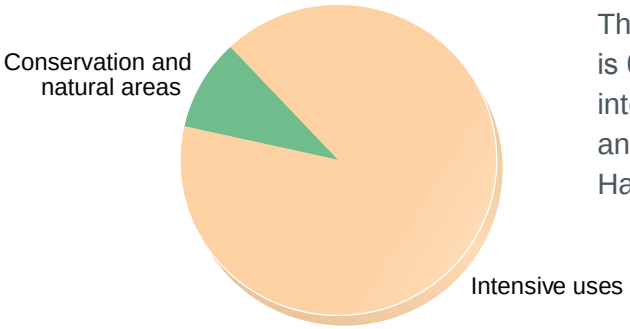
- High sediment, nutrient and other human-related pollutant loads during the wet season

View of lower Rapid Creek looking towards urban areas

Rapid Creek catchment showing rivers and monitoring sites

Rapid Creek is known as Gurambai to Larrakia people.

Land use in the catchment



Catchment disturbance index

The CDI for the Rapid Creek catchment is 0.38. This reflects the dominance of intensive land uses within the catchment, and is the most disturbed in the Darwin Harbour region.

Water quality issues in the catchment

Plate-separator pollution control system to intercept hydrocarbon contaminants at Darwin International Airport.

Rapid Creek and nearby beaches are popular recreation areas.

Rapid Creek catchment ambient freshwater quality

Indicator and units	Water quality objective	Current condition	Number of samples	Compliance
Electrical conductivity (µS/cm)	<200	42	1	Insufficient
Turbidity (NTU)	<20	1.8	1	Insufficient
pH	6.0–7.5	5.7	1	Insufficient
Dissolved oxygen (%)	50–100	82	1	Insufficient
Total suspended solids (mg/L)	<5	NA	NA	
Chlorophyll a (µg/L)	<2	<1	1	Insufficient
NOx (µg N/L)	<8	6	1	Insufficient
Ammonia (µg N/L)	NA	1	1	
Total nitrogen (µg N/L)	<230	50	1	Insufficient
Total phosphorus (µg P/L)	<10	5	1	Insufficient
Filterable reactive phosphorus (µg P/L)	<5	2	1	Insufficient

Period sampled for current condition is 2009. NA Not available. Insufficient = Insufficient data available.

Biological health using the AUSRIVAS score

Site	2003	2009	Change
DW21	B	B	No change

Rapid Creek. Photo: Nolan Caldwell

Further reading

Various reports on water quality and biological health from the AHU can be found at: http://www.nt.gov.au/nreta/water/aquatic/publications/index.html

For further information on water quality and biological indicators in the region, see the NRETAS website http://www.nt.gov.au/nreta/water/aquatic/ausrivas/index.html

For further information on water quality, see ANZECC guidelines and publications http://www.environment.gov.au/about/councils/anzecc/index.html#reports http://www.mincos.gov.au/publications/national_water_quality_management_strategy

Glossary

Explanations of water quality and biological indicators are presented separately in the Interpretation section.

Terms	Definition
Ambient water quality	Background water quality levels in waterways. In freshwater streams this commonly refers to low flow (non event) conditions.
Diffuse source	Refers to transport (such as runoff) from non-point sources such as urban paved or non-paved areas, hillslopes, agricultural land and forest.
Enterococci	A group of faecal bacteria common to the faecal matter of warm-blooded animals, including humans. Now referred to in Europe as the intestinal enterococci (NHMRC 2008). Note that *Enterococcus* is a genus and enterococci is a group.
Event-mean concentration	A measure of total load in an event such as a storm divided by total flow.
Flushing	The capacity of tidal movement to dilute a body of water.
Macroinvertebrate (or 'water-bug')	Aquatic macroinvertebrates are animals that have no backbone, are visible with the naked eye and spend all or part of their life in water. This diverse group includes insects, crustaceans, worms, and molluscs.
Mixing zone	An agreed area of receiving waters where water quality objectives may not be met. Mixing zones are at licensed wastewater discharge outfalls. The mixing zone should be determined through modelling to the satisfaction of the Controller (e.g. from NRETAS), and be verified with field monitoring.
Phytoplankton	Microscopic aquatic plants.
Point source	Discharge from a single point, such as an outlet pipe. Can refer to runoff or wastewater discharges.
Sewage treatment plant	A facility that processes wastewater and partially removes materials that damage water quality.
Water quality objective	Water quality objectives act as local waterbody guideline levels and/or reference levels to help guide planning and water management. Water quality objectives describe the water quality needed to protect Beneficial Uses identified by the community.