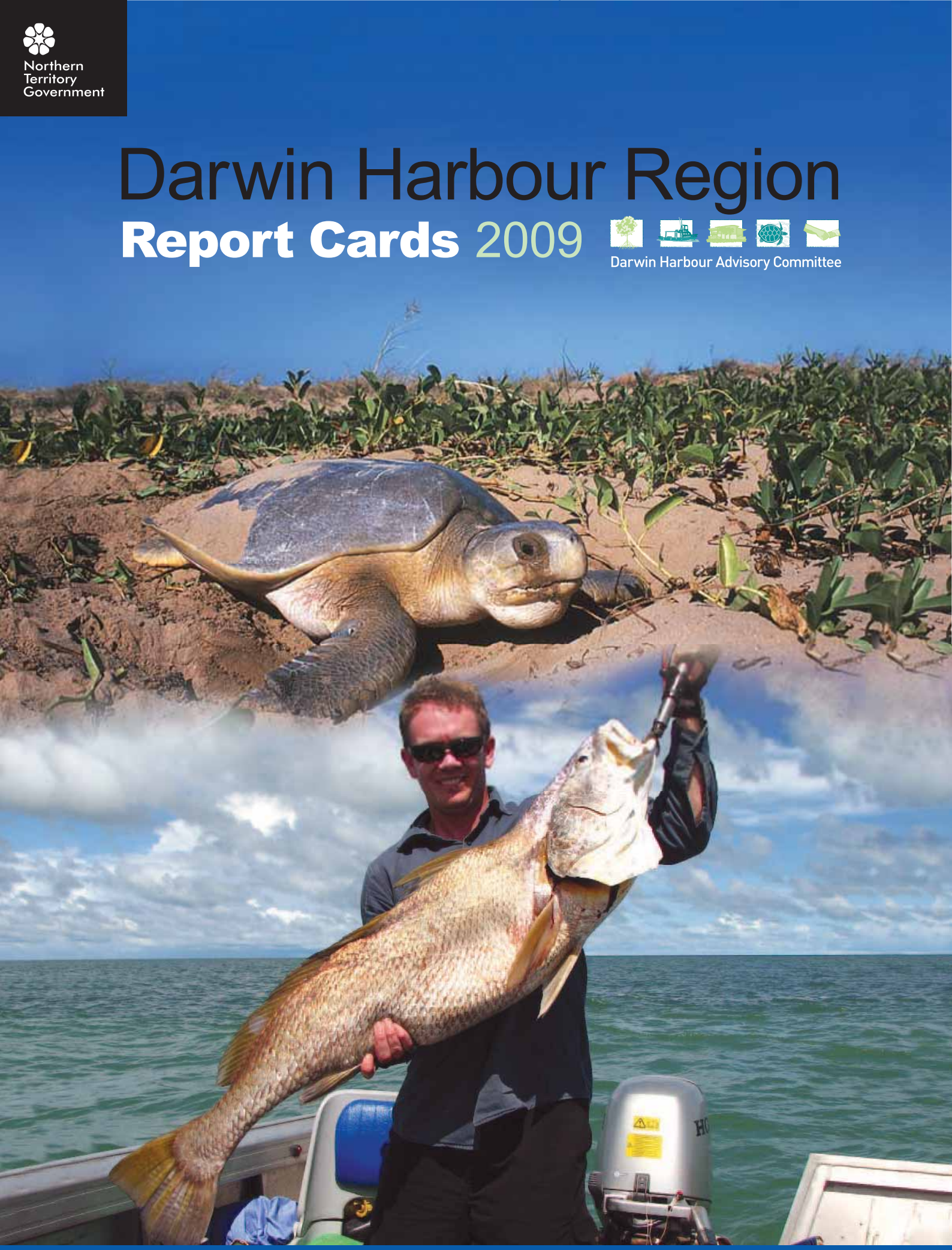
Northern Territory Government

Darwin Harbour Region

Report Cards 2009

Darwin Harbour Advisory Committee



fresh ideas | real results

This report was compiled by Julia Fortune and John Drewry, with contributions from Gisela Lamche, Peter Dostine, Julia Schult, Tony Boland, Matt Majid and George Maly.

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Darwin Harbour Advisory Committee

Our Harbour, Our Life, Our Future

Australian Government

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Cover photos
The Black Jewfish (*Protonibea diacanthus)* is one of the Top End's largest reef fish. This 120 cm specimen was caught in Shoal Bay. Photo by Mike Welch.
Flatback turtle (*Natator depressus*) in the Darwin Harbour region. Photo by Scott Whiting.
Tornier's Frog (*Litoria tornieri)* is infrequently encountered throughout the Darwin Harbour region. Photo by Peter Dostine.
A new boat ramp at East Arm. Photo by Tony Boland.

Minister's Message

Territorians and visitors to the Top End place a high value on Darwin Harbour. It is a wonderful natural asset - a special place which encapsulates the tropical character for which the region is renowned. It is a place which we use for fishing, boating and other recreational pursuits and a place which holds significant heritage and cultural value. The Harbour is also the hub of commercial activity in the region and a major port vital to our regional economic growth. Government and the community play an important role in striking the balance between these competing uses and maintaining the region's environmental integrity.

Protecting water quality and aquatic health will allow us to continue to enjoy the ecosystem services that Darwin Harbour and its environment provide. Monitoring aquatic health in the face of growing pressures is essential. The report card allows all of us to track water quality and aquatic health for management actions necessary to protect our waterways and their important values.

The Northern Territory Government, through the Department of Natural Resources, Environment, The Arts and Sport and the Darwin Harbour Advisory Committee is committed to supporting actions to maintain and monitor water quality in and around Darwin Harbour.

The Australian Government's investment in water quality and research effort through the Water Quality Protection Plan in the region will ensure the continued viability of waterways for future generations and lay the foundations for maintaining our waterways as important natural and cultural assets.

Karl Hampton
Minister for the Natural Resources, Environment and Heritage.

Message from the Chair of the Darwin Harbour Advisory Committee

As the Chair of the Darwin Harbour Advisory Committee (DHAC), I am pleased to share with you the first Darwin Harbour region report cards.

I believe that better understanding our beautiful Harbour is the responsibility of all of us who fish her waters or walk her beaches. Becoming better informed about Darwin Harbour's health is a important step towards managing this culturally, economically and environmentally vital area for our sustainable use and appreciation, today and in the future. These report cards help make that vision possible.

The Darwin Harbour region report cards are the result of hard work by DHAC's partners at the Aquatic Health Unit of the Department of Natural Resources, Environment, The Arts and Sport, and I applaud their commitment to share the results of their research and monitoring efforts with the public. DHAC has supported this work, and we see the report cards as advancing the broader goals of the Darwin Harbour Strategy 2009–2015, a strategy that provides guidance for the integrated management of the Harbour.

While the report cards highlight the excellent condition of many parts of the Harbour, there remains much work to be done. Declining water quality in the region has the potential to affect aquatic ecosystems, biodiversity, tourism, aquaculture, Indigenous harvest and the recreational fishing that I so enjoy. We all have an interest in understanding – and improving – the health of our waterways, and the release of these report cards is truly a milestone in our united effort to be good stewards of Darwin Harbour.

Bill Stuchbery
Chair
Darwin Harbour Advisory Committee

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

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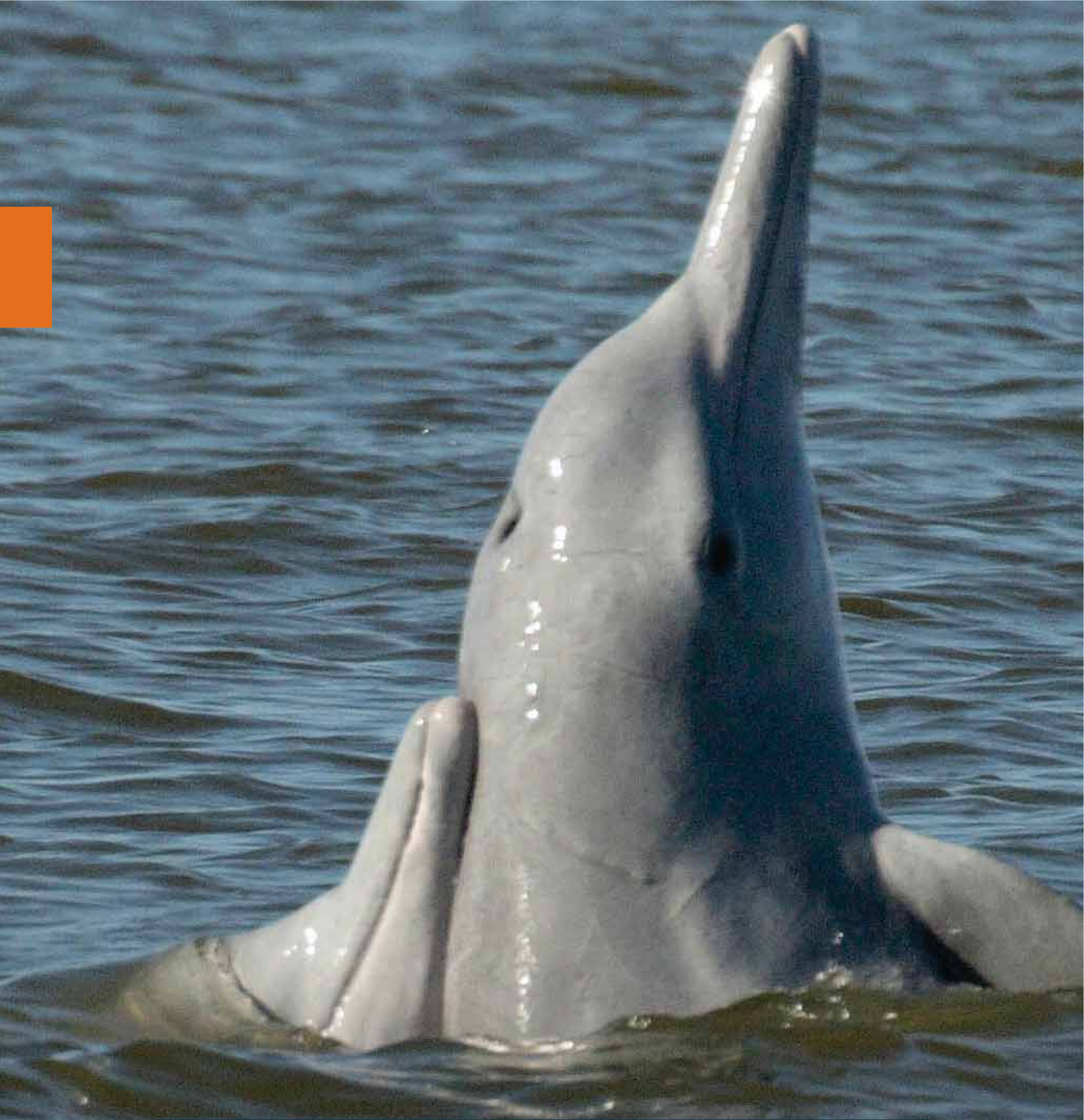


The Indo-Pacific humpback dolphin (*Sousa chinensis*) is known as a coastal or near-shore dolphin and is typically found in small populations inhabiting shallow, coastal and estuarine waters, usually within about 10 km of land, in water less than 15 m deep and within about 20 km from the nearest river mouth. Indo-Pacific humpback dolphins are residents of Darwin Harbour and have been recorded in the main harbour but also in many of the rivers that flow into the harbour. The harbour and associated estuaries are important areas for foraging, calving and raising young. The 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 Northern Territory Government's 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 of the Darwin harbour region. Photo by Carol Palmer

Darwin Harbour Region

This coral (*Tubastrea sp.*) is commonly found in Darwin Harbour.
Photo by Tony Ayling

Summary

The aquatic environment of the Darwin Harbour region is overall in a healthy state, but vulnerable to localised degradation mainly from wastewater, urban stormwater, and the impact of aquatic weeds and pests.

Rivers and streams of Darwin Harbour's catchment are largely in good health. River flows have not been significantly modified by dams and weirs, water quality is considered good in most cases, and it supports a diverse range of flora and fauna. The fringing vegetation or the riparian zone of streams helps protect them from the effects of catchment land use, and is mostly in good condition, except in urban areas of the Darwin region where the pressures of land use have impacted stream water quality and macroinvertebrate diversity.

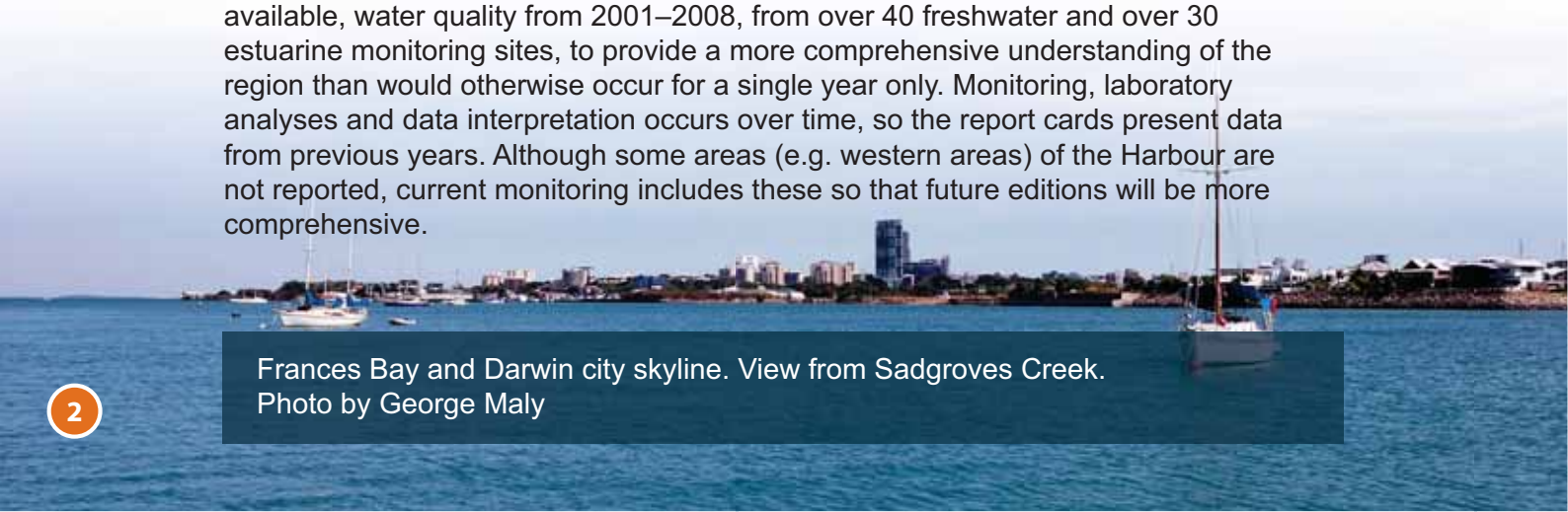
Darwin Harbour is a large estuary that experiences substantial tidal variation. The water quality of Darwin Harbour varies with tide, season and location. Over each tidal cycle, and between neap and spring tides, the water clarity can change dramatically. This is most notable in the upper reaches of the estuary where water carrying sediment flows out of mangrove-lined tidal creeks. River inflows affect the salinity of the Harbour and for lengthy periods of time during the wet season the upper reaches can be affected by large plumes of freshwater and the pollutants they carry. The estuary is a complex system. Understanding how the system 'ticks' is important in determining monitoring requirements, management interventions and measuring their effectiveness.

Darwin Harbour estuary is subject to point source discharges (licensed wastewater input from sewage treatment plants), and diffuse source discharges (non-point, such as stormwater from a catchment). These discharges are typically high in sediment and nutrients and can result in degraded water quality, particularly in parts of the Harbour that are poorly flushed. Although the estuarine waterways of the region are generally in good shape, several areas subject to point sources and urban influence show signs of localised impact, and poor water quality.

The report cards

This first series of Darwin Harbour region report cards describes the health of aquatic ecosystems across the Harbour and its catchment. The report cards provide a snapshot of water quality and biological health, and show how these natural systems appear to be coping with growing pressures in the region. They have been produced by the Department of Natural Resources, Environment, The Arts and Sport Aquatic Health Unit in conjunction with the Darwin Harbour Advisory Committee.

This first series of report cards produced in 2009 summarise data collected by the Northern Territory Government for biological health from 2001–2007 and, where available, water quality from 2001–2008, from over 40 freshwater and over 30 estuarine monitoring sites, to provide a more comprehensive understanding of the region than would otherwise occur for a single year only. Monitoring, laboratory analyses and data interpretation occurs over time, so the report cards present data from previous years. Although some areas (e.g. western areas) of the Harbour are not reported, current monitoring includes these so that future editions will be more comprehensive.



Frances Bay and Darwin city skyline. View from Sadgroves Creek.
Photo by George Maly

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 turtles, dugong, barramundi, sea eagles, magpie geese and agile wallabies 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.

Our intact natural systems underpin our lifestyle. Many Darwin region residents have an appreciation of the great wealth of natural resources that this region provides. Sustainability demands that our use of the natural resources we so value and derive benefit from are maintained for future generations. Therefore, to maintain the enviable Darwin lifestyle we all enjoy, it will be necessary to match economic growth with sound environmental management.

Water resources in the region support a diverse range of aquatic ecosystems and species which are significant cultural and recreational assets. However, the recent discovery of the aquatic freshwater weed Cabomba (*Cabomba caroliniana*) in Darwin River, 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 preserve 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 catchments. 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

Darwin Harbour has been home to the Larrakia people for thousands of years. For the Larrakia, the region's environments are 'cultural landscapes' that are vital to their well-being. Larrakia 'country' consists of both land and sea. Tidal mudflats and mangrove lined waterways, lagoons, floodplains, woodland and the sea itself comprise a variety of plant, animal and marine resources which are managed, harvested, hunted and fished by Larrakia people. Larrakia people have oral traditions and written documentation of their unbroken relationship to their land, sacred sites, stories and resources. A rich oral history links land, sea and culture from generation to generation.

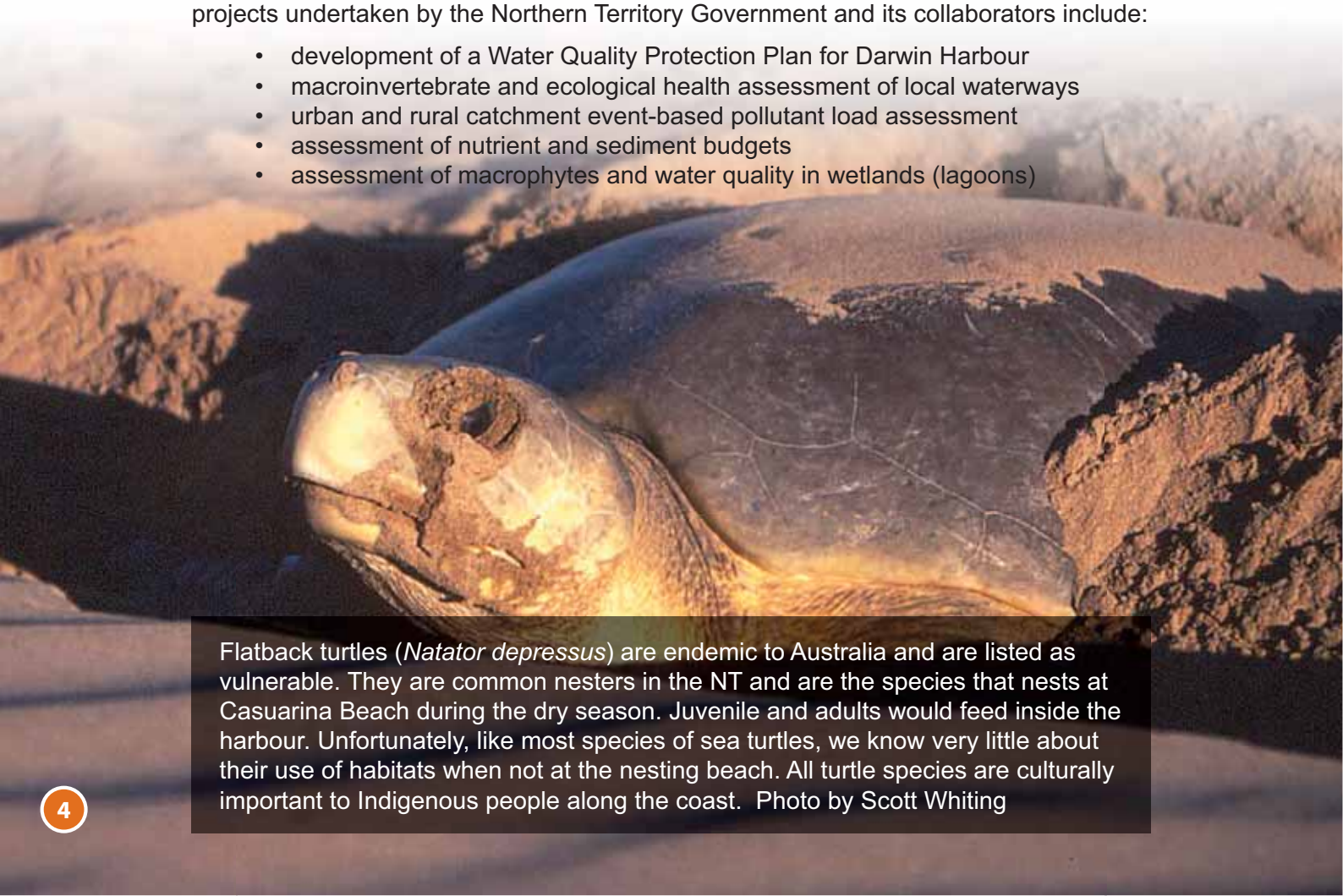
The incredible value of the Harbour's biodiversity is still being realised. Its flora, in particular mangroves and aquatic plants, and threatened or rare fauna present immense biological and cultural value to the region. Exploring opportunities to maintain these iconic species through the combination of traditional knowledge and scientific approaches to conservation is important.

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
- macroinvertebrate and ecological health assessment of local waterways
- urban and rural catchment event-based pollutant load assessment
- assessment of nutrient and sediment budgets
- assessment of macrophytes and water quality in wetlands (lagoons)



Flatback turtles (*Natator depressus*) are endemic to Australia and are listed as vulnerable. They are common nesters in the NT and are the species that nests at Casuarina Beach during the dry season. Juvenile and adults would feed inside the harbour. Unfortunately, like most species of sea turtles, we know very little about their use of habitats when not at the nesting beach. All turtle species are culturally important to Indigenous people along the coast. Photo by Scott Whiting

Understanding water quality and pollution sources

Mangroves in Bleesers Creek. Conservation of mangroves helps prevent erosion of land surrounding the harbour. Photo by George Maly

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 phosphorus to the Harbour (see project section).

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, and these are reported in the report cards.

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 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 turbidity, oxygen and phytoplankton growth.

Other pollutants

For some pollution indicators little data is 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 region

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. 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. Mangrove 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.

Legend

Monitoring sites

- Estuarine

Pollution sources

- Aquaculture
- Sewage treatment plant wastewater
- Sediment/nutrient inputs
- Nutrient inputs
- Toxicant inputs
- Grazing
- Horticulture
- Industry

Process/transport

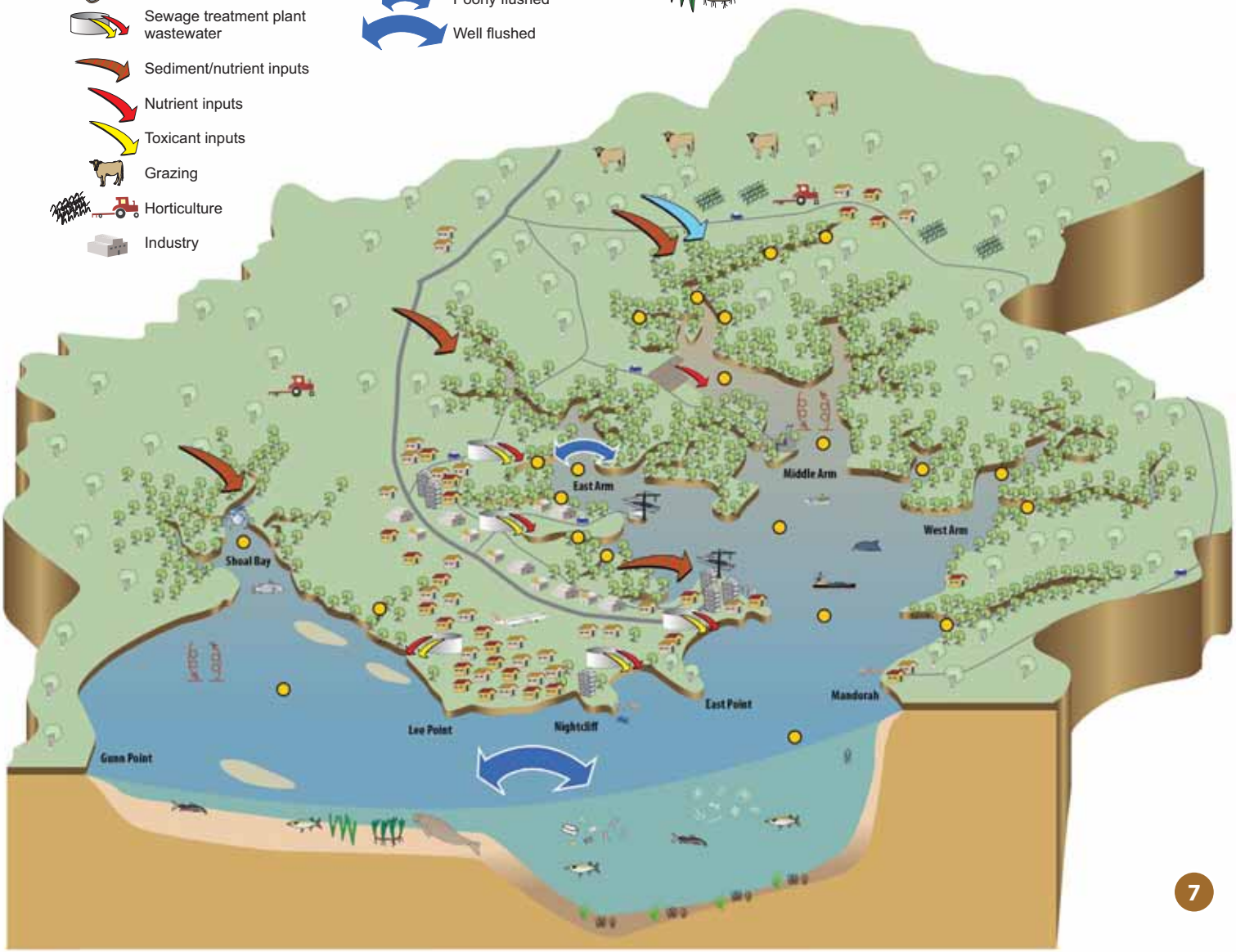
- Deposition
  Resuspension
- Freshwater inflows/inputs
- Poorly flushed
- Well flushed

Ecological impacts

- Diatoms
- Phytoplankton
- Seagrass

Other

- Sandbar
- Mangrove
- Urban/residential



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 outer Harbour areas scour the bottom so this area is not as productive. Rocky areas are rich in corals, algae and aquatic fauna.

Salinity

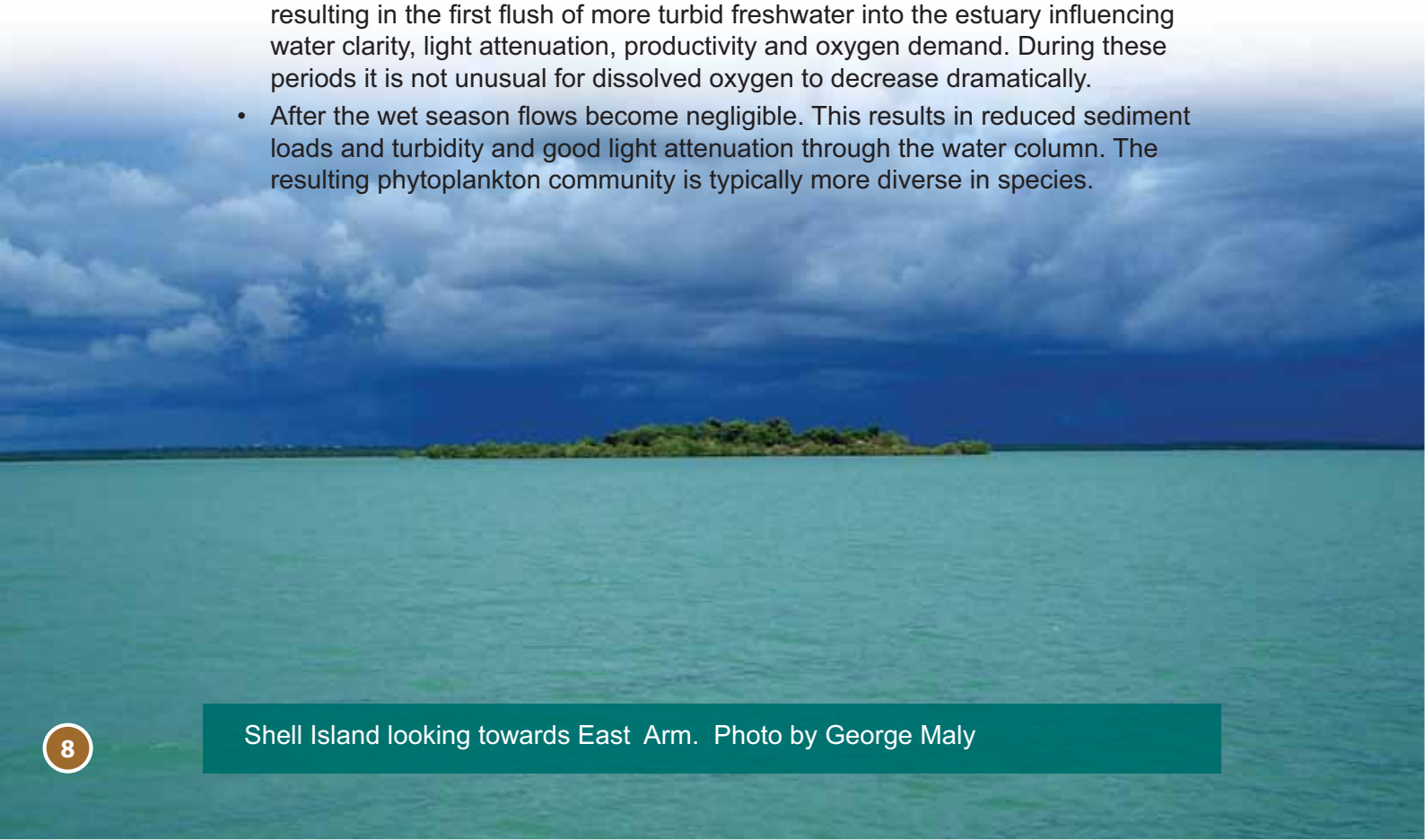
- The diagram shows that water quality in the estuary is distinct between the wet and dry seasons. During the dry season the salinity gradient is quite uniform and the estuary well mixed. This contrasts with wet season conditions where the salinity gradient is met in the upper estuary by a buoyant plume 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.

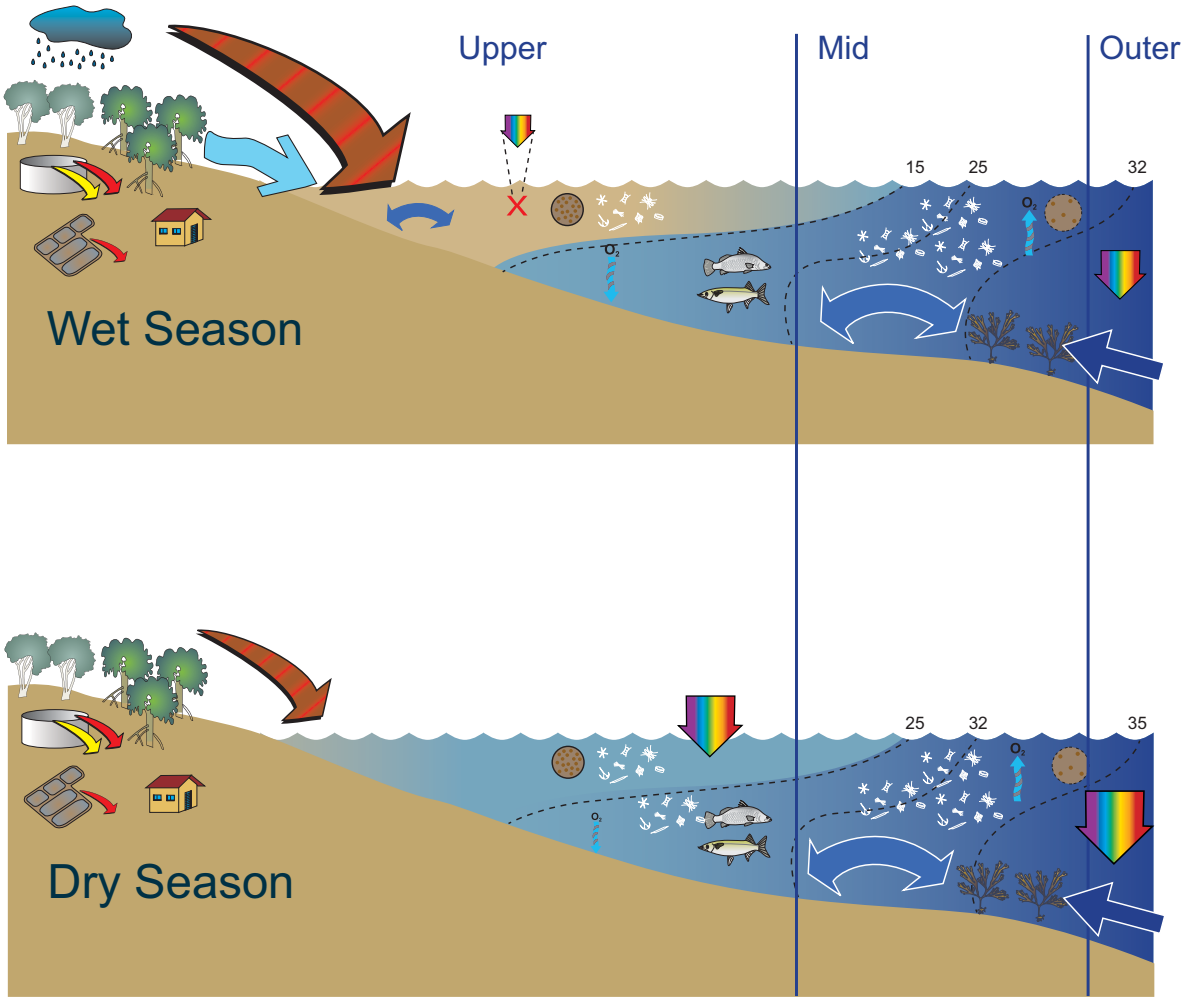
Turbidity, dissolved oxygen and phytoplankton

- Turbidity is at its highest in the wet season. Rainfall events begin in November resulting 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 by George Maly

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



Legend

Pollution sources

- Sewage treatment plant input
- Aquaculture input
- Sediment and nutrient inflow
- Urban/ residential

Process/transport

- Freshwater inflow
- Flushing
- Upstream flow at bed (tidal influence)
- Oxygen flux Sediment

Impacts

- High turbidity
- Low turbidity
- Light limitation
- High light level
- Phytoplankton
- Macroalgae
- Isohalines (ppt) of salinity

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. As shown in the previous diagram, 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

This table shows key indicators for water quality.

Symbol	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 (Chl-a)	The green component of plants used in photosynthesis.	Is used as an index of the amount (biomass) of algae.
NOx	NO_x	Nitrate + nitrite (dissolved) forms of nitrogen	Nitrate stimulates plant growth. Travels with water in solution.
AM	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.
TN	Total nitrogen	Nitrogen.	Nitrogen is essential for living organisms. Includes all forms of nitrogen.
TP	Total phosphorus	Phosphorus.	Phosphorus is essential for living organisms. Travels with sediment in water.
FRP	Filterable reactive phosphorus	Fraction of phosphorus that passes through a fine filter.	Stimulates aquatic plant growth. Travels with water in solution.

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.

Interpreting the report cards

Dugongs (*Dugong dugon*) are sometimes seen in the Channel Island, Elizabeth River estuary and other parts of Darwin Harbour. Better knowledge of habitat use by dugongs and other species in the harbour is a priority area for future research to help protect them from habitat loss, boat strikes and pollution. Darwin is the only known location where dugongs feed off algae and plants that grow on shallow rock reefs rather than seagrass only. Casuarina Coastal Reserve is the only known seagrass habitat in Darwin Harbour, and is a key habitat for dugongs. Seagrasses are highly vulnerable to human impacts such as pollution, and climate change. Dugongs are culturally important to Indigenous people along the coast. Photo by Scott Whiting

Introduction

This section contains information to help interpret the report cards.

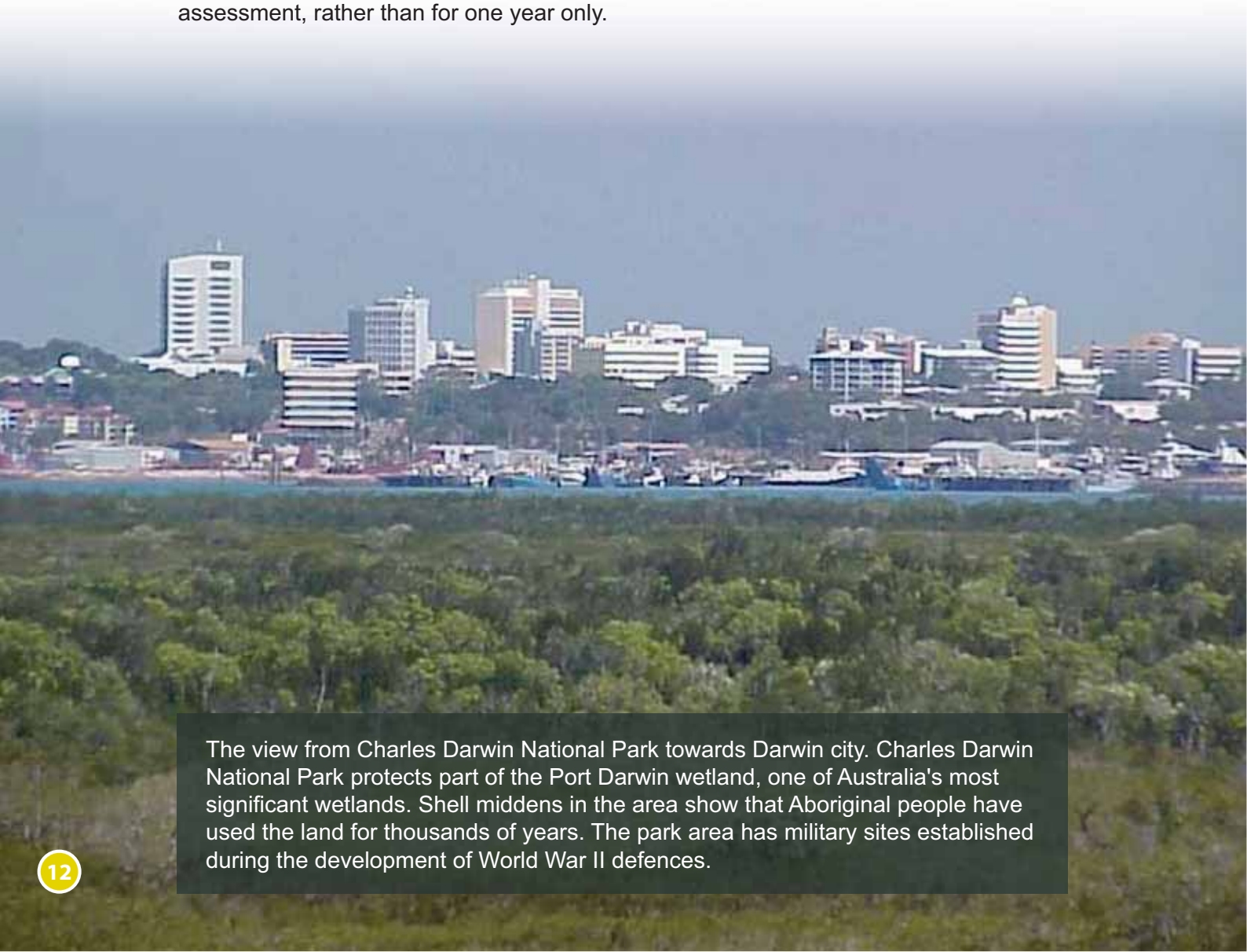
Water quality

Darwin Harbour water quality (referred to as estuarine), catchment freshwater (ambient or low flow conditions) and catchment event-based monitoring 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 ANZECC guidelines and related publications.

Biological indictors

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 from 2001–2007, so these results in the report cards provide a robust assessment, rather than for one year only.



The view from Charles Darwin National Park towards Darwin city. Charles Darwin National Park protects part of the Port Darwin wetland, one of Australia's most significant wetlands. Shell middens in the area show that Aboriginal people have used the land for thousands of years. The park area has military sites established during the development of World War II defences.

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 becomes 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 will be 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.

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.

Event-based freshwater quality loads and event-mean concentrations

Current condition: The current water quality condition, as event mean concentration (EMC), was estimated from event-based loads for the catchment draining to the stream gauge station during storms in the 2006–07 wet season, where available. EMC is useful to help compare concentrations between catchments. Water quality samples were collected using a flow-weighted composite sampling technique. Northern Territory Government monitoring sites are shown on the maps.

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

Whole catchment load for an average wet season: In addition, an estimate of the total load in an average wet season for the larger surrounding catchment area was made from load and catchment data on a generation rate per unit area basis from Skinner et al. (2009).

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 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 A means streams are equivalent to high quality reference steams; bands B, C, or D indicate that the stream is below reference condition and is degraded to varying degrees. Northern Territory Government monitoring sites are shown on the maps. The number of types of water-bug present in Darwin streams varies between 19 and 51. A total of 150 different water-bug types are used in assessment of streams in the region.

The table explains how to interpret bands from AUSRIVAS.

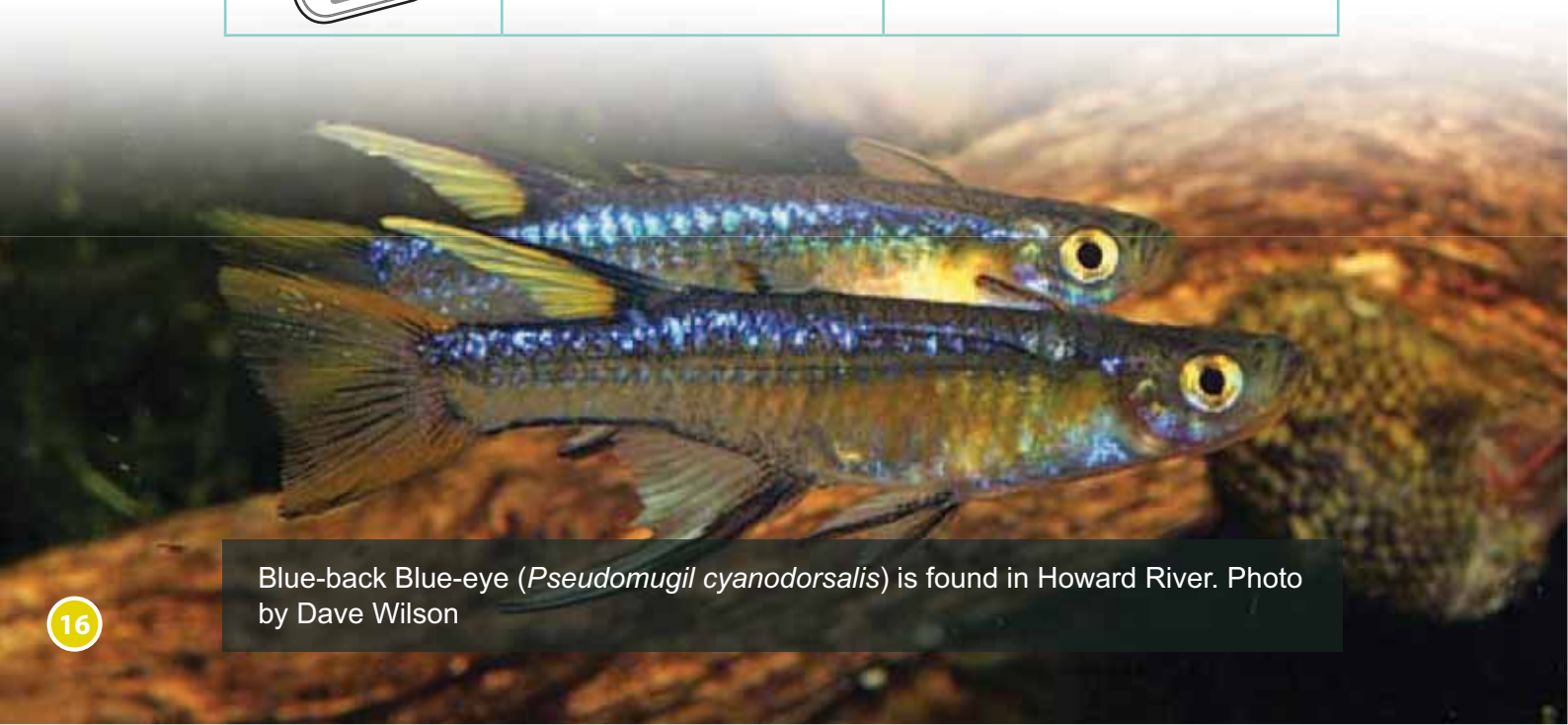
Band	Description	What it represents
X	More biologically diverse than reference	More types found than expected. Potential biodiversity "hot-spot" or mild organic enrichment.
A	Similar to reference	O/E scores range found at 80% of the reference sites, or equivalent to reference condition.
B	Significantly 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.

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 (see previous page) listed for ambient freshwater or marine water. Where available, the rating uses the compliance of 9 indicators for marine water, and 10 indicators for ambient freshwater. Further details are presented below. This rating method may change when other catchment and water quality assessment schemes are further developed.

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



Blue-back Blue-eye (*Pseudomugil cyanodorsalis*) is found in Howard River. Photo by Dave Wilson

Darwin Harbour report card 2009

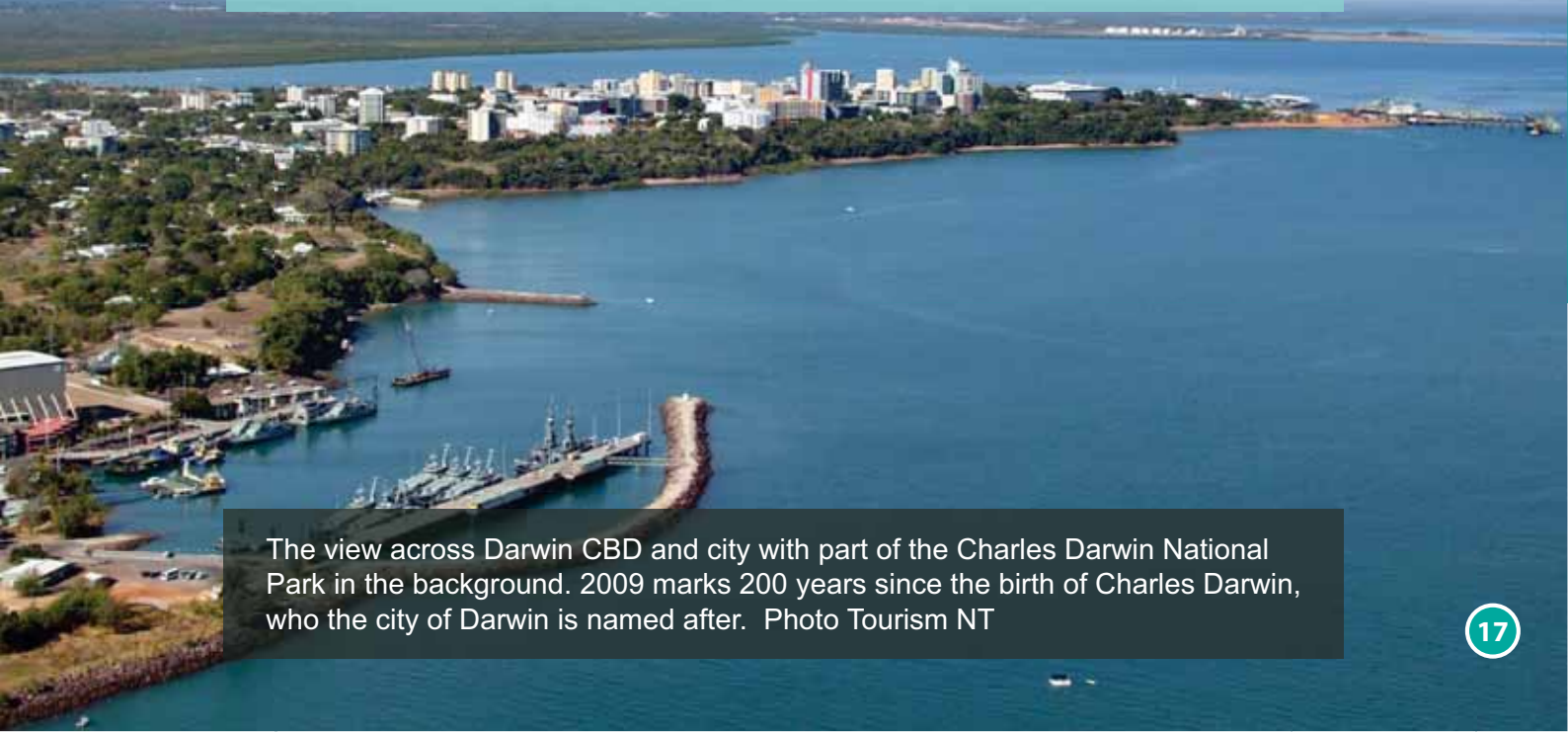
Water quality at the outer and mid Harbour monitoring sites is in excellent condition and complies with water quality objectives.

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

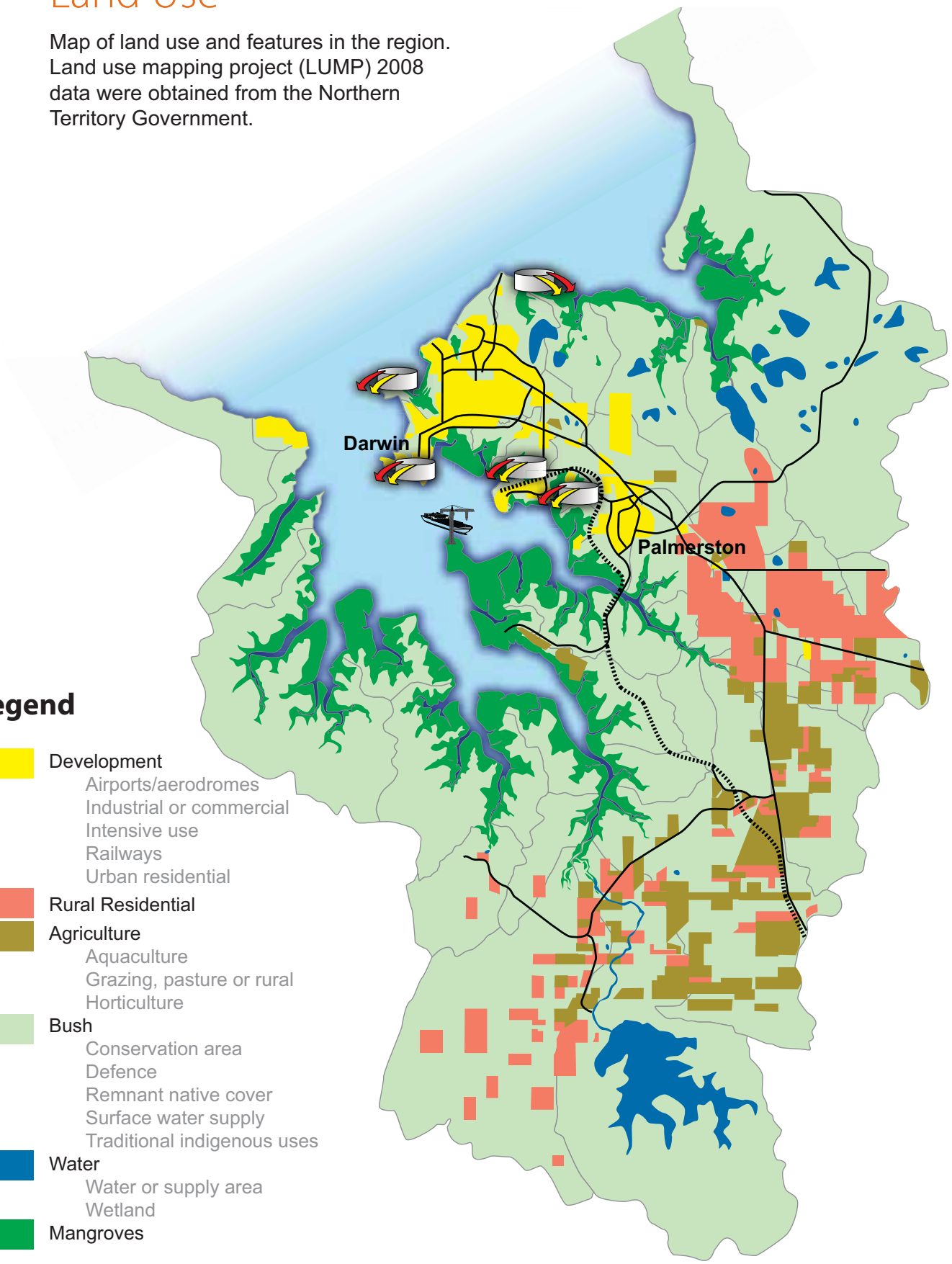
- High sediment, nutrient, industrial and other human-related pollutant loads during the wet season
- Sewage treatment plant wastewater discharges at several points in the Harbour
- Other licensed wastewater discharges at several points in the Harbour
- Sediment and nutrient loads in stormwater runoff 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. 2009 marks 200 years since the birth of Charles Darwin, who the city of Darwin is named after. Photo Tourism NT

Land Use

Map of land use and features in the region. Land use mapping project (LUMP) 2008 data were obtained from the Northern Territory Government.



Legend

- Development
  - Airports/aerodromes
  - Industrial or commercial
  - Intensive use
  - Railways
  - Urban residential
- Rural Residential
- Agriculture
  - Aquaculture
  - Grazing, pasture or rural
  - Horticulture
- Bush
  - Conservation area
  - Defence
  - Remnant native cover
  - Surface water supply
  - Traditional indigenous uses
- Water
  - Water or supply area
  - Wetland
- Mangroves
- Sewage treatment plant
- LNG plant
- Road
- Railway
- Catchment boundary

0 6 12km

N

Darwin Harbour outer area marine ambient water quality

Symbol	Indicator and units	Water quality objective	Current condition	Sample number for current condition	Compliance
	Electrical conductivity (µS/cm)	NA	53700	38	
	Turbidity (NTU)	NA	5.2	38	
	pH	7.0-8.5	8.1-8.3	38	✔
O_2	Dissolved oxygen (%)	80-100	89-94	38	✔
	Total suspended solids (mg/L)	<10	4	33	✔
	Chlorophyll a (µg/L)	<1	0.5	36	✔
NO_x	NOx (µg N/L)	<10	5	37	✔
AM	Ammonia (µg N/L)	<20	5	36	✔
TN	Total nitrogen (µg N/L)	<440	363	30	✔
TP	Total phosphorus (µg P/L)	<20	5	37	✔
FRP	Filterable reactive phosphorus (µg P/L)	<10	7	37	✔

Period sampled for current condition is 2003-2006. NA not available

A

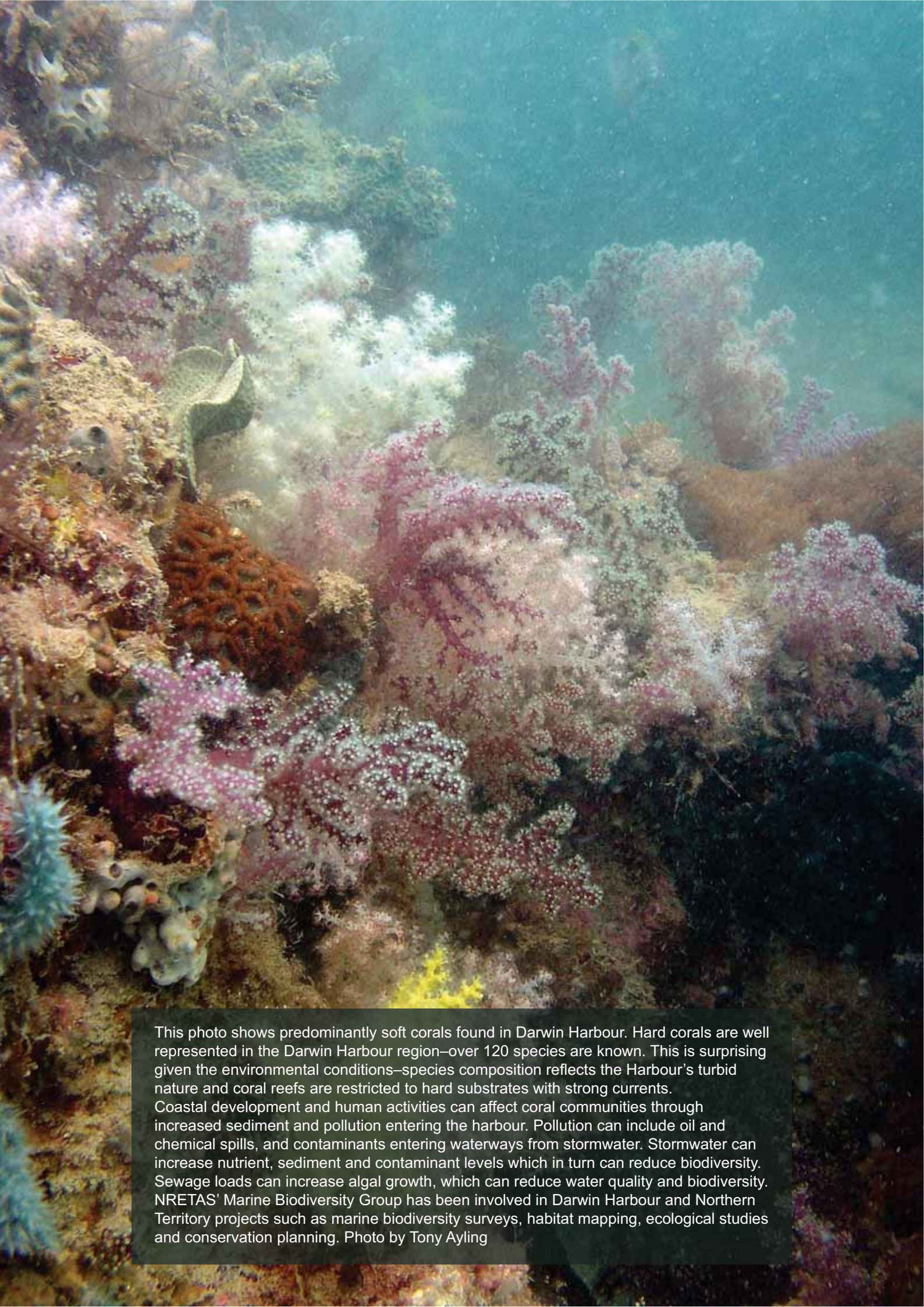
Darwin Harbour mid estuary marine ambient water quality

Symbol	Indicator and units	Water quality objective	Current condition	Sample number for current condition	Compliance
	Electrical conductivity (µS/cm)	NA	51500	55	
	Turbidity (NTU)	NA	2.2	55	
	pH	7.0-8.5	8.2-8.4	55	✔
O_2	Dissolved oxygen (%)	80-100	84-90	55	✔
	Total suspended solids (mg/L)	<10	5	40	✔
	Chlorophyll a (µg/L)	<2	0.9	49	✔
NO_x	NOx (µg N/L)	<20	2	55	✔
AM	Ammonia (µg N/L)	<20	4	37	✔
TN	Total nitrogen (µg N/L)	<270	141	43	✔
TP	Total phosphorus (µg P/L)	<20	11.5	52	✔
FRP	Filterable reactive phosphorus (µg P/L)	<5	3	53	✔

Period sampled for current condition is 2001-2005. NA not available

A

Wharf and Darwin City. Photo by George Maly



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' Marine 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 by Tony Ayling

Darwin - Palmerston report card 2009

Water quality at the Darwin - Palmerston upper estuary monitoring sites is in very good condition and, with the exception of high total nitrogen, complies with water quality objectives. Water quality at the ambient freshwater monitoring sites is in excellent condition, and complies with water quality objectives. The water-bug community at the biological monitoring sites is assessed as similar to reference or significantly impaired. One site was assessed as severely impaired in 2005.

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

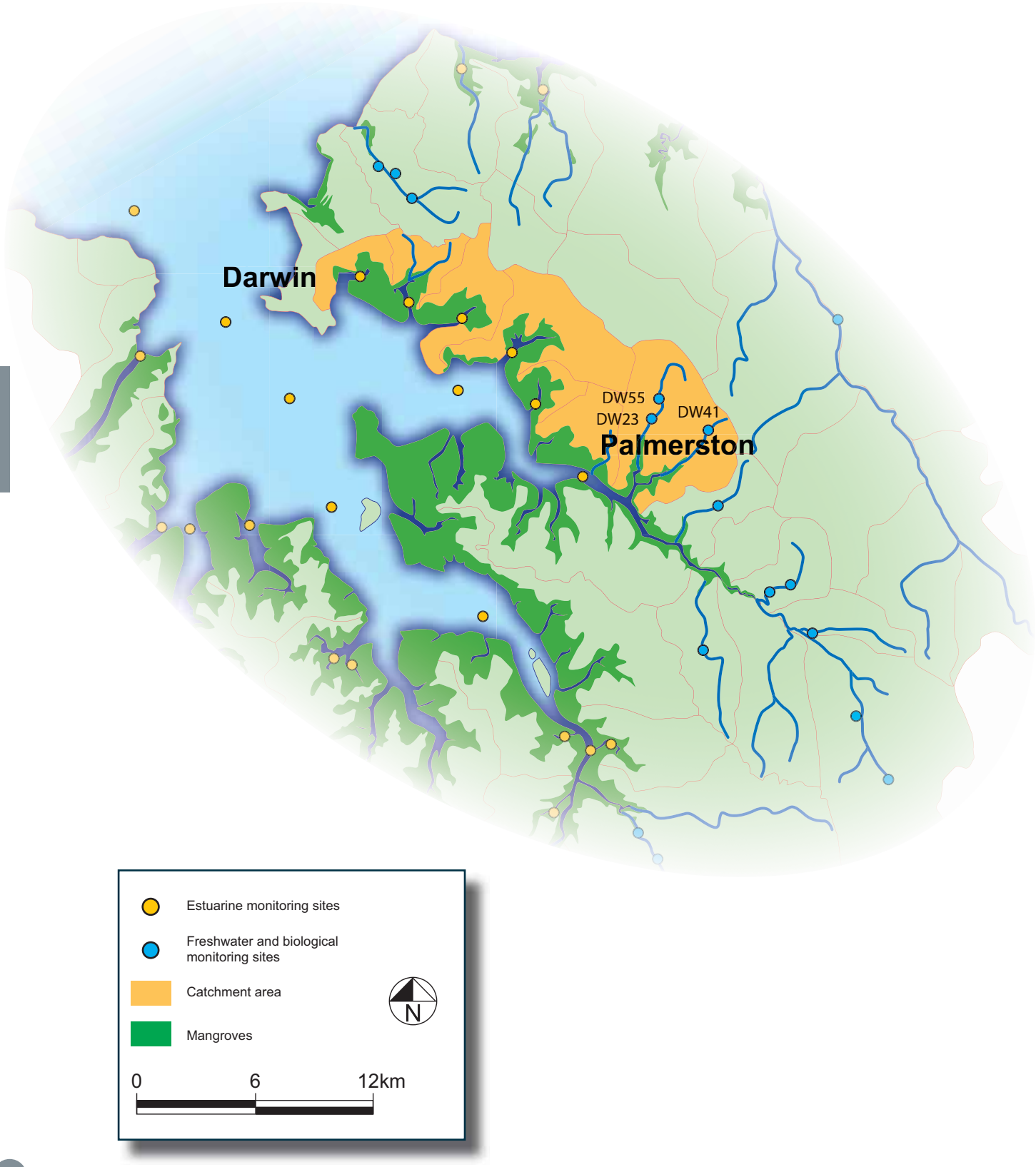
Sources of pollution

- Several sewage treatment plants with wastewater discharge from Darwin and Palmerston
- 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 a defined channel. The Mitchell Creek catchment is under increasing pressure from urban residential development, such as the proposed suburb of Johnston. Proposed development in Johnston includes initiatives such as protection of much of the main channel. 'Water sensitive urban design' features that are being planned will help improve stormwater quality draining from some proposed urban areas to Mitchell Creek. The Northern Territory Government has monitored water quality and water-bugs in Mitchell Creek since 2001. Photo by Gisela Lamche

Darwin - Palmerston area

Darwin-Palmerston area catchment showing subcatchments, features and monitoring sites.



Darwin-Palmerston area ambient freshwater quality

Symbol	Indicator and units	Water quality objective	Current condition	Sample number for current condition	Compliance
	Electrical conductivity (µS/cm)	<200	72	11	✔
	Turbidity (NTU)	<20	4.6	11	✔
	pH	6.0 – 7.5	6.0 – 6.6	11	✔
O_2	Dissolved oxygen (%)	50 – 100	76 – 92	4	✔
	Total suspended solids (mg/L)	<5	5	9	✔
	Chlorophyll a (µg/L)	<2	1	7	✔
NO_x	NOx (µg N/L)	<8	4	10	✔
AM	Ammonia (µg N/L)	NA	7	8	
TN	Total nitrogen (µg N/L)	<230	113	10	✔
TP	Total phosphorus (µg P/L)	<10	4	10	✔
FRP	Filterable reactive phosphorus (µg P/L)	<5	2	10	✔
Period sampled for current condition is 2001-2005. NA Not available					

A

Biological health using the AUSRIVAS score

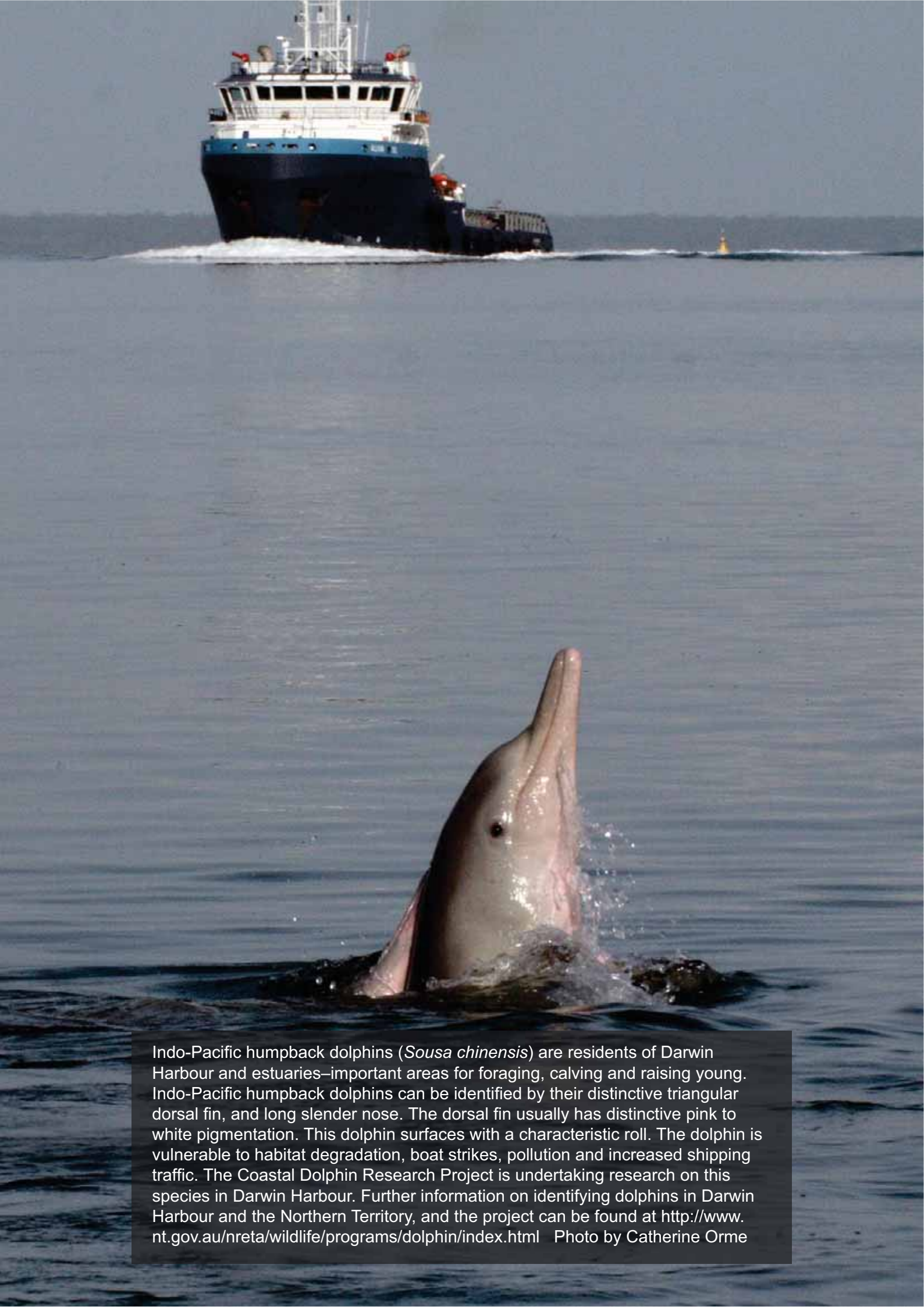
Site number	2001	2002	2003	2004	2005	2006	2007
DW23	A	A	B	A	C	B	B
DW41	A	B	B		B	B	
DW55					B	A	

Darwin-Palmerston area marine ambient water quality

Symbol	Indicator and units	Water quality objective	Current condition	Sample number for current condition	Compliance
	Electrical conductivity (µS/cm)	NA	51700	19	
	Turbidity (NTU)	NA	2.4	19	
	pH	6-8.5	8.2-8.4	19	✔
O_2	Dissolved oxygen (%)	80-100	83-89	19	✔
	Total suspended solids (mg/L)	<10	2	14	✔
	Chlorophyll a (µg/L)	<4	2	50	✔
NO_x	NOx (µg N/L)	<20	2	51	✔
AM	Ammonia (µg N/L)	<20	5	44	✔
TN	Total nitrogen (µg N/L)	<300	1250	22	✘
TP	Total phosphorus (µg P/L)	<30	15	50	✔
FRP	Filterable reactive phosphorus (µg P/L)	<10	4	47	✔
Period sampled for current condition is 2001-2007. NA not available					

B

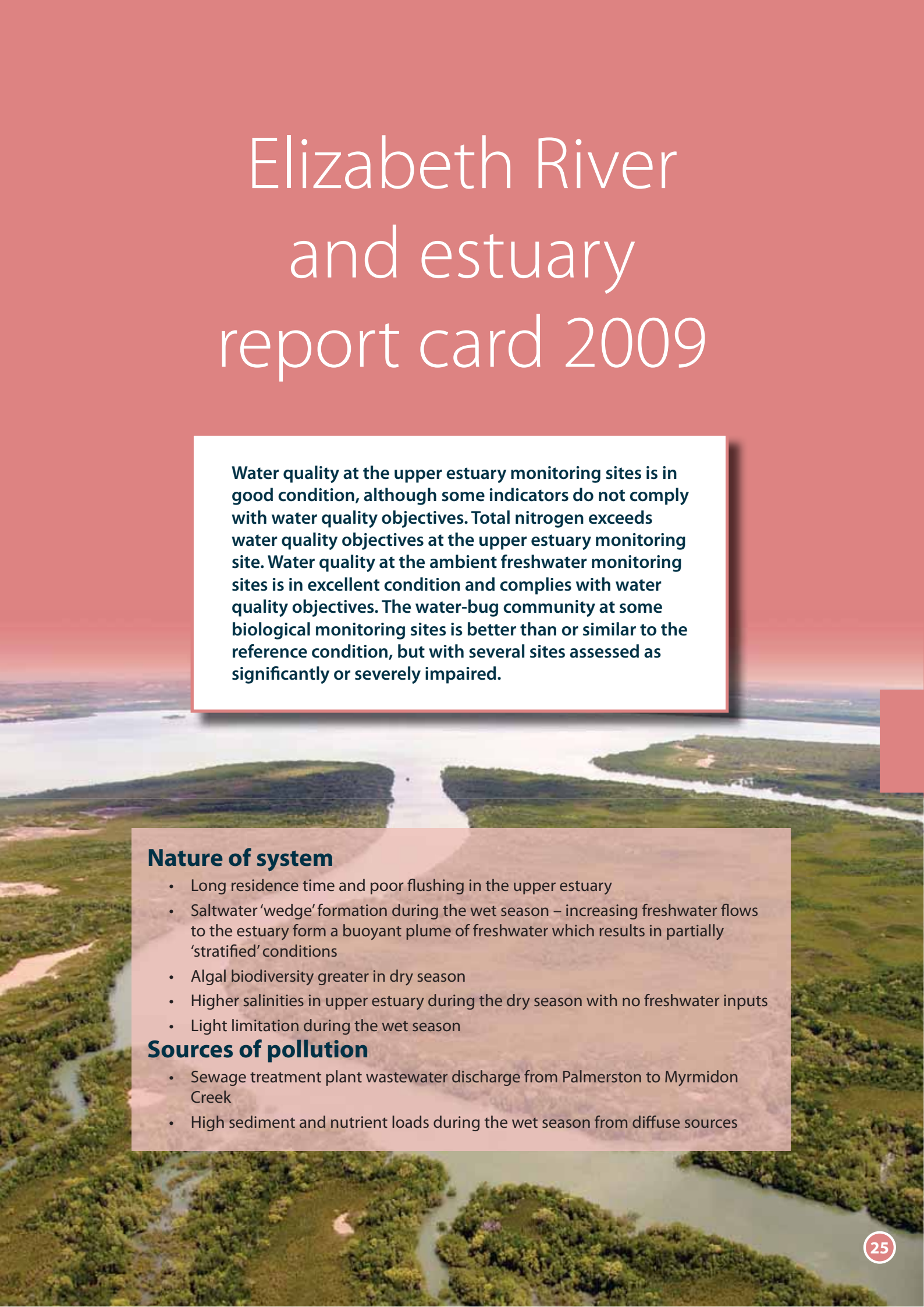
East Arm port. Photo by George Maly



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 by Catherine Orme

Elizabeth River and estuary report card 2009

Water quality at the upper estuary monitoring sites is in good condition, although some indicators do not comply with water quality objectives. Total nitrogen exceeds water quality objectives at the upper estuary monitoring site. Water quality at the ambient freshwater monitoring sites is in excellent condition and complies with water quality objectives. The water-bug community at some biological monitoring sites is better than or similar to the reference condition, but with several sites assessed as significantly or severely impaired.



Nature of system

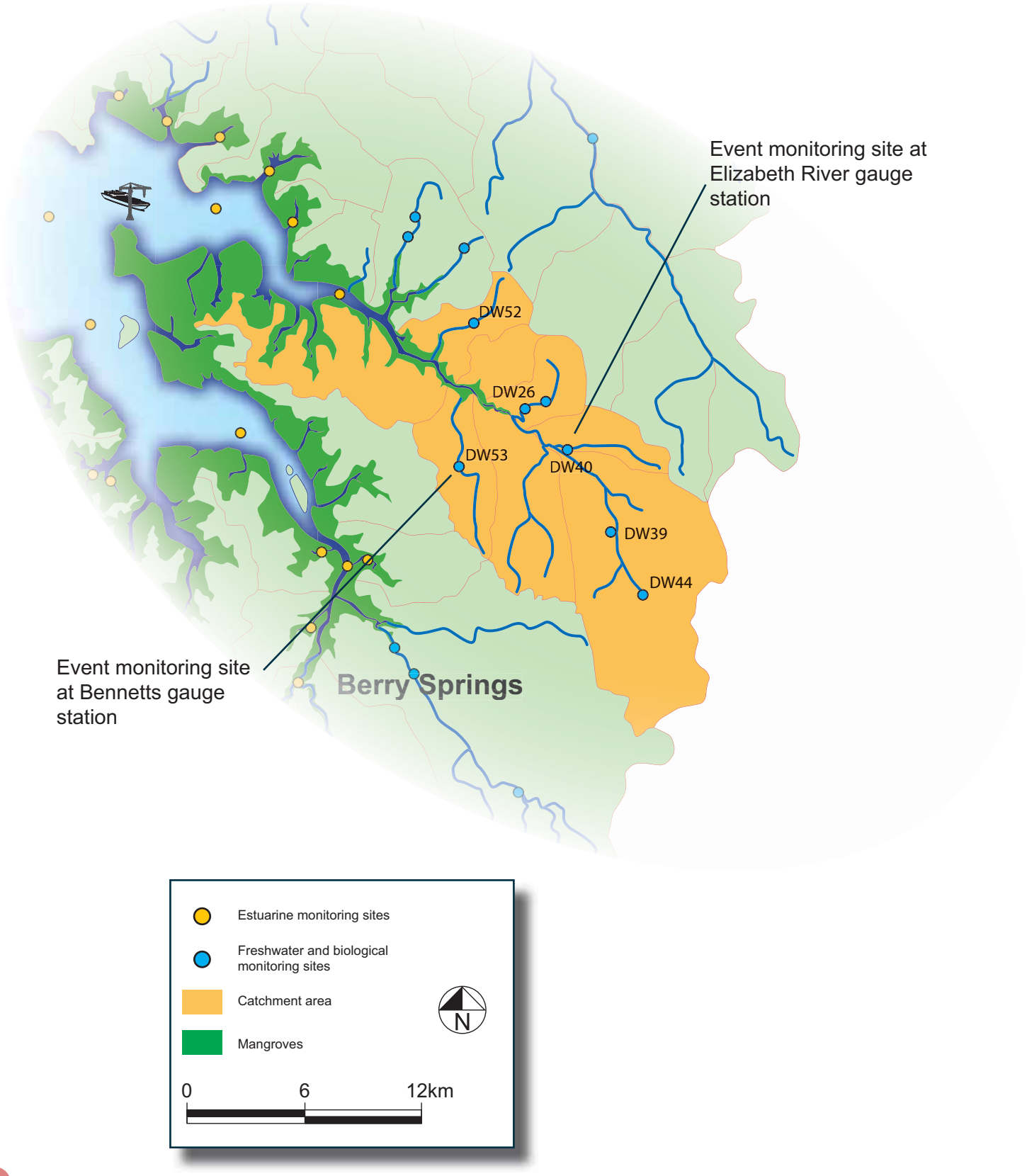
- Long residence time and poor flushing in the upper estuary
- Saltwater 'wedge' formation during the wet season – increasing freshwater flows to the estuary form a buoyant plume of freshwater which results in partially 'stratified' conditions
- Algal biodiversity greater in dry season
- Higher salinities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

Sources of pollution

- Sewage treatment plant wastewater discharge from Palmerston to Myrmidon Creek
- High sediment and nutrient loads during the wet season from diffuse sources

Elizabeth River and estuary

Elizabeth River catchment showing
subcatchments, features and monitoring sites.



Elizabeth River catchment fresh ambient water quality

Symbol	Indicator and units	Water quality objective	Current condition	Sample number for current condition	Compliance
	Electrical conductivity (µS/cm)	<200	25	30	✔
	Turbidity (NTU)	<20	4.3	30	✔
	pH	6.0 –7.5	6.3 – 6.9	30	✔
	Dissolved oxygen (%)	50 –100	69 – 92	12	✔
	Total suspended solids (mg/L)	<5	4	26	✔
	Chlorophyll a (µg/L)	<2	0.3	22	✔
NOx	NOx (µg N/L)	<8	6	30	✔
AM	Ammonia (µg N/L)	NA	10	26	
TN	Total nitrogen (µg N/L)	<230	176	30	✔
TP	Total phosphorus (µg P/L)	<10	5	30	✔
FRP	Filterable reactive phosphorus (µg P/L)	<5	1	30	✔

Period sampled for current condition is 2001-2005. NA Not available

A

Elizabeth estuary marine ambient water quality

Symbol	Indicator and units	Water quality objective	Current condition	Sample number for current condition	Compliance
	Electrical conductivity (µS/cm)	NA	48000	140	
	Turbidity (NTU)	NA	3.7	11	
	pH	6-8.5	7.6-8.2	140	✔
	Dissolved oxygen (%)	80-100	70-81	11	✘
	Total suspended solids (mg/L)	<10	1	6	✔
	Chlorophyll a (µg/L)	<4	4.3	38	✘
NOx	NOx (µg N/L)	<20	2	39	✔
AM	Ammonia (µg N/L)	<20	5	37	✔
TN	Total nitrogen (µg N/L)	<300	1270	20	✘
TP	Total phosphorus (µg P/L)	<30	15	38	✔
FRP	Filterable reactive phosphorus (µg P/L)	<10	4	35	✔

Period sampled for current condition is 2003-2007. NA Not available

C

Crocodile traps are used in the Darwin harbour region to remove some crocodiles from waterways. Photo by John Drewry

Elizabeth River catchment loads and event-mean concentrations

Symbol	Indicator and units	Bennetts subcatchment current condition event-mean concentration	Elizabeth subcatchment current condition event-mean concentration
	Total suspended solids (mg/L)	3.4	12.9
TN	Total nitrogen (µg N/L)	340	473
TP	Total phosphorus (µg P/L)	2.7	12.6
	Subcatchment area (ha)	932	10100
Wet season sampled for current condition is 2006-2007			
Symbol	**Elizabeth River whole catchment load for an average wet season**		
	Total suspended solids load (tonnes/year)	3100	
TN	Total nitrogen (tonnes/year)	72	
TP	Total phosphorus (tonnes/year)	3.6	
	Total catchment area (ha)	22870	

Biological health using the AUSRIVAS score

Site number	2001	2002	2003	2004	2005	2006	2007
DW44		A	X		B	A	
DW39	A	A	A		B	A	
DW40	A	B	A	B	B	A	B
DW26	A	B	A	B	B	B	B
DW52			B	A	B	C	
DW53			A	A	C	A	

Liquefied Natural Gas (LNG) is exported from Middle Arm. Further development of Middle Arm is planned through the proposed gas project joint venture between INPEX and Total. Photo by SkyScans

Blackmore River and estuary report card 2009

Water quality at the upper estuary monitoring sites is in very good condition. Only dissolved oxygen did not comply with water quality objectives at the upper estuary monitoring sites. Water quality at the ambient freshwater monitoring sites is in very good condition, and with one exception, complies with water quality objectives. The water-bug community at some biological monitoring sites is better than or similar to reference condition, but with several sites assessed as significantly impaired on occasions.

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
- Algal biodiversity greater in dry season

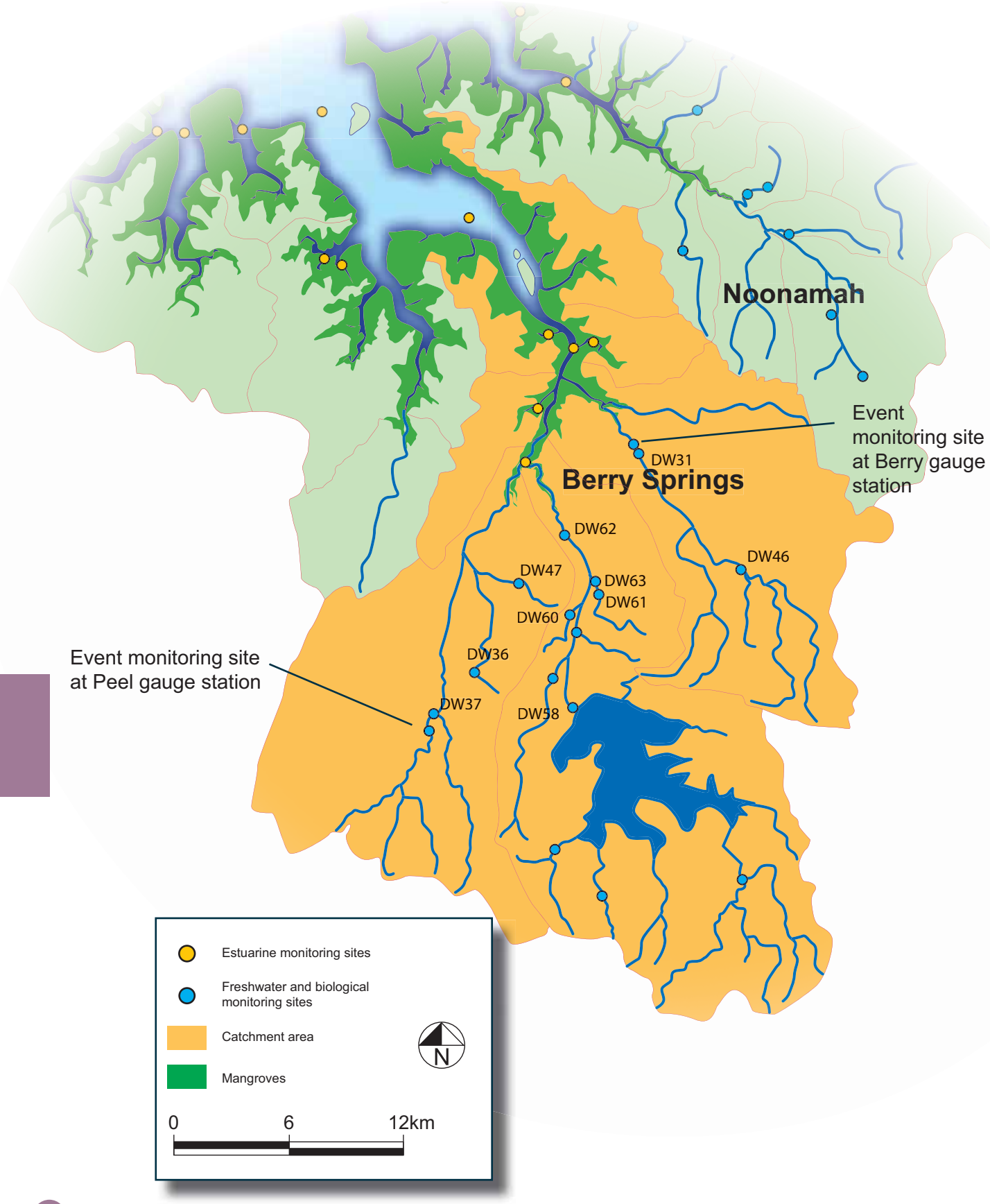
Sources of pollution

- 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 is often at full capacity at the end of the wet season. The dam was constructed in 1972 and is designed to supply 200,000 people. It is the main drinking water supply for Darwin and surrounding area. Darwin people use up to three times more water than in other capital cities across Australia. Photo by John Drewry

Blackmore River catchment

Blackmore River catchment showing subcatchments, features and monitoring sites.



Blackmore River catchment fresh ambient water quality

Symbol	Indicator and units	Water quality objective	Current condition	Sample number for current condition	Compliance
	Electrical conductivity (µS/cm)	<200	47	30	✓
	Turbidity (NTU)	<20	3.0	30	✓
	pH	6.0 –7.5	5.8 – 7.0	30	✗
	Dissolved oxygen (%)	50 – 100	59 – 72	15	✓
	Total suspended solids (mg/L)	<5	5	27	✓
	Chlorophyll a (µg/L)	<2	1.9	24	✓
NOx	NOx (µg N/L)	<8	5	29	✓
AM	Ammonia (µg N/L)	NA	6	26	
TN	Total nitrogen (µg N/L)	<230	204	29	✓
TP	Total phosphorus (ug P/L)	<10	9	29	✓
FRP	Filterable reactive phosphorus (µg P/L)	<5	1	29	✓

Period sampled for current condition is 2001-2005. NA Not available

B

Blackmore marine ambient water quality

Symbol	Indicator and units	Water quality objective	Current condition	Sample number for current condition	Compliance
	Electrical conductivity (µS/cm)	NA	49500	115	
	Turbidity (NTU)	NA	5.7	118	
	pH	6-8.5	7.9-8.2	118	✓
	Dissolved oxygen (%)	80-100	61-82	118	✗
	Total suspended solids (mg/L)	<10	7	42	✓
	Chlorophyll a (µg/L)	<4	2.5	61	✓
NOx	NOx (µg N/L)	<20	8	77	✓
AM	Ammonia (µg N/L)	<20	10	61	✓
TN	Total nitrogen (µg N/L)	<300	NA	NA	
TP	Total phosphorus (µg P/L)	<30	20	69	✓
FRP	Filterable reactive phosphorus (µg P/L)	<10	6	76	✓

Period sampled for current condition is 2001-2005. NA Not available

B

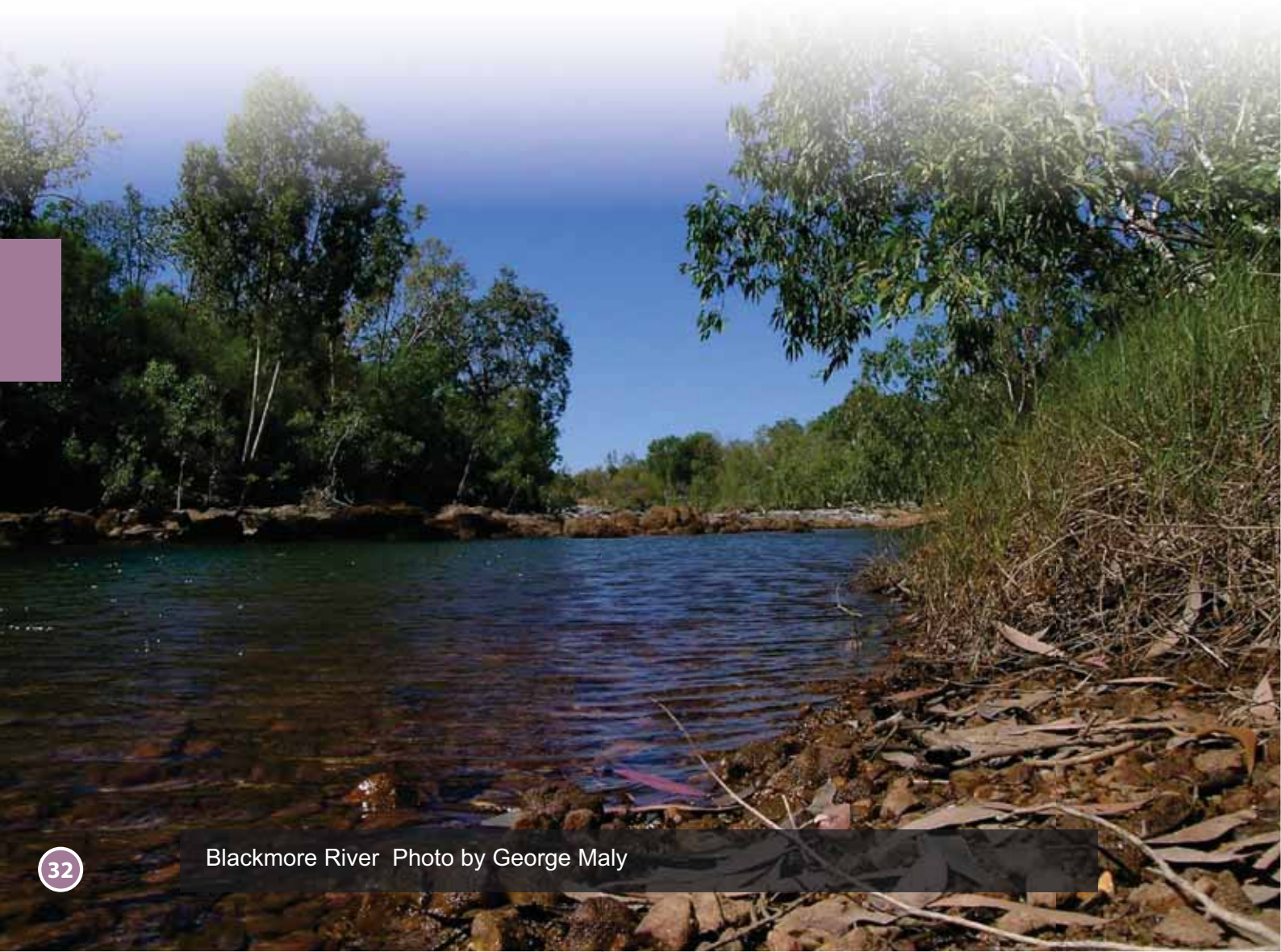
Aerial view of an aquaculture operation in the Blackmore River catchment. Barramundi, (*Lates calcarifer*), is a common aquaculture fish in the region. Photo by Jeremy Freeman

Blackmore River catchment loads and event-mean concentrations

Symbol	Indicator and units	Peel subcatchment current condition event-mean concentration	Berry subcatchment current condition event-mean concentration
	Total suspended solids (mg/L)	15.5	13
TN	Total nitrogen (µg N/L)	605	316
TP	Total phosphorus (µg P/L)	10	14
	Subcatchment area (ha)	5680	13700
Wet season sampled for current condition is 2006-2007			
Symbol	**Blackmore River whole catchment load for an average wet season**		
	Total suspended solids load (tonnes/year)	7740	
TN	Total nitrogen (tonnes/year)	191	
TP	Total phosphorus (tonnes/year)	8.7	
	Total catchment area (ha), excludes Darwin River dam catchment	63500	

Biological health using the AUSRIVAS score

Site number	2001	2002	2003	2004	2005	2006	2007
DW31	X	X	X	A	B	A	B
DW46		A	A		A	A	
DW47		A	B		A	A	A
DW36	A	A	B		A	B	
DW37	A	A	A	A	B	B	A



Blackmore River Photo by George Maly

Shoal Bay and Buffalo Creek report card 2009

Water quality in outer Shoal Bay is in excellent condition and complies with water quality objectives. Several water quality indicators at some Shoal Bay upper estuary and freshwater monitoring sites do not comply with water quality objectives. The water-bug community at the Howard River biological monitoring site is significantly impaired.

Estuarine water quality at the monitoring site in Buffalo Creek is in very poor condition. Of the sites monitored, this site has 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

Crocodile in the Hope Inlet, Shoal Bay. Photo by Tony Boland

Map of Shoal Bay catchment

Shoal Bay catchment showing subcatchments, features and monitoring sites.

Shoal Bay catchment ambient freshwater quality

Symbol	Indicator and units	Water quality objective	Current condition	Sample number for current condition	Compliance
	Electrical conductivity (µS/cm)	<200	102	9	✓
	Turbidity (NTU)	<20	2.9	9	✓
	pH	6.0 – 7.5	5.8 – 7.0	9	✗
	Dissolved oxygen (%)	50 – 100	33 – 56	5	✗
	Total suspended solids (mg/L)	<5	4	6	✓
	Chlorophyll a (µg/L)	<2	0.3	5	✓
NOx	NOx (µg N/L)	<8	12	7	✗
AM	Ammonia (µg N/L)	NA	12	6	
TN	Total nitrogen (µg N/L)	<230	174	7	✓
TP	Total phosphorus (µg P/L)	<10	10	7	✓
FRP	Filterable reactive phosphorus (µg P/L)	<5	2	7	✓
Period sampled for current condition is 2001-2005. NA Not available					

C

Shoal Bay upper area marine ambient water quality

Symbol	Indicator and units	Water quality objective	Current condition	Sample number for current condition	Compliance
	Electrical conductivity (µS/cm)	NA	41200	13	
	Turbidity (NTU)	NA	13.0	13	
	pH	6-8.5	8.1-8.5	13	✓
	Dissolved oxygen (%)	80-100	74-92	13	✗
	Total suspended solids (mg/L)	<10	12	3	✗
	Chlorophyll a (µg/L)	<4	8	9	✗
NOx	NOx (µg N/L)	<20	4	13	✓
AM	Ammonia (µg N/L)	<20	2	7	✓
TN	Total nitrogen (µg N/L)	<300	311	9	✗
TP	Total phosphorus (µg P/L)	<30	30	11	✓
FRP	Filterable reactive phosphorus (µg P/L)	<10	3	13	✓
Period sampled for current condition is 2004-2005. NA Not available					

C

Shoal Bay outer area marine ambient water quality

Symbol	Indicator and units	Water quality objective	Current condition	Sample number for current condition	Compliance
	Electrical conductivity (µS/cm)	NA	51200	13	
	Turbidity (NTU)	NA	2.7	13	
	pH	7.0-8.5	8.3-8.5	13	✓
	Dissolved oxygen (%)	80-100	86-95	13	✓
	Total suspended solids (mg/L)	<10	3	3	✓
	Chlorophyll a (µg/L)	<2	0.8	9	✓
NOx	NOx (µg N/L)	<20	2	13	✓
AM	Ammonia (µg N/L)	<20	2	7	✓
TN	Total nitrogen (µg N/L)	<270	166	8	✓
TP	Total phosphorus (µg P/L)	<20	10	11	✓
FRP	Filterable reactive phosphorus (µg P/L)	<5	3	11	✓
Period sampled for current condition is 2004-2005. NA Not available					

A

Shoal Bay catchment loads and event-mean concentrations

Symbol	Indicator and units	Howard subcatchment current condition event-mean concentration
	Total suspended solids (mg/L)	9.3
TN	Total nitrogen (µg N/L)	432
TP	Total phosphorus (µg P/L)	9.6
	Subcatchment area (ha)	14960
Wet season sampled for current condition is 2006-2007		
Symbol	**Shoal Bay whole catchment load for an average wet season**	
	Total suspended solids load (tonnes/year)	15200
TN	Total nitrogen (tonnes/year)	288
TP	Total phosphorus (tonnes/year)	18.6
	Total catchment area (ha)	76170

Biological health using the AUSRIVAS score

Site number	2001	2002	2003	2004	2005	2006	2007
DW43	B	B	B	B	B	B	

Buffalo Creek marine ambient water quality

Symbol	Indicator and units	Water quality objective	Current condition	Sample number for current condition	Compliance
	Electrical conductivity (µS/cm)	NA	37400	7	
	Turbidity (NTU)	NA	29.5	7	
	pH	6-8.5	8.0-8.4	7	✗
O_2	Dissolved oxygen (%)	80-100	39-112	7	✗
	Total suspended solids (mg/L)	<10	30	2	✗
	Chlorophyll a (µg/L)	<4	146	5	✗
NO_x	NOx (µg N/L)	<20	17	7	✓
AM	Ammonia (µg N/L)	<20	15	4	✓
TN	Total nitrogen (µg N/L)	<300	1630	5	✗
TP	Total phosphorus (µg P/L)	<30	600	6	✗
FRP	Filterable reactive phosphorus (µg P/L)	<10	187	7	✗
Period sampled for current condition is 2004-2005. NA Not available					

The Buffalo Creek monitoring site is in the estuary and is subject to wastewater discharge from the Leanyer-Sanderson sewage treatment plant. The licensed mixing zone is yet to be fully determined. Water quality objectives will not apply within a licensed discharge mixing zone.

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 by Julia Fortune

Rapid Creek report card 2009

Water quality at the monitoring sites is in very good condition and in most cases complies with water quality objectives. Event-mean concentrations in the Moil subcatchment were greater than for the other sites in the region, indicating greater pollutant loads. The water-bug community at the biological monitoring sites is significantly or severely impaired.

Nature of system

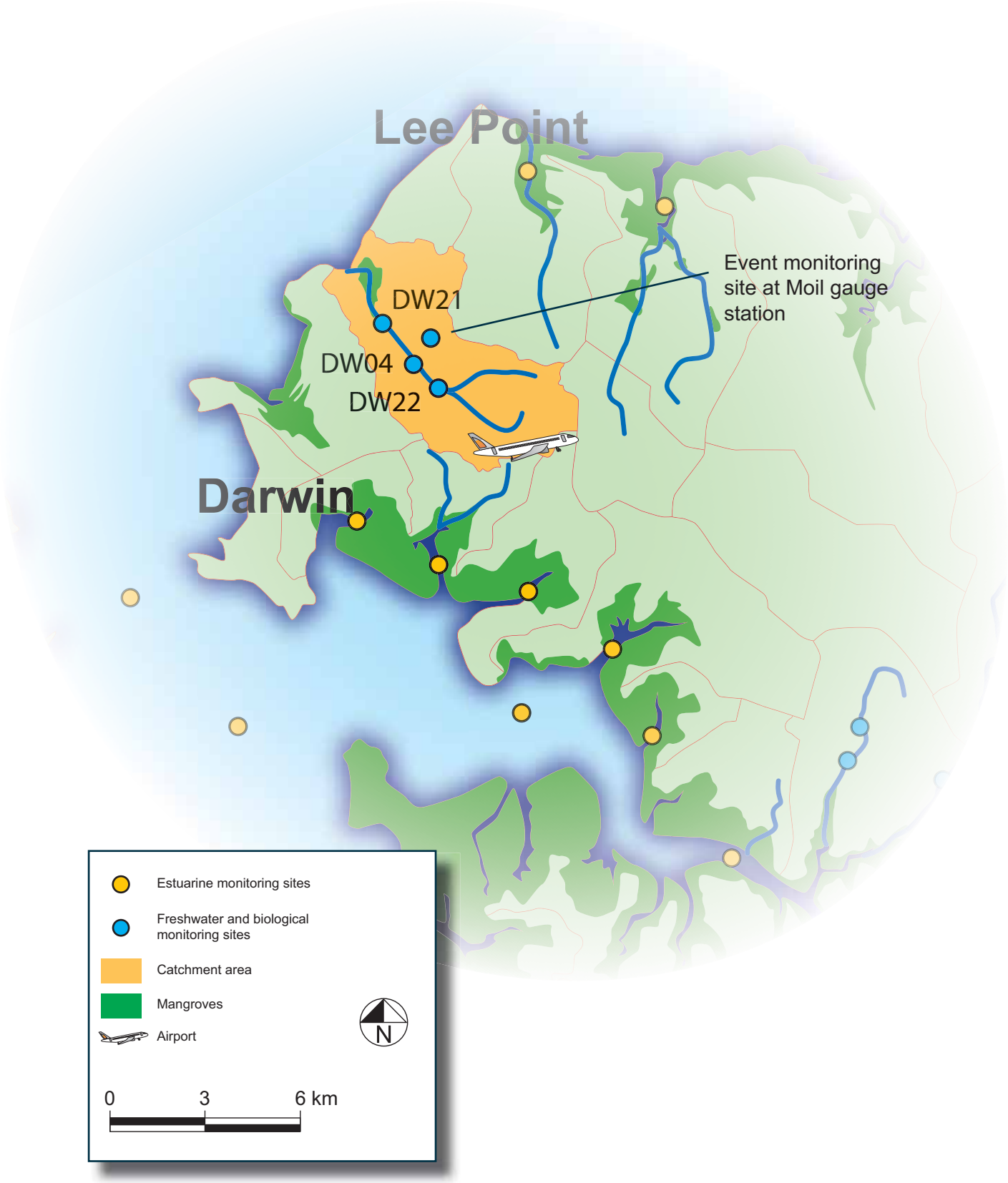
- Rapid Creek is the largest freshwater system within the Darwin city area
- A large proportion of the catchment has been cleared
- Stream corridor and riparian area remains relatively intact

Sources of pollution

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

Rapid Creek catchment

Rapid Creek catchment showing catchment boundary, features and monitoring sites.



Rapid Creek ambient freshwater quality

Symbol	Indicator and units	Water quality objective	Current condition	Sample number for current condition	Compliance
	Electrical conductivity (µS/cm)	<200	42	24	✓
	Turbidity (NTU)	<20	2.5	24	✓
	pH	6.0 –7.5	4.9 – 6.0	24	✗
	Dissolved oxygen (%)	50 –100	54 – 83	21	✓
	Total suspended solids (mg/L)	<5	NA	NA	NA
	Chlorophyll a (µg/L)	<2	0.3	20	✓
NOx	NOx (µg N/L)	<8	6	17	✓
AM	Ammonia (µg N/L)	NA	5	17	
TN	Total nitrogen (µg N/L)	<230	71	17	✓
TP	Total phosphorus (µg P/L)	<10	2.5	17	✓
FRP	Filterable reactive phosphorus (µg P/L)	<5	0.5	17	✓
Period sampled for current condition is 2005-2008. NA Not available					

B

Rapid Creek catchment loads and event-mean concentrations

Symbol	Indicator and units	Moil subcatchment current condition event-mean concentration
	Total suspended solids (mg/L)	56
TN	Total nitrogen (µg N/L)	821
TP	Total phosphorus (µg P/L)	87
	Subcatchment area (ha)	36
Wet season sampled for current condition is 2006-2007		
Symbol	**Rapid Creek whole catchment load for an average wet season**	
	Total suspended solids load (tonnes/year)	1680
TN	Total nitrogen (tonnes/year)	21.7
TP	Total phosphorus (tonnes/year)	2.2
	Total catchment area (ha)	2770

Site number	2001	2002	2003	2004	2005	2006	2007
DW04					C	B	
DW21	C	C	B	B	C	C	C
DW22					C		

Community planting day at Darwin International Airport, Rapid Creek.
Acknowledgement - Darwin International Airport. Copyright David Silva

Electrofishing in Rapid Creek

Fish surveys in Rapid Creek provide an indication of the health of fish communities in the creek and also help to identify exotic fish. Native fish species surveyed in 2006 and 2007 are shown in the Rapid Creek report card.

Electrofishing is a non-lethal way to research and collect data pertinent to endangered fish species. Electrofishing is a widely recognised research method for all freshwater fish species in Australia, as well as turtles and freshwater crustaceans. Data collected include species name, length, size classes (adult and juvenile) and relative abundance of captured and observed species.

Hyrtl's Catfish (*Neosilurus hyrtlii*) is found in Howard River and Rapid Creek Photo by Dave Wilson

The process applies an electric current through a waterbody to create an electromagnetic field, which causes fish to swim toward the centre of the field and results in temporary stunning. Fish are then released back into the water unharmed. Data collection is undertaken on a 'shot by shot' basis, where a habitat is sampled over a five minute period (1 shot). Fish are then identified, measured and habitat data are collected. A total of 10 shots per stream reach are undertaken, which includes different habitat types in the stream reach such as riffles and pools.

Electrofishing in Rapid Creek. Photo by Julia Fortune

Fish survey results

July 2007 survey	Site DW22		Site DW21	
Species	Mean length (mm)	Count	Mean length (mm)	Count
Hypseleotris compressa (Empire Gudgeon)	33	18	30	17
Lates calcarifer (Barrumundi)	-	-	310	1
Leiopotherapon unicolor (Spangled Perch)	43	14	106	2
Melanotaenia australis (Western Rainbowfish)	45	10	30	14
Melanotaenia nigrans (Blackbanded Rainbowfish)	28	1199	25	626
Mogurnda mogurnda (Northern Trout Gudgeon)	61	222	27	24
Neosilurus hyrtlii (Hyrtl's Catfish or Yellow-fin Catfish)	72	40	60	16
Megalops cyrinoides (Tarpon)	-	12	-	-
Note: Survey undertaken over set time (10 shots of 5 min = 50 min) at each site and counts include visual observations.				

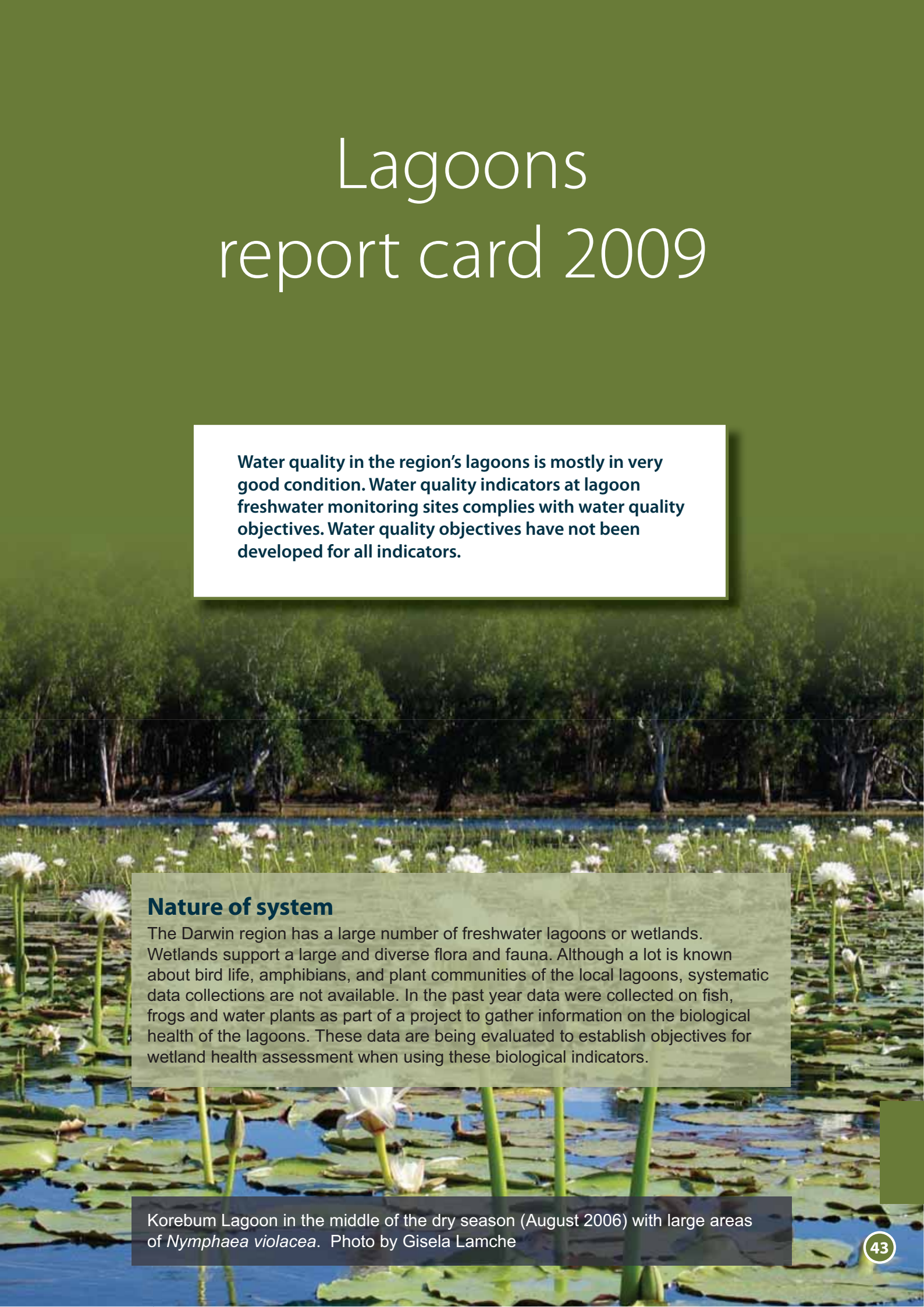
August 2006 survey	Site DW22		Site DW21		Site DW04	
Species	Mean length (mm)	Count	Mean length (mm)	Count	Mean length (mm)	Count
Hypseleotris compressa (Empire Gudgeon)	48	2	44	3	44	5
Leiopotherapon unicolor (Spangled Perch)	72	23	61	26	59	16
Melanotaenia australis (Western Rainbowfish)	51	1	53	2	-	-
Melanotaenia nigrans (Blackbanded Rainbowfish)	40	217	37	204	34	3
Mogurnda mogurnda (Northern Trout Gudgeon)	71	219	49	7	74	85
Neosilurus hyrtlii (Hyrtl's Catfish or Yellow-fin Catfish)	97	23	85	24	96	85
Ophisternon gutturale (Australian Swamp Eel)	-	-	280	1	300	1
Note: Survey undertaken over set distance (100 m) at each site and counts do not include visual observations.						

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

Aerial view of parts of Girraween Lagoon in the wet season (February 2008) displays large areas of different aquatic macrophyte communities. Photo by Jeremy Freeman

Lagoons report card 2009

Water quality in the region's lagoons is mostly in very good condition. Water quality indicators at lagoon freshwater monitoring sites complies with water quality objectives. Water quality objectives have not been developed for all indicators.



Nature of system

The Darwin region has a large number of freshwater lagoons or wetlands. Wetlands support a large and diverse flora and fauna. Although a lot is known about bird life, amphibians, and plant communities of the local lagoons, systematic data collections are not available. In the past year data were collected on fish, frogs and water plants as part of a project to gather information on the biological health of the lagoons. These data are being evaluated to establish objectives for wetland health assessment when using these biological indicators.

Korebum Lagoon in the middle of the dry season (August 2006) with large areas of *Nymphaea violacea*. Photo by Gisela Lamche

Darwin region lagoons

Lagoons in the region are shown on the land use map of the Darwin Harbour region report card. The water quality of standing water bodies such as lagoons is in many ways similar to that of streams. A few of the measurements can have different values from freshwater streams but are still considered healthy. For example, dissolved oxygen in a healthy flowing stream is never close to zero. Dissolved oxygen values can reach zero in a very healthy wetland early in the morning or at the bottom of the water body.

Water quality objectives are available for chlorophyll-a and turbidity. Others have not yet been determined. Median values for ambient water quality of 12 lagoons in the Darwin region are shown below.

Median values for 12 lagoons

Symbol	Indicator and units	Water quality objective	Current condition	Sample number for current condition	Compliance*
	Electrical conductivity (µS/cm)	NA	16.8	102	Good
	Turbidity (NTU)	<5	1.4	102	✔
	pH	NA	5.4-6.0	102	Good
	Chlorophyll a (µg/L)	<10	3.5	102	✔
TN	Total nitrogen (µg N/L)	NA	450	102	Good
TP	Total phosphorus (µg P/L)	NA	11	102	Good
Period sampled is 2004-2005. NA Not available					

Girraween Lagoon

Symbol	Indicator and units	Water quality objective	Current condition	Compliance*
	Electrical conductivity (µS/cm)	NA	13.9	Good
	Turbidity (NTU)	<5	1.8	✔
	pH	NA	5.5-5.7	Good
	Chlorophyll -a µg/L	<10	2	✔
TN	Total nitrogen (µg N/L)	NA	310	Good
TP	Total phosphorus (µg P/L)	NA	5	Good
NA Not available				

Knuckey Lagoon

Symbol	Indicator and units	Water quality objective	Current condition	Compliance*
	Electrical conductivity (µS/cm)	NA	16.6	Good
	Turbidity (NTU)	<5	2.4	✔
	pH	NA	5.6-5.8	Good
	Chlorophyll -a µg/L	<10	4	✔
TN	Total nitrogen (µg N/L)	NA	730	Poor
TP	Total phosphorus (µg P/L)	NA	22	Poor
NA Not available				

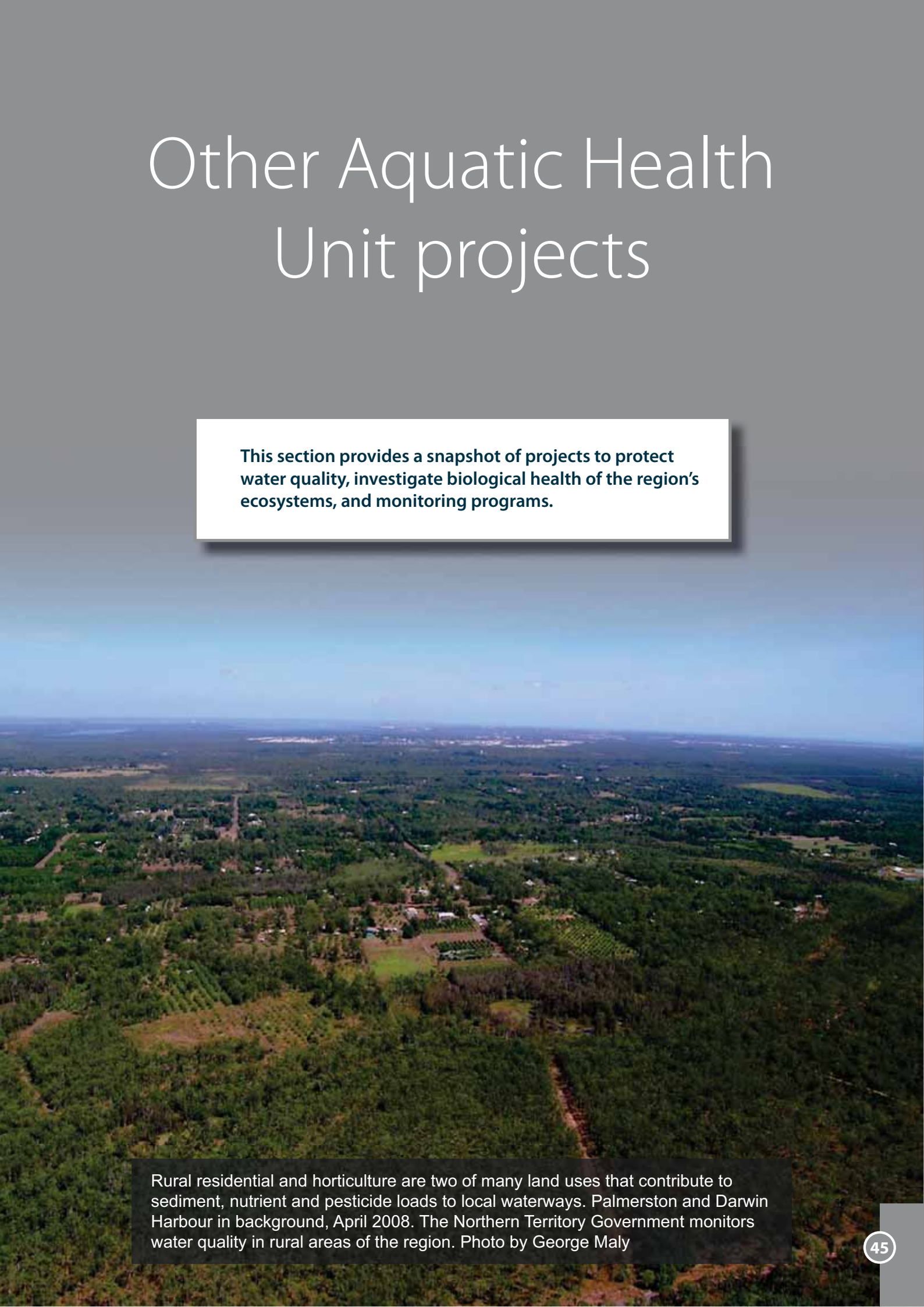
McMinns Lagoon

Symbol	Indicator and units	Water quality objective	Current condition	Compliance*
	Electrical conductivity (µS/cm)	NA	13.8	Good
	Turbidity (NTU)	<5	1.4	✔
	pH	NA	5.9-6.3	Good
	Chlorophyll -a µg/L	<10	3.5	✔
TN	Total nitrogen (µg N/L)	NA	440	Good
TP	Total phosphorus (µg P/L)	NA	8.5	Good
NA Not available				

* Where water quality objective is not available, a 'good' or 'poor' ranking is assessed.
Sample numbers were: Girraween Lagoon 11; Knuckey Lagoon 7; McMinns Lagoon 10.

Other Aquatic Health Unit projects

This section provides a snapshot of projects to protect water quality, investigate biological health of the region's ecosystems, and monitoring programs.



Rural residential and horticulture are two of many land uses that contribute to sediment, nutrient and pesticide loads to local waterways. Palmerston and Darwin Harbour in background, April 2008. The Northern Territory Government monitors water quality in rural areas of the region. Photo by George Maly

A water quality protection plan

The water quality of Darwin Harbour is regarded as being in a near-pristine or slightly modified condition. However there are concerns that continuing economic growth in the region will have a negative impact on the quality of waterways particularly around urban areas.

While the population residing in the Darwin Harbour catchment currently totals over 120,000 people, by 2026 it is expected to increase to 165,000 people. Population increase often leads to urban and rural growth which can lead to increased erosion and increased loads of pollutants entering waterways. High pollutant loads can compromise water quality particularly in areas where tidal flushing is limited, such as the upper estuaries, near the end of tidal influence.

A Water Quality Protection Plan for Darwin Harbour (WQPP) has been developed to ensure that the quality of the region's water resources is maintained and that the community's values and uses of waterways are protected from the adverse effects of urbanisation and other polluting activities.

Preparation of water quality objectives (water quality guidelines for local waterways) is a key component of the WQPP. Water quality objectives describe the water quality needed to protect values and uses of regional water resources. 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.

The water quality objectives also are:

- aimed at protecting human health and the health of the aquatic ecosystems;
- for regions of relative homogeneity in water quality;
- not for heavily urbanised or disturbed areas;
- applied to perennial rivers and streams;
- not developed for intermittent streams, lakes, wetlands, estuaries or marine waters; and
- not to be used as a value to 'pollute up to' but instead be used to limit the amount and type of discharge flushed into Harbour waters or a particular body of water.

Water quality objectives for the Darwin Harbour catchment are intended for the community, local councils and government agencies to use in catchment management and land use planning activities. They are a tool for strategic planning and development assessment processes. Water quality objectives are agreed to by stakeholders.

Water quality objectives will be formally declared under the Northern Territory legislation (*Water Act* part 7). Formalisation of the water quality objectives will ensure that they are included in future policy and planning initiatives to protect Beneficial Uses identified by the community.

Environmental values (defined as Beneficial Uses under the *Northern Territory Water Act 1992*) are particular values or uses of water that are conducive to a healthy ecosystem and/or contribute to public benefit, welfare, safety and health. These environmental values require protection from the effects of pollution. The *Northern Territory Water Act 1992* defines these values or uses as Beneficial Uses. Examples include recreational and aesthetic values and maintaining aquatic ecosystem health. A public consultation process was undertaken in 2007 to evaluate existing Beneficial Uses originally declared in 1996. The community's preference was for existing uses to be retained and for the environment to be in the highest ranking category of Beneficial Uses.

Water quality objectives provide appropriate criteria to assess whether a designated Beneficial Use is being maintained – to protect our waterways. Nitrogen, phosphorus and total suspended sediment were identified as a broader management issues in the region and selected as key water quality indicators. Further information can be found at website http://www.nt.gov.au/nreta.

Darwin frog monitoring trial

Frogs are useful indicators of environmental quality. Their eggs and larvae are fully aquatic and therefore potentially exposed to water-borne contaminants. Elsewhere in the world there are concerns about declines in frog populations and loss of species. The causes are not always clear but involve change in habitat quality, habitat fragmentation and disease.

The frog fauna of northern Australia has not suffered the same patterns of decline that are evident elsewhere. There are 29 frog species present in the Top End of the Northern Territory. None are considered to be endangered. Twenty-one species have been recorded in the Darwin area. Species that have not been recorded, but which are present elsewhere in the Top End, are mostly rock habitat specialists.

In the wet season of 2008–09 the NRETAS Aquatic Health Unit, together with staff from the NRETAS Biodiversity Unit conducted surveys of frog species present at sites throughout the suburban and rural areas of the Darwin Harbour catchment. The aim of the surveys was to catalogue the number of species present at each site, and to provide data to design an ongoing monitoring program. Thirty sites were visited on 10 occasions each throughout the wet season. On each occasion frogs were identified by species-specific calls within a five-minute survey period.

Nineteen of the expected 21 species were identified during these surveys. One of the remaining species, Dahl's Aquatic Frog was seen at survey sites but does not call; the other was found at non-survey sites. For most sites, between seven and nine species were detected, and at one site, 12 species were detected. Common species include the Javelin Frog (*Litoria microbelos*) and the Northern Dwarf Tree Frog (*Litoria bicolor*).

Modelling revealed that detectability is influenced by factors such as recent rainfall and water temperature. This information will assist in the design of a monitoring program to detect long-term changes in the occurrence of frog species throughout the Darwin area. A rigorous monitoring program is required to document amphibian responses to intensification of land use, and the spread of exotic plants and animals such as the Cane Toad. The continuation of this work will be dependent on available funds and resources.

Northern Dwarf Tree Frog, (*Litoria bicolor*), is a very common species, usually associated with Pandanus. It was found at many sites during the recent survey. Photo by Leonie Richards

Common names and species of frogs recorded during surveys in the Darwin region, and the number of survey sites (of 30) and weeks (of 10) in which they were detected.

Common name	Species	Number of sites	Number of weeks detected
Species recorded in surveys			
Giant Frog	*Cyclorana australis*	7	4
Long-footed Frog	*Cyclorana longipes*	2	2
Green Tree Frog	*Litoria caerulea*	14	8
Northern Dwarf Tree Frog	*Litoria bicolor*	25	10
Javelin Frog	*Litoria microbelos*	26	10
Red Tree Frog	*Litoria rubella*	15	10
Red-eyed Tree Frog	*Litoria rothii*	14	10
Rocket Frog	*Litoria nasuta*	26	10
Peter's Frog	*Litoria inermis*	2	2
Tornier's Frog	*Litoria tornieri*	7	10
Wotjulum Frog	*Litoria wotjulumensis*	2	3
Ratchet Frog	*Crinia remota*	26	10
Marbled Frog	*Limnodynastes convexiusculus*	24	10
Ornate Burrowing Frog	*Limnodynastes ornatus*	1	1
Golfball Frog	*Notaden melanoscaphus*	1	2
Stonemason Toadlet	*Uperoleia lithomoda*	4	10
Floodplain Toadlet	*Uperoleia inundata*	17	10
Howard River Toadlet	*Uperoleia daviesae*	1	10
Cane Toad	*Bufo marinus*	12	9
Known to occur in region but not recorded at a survey site			
Pale Frog	*Litoria pallida*	-	-
Known to occur but does not call			
Dahl's Aquatic Frog	*Litoria dahlii*	observed	-

Tornier's Frog (*Litoria tornieri*) is infrequently encountered throughout the Darwin Harbour region. Photo by Peter Dostine

Water-bugs

Identifying water-bugs requires specialist taxonomic expertise to identify to genus level.

Invertebrate animals which live in streams are often collectively called ‘water-bugs’. They are more properly termed aquatic macro-invertebrates. They include a diverse set of animals, some of which are well known to many people such as freshwater mussels and large freshwater prawns, but most are relatively small, obscure animals which live unseen in our streams, rivers and lagoons. Most of the types of animals found in our waterways are insects: many of these have an immature aquatic phase, and a free-flying terrestrial adult phase in their life cycle. Common examples include dragonflies, caddis flies and mayflies.

Aquatic macro-invertebrates are important in both aquatic and terrestrial food-webs. Fish, waterbirds and aquatic reptiles all depend on aquatic macro-invertebrates for food. For example, the freshwater crab forms a large part of the diet of the Water Monitor.

Larvae of all damselflies (*Ceriagrion aeruginosum* shown in photo) and dragon flies are aquatic.

Many types of freshwater animals have fascinating life cycles. The immature stages of freshwater mussels snap shut on the fins of freshwater fish and are transported upstream as fish migrate to refuge habitats. The life cycle of some shrimps and prawns involves an estuarine phase where the larvae migrate to saline waters and then juveniles undertake a return migration upstream. These species rely on the ecological health of both the freshwater and marine parts of the system.

The most common types of animals in our waterways are larvae of the dipteran family Chironomidae. These animals are found in freshwater environments throughout the world and are commonly used to assess environmental quality. Different types of larval chironomids have different ways of obtaining food – some are predators on other aquatic animals, some consume microscopic algae, others trap small particles of food using a mucous net suspended at the mouth of protective tubes. The larval stage is followed by a pupal stage during which the animals metamorphose to adults. Adults emerge from the pupal skin at the water surface, leaving the shed pupal skin to float downstream. These shed skins (or exuviae) are useful in bio-assessment as they provide an easy way to tell what types of chironomids are present.

The composition of the water-bug fauna of our streams, rivers and lagoons is now reasonably well known. They are an important part of our monitoring work to track the condition of waterways in the Darwin area.

Sediment and nutrient loads in Darwin Harbour catchment streams

In areas with highly variable rainfall such as in the wet-dry tropical north, it is important to use storm event-based sampling for pollutant load estimation, as this is when most sediment and nutrients are transported. In the Darwin region, the climate is tropical with distinct wet and dry seasons. The monsoonal wet brings rainfall averaging 1,700 mm per year, with about 80 per cent falling between December and March inclusive (data from Bureau of Meteorology, 2009). The period from May to October is much drier.

Event-based water quality monitoring is being used to increase our understanding of catchment pollutant sources and help identify sources for management actions to protect the water quality in the region. The transfer of pollutants such as sediment and nutrients from land to water bodies originate from diffuse (non-point, such as a whole catchment) and point (e.g. sewage treatment plant) sources.

Event-load estimates to the Harbour have been made using wet season streamflow data from the Department of Natural Resources, Environment, The Arts and Sport (NRETAS) stream gauge sites (see photo) in urban, rural or undeveloped catchments. Water quality samples were collected by the NRETAS Aquatic Health Unit at Peel, Bennett, Berry, Howard, Elizabeth, Celia, Karama and Moil catchment gauge stations, and loads determined. Urban land use contributes greater diffuse source pollutant loads per hectare than non-urban land use. Some metal loads per hectare are greater for urban areas than non-urban areas due to metals associated with building materials. Other pollutants are from vehicle emissions, construction, manufacturing industry and roads.

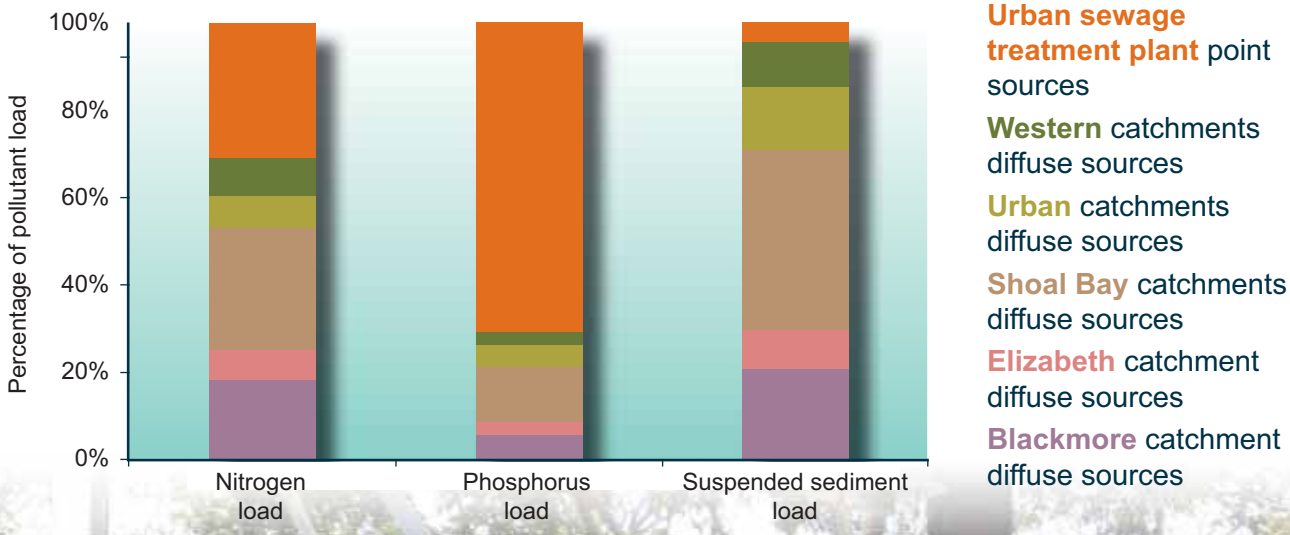
The table shows average wet season load per hectare for urban and non-urban land use in the Darwin Harbour catchment (adapted from Skinner et al. 2009)*.

Pollutant	Catchment classification	
	Non-urban	Urban
Total suspended sediment TSS (kg/ha)	110	730
Aluminium Al (kg/ha)	3.8	50
Total nitrogen TN (kg/ha)	3.2	9.9
Total phosphorus TP (kg/ha)	0.12	1
Zinc Zn (g/ha)	71	890
Copper Cu (g/ha)	13	200
Chromium Cr (g/ha)	8.5	44
Nickel Ni (g/ha)	4.3	13
Lead Pb (g/ha)	4.1	270
Arsenic As (g/ha)	2.2	11
Cadmium Cd (g/ha)	0.93	1.9

* Skinner, L., S. Townsend, and J. Fortune, (2009), The impact of urban land use on total pollutant loads entering Darwin Harbour, Department of Natural Resources, Environment, the Arts and Sport, Report 06/2008D, Darwin.

In an average wet season, about 36,000 tonnes of suspended sediment flow into Darwin Harbour from catchments – that is about 36,000 ute loads. Most of this is from soil erosion.

About 1,000 tonnes of nitrogen enter Darwin Harbour per year. Diffuse sources from catchments are an important source of nitrogen. The Blackmore River and Shoal Bay catchments are large in area and contribute about 18 per cent and 28 per cent of average annual loads, respectively. About 140 tonnes of phosphorus enter Darwin Harbour in an average year. The graph shows sewage treatment plants are currently an important source of phosphorus to the harbour from land-based activities. Much of the remaining phosphorus is from diffuse sources in the catchment.



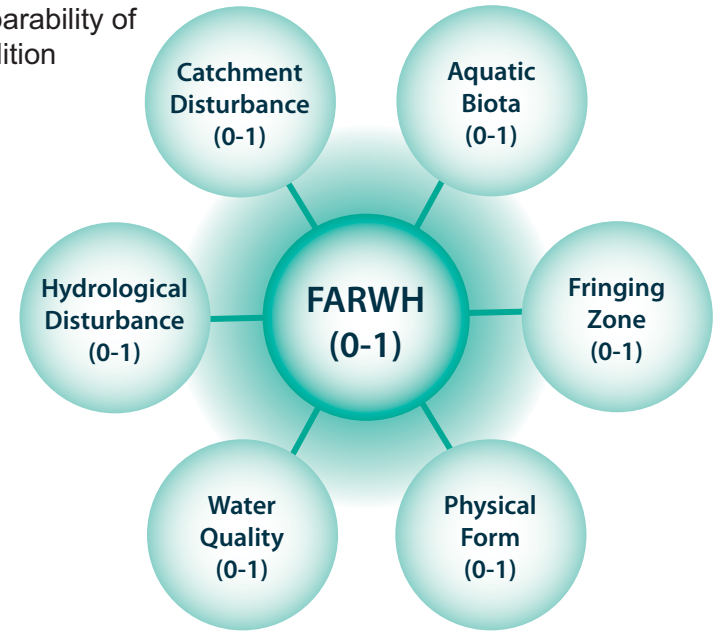
Contribution of catchment land-based diffuse and point source loads to Darwin Harbour in an average wet season.

Peel gauge station in the Department of Natural Resources, Environment, The Arts and Sport hydrographic network. Water quality samples and flow data are collected to determine pollutant loads.

A framework for river and wetland health – FARWH index

The Framework for River and Wetland Health has been developed as a monitoring system to guide the national assessment of river and wetland health to determine if there is long-term change in condition. The aim of the framework is to allow for national comparability of assessments of river and wetland condition based on the impacts of resource use.

The FARWH for river health has six components or sub-indices which are appropriate for the assessment of river and wetland health, as they evaluate ecological integrity. The components for river health are shown below.



FARWH indicator scores and banding system for wetlands

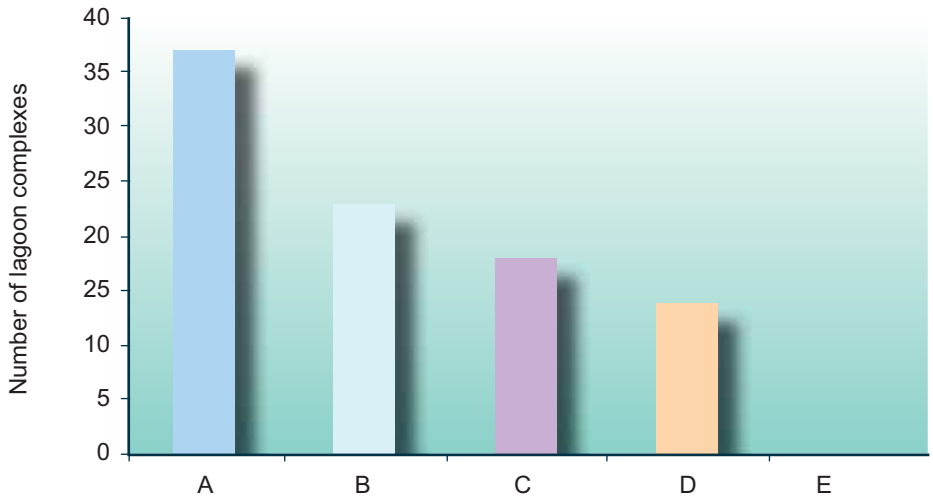
Band*	Indicator score	Description
A	0.8 – 1	Largely unmodified
B	0.6 – <0.8	Slightly modified
C	0.4 – <0.6	Moderately modified
D	0.2 – <0.4	Substantially modified
E	0 – <0.2	Severely modified

*This colour coding is used in the FARWH system for wetlands.

For wetland health, the FARWH includes similar components and water and soil quality. Each index component may comprise more than one sub-index. The catchment disturbance component for rivers, for example, may include land use and fire sub-indices. In the FARWH system, water quality assessment focuses on ecosystem health. The water quality component for rivers has several water quality parameters affecting ecosystem health. The water quality component for rivers is being trialled, including total and dissolved nutrients, dissolved oxygen, total suspended solids, electrical conductivity and pH.

The aquatic biota index may include macro-invertebrates, fish and aquatic weeds. The macro-invertebrate sub-index for streams is based on the AUSRIVAS system shown in some of the report cards. The indices, including the FARWH index, are scored between 0 and 1. A score of 1 refers to minimally disturbed reference condition. The scoring system is associated with condition bands A to E.

The FARWH index is currently being trialled on the streams of the Darwin Harbour region. Trials of the FARWH index on wetlands in the Darwin Harbour region has been completed. Results revealed more than a third of the 92 natural lagoon complexes to be in the 'largely unmodified' condition. A quarter were categorised as 'slightly modified', approximately a fifth classed as 'moderately modified' and the remainder as 'substantially modified'. No lagoons were classed as the worst condition 'severely modified'. The overall score of all natural lagoon complexes was 0.76, which is classed as slightly modified.



Condition of natural lagoons in the Darwin Harbour region, using the FARWH system

Further reading

For 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

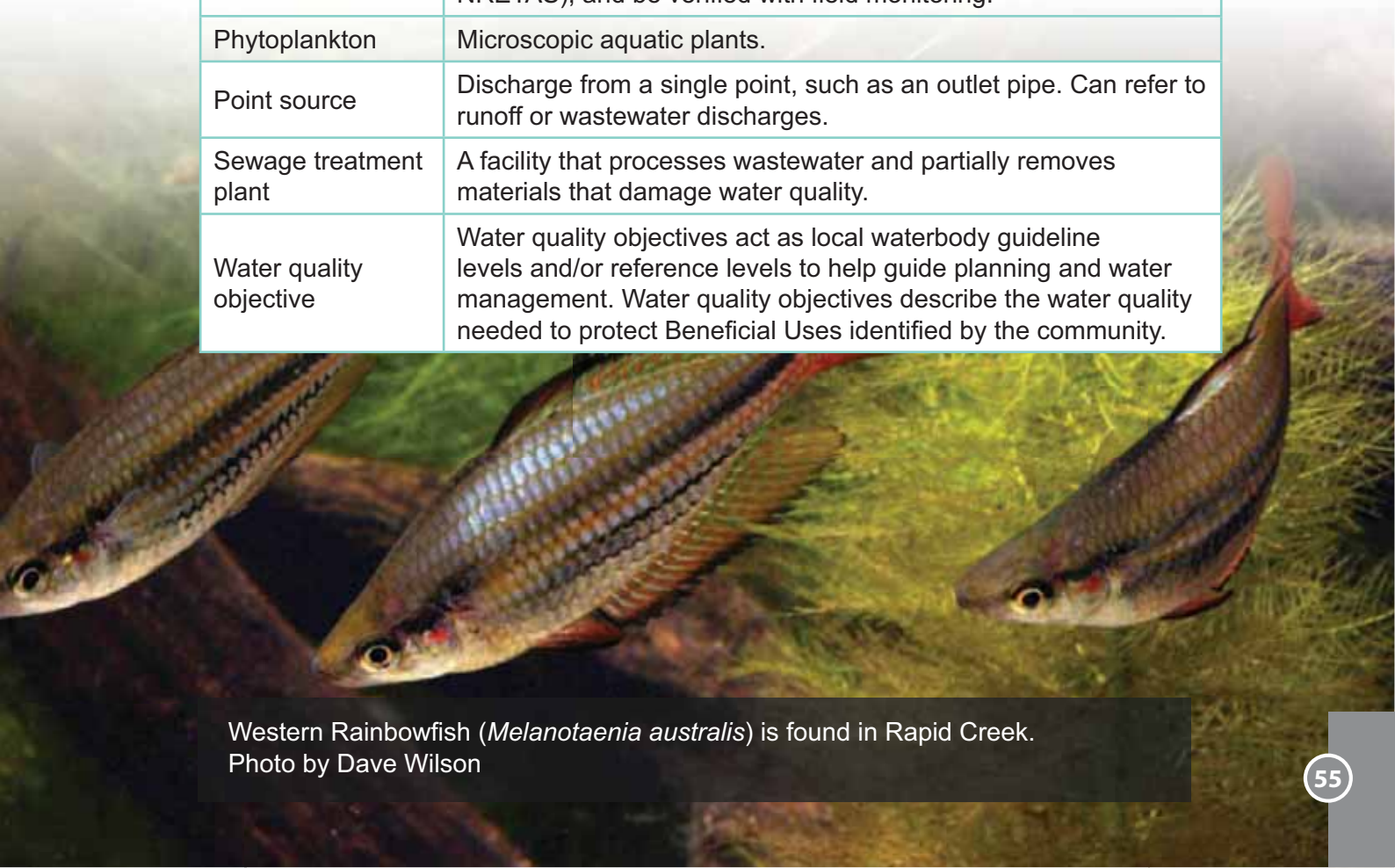
For further information on water quality, see ANZECC guidelines and publications
http://www.environment.gov.au/about/councils/anzecc/index.html#reports
http://www.mincos.gov.au/publications/national_water_quality_management_strategy

Horticulture is an important industry in the region. Photo by George Maly

Glossary

Explanations of water quality and biological indicators (e.g. chlorophyll-a) 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 run-off) from non-point sources such as urban paved or non-paved areas, hillslopes, agricultural land and forest.
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. In the Darwin Harbour region, upper estuaries and tidal creeks are generally poorly flushed.
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.



Western Rainbowfish (*Melanotaenia australis*) is found in Rapid Creek.
Photo by Dave Wilson