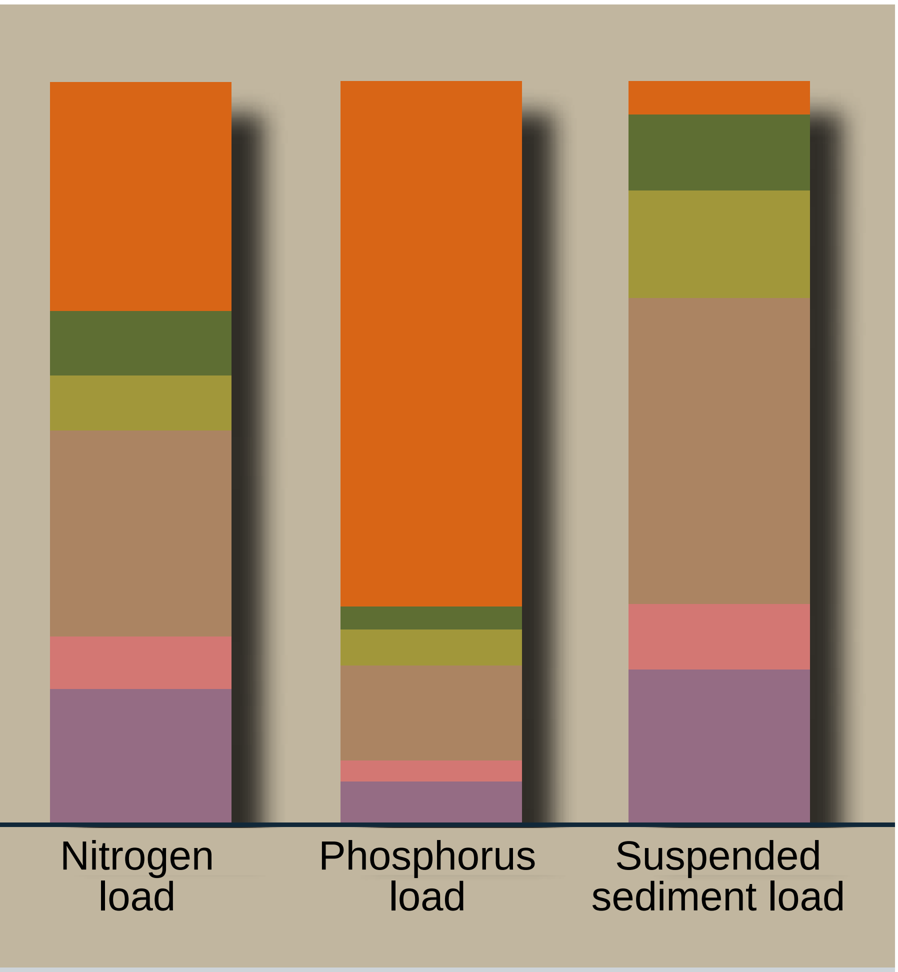
Understanding water quality and pollution sources

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

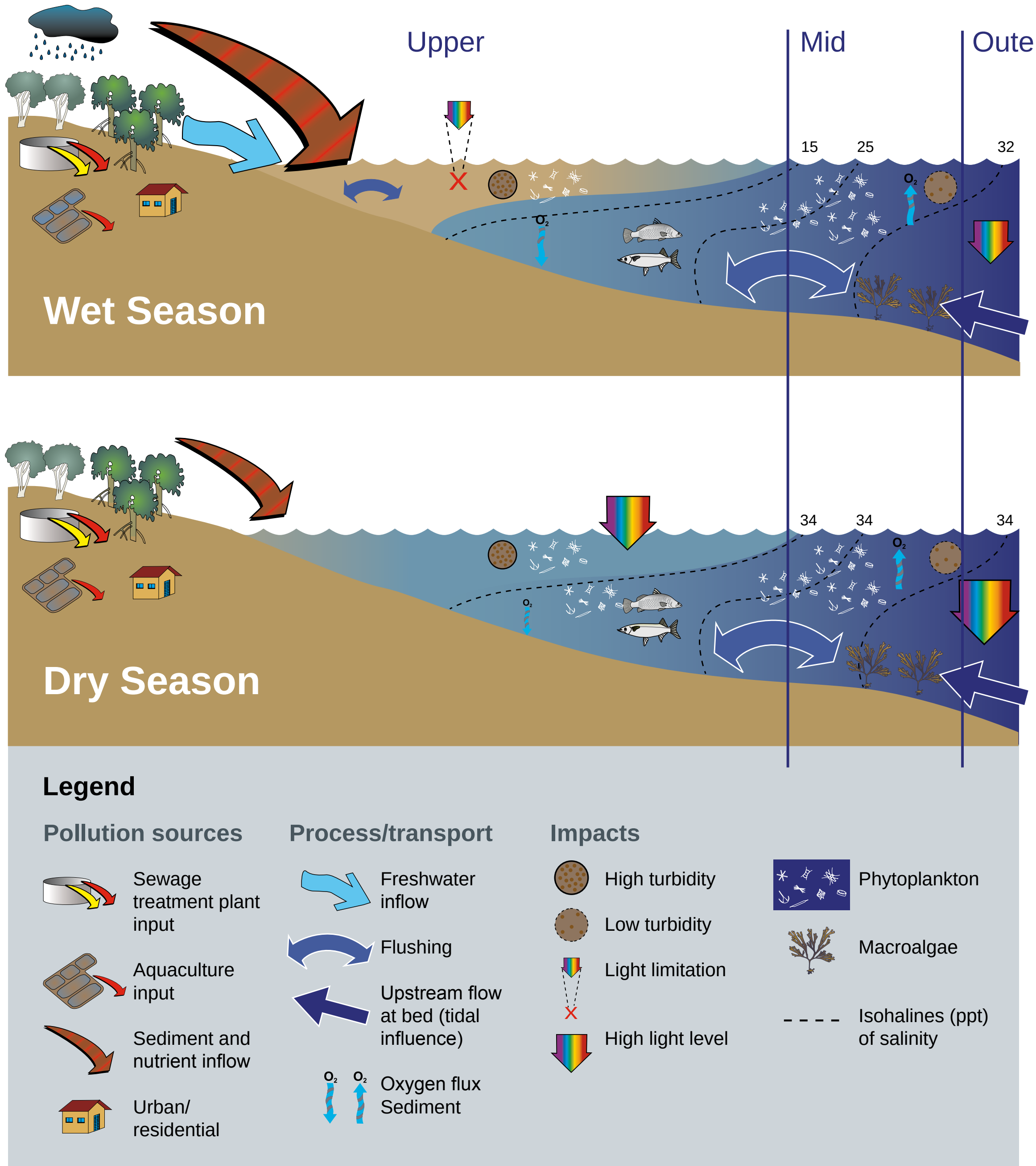
- Runoff entering the estuary from the urban and rural area increases available nutrients such as nitrate which can result in increased algal growth.

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.

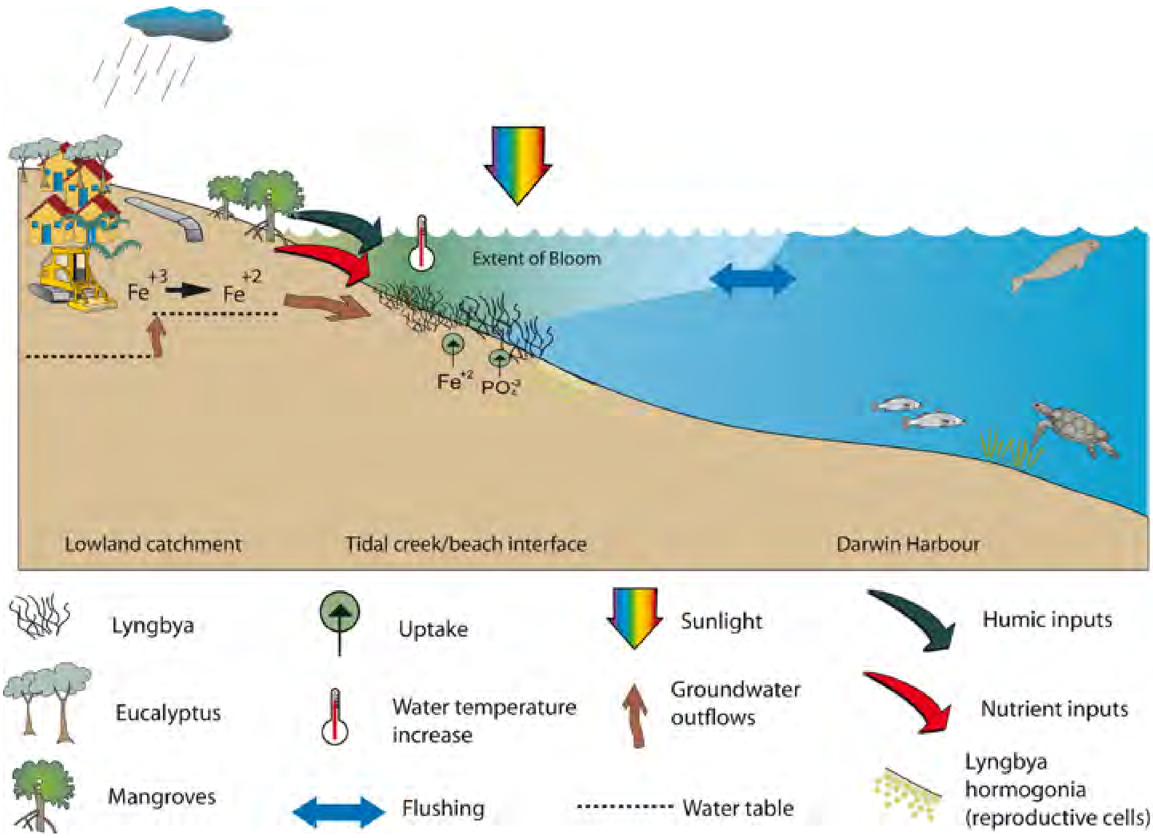


Formation of cyanobacteria blooms in Darwin Harbour and beach areas

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.

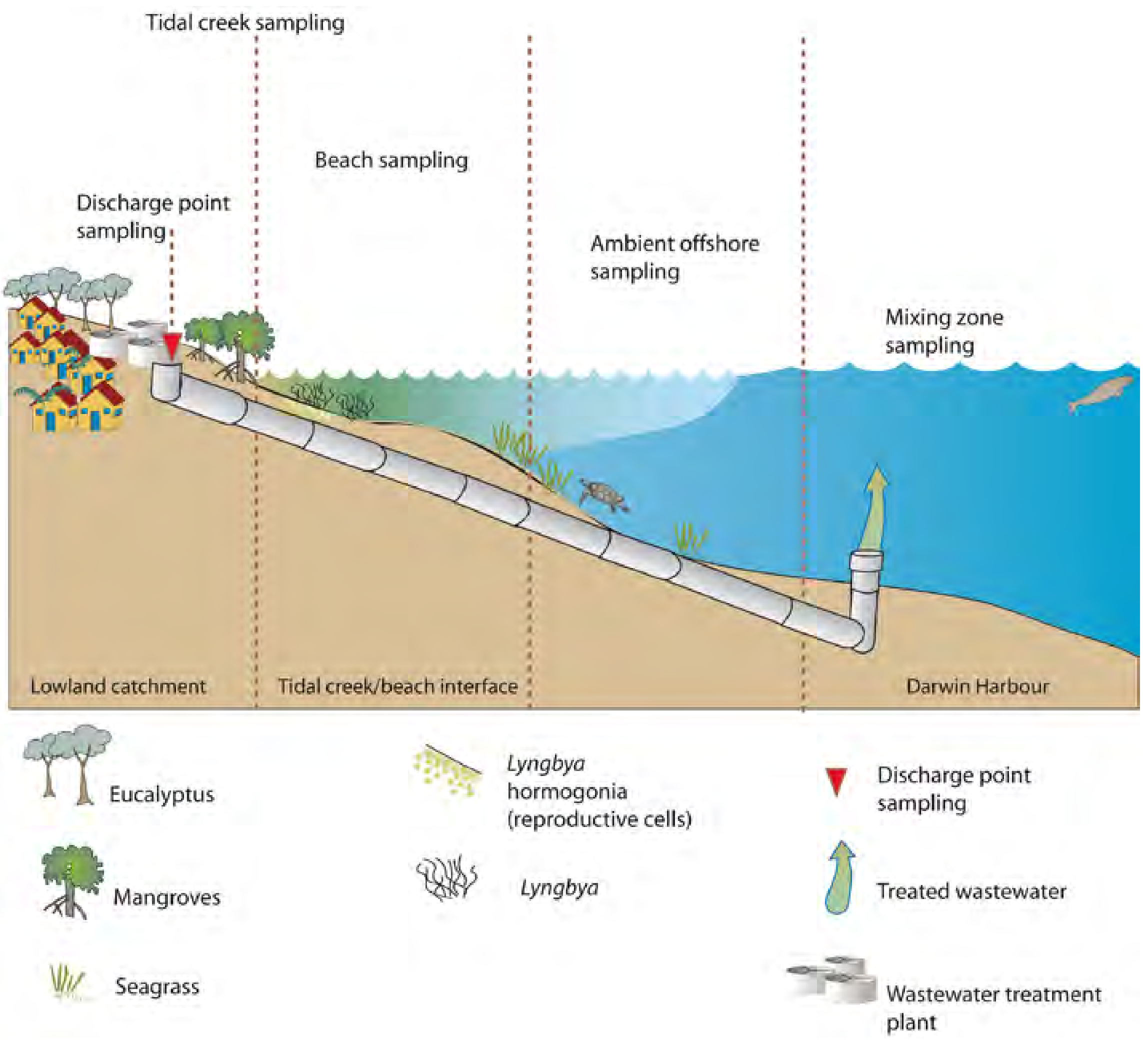


Monitoring sites for beach areas, tidal creeks and mixing zone areas

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.

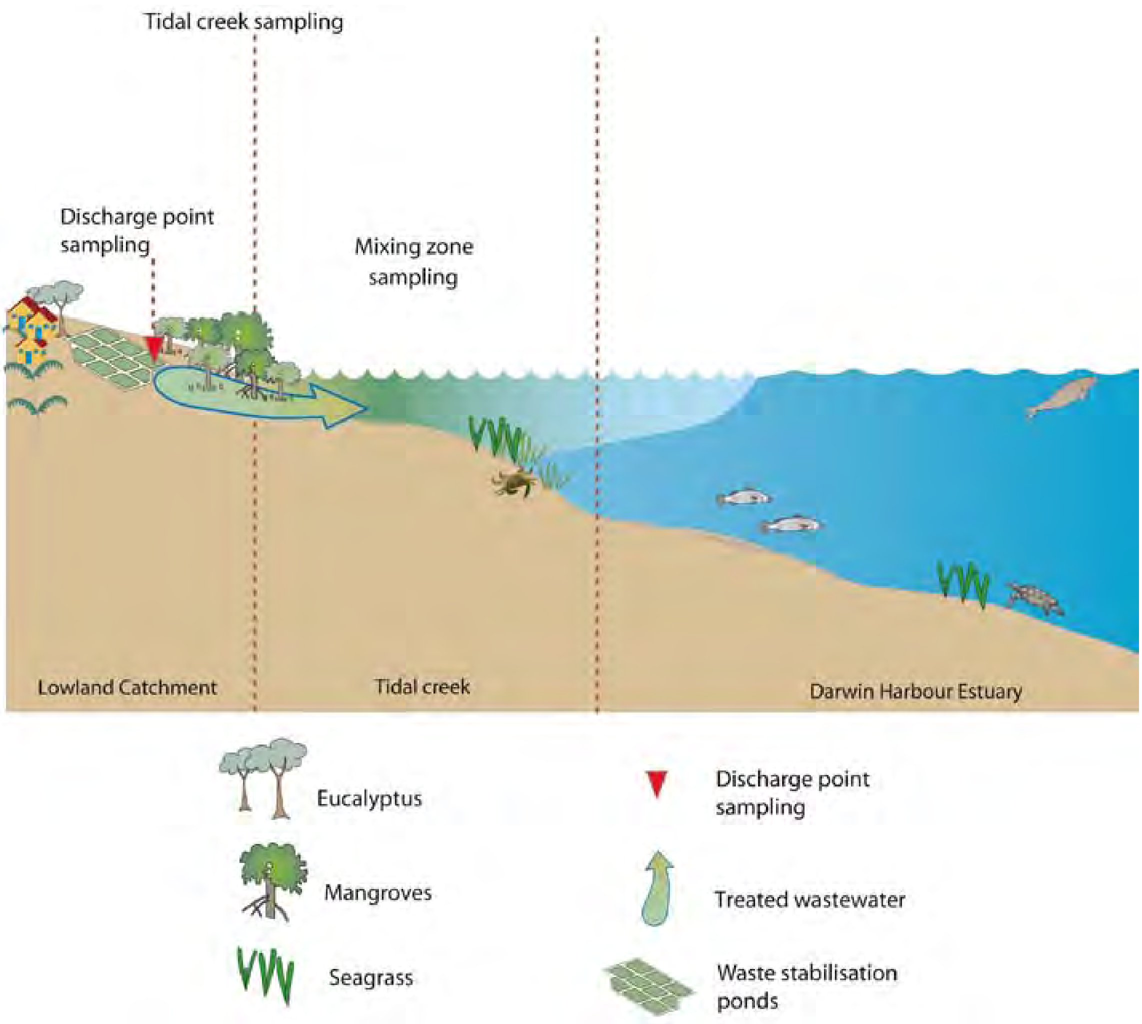
The tidal creek sites include Little Mindil Creek, Mindil Creek, Rapid Creek, and Vesteys Creek which are monitored weekly. The treatment plant mixing zone areas at East Point and Larrakeyah are independently monitored by the Aquatic Health Unit at fortnightly intervals. Up to six sites per mixing zone 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.