Coastal water quality

Summary

Diffuse and point source discharges of nutrients, sediments and contaminants such as heavy metals and synthetic agricultural and industrial chemicals pose a significant risk to the ecological condition of coastal and estuarine waterways. With continued population growth and development in the coastal zone, it can be expected that more water will be needed and more wastewater will be generated. Unless the pressures on coastal water quality are firmly managed and progressively reduced, undesirable and costly ecological, health and economic impacts are likely.

Regional assessments of coastal water quality condition found that sites in the Burdekin, Mackay–Whitsunday and south-east Queensland regions most commonly experienced poor water quality. Phosphorus and nitrogen were the two indicators contributing to this rating. Metals bioaccumulated in prawns, shellfish and other marine fauna were greatest in south-east Queensland waterways, particularly canals, and occasionally exceeded Australian food quality standards. In central and north Queensland the persistence of pesticides and herbicides, including a number of banned substances, in sediment, seagrass and some marine mammals is an issue.

Current and future efforts to deal with water quality centre on integrating coastal and catchment management, setting and assessing water quality targets and working with communities and industries to reduce and recycle wastewater. Discharges of nutrients from point sources have been reduced significantly in the past five years through concerted efforts to upgrade treatment technology and amalgamate and reduce the number of actual discharges. While there have been localised improvements in reducing diffuse inputs, managing and progressively reducing these inputs to the coast remains a great challenge for Queensland in the next five years. Initiatives such the Reef Water Quality protection plan, the National Action Plan for Salinity and Water Quality and the Natural Heritage Trust will develop catchment-specific nutrient targets to further drive management actions to reduce sediment and nutrient loads. To improve our knowledge of coastal water quality and monitoring of its effect on aquatic resource condition, resources will need to be augmented and better coordinated to provide more comprehensive and timely information on basic water quality indicators, conduct targeted regional assessments of contaminants and deal with significant knowledge gaps such as the inadequacy of water quality data from the Gulf and Cape York regions.

Description

A variety of human activities occurring within and adjacent to a catchment can contribute to changes in water quality. Unsustainable land use practices such as land clearing, removal of riparian vegetation and excessive stocking rates increase mobilisation of soil (sediment) and expose acidic soils. Inappropriate application of fertilisers, pesticides and herbicides on crops and the discharge of domestic and industrial wastes from point source discharges and stormwater overflow affect water quality in adjacent waterways.

The pressures on coastal and estuarine water quality need to be firmly managed and progressively reduced to prevent undesirable impacts such as loss of biodiversity and habitat, fisheries production and visual and recreational amenity; increased incidence of algal blooms; fish kills; and increases in the number of invasive species. Failure to do so may lead to a number of socioeconomic consequences including loss of income (tourism and fisheries), the need for costly remediation technologies (in areas such as water treatment and site rehabilitation), negative health outcomes and associated costs, as well as community concern.

The major issues relating to definitions of good or poor water quality are the presence, concentration or load of:

- nutrients—the oversupply of nutrients, principally nitrogen and phosphorus, can lead to organic enrichment (eutrophication) resulting in outcomes such as increased algal blooms, which, if unchecked, can have significant health, recreational and commercial repercussions such as the closure of fisheries and swimming areas;
- sediments—oversupply of sediments increases the turbidity of water, reducing the light available to plants for photosynthesis. It can also smother and abrade benthic organisms;
- bioaccumulated contaminants—pesticides, herbicides, heavy metals and other endocrine-disrupting chemicals used by industry and released, either deliberately (as point discharges) or accidentally (as chemical spills), to coastal and estuarine waters can accumulate in plants and animals, and have adverse physiological effects. Subsequent human consumption of contaminated seafood can result in a range of mild to severe health outcomes;
- pathogens—human faecal contamination of drinking water can potentially lead to gastroenteric and respiratory illnesses in humans participating in recreational activities in the water;
- litter—the introduction of litter, such as cigarette butts and plastics, may choke aquatic fauna including birds, fish and marine mammals and reptiles;
- flow—while flow was often considered a separate issue from water quality, there is now widespread recognition that sustainable and variable flows of water help to prevent algal bloom formation and are an important cue for the spawning of estuarine fishes. Recent droughts have highlighted the fact that healthy estuarine and coastal water quality is also essential to definitions of water quality; and
- acid sulfate soils—in exposed low-lying coastal areas acid sulfate soils can result in disease and death of fish, and cause deterioration in concrete, steel and road infrastructure.

Water quality assessment (Photo: EPA)

Pressures

The water quality and ecological condition of Queensland's estuarine and coastal waterways are integrally related to surrounding and upstream land use activities. Coastal and estuarine water quality is affected by:

- wastewater discharges;
- land clearing and loss of riparian vegetation;
- alterations to surface water flows;
- agriculture;
- aquaculture; and
- land-based and shipping industries.

Wastewater discharges

It is still common practice to discharge domestic and industrial wastes—a cocktail of sediments, nutrients and contaminants—to nearby estuarine and coastal waterways. These point sources or wastewater treatment plants (WWTPs) can include domestic sewage treatment plants (STPs), industrial or agricultural facilities (such as piggeries and feedlots) and mining discharges.

Upgrades at sewage treatment plants in south-east Queensland have reduced the nitrogen and phosphorus loads being discharged into Moreton Bay. (Photo: EPA)

In south-east Queensland nutrients discharged via wastewater discharges account for approximately 40% of the total nitrogen and 60% of the total phosphorus released to coastal and estuarine waters; elsewhere in the state they typically account for less than 10% (figure 6.14). The standard of this effluent, the quality of the receiving waters and their capacity to absorb additional nutrients and other contaminants vary along the coast. Accidental spills and overflows of domestic untreated sewage can also occur, mostly as a result of wet weather infiltration or pump station failures.

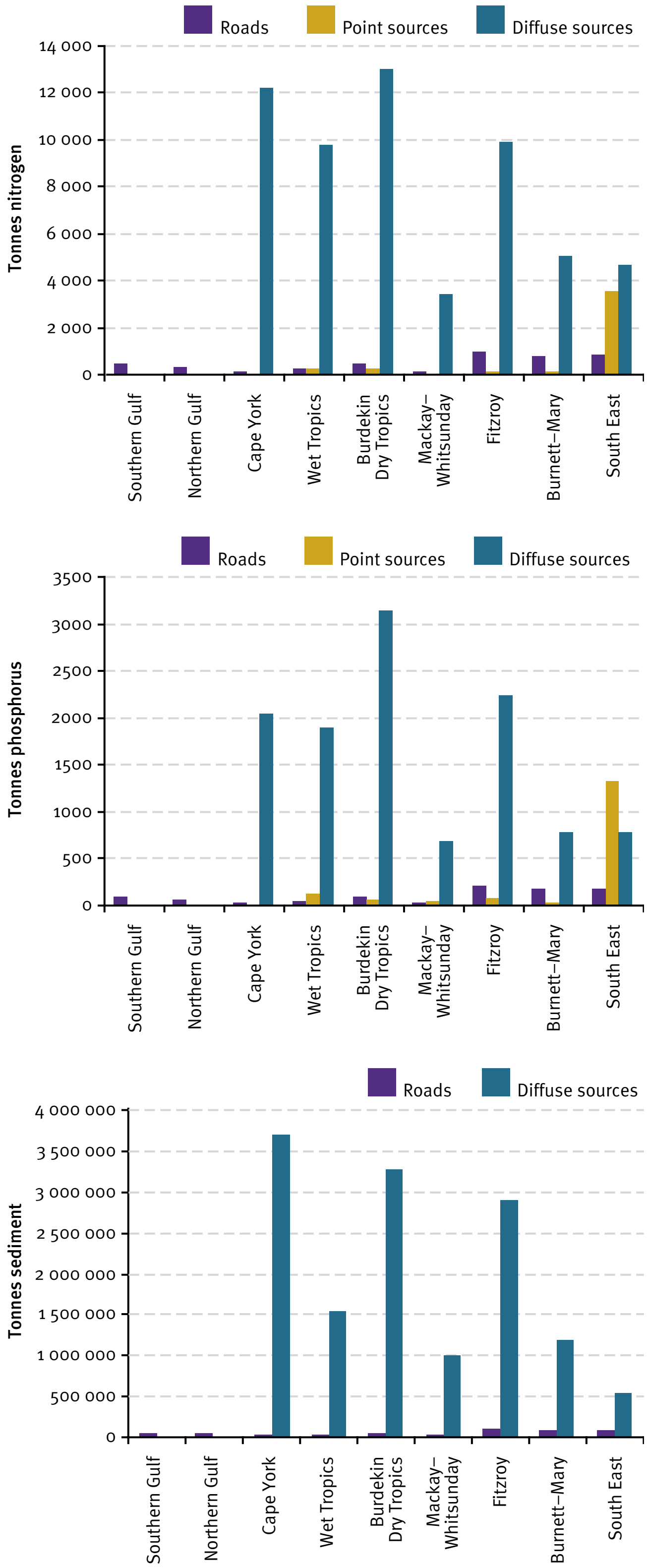


Figure 6.14 *Relative contribution of point sources (wastewater treatment plants), diffuse sources and impervious surfaces to annual catchment loads (tonnes) of nitrogen, phosphorus and sediment in Queensland NRM regions*

Sources: WWTP data from local governments; diffuse sources are taken from SEDNET predictions (NLWRA 2002); impervious surfaces are calculated from runoff coefficients (WBM 2002) scaled to the area of road in each region.

Over 200 STP discharges throughout Queensland are currently licensed and many of these discharge to coastal waters. Since 1999, many of the larger STPs in south-east Queensland have significantly reduced nutrient discharges through concerted efforts by local governments to upgrade treatment technology (Caboolture Shire), decommission old plants (Logan City), amalgamate discharges (Gold Coast City), or divert discharges to more suitable receiving environments (Maroochy Shire) (table 6.17). This has resulted in a reduction in nitrogen loads across the region of almost 35%. Significant reductions in phosphorus loads from some STPs, notably on the Gold Coast, have been offset by increases from other plants discharging into or close to Moreton Bay; across the region phosphorus loads have been reduced by more than 4%. In north Queensland upgrades to some of the smaller plants have reduced nitrogen and phosphorus discharges by 30–90%.

Table 6.17 Nitrogen and phosphorus discharges from selected wastewater treatment plants in 2001–02 and the percentage change in nutrient discharge since 1999

Wastewater treatment plants	Nitrogen		Phosphorus	
	2001–02 load (kg)	Change since 1999 (%)	2001–02 load (kg)	Change since 1999 (%)
South-east Queensland				
Luggage Point	350 035	–66	408 800	–20
All Gold Coast plants	226 139	–40	156 475	–43
Redcliffe	20 212	–91	4 513	–89
All Ipswich plants	120 401	–34	–	–
Pine Rivers Shire	55 000	–75	34 700	-21
North Queensland				
Gordonvale	6 410	–75	2 959	–57
Babinda	5 625	–36	1 607	–31
Atherton	3 105	–80	621	–93
Port Douglas	4 748	–80	950	–93
Queensland total	**2 919 000**	**–30**	**1 508 000**	**–4**

Source: EPA

In non-sewered areas in south-east Queensland and along the Queensland coast, it is estimated there are approximately 225 000 septic tanks and 25 000 household sewage treatment plants. The environmental impacts of these facilities depend on the effectiveness of the facility and maintenance by the property owner.

Land clearing and loss of riparian vegetation

Vegetation clearing leads to increased flows, erosion and delivery of nutrients and sediments from catchments to adjacent waterways as a result of the loss of the natural filtering systems provided by riparian areas and coastal wetlands. Soil and nutrient losses increase significantly when vegetation cover (particularly grasses) falls below 40%, or when pastures are overgrazed or overburnt for the prevailing climate and pasture growth conditions.

In south-east Queensland, only 26% of the catchments' original vegetation remains. Channel (gully and stream bank) erosion is the dominant form of erosion in these catchments, with more than 60% of the sediment coming from less than 30% of the area (figure 6.15).

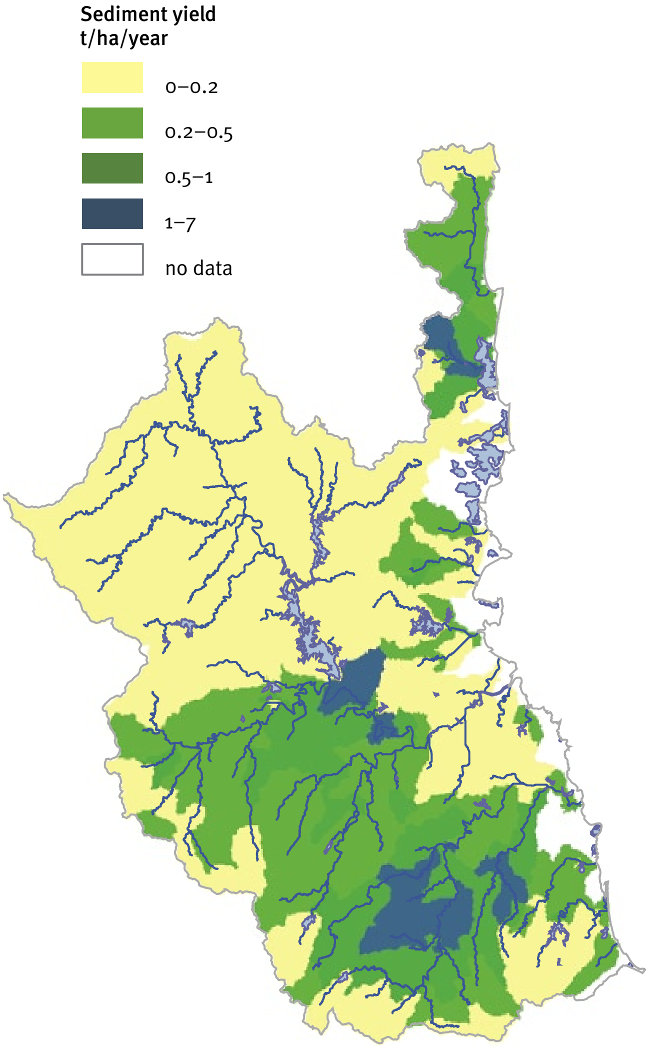


Figure 6.15 Predicted contribution of different areas in the catchments to sediment loads in Moreton Bay, as determined by SEDNET predictions
Source: CSIRO Land and Water

In catchments adjacent to the Great Barrier Reef, vegetation clearing continues, the coastal lowlands and wetland areas being under the greatest pressure. Here, hill slope erosion dominates, supplying 63% of sediment to rivers (Brodie et al. 2003). Gully and riverbank erosion can also be significant but these are confined to a few catchments. Overall, 70% of sediment delivered to the coast comes from just 20% of the catchment area. The areas responsible for the highest contribution are relatively close to the coast, from the Burnett–Mary to the Fitzroy, from Mackay to Bowen, and in the Wet Tropics and the Normanby River basin (figure 6.16).

Soil erosion in these catchments is also the greatest source of particulate nutrients, gully and riverbank erosion accounting for less than 10% of the total nutrient sources. Total loads of nitrogen and phosphorus delivered to the coast largely reflect soil erosion patterns because particulate nutrients, resulting primarily from hill slope erosion, account for more than 70% of total nutrient sources.

Acid sulfate soils are present along much of the Queensland coast. Acidic water draining from disturbed acid sulfate soils is generally poorly oxygenated, has a low pH and may contain elevated concentrations of heavy metals and aluminium. These conditions have the potential to have adverse impacts on fish habitat and health.

Alterations to surface water flows

Reductions in vegetation cover and increases in areas of impervious surfaces such as roads and built urban environments can significantly increase the volume and alter the pattern of surface water runoff to nearby waterways, leading to increased nutrient, sediment and contaminant loads. In urbanised south-east Queensland catchments, it is estimated that roads contribute approximately 10% of total nutrient and sediment loads.

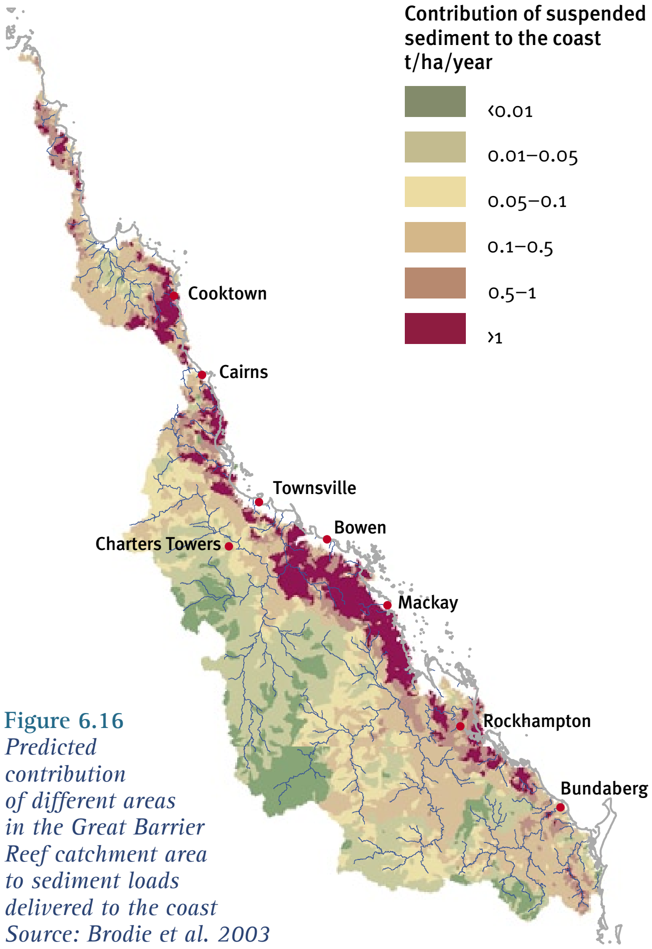


Figure 6.16 Predicted contribution of different areas in the Great Barrier Reef catchment area to sediment loads delivered to the coast
Source: Brodie et al. 2003

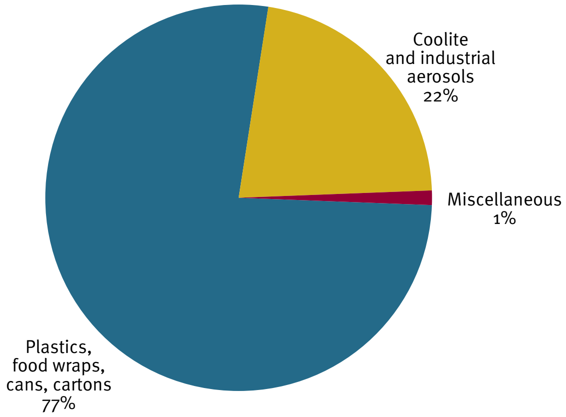


Figure 6.17 Rubbish collected from the Brisbane River, December 2001 to October 2002.
Source: Maritime Care

Carelessly discarded litter eventually finds its way into waterways. While litter is widely regarded as a significant environmental issue, relatively little quantitative information is available. A Maritime Care study in 2002 covering an 80 km stretch of the Brisbane River collected more than 160 000 items of rubbish over a 10-month period; plastics, food wrapping, cartons and cans accounted for more than 77% of this litter (figure 6.17).

The construction of dams, weirs and barrages to meet the needs of agriculture, industry and urban development has led to flow regulation of rivers, which can impair the chemical, physical and biological characteristics of estuarine and coastal habitats and potentially limit fisheries resources by inhibiting the passage and spawning of fishes. Dams change both the volume and pattern of flows downstream in the catchment by attenuating periods of naturally high flow but often eliminating low flows altogether during dry periods. All 13 Natural Resource Management (NRM) regions are now subject to some degree of flow regulation (table 6.18).

Table 6.18 Catchment area, number of streams, number of dams and weirs and storage capacity, and largest dam in each of Queensland's NRM regions in 2000

NRM region	Total catchment area (km²)	Number of streams	Number of dams and weirs	Total dam and weir capacity (ML)	Largest dam
Coastal					
Southern Gulf	106 595	201	28	200 000	Flinders River d/s 828.5
Northern Gulf	47 044	179	19	20 600	Copperfield River George Dam
Cape York	8 310	171	4	135	Two Mile Creek Weir
Wet Tropics	14 855	77	42	666 889	Tinaroo Falls Dam
Burdekin Dry Tropics	1 361 966	155	75	2 468 058	Burdekin Falls Dam
Fitzroy	3 098 770	258	174	4 286 226	Fairbairn Dam
Mackay–Whitsunday	12 578	38	43	749 804	Peter Faust Dam
Burnett–Mary	996 996	300	244	1 449 518	Fred Haigh Dam
South East	1 165 200	154	173	2 408 552	Wivenhoe Dam
Inland					
Murray–Darling	1 255 465	298	202	254 000	Glenlyon Dam
Desert Channels	273 259	271	10	50 585	Lena Creek No. 8 Tailings Dam
South West	125 855	72	7	3 520	Cunnamulla Weir
Desert Uplands	103 624	226	10	457	Charles Lloyd Jones Weir

Source: DNRM

Agriculture

The major agricultural land use in catchments adjacent to the Great Barrier Reef is grazing (77%) on native or improved pastures; cropping of sugar, horticulture, grains and cotton accounts for approximately a further 3% (Gilbert et al. 2003). Diffuse runoff from these cropping and grazing lands contributes more than 90% of nutrient loads in catchments north of Bundaberg (figure 6.16).

Cattle grazing affects downstream water quality. (Photo: DNRM)

Beef cattle grazing in the large, dry Burdekin and Fitzroy catchments has resulted in widespread erosion and nutrient loss, because cattle strip vegetation and groundcover, and loosen the soil surface by trampling. Cattle with access to waterways can also strip riparian vegetation, and defecation introduces nutrients and pathogens directly to the water.

Cropping involves intensive fertiliser and pesticide use and has resulted in substantial soil erosion. Sugarcane is the most important cultivated crop and is now harvested from 430 000 ha, primarily on the coastal plain south of the Daintree River (17°S). Although application rates of nitrogen and phosphorus fertilisers vary regionally, under average cultivation practices approximately 180 kg/ha of nitrogen fertiliser is applied annually. More than 60% of this nitrogen is lost to the atmosphere, is stored in the soil, or enters waterways through surface runoff or as groundwater. The cotton industry uses nitrogenous fertilisers at an average application rate of 150 kg/ha/year, whereas banana cultivators can apply more than 400 kg/ha/year.

Over the past 30 years, application rates of nitrogenous fertilisers have continued to increase at a rate of approximately 4000 kg/year; it is estimated that 100 000 t of nitrogen are applied annually (Furnas 2003). Although soil phosphorus concentrations are now in excess of crop requirements following many years of application, the use of phosphatic fertiliser has increased in the past four years; it is estimated that currently approximately 20 000 t of phosphorus are applied to the Great Barrier Reef catchment each year (Furnas 2003).

The sugarcane and cotton industries are major users of pesticides and herbicides. In 1996, an audit of the sugarcane industry showed that the most commonly applied herbicides were atrazine (~ 332 t), diuron (197 t), 2,4-D (142 t), glyphosate (86 t) and ametryn (76 000 kg); significant quantities of the insecticide chlorpyrifos (74 t) were also used (Hamilton and Haydon 1996).

Endosulfan is still widely used in the cotton and fruit and vegetable industries. Although the use of organochlorine pesticides was banned in the 1980s, several assessments have found significant concentrations of aldrin, lindane, DDT, dieldrin and heptachlor in sediments, highlighting their persistence.

Aquaculture

Land-based and offshore aquaculture has continued to grow, and a total area of 1088 ha is under cultivation for the farming of prawns, barramundi, crayfish and eels (table 6.16). The major pressures associated with aquaculture relate to the quantity and potentially high concentrations of nutrients contained in waste discharged into nearby waterways. Aquaculture also carries the risk of release of disease to the environment through the accidental introduction of exotic pathogens and parasites to wild fish stocks and other marine animals.

Oil tanker, Tangalooma wrecks (Photo: EPA)

Land-based and shipping industries

Heavy metals (lead, zinc, copper, cadmium, mercury, nickel and chromium) and the metalloids arsenic and selenium occur naturally in low concentrations in coastal and estuarine waters, but mining, manufacturing and agricultural industries, as well as runoff from roads that carry heavy traffic, have the potential to release increased levels of these heavy metals to adjacent waterways. The highest concentrations are found in canal estates, common in south-east Queensland; there is little evidence of elevated levels of heavy metals in other coastal areas (table 6.19).

Wastes such as oils and shipboard sewage, generated by boating and slipway activities, can affect the local marine environment around commercial and recreational port facilities. Another significant concern is the use of organotins such as tributyltin (TBT) as biocides in anti-fouling paints, commonly applied to vessels and industrial structures. Although the use of TBT anti-foulant paints was banned on vessels less than 25 m in length in 1989, there is evidence of recent TBT contamination around commercial port facilities (table 6.20).

Dredging for reclamation, sale or maintenance of port and shipping channels increases turbidity through resuspension of sediment. Over 6 million cubic metres of material are estimated to have been removed from dredging sites between July 1999 and June 2002 (table 6.11).

Oil from a leaking pipeline spread into wetlands and waterways at Lytton in March 2003. (Photo: QFRS)

Accidents resulting in the spillage of chemicals and oils can have profound effects on coastal and estuarine waters; a massive concerted effort is required to contain them and remediate the sites. In 2001–02, 96 oil spills in Queensland waters were reported to Queensland Transport (figure 6.9); the majority were around Brisbane. Significant industrial spills in the past three years included the accidental release of pesticides from an industrial plant that had caught fire into a nearby waterway at Salisbury, the release of 3000 litres of diesel fuel into Shute Harbour from a storage facility, and the release of approximately 1 500 000 litres of light crude oil in the wetlands and waterways at Lytton from a leak in an oil pipeline. The grounding of a Malaysian container ship on Sudbury Reef in the Great Barrier Reef Marine Park in late 2000 resulted in 100 times the safe level of TBT on the reef.

Condition and trends

Regional water quality condition and trends

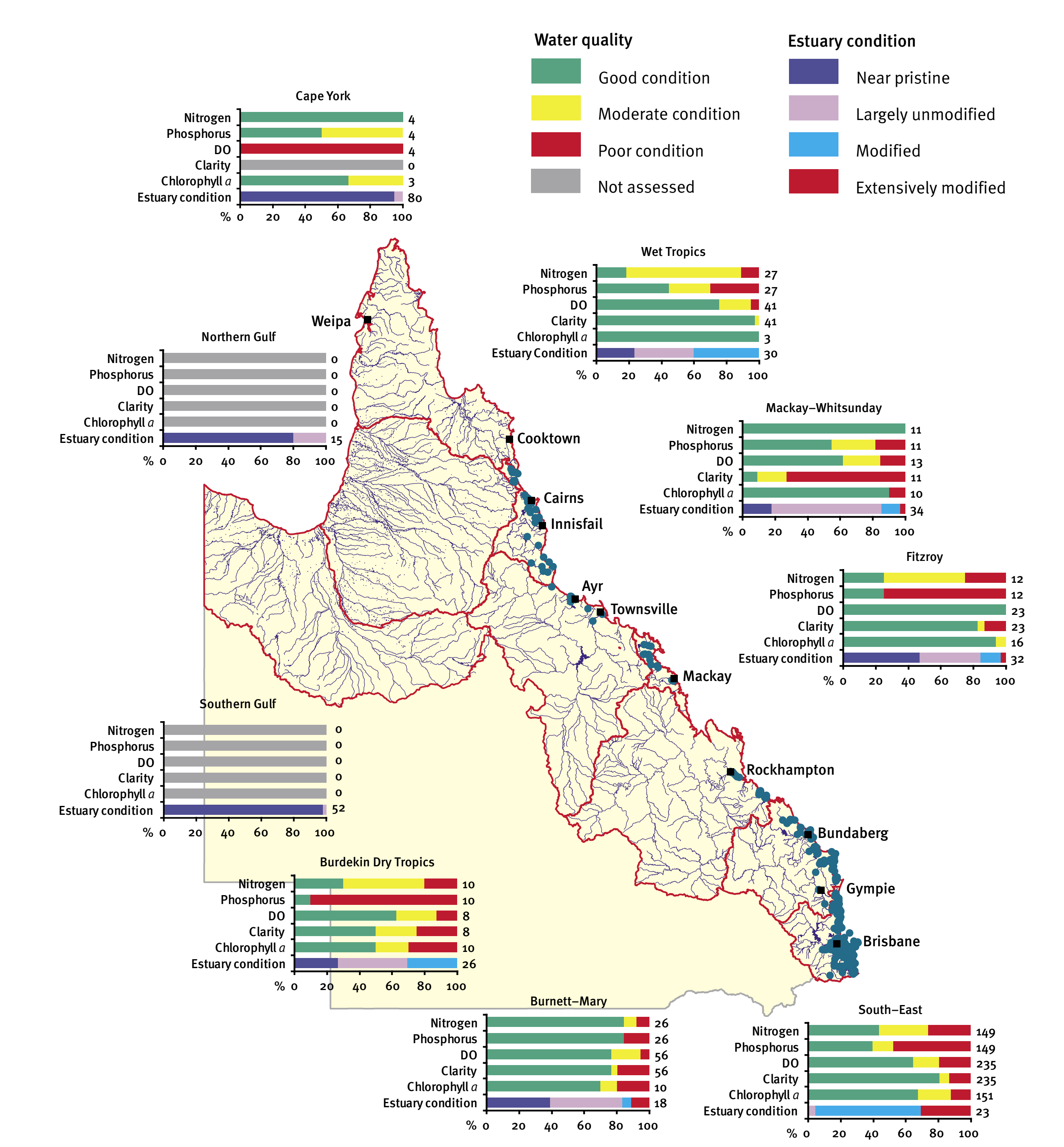
Figure 6.18 summarises recent (1999–2002) water quality conditions in eight coastal catchments. Concentrations of the macro-nutrients nitrogen and phosphorus, water clarity, dissolved oxygen and chlorophyll *a* that were measured monthly at over 440 sites are benchmarked against national standards, or trigger values, defined in the Australian and New Zealand Water Quality Guidelines (ANZECC and ARMCANZ 2000) for the maintenance and protection of aquatic ecosystems. The water quality of a site was rated as poor if less than 20% of results complied with these standards, moderate if 20–50% of results met the standards, and good if more than 50% of sites attained the standard. As healthy aquatic ecosystems can thrive in a range of water quality conditions which may vary naturally—between water bodies (such as estuaries and coastal waters) and among regions—and may exceed the current standards, care is needed in judging whether any exceedences are the result of human activity.

Across all sampling sites, phosphorus was the indicator that caused the greatest percentage of sites (43%) to be rated as poor; the majority of these sites were in the Burdekin Dry Tropics, Fitzroy and South East Queensland NRM regions. In more than 85% of recordings dissolved oxygen, clarity and chlorophyll *a* were rated as in either good or moderate condition. Regionally, the following observations can be made:

- no ongoing assessment of water quality has been made in the northern and southern parts of the Gulf of Carpentaria and Cape York, resulting in a significant knowledge gap;
- most waterways in the Wet Tropics are in good condition, less than 9% of sites receiving a poor rating. Nutrient concentrations often exceed guidelines in Trinity Inlet and the Barron River, although these concentrations have declined significantly in the past ten years due to improved sewage treatment;
- more than 35% of sites in the Burdekin Dry Tropics were rated as poor, phosphorus concentrations complying with objectives at only 10% of sites;
- 23% of sites in Mackay–Whitsunday were rated as poor, many of the exceedences being due to high phosphorus concentrations, low dissolved oxygen concentrations and poor clarity;
- 17% of sites in the Fitzroy were rated as poor, due mainly to high phosphorus concentrations. Chlorophyll *a* and dissolved oxygen achieved complete compliance with objectives, and water clarity did so at more than 85% of sites;
- 13% of sites in the Burnett–Mary region did not comply with environmental objectives, high phosphorus concentrations and low water clarity being the main concerns; and
- 22% of sites in South East Queensland did not comply with environmental objectives, nitrogen and phosphorus concentrations exceeding objectives on 20–40% of occasions (figure 6.18). Recent reports from several other monitoring programs conducted in south-east Queensland, the most well known being the Ecosystem Health Monitoring Program (see page 6.40), have all concluded that nitrogen, phosphorus, water clarity and dissolved oxygen concentrations are the parameters for which the greatest number of sites were rated as being in poor condition (Abal et al. 2002; Counihan et al. 2002; GCCC 2003; Ramsay et al. 2002).

A recent assessment of long-term trends of these parameters over the past ten years (EPA 2003) highlights the difficulty in discerning long-term regional trends; significant increases and decreases, notably in nutrient concentrations and water clarity, were usually confined to one or two sites on a water body, emphasising the influence of local land use practices.

A lack of continuing water quality assessment in Cape York and parts of the Gulf of Carpentaria results in a significant gap in knowledge. (Photo: L. Knight, EPA)



	NH_3	NO_x	TN	FRP	TP	Chl *a*	Turbidity	DO	pH
Tropical Australia	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(µg/L)	(NTU)	(% sat)	
Upland river	0.006	0.03	0.15	0.005	0.01	NA	15	90–120	6.0–7.5
Lowland river	0.01	0.01	0.3	0.004	0.01	5	15	85–120	6.0–8.0
Estuaries	0.015	0.03	0.25	0.005	0.02	2	20	80–120	7.0–8.5
Marine	0.01	0.008	0.1	0.005	0.015	1.4	20	90–120	8.0–8.4
South-east Australia									
Upland river	0.01	0.015	0.25	0.015	0.03	NA	25	90–110	6.5–7.5
Lowland river	0.02	0.06	0.5	0.02	0.05	5	50	85–110	6.5–8.0
Estuaries	0.015	0.015	0.3	0.015	0.03	5	20	80–110	7.0–8.5
Marine	0.015	0.005	0.12	0.01	0.025	1.5	1	90–110	8.0–8.4

Guideline values used for assessment (from ANZECC 2000)
NH_3 = ammonia nitrogen
NO_x = oxidised nitrogen
TN = total nitrogen
FRP = filterable reactive phosphorus
TP = total phosphorus
Chl *a* = chlorophyll *a*
DO = dissolved oxygen
NA = not assessed.

Figure 6.18 *Summary of regional water quality condition in coastal areas of Queensland. The regional bar graphs for nitrogen, phosphorus, dissolved oxygen, clarity and chlorophyll* a *show the percentage of sites (numbers of which are shown at right of each bar) classified from data collected from the most recent year of sampling as being in good condition (at least 50% of samples comply with guidelines), moderate (between 20% and 50% comply with guidelines) or poor (less than 20% comply with guidelines). The ANZECC guideline values used to benchmark these parameters are shown in the inset. The estuary condition shown in each region is taken from the NLWRA, which used data and expert opinion of a number of factors to classify estuaries as either near pristine, largely unmodified, modified or extensively modified.*
Source: EPA

Bioaccumulation of contaminants

While the accumulation of heavy metals, pesticides and derivative chemicals in biota resident in waterways has been assessed in specific areas, no ongoing statewide program is in place. Tables 6.19 and 6.20 show the ranges of organic contaminants and metals reported in various studies involving marine biota, including oysters, fish and crabs, and sediments in the period 1998–2003 for southern, central and northern regions. Metal concentrations are benchmarked against the Australian Food Standards Code (ANZFA 1996).

Canals are a common feature of coastal residential areas in south-east Queensland. The metal burden (zinc, copper and cadmium) in bivalves collected from these canals is distinctly greater than in those collected from other natural water bodies because of inputs from stormwater and intensive boating activity. Average concentrations of zinc, arsenic and lead in oysters, prawns, crab and fish complied with the Australian Food Standards Code in all regions. Selenium concentrations in mud crabs exceeded the standard in all three regions, and did so also in the few oyster, prawn and fish samples collected in south-east Queensland (table 6.19).

The food standard for copper in prawns was exceeded occasionally in samples collected from south-east Queensland, as was the cadmium standard for oysters sampled from canals and in edible and non-edible crabs collected from south-east and central Queensland.

Metal concentrations in marine biota, including oysters, are tested in coastal waterways of Queensland. (Photos: M. Mortimer, EPA)

Table 6.19 Range of metal concentrations (mg/kg) in marine biota grouped according to Southern, Central and Northern EPA regions

Biota	Metal or metalloid (mg/kg)						References
	Selenium	Zinc	Copper	Cadmium	Arsenic	Lead	
Southern Region							
Fish	0.2–2.86 (28)	2.8–62.3 (28)	0.15–4.3 (28)	<0.001–0.009 (4)	–	–	1, 9
Crabs (edible)	0.51–1.33 (5)	34.8–90.0	7.6–36	0.01–0.09	1.53–3.62	0.01–0.03	8
Crabs (non-edible)	1.78–4.14 (12)	68.8–98.8 (12)	62.5–110 (12)	0.11–0.887 (12)	4.6–16.3 (12)	0.83–6.51 (12)	8
Prawns	0.4–1.09 (12)	11.7–66.8 (12)	4.1–25 (12)	0.1–0.5 (2)	–	–	9
Bivalves (natural)	0.47–1.14 (15)	11.6–278 (15)	0.89–28.7 (15)	0.12–1.02 (14)	–	–	2, 9
Bivalves (canals)	0.01–1.2 (8)	130–56 (8)	21–110 (8)	nd–3.0 (8)	1.5–4.5 (8)	0.011–0.07 (8)	3, 4, 5, 6, 7
Seagrass	–	105–391	4.0–8.5	–	–	–	10
Central Region							
Crabs (edible)	1.88 (1)	34.4–50.4 (2)	3.32–39.27(2)	<0.02–0.02 (2)	4.05–9.49 (2)	<0.02–0.02 (2)	8
Crabs (non-edible)	1.94–4.38 (5)	56–160	66.2–245	0.074–0.84	8.19–18.3	1.32–26.7	8
Seagrass	–	65–235	5.0–22.9	–	–	–	10
Northern Region							
Crabs (non-edible)	3.12–3.78 (4)	79–124	72.5–102	<0.01	14.9–18.5	1.32–3.22	8

Note: The numbers in parentheses are the numbers of samples. Measurements were made on composite tissue samples of biota, except for edible crabs, where muscle tissue was extracted. Data were standardised to wet weight except for non-edible crabs and seagrass, which are normalised to dry weight. nd = not detected.
References: 1 = Batley et al. 2000; 2 = EPA Qld Waterways Database; 3 = Kanduri et al. 2003; 4 = Keys and Mortimer 2001, 2002a, 2002b; 5 = Keys and Mortimer 2003; 6 = Keys et al. 2002; 7 = Keys et al. 2003; 8 = Mortimer 2000; 9 = Müller et al. 1999; 10 = Prange and Dennison 2000.

Source: EPA

The highest concentrations of the commonly used herbicides atrazine and diuron have been detected in northern and central sediments. Atrazine was restricted to some Wet Tropics waterways, but diuron was more widespread along the Queensland coast (Haynes et al. 2000a), and was observed in concentrations high enough to inhibit the growth of seagrass communities (Haynes et al. 2000b). Banned organochlorine pesticides, including DDT, lindane and dieldrin, persist in sediments along the Queensland coast, in areas adjacent to agricultural catchments (Mortimer 2000; Haynes et al. 2000a). Dieldrin persists in soil, sediment and biota at levels sometimes exceeding ANZECC standards (Mortimer 2000). Dioxin contamination is widespread along the Queensland coast, high levels (relative to international criteria) being detected in seagrass, dugongs and inshore marine sediments (Gaus 2002).

In 2001, a national survey of ports and marinas revealed that TBT contamination in Queensland had declined significantly in areas associated with recreational vessel traffic. Some decreases in TBT concentrations in and around commercial port facilities have occurred, but there is still evidence of recent contamination of waterways close to commercial vessel repair facilities, notably on the Maroochy and Brisbane rivers, and at Cairns. Most of these sources have been identified and regulatory agencies have worked with industry to eliminate discharges through remedial actions including on-site treatment, no discharge to rivers, and removal of existing contaminated sediments.

Table 6.20 Range of pesticides and TBT concentrations (µg/kg) in marine organisms and sediments grouped according to Southern, Central and Northern EPA regions observed in studies in the period 1998–2003

Biota	Pesticide (µg/kg)								References
	Dieldrin	Other persistent organo-chlorines	Chlor-pyrifos	Bifenthrin	PCBs	Total herbicide (atrazine + diuron)	Dioxins	TBT (µg/kg)	
Southern Region									
Dugongs	–	–	–	–	–	–	0.047–0.182 (2)	–	2
Fish	1.5–18 (4)	0.2–56 (5)	–	–	–	–	–	–	1
Crabs (edible)	0.026–0.66 (4)	0.018–2.8	–	–	–	–	–	–	10
Crabs (non-edible)	0.21–1.6 (10)	<0.05–2.25	–	–	–	–	–	–	10
Prawns	0.4–2.45 (2)	1.1–4.4 (3)	–	–	–	-	–	–	1
Bivalves	<0.001–6.2 (9)	nd–8.8	0.001–16	nd–120	nd–4.3	-	–	11–30 (2)	4, 5, 6, 7, 8, 11, 12
Seagrass	–	<1.0 (2)	<1.0 (2)	–	<50 (2)	<1.0–2.2 (2)	0.198–0.28 (2)	–	2, 3
Sediments	–	<1.0 (2)	<1.0 (2)	–	<50 (2)	<1.0 (2)	0.26–0.51 (2)	5–10500 (2)	2, 3, 12
Central Region									
Dugongs	–	–	–	–	–	–	0.075–1.85 (5)	–	2
Crabs (edible)	<0.03 (1)	<0.03 (2)	–	–	–	–	–	–	10
Crabs (non-edible)	0.069–5.5 (5)	0.027–2.2	–	–	–	–	–	–	10
Bivalves	–	–	–	–	–	–	–	14–21 (2)	12
Seagrass	–	<1.0 (9)	<1.0 (9)	–	<50 v	<1.0–1.3 (9)	0.7–16 (3)	–	2, 3
Sediments	<0.05 (6)	<1.15–1.21 (15)	<1.0 (9)	–	<50 (9)	nd–<2.6 (20)	0.42–21 (4)	2.9–3.5 (2)	2, 3, 9, 12
Northern Region									
Dugongs	–	–	–	–	–	–	0.016–0.56 (7)	–	2
Crabs (non-edible)	0.043–0.84 (4)	0.043–0.21	–	–	–	–	–	–	9
Bivalves	–	–	–	–	–	–	–	44 (1)	11
Seagrass	–	<1.0 (5)	<1.0 (5)	–	<50 (5)	<1.0 (5)	–	–	2
Sediments	<0.05–0.37 (19)	<1.15–1.36 (24)	<1.0 (5)	–	<50 (5)	<1.2–11.2 (24)	0.056–1.6 (8)	140 (1)	2, 3, 12

Note: The numbers in parentheses are the numbers of samples. Measurements were made on composite tissue samples of biota except for edible crabs, where muscle tissue was extracted. Data are standardised to wet weight except for seagrass and sediment, which were normalised to dry weight, dugong to lipid, and TBT to either 1% lipid or total organic carbon. nd = not detected. References: 1 = Batley et al. 2000; 2 = Gaus 2002; 3 = Haynes et al. 2000a, 2000b; 4 = Kanduri et al. 2003; 5 = Keys and Mortimer 2001, 2002a, 2002b; 6 = Keys and Mortimer 2003; 7 = Keys et al. 2002; 8 = Keys et al. 2003; 9 = McMahon et al. 2003; 10 = Mortimer 2000; 11 = Mortimer and Cox 1998; 12 = NHT TBT project.

Source: EPA

Recreational water quality

There has been a general improvement in recreational water quality at both beach and river sites in south-east Queensland, river sites increasing from 44% to 83% compliance (figure 6.19). Recreational water quality monitoring of popular rivers and beaches in south-east Queensland over the summer months for the past five years found that 35 of 46 beaches complied with national guidelines (ANZECC and ARMCANZ 2000) on all occasions and only two sites complied on less than 67% of occasions. Of the 18 rivers sampled, only two complied fully, while 10 complied on less than 68% of occasions.

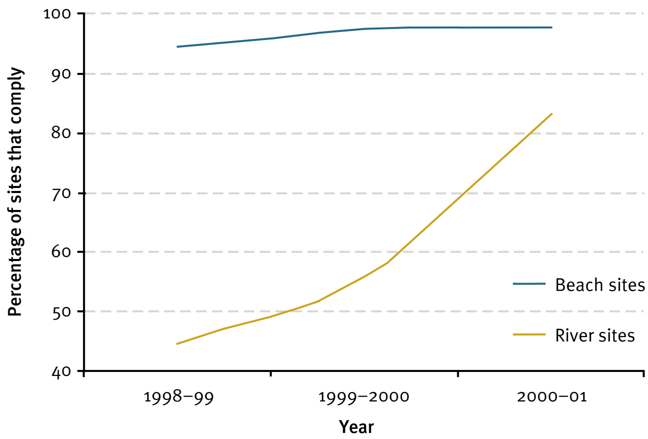


Figure 6.19 Recreational water quality compliance for beach and river sites in south-east Queensland from 1998 to 2001. Medians and 80th percentiles were compared with national guidelines.
Source: EPA

Aquatic ecosystem condition

An audit of the condition of the nation's estuaries rated the condition of more than 82% of the 300 or so estuaries in Queensland as good (NLWRA 2002). The majority of these estuaries are in the Gulf Country. South-east Queensland, followed by the Burnett–Mary, has the highest proportion of estuaries rated in poor or moderate condition (see summary table, page 6.43).

In south-east Queensland, the Ecosystem Health Monitoring Program summarises the condition of Moreton Bay (see page 6.41). This monitoring program results in an annual report card and report that integrate a number of physico-chemical and biological indicators to assess the condition of regions within Moreton Bay and its estuaries. Several improvements in ecosystem health between 1998–99 and 2001–02 were attributed to improvements to a number of sewage treatment plants in the region.

One of the greatest concerns is the potential impact of increased sediment and nutrient loads on the nearshore regions of the Great Barrier Reef (GBR). Areas of the GBR that have been specifically identified as being at high risk of impact from terrestrial runoff are the Port Douglas to Hinchinbrook and Whitsunday to Mackay regions. Several reports conclude that although there is little evidence that there has been any serious impact on the World Heritage values of the GBR, changes in nutrient and sediment loading from inappropriate and unsustainable land use practices call for a precautionary approach to reduce catchment runoff, to be implemented through a reef protection plan.

Long-term monitoring of phytoplankton chlorophyll *a* concentrations has been undertaken since 1992 at 86 stations in the Great Barrier Reef lagoon. Recent analysis of the data showed that strong regional patterns in chlorophyll *a* are evident and although no significant long-term trends could be discerned, regional patterns may be closely correlated with the influence of El Niño Southern Oscillation (ENSO) or river discharge volumes. Chlorophyll *a* concentrations in inshore areas adjacent to catchments that are highly developed for agricultural and urban uses are more than double the mean concentrations in inshore areas adjacent to Cape York catchments in the north, which are largely undeveloped (Brodie et al. 2003).

Algal blooms are often natural events, but excessive nutrient levels sometimes lead to unwanted nuisance or harmful algal blooms with potentially significant and costly health, recreational and commercial repercussions. Excessive chlorophyll *a* concentrations occurring in water bodies can indicate the presence of algal blooms and, indirectly, nutrient status. In the past five years, two potentially toxic algae occurring naturally throughout parts of Queensland have required dedicated responses to understand their occurrence and to manage their impacts. *Lyngbya majuscula* (Lyngbya), a benthic blue-green algae, occurs from Moreton Bay to Hinchinbrook Channel (see 'Biodiversity'). State and local governments have responded to Lyngbya blooms in Moreton Bay by developing a Lyngbya Management Strategy (MBWCP 2002), including the development of a contingency plan and funding for scientific research into the cause of the blooms. The dinoflagellate *Pfiesteria piscicida* was found in low concentrations in south-east Queensland waterways in 2002, but there is no evidence that Pfiesteria is having any impact on human health or fish populations in Australia.

Fish kills can result from poor water quality conditions including low dissolved oxygen, blooms of toxic plankton and chemical contamination and are often more common following significant rainfall events. No comprehensive reporting of fish kills in Queensland coastal water has been done in the reporting period. The recently implemented Queensland Fish-kill database (www.epa.qld.gov.au) reports 71 fish kills in 2002 and a further 26 to July 2003. More than 40% of these incidents occurred in south-east Queensland, notably around the Gold Coast region, and in the Northern region, where in 2002 a total of approximately 150 000 fish were found dead in three separate incidents in the Cairns and Townsville regions. On more than 25% of occasions mullet and bony bream were reported as the key species, and the causes of these fish kills were most commonly attributed to low dissolved oxygen (38%), chemical contamination (21%) and trawl or fishing bycatch (15%).

Responses

Integrating coastal and catchment management

The State Coastal Management Plan—Queensland's Coastal Policy (EPA 2001) provides policy direction to manage stormwater runoff (quality and quantity) in accordance with best practice to ensure that the environmental values of estuaries and coastal areas are protected.

The Reef Water Quality Protection Plan is a joint initiative of the Queensland and Commonwealth governments to implement actions in catchments to mitigate the potential risk to the Great Barrier Reef by halting and reversing the decline in quality of water entering the Reef. Building on government, industry and community-based programs, the plan identifies a broad mix of 65 actions, ranging from regulatory and planning frameworks to self-management and economic incentives and extension, that support progressive improvement in land use practices.

A major initiative in water quality management in Queensland has been the development of the South East Queensland Regional Water Quality Management Strategy. This is a comprehensive, integrated water quality plan for south-east Queensland waterways and catchments. It provides the framework for future management actions that are workable, practical and affordable. The strategy has been developed in light of the findings from detailed baseline monitoring and modelling of water quality indicators.

Setting targets, monitoring and assessment

The setting of environmental values and water quality objectives for waters is a requirement under the National Water Quality Management Strategy and is mirrored in Queensland's Water EPP. Areas in Queensland for which environmental values and water quality objectives have been or are being set include south-east Queensland, the Condamine-Balonne catchment and the Trinity Inlet and Mossman-Daintree catchments. It is intended that setting of environmental values in other areas of Queensland will be aligned with both the water resource planning process and the target-setting regional processes that will occur as part of the National Action Plan for Salinity and Water Quality.

A range of monitoring programs is conducted throughout Queensland's coastal environment by the state and local governments, community groups, universities and other research organisations:

- the latest summary of monitoring in the Great Barrier Reef World Heritage Area lists a total of 52 monitoring programs looking at water quality and aquatic communities in the region (Harriot et al. 2002);
- a collaborative water quality monitoring program in south-east Queensland now covers more than 360 sites across a region extending from the Noosa River south to the New South Wales border;
- Waterwatch is a significant community monitoring program involving close to 2500 individuals in monitoring Queensland's aquatic environment; and
- the Queensland Government is currently reviewing and redesigning its monitoring programs to better meet current and future needs for water quality information. The review will also suggest how both regional and community monitoring programs could fit into an overall framework of monitoring in Queensland.

Working with community and industry to reduce and recycle wastewater contaminants

The National Action Plan for Salinity and Water Quality is a major Commonwealth and state government initiative to prevent, stabilise and reverse trends in salinity and improve water quality in Queensland. It will provide funding over seven years for priority areas including the Fitzroy and Burdekin River catchments and the Lockyer, Burnett and Mary River catchments. Regional community-based groups are funded on the basis of an integrated natural resource management plan that specifies targets for resource condition and management actions.

The significant reductions in point source nutrient discharges achieved in the past five years are the result of well-directed collaborative partnerships, including the Moreton Bay Waterways and Catchments Partnership, and the production of guiding documents such as management plans and the development of operational guidelines for aquatic discharges. In south-east Queensland significant investments by local councils to upgrade a number of the larger STPs have resulted in an overall reduction of almost 35% in the total nitrogen load since 1999. Further upgrades to sewage treatment infrastructure will reduce the pressure of increased nutrient loads from point source discharges.

The Queensland Water Recycling Strategy, released in 2001, provides a framework to encourage the adoption of sustainable and cost-effective water recycling by providing a set of guiding principles, policy positions on uses and sources of recycled water, and action plans with objectives and targets to guide public and private sector initiatives.

The management of urban stormwater is recognised as one of the key issues for maintaining and improving water quality in urban areas. The Water EPP requires local governments with an urban stormwater system to develop an urban stormwater quality management plan. Many local governments in Queensland have developed and are now implementing these plans. A key part of the implementation is installation of stormwater quality improvement devices (SQIDs), ranging from simple litter traps and gully pit baskets to larger end-of-pipe structures, to reduce the amount of sediment and litter entering waterways. Since 1999, over $15 million has been expended on SQIDs in the urban areas of the state's south-east.

A number of on-farm best management programs such as COMPASS (Combining Profitability and Sustainability in Sugar) for the sugar industry and the Best Management Practice for the Cotton Industry have been implemented to encourage sustainable primary production practices. ChemCollect was a free collection and destruction scheme for unwanted agricultural and veterinary chemicals, which ran for three years and was completed in August 2002. It enabled more than 3000 primary producers to safely rid their properties of some 400 tonnes of unwanted chemicals, representing a direct cost benefit to the community of between $11.3 and $14.0 million.

Case study: Bremer River carbon inputs

Historical commentary on the Bremer River describes a once-pristine waterway that, over time, deteriorated because of pressures from land use in the surrounding catchment. Improvements in management practices in recent decades have resulted in reduced pollution, particularly by acutely dangerous pollutants such as toxins and heavy metals.

Unfortunately, the more insidious and chronic pollutants such as nutrients and sediments still have a major impact on the river. This poor condition has been summarised in an annual report card, which rated the Bremer as an 'F' (fail) from 2000 to 2002. The causes of this condition have been difficult to identify. Figure 6.20 illustrates the key sources of pollution in the Bremer catchment.

A particularly important issue for the Bremer is repeated occurrences of low dissolved oxygen. A recent study by the Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management (Coastal CRC) indicated that organic carbon is an important contaminant, particularly from runoff in wet periods. Carbon is present naturally in all rivers and is the primary food and energy source of most bacteria. Bacterial depletion of oxygen is the major cause of fish kills. Bacterial growth in the Bremer, unlike most rivers, remains high in dry times, pointing to a constant background source of carbon. This constant source maintains bacterial growth, causing repeated depletion of dissolved oxygen, and is one of the main reasons the Bremer estuary was failed in 2002.

This research has catalysed a collaborative audit of the Bremer catchment involving the EPA, Boonah Shire Council, Ipswich City Council, the Coastal CRC, the Moreton Bay Waterways and Catchments Partnership and the Bremer Catchment Association. The focus is on developing solutions for priority issues and identifying ongoing management options that will ensure improvements in the Bremer River, making it a sustainable working river in the long term.

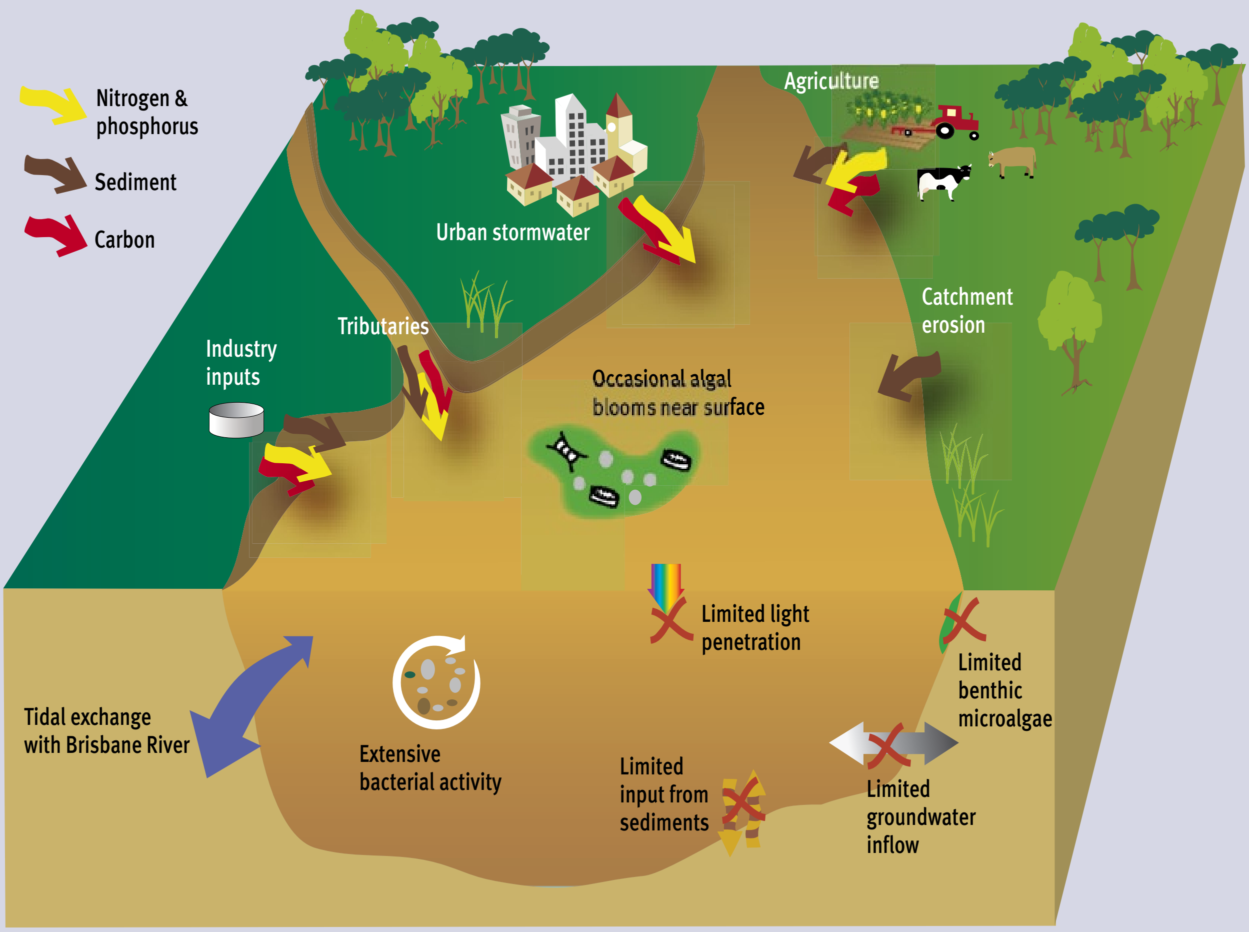


Figure 6.20 Key issues and drivers in the Bremer catchment
Source: Coastal CRC

Case study: Managing acid sulfate soils

During the past decade acid sulfate soils have been recognised as one of the most important environmental issues resulting from drainage in low-lying coastal areas (figure 6.21). Past expansion of the sugar industry and drainage schemes on coastal lowlands have led to unintended offsite impacts that have lasted for decades. The expansion of sugarcane into the East Trinity area near Cairns collapsed because of acid sulfate soil problems. Issues associated with acid sulfate soils include major fish kills and outbreaks of red spot disease in fish, and the increased incidence of disease-carrying, acid-tolerant mosquitoes. The acid can also attack concrete, steel and road infrastructure (bridges, bitumen, pipes and foundations). Impacts can persist for decades.

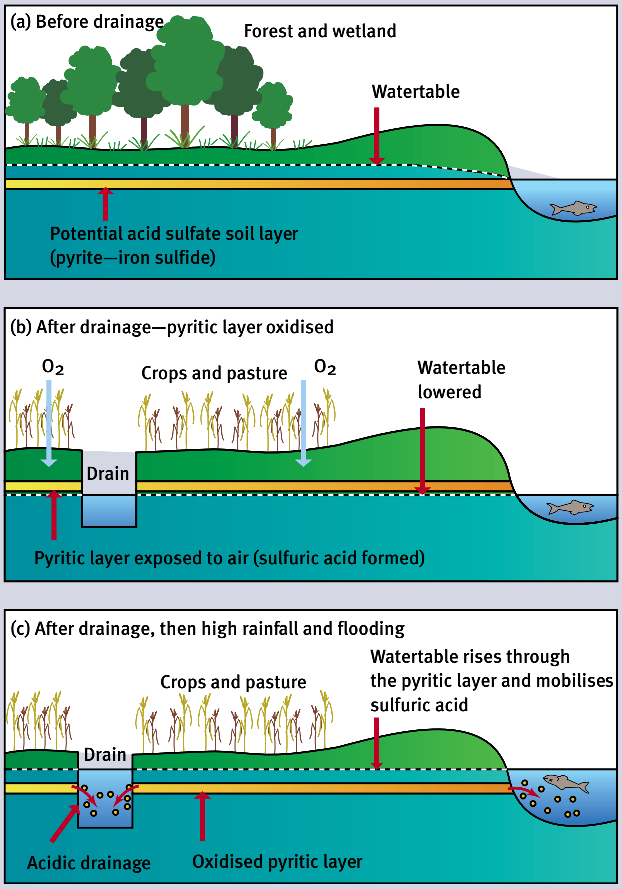


Figure 6.21 Potential acid sulfate soils do not harm the environment when covered by water (a), but when drained and exposed to air (b) they react following rainfall to release sulfuric acid into the drainage system (c), affecting aquatic life.
Source: DNRM

Acid sulfate soils are found in low-lying areas generally below 5 m Australian Height Datum along the Queensland coast (figure 6.22). Acid sulfate soils along the Queensland coast cover an estimated 2.3 million hectares.

No statewide statistics on the total area of disturbed acid sulfate soils or the number of hotspots causing acidification of waterways are available. The known acidified area of disturbed acid sulfate soils in south-east Queensland is 8219 ha, representing 11% of mapped acid sulfate soils (78 000 ha).

Figure 6.22 Distribution of acid sulfate soils along the Queensland coast
Source: DNRM

Major growth areas where acid sulfate soils management has been required include developments at Cairns, Cardwell, Townsville, Proserpine, Yeppoon, Gladstone, the Sunshine Coast, Redcliffe, Bribie Island, and the Gold Coast. Eighty-nine licences with acid sulfate soil conditions were issued in south-east Queensland between 1995 and 2001. Further sugarcane expansion onto coastal lowlands also carries a risk of draining acid sulfate soils. Another pressure has emerged with the development of an aquaculture industry involving the construction of ponds and channels. In south-east Queensland, 14 currently active EPA licences (with acid sulfate soil conditions) apply to aquaculture.

Planning policies and regulations launched by the Queensland Government in 2002 require best practice management of acid sulfate soils and are reducing the risk of environmental damage and future remediation costs. The Queensland Acid Sulfate Soils Management Advisory Committee (QASSMAC) represents the urban development, sugar and fishing industries, Landcare and conservation groups, local governments and affected state government agencies. In 2002, the Queensland Government released *SPP 2/02: Planning and Managing Development Involving Acid Sulfate Soils.* QASSMAC, in collaboration with government agencies, has also released soil management guidelines for acid sulfate soils.

Case study: Managing acid sulfate soils *(continued)*

Red spot disease in fish is an indicator of acid sulfate soil problems. (Photo: D. Callinan, NSW Agriculture)

SPP 2/02 and the guidelines for planning and managing development involving acid sulfate soils cover best practice methods. The number of acid sulfate soil management plans required in development applications has grown dramatically since 1994 and industry-based guidelines or codes of practice have also been developed to deal specifically with acid sulfate soils. For example, DPI has developed Fish Habitat Codes of Practice for use with Strategic Permits issued under section 51 of the *Fisheries Act 1994*.

Indicator	FN	N	NW	MK	F	GN	WB	MN	BN
Coastal population growth, 1991–2002	▲	▲	▲	▲	▲	▲	▲	▲	▲
Area of land extremely acidified by acid sulfate soils (ha)	P	P	X	P	P	P	P	8219*	P
Number of 'hotspot' areas causing acidified waterways	P	P	X	?	P	?	P	P	?
Number of currently active EPA licences with acid sulfate soil conditions	X	X	X	X	X	X	– 0	▲ 48	▲ 41

Key to Statistical Divisions (regions): FN = Far North; N = Northern; NW = North West; MK = Mackay; F = Fitzroy; GN = Gladstone; WB = Wide Bay–Burnett; MN = Moreton; BN = Brisbane

Key to condition for coastal population growth:
- (green) Low growth (<20 000)
- (yellow) Moderate growth (20 000–60 000)
- (red) High growth (>60 000)
- ▲ Increasing pressure

Key to condition:
- (green) Good progress
- (yellow) Moderate progress
- (red) Poor progress
- (white) Not rated
- 41 Number of active licences

Key to trend:
- ▲ Increasing
- ? Not clear
- X Not assessed
- – No change
- P Present but extent unknown
- * Underestimate, based on available mapping

Case study: Ecosystem Health Monitoring Program

The Ecosystem Health Monitoring Program (EHMP) is an environmental monitoring program established by the Moreton Bay Waterways and Catchments Partnership with the aim of assessing the effectiveness of management actions. EHMP is a collaborative program between local, state and Commonwealth government agencies, universities and CSIRO.

EHMP consists of a freshwater component and a marine and estuarine component. These components aim to assess ecosystem health in south-east Queensland through the use of a range of ecosystem health indicators. Over 240 sites are monitored monthly for the marine and estuarine component, and 120 sites are assessed twice a year for the freshwater component.

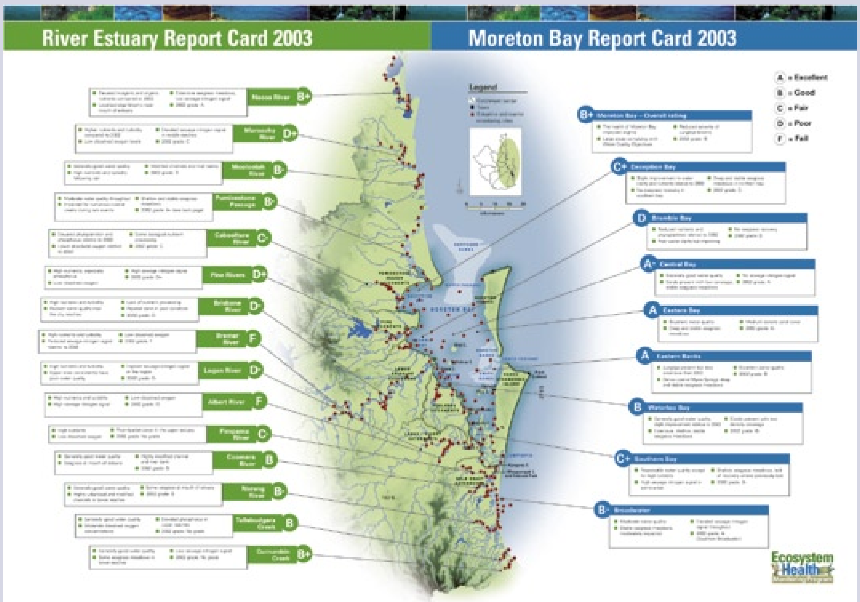


Figure 6.23 *2002 report card for the Ecosystem Health Monitoring Program*
Source: MBWCP

An effective communication tool, such as the annual report card, rates the health of the region's waterways from A (excellent condition) to F (fail). Report cards help to highlight changes in regions and are useful in communicating monitoring information to the community.

Outputs such as processed nitrogen mapping help assess the effectiveness of management actions (the predominant source of processed nitrogen is sewage). The most prominent processed nitrogen plumes of Moreton Bay occurred in Bramble Bay. Over the past four years the size and intensity of processed nitrogen plumes in Bramble Bay have decreased significantly. It is possible that this decrease is related to upgrades to a number of wastewater treatment plants in the region.

Case study: Conceptual understanding of sediment and nutrient processing in the Fitzroy River and estuary

The Great Barrier Reef Water Quality Protection Plan has identified reduction in sediment and nutrient inputs from coastal Queensland catchments as its primary objective. Regional bodies will develop plans and investment strategies to determine the most effective management actions to achieve these reductions.

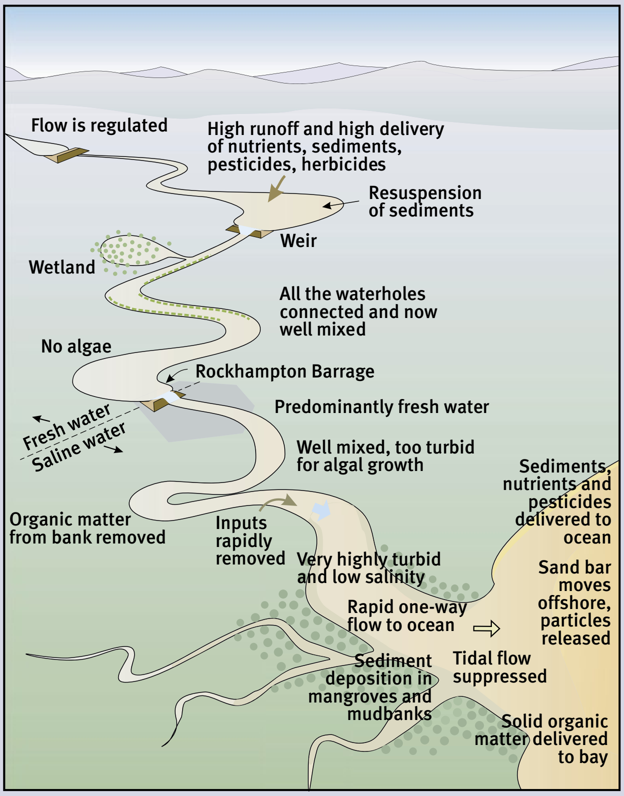


Figure 6.24(a) High flow model for the Fitzroy River
Source: CSIRO Land and Water

A major issue in assessing alternative management strategies is understanding what happens to the nutrients and sediments that are washed off the catchment as they move through the rivers and estuaries and then out into the Great Barrier Reef lagoon. For the past three years, the Coastal CRC has been studying the instream processing of these sediments and nutrients, especially in the Fitzroy estuary between the barrage at Rockhampton and the mouth of the river 60 km downstream, and has developed a more complete understanding of them. The processes are highly dependent on the freshwater flows in the system: major transport and relocation of sediments occur during high flows, and more localised instream processing occurs during medium and low flows. During periods of low freshwater flows, inputs of nutrients into the estuary from the three sewage treatment plants at Rockhampton have a significant effect on water chemistry. Also, because of appreciable tidal velocities in the lower estuary, sediments are resuspended during each tidal cycle (figures 6.24(a) and (b)).

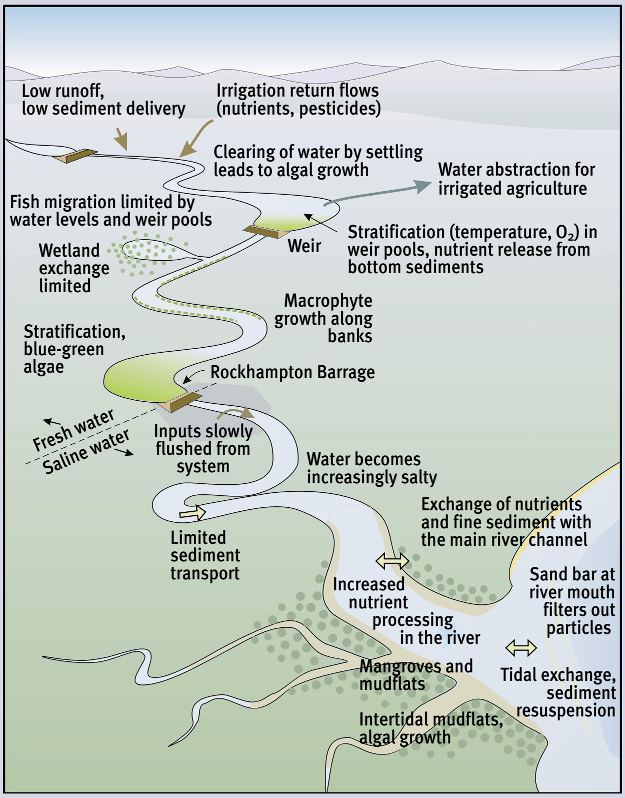
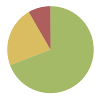
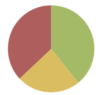
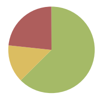
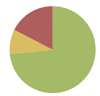
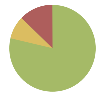
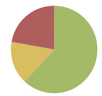
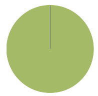
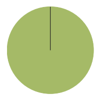
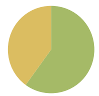
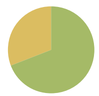
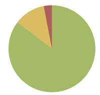
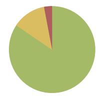
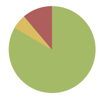
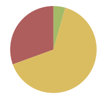


Figure 6.24(b) Low flow model for the Fitzroy River
Source: CSIRO Land and Water

Research in the next three years will focus on a fuller understanding of the processing of sediments and nutrients in the estuary, and especially on how these move from the mouth of the river into Keppel Bay and offshore to the Great Barrier Reef lagoon.

This research will help the Fitzroy stakeholders develop and refine sediment and nutrient reduction management actions in their integrated natural resource management plan.

Coastal water quality

Indicator	Type	Source	NRM regions								
			Southern Gulf	Northern Gulf	Cape York	Wet Tropics	Burdekin Dry Tropics	Mackay–Whitsunday	Fitzroy	Burnett–Mary	South East
Total annual coastal discharges per region (tonnes/year)	Nitrogen	NLWRA/EPA	X	X	8 577	8 543	3 917	2 699	2 574	2 534	4 919
	Phosphorus	NLWRA/EPA	X	X	1 364	1 693	792	591	486	319	1 288
	Sediment	NLWRA/EPA	X	X	3 703 566	1 552 675	3 266 483	996 826	2 902 345	1 193 910	530 474
Total annual discharge volume of licensed discharges			X	X	X	X	X	X	X	X	X
Percentage of area of road (impervious surfaces) in each region		EPA/WBM	0.09	0.07	X	0.43	0.16	0.55	0.22	0.53	1.31
Number of marine pollution incidents			X	X	X	X	X	X	X	X	X
Regional water quality condition			X	X	X						
Regional estuarine condition											
Number of catchments with specific water quality objectives and environmental values			X	X	X	1	X	X	X	X	X
Number of urban stormwater plans			X	X	X	X	X	X	X	X	X

Note: X = not assessed
Pie chart legend:
Good
Moderate
Poor