Environmental Protection (Water) Policy 2009

Ross River Basin and Magnetic Island Environmental Values and Water Quality Objectives

Basin No. 118 including all waters of the Ross River Basin, and adjacent coastal waters (including Magnetic Island)

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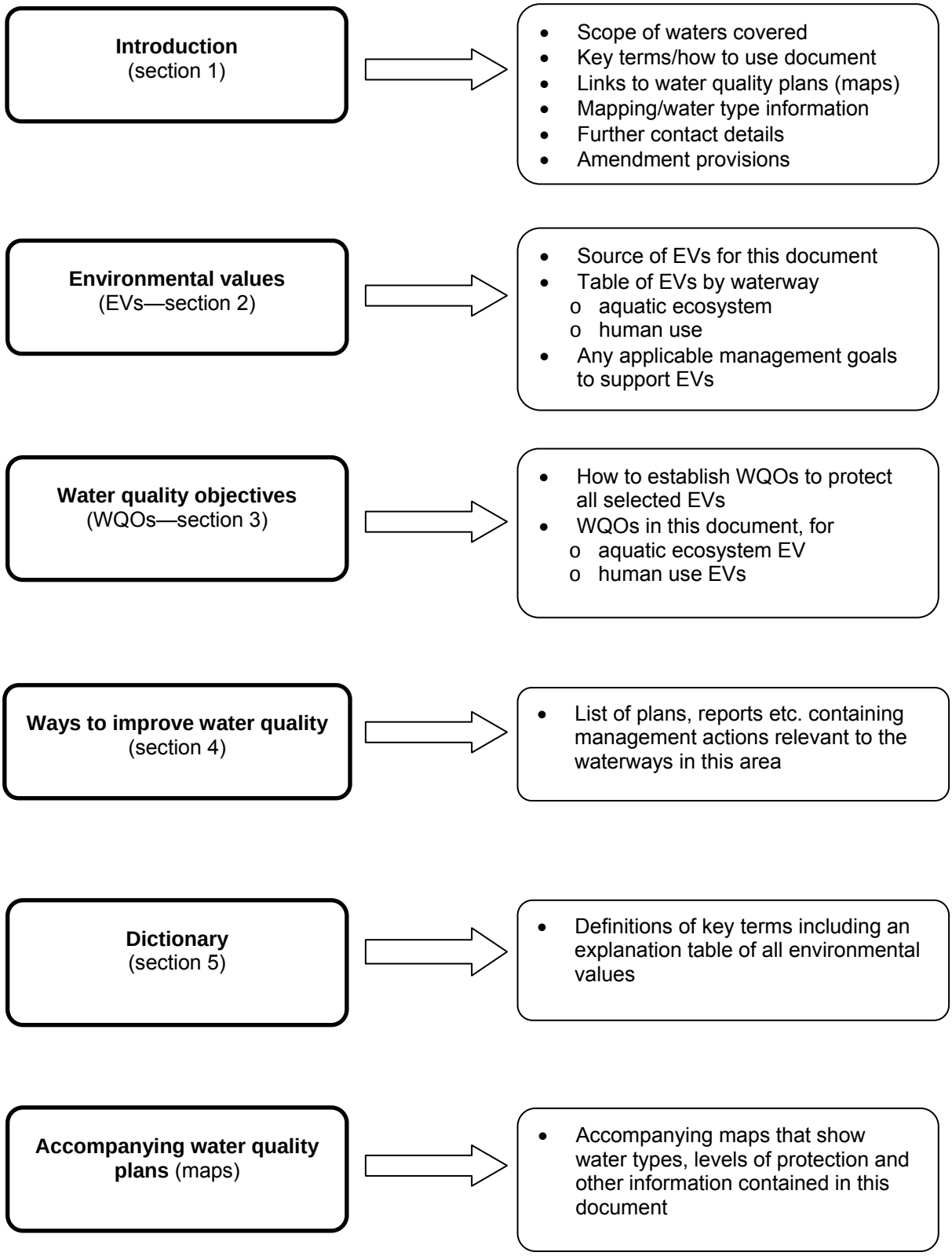
Main parts of this document and what they contain



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1 Introduction

This document is made pursuant to the provisions of the Environmental Protection (Water) Policy 2009 (EPP (Water)), which is subordinate legislation under the *Environmental Protection Act 1994*. The EPP (Water) provides a framework for:

- identifying environmental values (EVs) for Queensland waters, and deciding the water quality objectives (WQOs) to protect or enhance those EVs. (WQOs are long term goals for receiving waters, not individual point source emission objectives.)
- including the identified EVs and WQOs under Schedule 1 of the EPP (Water).

This document contains EVs and WQOs for waters in the Ross River Basin and adjacent coastal waters, and is listed under schedule 1 of the EPP (Water).

1.1 Waters to which this document applies

This document applies to fresh and estuarine surface waters and groundwaters draining the catchments of Ross and Bohle rivers, Alligator and Stuart creeks, Magnetic Island, and adjacent coastal waters, as indicated in the accompanying plans (WQ1181—Ross River Basin mainland surface waters, WQ1182—Magnetic Island, WQ1183—coastal waters, WQ1184—groundwaters)[1]. These waters fall within and adjacent to the Ross River Basin (basin 118)[2].

Waters covered by this document include:

- Ross River and tributaries, including fresh and estuarine waters of the Ross River
- Bohle River catchment, including fresh and estuarine waters of Stony, Saunders, Middle Bohle and Louisa creeks, Little Bohle River and Town Common
- Lower Ross River catchment, including fresh and estuarine waters of Ross River (below Ross River Dam), Black Weir, Gleesons and Aplins Weirs, Mt Stuart Training Area streams, Campus and Ross creeks and Pallarenda
- Upper Ross River catchment, including fresh waters of Lake Ross (Ross River Dam), Ross River, Round Mountain, Lagoon, Plum Tree, Ross, Sandy, Deep, Cattle, Leichardt, Six Mile, Four Mile, Flagstone, Antill Plains, One Mile, Spring, Landsdowne and Sachs creeks, Jimmys and Toonpan lagoons and Blacksoil Gully/Mt Stuart
- Stuart Creek catchment, including fresh and estuarine waters of Stuart and Sandfly creeks
- Alligator Creek catchment, including fresh and estuarine waters of Alligator, Whites, Slippery Rocks, Killymoon, Crocodile creeks and the western side of Cape Cleveland
- Waters within the Townsville State Development Area (including Sandfly and Stuart creeks), and adjacent coastal waters
- fresh and estuarine waters of Magnetic Island, including Retreat, Duck, Ned Lee, Butlers, Gustav, Petersen, Gorge, Endeavour, Chinamans Gully and Hoyer Creek (Nelly Bay)
- wetlands, lakes and reservoirs
- groundwaters
- enclosed coastal and open coastal waters, including Cleveland Bay, West Channel, Halifax Bay (part) and Horseshoe Bay.

[1] This document and the accompanying plans are available from the department's website at www.ehp.qld.gov.au. The boundaries in the accompanying plans WQ1181, WQ1182, WQ1183 and WQ1184 are indicative only. EVs, water types and aquatic ecosystem management intent (level of protection) depicted in the accompanying plans are stored in electronic form as part of the Central Queensland Environmental Values Schedule 1 Geodatabase August 2013, and held at the department's offices at 400 George Street Brisbane. Geodatabase regions are based on the regions established in the Queensland Water Quality Guidelines. Spatial (GIS) datasets can be downloaded free of charge from the Queensland Government Information Service (QGIS) at http://dds.information.qld.gov.au/dds. For further information, email the department at epa.ev@ehp.qld.gov.au.

[2] Australia's River Basins 1997—Product User Guide. Published by Geoscience Australia. Canberra, ACT (3rd edition, 2004).

The geographical extent of waters addressed by this document is shown in plans WQ1181, WQ1182 and WQ1183, and is broadly:

- north to the limit of Queensland Coastal Waters
- west to the boundary of the Ross River Basin with the Black and Burdekin River basins
- south to the boundary of the Ross River Basin with the Haughton River Basin
- east to the boundary of Alligator Creek catchment.

1.2 Guidance on using this document

1.2.1 Key terms (refer to dictionary for additional terms)

ADWG means the Australian Drinking Water Guidelines (2011), prepared by the National Health and Medical Research Council (NHMRC) in collaboration with the Natural Resource Management Ministerial Council (NRMMC)[3].

AWQG means the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (October 2000), prepared by the Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ)[4].

Environmental values (EVs) for water means the EVs specified in Table 1 of this document for the corresponding water.

EVs for water are the qualities of water that make it suitable for supporting aquatic ecosystems and human water uses. These EVs need to be protected from the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe for community use. Particular waters may have different EVs. The range of EVs and the waters they can potentially apply to are listed below, and further details are provided in the dictionary (refer section 5).

List of EVs and applicable waters

Environmental value (EV)	Potentially applicable to:	
	Tidal waters	Fresh (non-tidal) waters
Protection of aquatic ecosystems (aquatic ecosystem EV)		
Protection or enhancement of aquatic ecosystem values, under four possible levels of ecosystem conditions: • high ecological value (effectively unmodified) waters • slightly disturbed waters • moderately disturbed waters • highly disturbed waters. (Suitability for seagrass and wildlife habitat have also been specifically identified for some Queensland waters as a component of this EV).	✓	✓
EVs other than aquatic ecosystem EV (called human use EVs)		
Suitability for drinking water supplies		✓
Suitability for primary contact recreation (e.g. swimming)	✓	✓
Suitability for secondary contact recreation (e.g. boating)	✓	✓
Suitability for visual (no contact) recreation	✓	✓
Suitability for human consumers of wild or stocked fish, shellfish or crustaceans (suitability for oystering has also been specifically identified for some Queensland waters)	✓	✓
Protection of cultural and spiritual values, including traditional owner values of water	✓	✓

[3] The ADWG are available on the National Health and Medical Research Council website at www.nhmrc.gov.au.

[4] The AWQG are available on the Australian Government's National Water Quality Management Strategy website.

Environmental value (EV)	Potentially applicable to:	
	Tidal waters	Fresh (non-tidal) waters
Suitability for industrial use (including mining, minerals refining/processing)	✓	✓
Suitability for aquaculture (e.g. red claw, barramundi)	✓	✓
Suitability for crop irrigation		✓
Suitability for stock watering		✓
Suitability for farm supply/use		✓

Level of protection for a water (aquatic ecosystem EV) means the level of aquatic ecosystem condition specified in Table 2 of this document that the corresponding WQOs for that water are intended to achieve (refer to management intent definition below for further information).

Management goal means the goals (if any) stated in section 2 of this document to support the EVs for waters identified in Table 1.

Management intent (level of protection) for a water (aquatic ecosystem EV) means the level of aquatic ecosystem condition specified in Table 2 of this document that the corresponding WQOs for that water are intended to achieve. For example, the intent for high ecological value waters is that their effectively unmodified condition is maintained.

QWQG means the Queensland Water Quality Guidelines[5].

Water quality guidelines (defined in the EPP (Water)) are numerical concentration levels or statements for indicators that protect a stated environmental value. Under the EVs setting process contained in the EPP (Water), water quality guidelines are used as an input to the development of WQOs.

Water quality indicator (for an EV) means a property that is able to be measured or decided in a quantitative way. Examples of water quality indicators include physical indicators (e.g. temperature), chemical indicators (e.g. nitrogen, phosphorus, metals), and biological indicators (e.g. macroinvertebrates, seagrass, fish).

Water quality objectives (WQOs) means the WQOs specified in tables 2–12 and 14 of this document to support the EVs for waters identified in Table 1.

WQOs are long-term goals for water quality management. They are numerical concentration levels or narrative statements of indicators established for receiving waters to support and protect the designated EVs for those waters. Water quality objectives are not individual point source emission objectives, but the receiving water quality objectives.

They are based on scientific criteria or water quality guidelines but may be modified by other inputs (e.g. social, cultural, economic).

Examples of WQOs include:

- total phosphorus concentration less than 20 micrograms per litre (µg/L)
- chlorophyll a concentration less than 1 µg/L
- dissolved oxygen between 95 per cent and 105 per cent saturation
- family richness of macroinvertebrates greater than 12 families
- exotic individuals of fish less than five per cent.

Water type means groupings of waters with similar characteristics, as shown in the accompanying plans. The water types covered by this document are based on mapping and definitional rules for water types established in the QWQG and, where available, other site-specific studies and documents. Water types can include fresh waters (lowland, upland, lakes/reservoirs), wetlands and groundwaters, estuarine waters (lower, middle and upper estuaries), tidal canals, constructed estuaries, marinas and boat harbours, and coastal marine waters (open coastal, enclosed coastal). WQOs applying to different water types are outlined in this document. More detail on water types is provided in section 1.4.

Refer to dictionary for additional terms.

[5] The QWQG are available on the department's website.

1.2.2 Main components of this document

The main components of this document are:

- Plan WQ1181—showing the spatial extent and boundaries of Ross River Basin mainland surface water types covered by this document
- Plan WQ1182—showing the spatial extent and boundaries of Magnetic Island surface water types covered by this document
- Plan WQ1183—showing the spatial extent and boundaries of coastal water types covered by this document
- Plan WQ1184—showing the spatial extent and boundaries of groundwater types in the Black and Ross River basins
- Section 1—introduction and guidance on how to use the document
- Section 2 (Table 1)—EVs applying to waters covered by this document
- Section 3 (tables 2–12 and 14)—WQOs applying to different EVs:
  - Tables 2 and 14 provide WQOs to protect the aquatic ecosystem EV, and closely link to the water types shown on plans WQ1181 (Ross River Basin mainland), WQ1182 (Magnetic Island), WQ1183 (coastal waters), and WQ1184 (groundwaters)
  - tables 3 to 12 provide WQOs to protect human use EVs
- Section 4—ways to improve water quality: containing a list of relevant documents, provided for information purposes only
- Section 5—a dictionary of other terms relevant to EVs and WQOs.

1.2.3 Use of this document

Section 2 (Table 1) lists the identified EVs for protection for particular waters. The aquatic ecosystem EV is a default applying to all Queensland waters. Reference to section 3 (Tables 2 and 14) provides the corresponding WQOs to protect the aquatic ecosystem EV. Where relevant, different WQOs are specified to protect the aquatic ecosystem EV in different water types (refer to the tables and the accompanying plans). For the human use EVs specified in Table 1, tables 3 to 12 provide the corresponding WQOs to support these EVs.

Where reference to Table 1 indicates more than one EV applies to a given water, the adoption of the most stringent WQO for the identified EVs applies to each water quality indicator in order to protect all identified EVs. Further detail on selection of most stringent WQOs is provided in section 3.

This document also refers to a number of guidelines, codes and other reference sources on water quality. In particular, the QWQG prepared by the department provide a technical basis for the majority of the WQOs contained in this document. The QWQG also provide more detailed information on water types, water quality indicators, derivation of local water quality guidelines, application during flood events, monitoring, and predicting and assessing compliance.

1.3 Information about mapped areas and boundaries

The boundaries in the accompanying plans WQ1181, WQ1182, WQ1183, and WQ1184 are indicative only. EVs, water types and aquatic ecosystem management intent (level of protection) depicted in the accompanying plans are stored in electronic form as part of the Central Queensland Environmental Values Schedule 1 Geodatabase August 2013, and held at the department's offices at 400 George Street Brisbane. Geodatabase regions are based on the regions established in the QWQG. Spatial (GIS) datasets can be downloaded free of charge from the Queensland Government Information Service (QGIS) at http://dds.information.qld.gov.au/dds. For further information, email the department at epa.ev@ehp.qld.gov.au.

1.4 Water types and basis for boundaries

1.4.1 Water types

Waters in this document have been classified into the following different water types (not all water types are present in all areas):

- lowland freshwaters—larger slow moving freshwater streams and rivers, shown on the accompanying plan as freshwaters under 150 metres altitude

- upland freshwaters—small upstream streams, moderate - fast flowing with steeper gradients than lowland freshwaters. Shown on the accompanying plan as freshwaters above 150 metres altitude
- freshwater lakes/reservoirs
- groundwaters
- mid estuary—waters extending the majority of the length of estuaries with a moderate amount of water movement from either freshwater inflow or tidal exchange
- enclosed coastal/lower estuary—waters occurring at the downstream end of estuaries and including shallow coastal waters in adjacent enclosed bays
- marinas, boat harbours, tidal canals, and constructed estuaries
- wetlands
- open coastal waters—waters extending to the seaward limits of Queensland waters.

The water types are based on local water quality studies in the Black and Ross River basins (refer to the source documents listed after Table 2), the AWQG and mapping and definitional rules contained in the QWQG. Further detail on water types is contained in these sources.

Water types identified in this document are shown in Table 2 and the accompanying plans (WQ1181, WQ1182, WQ1183, and WQ1184).

1.4.2 Water type boundaries

The boundaries of different water types have been mapped using a variety of attributes, including:

1. geographic coordinates
2. catchment or subcatchment boundaries
3. highest/lowest astronomical tide
4. tidal limiting structure (weirs)
5. maritime mapping conventions
6. coastline
7. surveyed terrestrial boundaries
8. altitude.

The basis of different boundaries is shown in the plan. The boundaries of water types may be confirmed or revised by site investigations. Refer to section 1.3 above.

1.5 Matters for amendment

Amendments of the following type may be made to this schedule 1 document for the purposes of replacement under section 12(2)(b) of the EPP (Water):

- changes to EVs
- changes to management goals
- changes to WQOs
- changes to management intent (level of protection) categories
- changes to waterway or water type boundaries/descriptions
- updates to information/data sources, websites and email contact details, agency/departmental names, other institutional names, references.

2 Environmental values

2.1 Environmental values

Table 1a and the accompanying plan WQ1181 outline the EVs for waters of the mainland Ross River Basin. Table 1b and the accompanying plan WQ1182 outline the EVs for waters of Magnetic Island, including adjacent coastal waters. These tables and plan WQ1183 also include EVs for coastal and marine waters.

These EVs are based on stakeholder consultations undertaken by the department and Creek to Coral (Townsville City Council) to identify EVs as part of the Black-Ross water quality improvement plan, and additional consultation by the department in preparing this document. Consultation results are reported in:

- Gunn, J & Manning, C 2010, Black Ross (Townsville) Water Quality Improvement Plan (WQIP): Improving water quality from Creek to Coral, Townsville City Council - Creek to Coral, Townsville, available on the Creek to Coral website at www.creektocoral.org.
- Gunn, J, Manning, C & McHarg, A 2009, Environmental values, water quality objectives and targets for the Black Ross Water Quality Improvement Plan, Townsville City Council - Creek to Coral, Townsville, available on the Creek to Coral website.
- McGann, C & Gunn, J 2007, A summary review of groundwater research and knowledge for the Black River and Ross River basins, Townsville City Council - Creek to Coral, Townsville, available on the Creek to Coral website.

The dictionary to this document provides further explanation of EVs (refer section 5).

2.2 Management goals to support environmental values

There are no management goals specified under this document.

Table 1a Environmental values for Ross River Basin waters (excluding Magnetic Island—see Table 1b)

	Environmental values[1,2,3,4,5]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation[5]	Secondary recreation[5]	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
Water												
TOWNSVILLE STATE DEVELOPMENT AREA WATERS [6]	✓	✓		✓					✓		✓	✓
FRESH WATERS outside Townsville State Development Area (listed below alphabetically by catchment then subcatchment (upland then lowland)												
Alligator Creek catchment fresh waters outside Townsville State Development Area (listed alphabetically by subcatchment, upland then lowland)												
Alligator Creek upland fresh waters	✓	✓					✓	✓	✓	✓		✓
Alligator Creek lowland fresh waters	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓
Cape Cleveland fresh waters	✓						✓	✓	✓			✓
Crocodile Creek fresh waters	✓	✓		✓		✓	✓	✓	✓	✓		✓
Killymoon Creek upland fresh waters	✓											✓
Killymoon Creek lowland fresh waters	✓	✓		✓		✓	✓	✓	✓	✓		✓
Slippery Rocks Creek upland fresh waters	✓											✓

	Environmental values[1,2,3,4,5]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation[5]	Secondary recreation[5]	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
Water												
Slippery Rocks Creek lowland fresh waters	✓	✓		✓		✓	✓	✓	✓			✓
Whites Creek upland fresh waters	✓											✓
Whites Creek lowland fresh waters	✓	✓		✓		✓	✓	✓	✓			✓
Bohle River catchment fresh waters (listed alphabetically by subcatchment, upland then lowland)												
Bohle River (upper) fresh waters	✓	✓	✓	✓		✓	✓	✓	✓			✓
Bohle River (lower) fresh waters	✓	✓	✓	✓		✓	✓	✓	✓			✓
Louisa Creek fresh waters	✓					✓		✓	✓			✓
Stony, Saunders, Middle Bohle creeks and Little Bohle River fresh waters	✓	✓		✓		✓	✓	✓	✓			✓
Town Common fresh waters	✓							✓	✓			✓

	Environmental values[1,2,3,4,5]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation[5]	Secondary recreation[5]	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
Water												
Ross River (upper) catchment fresh waters (listed alphabetically by subcatchment, upland then lowland)												
Anthill Plains Creek fresh waters	✓	✓	✓	✓					✓			✓
Lake Ross (Ross River Dam)	✓	✓				✓	✓	✓	✓	✓	✓	✓
Mt Stuart and Blacksoil Gully upland fresh waters	✓											✓
Mt Stuart and Blacksoil Gully lowland fresh waters	✓						✓	✓	✓			✓
One Mile, Spring and Landsdowne creeks fresh waters	✓	✓	✓	✓	✓				✓			✓
Ross River (upper), Lagoon, Plum Tree, Ross, Sandy, Deep, Cattle and Leichhardt creeks fresh waters	✓	✓		✓			✓	✓	✓			✓
Round Mountain Creek upland fresh waters	✓											✓
Round Mountain Creek lowland fresh waters	✓	✓		✓			✓	✓	✓			✓
Sachs Creek upland fresh waters	✓											✓
Sachs Creek lowland fresh waters	✓	✓					✓	✓	✓	✓		✓
Six Mile, Four Mile and Flagstone creeks, and Jimmys Lagoon fresh waters	✓	✓	✓	✓					✓			✓

	Environmental values[1,2,3,4,5]											
Water	**Aquatic ecosystems**	**Irrigation**	**Farm supply/use**	**Stock water**	**Aquaculture**	**Human consumer**	**Primary recreation**[5]	**Secondary recreation**[5]	**Visual recreation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
Toonpan Lagoon fresh waters	✓	✓	✓	✓					✓			✓
Ross River (lower) catchment fresh waters outside Townsville State Development Area (listed alphabetically by subcatchment, upland then lowland)												
Aplins Weir	✓	✓				✓	✓	✓	✓			✓
Black Weir	✓	✓				✓	✓	✓	✓	✓		✓
Gleesons Weir	✓	✓				✓	✓	✓	✓			✓
Mt Stuart Training Area/Campus Creek fresh waters	✓					✓	✓	✓	✓			✓
Pallarenda fresh waters	✓					✓		✓	✓			✓
Ross Creek fresh waters	✓					✓	✓	✓	✓			✓
Ross River (below dam) fresh waters	✓	✓	✓			✓	✓	✓	✓			✓
Stuart Creek catchment fresh waters outside Townsville State Development Area (listed alphabetically by subcatchment, upland then lowland)												
Sandfly Creek fresh waters	✓			✓				✓	✓			✓
Stuart Creek upland fresh waters	✓	✓	✓	✓			✓		✓			✓
Stuart Creek lowland fresh waters	✓	✓	✓	✓		✓	✓	✓	✓			✓

	Environmental values[1,2,3,4,5]											
	Aquatic ecosystems	**Irrigation**	**Farm supply/use**	**Stock water**	**Aquaculture**	**Human consumer**	**Primary recreation**[5]	**Secondary recreation**[5]	**Visual recreation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
Water												
GROUNDWATERS	✓	✓	✓	✓	✓					✓		✓
ESTUARIES outside Townsville State Development Area (listed alphabetically by subcatchment)												
Alligator Creek estuarine waters	✓					✓		✓	✓			✓
Bohle River estuarine waters	✓					✓		✓	✓			✓
Cape Cleveland estuarine waters	✓					✓		✓	✓			✓
Crocodile Creek estuarine waters	✓				✓	✓		✓	✓			✓
Killymoon Creek estuarine waters	✓					✓		✓	✓			✓
Louisa Creek estuarine waters	✓					✓		✓	✓			✓
Pallarenda estuarine waters	✓					✓		✓	✓			✓
Ross Creek estuarine waters	✓					✓		✓	✓		✓	✓
Ross River estuarine waters	✓					✓		✓	✓		✓	✓
Sandfly Creek estuarine waters	✓					✓		✓	✓			✓

	Environmental values[1,2,3,4,5]											
	Aquatic ecosystems	**Irrigation**	**Farm supply/use**	**Stock water**	**Aquaculture**	**Human consumer**	**Primary recreation**[5]	**Secondary recreation**[5]	**Visual recreation**	**Drinking water**	**Industrial use**	**Cultural and spiritual values**
Water												
Stuart Creek estuarine waters	✓					✓		✓	✓			✓
Stony Creek estuarine waters	✓					✓		✓	✓			✓
Town Common estuarine waters	✓					✓			✓			✓
COASTAL WATERS												
Townsville Port[6] **sub-zone** (MD2241) - see plan WQ1183	✓					✓	✓	✓	✓		✓	✓
Cleveland Bay (outside port sub-zone) - see plan WQ1183	✓					✓	✓	✓	✓			✓
Offshore marine waters - see plan WQ1183	✓					✓	✓	✓	✓			✓
West Channel - see plan WQ1183	✓					✓	✓	✓	✓			✓
Halifax Bay (extends into Black Basin) - see plan WQ1183	✓					✓	✓	✓	✓			✓

Notes:

1. Refer to the accompanying plans WQ1181 and WQ1183 for locations of EVs. For fresh water and estuarine rows, the EVs shown relate to waters within each subcatchment. For example the EVs for 'Alligator Creek upland fresh waters' apply to all upland fresh waters in Alligator Creek subcatchment.
2. ✓ means the EV is selected for protection. Blank indicates that the EV is not chosen for protection.
3. Refer to the dictionary for further explanation of EVs.

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4. Refer to section 3 for WQOs applying to the EVs in this table.
5. The selection of recreational EVs for waters does not mean that these waters are free of venomous or dangerous aquatic organisms, for example venomous organisms (e.g. marine stingers including box jellyfish, irukandji jellyfish), crocodiles, and sharks. Direct contact with venomous or dangerous aquatic organisms should be avoided. Refer to www.townsville.qld.gov.au, www.health.qld.gov.au, www.beachsafe.org.au, www.marinestingers.com.au and other information sources for further details on swimming safety and information on specific waters.
6. For more specific information on land use designations and corresponding indicative uses within Townsville State Development Area, refer to Townsville State Development Area Development Scheme. Some EVs within TSDA only applicable to fresh waters. For information on activity restrictions within port waters, refer to the Port of Townsville Limited. For more detail on land use designations and corresponding indicative uses within ports, refer to the land use plan for Port of Townsville, prepared by Port of Townsville Limited. Land use plans provide an overall framework for management of development and activities on strategic port land.

Table 1b Environmental values for Magnetic Island Sub-basin waters

	Environmental values[1,2,3,4, 5]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation[5]	Secondary recreation[5]	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
Water												
FRESH WATERS (listed by subcatchment in anti-clockwise order, starting from the western side of Magnetic Island)												
Retreat Creek fresh waters	✓	✓				✓	✓	✓	✓	✓	✓	✓
Chinaman Creek fresh waters	✓					✓	✓	✓	✓			✓
Duck Creek fresh waters	✓	✓				✓	✓	✓	✓	✓		✓
Ned Lee Creek fresh waters	✓					✓	✓	✓	✓	✓		✓
Butlers Creek fresh waters	✓					✓	✓	✓	✓			✓
Hoyer Creek (Nelly Bay) fresh waters	✓						✓	✓	✓			✓
Gustav Creek upland fresh waters	✓					✓	✓	✓	✓			✓
Gustav Creek lowland fresh waters	✓					✓	✓	✓	✓			✓
Northern Nelly Bay creek fresh waters	✓							✓	✓			✓

	Environmental values[1,2,3,4, 5]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation[5]	Secondary recreation[5]	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
Water												
Petersen Creek upland freshwaters	✓					✓	✓	✓	✓			✓
Petersen Creek lowland fresh waters	✓						✓	✓	✓			✓
Eastern Magnetic Island fresh waters	✓					✓	✓	✓	✓			✓
Eastern Horseshoe Bay fresh waters	✓					✓	✓	✓	✓			✓
Gorge Creek upland fresh waters	✓					✓	✓	✓	✓			✓
Gorge Creek lowland fresh waters	✓					✓	✓	✓	✓			✓
Endeavour Creek upland fresh waters	✓					✓	✓	✓	✓			✓
Endeavour Creek lowland fresh waters	✓						✓	✓	✓			✓
Five Beach Bay fresh waters	✓						✓	✓	✓			✓
Rollingstone Bay fresh waters	✓						✓	✓	✓			✓
GROUNDWATERS	✓		✓							✓		

	Environmental values[1,2,3,4, 5]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation[5]	Secondary recreation[5]	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
Water												
ESTUARIES (estuaries below have the same EVs, and are shown in a grouped 'estuarine waters' box on Plan WQ1182)												
Butlers Creek estuarine waters	✓					✓		✓	✓			✓
Gustav Creek estuarine waters	✓					✓		✓	✓			✓
Eastern Horseshoe Bay estuarine waters	✓					✓		✓	✓			✓
All other Magnetic Island estuarine waters	✓					✓		✓	✓			✓
COASTAL WATERS												
Horseshoe Bay	✓				✓	✓	✓	✓	✓			✓
West Channel	✓					✓	✓	✓	✓			✓
All other Magnetic Island coastal waters	✓					✓	✓	✓	✓			✓

Notes:

1. Refer to the accompanying plans WQ1182 and WQ1183 for locations of EVs. For fresh water and estuarine rows, the EVs shown relate to waters within each subcatchment. For example the EVs for 'Retreat Creek fresh waters' apply to all fresh waters in Retreat Creek subcatchment.
2. ✓ means the EV is selected for protection. Blank indicates that the EV is not chosen for protection.
3. Refer to the dictionary for further explanation of EVs.

4. Refer to section 3 for WQOs applying to the EVs in this table.
5. The selection of recreational EVs for waters does not mean that these waters are free of venomous or dangerous aquatic organisms, for example venomous organisms (e.g. marine stingers including box jellyfish, irukandji jellyfish), crocodiles, and sharks. Direct contact with venomous or dangerous aquatic organisms should be avoided. Refer to www.townsville.qld.gov.au, www.health.qld.gov.au, www.beachsafe.org.au, www.marinestingers.com.au and other information sources for further details on swimming safety and information on specific waters.

3 Water quality objectives to protect environmental values

This section provides WQOs to support and protect different EVs identified for waters within the Ross River Basin and Magnetic Island in Table 1. WQOs are long-term goals for water quality management. They are numerical concentration levels or narrative statements of indicators established for receiving waters to support and protect the designated EVs for those waters. Water quality objectives are not individual point source emission objectives, but the receiving water quality objectives.

This section is in two main parts:

- Section 3.1 (Tables 2 and 14) outlines WQOs to protect the aquatic ecosystem EV. The aquatic ecosystem EV is a default applying to all Queensland waters, and therefore the WQOs for aquatic ecosystems form the minimum WQOs for all waters. Where no human use EVs are identified, the WQOs identified for aquatic ecosystem protection remain applicable.
- Section 3.2 (tables 3 to 12) provides WQOs for EVs other than aquatic ecosystem ('human use EVs') such as recreational water use, irrigating crops, and aquaculture.

Sources used in deriving WQOs are provided after the tables.

Reference to the identified EVs in Table 1 of this document provides guidance on the EVs applying to waters within the catchment. Where reference to Table 1 indicates more than one EV applies to a given water (for example aquatic ecosystem and recreational use), the most stringent WQO for each water quality indicator applies, which will then protect all identified EVs. Refer to the two following examples on selection of most stringent WQOs. Note that these are examples only and should not be directly adopted for use.

Example 1

For lowland freshwater streams with aquatic ecosystem and drinking water EVs, the respective turbidity WQOs are:

- aquatic ecosystem lowland freshwater stream: less than 10 nephelometric turbidity units (NTU)
- drinking water: less than 25 NTU.

In this case the aquatic ecosystem WQO for turbidity (less than 10 NTU) is the more stringent, and its adoption therefore supports both the aquatic ecosystem and drinking water EVs.

Example 2

In the following situation there are stock watering and irrigation EVs, with differing WQOs for thermotolerant (faecal) coliforms (measured as median number of organisms per 100 millilitre (mL)):

- stock watering: less than 100 organisms per 100 mL
- raw human food crops in direct contact with irrigation water: less than 10 organisms per 100 mL
- pasture and fodder for dairy animals: less than 100 organisms per 100 mL.

The most stringent WQO for faecal coliform in this example is that for direct irrigation of raw human food crops (less than 10 organisms per 100 mL) and its adoption would in turn provide faecal coliform WQOs that protect all the above-identified human use EVs.

3.1 Water quality objectives to protect aquatic ecosystems

This section provides physico-chemical, biological (section 3.1.1) and riparian (section 3.1.2) WQOs to support the aquatic ecosystem EV. Sources used in deriving locally relevant WQOs are provided after the tables in each of these sections.

Section 5 and Appendix D of the QWQG address procedures for the application of guidelines for aquatic ecosystem protection, and compliance assessment protocols. For the comparison of test site monitoring data against WQOs, the median water quality value (e.g. concentration) of a number (preferably five or more) of independent samples at a particular monitoring ('test') site should be compared against the water quality objective of the same indicator, water type and level of aquatic ecosystem protection, as listed in Table 2 below. For WQOs based on GBRMPA data, refer to notes after tables, and protocols contained in *Water quality guidelines for the Great Barrier Reef Marine Park 2010.*

3.1.1 Physico–chemical and biological water quality objectives

Table 2 includes the following information:

- water area or water type (column 1) (for boundaries of specified areas, refer to the accompanying plan)
- the corresponding management intent (level of protection) for the identified waters (column 2)
- the corresponding physico-chemical and biological WQOs to achieve the management intent (level of protection) for the identified waters.

The EPP (Water) s. 14 identifies the management intent (level of protection) for different waters. The framework and how it is addressed in this document are summarised below.

- The EPP (Water) identifies some waters for which the management intent (level of protection) is to maintain or achieve an effectively unmodified waterway condition (‘high ecological value’—HEV). These may include waters that are currently HEV, ‘slightly disturbed’ (SD), or potentially, more modified waters which can be progressively improved to achieve HEV condition.
- In this document, waters for which all physico-chemical WQOs (e.g. nutrients, toxicants) have been set corresponding to HEV management intent are identified in columns 1 and 2 of Table 2. Each of these waters is given a specific label in the table (e.g. 'HEV1234' for effectively unmodified waters, 'SD 1234' for slightly disturbed waters) which links to labels and cross-hatching on the accompanying plans.
- The management intent (level of protection) for most waters other than HEV or SD is to achieve a 'moderately disturbed' (MD) condition, for which corresponding WQOs have been derived. For some indicators and water types, WQOs correspond with a 'slightly to moderately disturbed' (SMD) level of protection, based on management intent categories specified in source technical guidelines, in particular the ANZECC (2000) Australian water quality guidelines. For ease of interpretation, this document and accompanying mapping include these within the MD level of protection. For some MD waters a higher level of protection may be provided for toxicants (e.g. pesticides).
- The management intent (level of protection) for ‘highly disturbed’ waters is that they be progressively improved. Some highly disturbed waters may require a long timeframe to return to a moderately disturbed condition level. In some circumstances, interim WQOs that reflect a highly disturbed (HD) condition level (which is an improvement on current condition) may be determined for such waters. Any such locations and their corresponding management intent (level of protection) are also identified in the table and accompanying plan.
- some objectives apply to specific areas or water types as indicated in Table 2 and shown on plans WQ1181, WQ1182, WQ1183 and WQ1184, while others apply to more than one water type, as indicated in the table.

Table 2a Water quality objectives to protect Ross River Basin mainland aquatic ecosystem environmental value under baseflow conditions

Water area/type (refer plans WQ1181, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
SURFACE FRESH WATERS (refer plan WQ1181) **Listed by HEV and SD waters, waters outside Townsville State Development Area (TSDA), waters within TSDA, lakes/reservoirs, toxicants, other**		
Fresh waters in areas: **HEV2221 (upper Stony/Bohle)** **2222 (Mt Stuart)** **2223 (upper Ross)** **2224 (Upper Stuart)** **2225 (upper Alligator Creek)** **SD2221 (Many Peaks)**	Aquatic ecosystem—high ecological value (HEV)	HEV: Maintain existing water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas. SD: Achieve effectively unmodified water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas. • sodium (Na): 5–7–11 mg/L[q] • calcium (Ca): 2–3–5 mg/L[q] • magnesium (Mg): 1–2–4 mg/L[q] • bicarbonate (HCO_3): 14–25–40 mg/L[q] • chloride (Cl): 6–9–14 mg/L[q] • sulfate (SO_4): 1–1–2 mg/L[q] • electrical conductivity (EC): 47–72–98µS/cm (20th, 50th and 75th percentiles)[j, q] • hardness: 8–17–29 mg/L[q] • alkalinity: 11–20–33 mg/L[q] • silica (SiO_2): 10.1–14.1–21.1mg/L[q] • fluoride (F): 0.010–0.060–0.110 mg/L[q] • sodium adsorption ratio (SAR): 0.60–0.70–0.95[q] • toxicants: refer to HEV waters toxicants row later in this table Note: for other indicators, there is insufficient information available to establish water quality objectives for these waters. Refer to QWQG for details on how to establish a minimum water quality data set for deriving local 20th, 50th and 80th percentiles.
Toxicants for all HEV and SD fresh waters	Aquatic ecosystem—high ecological value (HEV)	WQOs for pesticides identified in the Black Ross Water Quality Improvement Plan (WQIP), to protect freshwater species at the HEV level of protection[a]: • Ametryn: nd[b] • Atrazine: <0.7 µg/L (micrograms/Litre) • Chlorpyrifos: <0.00004 µg/L • Diazinon: <0.00003 µg/L • Diuron: nd[b] • Endosulfan: <0.03 µg/L • Hexazinone: nd[b] • Malathion: <0.002 µg/L • MEMC: nd[b] • Simazine: <0.2 µg/L • Tebuthiuron: <0.02 µg/L • Tributyltin: nd[b] • 2,4-D: <140 µg/L WQOs for heavy metals identified in the Black Ross WQIP, to protect freshwater species at the HEV level of protection[a]: • Cadmium: <0.06 µg/L • Chromium: <0.01 µg/L • Copper: <1.0 µg/L

Water area/type (refer plans WQ1181, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
		• Lead: <1.0 µg/L • Nickel: <8 µg/L • Zinc: <2.4 µg/L All other toxicants in water and sediment as per AWQG, to protect freshwater species at the HEV level of protection: • Toxicants in water[a]: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8) • Toxicants in sediments: refer to AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8) Comply with Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance, ANZECC.
Upland fresh waters outside the Townsville State Development Area, and not identified as HEV or SD (including waters in Alligator, Bohle, Ross and Stuart Creek catchments)	Aquatic ecosystem—moderately disturbed (MD)	• ammonia N: <10 µg/L[c, d, e] (micrograms/Litre) • oxidised N: <15 µg/L[c, d, e, f] • dissolved inorganic N (DIN): <25 µg/L[d, e, g] • organic N: <225 µg/L[c, d, e] • total N: <250 µg/L[c, d, e] • filterable reactive phosphorus (FRP): <15 µg/L[c, d] • total P: <30 µg/L[c, d] • chlorophyll a: n/a[b, c] • dissolved oxygen: 90%–110% saturation[c, h] • turbidity: <25 NTU[c] • suspended solids: n/a[b, c] • pH: 6.5–7.5[c, i] • temperature: nd[b, k] • macroinvertebrates: nd[b] • fish: nd[b] • toxicants: refer to toxicants row later in this table • sodium (Na): <11 mg/L[q] • calcium (Ca): <5 mg/L[q] • magnesium (Mg): <4 mg/L[q] • bicarbonate (HCO_3): <40 mg/L[q] • chloride (Cl): <14 mg/L[q] • sulfate (SO_4): <2 mg/L[q] • electrical conductivity (EC): <98µS/cm (75th percentile)[j, q] • hardness: <29 mg/L[q] • alkalinity: <33 mg/L[q] • silica (SiO_2): <21.1mg/L[q] • fluoride (F): <0.110 mg/L[q] • sodium adsorption ratio (SAR): 0.60–0.95[q]

Water area/type (refer plans WQ1181, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
Lowland fresh waters outside Townsville State Development Area and not identified as HEV or SD Including lowland fresh waters within Alligator, Ross and Stuart Creek catchments that are **outside** TSDA, and not identified as HEV or SD Excludes Bohle River - refer separate row below	Aquatic ecosystem—moderately disturbed (MD)	• ammonia N: <20 µg/L[c, d, e] • oxidised N: <60 µg/L[c, d, e, f] • dissolved inorganic N: <80 µg/L[d, e, g] • organic N: <420 µg/L[c, d, e] • total N: <500 µg/L[c, d, e] • filterable reactive phosphorus (FRP): <20 µg/L[c, d] • total P: <50 µg/L[c, d] • chlorophyll a: <5 µg/L[c] • dissolved oxygen: 85%–110% saturation[c, h] • turbidity: <50 NTU[c] • suspended solids: <10 mg/L[c] • pH: 6.5–8.0[c, i] • temperature: nd[b, k] • macroinvertebrates: nd[b] • fish: nd[b] • toxicants: refer to toxicants row later in this table • sodium (Na): <11 mg/L[q] • calcium (Ca): <5 mg/L[q] • magnesium (Mg): <4 mg/L[q] • bicarbonate (HCO_3): <40 mg/L[q] • chloride (Cl): <14 mg/L[q] • sulfate (SO_4): <2 mg/L[q] • electrical conductivity (EC): <98µS/cm (75th percentile)[j, q] • hardness: <29 mg/L[q] • alkalinity: <33 mg/L[q] • silica (SiO_2): <21.1mg/L[q] • fluoride (F): <0.110 mg/L[q] • sodium adsorption ratio (SAR): 0.60–0.95[q]
Bohle River fresh waters (outside TSDA)	Aquatic ecosystem—moderately disturbed (MD)	• ammonia N: <20 µg/L (DO >80% sat) [d, e, s] • ammonia N <30 µg/L (DO 40–80% sat) [d, e, s] • ammonia N <60 µg/L (DO <40% sat) [d, e, s] • oxidised N: <60 µg/L[c, d, e, f] • dissolved inorganic N: <80 µg/L[d, e, g] • organic N: <420 µg/L[c, d, e] • total N: <620 µg/L[d, e, t] • filterable reactive phosphorus (FRP): <20 µg/L[c, d] • total P: <50 µg/L[c, d] • chlorophyll a: <4 µg/L[s] • dissolved oxygen: 60%–90% saturation [h, t] • turbidity: <22 NTU [t] • suspended solids: <10 mg/L[c] • pH: 6.5–8.0[c, i] • temperature: nd[b, k] • macroinvertebrates: nd[b] • fish: nd[b] • toxicants: refer to toxicants row later in this table • sodium (Na): <11 mg/L[q] • calcium (Ca): <5 mg/L[q]

Water area/type (refer plans WQ1181, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
		• magnesium (Mg): <4 mg/L[q] • bicarbonate (HCO_3): <40 mg/L[q] • chloride (Cl): <14 mg/L[q] • sulfate (SO_4): <2 mg/L[q] • electrical conductivity (EC): <660µS/cm[j, t] (75th -%-ile) • hardness: <29 mg/L[q] • alkalinity: <33 mg/L[q] • silica (SiO_2): <21.1mg/L[q] • fluoride (F): <0.110 mg/L[q] • sodium adsorption ratio (SAR): 0.60–0.95[q]
Townsville State Development Area lowland fresh waters	Aquatic ecosystem—moderately disturbed (MD)	Water quality to be managed in accordance with provisions of the Townsville State Development Area Development Scheme. • ammonia N: <20 µg/L (DO >80% sat) [d, e, s] • ammonia N <30 µg/L (DO 40–80% sat) [d, e, s] • ammonia N <60 µg/L (DO <40% sat) [d, e, s] • oxidised N: <60 µg/L[c, d, e, f] • dissolved inorganic N: <80 µg/L[d, e, g] • organic N: <420 µg/L[c, d, e] • total N: <630 µg/L [d, s] • filterable reactive phosphorus (FRP): <20 µg/L[c, d] • total P: <50 µg/L[c, d] • chlorophyll a: <4 µg/L [s] • dissolved oxygen: 85%–110% saturation[c, h] • turbidity: <22 NTU [t] • suspended solids: <10 mg/L[c] • pH: 6.5–8.0[c, i] • temperature: nd[b, k] • macroinvertebrates: nd[b] • fish: nd[b] • toxicants: refer to toxicants row later in this table • sodium (Na): <11 mg/L[q] • calcium (Ca): <5 mg/L[q] • magnesium (Mg): <4 mg/L[q] • bicarbonate (HCO_3): <40 mg/L[q] • chloride (Cl): <14 mg/L[q] • sulfate (SO_4): <2 mg/L[q] • electrical conductivity (EC): <660µS/cm [j, t] (75th %-ile) • hardness: <29 mg/L[q] • alkalinity: <33 mg/L[q] • silica (SiO_2): <21.1mg/L[q] • fluoride (F): <0.110 mg/L[q] • sodium adsorption ratio (SAR): 0.60–0.95[q]

Water area/type (refer plans WQ1181, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
Townsville State Development Area upland fresh waters (located within Muntalunga Range, in eastern part of Townsville State Development Area - WQOs are identical to upland fresh waters outside TSDA)	Aquatic ecosystem—moderately disturbed (MD)	Water quality to be managed in accordance with provisions of the Townsville State Development Area Development Scheme. • ammonia N: <10 µg/L[c, d, e] (micrograms/Litre) • oxidised N: <15 µg/L[c, d, e, f] • dissolved inorganic N (DIN): <25 µg/L[d, e, g] • organic N: <225 µg/L[c, d, e] • total N: <250 µg/L[c, d, e] • filterable reactive phosphorus (FRP): <15 µg/L[c, d] • total P: <30 µg/L[c, d] • chlorophyll a: n/a[b, c] • dissolved oxygen: 90%–110% saturation[c, h] • turbidity: <25 NTU[c] • suspended solids: n/a [b, c] • pH: 6.5–7.5[c, i] • temperature: nd[b, k] • macroinvertebrates: nd[b] • fish: nd[b] • toxicants: refer to toxicants row later in this table • sodium (Na): <11 mg/L[q] • calcium (Ca): <5 mg/L[q] • magnesium (Mg): <4 mg/L[q] • bicarbonate (HCO_3): <40 mg/L[q] • chloride (Cl): <14 mg/L[q] • sulfate (SO_4): <2 mg/L[q] • electrical conductivity (EC): <98µS/cm (75th percentile) [j, q] • hardness: <29 mg/L[q] • alkalinity: <33 mg/L[q] • silica (SiO_2): <21.1mg/L[q] • fluoride (F): <0.110 mg/L[q] • sodium adsorption ratio (SAR): 0.60–0.95[q]
Freshwater lakes/reservoirs	Aquatic ecosystem—moderately disturbed (MD)	• ammonia N: <10 µg/L[c, d, e] • oxidised N: <10 µg/L[c, d, e, f] • dissolved inorganic N (DIN): <20 µg/L[d, e, g] • organic N: <330 µg/L[c, d, e] • total N: <350 µg/L[c, d, e] • filterable reactive phosphorus (FRP): <5 µg/L[c, d] • total P: <10 µg/L[c, d] • chlorophyll a: <5 µg/L[c] • dissolved oxygen: 90%–110% saturation[c, h] • turbidity: 1–20 NTU[c] • Secchi depth: nd[b, c] • suspended solids: nd[b, c] • pH: 6.5–8.0[c, i] • temperature: nd[b, k] • toxicants: refer to toxicants row below

Water area/type (refer plans WQ1181, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
Toxicants for ALL moderately disturbed fresh waters within this table	Aquatic ecosystem—moderately disturbed (MD)	WQOs for pesticides identified in the Black Ross WQIP, to protect freshwater species at the MD level of protection (identified in the AWQG as slightly to moderately disturbed)[a]: • Ametryn: nd[b] • Atrazine: <13 µg/L • Chlorpyrifos: <0.01 µg/L • Diazinon: <0.01 µg/L • Diuron: nd[b] • Endosulfan: <0.03 µg/L • Hexazinone: nd[b] • Malathion: <0.05 µg/L • MEMC: nd[b] • Simazine: <3.2 µg/L • Tebuthiuron: <2.2 µg/L • Tributyltin: nd[b] • 2,4-D: <280 µg/L WQOs for heavy metals identified in the Black Ross WQIP, to protect freshwater species at the MD level of protection (identified in the AWQG as slightly to moderately disturbed)[a]: • Cadmium: <0.2 µg/L • Chromium: <1.0 µg/L • Copper: <1.4 µg/L • Lead: <3.4 µg/L • Nickel: <11 µg/L • Zinc: <8.0 µg/L WQOs for heavy metals in sediments identified in the Black Ross WQIP, to protect freshwater species at the MD level of protection (identified in the AWQG as slightly to moderately disturbed)[a]: • Cadmium: <1.5 mg/kg • Chromium: <80 mg/kg • Copper: <65 mg/kg • Lead: <50 mg/kg • Nickel: <21 mg/kg • Zinc: <200 mg/kg All other toxicants in water and sediment as per AWQG, to protect species at the MD level of protection: • Toxicants in water[a]: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8) • Toxicants in sediments: refer to AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8) Comply with Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance, ANZECC.
Freshwater riparian areas	Aquatic ecosystem—moderately disturbed (MD)	Protect or restore riparian areas. Refer section 3.1.2—riparian WQOs

Water area/type (refer plans WQ1181, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
Wetlands	Aquatic ecosystem—moderately disturbed (MD)	Objectives as per AWQG and section 3.1.2. Note: for high impact earthworks within Great Barrier Reef wetland protection areas, refer to the guideline 'Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments', and the Queensland wetland buffer planning guideline, available from the department's website.
GROUNDWATERS		
Groundwaters (refer plan WQ1184)	Aquatic ecosystem—high ecological value (HEV)	Where groundwaters interact with surface waters, groundwater quality should not compromise identified EVs and WQOs for those waters. Note: the AWQG recommends that the highest level of protection should be provided to underground aquatic ecosystems, given their high conservation value. Where groundwaters are in good condition the intent is to maintain existing water quality (20th, 50th and 80th percentiles). WQOs for Ross River Basin mainland groundwaters are provided according to their chemistry zone (refer plan WQ1184) and depth category in Table 14.
ESTUARINE AND COASTAL WATERS - listed estuarine waters, MD2241 port sub-zone, MD2242 Cleveland Bay sub-zone, Breakwater marina, SD2245 eastern Cleveland Bay, open coastal waters outside Bay, Halifax Bay (refer plans WQ1181 and WQ1183) The following WQOs apply to Ross River Basin estuarine and coastal waters in plans WQ1181 and WQ1183, including the Townsville State Development Area, Townsville Port sub-zone and Cleveland Bay. Magnetic Island waters are listed separately in Table 2b. (All coastal waters covered in this table are landward of the plume line identified by GBRMPA[n]. Refer to the Black River Basin document for coastal waters seaward of the plume line.)		
Estuarine and coastal waters	Aquatic ecosystem—all	Release of sewage from vessels to be controlled in accordance with requirements of the *Transport Operations (Marine Pollution) Act 1995* and Regulations. (Refer to Maritime Services Queensland website for further information.)
Estuarine waters in areas HEV2224, HEV2225 and SD2221	Aquatic ecosystem—high ecological value (HEV)	HEV: Maintain existing water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas. SD: Achieve effectively unmodified water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas. Note: there is insufficient information available to establish water quality objectives for these waters. Refer to QWQG for details on how to establish a minimum water quality data set for deriving local 20th, 50th and 80th percentiles. • toxicants: refer to toxicants row below
Mid estuary waters: • **within Townsville State Development Area** • **Stuart Creek estuary north of Townsville State Development Area**	Aquatic ecosystem—moderately disturbed (MD)	• ammonia N: <10 µg/L[c, d] • oxidised N: <10 µg/L[c, d, f] • dissolved inorganic N (DIN): <20 µg/L[d, g] • organic N: <260 µg/L[c, d] • total N: <300 µg/L[c, d] • filterable reactive phosphorus (FRP): <8 µg/L[c, d] • total P: <25 µg/L[c, d] • chlorophyll a: <4 µg/L[c] • dissolved oxygen: 85%–100% saturation [t] • turbidity: <20 NTU [t] • Secchi depth: >1.0 m[c] • suspended solids: <20 mg/L[c] • pH: 7.0–8.4[c] • temperature: nd[b, k] • toxicants: refer to toxicants row below

Water area/type (refer plans WQ1181, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
Mid estuary waters outside Townsville State Development Area (other than Bohle and Sandfly mid estuaries - refer separate row below) **Including mid estuary waters of Ross Creek, Ross River, Townsville Yacht Club Marina** **(Note: for Townsville Port sub-zone waters, refer to 'MD2241 Townsville Port sub-zone waters' in this table)**	Aquatic ecosystem—moderately disturbed (MD)	Note: For waters shown on the plan as being mid estuary (orange colour) and occurring within inter-tidal zone adjacent to the enclosed coastal/lower estuary water type, these waters may have water quality characteristics more in common with the adjacent enclosed coastal/lower estuary water type. Under such circumstances, reference should be made to the WQOs for enclosed coastal/lower estuary water type. • ammonia N: <10 µg/L[c, d] • oxidised N: <10 µg/L[c, d, f] • dissolved inorganic N (DIN): <20 µg/L[d, g] • organic N: <260 µg/L[c, d] • total N: <300 µg/L[c, d] • filterable reactive phosphorus (FRP): <8 µg/L[c, d] • total P: <25 µg/L[c, d] • chlorophyll a: <4 µg/L[c] • dissolved oxygen: 85%–100% saturation[c, h] • turbidity: <8 NTU[c] • Secchi depth: >1.0 m[c] • suspended solids: <20 mg/L[c] • pH: 7.0–8.4[c] • temperature: nd[b, k] • toxicants: refer to toxicants row below
Bohle River and Sandfly Creek mid estuary waters outside Townsville State Development Area	Aquatic ecosystem—moderately disturbed (MD)	• ammonia N: <30 µg/L[d, t] • oxidised N: <40 µg/L [d, f, t] • dissolved inorganic N (DIN): <20 µg/L[d, g] • organic N: <260 µg/L[c, d] • total N: <500 µg/L[d, t] • filterable reactive phosphorus (FRP): <10 µg/L[d, t] • total P: <50 µg/L[d, t] • chlorophyll a: <6 µg/L[t] • dissolved oxygen: 85%–100% saturation[h, t] • turbidity: <20 NTU [t] • Secchi depth: >1.0 m[c] • suspended solids: <20 mg/L[c] • pH: 7.0–8.4.4[c] • temperature: nd[b, k] • toxicants: refer to toxicants row below
Toxicants for ALL estuarine waters within this table	Aquatic ecosystem—all	Toxicants in water and sediment as per AWQG: • Toxicants in water[a]: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1) and AWQG volume 2 (section 8) • Toxicants in sediments: refer to AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1) and AWQG volume 2 (section 8) Release of sewage from vessels to be controlled in accordance with requirements of the *Transport Operations (Marine Pollution) Act 1995* and Regulations. Comply with Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance, ANZECC.
Estuarine riparian areas	Aquatic ecosystem—moderately disturbed (MD)	Protect or restore riparian areas. Refer section 3.1.2—riparian WQOs.

Water area/type (refer plans WQ1181, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
MD2241 Townsville Port sub-zone waters **(includes waters in port, marine precinct, and other enclosed and open coastal waters within MD2241)**	Aquatic ecosystem—moderately disturbed (MD)	• ammonia N: <20 µg/L [d, l] • oxidised N: <9 µg/L [d, f, l] • dissolved inorganic N (DIN): <29 µg/L [d, g, l] • total N: <220 µg/L [d, l] • filterable reactive phosphorus (FRP): <11 µg/L [d, l] • total P: <30 µg/L [d, l] • chlorophyll a: <2.6 µg/L [l] • dissolved oxygen: 90–105% saturation [h, l] • turbidity: <4.9 NTU [l, p] • Secchi depth: >1.0m [l, p] • Suspended solids 13-22-34 mg/L [r] • pH: 8.2–8.5 [l] • temperature: <1°C increase above long-term average maximum [m] • toxicants: refer to toxicants rows later in this table
MD2242 Cleveland Bay enclosed coastal/ lower estuary waters, and Breakwater Marina **(outside Townsville Port sub-zone waters)** **(Note: for open coastal waters within MD2242 refer to following cell)**	Aquatic ecosystem—moderately disturbed (MD)	• ammonia N: <20 µg/L [d, l] • oxidised N: <9 µg/L [d, f, l] • dissolved inorganic N (DIN): <29 µg/L [d, g, l] • total N: <220 µg/L [d, l] • filterable reactive phosphorus (FRP): <11 µg/L [d, l] • total P: <30 µg/L [d, l] • chlorophyll a: <2.6 µg/L [l] • dissolved oxygen: 90–105% saturation [h, l] • turbidity: <4.9 NTU [l, p] • Secchi depth: >1.0m [l, p] • Suspended solids: <15 mg/L [l, p] • pH: 8.2–8.5 [l] • temperature: <1°C increase above long-term average maximum [m] • toxicants: refer to toxicants rows later in this table
MD2242 Cleveland Bay open coastal waters **(outside MD2241 Townsville Port sub-zone)** **(Note: for enclosed coastal waters within MD2242 refer to above cell)**	Aquatic ecosystem—moderately disturbed (MD)	• ammonia N: <15 µg/L [l] • oxidised N: <2 µg/L [f, l] • particulate N (annual mean): ≤ 20 µg/L [c, m] • total dissolved N: <94 µg/L [o] • total N: <130 µg/L [l] • filterable reactive phosphorus (FRP): <7 µg/L [l] • particulate P (annual mean): ≤ 2.8 µg/L [c, m] • total dissolved P: <10 µg/L [o] • total P: <20 µg/L [l] • chlorophyll a: <1 µg/L [l] • dissolved oxygen: 95%–105% saturation [c] • turbidity: <3 NTU [l, p] • Secchi depth (annual mean): ≥ 3 m [o, p] • suspended solids: <10 mg/l [1, p] • pH: 8.1–8.4 [c] • temperature: <1°C increase above long-term average maximum [m] • toxicants: refer to toxicants rows below

Water area/type (refer plans WQ1181, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
SD2245 enclosed coastal waters (eastern Cleveland Bay) **(Note: for open coastal waters within SD2245, refer to following row)**	Aquatic ecosystem—high ecological value (HEV)	• ammonia N: 7–12–20 µg/L[d, l] • oxidised N: 2–4–9 µg/L[d, f, l] • total N: 115–120–220 µg/L[d, l] • filterable reactive phosphorus (FRP): 3–5–11 µg/L[d, l] • total P: 15–20–30 µg/L[d, l] • chlorophyll a: 1.0–1.6–2.6 µg/L[l] • dissolved oxygen: 90–95–105% saturation[l] • turbidity: 0.4–1.0–4.9 NTU[l, p] • Secchi depth: 1.0–1.4 –1.9m[l, p] • suspended solids: 7–10–15 mg/L[l, p] • pH: 8.2–8.3 –8.5[l] • temperature: <1°C increase above long-term average maximum[m] • toxicants: refer to toxicants rows later in this table
SD2245 open coastal waters (eastern Cleveland Bay) **(Note: for enclosed coastal waters within SD2245, refer to above row)**	Aquatic ecosystem—high ecological value (HEV)	• ammonia N: 6–11–15 µg/L[l] • oxidised N: 2–2–2 µg/L[f, l] • total N: 110–115–130 µg/L[l] • filterable reactive phosphorus (FRP): 3–4–7 µg/L[l] • total P: 10–20–20 µg/L[l] • chlorophyll a: 0.5–0.6–1.0 µg/L[l] • dissolved oxygen: 95–100–105% saturation[l] • turbidity: 0–0.4–3.0 NTU[l, p] • Secchi depth: 2.0–3.3–5.0m[l, p] • suspended solids: 4–7–10 mg/L[l, p] • pH: 8.2–8.3 –8.5[l] • temperature: <1°C increase above long-term average maximum[m] • toxicants: refer to toxicants rows later in this table
Open coastal waters, outside of Cleveland Bay sub-zones, landward of the plume line[n] shown in WQ1183 **(Note: For Halifax Bay waters, refer to following row)**	Aquatic ecosystem—slightly to moderately disturbed (SMD), mapped as MD	• ammonia N: 0–3–8 µg/L[o] • oxidised N: 0–0–1 µg/L[o] • particulate N (annual mean): ≤ 20 µg/L[c, m] • total dissolved N: 56–72–94 µg/L[o] • total N: 75–105–130 µg/L[o] • filterable reactive phosphorus (FRP): 0–1–3 µg/L[o] • particulate P (annual mean): ≤ 2.8 µg/L[c, m] • total dissolved P: 3–6–10 µg/L[o] • total P: 5–10–20 µg/L[o] • chlorophyll a (annual mean): ≤ 0.45 µg/L[c, m] • turbidity: <1 NTU[c, p] • Secchi depth (annual mean): ≥ 10 m[c, m, p] • suspended solids (annual mean): ≤ 2.0 mg/L[c, m, p] • dissolved oxygen: 95% – 105% saturation[c, h] • pH: 8.1–8.4[c] • temperature: <1°C increase above long-term average maximum[m] • toxicants: refer to toxicants rows later in this table

Water area/type (refer plans WQ1181, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
Halifax Bay enclosed coastal/ lower estuary waters (outside Cleveland Bay sub-zone waters) **(Note: Halifax Bay waters extend into Black River Basin)**	Aquatic ecosystem—moderately disturbed (MD)	• ammonia N: <8 µg/L[c, d] • oxidised N: <3 µg/L[c, d, f] • dissolved inorganic N (DIN): <11 µg/L[c, d, g] • organic N: <180 µg/L[c, d] • total N: <200 µg/L[c, d] • filterable reactive phosphorus (FRP): <6 µg/L[c, d] • total P: <20 µg/L[c, d] • chlorophyll a: <2 µg/L[c] • dissolved oxygen: 90%–105% saturation[h, l] • turbidity: <6 NTU[c, p] • Secchi depth: >1.5 m[c, p] • suspended solids: <15 mg/L[c, p] • pH: 8.0–8.4[c] • temperature: <1°C increase above long-term average maximum[m] • toxicants: refer to toxicants rows later in this table
Halifax Bay open coastal waters (outside Cleveland Bay sub-zone waters) **(Note: Halifax Bay waters extend into Black River Basin)**	Aquatic ecosystem—slightly to moderately disturbed (SMD), mapped as MD	• ammonia N: 0–3–8 µg/L[o] • oxidised N: 0–0–1 µg/L[o] • particulate N (annual mean): ≤ 20 µg/L[c, m] • total dissolved N: 56–72–94 µg/L[o] • total N: 75–105–130 µg/L[o] • filterable reactive phosphorus (FRP): 0–1–3 µg/L[o] • particulate P: (annual mean) ≤ 2.8 µg/L[c, m] • total dissolved P: 3–6–10 µg/L[o] • total P: 5–10–20 µg/L[o] • chlorophyll a (annual mean): ≤ 0.45 µg/L [c, m] • dissolved oxygen: 95% – 105% saturation [c, h] • turbidity: <1 NTU[c, p] • Secchi depth (annual mean): ≥ 10m[c, m, p] • suspended solids (annual mean): ≤ 2.0 mg/L [c, m, p] • pH: 8.1–8.4[c] • temperature: <1°C increase above long-term average maximum[m] • toxicants: refer to toxicants rows below
Magnetic Island coastal waters: refer to Table 2b		
COASTAL WATERS - TOXICANTS		
Toxicants for: • **MD2241 Townsville Port sub-zone** • **MD2242 Cleveland Bay sub-zone** • **approved spoil grounds, marinas, boat harbours, tidal canals, constructed estuaries**	Aquatic ecosystem—moderately disturbed (MD) (pesticides: high ecological value (HEV))	WQOs for pesticides identified in the Black Ross WQIP, to protect marine species at the HEV level of protection[m]: • Ametryn: <0.5 µg/L • Atrazine: <0.6 µg/L • Chlorpyrifos: <0.0005 µg/L • Diazinon: <0.00003 µg/L • Diuron: <0.9 µg/L • Endosulfan: <0.005 µg/L • Hexazinone: <1.2 µg/L • Malathion: nd[b] • MEMC: <0.002 µg/L • Simazine: <0.2 µg/L • Tebuthiuron: <0.02 µg/L • Tributyltin: <0.006 µg/L (95% species protection)

Water area/type (refer plans WQ1181, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
		• 2,4-D: <0.8 µg/L WQOs for heavy metals identified in the Black Ross WQIP, to protect marine species at the MD level of protection (identified in the AWQG as slightly to moderately disturbed)[a]: • Cadmium: <0.7 µg/L • Chromium: <4.4 µg/L • Copper: <1.3 µg/L • Lead: <4.4 µg/L • Nickel: <7 µg/L • Zinc: <15 µg/L WQOs for heavy metals in sediments identified in the Black Ross WQIP, to protect marine species at the MD level of protection (identified in the AWQG as slightly to moderately disturbed)[a]: • Cadmium: <1.5 mg/kg • Chromium: <80 mg/kg • Copper: <65 mg/kg • Lead: <50 mg/kg • Nickel: <21 mg/kg • Zinc: <200 mg/kg WQOs for all other toxicants in these waters as per GBRMPA and AWQG water quality guidelines, to protect marine species at MD level of protection (identified in the AWQG as slightly to moderately disturbed). For toxicants not listed in GBRMPA guidelines: • Toxicants in water[a]: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8) • Toxicants in sediments: refer to AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8) Comply with Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance, ANZECC.
Toxicants for: • **SD2245 coastal waters in eastern Cleveland Bay,** • **ALL coastal waters outside MD2241 and MD2242 sub-zones, including Halifax Bay** **(Note: for Cleveland Bay waters in MD2241 and MD2242, refer to above row)** **(Note: for Magnetic Island waters refer to Table 2b**)	Aquatic ecosystem—high ecological value (HEV)	WQOs for pesticides identified in the Black Ross WQIP, to protect marine species at the HEV level of protection[m]: • Ametryn: <0.5 µg/L • Atrazine: <0.6 µg/L • Chlorpyrifos: <0.0005 µg/L • Diazinon: <0.00003 µg/L • Diuron: <0.9 µg/L • Endosulfan: <0.005 µg/L • Hexazinone: <1.2 µg/L • Malathion: nd[b] • MEMC: <0.002 µg/L • Simazine: <0.2 µg/L • Tebuthiuron: <0.02 µg/L • Tributyltin: <0.0004 µg/L • 2,4-D: <0.8 µg/L WQOs for heavy metals identified in the Black Ross WQIP, to protect marine species at the HEV level of protection[a]: • Cadmium: <0.7 µg/L • Chromium: <0.14 µg/L • Copper: <0.3 µg/L • Lead: <2.2 µg/L

Water area/type (refer plans WQ1181, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
		• Nickel: <7 µg/L • Zinc: <7 µg/L WQOs for all other toxicants in these waters as per GBRMPA and AWQG water quality guidelines, to protect marine species at the HEV level of protection. For toxicants not listed in GBRMPA guidelines: • Toxicants in water[a]: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8) • Toxicants in sediments: refer to AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8) Comply with Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance, ANZECC.
WATER QUALITY REFERENCE SITES		
Fresh, estuarine, and coastal waters: water quality reference (least disturbed) sites	Aquatic ecosystem—high ecological value (HEV)	For sites identified in the Queensland water quality guidelines, the water quality improvement plan, or by other recognised entities under the EPP Water as reference (least disturbed) sites for water quality monitoring, the management intent is to maintain or achieve effectively unmodified water quality (20th, 50th and 80th percentiles), habitat, biota, and flow.

Notes:

Units:

µg/L = micrograms/Litre

mg/L = milligrams/Litre

µS/cm = microSiemens/centimetre

mg/kg = milligrams/kilogram

a) The values for these indicators are based on the AWQG. Under the AWQG, a single set of values is provided for the 'slightly to moderately disturbed' (SMD) level of protection, which is identified in this document as 'moderately disturbed' (MD). The HEV and SMD levels of protection typically correspond to 99 per cent and 95 per cent species protection, respectively. For a small number of toxicants with potential toxicity and bioaccumulation effects, the AWQG identify SMD protection level values corresponding to 99% species protection. For further details on toxicant guidelines, e.g. toxicant species, and variability in relation to water quality characteristics (such as pH, hardness) refer to AWQG.

b) nd = insufficient or no data, n/a = not applicable for this indicator and water type, ng = no guideline. Will be updated if guidelines become available.

c) The values for these indicators are based on the QWQG Central Coast regional water quality guidelines.

d) Nutrient objectives do not apply during high flow events. See QWQG section 5 and Appendix D for more information on applying guidelines under high flow conditions.

e) During periods of low flow and particularly in smaller creeks, build up of organic matter derived from natural sources (e.g. leaf litter) can result in increased organic N levels (generally in the range of 400 to 800µg/L). This may lead to total N values exceeding the WQOs. Provided that levels of inorganic N (i.e. NH_3 + oxidised N) remain low, then the elevated levels of organic N should not be seen as a breach of the WQOs, provided this is due to natural causes.

f) Oxidised N = NO_2 + NO_3.

g) DIN = ammonia N + oxidised N.

h) Dissolved Oxygen (DO) objectives apply to daytime conditions. Lower values will occur at night in most waters. In estuaries, reductions should only be in the region of 10–15 per cent saturation below daytime values. In freshwaters, night-time reductions are more variable. Following significant rainfall events, reduced DO values may occur due to the influx of organic material. In estuaries post-event values as low as 40 per cent saturation may occur naturally for short periods but values well below this would indicate some anthropogenic effect. In freshwaters, post-event DO reductions are again more variable. In general, DO values consistently less than 50 per cent are likely to impact on the ongoing ability of fish to persist in a water body while short term DO values less than 30 per cent saturation are toxic to some fish species. Very high DO (supersaturation) values can be toxic to some fish as they cause gas bubble disease. DO values for fresh waters should only be applied to flowing waters. Stagnant pools in intermittent streams naturally experience values of DO below 50 per cent saturation.

i) Wallum/tannin-stained waters contain naturally high levels of humic acids (and have a characteristic brown tea-tree stain). In these types of waters, natural pH values may range from 3.6 to 6. During flood events or nil flow periods, pH values should not fall below 5.5 (except in wallum/tannin waters) or exceed 9.

j) Conductivity, under natural conditions, is highly dependent on local geology and soil types. Refer to note q for conductivity sources in this

table. In the absence of sub-regional conductivity WQOs, the QWQG (Appendix G) provides information on conductivity values in a set of 18 defined salinity zones throughout Queensland. For each zone, the QWQG provide a range of percentile values based on data from all the sites within that zone. This provides a useful first estimate of background conductivity within a zone. However, even within zones there is a degree of variation between streams and therefore the values for the zone would still need to be ground truthed against local values.

k) Temperature varies both daily and seasonally, it is depth dependent and is also highly site specific. It is therefore not possible to provide simple generic WQOs for this indicator. The recommended approach is that local WQOs be developed. Thus, WQOs for potentially impacted streams should be based on measurements from nearby streams that have similar morphology and which are thought not to be impacted by anthropogenic thermal influences. From an ecological effects perspective, the most important aspects of temperature are the daily maximum temperature and the daily variation in temperature. Therefore measurements of temperature should be designed to collect information on these indicators of temperature and, similarly, local WQOs should be expressed in terms of these indicators. Clearly, there will be an annual cycle in the values of these indicators and therefore a full seasonal cycle of measurements is required to develop guideline values.

l) The values for all indicators are based on monitoring data and analysis by the department, including data from Cleveland Bay.

m) The values for these indicators are based on GBRMPA (2010) Water Quality Guidelines for the Great Barrier Reef Marine Park 2010 (refer 'sources' below). For open coastal waters, where single value WQOs are given for Particulate N, Particulate P, chlorophyll a, Secchi and suspended solids, these should be compared to annual mean (rather than median) values. WQOs for coastal water pesticides in this table are based on GBRMPA species protection levels. For Hexazinone and MEMC there is insufficient data to determine species protection levels. Note that coastal water values for Diazinon, Hexazinone, MEMC, Simazine, and Tebuthiuron, are based on low reliability guidelines that may be updated with additional information. Refer to GBRMPA Water Quality Guidelines for further details. Also refer to note 'a' re toxicants.

n) The GBR plume discharge area is derived from combining the high and very high frequency influence areas of river discharges that contain high and very high pollutant loads including sediment and nutrient. Refer to Devlin *et al* in ‘sources’ below for more details.

o) The values for these indicators are based on monitoring data and analysis by GBRMPA. For open coastal waters, where single value WQOs are given for Particulate N, Particulate P, chlorophyll a, Secchi and suspended solids, these should be compared to annual mean (rather than median) values. Refer to GBRMPA Water Quality Guidelines for further details.

p) Suspended solids (and hence turbidity and Secchi depth) levels in coastal waters are naturally highly variable depending on wind speed/wave height and in some cases on tidal cycles. The values in this table provide guidance on what the long term values of turbidity, Secchi depth or TSS should comply with. However, these values will often be naturally exceeded in the short term during windy weather or spring tides. They therefore should not be used for comparison with short term data sets. Where assessable coastal developments are proposed, proponents should carry out site specific intensive monitoring of these indicators (or equivalent light penetration indicators) and use these as a baseline for deriving local guidelines and for comparison with post development conditions.

q) WQOs for these indicators are based on data collected as part of the Queensland Government Surface Water Ambient Network (SWAN) monitoring program, and stored on the 'Hydstra' database. For electrical conductivity, the 75th percentile value is used instead of the 80th percentile, based on QWQG (2009).

r) The values for TSS in the Townsville Port sub-zone are based on 2004–2012 data provided by Ports Corporation and are set to reflect current water quality condition (shown as 20th, 50th and 80th percentiles within the port sub-zone, as defined on the accompanying plan).

s) Data from DSITIA water quality monitoring in Shoalwater Bay (military) Training Area freshwater creeks, 2008–2013. The ammonia value of <20 µg/L corresponds to DO of >80% saturation. For waters where DO is 40–80% ammonia values of <30 µg/L would be expected.

t) Values are based on DSITIA analysis of council receiving environment monitoring program data, 2010–2011 (Bohle River, Black River).

Table 2b Water quality objectives to protect Magnetic Island aquatic ecosystem environmental value under baseflow conditions

Water area/type(refer plans WQ1182, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
SURFACE FRESH WATERS (refer plan WQ1182)		
HEV2226 fresh waters	Aquatic ecosystem—high ecological value (HEV)	Maintain existing water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas • sodium (Na): 5–7–11 mg/L[q] • calcium (Ca): 2–3–5 mg/L[q] • magnesium (Mg): 1–2–4 mg/L[q] • bicarbonate (HCO_3): 14–25–40 mg/L[q] • chloride (Cl): 6–9–14 mg/l[q] • sulfate (SO_4): 1–1–2 mg/L[q] • electrical conductivity (EC): 47–72–98µS/cm (20th, 50th and 75th percentiles)[j, q] • hardness: 8–17–29 mg/L[q] • alkalinity: 11–20–33 mg/L[q] • silica (SiO_2): 10.1–14.1–21.1mg/L[q] • fluoride (F): 0.010–0.060–0.110 mg/L[q] • sodium adsorption ratio (SAR): 0.60–0.70–0.95[q] • toxicants: refer to HEV waters toxicants row later in this table Note: For other indicators, there is insufficient information available to establish current water quality for these waters. Refer to QWQG for details on how to establish a minimum water quality data set for deriving local 20th, 50th and 80th percentiles.
SD2221 fresh waters **(wetland)**	Aquatic ecosystem—high ecological value (HEV)	SD: Achieve effectively unmodified water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas Note: There is insufficient information available to establish WQOs for these waters. Refer to QWQG for details on how to establish a minimum water quality data set for deriving local 20th, 50th and 80th percentiles.
Toxicants for all HEV and SD fresh waters	Aquatic ecosystem—high ecological value (HEV)	WQOs for pesticides identified in the Black Ross Water Quality Improvement Plan (WQIP), to protect freshwater species at the HEV level of protection[a]: • Ametryn: nd[b] • Atrazine: <0.7 µg/L (micrograms/Litre) • Chlorpyrifos: <0.00004 µg/L • Diazinon: <0.00003 µg/L • Diuron: nd[b] • Endosulfan: <0.03 µg/L • Hexazinone: nd[b] • Malathion: <0.002 µg/L • MEMC: nd[b] • Simazine: <0.2 µg/L • Tebuthiuron: <0.02 µg/L • Tributyltin: nd[b] • 2,4-D: <140 µg/L WQOs for heavy metals identified in the Black Ross WQIP, to protect freshwater species at the HEV level of protection[a]: • Cadmium: <0.06 µg/L • Chromium: <0.01 µg/L • Copper: <1.0 µg/L

Water area/type(refer plans WQ1182, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
		• Lead: <1.0 µg/L • Nickel: <8 µg/L • Zinc: <2.4 µg/L All other toxicants in water and sediment as per AWQG, to protect freshwater species at the HEV level of protection: • Toxicants in water[a]: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8) • Toxicants in sediments: refer to AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8) Comply with Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance, ANZECC.
Lowland fresh waters	Aquatic ecosystem—moderately disturbed (MD)	• ammonia N: <20 µg/L[c, d, e] • oxidised N: <60 µg/L[c, d, e, f] • dissolved inorganic N (DIN): <80 µg/L[d, e, g] • organic N: <420 µg/L[c, d, e] • total N: <500 µg/L[c, d, e] • filterable reactive phosphorus (FRP): <20 µg/L[c, d] • total P: <50 µg/L[c, d] • chlorophyll a: <5 µg/L[c] • dissolved oxygen: 85%–110% saturation[c, h] • turbidity: <50 NTU[c] • suspended solids: <10 mg/L[c] • pH: 6.5–8.0[c, i] • temperature: nd[b, k] • macroinvertebrates: nd[b] • fish: nd[b] • sodium (Na): <11 mg/L[q] • calcium (Ca): <5 mg/L[q] • magnesium (Mg): <4 mg/L[q] • bicarbonate (HCO_3): <40 mg/L[q] • chloride (Cl): <14 mg/l[q] • sulfate (SO_4): <2 mg/L[q] • electrical conductivity (EC): <98µS/cm (75th percentile)[j, q] • hardness: <29 mg/L[q] • alkalinity: <33 mg/L[q] • silica (SiO_2): <21.1mg/L[q] • fluoride (F): <0.110 mg/L[q] • sodium adsorption ratio (SAR): 0.60–0.95[q] • toxicants: refer to toxicants row later in this table
Freshwater lakes/reservoirs	Aquatic ecosystem—moderately disturbed (MD)	• ammonia N: <10 µg/L[c, d, e] • oxidised N: <10 µg/L[c, d, e, f] • dissolved inorganic N (DIN): <20 µg/L[d, e, g] • organic N: <330 µg/L[c, d, e] • total N: <350 µg/L[c, d, e] • filterable reactive phosphorus (FRP): <5 µg/L[c, d] • total P: <10 µg/L[c, d] • chlorophyll a: <5 µg/L[c]

Water area/type(refer plans WQ1182, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
		• dissolved oxygen: 90%–110% saturation[c, h] • turbidity: 1–20 NTU[c] • Secchi depth: nd[b, c] • suspended solids: nd[b, c] • pH: 6.5–8.0[c, i] • temperature: nd[b, k] • toxicants: refer to toxicants row below
Toxicants for ALL moderately disturbed fresh waters within this table	Aquatic ecosystem—moderately disturbed (MD)	WQOs for pesticides identified in the Black Ross WQIP, to protect freshwater species at the MD level of protection (identified in the AWQG as slightly to moderately disturbed)[a]: • Ametryn: nd[b] • Atrazine: <13 µg/L • Chlorpyrifos: <0.01 µg/L • Diazinon: <0.01 µg/L • Diuron: nd[b] • Endosulfan: <0.03 µg/L • Hexazinone: nd[b] • Malathion: <0.05 µg/L • MEMC: nd[b] • Simazine: <3.2 µg/L • Tebuthiuron: <2.2 µg/L • Tributyltin: nd[b] • 2,4-D: <280 µg/L WQOs for heavy metals identified in the Black Ross WQIP, to protect freshwater species at the MD level of protection (identified in the AWQG as slightly to moderately disturbed)[a]: • Cadmium: <0.2 µg/L • Chromium: <1.0 µg/L • Copper: <1.4 µg/L • Lead: <3.4 µg/L • Nickel: <11 µg/L • Zinc: <8.0 µg/L WQOs for heavy metals in sediments identified in the Black Ross WQIP, to protect freshwater species at the MD level of protection (identified in the AWQG as slightly to moderately disturbed)[a]: • Cadmium: <1.5 mg/kg • Chromium: <80 mg/kg • Copper: <65 mg/kg • Lead: <50 mg/kg • Nickel: <21 mg/kg • Zinc: <200 mg/kg All other toxicants in water and sediment as per AWQG, to protect freshwater species at the MD level of protection: • Toxicants in water[a]: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8) • Toxicants in sediments: refer to AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8) Comply with Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance, ANZECC.

Water area/type(refer plans WQ1182, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
Freshwater riparian areas	Aquatic ecosystem—moderately disturbed (MD)	Protect or restore riparian areas. Refer section 3.1.2—riparian WQOs.
Wetlands	Aquatic ecosystem—moderately disturbed (MD)	Objectives as per AWQG and section 3.1.2. Note: for high impact earthworks within Great Barrier Reef wetland protection areas, refer to the guideline 'Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments', and the Queensland wetland buffer planning guideline, available from the department's website.
GROUNDWATERS		
Groundwaters	Aquatic ecosystem—high ecological value (HEV)	Where groundwaters interact with surface waters, groundwater quality should not compromise identified EVs and WQOs for those waters. Note: the AWQG recommends that the highest level of protection should be provided to underground aquatic ecosystems, given their high conservation value. Where groundwaters are in good condition the intent is to maintain existing water quality (20th, 50th and 80th percentiles). There is insufficient information available to establish WQOs for this water type. Refer to QWQG for details on how to establish a minimum water quality data set for deriving local 20th, 50th and 80th percentiles.
ESTUARINE AND COASTAL WATERS - listed estuarine, marina/harbour, open coastal (refer plans WQ1182 and WQ1183) The following WQOs apply to estuarine and coastal waters within and adjacent to Magnetic Island, as shown in plans WQ1182 and WQ1183. Other coastal waters off Ross River Basin (e.g. Cleveland Bay) are included in Table 2a. (All coastal waters covered in this table are landward of the plume line identified by GBRMPA[o]. Refer to the Black River Basin document for Halifax Bay coastal waters and offshore waters seaward of the plume line.)		
Estuarine and coastal waters	Aquatic ecosystem—all	Release of sewage from vessels to be controlled in accordance with requirements of the *Transport Operations (Marine Pollution) Act 1995* and Regulations. (Refer to Maritime Services Queensland website for further information.)
HEV2226 estuarine waters	Aquatic ecosystem—high ecological value (HEV)	Maintain existing water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas. Note: there is insufficient information available to establish current water quality for these waters. Refer to QWQG for details on how to establish a minimum water quality data set for deriving local 20th, 50th and 80th percentiles. • toxicants: refer to toxicants row later in this table
Mid estuary waters	Aquatic ecosystem—moderately disturbed (MD)	Note: For waters shown on the plan as being mid estuary (orange colour) and occurring within inter-tidal zone adjacent to the enclosed coastal/lower estuary water type, these waters may have water quality characteristics more in common with the adjacent enclosed coastal/lower estuary water type. Under such circumstances, reference should be made to the WQOs for enclosed coastal/lower estuary water type. • ammonia N: <10 µg/L[c, d, e] • oxidised N: <10 µg/L[c, d, e, f] • dissolved inorganic N (DIN): <20 µg/L[d, e, g] • organic N: <260 µg/L[c, d, e] • total N: <300 µg/L[c, d, e] • filterable reactive phosphorus (FRP): <8 µg/L[c, d] • total P: <25 µg/L[c, d] • chlorophyll a: <4 µg/L[c] • dissolved oxygen: 85%–100% saturation[c, h] • turbidity: <8 NTU[c] • Secchi depth: >1.0 m[c]

Water area/type(refer plans WQ1182, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
		• suspended solids: <20 mg/L[c] • pH: 7.0–8.4[c, i] • temperature: nd[b, k] • toxicants: refer to toxicants row below
Toxicants for ALL estuarine waters within this table	Aquatic ecosystem—all	Toxicants in water and sediment as per AWQG: • Toxicants in water[a]: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1) and AWQG volume 2 (section 8) • Toxicants in sediments: refer to AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1) and AWQG volume 2 (section 8) Comply with Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance, ANZECC.
Estuarine riparian areas	Aquatic ecosystem—moderately disturbed (MD)	Protect or restore riparian areas. Refer section 3.1.2—riparian WQOs.
Nelly Bay Harbour/Marina and channel	Aquatic ecosystem—moderately disturbed (MD)	• ammonia N: <8 µg/L[l] • oxidised N: <1 µg/L[l] • particulate N: <21 µg/L[l] • total dissolved N: <94 µg/L[l] • total N: <130 µg/L[l] • filterable reactive phosphorus (FRP): <3 µg/L[l] • particulate P: ≤ 2.8 µg/L[l] • total dissolved P: <10 µg/L[l] • total P: <20 µg/L[l] • chlorophyll a: <0.84 µg/L[l] • dissolved oxygen: 95–105% saturation[c] • turbidity: <2.7 NTU[l, p] • Secchi depth (annual mean): ≥ 3 m[l, p] • suspended solids: <3.7 mg/L[l, p] • pH: 8.1–8.4[c] • temperature: <1°C increase above long-term average maximum[n] • toxicants: refer to toxicants rows later in this table
SD2243 open coastal waters, on the northern side of Magnetic Island, shown in WQ1183	Aquatic ecosystem—high ecological value (HEV)	Achieve effectively unmodified water quality (20th, 50th and 80th percentiles), habitat, biota, and flow. The 20th, 50th and 80th percentiles to be achieved are: • ammonia N: 0–3–8 µg/L[l] • oxidised N: 0–0–1 µg/L[l] • particulate N: 10–12–16 µg/L[l] • total dissolved N: 56–72–94 µg/L[l] • total N: 75–105–130 µg/L[l] • filterable reactive phosphorus (FRP): 0–1–3 µg/L[l] • particulate P: 1.8–2.2–3.0 µg/L[l] • total dissolved P: 3–6–10 µg/L[l] • total P: 5–10–20 µg/L[l] • chlorophyll a: 0.27–0.35 –0.63 µg/L[l] • dissolved oxygen: 95–100–105% saturation[c] • turbidity: 0.6–0.8–1.3 NTU[l, p] • Secchi depth (annual mean): ≥10 m[c, n, p]

Water area/type(refer plans WQ1182, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
		• suspended solids: 0.6–1.2–2.3 mg/L[l, p] • pH: 8.1–8.3–8.4[c] • temperature: <1°C increase above long-term average maximum[n] • toxicants: refer to toxicants rows later in this table
SD2244 open and enclosed coastal waters on the Cleveland Bay and West Channel sides of Magnetic Island shown in WQ1183	Aquatic ecosystem—high ecological value (HEV)	Achieve effectively unmodified water quality (20th, 50th and 80th percentiles of HEV waters), habitat, biota, and flow. The 20th, 50th and 80th percentiles to be achieved are: • ammonia N: 0–3–8 µg/L[l] • oxidised N: 0–0–1 µg/L[l] • particulate N: 14–17–21 µg/L[l] • total dissolved N: 56–72–94 µg/L[l] • total N: 75–105–130 µg/L[l] • filterable reactive phosphorus (FRP): 0–1–3 µg/L[l] • particulate P (annual mean): ≤2.8 µg/L[c, n] • total dissolved P: 3–6–10 µg/L[l] • total P: 5–10–20 µg/L[l] • chlorophyll a: 0.35–0.59 –0.84 µg/L[l] • dissolved oxygen: 95–100–105%[c] • turbidity: 0.8–1.3–2.7 NTU[l, p] • Secchi depth: 3–4–6 m[l, p] • suspended solids: 1.2–1.9–3.7 mg/L[l, p] • pH: 8.1–8.3–8.4[c] • temperature: <1°C increase above long-term average maximum[n] • toxicants: refer to toxicants rows later in this table
Other coastal waters in Cleveland Bay: refer to Table 2a of this document **Other coastal waters in Halifax Bay**: refer to Table 2a of this document, and Black River Basin document		

Water area/type(refer plans WQ1182, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
COASTAL WATERS – TOXICANTS		
Toxicants for ALL Magnetic Island enclosed and open coastal waters in SD2243 and SD 2244, (**excluding waters in Nelly Bay Harbour/marina, approved spoil grounds, marinas, boat harbours, tidal canals, constructed estuaries** - **refer to following row)** **(Note: refer to Table 2a for Cleveland Bay)**	Aquatic ecosystem—high ecological value (HEV)	WQOs for pesticides identified in the Black Ross WQIP, to protect marine species at the HEV level of protection[n]: • Ametryn: <0.5 µg/L • Atrazine: <0.6 µg/L • Chlorpyrifos: <0.0005 µg/L • Diazinon: <0.00003 µg/L • Diuron: <0.9 µg/L • Endosulfan: <0.005 µg/L • Hexazinone: <1.2 µg/L • Malathion: nd[b] • MEMC: <0.002 µg/L • Simazine: <0.2 µg/L • Tebuthiuron: <0.02 µg/L • Tributyltin: <0.0004 µg/L • 2,4-D: <0.8 µg/L WQOs for heavy metals identified in the Black Ross WQIP, to protect marine species at the HEV level of protection[a]: • Cadmium: <0.7 µg/L • Chromium: <0.14 µg/L • Copper: <0.3 µg/L • Lead: <2.2 µg/L • Nickel: <7 µg/L • Zinc: <7 µg/L WQOs for all other toxicants in these waters as per GBRMPA and AWQG water quality guidelines, to protect marine species at the HEV level of protection. For toxicants not listed in GBRMPA guidelines: • Toxicants in water[a]: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8) • Toxicants in sediments: refer to AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8) Comply with Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance, ANZECC.
Toxicants for approved spoil grounds, Nelly Bay Harbour/marina, other marinas, boat harbours, tidal canals, constructed estuaries	Aquatic ecosystem—moderately disturbed (MD) (pesticides: high ecological value (HEV))	WQOs for pesticides identified in the Black Ross WQIP, to protect marine species at the HEV level of protection[n]: • Ametryn: <0.5 µg/L • Atrazine: <0.6 µg/L • Chlorpyrifos: <0.0005 µg/L • Diazinon: <0.00003 µg/L • Diuron: <0.9 µg/L • Endosulfan: <0.005 µg/L • Hexazinone: <1.2 µg/L • Malathion: nd[b] • MEMC: <0.002 µg/L • Simazine: <0.2 µg/L • Tebuthiuron: <0.02 µg/L • Tributyltin: <0.006 µg/L (SMD/ 95% species protection)

Water area/type(refer plans WQ1182, WQ1183)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
		• 2,4-D: <0.8 µg/L WQOs for heavy metals as identified in the Black Ross WQIP, to protect marine species at the MD level of protection (identified in the AWQG as slightly to moderately disturbed)[a]: • Cadmium: <0.7 µg/L • Chromium: <4.4 µg/L • Copper: <1.3 µg/L • Lead: <4.4 µg/L • Nickel: <7 µg/L • Zinc: <15 µg/L WQOs for heavy metals in sediments as identified in the Black Ross WQIP, to protect marine species at the MD level of protection (identified in the AWQG as slightly to moderately disturbed)[a]: • Cadmium: <1.5 mg/kg • Chromium: <80 mg/kg • Copper: <65 mg/kg • Lead: <50 mg/kg • Nickel: <21 mg/kg • Zinc: <200 mg/kg WQOs for all other toxicants in these waters as per GBRMPA and AWQG water quality guidelines, to protect marine species at the MD level of protection (identified in the AWQG as slightly to moderately disturbed). For toxicants not listed in GBRMPA guidelines: • Toxicants in water[a]: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8) • Toxicants in sediments: refer to AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8) Comply with Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance, ANZECC.
WATER QUALITY REFERENCE SITES		
Fresh, estuarine, and coastal waters: water quality reference (undisturbed) sites	Aquatic ecosystem—high ecological value (HEV)	For sites identified in the Queensland Water Quality Guidelines, the water quality improvement plan, or by other recognised entities under the EPP Water as reference (undisturbed) sites for water quality monitoring, the management intent is to maintain or achieve effectively unmodified water quality (20th, 50th and 80th percentiles), habitat, biota, and flow.

Notes:

Units:

µg/L = micrograms/Litre; mg/L = milligrams/Litre; µS/cm = microSiemens/centimetre; mg/kg = milligrams/kilogram

a) The values for these indicators are based on the AWQG. Under the AWQG, a single set of values is provided for the 'slightly to moderately disturbed' (SMD) level of protection, which is identified in this document as 'moderately disturbed' (MD). The HEV and SMD levels of protection typically correspond to 99 per cent and 95 per cent species protection, respectively. For a small number of toxicants with potential toxicity and bioaccumulation effects, the AWQG identify SMD protection level values corresponding to 99% species protection. For further details on toxicant guidelines, e.g. toxicant species, and variability in relation to water quality characteristics (such as pH, hardness) refer to AWQG.

b) nd = insufficient or no data, n/a = not applicable for this indicator and water type, ng = no guideline. Will be updated if guidelines become available.

c) The values for these indicators are based on the QWQG Central Coast regional water quality guidelines.

d) Nutrient objectives do not apply during high flow events. See QWQG Section 5 and Appendix D for more information on applying guidelines under high flow conditions.

e) During periods of low flow and particularly in smaller creeks, build up of organic matter derived from natural sources (e.g. leaf litter) can result in increased organic N levels (generally in the range of 400 to 800µg/L). This may lead to total N values exceeding the WQOs.

Provided that levels of inorganic N (i.e. NH_3 + oxidised N) remain low, then the elevated levels of organic N should not be seen as a breach of the WQOs, provided this is due to natural causes.

f) Oxidised N = NO_2 + NO_3.

g) DIN = ammonia N + oxidised N.

h) Dissolved Oxygen (DO) objectives apply to daytime conditions. Lower values will occur at night in most waters. In estuaries, reductions should only be in the region of 10–15 per cent saturation below daytime values. In freshwaters, night-time reductions are more variable. Following significant rainfall events, reduced DO values may occur due to the influx of organic material. In estuaries post-event values as low as 40 per cent saturation may occur naturally for short periods but values well below this would indicate some anthropogenic effect. In freshwaters, post-event DO reductions are again more variable. In general, DO values consistently less than 50 per cent are likely to impact on the ongoing ability of fish to persist in a water body while short term DO values less than 30 per cent saturation are toxic to some fish species. Very high DO (supersaturation) values can be toxic to some fish as they cause gas bubble disease. DO values for fresh waters should only be applied to flowing waters. Stagnant pools in intermittent streams naturally experience values of DO below 50 per cent saturation.

i) Wallum/tannin-stained waters contain naturally high levels of humic acids (and have a characteristic brown tea-tree stain). In these types of waters, natural pH values may range from 3.6 to 6. During flood events or nil flow periods, pH values should not fall below 5.5 (except in wallum/tannin waters) or exceed 9.

j) Conductivity, under natural conditions, is highly dependent on local geology and soil types. Refer to note q for conductivity sources in this table. In the absence of sub-regional conductivity WQOs, the QWQG (Appendix G) provides information on conductivity values in a set of 18 defined salinity zones throughout Queensland. For each zone, the QWQG provide a range of percentile values based on data from all the sites within that zone. This provides a useful first estimate of background conductivity within a zone. However, even within zones here is a degree of variation between streams and therefore the values for the zone would still need to be ground truthed against local values.

k) Temperature varies both daily and seasonally, it is depth dependent and is also highly site specific. It is therefore not possible to provide simple generic WQOs for this indicator. The recommended approach is that local WQOs be developed. Thus, WQOs for potentially impacted streams should be based on measurements from nearby streams that have similar morphology and which are thought not to be impacted by anthropogenic thermal influences. From an ecological effects perspective, the most important aspects of temperature are the daily maximum temperature and the daily variation in temperature. Therefore measurements of temperature should be designed to collect information on these indicators of temperature and, similarly, local WQOs should be expressed in terms of these indicators. Clearly, there will be an annual cycle in the values of these indicators and therefore a full seasonal cycle of measurements is required to develop guideline values.

l) The values for these indicators are based on monitoring data and analysis by GBRMPA. For open coastal waters, where single value WQOs are given for Particulate N, Particulate P, chlorophyll a, Secchi and suspended solids, these should be compared to annual mean (rather than median) values. Refer to GBRMPA Water Quality Guidelines for further details.

m) The values for these indicators are based on monitoring data and analysis by the department.

n) The values for these indicators are based on GBRMPA (2010) Water Quality Guidelines for the Great Barrier Reef Marine Park 2010 (refer 'sources' below). For open coastal waters, where single value WQOs are given for Particulate N, Particulate P, chlorophyll a, Secchi and suspended solids, these should be compared to annual mean (rather than median) values. WQOs for coastal water pesticides in this table are based on GBRMPA species protection levels. For Hexazinone and MEMC there is insufficient data to determine species protection levels. Note that coastal water values for Diazinon, Hexazinone, MEMC, Simazine, and Tebuthiuron, are based on low reliability guidelines that may be updated with additional information. Refer to GBRMPA Water Quality Guidelines for further details. Also refer to note 'a' re toxicants.

o) The GBR plume discharge area is derived from combining the high and very high frequency influence areas of river discharges that contain high and very high pollutant loads including sediment and nutrient. Refer to Devlin *et al* in 'sources' below for more details.

p) Suspended solids (and hence turbidity and Secchi depth) levels in coastal waters are naturally highly variable depending on wind speed/wave height and in some cases on tidal cycles. The values in this table provide guidance on what the long term values of turbidity, Secchi depth or TSS should comply with. However, these values will often be naturally exceeded in the short term during windy weather or spring tides. They therefore should not be used for comparison with short term data sets. Where assessable coastal developments are proposed, proponents should carry out site specific intensive monitoring of these indicators (or equivalent light penetration indicators) and use these as a baseline for deriving local guidelines and for comparison with post development conditions.

q) WQOs for these indicators are based on data collected as part of the Queensland Government Surface Water Ambient Network (SWAN) monitoring program, and stored on the 'Hydstra' database. For electrical conductivity, the 75th percentile value is used instead of the 80th percentile, based on QWQG (2009).

Sources:

The WQOs were determined from a combination of documents (and supporting data), including:

ANZECC (1997) Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance.

ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (AWQG).

Connell Wagner (2008) Water quality condition of the Black and Ross River Basins, Townsville City Council - Creek to Coral, Townsville.

De'ath G, Fabricius KE (2008) Water quality of the Great Barrier Reef: distributions, effects on reef biota and trigger values for the protection of ecosystem health. Final Report to the Great Barrier Reef Marine Park Authority. Australian Institute of Marine Science, Townsville. (104 pp.).

Devlin, M, Harkness, P, McKinna, L & Waterhouse, J (2011) *Mapping the surface exposure of terrestrial pollutants in the Great Barrier Reef*. Report to the Great Barrier Reef Marine Park Authority, August 2010. Australian Centre for Tropical Freshwater Research. Report Number 10/12.

Great Barrier Reef Marine Park Authority (2010) Water quality guidelines for the Great Barrier Reef Marine Park 2010, Great Barrier Reef Marine Park Authority, Townsville, available on the Great Barrier Reef Marine Park Authority's website.

Gunn, J & Manning, C (2009) Basins, catchments and receiving waters of the Black Ross Water Quality Improvement Plan area, Townsville City

Council - Creek to Coral, Townsville.

Gunn, J & Manning, C (2010) Black Ross (Townsville) Water Quality Improvement Plan: Improving water quality from creek to coral, Townsville City Council - Creek to Coral, Townsville.

Gunn, J, Manning, C & McHarg, A (2009) Environmental values, water quality objectives and targets for the Black Ross Water Quality Improvement Plan, Townsville City Council - Creek to Coral, Townsville.

Queensland Government (2009, as amended) Queensland Water Quality Guidelines, version 3. (Refer to section 5 and Appendix D of the QWQG for more detail on compliance assessment protocols.)

Schaffelke B, Carleton J, Doyle J, Furnas M, Gunn K, Skuza M, Wright M, Zagorskis I (2011) Reef Rescue Marine Monitoring Program. Final Report of AIMS Activities 2010/11– Inshore Water Quality Monitoring. Report for the Great Barrier Reef Marine Park Authority. Australian Institute of Marine Science, Townsville. (83 p.). Additional years also published accessible for download from GBRMPA.

Townsville City Council (2009) Wastewater upgrade program - receiving environment monitoring program. prepared by AECOM, and supporting water quality data

Transport Operations (Marine Pollution) Act 1995 and Regulations 2008, available on the Office of Queensland Parliamentary Counsel website.

3.1.2 Riparian water quality objectives

For vegetation management relating to waterways, reference should be made to the relevant regional vegetation management codes under the *Vegetation Management Act 1999*. These codes include performance requirements relating to watercourses and wetlands, aimed at maintaining water quality, bank stability, aquatic and terrestrial habitat. Codes include vegetation clearing controls that vary according to stream order.

To review the latest applicable vegetation management code (and other explanatory information) for waters for this area, contact the Department of Natural Resources and Mines website.

Planning schemes under the *Sustainable Planning Act 2009* may also specify riparian buffers (for example under catchment protection or waterway codes). Contact the Department of State Development, Infrastructure and Planning website and local government websites for further information about planning schemes.

3.1.3 Stormwater management design objectives

Stormwater management design objectives for urban development are detailed in the department's Urban Stormwater Quality Planning Guidelines 2010 (as amended). Stormwater quality and flow management design objectives are specified for both the construction and operational phases of development in accordance with landscape features and the regional location of proposed development. The guidelines are available from the department's website.

3.2 Water quality objectives for human use environmental values

This section outlines WQOs to protect human use EVs, which comprise those EVs other than the aquatic ecosystem EV (e.g. recreation, stock watering, aquaculture and crop irrigation). Table 1 of this document outlines the EVs that have been identified for different waters in the catchment. Where a human use EV has been identified, the following tables can be used to identify the WQOs to support that EV. Where Table 1 indicates more than one EV applies to a given water (for example aquatic ecosystem and recreational use), the adoption of the most stringent WQO for each water quality indicator will then protect all identified EVs.

WQOs in this section are, unless otherwise specified, based on relevant national water quality guidelines including AWQG and the ADWG[6]. Table 3 outlines human use EVs, applicable water types, and a selection of more commonly used WQOs to support those EVs. Tables 4 to 12 provide further WQOs to protect particular human use EVs (based on national guidelines or other more local studies). Where national guidelines or other codes remain the primary source for WQOs, reference to those national guidelines or codes is necessary to obtain comprehensive listings of all indicators and corresponding WQOs.

Table 3 Water quality objectives to protect human use environmental values

Environmental value	Water type/area (refer Table 1 and plans WQ1181, WQ1182, WQ1183)	Water quality objectives to protect EV (refer to specified codes and guidelines for full details)
Suitability for drinking water supply	All fresh waters including groundwaters	Local WQOs for drinking water supply are provided in Table 4. Note: For water quality after treatment or at point of use refer to legislation and guidelines, including: • *Public Health Act 2005* and Regulations • *Water Supply (Safety and Reliability) Act 2008*, including any approved drinking water quality management plan under the Act • *Water Fluoridation Act 2008* • ADWG 2011.
Protection of the human consumer for oystering	Estuarine and coastal waters	Objectives as per AWQG and Australia New Zealand Food Standards Code[7], Food Standards Australia New Zealand, 2007 and updates.
Protection of the human consumer	Fresh waters, estuarine and coastal waters	Objectives as per AWQG and Australia New Zealand Food Standards Code, Food Standards Australia New Zealand, 2007 and updates.
Protection of cultural and spiritual values	Fresh waters (including groundwaters), estuarine and coastal waters	Protect or restore indigenous and non-indigenous cultural heritage consistent with relevant policies and plans.
Suitability for industrial use	Fresh waters, estuarine and coastal waters	No WQOs are provided in this scheduling document for industrial uses. Water quality requirements for industry vary within and between industries. The AWQG (2000) do not provide guidelines to protect industries, and indicate that industrial water quality requirements need to be considered on a case-by-case basis. This EV is usually protected by other values, such as the aquatic ecosystem EV.

[6] The AWQG are available on the National Water Quality Management Strategy website.

The ADWG are available on the NHMRC website.

[7] The Australia New Zealand Food Standards Code is available on the Food Standards Australia and New Zealand website.

Environmental value	Water type/area (refer Table 1 and plans WQ1181, WQ1182, WQ1183)	Water quality objectives to protect EV (refer to specified codes and guidelines for full details)
Suitability for aquaculture	Fresh waters, estuarine and coastal waters	Objectives as per: • tables 5–7 • AWQG and Australia New Zealand Food Standards Code, Food Standards Australia New Zealand, 2007 and updates.
Suitability for irrigation	All fresh waters including groundwaters	ANZECC objectives for pathogens and metals are provided in tables 8 and 9. For other indicators, such as salinity, sodicity and herbicides, see AWQG.
Suitability for stock watering	All fresh waters including groundwaters	Objectives as per AWQG, including median faecal coliforms <100 organisms per 100 mL. WQOs for total dissolved solids and metals are provided in tables 10 and 11, based on AWQG. For other objectives, such as cyanobacteria and pathogens, see AWQG.
Suitability for farm supply/use	All fresh waters including groundwaters	Objectives as per AWQG.
Suitability for primary contact recreation	Fresh waters, estuarine and coastal waters	Objectives as per NHMRC (2008)[8], including: • water free of physical (floating and submerged) hazards • temperature range: 16–34°C • pH range: 6.5–8.5 • DO: >80% • faecal contamination: designated recreational waters are protected against direct contamination with fresh faecal material, particularly of human or domesticated animal origin. Two principal components are required for assessing faecal contamination: − assessment of evidence for the likely influence of faecal material − counts of suitable faecal indicator bacteria (usually enterococci) These two components are combined to produce an overall microbial classification of the recreational water body. • intestinal enterococci: 95th percentile ≤ 40 organisms per 100 mL (for healthy adults) (NHMRC, 2008; Table 5.7) • direct contact with venomous or dangerous aquatic organisms should be avoided. Recreational water bodies should be reasonably free of, or protected from, venomous organisms (e.g. box jellyfish and bluebottles) • waters contaminated with chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreational purposes.
Suitability for primary contact recreation	Fresh waters	• cyanobacteria/algae: Recreational water bodies should not contain: − Level 1 [1]: ≥ 10 µg/L total microcystins; or ≥ 50 000 cells/mL toxic *Microcystis aeruginosa*; or biovolume equivalent of ≥ 4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume or − Level 2 [1]: ≥ 10 mm^3/L for total biovolume of all cyanobacterial material where known toxins are not present or − cyanobacterial scums consistently present. Further details are contained in NHMRC (2008) and Table 12.
	Estuarine, coastal waters	• cyanobacteria/algae: Recreational water bodies should not contain ≥ 10 cells/mL *Karenia brevis* and/or have *Lyngbya majuscula* and/or *Pfiesteria* present in high numbers[2]. Further details are contained in NHMRC (2008) and Table 12.

[8] Guidelines for Managing Risks in Recreational Water are available on the NHMRC website.

Environmental value	Water type/area (refer Table 1 and plans WQ1181, WQ1182, WQ1183)	Water quality objectives to protect EV (refer to specified codes and guidelines for full details)
Suitability for secondary contact recreation	Fresh waters, estuarine and coastal waters	Objectives as per NHMRC (2008), including: • intestinal enterococci: 95th percentile ≤ 40 organisms per 100 mL (for healthy adults) (NHMRC, 2008; Table 5.7) • cyanobacteria/algae—refer objectives for primary recreation, NHMRC (2008) and Table 12
Suitability for visual recreation	Fresh waters, estuarine and coastal waters	Objectives as per NHMRC (2008), including: • recreational water bodies should be aesthetically acceptable to recreational users. The water should be free from visible materials that may settle to form objectionable deposits; floating debris, oil, scum and other matter; substances producing objectionable colour, odour, taste or turbidity; and substances and conditions that produce undesirable aquatic life. • cyanobacteria/algae—refer objectives for primary recreation, NHMRC (2008) and Table 12.

Notes:

1. Level 1 recognises the probability of adverse health effects from ingestion of known toxins, in this case based on the toxicity of microcystins. Level 2 covers circumstances in which there are very high cell densities of cyanobacterial material, irrespective of the presence of toxicity or known toxins. Increased cyanobacterial densities increase the likelihood of non-specific adverse health outcomes, principally respiratory, irritation and allergy symptoms. (NHMRC, 2008; 8).
2. The NHMRC states that its guidelines are concerned '*only with risks that may be associated with recreational activities in or near coastal and estuarine waters.This includes exposure through dermal contact, inhalation of sea-spray aerosols and possible ingestion of water or algal scums, but does not include dietary exposure to marine algal toxins*.' (NHMRC, 2008; 121).

Sources:

The WQOs were determined from a combination of documents, including:

- Australian Drinking Water Guidelines (NHMRC, 2011)
- Australia New Zealand Food Standards Code (Australian Government: Food Standards Australia New Zealand)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000)
- Guidelines for Managing Risks in Recreational Water (NHMRC, 2008).

Table 4 Drinking water EV: Priority water quality objectives for drinking water supply in the vicinity of off-takes, including groundwater, before treatment

This table outlines WQOs for water **before treatment**, unless otherwise stated. For water quality after treatment or at the point of use, refer to relevant legislation and guidelines, including *Public Health Act 2005* and Regulations, *Water Supply (Safety and Reliability) Act 2008*, including any approved drinking water quality management plan under the Act, *Water Fluoridation Act 2008*, and the Australian Drinking Water Guidelines (ADWG, 2011). Objectives are derived following advice from Townsville Water, Queensland Water Supply Regulator and Queensland Health.

Indicator	Water quality objective[1]
Giardia	0 cysts (Queensland Water Supply Regulator) If *Giardia* is detected in drinking water then the health authorities should be notified immediately and an investigation of the likely source of contamination undertaken (ADWG).
Cryptosporidium	0 cysts (Queensland Water Supply Regulator) If *Cryptosporidium* is detected in drinking water then the health authorities should be notified immediately and an investigation of the likely source of contamination undertaken (ADWG).
E. coli	<50 cfu/100mL Well designed treatment plants with effective barriers and disinfection are designed to address faecal contamination. *E. coli* or thermotolerant coliforms should not be present in any 100 mL sample of (treated) drinking water (ADWG).
Blue-green algae (cyanobacteria)	<100 cells/mL
Algal toxin	<1 µg/L Microcystin
Turbidity	<15 NTU
Colour	<25 Hazen Units
pH	6.5–8.5
Total hardness	<40 mg/L as $CaCO_3$
Conductivity	<200 µS/cm
Total dissolved solids	<90 mg/L
Sodium	Raw water supply: <10 mg/L General[2]: The concentration of sodium in reticulated drinking water supplies should not exceed 180 mg/L (ADWG, based on threshold at which taste becomes appreciable). At-risk groups (medical)[2]: The concentration of sodium in water supplies for at-risk groups should not exceed 20 mg/L (ADWG). Sudden changes in sodium levels in raw water supplies should be advised to Queensland Health, as these can affect medical equipment.
Sulfate	Raw water supply: <5 mg/L The concentration of sulfate in drinking water should not exceed 250 mg/L (ADWG 2011, based on taste/aesthetic considerations). ADWG 2011 health guideline: <500 mg/L
Dissolved oxygen	7–9.5 mg/L
Pesticides	Raw supplies: Below detectable limits. Treated drinking water: Refer to ADWG.
Other indicators (including physico-chemical indicators)	Refer to ADWG.

Notes:

1. All values are based on advice/historical data provided by Townsville Water, except where otherwise indicated.
2. Sudden changes in sodium levels impact on medical equipment use, operation and calibration. Queensland Health should be advised of any such changes. The ADWG notes that 50 mg/L is a '*typical value*' in reticulated supplies. The ADWG value for sodium is 180 mg/L (based on level at which taste become appreciable) however 'sodium *salts cannot be easily removed from drinking water*' and '*water authorities are strongly encouraged to keep sodium concentrations as low as possible*'. It further notes that '*medical practitioners treating*

people with severe hypertension or congestive heart failure should be aware if the sodium concentration in the patient's drinking water exceeds 20 mg/L' (ADWG; sodium factsheet). The US EPA (2012 Drinking Water Standards and Health Advisories) health based value for sodium is 20 mg/L (for individuals on a 500 mg/day restricted sodium diet).

Sources: Townsville Water, Qld Health, Queensland Water Supply Regulator, Australian Drinking Water Guidelines (NHMRC, 2011)

Table 5 Aquaculture EV: Water quality objectives for tropical aquaculture

Water parameter	Recommended range		Water parameter	Recommended range
	Fresh water	Marine		General aquatic
Dissolved oxygen	>4 mg/L	>4 mg/L	**Arsenic**	<0.05 mg/L
Temperature ˚C	21–32	24–33	**Cadmium**	<0.003 mg/L
pH	6.8–9.5	7–9.0	**Calcium/Magnesium**	10–160 mg/L
Ammonia (TAN, total ammonia-nitrogen)	<1.0 mg/L	<1.0 mg/L	**Chromium**	<0.1 mg/L
Ammonia (NH_3, un-ionised form)	<0.1 mg/L	<0.1 mg/L	**Copper**	<0.006 mg/L in soft water
Nitrate (NO_3)	1–100 mg/L	1–100 mg/L	**Cyanide**	<0.005 mg/L
Nitrite (NO_2)	<0.1 mg/L	<1.0 mg/L	**Iron**	<0.5 mg/L
Salinity	0–5 ppt	15–35 ppt	**Lead**	<0.03 mg/L
Hardness	20–450 mg/L		**Manganese**	<0.01 mg/L
Alkalinity	20–400 mg/L	>100mg/L	**Mercury**	<0.00005 mg/L
Turbidity	<80 NTU		**Nickel**	<0.01 mg/L in soft water <0.04 mg/L in hard water
Chlorine	<0.003 mg/L		**Tin**	<0.001 mg/L
Hydrogen sulphide	<0.002 mg/L		**Zinc**	0.03–0.06 mg/L in soft water 1–2 mg/L in hard water

Source: Department of Primary Industries and Fisheries: Water Quality in Aquaculture—DPI Notes April 2004.

Table 6 Aquaculture EV: Water quality objectives for optimal growth of particular species in fresh water

Water parameter	Barramundi	Eel	Silver perch	Jade perch	Sleepy cod	Redclaw
Dissolved oxygen	4–9 mg/L	>3 mg/L	>4 mg/L	>3 mg/L	>4.0 mg/L	>4.0 mg/L
Temperature ˚C	26–32	23–28	23–28	23–28	22–31	23–31
pH	7.5–8.5	7.0–8.5	6.5–9	6.5–9	7.0–8.5	7.0–8.5
Ammonia (TAN, Total ammonia-nitrogen)		<1.0 mg/L			<1.0 mg/L	<1.0 mg/L
Ammonia (NH_3, un-ionised form)*pH dependent.	<0.46 mg/L	<0.1 mg/L	<0.1 mg/L	<0.1 mg/L	<0.1 mg/L	<0.1 mg/L
Nitrate (NO_3)			<100 mg/L			
Nitrite (NO_2)	<1.5 mg/L	<1.0 mg/L	<0.1 mg/L		<1.0 mg/L	<1.0 mg/L
Salinity (extended periods)	0–35 ppt		<5 ppt	<5 ppt		<4 ppt
Salinity bath	0–35 ppt		5–10 ppt for 1 hour		max. 20 ppt for one hour	
Hardness ($CaCO_3$)			>50 mg/L	>50 mg/L	>40 mg/L	>40 mg/L
Alkalinity	>20 mg/L		100–400 ppm	100–400 ppm	>40 mg/L	>40 mg/L
Chlorine	<0.04 mg/L				<0.04 mg/L	
Hydrogen sulphide	0–0.3 mg/L				0–0.3 mg/L	
Iron	<0.1 mg/L		<0.5 mg/L	<0.5 mg/L	<0.1 mg/L	<0.1 mg/L
Spawning temperature ˚C	Marine		23–28	23–28	>24 for more than three days	

Source: Department of Primary Industries and Fisheries: Water Quality in Aquaculture—DPI Notes April 2004.

Table 7 Aquaculture EV: Water quality objectives for optimal growth of particular marine species

Water parameter	Barramundi		Tiger prawn		Kuruma prawn
	Hatchery	Grow out	Hatchery	Grow out	Grow out
Dissolved oxygen	Saturation	>4 mg/L	>4 mg/L	>3.5 mg/L	>4 mg/L
Temperature ˚C	28–30 optimum 25–31 range	28–30 optimum		26–32	24
pH	~8	~8	~8	7.5–8.5	7.5–8.5
Ammonia (TAN, total ammonia-nitrogen)		0.1–0.5 mg/L			
Ammonia (NH_3, un-ionised form)	<0.1 mg/L	<0.1 mg/L	<0.1 mg/L	<0.1 mg/L	<0.1 mg/L
Nitrate (NO_3)	<1.0 mg/L	<1.0 mg/L	<1.0 mg/L	<1.0 mg/L	<1.0 mg/L
Nitrite (NO_2)	<0.2 mg/L	<1.0 mg/L	<0.2 mg/L	<0.2 mg/L	<0.2 mg/L
Salinity	28–31 ppt	0–35 ppt		10–25 ppt optimum	30–35 ppt optimum
Alkalinity		105–125 mg/L $CaCO_3$			
Clarity				30–40 cm Secchi disk	30–40 cm Secchi disk
Hydrogen sulphide		<0.3 mg/L			
Iron		<0.02 mg/L		<1.0 mg/L	
Spawning temperature ˚C		28–32		27–32	

Source: Department of Primary Industries and Fisheries—Water Quality in Aquaculture—DPI Notes April 2004 (as amended).

Table 8 Irrigation EV: Water quality objectives for thermotolerant (faecal) coliforms in irrigation waters used for food and non-food crops[1]

Intended use	Median values of thermotolerant coliforms (colony forming units—cfu)[2]
Raw human food crops in direct contact with irrigation water (e.g. via sprays, irrigation of salad vegetables)	<10 cfu/100 mL
Raw human food crops not in direct contact with irrigation water (edible product separated from contact with water, e.g. by peel, use of trickle irrigation); or crops sold to consumers cooked or processed	<1000 cfu/100 mL
Pasture and fodder for dairy animals (without withholding period)	<100 cfu/100 mL
Pasture and fodder for dairy animals (with withholding period of five days)	<1000 cfu/100 mL
Pasture and fodder (for grazing animals except pigs and dairy animals, i.e. cattle, sheep and goats)	<1000 cfu/100 mL
Silviculture, turf, cotton, etc. (restricted public access)	<10 000 cfu/100 mL

Notes:

1. Adapted from ARMCANZ, ANZECC and NHMRC (1999).
2. Refer to AWQG Volume 1, Section 4.2.3.3 for advice on testing protocols.

Source: AWQG, Volume 1, Section 4.2.3.3, Table 4.2.2.

Table 9 Irrigation EV: Water quality objectives for heavy metals and metalloids in agricultural irrigation water[1]—long-term trigger value (LTV), short-term trigger value (STV) and soil cumulative contamination loading limit (CCL)

Element	Soil cumulative contaminant loading limit (CCL)[2] (kg/ha)	Long-term trigger value (LTV) in irrigation water (up to 100 years) (mg/L)	Short-term trigger value (STV) in irrigation water (up to 20 years) (mg/L)
Aluminium	ND[2]	5	20
Arsenic	20	0.1	2.0
Beryllium	ND	0.1	0.5
Boron	ND	0.5	Refer to AWQG Vol 3, Table 9.2.18
Cadmium	2	0.01	0.05
Chromium	ND	0.1	1
Cobalt	ND	0.05	0.1
Copper	140	0.2	5
Fluoride	ND	1	2
Iron	ND	0.2	10
Lead	260	2	5
Lithium	ND	2.5 (0.075 for citrus crops)	2.5 (0.075 for citrus crops)
Manganese	ND	0.2	10
Mercury	2	0.002	0.002
Molybdenum	ND	0.01	0.05
Nickel	85	0.2	2
Selenium	10	0.02	0.05
Uranium	ND	0.01	0.1
Vanadium	ND	0.1	0.5
Zinc	300	2	5

Notes:

1. Concentrations in irrigation water should be less than the trigger values. Trigger values should only be used in conjunction with information on each individual element and the potential for off-site transport of contaminants (refer AWQG, Volume 3, Section 9.2.5).
2. ND = Not determined; insufficient background data to calculate CCL.

Source: AWQG, Volume 1, Section 4.2.6, Table 4.2.10.

Table 10 Stock watering EV: Water quality objectives for tolerances of livestock to total dissolved solids (salinity) in drinking water[1]

Livestock	Total dissolved solids (TDS) (mg/L)		
	No adverse effects on animals expected.	Animals may have initial reluctance to drink or there may be some scouring, but stock should adapt without loss of production	Loss of production and decline in animal condition and health would be expected. Stock may tolerate these levels for short periods if introduced gradually
Beef cattle	0–4000	4000–5000	5000–10 000
Dairy cattle	0–2500	2500–4000	4000–7000
Sheep	0–5000	5000–10 000	10 000–13 000[2]
Horses	0–4000	4000–6000	6000–7000
Pigs	0–4000	4000–6000	6000–8000
Poultry	0–2000	2000–3000	3000–4000

Notes:

1. From ANZECC (1992), adapted to incorporate more recent information.
2. Sheep on lush green feed may tolerate up to 13 000 mg/L TDS without loss of condition or production.

Source: AWQG, Volume 1, Section 4.3.3.5, Table 4.3.1.

Table 11 Stock watering EV: Water quality objectives (low risk trigger values) for heavy metals and metalloids in livestock drinking water

Metal or metalloid	Trigger value (low risk)[1,2] (mg/L)
Aluminium	5
Arsenic	0.5 (up to 5[3])
Beryllium	ND
Boron	5
Cadmium	0.01
Chromium	1
Cobalt	1
Copper	0.4 (sheep), 1 (cattle), 5 (pigs), 5 (poultry)
Fluoride	2
Iron	not sufficiently toxic
Lead	0.1
Manganese	not sufficiently toxic
Mercury	0.002
Molybdenum	0.15
Nickel	1
Selenium	0.02
Uranium	0.2
Vanadium	ND
Zinc	20

Notes:

1. Higher concentrations may be tolerated in some situations (further details provided in AWQG, Volume 3, Section 9.3.5).
2. ND = not determined, insufficient background data to calculate.
3. May be tolerated if not provided as a food additive and natural levels in the diet are low.

Source: AWQG, Volume 1, Section 4.3.4, Table 4.3.2.

Table 12 Recreational waters: Alert levels and corresponding actions for management of cyanobacteria

When cyanobacteria are present in large numbers they can present a significant hazard, particularly to primary contact users of waters. Water quality objectives for cyanobacteria in recreational waters are provided in Table 3. Monitoring/action requirements relative to cyanobacteria 'alert' levels are summarised below, and are explained more fully in the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008). Further details on the process to determine suitability of waters for recreation, relative to historical cyanobacterial levels and susceptibility to cyanobacterial contamination, are contained in sections 6 and 7 of the NHMRC guidelines.

Green level surveillance mode[1]	Amber level alert mode[1]	Red level action mode[1]
Fresh waters		
≥ 500 to <5000 cells/mL *M. aeruginosa* or biovolume equivalent of >0.04 to <0.4 mm^3/L for the combined total of all cyanobacteria.	≥ 5000 to <50 000 cells/mL *M. aeruginosa* or biovolume equivalent of ≥ 0.4 to <4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume[2]. or[3] ≥ 0.4 to <10 mm^3/L for the combined total of all cyanobacteria where known toxin producers are not present.	Level 1 guideline[4]: ≥ 10 µg/L total microcystins or ≥ 50 000 cells/mL toxic *M. aeruginosa* or biovolume equivalent of ≥ 4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume. or[3] Level 2 guideline[4]: ≥ 10 mm^3/L for total biovolume of all cyanobacterial material where known toxins are not present. or cyanobacterial scums are consistently present[5].
Coastal and estuarine waters		
Karenia brevis		
≤ 1 cell/mL	> 1– < 10 cells/mL	≥ 10 cells/mL
Lyngbya majuscula, Pfiesteria spp.		
History but no current presence of organism	Present in low numbers	Present in high numbers. (For *Lyngbya majuscula* this involves the relatively widespread visible presence of dislodged algal filaments in the water and washed up onto the beach)
Nodularia spumigena: See NHMRC, Chapter 6 (Cyanobacteria and algae in fresh water) for details.		

Notes:

1. Recommended actions at different alert levels are outlined below (based on NHMRC, 2008, Table 6.6—fresh waters. Similar actions are outlined for coastal/estuarine waters in NHMRC Table 7.6):

   a. **Green:** Regular monitoring. Weekly sampling and cell counts at representative locations in the water body where known toxigenic species are present (i.e. *Microcystis aeruginosa, Anabaena circinalis, Cylindrospermopsis raciborskii, Aphanizomenon ovalisporum, Nodularia spumigena*); or fortnightly for other types including regular visual inspection of water surface for scums.

   b. **Amber:** Notify agencies as appropriate. Increase sampling frequency to twice weekly at representative locations in the water body where toxigenic species (above) are dominant within the alert level definition (i.e. total biovolume) to establish population growth and spatial variability in the water body. Monitor weekly or fortnightly where other types are dominant. Make regular visual inspections of water surface for scums. Decide on requirement for toxicity assessment or toxin monitoring.

   c. **Red:** Continue monitoring as for (amber) alert mode. Immediately notify health authorities for advice on health risk. ('In action mode the local authority and health authorities warn the public of the existence of potential health risks; for example, through the media and the erection of signs by the local authority.' NHMRC, 2008; 114). Make toxicity assessment or toxin measurement of water if this has not already been done. Health authorities warn of risk to public health (i.e. the authorities make a health risk assessment considering toxin monitoring data, sample type and variability).

2. The definition of 'dominant' is where the known toxin producer comprises 75 per cent or more of the total biovolume of cyanobacteria in a representative sample.

3. This applies where high cell densities or scums of 'non toxic' cyanobacteria are present i.e. where the cyanobacterial population has been tested and shown not to contain known toxins (mycrocystins, nodularian, cylindrospermopsin or saxitoxin).

4. Health risks and levels: Level 1 is developed to protect against short-term health effects of exposure to cyanobacterial toxins ingested

during recreational activity, whereas the Level 2 applies to the circumstance where there is a probability of increased likelihood of non-specific adverse health outcomes, principally respiratory, irritation and allergy symptoms, from exposure to very high cell densities of cyanobacterial material irrespective of the presence of toxicity or known toxins (NHMRC, 2008;114).

5. This refers to the situation where scums occur at the recreation site each day when conditions are calm, particularly in the morning. Note that it is not likely that scums are always present and visible when there is a high population as the cells may mix down with wind and turbulence and then reform later when conditions become stable.

Source: Based on NHMRC (2008) Guideline for Managing Risks in Recreational Water (tables 6.2, 6.6, 7.3).

4 Ways to improve water quality

The following documents are relevant in considering ways to improve water quality in the Ross River Basin. The document list below is additional to the plans, guidelines and other sources referred to in previous sections, **and is provided for information only**.

Local plans, studies

- Council planning scheme and supporting codes, policies, available from the Townsville City Council website.
- Water Sensitive Urban Design for the Coastal Dry Tropics (Townsville)–Technical design guidelines for stormwater management, available from Townsville City Council's website.
- Townsville State Development Area Development Scheme, Queensland Government.

Regional plans, studies

- Gunn, J. and Manning, C. 2010, Black Ross (Townsville) Water Quality Improvement Plan (WQIP): Improving Water Quality from Creek to Coral, Townsville City Council - Creek to Coral, Townsville, available from the Creek to Coral website.
- Burdekin Dry Tropics Natural Resource Management Plan 2005-2010, available from the NQ Dry Tropics website.

State plans, policies, guidelines, agreements etc

- State Planning Policy 4/10: Healthy Waters, available from the department's website.
- Urban Stormwater Quality Planning Guidelines (Queensland Government), available from the department's website.
- Draft Townsville Futures Plan - A second capital for Queensland 2011 (DLGP), available from the Department of State Development, Infrastructure and Planning.
- Queensland Water Quality Guidelines (QWQG), available from the department's website.
- Monitoring and Sampling Manual, available from the department's website.
- Reef Water Quality Protection Plan, Australian and Queensland Governments, available from the Reef Water Quality Protection Plan website.

Other supporting technical information – riparian management

- Managing riparian widths to achieve multiple objectives, fact sheet 13, Land and Water Australia, Australian Government, 2004.
- Improving water quality, fact sheet 3, Land & Water Australia, Australian Government, 2002.
- Riparian Land Management Technical Guidelines—Volume 1 and 2, November 1999, Land and Water Resources Research and Development Corporation (LWRRDC).
- Guidelines for Queensland Streambank Stabilisation with Riparian Vegetation, CRC for Catchment Hydrology, September 1999.
- Restoration of Fish Habitats—Fisheries Guidelines for Marine Areas, FHG002, available from the Department of Agriculture, Fisheries and Forestry.
- Fisheries Guidelines for Fish Habitat Buffer Zones, FHG003, available from the Department of Agriculture, Fisheries and Forestry.
- Guidelines for Riparian Filter Strips for Queensland Irrigators, CSIRO Land and Water, September 1999.

5 Dictionary

AMTD means the adopted middle thread distance which is the distance in kilometres, measured along the middle of a watercourse, that a specific point in the watercourse is from the watercourse's mouth or junction with the main watercourse (definition based on Water Regulation 2002).

ANZECC means the Australian and New Zealand Environment and Conservation Council.

Aquatic ecosystems (defined in the AWQG) comprise the animals, plants and micro-organisms that live in water, and the physical and chemical environment and climatic regime in which they interact. It is predominantly the physical components (e.g. light, temperature, mixing, flow, habitat) and chemical components (e.g. organic and inorganic carbon, oxygen, nutrients) of an ecosystem that determine what lives and breeds in it, and therefore the structure of the food web. Biological interactions (e.g. grazing and predation) can also play a part in structuring many aquatic ecosystems.

ARMCANZ means the Agriculture and Resource Management Council of Australia and New Zealand.

Basin means the basin name and number provided by Geoscience Australia, Canberra (3rd edition, 2004).

Biological integrity, of water, means the water's ability to support and maintain a balanced, integrative, adaptive community of organisms having a species composition, diversity and functional organisation comparable to that of the natural habitat of the locality in which the water is situated.

Biotoxin (defined in the AWQG) means a toxin (poison) which originates from a living thing (a plant, animal, fungi, bacteria, etc).

Catchment means the total area draining into a river, creek, reservoir or other body of water. The limits of a given catchment are the heights of land (such as hills or mountains) separating it from neighbouring catchments. Catchments can be made up of smaller subcatchments.

Ecological health (defined in the AWQG) means the 'health' or 'condition' of an ecosystem. It is the ability of an ecosystem to support and maintain key ecological processes and organisms so that their species compositions, diversity and functional organisations are as comparable as possible to those occurring in natural habitats within a region (also termed ecological integrity).

Environmental value (EV) means:

(a) a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or

(b) another quality of the environment identified and declared to be an environmental value under an Environmental Protection Policy or Regulation (e.g. water suitable for swimming in or drinking).

The EVs for water that can be identified for protection are outlined in Table 13.

Highest astronomical tide (HAT) (defined in Marine Parks (Declaration) Regulation 2006) means the highest level of the tides that can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions.

High water mark (defined in *Coastal Protection and Management Act 1995*) means the ordinary high water mark at spring tides.

Mean high water spring refer high water mark.

Queensland waters (as defined in *Acts Interpretation Act 1954*) means all waters that are a) within the limits of the State; or b) coastal waters of the State.

Sub-basin means part of a basin.

Subcatchment means part of a catchment.

Toxicant (defined in the AWQG) means a chemical capable of producing an adverse response (effect) in a biological system at concentrations that might be encountered in the environment, seriously injuring structure or function or producing death. Examples include pesticides, heavy metals and biotoxins.

Table 13 Suite of environmental values that can be chosen for protection

Environmental values and definitions	ICON (as shown on plans)
Aquatic ecosystem 'A community of organisms living within or adjacent to water, including riparian or foreshore area.' (EPP (Water), schedule 2 - Dictionary) The intrinsic value of aquatic ecosystems, habitat and wildlife in waterways and riparian areas, for example, biodiversity, ecological interactions, plants, animals, key species (such as turtles, platypus, seagrass and dugongs) and their habitat, food and drinking water. Waterways include perennial and intermittent surface waters, groundwaters, tidal and non-tidal waters, lakes, storages, reservoirs, dams, wetlands, swamps, marshes, lagoons, canals, natural and artificial channels and the bed and banks of waterways. (This EV incorporates the 'wildlife habitat' EV used in the South East Queensland Regional Water Quality Management Strategy). See below for more details on aquatic ecosystems, based on the EPP (Water).	
High ecological/conservation value waters 'Waters in which the biological integrity of the water is effectively unmodified or highly valued.' (EPP (Water), schedule 2)	None
Slightly disturbed waters 'Waters that have the biological integrity of high ecological value waters with slightly modified physical or chemical indicators but effectively unmodified biological indicators.' (EPP (Water), schedule 2)	None
Moderately disturbed waters 'Waters in which the biological integrity of the water is adversely affected by human activity to a relatively small but measurable degree.' (EPP (Water), schedule 2)	None
Highly disturbed waters 'Waters that are significantly degraded by human activity and have lower ecological value than high ecological value waters or slightly or moderately disturbed waters.' (EPP (Water), schedule 2)	None
Seagrass (goal within the aquatic ecosystem EV) Maintenance or rehabilitation of seagrass habitat. (Applies only to tidal waterways.)	

Environmental values and definitions	ICON (as shown on plans)
Irrigation Suitability of water supply for irrigation, for example, irrigation of crops, pastures, parks, gardens and recreational areas.	
Farm water supply/use Suitability of domestic farm water supply, other than drinking water. For example, water used for laundry and produce preparation.	
Stock watering Suitability of water supply for production of healthy livestock.	
Aquaculture Health of aquaculture species and humans consuming aquatic foods (such as fish, molluscs and crustaceans) from commercial ventures.	
Human consumers of aquatic foods Health of humans consuming aquatic foods, such as fish, crustaceans and shellfish from natural waterways. Note that in some areas oystering is a more specific goal identified under the human consumer EV (see below).	
Oystering (goal within the EV of human consumers of aquatic foods) Health of humans consuming oysters from natural waterways and commercial ventures. (Applies only to tidal waterways.)	
Primary recreation Health of humans during recreation which involves direct contact and a high probability of water being swallowed, for example, swimming, surfing, windsurfing, diving and water-skiing. Primary recreational use, of water, means full body contact with the water, including, for example, diving, swimming, surfing, waterskiing and windsurfing. (EPP (Water), s 6).	
Secondary recreation Health of humans during recreation which involves indirect contact and a low probability of water being swallowed, for example, wading, boating, rowing and fishing. Secondary recreational use, of water, means contact other than full body contact with the water, including, for example, boating and fishing. (EPP (Water), s. 6).	
Visual recreation Amenity of waterways for recreation which does not involve any contact with water—for example, walking and picnicking adjacent to a waterway. Visual recreational use, of a water, means viewing the water without contact with it. (EPP (Water), s. 6).	

Environmental values and definitions	ICON (as shown on plans)
Drinking water supply Suitability of raw drinking water supply. This assumes minimal treatment of water is required, for example, coarse screening and/or disinfection.	
Industrial use Suitability of water supply for industrial use, for example, food, beverage, paper, petroleum and power industries, mining and minerals refining/processing. Industries usually treat water supplies to meet their needs.	
Cultural and spiritual values Indigenous and non-indigenous cultural heritage, for example: • custodial, spiritual, cultural and traditional heritage, hunting, gathering and ritual responsibilities • symbols, landmarks and icons (such as waterways, turtles and frogs) • lifestyles (such as agriculture and fishing). Cultural and spiritual values, of water, means its aesthetic, historical, scientific, social or other significance, to the present generation or past or future generations. (EPP (Water), s. 6).	

Table 14 Townsville region groundwater: water quality objectives (aquatic ecosystem) according to water chemistry zone and depth (refer plan WQ1184)

Zone 1 – Townsville [1, 2, 3, 4]

Depth[2]	Percentile[3]	Indicator[4]																								
		Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC	Hardness (mg·L-1)	pH	Alkalinity (mg·L-1)	SiO_2 (mg·L-1)	F (mg·L-1)	Fe (mg·L-1)	Mn (mg·L-1)	Zn (mg·L-1)	Cu (mg·L-1)	SAR	RAH (meqL-1)	eH (mV)
		mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	µS·cm-1												
shallow	20th	31	31	44	13	7	10	179	28	23	15	1	0	-	-	636	203	7.7	148	28.1	0.130	0.003	0.003	-	-	1.13	0.17	-
	50th	175	49	80	32	32	17	319	34	275	54	20	4	2	0	1,488	253	8.0	265	44.0	0.300	0.015	0.020	-	-	3.80	0.40	-
	80th	400	74	89	55	37	20	396	73	592	72	51	9	43	6	2,393	388	8.0	330	89.7	0.440	0.111	0.170	-	-	10.62	1.32	-
moderate	20th	691	53	113	3	62	15	214	0	1,257	81	16	1	-	-	4,381	533	7.3	178	51.4	0.200	0.009	0.000	0.020	0.05	9.27	0.00	-
	50th	2,615	77	502	11	1,694	18	312	1	14,250	91	240	6	1	0	30,534	9,956	7.6	259	65.0	0.300	0.030	0.020	0.060	0.18	13.25	0.00	-
	80th	20,730	81	701	24	2,488	22	454	19	38,640	93	4,710	8	10	0	90,500	13,054	7.9	372	89.3	1.156	0.110	0.100	0.100	0.30	83.80	2.34	-
deep	20th	400	64	98	13	58	16	300	4	730	76	26	2	1	0	2,770	484	7.1	247	53.0	0.200	0.010	0.010	0.000	0.00	7.90	-	-
	50th	1,175	68	199	15	147	17	325	13	2,415	85	58	2	4	0	7,385	1,101	7.3	268	81.5	0.300	0.070	0.805	0.000	0.00	14.20	-	-
	80th	1,950	71	300	18	235	18	350	21	4,100	94	91	2	7	0	12,000	1,717	7.4	288	110.0	0.400	0.130	1.600	0.000	0.00	20.50	-	-

Zone 8 - Q91 [1, 2, 3, 4]

Depth[2]	Percentile[3]	Indicator[4]																								
		Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC	Hardness (mg·L-1)	pH	Alkalinity (mg·L-1)	SiO_2 (mg·L-1)	F (mg·L-1)	Fe (mg·L-1)	Mn (mg·L-1)	Zn (mg·L-1)	Cu (mg·L-1)	SAR	RAH (meqL-1)	eH (mV)
		mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	µS·cm-1												
shallow	20th	126	43	78	31	38	24	248	32	255	54	42	6	3	0	300	351	7.2	204	79.0	0.500	0.000	0.000	0.000	0.00	2.90	0.00	-
	50th	128	44	84	32	39	24	285	36	258	55	53	8	5	1	815	371	7.4	235	81.5	0.500	0.000	0.000	0.000	0.00	2.90	0.00	-
	80th	130	45	90	33	40	25	321	39	260	57	63	10	6	1	1,330	390	7.6	265	84.0	0.500	0.000	0.000	0.000	0.00	2.90	0.00	-
moderate	20th	47	29	42	31	21	19	103	18	71	24	11	2	1	0	564	190	7.5	85	41.6	0.160	0.020	0.020	-	-	1.63	0.00	-
	50th	120	38	115	35	60	27	259	35	278	46	15	6	2	0	1,566	570	7.6	214	55.0	0.300	0.100	0.020	-	-	2.25	0.24	-
	80th	166	49	145	38	73	36	396	58	443	64	313	41	3	2	2,021	630	7.7	326	60.0	0.300	0.180	0.020	-	-	2.94	0.48	-

Zone 9 - Low salinity coastal floodplains [1, 2, 3, 4]

Depth[2]	Percentile[3]	Indicator[4]																								
		Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC	Hardness (mg·L-1)	pH	Alkalinity (mg·L-1)	SiO_2 (mg·L-1)	F (mg·L-1)	Fe (mg·L-1)	Mn (mg·L-1)	Zn (mg·L-1)	Cu (mg·L-1)	SAR	RAH (meqL-1)	eH (mV)
		mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	µS·cm-1												
shallow	20th	6	57	1	6	1	10	7	18	8	39	-	-	-	-	51	7	5.8	6	9.0	0.000	0.000	0.000	0.010	0.00	1.00	0.00	-
	50th	13	67	2	11	2	18	18	32	17	54	2	4	1	2	96	14	6.6	15	19.5	0.050	0.008	0.018	0.020	0.01	1.50	0.02	-
	80th	24	81	5	21	4	27	41	52	28	70	6	11	4	8	156	26	7.3	34	30.0	0.150	0.040	0.094	0.075	0.02	2.90	0.28	-
moderate	20th	6	50	1	6	1	14	6	12	8	32	-	-	1	0	64	8	6.0	5	11.1	0.000	0.000	0.000	0.010	0.00	0.70	0.00	-
	50th	10	67	2	12	2	21	14	27	12	46	1	2	7	12	85	15	6.5	12	18.0	0.020	0.000	0.010	0.020	0.01	1.20	0.00	-
	80th	25	75	7	22	4	28	62	50	28	64	5	10	13	29	199	34	7.2	52	27.0	0.200	0.020	0.040	0.039	0.02	2.10	0.22	-
deep	20th	6	53	1	8	1	12	6	19	8	22	-	-	-	0	59	6	5.5	5	11.0	0.000	0.000	0.000	0.005	0.00	0.90	0.00	-
	50th	9	65	2	14	2	18	16	35	10	43	1	2	3	5	82	12	6.5	14	17.0	0.050	0.002	0.010	0.010	0.01	1.30	0.10	-
	80th	18	76	6	25	3	24	64	68	15	65	4	5	9	22	163	34	7.2	52	35.0	0.180	0.030	0.060	0.030	0.02	1.65	0.49	-
very deep	20th	7	54	1	10	1	10	13	21	7	20	1	2	1	0	64	9	6.1	11	16.0	0.010	0.000	0.000	0.000	0.00	0.70	0.00	-
	50th	9	59	3	15	3	16	29	46	9	39	1	4	4	9	95	19	6.9	24	23.0	0.100	0.005	0.005	0.010	0.02	1.30	0.13	-
	80th	78	74	18	26	8	25	103	65	65	60	16	8	8	16	511	67	7.5	85	43.7	0.610	0.020	0.020	0.030	0.02	5.25	1.47	-
artesian	-																											
unknown	20th	14	17	4	18	2	23	36	61	9	2	-	0	-	-	146	26	7.0	31	48.3	0.000	0.000	0.000	0.001	0.00	0.60	0.06	-
	50th	19	23	17	25	23	52	177	83	15	15	2	0	2	1	325	142	7.9	147	52.5	0.030	0.000	0.000	0.010	0.00	0.70	0.16	-
	80th	54	53	58	32	105	55	896	97	20	33	4	3	10	4	1,184	610	8.3	739	94.7	0.100	0.010	0.029	0.010	0.01	1.10	2.51	-

Zone 10 - Granitic uplands and slopes [1, 2, 3, 4]

Depth[2]	Percentile[3]	Indicator[4]																								
		Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC	Hardness (mg·L-1)	pH	Alkalinity (mg·L-1)	SiO_2 (mg·L-1)	F (mg·L-1)	Fe (mg·L-1)	Mn (mg·L-1)	Zn (mg·L-1)	Cu (mg·L-1)	SAR	RAH (meqL-1)	eH (mV)
		mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	µS·cm-1												
shallow	20th	16	46	10	9	3	8	68	33	13	26	1	1	0	0	158	38	6.9	56	30.6	0.100	0.000	0.000	0.010	0.00	1.10	0.13	-
	50th	109	55	16	21	7	15	194	45	125	52	5	2	2	0	800	72	7.6	161	70.0	0.200	0.020	0.010	0.030	0.02	3.15	1.07	-
	80th	168	84	45	33	21	24	254	66	175	59	12	8	7	7	997	195	7.9	208	101.1	0.550	0.422	0.037	0.054	0.02	8.47	2.04	-
moderate	20th	64	46	9	8	5	7	135	33	47	27	2	1	0	0	440	46	7.3	113	82.0	0.270	0.000	0.000	0.005	0.01	2.00	0.30	-
	50th	102	63	21	20	10	17	200	50	103	41	4	1	1	0	772	95	7.7	165	96.0	0.375	0.010	0.010	0.020	0.05	4.25	1.67	-
	80th	160	85	46	30	24	23	280	67	210	62	12	3	3	1	1,003	210	8.2	230	110.0	0.500	0.020	0.020	0.023	0.05	8.40	2.70	-
deep	20th	27	41	12	16	5	13	118	66	20	20	1	1	-	0	257	53	6.7	97	79.0	0.280	0.003	0.004	0.007	0.01	1.30	0.43	-
	50th	32	49	18	31	7	20	147	74	26	23	2	1	0	0	300	76	7.0	120	93.0	0.360	0.020	0.010	0.020	0.05	1.60	0.72	-
	80th	113	72	24	35	10	24	219	79	54	31	16	5	1	0	572	99	7.8	182	107.0	0.600	0.100	0.050	0.050	0.05	5.81	2.16	-

Zone 20 - Ross and Black alluvial [1, 2, 3, 4]

Depth[2]	Percentile[3]	Indicator[4]																								
		Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC	Hardness (mg·L-1)	pH	Alkalinity (mg·L-1)	SiO_2 (mg·L-1)	F (mg·L-1)	Fe (mg·L-1)	Mn (mg·L-1)	Zn (mg·L-1)	Cu (mg·L-1)	SAR	RAH (meqL-1)	eH (mV)
		mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	mg·L-1	%	µS·cm-1												
shallow	20th	22	41	15	33	6	20	100	76	16	19	1	0	-	-	210	62	6.4	82	89.0	0.200	0.020	0.005	0.005	0.01	1.20	0.30	-
	50th	24	43	17	34	7	22	115	78	17	20	2	2	0	0	240	70	6.6	94	94.0	0.260	0.080	0.008	0.015	0.03	1.30	0.53	-
	80th	27	45	20	36	8	24	137	80	21	22	2	2	0	1	270	80	7.1	112	100.0	0.337	0.135	0.050	0.050	0.05	1.30	0.70	-
moderate	20th	21	42	14	29	5	17	95	66	15	18	1	0	0	0	200	56	6.7	78	77.1	0.200	0.005	0.005	0.005	0.02	1.20	0.32	-
	50th	30	46	19	34	7	21	125	76	20	22	2	1	0	0	300	74	7.5	104	87.0	0.245	0.010	0.010	0.005	0.02	1.50	0.51	-
	80th	57	51	26	36	12	24	192	80	44	32	4	2	1	0	490	113	8.0	161	95.9	0.400	0.020	0.020	0.020	0.05	2.00	1.08	-
deep	20th	23	41	15	30	6	20	105	73	17	19	1	1	-	-	220	62	6.6	86	89.0	0.240	0.010	0.005	0.005	0.01	1.20	0.31	-
	50th	27	44	18	34	7	22	120	77	20	22	2	2	0	0	250	74	6.8	98	95.0	0.300	0.080	0.008	0.010	0.01	1.30	0.56	-
	80th	31	49	22	36	9	25	159	79	27	25	3	2	0	0	310	95	7.3	130	101.7	0.360	0.419	0.050	0.050	0.05	1.60	0.74	-

Source: Queensland Wet Tropics and Black and Ross catchments: Regional chemistry of the groundwater. Queensland Government (Raymond, M. A. A. and V. H. McNeil, 2013).

Notes:

1. Refer to plan WQ1184 to locate the relevant chemistry zone.
2. Within each chemistry zone, groundwater quality values are provided for different depths (Shallow: <15m, Moderate: 15–40m, Deep: 40–65m, Very deep: >65m, Artesian: all artesian).
3. The management intent is to maintain 20th, 50th and 80th percentile values. Values are provided for each of these percentiles
4. Abbreviations: EC: Electrical conductivity, $CaCO_3$: Calcium carbonate, Ca: Calcium, Mg: Magnesium, Na: Sodium, Cl: Chloride, SO_4: Sulfate, HCO_3: Bicarbonate, NO_3: Nitrate, SiO_2: Silica, F: Fluoride, Fe: Iron, Mn: Manganese, Zn: Zinc, Cu: Copper, SAR: Sodium adsorption ratio, RAH: Residual alkali hazard, EH: Redox (oxidation/reduction) potential, '-': insufficient data to perform statistical summaries, or the parameter was not tested.