Environmental Protection (Water) Policy 2009
Isaac River Sub-basin Environmental Values and Water Quality Objectives
Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River)

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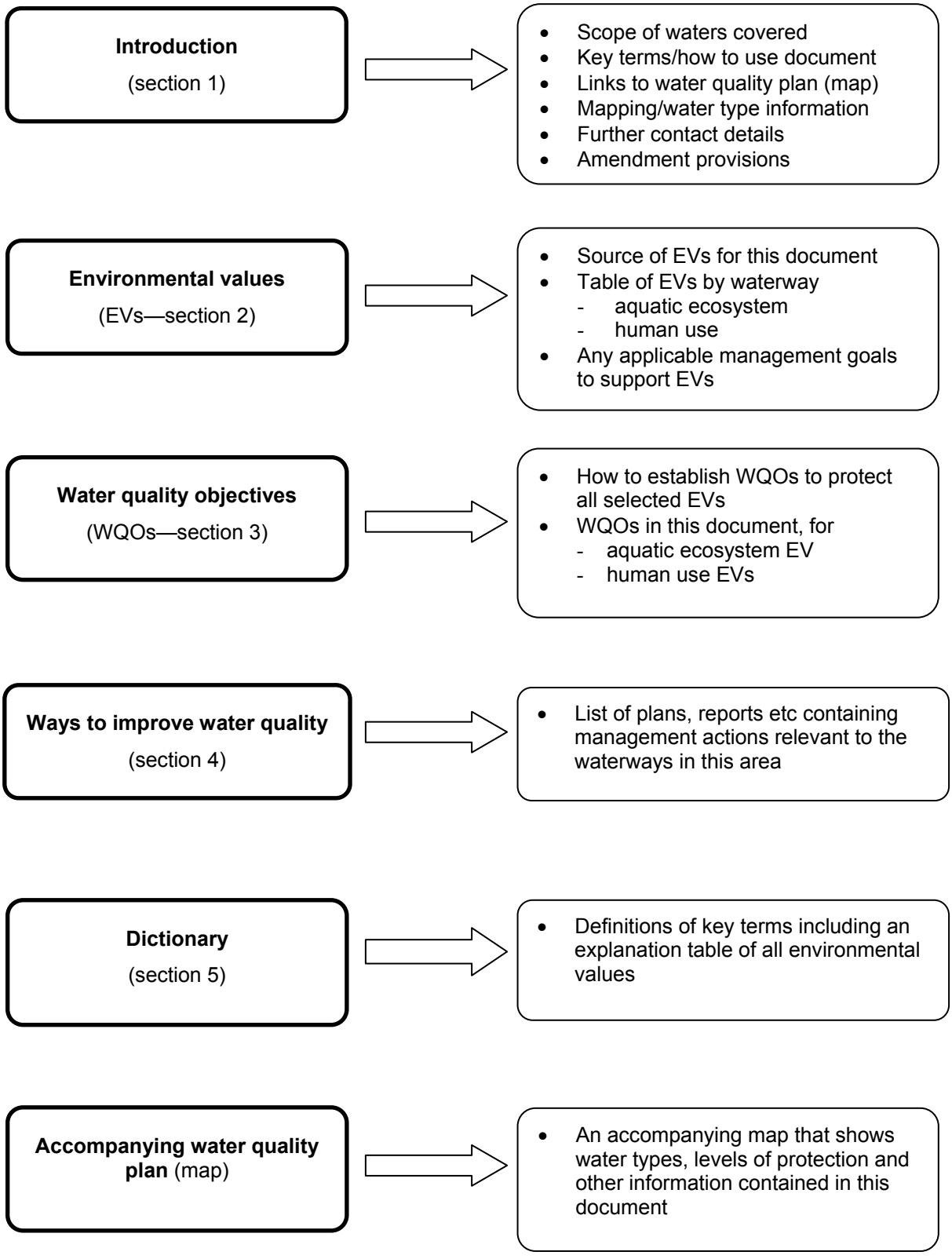
Main parts of this document and what they contain



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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
- including the identified EVs and WQOs under Schedule 1 of the EPP (Water).

This document contains EVs and WQOs for waters in the Isaac River Sub-basin, and is listed under schedule 1 of the EPP (Water).

1.1 Waters to which this document applies

This document applies to fresh surface waters and groundwaters draining the Isaac River Sub-basin, comprising catchments of the Isaac and Connors Rivers, as indicated in the accompanying plans (WQ1301—surface waters, WQ1310—Fitzroy Basin groundwaters)[1]. These waters fall within the broader Fitzroy Basin (basin 130)[2].

Waters covered by this document include:

- the Isaac River
- Isaac River western upland tributaries including Crooked, Rolf, Stephens, Phillips, Boomerang, Hughes, Harrow, and Hill creeks
- Isaac River northern tributaries, including Devlin, Black, North, Teviot and Anna creeks, and Teviot Brook
- the Connors River
- central tributaries including Bee, Hall, Funnel, Cooper, Billy, Harrybrandt, Thirty Mile, and Brumby creeks
- northern Connors Range tributaries, including Twelve Mile, Mahalla, Boothill, Funnel, Denison, Nebo, and Oaky creeks
- eastern tributaries, including Home, Palm, Hut, Whelan, Lotus, Croydon, Yatton, Stockyard and Clive creeks
- wetlands, lakes and reservoirs
- groundwaters.

The geographical extent of waters addressed by this document is shown in plan WQ1301, and is broadly:

- north to the boundary of the Isaac River Sub-basin the Pioneer and Burdekin River Basins
- west to the boundary of the Isaac River Sub-basin with the Burdekin River Basin
- south to the boundary of the Isaac River Sub-basin with the Mackenzie River Sub-basin
- east to the boundary of the Isaac River Sub-basin with the Plane Creek and Styx River basins.

[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 WQ1306 and WQ1310 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 September 2011, and held at the department's offices at 400 George Street Brisbane. Database 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).

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)	✓	✓

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

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

Environmental value (EV)	Potentially applicable to:	
	Tidal waters	Fresh (non-tidal) waters
Protection of cultural and spiritual values, including Traditional Owner values of water	✓	✓
Suitability for industrial use	✓	✓
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) 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. 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.

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

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.

1.2.2 Main components of this document

The main components of this document are:

- Plan WQ1301—showing the spatial extent and boundaries of surface water types covered by this document
- Plan WQ1310—showing the spatial extent and boundaries of groundwater types in the Fitzroy Basin
- 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 plan WQ1301 and plan WQ1310 (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 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 onwards 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 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 WQ1306 and WQ1310 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 September 2011 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 different the following water types from the list below (not all water types are present in all areas).

- fresh waters—for the Fitzroy Basin, fresh waters (and corresponding WQOs) are mapped at the catchment scale. Where sufficient information is available, mapping includes water sub-types
- freshwater lakes/reservoirs
- groundwaters
- upper estuary—waters in the upper reaches of estuaries, with limited flushing. This water type is absent from short estuaries, less than 15 kilometres (km) total estuary length
- 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
- tidal canals, constructed estuaries, marinas and boat harbours
- wetlands.

The water types are based on local water quality studies in the Fitzroy (refer to the source documents listed after Table 2), the AWQG and mapping and definitional rules contained in the QWQG (2009). Further detail on water types is contained in these sources. Water types identified in this document are shown in Tables 2 and 14 and the accompanying plans (WQ1301, WQ1310).

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 sub-catchment 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 1 and the accompanying plan WQ1301 outline the EVs for waters in the Isaac and Connors Rivers catchments. These are based on stakeholder consultations undertaken by the department and the Fitzroy Basin Association to identify EVs and WQOs in the Fitzroy Basin. Consultation results are reported in:

- Fitzroy Basin Association Inc (2011) Environmental values for the Fitzroy: community consultation. Final report. July 2011.

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 1 Environmental values for Isaac and Connors Rivers catchments waters

	Environmental values[1, 2, 3, 4]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
Water												
Isaac western upland tributaries—developed areas	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Isaac northern tributaries—developed areas	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Isaac and lower Connors River main channel—developed areas (includes Connors River main channel downstream of Funnel Creek junction)	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Burton Gorge Dam	✓			✓			✓	✓	✓	✓	✓	✓
Isaac fresh waters in undeveloped areas	✓			✓		✓	✓	✓	✓	✓		✓
Isaac groundwaters	✓	✓	✓	✓			✓			✓		✓
Central tributaries—developed areas	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Northern Connors Range tributaries—developed areas	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Eastern tributaries—developed areas	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓
Connors River main channel (above junction with Funnel Creek)—developed areas	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓

	Environmental values[1, 2, 3, 4]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
Water												
Connors freshwaters in undeveloped areas	✓			✓		✓	✓	✓	✓	✓		✓
Connors groundwaters	✓	✓	✓	✓			✓			✓	✓	✓

Notes:

1. Refer to the accompanying plan WQ1301 for locations of EVs.
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.

3 Water quality objectives to protect environmental values

This section provides WQOs to support and protect different EVs identified for waters within the Isaac and Connors Rivers catchments in Table 1.

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 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 of the QWQG addresses procedures for the application of guidelines for aquatic ecosystem protection. 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) 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 Tables 2 to 12 and 14 below.

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.

In summary:

- it 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, or potentially, more modified waters which can be progressively improved to achieve HEV condition. Any such waters are identified in columns 1 and 2 of Table 2 and are identified and labelled on the accompanying plan in cross-hatching
- the management intent (level of protection) for most waters is to achieve a moderately disturbed condition, for which corresponding WQOs have been derived
- 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 WOQs that reflect a more highly disturbed 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 Tables 2 and 14 and shown on plans WQ1301 and WQ1310, while others apply to more than one water type, as indicated in the table.

Table 2 Water quality objectives to protect aquatic ecosystem environmental value under baseflow (and, where specified, high flow) conditions

Water area/type (refer plans WQ1301, WQ1310)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV[1-11]
Surface fresh waters (refer plan WQ1301)		
Waters in areas: **HEVm2001–2010** **HEVm2063**	Aquatic ecosystem—high ecological value	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.
Waters in areas: **HEVa2001–2002**	Aquatic ecosystem—high ecological value	Achieve effectively unmodified water quality (20th, 50th and 80th percentiles of HEV waters), habitat, biota, flow and riparian areas. Note: there is insufficient information available to establish effectively unmodified 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.
Upper Isaac River catchment waters	Aquatic ecosystem—moderately disturbed	• ammonia N: <20 µg/L[a] • oxidised N: <60 µg/L[a] • organic N: <420 µg/L[a] • total nitrogen: <500 µg/L[a] • filterable reactive phosphorus (FRP): <20 µg/L[a] • total phosphorus: <50 µg/L[a] • chlorophyll a: <5.0 µg/L[a] • dissolved oxygen: 85%–110% saturation[a] • turbidity: <50 NTU[a] • suspended solids: <55 mg/L[b] • pH: 6.5–8.5 [b] • conductivity (EC) baseflow: <720 µS/cm[a] • conductivity (EC) high flow: <250 µS/cm[b] • sulfate: <25 mg/L[b] • Macroinvertebrates[c]: – Taxa richness (composite): 12–21 – Taxa richness (edge habitat): 23–33 – PET taxa richness (composite): 2–5 – PET taxa richness (edge habitat): 2–5 – SIGNAL index (composite): 3.33–3.85 – SIGNAL index (edge habitat): 3.31–4.20 – % tolerant taxa (composite): 25–50% – % tolerant taxa (edge habitat): 44–56%

Water area/type (refer plans WQ1301, WQ1310)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV[1-11]
Lower Isaac River catchment waters	Aquatic ecosystem—moderately disturbed	• ammonia N: <20 µg/L[a] • oxidised N: <60 µg/L[a] • organic N: <420 µg/L[a] • total nitrogen: <455 µg/L[b] • filterable reactive phosphorus (FRP): <20 µg/L[a] • total phosphorus: <75 µg/L[b] • chlorophyll a: <5.0 µg/L[a] • dissolved oxygen: 85%–110% saturation[a] • turbidity: <50 NTU[a] • suspended solids: <30 mg/L[b] • pH: 6.5–8.5 [b] • conductivity (EC) baseflow: <410 µS/cm[b] • conductivity (EC) high flow: <210 µS/cm[b] • sulfate: <5 mg/L[b] • Macroinvertebrates[c]: – Taxa richness (composite): 12–21 – Taxa richness (edge habitat): 23–33 – PET taxa richness (composite): 2–5 – PET taxa richness (edge habitat): 2–5 – SIGNAL index (composite): 3.33–3.85 – SIGNAL index (edge habitat): 3.31–4.20 – % tolerant taxa (composite): 25–50% – % tolerant taxa (edge habitat): 44–56%
Lower Isaac River catchment main trunk	Aquatic ecosystem—moderately disturbed	• Native fish species observed/expected (O/E) ratio ≥ 1. Native species found to be present in ≥ 50% of sampling events in main river trunks/channels in this catchment are outlined below (additional native species may also be present) [d]: – *Arius graeffei* – *Melanotaenia splendida* – *Nematolosa erebi* – *Craterocephalus stercusmuscarum* – *Neosilurus hyrtlii* – *Scleropages leichardti* – *Ambassis agassizii* – *Amniataba percoides* – *Glossamia aprion* – *Hypseleotris sp.* – *Scortum hillii* – *Strongylura krefftii* – *Tandanus tandanus*

Water area/type (refer plans WQ1301, WQ1310)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV[1-11]
		• Exotic fish species: no increase in number of exotic species relative to current number of exotic species identified in main channel. Current sampled species: – nil
Connors River catchment waters	Aquatic ecosystem—moderately disturbed	• ammonia N: <20 µg/L[a] • oxidised N: <60 µg/L[a] • organic N: <420 µg/L[a] • total nitrogen: <485 µg/L[b] • filterable reactive phosphorus (FRP): <20 µg/L[a] • total phosphorus: <60 µg/L[b] • chlorophyll a: <5.0 µg/L[a] • dissolved oxygen: 85%–110% saturation[a] • turbidity: <50 NTU[a] • suspended solids: <15 mg/L[b] • pH: 6.5–8.5 [b] • conductivity (EC) baseflow: <430 µS/cm[b] • conductivity (EC) high flow: <250 µS/cm[b] • sulfate: <5 mg/L[b] • Macroinvertebrates[c]: – Taxa richness (composite): 12–21 – Taxa richness (edge habitat): 23–33 – PET taxa richness (composite): 2–5 – PET taxa richness (edge habitat): 2–5 – SIGNAL index (composite): 3.33–3.85 – SIGNAL index (edge habitat): 3.31–4.20 – % tolerant taxa (composite): 25–50% – % tolerant taxa (edge habitat): 44–56%
Connors River catchment main trunk	Aquatic ecosystem—moderately disturbed	• Native fish species observed/expected (O/E) ratio ≥ 1. Native species found to be present in ≥ 50% of sampling events in main river trunks/channels in this catchment are outlined below (additional native species may also be present) [d]: – *Melanotaenia splendida* – *Nematolosa erebi* – *Amniataba percoides* – *Craterocephalus stercusmuscarum* – *Glossamia aprion* – *Leiopotherapon unicolor* – *Hypseleotris klunzingeri* – *Oxyeleotris lineolatus* – *Strongylura krefftii*

Water area/type (refer plans WQ1301, WQ1310)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV[1-11]
		– *Hypseleotris sp.* – *Scleropages leichardti* Exotic fish species: no increase in number of exotic species relative to current number of exotic species identified in main channel. Current sampled species: – *Hephaestus fuliginosus*
Freshwater lakes/reservoirs	Aquatic ecosystem—moderately disturbed	• ammonia N: <10 µg/L[a] • oxidised N: <10 µg/L[a] • organic N: <330 µg/L[a] • total nitrogen: <350 µg/L[a] • filterable reactive phosphorus (FRP): <5 µg/L[a] • total phosphorus: <10 µg/L[a] • chlorophyll a: <5.0 µg/L[a] • dissolved oxygen: 90%–110% saturation[a] • turbidity: 1–20 NTU[a] • Secchi depth: nd [a] • suspended solids: nd [a] • pH: 6.5–8.0[a] • conductivity (EC) no flow/ baseflow: <250 µS/cm[b]
For ALL fresh waters within this Table	All	Toxicants in water and sediment as per AWQG: • Toxicants in water: 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	Protect or restore riparian areas. Refer section 3.1.2—riparian area WQOs.
Wetlands	Aquatic ecosystem—moderately disturbed	Objectives as per AWQG and section 3.1.2. Note: for activities potentially impacting on wetlands refer to State Planning Policy 4/11: Protecting Wetlands of High Ecological Significance in Great Barrier Catchments, available from the department's website.

Water area/type (refer plans WQ1301, WQ1310)	Management intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV[1-11]
Groundwaters (refer plan WQ1310)		
Groundwaters	Aquatic ecosystem—high ecological value	Where groundwaters interact with surface waters, groundwater quality should not compromise identified EVs and WQOs for those waters. Note: the AWQG recommends that 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 Fitzroy Basin groundwaters are provided according to their chemistry zone (refer plan WQ 1310) and depth category in Table 14[e]. (For some areas there is insufficient information available to establish a WQO for this indicator. Refer to QWQG for details on how to establish a minimum water quality data set for deriving local values.)

Notes:

a) The values for these indicators are based on the QWQG Central Coast regional water quality guidelines. For EC, the values are based on Appendix G of the QWQG.

b) The values for these indicators are based on sub-regional low flow water quality guidelines derived by the department as part of the process to establish EVs and WQOs in the Fitzroy Basin. Refer to 'sources' below for more details.

c) The values for these macroinvertebrate biological indicators are based on the QWQG (2009) Central Coast regional water quality guidelines. They apply to support waters at a moderately disturbed level of protection. Values are provided for 20th and 80th percentiles. The median value of biological indicators at test sites is to be compared and assessed against these values. More details on indicators and derivation of values are in the QWQG. Refer to 'sources' below.

Values are provided for two habitat types: edge (along the streambank) and composite (a mixture of all bed habitats). Taxa richness refers to the number of macroinvertebrate taxa collected in a sample. PET taxa richness refers to the total number of families from three orders of aquatic insects considered to be sensitive to changes in their environment (Plecoptera, Ephemeroptera, Trichoptera). SIGNAL index (stream invertebrate grade number—average level) gives an indication of water quality in the river from which the sample was collected, based on the sensitivity of taxa to water quality change. A higher number indicates greater sensitivity. The % tolerant taxa index was developed to assist in identifying taxa sensitivity to pollution. If a site is experiencing an impact from pollution it is expected that there would be a reduction in the percentage of sensitive taxa collected, and an increase in the percentage of tolerant taxa collected.

d) The fish species in the table are those species sampled/recorded in at least 50 per cent of fish sampling events in this catchment. The biological indicator used is the observed/expected (50) species ratio, where E (the 'expected' number of native species) equates to the number of species listed in the table (those sampled in at least 50 per cent of sampling events) and O is the number of species actually observed. The O/E ratio is used as a summary of ecosystem health on the basis of species composition. A ratio greater than or equal to 1 indicates that the 'expected' number of species have been identified in a sampling procedure. The data for this WQO are applicable for the moderately disturbed level of protection in main trunk stream reaches. Additional species (recorded in less than 50 per cent of samples) have been recorded in these waterways but are not shown in this table. Refer to the department's website for further details.

e) The categorisation of groundwater chemistry zones and derivation of corresponding water quality values are based on the department's groundwater monitoring data and analysis. Refer to 'sources' below for more details.

1. Oxidised N = NO_2 + NO_3. Units for nitrogen indicators are micrograms per litre (µg/L) N.
2. Units for phosphorus indicators are micrograms per litre (µg/L) P.
3. nd = no data, n/a = not applicable for this indicator and water type, ng = no guideline.
4. 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 waterbody 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.
5. 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.
6. Wallum/tannin-stained waters contain naturally high levels of humic acids (and have a characteristic brown ti-tree stain). In these types of waters, natural pH values may range from 3.6 to 6.
7. During flood events or nil flow periods, pH values should not fall below 5.5 (except in wallum/tannin waters) or exceed 9.
8. 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.
9. 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.

10. Conductivity, under natural conditions, is highly dependent on local geology and soil types. Where sufficient data were available, conductivity WQOs have been derived for different catchments in the Fitzroy and are shown in the table. In the absence of sub-regional conductivity WQOs, the Queensland Water Quality Guidelines 2009 (Appendix G) provides information on conductivity values in a set of 18 defined salinity zones throughout Queensland. For each zone, the Queensland Water Quality Guidelines 2009 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.
11. 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.

Sources:

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

- Developing water quality guidelines for the protection of the freshwater aquatic ecosystems in the Fitzroy Basin. Phase 1. (Queensland Government).
- Regional chemistry of the Fitzroy Basin groundwater. (Raymond, M. A. A. and V. H. McNeil, 2011).
- Queensland Water Quality Guidelines. (Queensland Government).
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000).
- Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance. (Australian and New Zealand Environment and Conservation Council, 1997).

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 VM code (and other explanatory information) for waters for this area contact the Department of Natural Resources and Mines.

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 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 on 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 WQ1301, WQ1310)	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 management plan under the Act • ADWG.
Protection of the human consumer	Fresh waters (also 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 cultural and spiritual values	Fresh waters, groundwaters (also 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 (also 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 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.
Suitability for aquaculture	Fresh waters (also 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.

[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 WQ1301, WQ1310)	Water quality objectives to protect EV (refer to specified codes and guidelines for full details)
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 (also 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 • 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.
Suitability for secondary contact recreation	Fresh waters (also estuarine and coastal waters)	Objectives as per NHMRC (2008), including: • intestinal enterococci: 95th percentile ≤ 40 organisms per 100mL (for healthy adults) (NHMRC, 2008; Table 5.7) • cyanobacteria/algae—refer objectives for primary recreation, NHMRC (2008) and Table 12.

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

Environmental value	Water type/area (refer Table 1 and plans WQ1301, WQ1310)	Water quality objectives to protect EV (refer to specified codes and guidelines for full details)
Suitability for visual recreation	Fresh waters (also 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.

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)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000)
- Guidelines for Managing Risks in Recreational Water (NHMRC, 2008).

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).

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 water quality objectives 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 management plan under the Act, and the Australian Drinking Water Guidelines (ADWG, 2011). Objectives are derived following advice from Queensland Health, Office of the Water Supply Regulator, and Fitzroy River Water.

Indicator	Water quality objective (For those objectives expressed as levels under the Hazard and critical control point (HACCP) rating, refer notes 1, 2 for explanation)
Giardia	0 cysts 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 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	No water quality objective specified for *E. coli* in raw water. 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)	5000 cells/mL
Algal toxin	Level 1[1]: >1 µg/L Microcystin Level 2[2]: >10 µg/L Microcystin
Turbidity	Level 1[1]: >500 NTU Level 2[2]: >1000 NTU
Colour	Level 1[1]: 50 Hazen Units No Level 2
pH	6.5–8.5
Total hardness	Level 1[1]: >150 mg/L as $CaCO_3$ Level 2[2]: >200 mg/L
Conductivity	Level 1[1]: > 400 µS/cm Level 2[2]: same as Level 1 (no treatment options to remove salt)
Sodium	Raw water supply: 30 mg/L [3] General: 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): 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.

Indicator	Water quality objective (For those objectives expressed as levels under the Hazard and critical control point (HACCP) rating, refer notes 1, 2 for explanation)
Sulfate	Raw water supply: 200 mg/L[4] The concentration of sulfate in drinking water should not exceed 250 mg/L (ADWG, based on taste/aesthetic considerations).
Dissolved oxygen	Level 1[1]: < 4 mg/L at surface No Level 2[2]
Pesticides	Refer to ADWG
Other indicators (including physico-chemical indicators)	Refer to ADWG

Source: Queensland Health, Fitzroy River Water, Office of Water Supply Regulator, Australian Drinking Water Guidelines (NHMRC, 2011).

Notes:

1. 'Level 1' means Level 1 Hazard and Critical Control Point (HACCP) response rating, namely—treatment plant process change required to ensure water quality and quantity to customers is not compromised.
2. 'Level 2' means Level 2 HACCP response rating, namely—treatment plant process change required but water quality and quantity to customers may still be compromised.
3. The value of 30 mg/L for raw drinking water supply is based on advice from Queensland Health and Fitzroy River Water. Sudden changes in sodium levels impact on medical equipment use, operation and calibration. Queensland Health should be advised of any such changes. The US EPA (2012 Drinking Water Standards and Health Advisories) health based value for sodium is 20 mg/L (for individuals on a 500mg/day restricted sodium diet). The ADWG notes that 50 mg/L is a '*typical value*' in reticulated supplies. The ADWG guideline 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).
4. The value of 200 mg/L for raw drinking water supply is based on discussion with Fitzroy River Water. The ADWG states that an aesthetic guideline value for sulfate is 250 mg/L. A water quality objective of 200 mg/L for raw water is proposed due to the likely addition of sulfate through the use of water treatment chemicals such as aluminium sulfate. Each of these values remains significantly lower than the ADWG health guideline of 500 mg/L for sulfate in drinking water.

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 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 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	>100 mg/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 mg/L			<1 mg/L	<1 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	0–35ppt		5–10 ppt for one 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	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 mg/L	<1 mg/L	<1 mg/L	<1 mg/L	<1 mg/L
Nitrite (NO_2)	<0.2 mg/L	<1 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		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

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

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.

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) (kg/ha)[2]	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	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

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

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.

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

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

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.

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

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

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.

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].
Nodularia spumigena: See NHMRC, Chapter 6 (Cyanobacteria and algae in fresh water) for details.		

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

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):

   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.

   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.

   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.

4 Ways to improve water quality

The following documents are relevant in considering ways to improve water quality in the Fitzroy 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 council websites.

Regional plans, studies

- Fitzroy Basin Association. Central Queensland Strategy for Sustainability—2004 and Beyond (CQSS2), available from the Fitzroy Basin Association.
- Fitzroy Basin Association. Water Quality Improvement Report, 2008, available from the Fitzroy Basin Association.
- Marsden Jacob Associates (2011) The economic and social impacts of protecting the environmental values of the Fitzroy Basin Waters, available on the department's 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, available from the department's website.
- State Planning Policy 4/11: Protecting Wetlands of High Ecological Significance in Great Barrier Catchments, available from the department's website.
- Queensland Water Quality Guidelines, available from the department's website.
- Monitoring and Sampling Manual, available from the department's 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, available from the Cooperative Research Centre for Catchment Hydrology.
- 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, available from the CSIRO.

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 sub-catchments.

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.

Sub-catchment 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
Aquatic ecosystem 'A community of organisms living within or adjacent to water, including riparian or foreshore area.' (EPP (Water), schedule 2) 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 (SEQRWQMS)). 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
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
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. 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 Fitzroy groundwater: water quality objectives (aquatic ecosystem) according to water chemistry zones (refer plan WQ1310)[1-4]

Zone[1]	Depth[2] (±30m)	Percentile[3]	EC[4] (μScm^{-1})	Hardness (mgL^{-1} as $CaCO_3$)[4]	pH	Alkalinity (mgL^{-1})	Ca[4] (mgL^{-1})	Mg[4] (mgL^{-1})	Na[4] (mgL^{-1})	Cl[4] (mgL^{-1})	SO_4[4] (mgL^{-1})	HCO_3[4] (mgL^{-1})	NO_3[4] (mgL^{-1})	SiO_2[4] (mgL^{-1})	F[4] (mgL^{-1})	Fe[4] (mgL^{-1})	Mn[4] (mgL^{-1})	Zn[4] (mgL^{-1})	Cu[4] (mgL^{-1})	SAR[4]	RAH[4] (meqL-1)	EH[4] (mV)
1	Deep	20th	345	109	7.05	171	22	12	63	56	5	208	0.28	45	0.203	0.001	0.010	0.005	0.005	2.55	0.38	-28.40
1	Deep	50th	565	132	7.80	228	29	15	71	82	12	271	2.00	48	0.270	0.010	0.045	0.010	0.010	3.10	1.22	20.50
1	Deep	80th	901	204	8.05	279	41	26	140	113	35	327	3.41	54	0.350	0.195	0.385	0.040	0.030	4.85	2.15	75.00
1	Shallow	20th	490	187	6.70	217	38	21	41	47	5	263	0.10	48	0.150	0.010	0.020	0.000	0.000	1.30	0.17	33.30
1	Shallow	50th	640	243	6.90	280	47	29	81	85	9	341	0.50	54	0.200	0.020	0.085	0.000	0.020	2.30	0.54	38.50
1	Shallow	80th	984	304	7.20	330	59	39	113	144	11	402	0.50	61	0.300	0.060	0.400	0.020	0.030	3.00	1.17	115.10
2	Deep	20th	332	101	6.99	115	24	10	32	22	1	140	0.40	27	0.151	0.000	0.000	0.051	0.000	1.30	0.27	ID
2	Deep	50th	410	121	7.40	135	29	11	36	32	15	163	4.05	32	0.200	0.020	0.010	0.080	0.010	1.50	0.55	ID
2	Deep	80th	493	140	7.90	160	32	14	43	38	22	193	19.75	36	0.239	0.091	0.015	0.138	0.019	1.60	0.64	ID
2	Shallow	20th	559	170	7.50	175	38	17	38	40	6	212	0.00	36	0.229	0.000	0.000	0.011	0.000	1.29	0.00	ID
2	Shallow	50th	892	305	7.70	309	52	41	69	83	19	373	1.30	42	0.270	0.010	0.000	0.085	0.015	1.60	0.10	ID
2	Shallow	80th	1047	375	8.00	371	80	45	75	111	38	450	7.90	48	0.310	0.020	0.039	0.129	0.020	2.00	1.02	ID
3	Deep	20th	660	198	7.60	251	23	28	59	37	8	305	0.00	12	0.100	0.000	0.005	0.010	0.030	1.80	1.04	ID
3	Deep	50th	780	244	7.90	326	34	37	76	52	13	397	0.50	14	0.170	0.010	0.010	0.010	0.030	2.10	1.82	ID
3	Deep	80th	1036	292	8.20	432	48	45	120	80	22	519	0.50	16	0.300	0.020	0.015	0.010	0.030	3.19	2.98	ID
3	Shallow	20th	746	152	7.70	299	19	22	80	53	6	349	0.00	11	0.100	0.000	0.000	ID	ID	2.10	1.87	ID
3	Shallow	50th	858	223	7.90	385	39	36	92	62	14	455	0.50	13	0.105	0.010	0.010	ID	ID	2.60	2.84	ID
3	Shallow	80th	926	316	8.23	441	48	47	132	76	17	538	0.90	15	0.215	0.015	0.010	ID	ID	4.70	3.53	ID
4	Deep	20th	765	152	7.50	250	25	16	76	65	6	325	0.50	31	0.100	0.010	0.010	0.010	0.010	1.70	0.74	ID
4	Deep	50th	938	219	7.70	315	48	31	98	100	13	399	1.00	34	0.105	0.135	0.020	0.010	0.010	2.50	2.09	ID
4	Deep	80th	1243	437	8.00	400	65	67	137	215	20	487	5.35	43	0.200	1.400	0.060	0.010	0.010	4.80	2.69	ID
4	Shallow	20th	625	118	7.81	266	26	13	57	35	6	324	8.14	28	0.028	0.003	0.003	0.020	ID	1.53	0.68	ID
4	Shallow	50th	740	251	7.95	289	48	33	82	51	8	348	22.00	38	0.110	0.020	0.010	0.040	ID	2.30	2.25	ID
4	Shallow	80th	1012	321	8.28	357	52	49	143	100	18	435	27.62	40	0.200	0.044	0.024	0.060	ID	6.56	2.88	ID
5	Deep	20th	914	273	7.73	429	43	39	100	41	20	517	ID	ID	0.183	ID	ID	ID	ID	2.44	0.87	ID
5	Deep	50th	2400	475	7.90	516	55	82	350	381	173	621	ID	ID	0.335	ID	ID	ID	ID	7.10	1.09	ID
5	Deep	80th	4219	594	8.00	591	61	109	684	860	319	713	ID	ID	0.410	ID	ID	ID	ID	12.18	3.78	ID
5	Shallow	20th	633	182	7.39	242	35	23	44	53	5	294	0.38	17	0.127	0.000	0.000	ID	ID	1.09	0.18	ID
5	Shallow	50th	680	286	7.70	280	60	24	68	80	21	342	3.20	23	0.200	0.010	0.070	ID	ID	2.00	1.06	ID

Zone[1]	Depth[2] (±30m)	Percentile[3]	EC[4] (μScm^{-1})	Hardness (mgL^{-1} as $CaCO_3$)[4]	pH	Alkalinity (mgL^{-1})	Ca[4] (mgL^{-1})	Mg[4] (mgL^{-1})	Na[4] (mgL^{-1})	Cl[4] (mgL^{-1})	SO_4[4] (mgL^{-1})	HCO_3[4] (mgL^{-1})	NO_3[4] (mgL^{-1})	SiO_2[4] (mgL^{-1})	F[4] (mgL^{-1})	Fe[4] (mgL^{-1})	Mn[4] (mgL^{-1})	Zn[4] (mgL^{-1})	Cu[4] (mgL^{-1})	SAR[4]	RAH[4] (meqL-1)	EH[4] (mV)
5	Shallow	80th	750	322	7.82	417	75	38	195	137	45	506	9.89	33	1.010	0.020	0.203	ID	ID	6.89	4.00	ID
6	Deep	20th	1100	338	7.67	380	49	53	89	80	19	455	0.09	10	0.100	0.001	0.000	ID	ID	1.80	0.00	ID
6	Deep	50th	1350	499	8.00	500	64	86	97	148	33	580	4.10	20	0.400	0.020	0.010	ID	ID	2.15	1.08	ID
6	Deep	80th	2300	698	8.50	581	108	101	246	426	136	693	9.82	34	0.600	0.058	0.010	ID	ID	4.03	1.80	ID
6	Shallow	20th	650	234	7.50	195	46	27	43	75	10	240	0.50	27	0.110	0.000	0.000	0.000	0.003	1.20	ID	ID
6	Shallow	50th	910	314	7.80	255	58	39	73	123	16	310	1.80	31	0.200	0.010	0.010	0.020	0.020	1.70	ID	ID
6	Shallow	80th	1293	460	8.10	370	76	69	106	181	30	445	4.37	36	0.300	0.030	0.010	0.067	0.050	2.10	ID	ID
7	Deep	20th	744	205	8.30	354	13	40	51	21	5	410	0.18	47	0.110	ID	ID	ID	ID	1.22	1.04	ID
7	Deep	50th	780	293	8.30	390	17	64	55	47	6	463	0.90	50	0.200	ID	ID	ID	ID	1.40	1.93	ID
7	Deep	80th	807	343	8.57	395	19	72	101	56	7	468	2.43	55	0.290	ID	ID	ID	ID	3.11	2.98	ID
8	Deep	20th	31	83	8.20	83	12	11	30	28	16	12	ID	ID	0.100	ID	ID	ID	ID	1.32	0.00	ID
8	Deep	50th	310	99	8.20	99	16	17	31	50	20	119	ID	ID	0.100	ID	ID	ID	ID	1.50	0.00	ID
8	Deep	80th	641	203	8.20	197	52	18	80	111	22	241	ID	ID	0.370	ID	ID	ID	ID	2.40	0.33	ID
9	Deep	20th	18117	4491	6.90	535	353	888	3024	6030	1216	645	0.00	ID	ID	0.037	0.635	ID	ID	18.43	ID	ID
9	Deep	50th	19800	4685	7.10	542	365	920	3091	6870	1240	658	0.55	ID	ID	0.170	1.150	ID	ID	19.50	ID	ID
9	Deep	80th	20372	5074	7.35	618	437	963	3216	6907	1325	671	1.00	ID	ID	8.585	1.455	ID	ID	20.45	ID	ID
9	Shallow	20th	526	139	6.80	106	18	22	47	70	32	126	0.00	19	0.110	0.000	0.000	0.010	0.001	1.63	0.00	ID
9	Shallow	50th	642	165	7.40	129	21	26	65	95	47	157	0.70	22	0.140	0.010	0.010	0.030	0.020	2.20	0.00	ID
9	Shallow	80th	889	243	7.90	182	30	39	91	143	55	210	3.30	30	0.224	0.065	0.010	0.060	0.030	2.48	0.05	ID
10	Deep	20th	475	30	7.80	123	6	2	73	53	2	147	0.22	15	0.074	0.010	0.010	ID	ID	2.68	0.44	ID
10	Deep	50th	800	36	7.80	175	7	5	82	87	9	210	0.50	15	0.200	0.010	0.010	ID	ID	5.90	2.13	ID
10	Deep	80th	1200	366	8.50	383	55	56	173	225	44	462	14.15	55	0.200	0.028	0.010	ID	ID	14.23	2.80	ID
10	Shallow	20th	485	103	6.70	128	20	13	46	64	4	155	0.00	40	0.100	0.000	0.000	0.000	0.000	1.60	0.00	78.90
10	Shallow	50th	739	221	7.30	205	40	28	96	130	8	250	0.50	46	0.200	0.010	0.010	0.010	0.000	2.90	0.00	106.00
10	Shallow	80th	2360	711	7.90	415	109	99	272	578	25	503	4.47	57	0.290	0.045	0.085	0.020	0.030	6.17	0.71	131.40
11	Deep	20th	386	81	7.00	102	18	6	60	68	9	85	ID	18	0.100	ID	0.390	ID	ID	2.10	0.51	ID
11	Deep	50th	569	130	7.80	121	29	10	78	93	17	141	ID	57	0.175	ID	0.405	ID	ID	3.30	0.88	ID
11	Deep	80th	696	146	8.10	169	39	16	108	133	33	165	ID	71	0.500	ID	0.420	ID	ID	5.25	1.57	ID
11	Shallow	20th	0	73	7.50	86	20	6	47	57	7	0	ID	ID	ID	ID	ID	ID	ID	2.40	ID	ID
11	Shallow	50th	625	159	7.65	91	42	13	101	191	17	59	ID	ID	ID	ID	ID	ID	ID	3.35	ID	ID
11	Shallow	80th	1250	244	7.80	96	64	20	155	324	27	117	ID	ID	ID	ID	ID	ID	ID	4.30	ID	ID

Zone[1]	Depth[2] (±30m)	Percentile[3]	EC[4] (μScm^{-1})	Hardness (mgL^{-1} as $CaCO_3$)[4]	pH	Alkalinity (mgL^{-1})	Ca[4] (mgL^{-1})	Mg[4] (mgL^{-1})	Na[4] (mgL^{-1})	Cl[4] (mgL^{-1})	SO_4[4] (mgL^{-1})	HCO_3[4] (mgL^{-1})	NO_3[4] (mgL^{-1})	SiO_2[4] (mgL^{-1})	F[4] (mgL^{-1})	Fe[4] (mgL^{-1})	Mn[4] (mgL^{-1})	Zn[4] (mgL^{-1})	Cu[4] (mgL^{-1})	SAR[4]	RAH[4] (meqL-1)	EH[4] (mV)
12	Deep	20th	1298	212	7.79	552	11	45	172	80	39	660	0.00	ID	0.232	ID	ID	ID	ID	3.91	3.49	ID
12	Deep	50th	1835	266	8.15	782	29	47	304	148	48	933	0.00	ID	0.265	ID	ID	ID	ID	7.95	8.25	ID
12	Deep	80th	2085	467	8.37	867	55	81	430	170	97	1034	0.98	ID	0.361	ID	ID	ID	ID	12.41	12.96	ID
12	Shallow	20th	690	164	7.70	113	26	24	44	13	10	117	ID	ID	0.190	0.000	ID	ID	ID	1.20	ID	ID
12	Shallow	50th	761	219	8.00	237	42	28	77	91	30	277	ID	ID	0.270	0.400	ID	ID	ID	2.45	ID	ID
12	Shallow	80th	832	273	8.30	360	58	31	109	168	50	436	ID	ID	0.350	0.800	ID	ID	ID	3.70	ID	ID
13	Deep	20th	720	136	7.50	262	21	15	75	54	8	315	0.00	18	0.157	0.000	0.000	0.010	0.000	2.00	0.51	ID
13	Deep	50th	1256	326	7.90	355	40	51	139	141	25	429	1.00	37	0.200	0.020	0.010	0.035	0.010	3.50	2.23	ID
13	Deep	80th	1950	540	8.20	560	72	88	279	327	67	673	4.93	56	0.370	0.090	0.040	0.135	0.035	8.96	3.98	ID
13	Shallow	20th	630	145	7.50	249	21	21	56	30	5	295	0.50	28	0.200	0.000	0.000	0.000	0.000	1.60	0.30	ID
13	Shallow	50th	1150	350	8.00	409	40	54	135	110	24	490	3.00	46	0.310	0.010	0.010	0.015	0.010	3.15	1.79	ID
13	Shallow	80th	2509	650	8.30	626	73	119	326	400	125	754	16.39	60	0.594	0.040	0.020	0.050	0.030	7.01	4.08	ID
14	Deep	20th	756	209	7.50	270	24	28	66	68	15	314	0.47	31	0.165	0.000	0.000	0.020	0.001	1.77	0.00	ID
14	Deep	50th	1420	433	7.80	380	64	57	135	147	32	450	2.50	47	0.350	0.000	0.010	0.040	0.020	2.70	0.49	ID
14	Deep	80th	2150	777	8.10	507	129	129	212	382	99	615	6.49	80	0.545	0.020	0.057	0.139	0.050	4.10	1.63	ID
14	Shallow	20th	1006	294	7.50	284	51	36	88	129	29	343	0.50	40	0.200	0.000	0.000	0.010	0.010	2.00	0.00	ID
14	Shallow	50th	1619	458	7.90	377	80	61	164	260	52	454	3.00	69	0.350	0.005	0.000	0.030	0.020	3.20	0.00	ID
14	Shallow	80th	2765	743	8.10	507	125	108	308	604	103	609	13.20	84	0.530	0.030	0.020	0.091	0.050	5.49	1.27	ID
15	Deep	20th	330	74	6.69	67	19	4	19	35	25	61	0.00	11	0.100	0.000	0.049	0.010	ID	0.99	0.00	ID
15	Deep	50th	1200	111	7.45	135	32	12	166	190	110	142	0.35	19	0.180	0.000	0.220	0.060	ID	3.95	0.02	ID
15	Deep	80th	1340	263	8.00	188	57	31	216	290	151	224	3.10	24	0.313	0.018	0.220	0.110	ID	9.33	1.90	ID
15	Shallow	20th	229	50	6.61	74	8	7	33	33	0	91	0.32	15	0.065	ID	ID	ID	ID	1.25	0.24	ID
15	Shallow	50th	1050	464	7.95	280	18	69	56	43	0	262	0.50	28	0.200	ID	ID	ID	ID	2.20	1.00	ID
15	Shallow	80th	1515	500	8.17	525	70	96	133	259	49	632	0.95	38	0.370	ID	ID	ID	ID	3.10	1.29	ID
16	Deep	20th	1859	513	7.80	385	78	76	202	311	45	459	0.58	22	0.260	0.000	0.000	0.028	0.009	3.70	0.00	ID
16	Deep	50th	2000	580	8.00	461	101	81	225	331	89	550	4.60	29	0.300	0.010	0.010	0.650	0.030	4.10	0.00	ID
16	Deep	80th	2285	634	8.30	543	114	86	294	434	130	650	7.32	35	0.489	0.049	0.078	1.183	0.052	5.38	0.79	ID
16	Shallow	20th	1000	310	7.40	194	58	38	86	177	22	235	0.00	28	0.140	0.000	0.000	0.010	0.000	2.00	ID	ID
16	Shallow	50th	1700	527	7.80	335	90	70	165	350	45	405	1.50	35	0.210	0.020	0.010	0.020	0.010	3.10	ID	ID
16	Shallow	80th	2800	810	8.10	476	136	120	310	650	97	570	5.00	41	0.300	0.040	0.040	0.174	0.030	4.90	ID	ID
17	Deep	20th	2370	630	7.42	460	62	108	284	473	105	560	0.73	28	0.443	0.010	0.025	0.010	0.030	4.95	ID	ID

Zone[1]	Depth[2] (±30m)	Percentile[3]	EC[4] (μScm^{-1})	Hardness (mgL^{-1} as $CaCO_3$)[4]	pH	Alkalinity (mgL^{-1})	Ca[4] (mgL^{-1})	Mg[4] (mgL^{-1})	Na[4] (mgL^{-1})	Cl[4] (mgL^{-1})	SO_4[4] (mgL^{-1})	HCO_3[4] (mgL^{-1})	NO_3[4] (mgL^{-1})	SiO_2[4] (mgL^{-1})	F[4] (mgL^{-1})	Fe[4] (mgL^{-1})	Mn[4] (mgL^{-1})	Zn[4] (mgL^{-1})	Cu[4] (mgL^{-1})	SAR[4]	RAH[4] (meqL-1)	EH[4] (mV)
17	Deep	50th	3000	781	7.60	481	90	128	366	620	151	586	10.25	42	0.600	0.015	0.070	0.010	0.030	5.80	ID	ID
17	Deep	80th	4925	908	7.80	576	170	166	540	795	450	702	35.95	48	0.770	0.216	0.214	0.010	0.030	7.80	ID	ID
17	Shallow	20th	414	128	6.55	134	23	16	63	87	5	153	0.00	27	0.101	0.000	0.000	0.010	0.000	2.42	0.00	ID
17	Shallow	50th	900	394	7.20	333	51	57	191	318	31	393	0.90	49	0.250	0.000	0.020	0.010	0.000	4.25	0.00	ID
17	Shallow	80th	2276	945	7.90	622	120	145	563	1052	124	754	3.60	56	0.500	0.056	0.283	0.019	0.009	8.99	0.58	ID
18	Deep	20th	3310	343	7.90	397	13	72	635	532	59	475	1.00	30	0.400	ID	ID	ID	ID	9.80	12.66	ID
18	Deep	50th	4675	989	8.05	690	119	172	790	905	731	818	2.05	31	0.600	ID	ID	ID	ID	12.10	13.03	ID
18	Deep	80th	5900	1628	8.27	1003	215	265	910	1250	1400	1188	3.80	32	0.800	ID	ID	ID	ID	15.38	13.40	ID
18	Shallow	20th	1532	466	7.70	413	43	82	143	191	23	501	1.00	38	0.330	0.005	0.003	ID	ID	2.20	0.00	ID
18	Shallow	50th	2400	696	7.90	582	72	126	190	390	95	690	4.75	50	0.520	0.020	0.010	ID	ID	3.20	0.71	ID
18	Shallow	80th	4440	1230	8.20	683	144	203	521	966	351	813	9.85	59	0.770	0.035	0.020	ID	ID	7.20	1.43	ID
19	Deep	20th	2721	551	7.20	206	74	64	347	690	46	243	0.50	29	0.100	0.010	0.000	0.010	0.000	5.50	0.00	ID
19	Deep	50th	3900	928	7.80	351	137	120	495	1095	100	425	2.50	42	0.140	0.050	0.010	0.010	0.030	7.70	0.00	ID
19	Deep	80th	7200	1643	8.10	449	320	230	1050	2285	296	544	7.00	64	0.210	0.140	0.109	0.020	0.030	11.60	1.85	ID
19	Shallow	20th	2000	577	7.30	180	99	70	170	466	40	217	0.50	32	0.100	0.010	0.000	0.010	0.000	2.90	ID	ID
19	Shallow	50th	3500	1112	7.70	243	180	155	306	890	140	292	2.20	40	0.200	0.050	0.010	0.010	0.030	3.90	ID	ID
19	Shallow	80th	5100	1676	8.00	421	299	225	495	1400	530	506	6.51	53	0.290	0.130	0.050	0.081	0.030	6.00	ID	ID
20	Deep	20th	317	41	7.18	140	9	3	79	75	0	142	0.00	12	0.085	0.001	0.010	ID	ID	4.02	1.02	ID
20	Deep	50th	595	66	7.70	154	12	6	105	100	2	183	0.50	14	0.120	0.015	0.010	ID	ID	5.50	2.00	ID
20	Deep	80th	743	114	8.01	196	24	11	143	164	6	237	1.05	17	0.200	0.030	0.015	ID	ID	7.56	2.58	ID
20	Shallow	20th	90	35	7.25	48	12	1	57	64	0	16	0.03	13	0.170	0.000	0.000	ID	ID	2.53	0.35	ID
20	Shallow	50th	785	91	7.80	186	23	10	132	145	2	218	0.50	17	0.210	0.010	0.020	ID	ID	4.35	1.75	ID
20	Shallow	80th	1195	413	8.11	337	87	46	171	305	29	355	1.93	22	0.330	0.053	0.031	ID	ID	6.60	2.35	ID
21	Deep	20th	217	21	6.60	47	6	1	42	55	0	27	0.00	11	0.100	0.000	0.000	0.100	0.030	2.80	0.10	ID
21	Deep	50th	585	84	7.40	143	20	3	145	170	5	168	0.00	13	0.200	0.020	0.080	0.125	0.045	5.40	2.02	ID
21	Deep	80th	2060	428	7.92	317	126	35	324	572	112	242	1.00	16	0.400	0.495	0.268	0.150	0.060	15.20	3.37	ID
21	Shallow	20th	1033	272	7.40	223	61	30	103	153	16	269	0.00	29	0.157	0.000	0.000	0.020	0.030	2.50	0.00	ID
21	Shallow	50th	2000	522	7.90	345	96	63	237	445	45	416	1.00	37	0.210	0.020	0.010	0.020	0.050	4.10	0.02	ID
21	Shallow	80th	4609	1566	8.20	478	300	200	715	1765	125	570	5.88	44	0.400	0.060	0.224	0.040	0.050	9.00	0.95	ID
22	Deep	20th	1507	433	7.40	365	62	47	161	253	15	438	0.79	27	0.152	0.000	0.000	0.010	0.000	2.70	0.00	ID
22	Deep	50th	2735	830	7.90	570	101	134	275	721	44	655	6.90	41	0.400	0.000	0.000	0.060	0.010	4.25	0.00	ID

Zone[1]	Depth[2] (±30m)	Percentile[3]	EC[4] (μScm^{-1})	Hardness (mgL^{-1} as $CaCO_3$)[4]	pH	Alkalinity (mgL^{-1})	Ca[4] (mgL^{-1})	Mg[4] (mgL^{-1})	Na[4] (mgL^{-1})	Cl[4] (mgL^{-1})	SO_4[4] (mgL^{-1})	HCO_3[4] (mgL^{-1})	NO_3[4] (mgL^{-1})	SiO_2[4] (mgL^{-1})	F[4] (mgL^{-1})	Fe[4] (mgL^{-1})	Mn[4] (mgL^{-1})	Zn[4] (mgL^{-1})	Cu[4] (mgL^{-1})	SAR[4]	RAH[4] (meqL-1)	EH[4] (mV)
22	Deep	80th	5276	1861	8.10	636	181	283	809	1973	218	775	16.29	57	0.697	0.010	0.030	0.695	0.050	12.36	2.20	ID
22	Shallow	20th	1403	367	7.20	245	60	41	145	218	30	295	0.00	35	0.163	0.000	0.000	0.010	0.000	3.00	0.00	ID
22	Shallow	50th	2220	591	7.70	360	105	76	240	475	61	439	1.30	45	0.300	0.000	0.010	0.020	0.010	4.40	0.00	ID
22	Shallow	80th	3722	1001	8.00	510	175	145	420	979	95	610	9.20	64	0.560	0.050	0.100	0.080	0.037	6.93	1.01	ID
23	Deep	20th	2496	350	7.51	233	50	55	312	553	42	282	0.00	20	0.149	0.014	0.000	ID	ID	5.50	0.00	ID
23	Deep	50th	3465	1098	7.80	463	138	165	587	851	100	565	0.00	47	0.370	0.040	0.025	ID	ID	10.45	0.73	ID
23	Deep	80th	7450	1621	7.99	618	260	244	1106	1930	520	753	2.25	54	1.020	0.382	0.340	ID	ID	13.00	10.83	ID
23	Shallow	20th	3333	461	7.60	445	51	70	501	558	50	543	0.00	13	0.680	0.006	0.020	ID	ID	5.71	1.83	ID
23	Shallow	50th	3850	793	7.75	650	100	140	561	750	95	793	0.50	21	0.800	0.035	0.035	ID	ID	8.40	2.85	ID
23	Shallow	80th	4506	1146	8.45	903	223	185	599	989	832	1091	1.65	48	1.200	0.085	0.176	ID	ID	14.36	9.36	ID
24	Shallow	20th	1790	559	7.90	360	73	88	194	328	45	433	0.09	36	0.480	0.000	0.000	ID	ID	3.84	ID	ID
24	Shallow	50th	3140	762	8.00	402	126	109	350	605	160	485	7.30	52	0.650	0.000	0.010	ID	ID	5.50	ID	ID
24	Shallow	80th	6908	1400	8.23	601	176	234	1151	1935	318	729	12.76	62	1.060	0.015	0.025	ID	ID	15.39	ID	ID
25	Deep	20th	791	15	7.90	301	4	1	159	67	11	358	0.00	17	0.150	0.000	0.000	0.012	0.000	5.50	2.46	ID
25	Deep	50th	1037	40	8.35	332	10	3	198	96	20	391	0.00	19	0.260	0.000	0.000	0.030	0.000	14.15	5.32	ID
25	Deep	80th	1345	229	8.50	457	30	41	263	178	38	544	0.60	37	0.379	0.100	0.020	0.507	0.000	23.80	6.07	ID
25	Shallow	20th	685	49	7.70	251	11	5	68	37	6	300	0.20	19	0.190	0.000	0.000	ID	ID	1.83	0.84	ID
25	Shallow	50th	1085	171	7.90	350	27	22	142	118	10	421	2.20	28	0.300	0.010	0.010	ID	ID	4.70	3.90	ID
25	Shallow	80th	1420	370	8.19	579	59	55	267	194	48	630	8.62	34	0.400	0.020	0.020	ID	ID	15.47	6.70	ID
26	Deep	20th	450	13	7.38	197	4	1	111	27	0	208	0.91	10	0.500	0.000	0.000	ID	ID	10.15	3.39	ID
26	Deep	50th	550	18	8.00	240	4	2	128	58	0	256	1.00	12	0.600	0.000	0.000	ID	ID	12.95	4.18	ID
26	Deep	80th	667	38	8.20	254	9	4	159	89	5	303	2.00	14	0.600	0.000	0.000	ID	ID	15.39	4.69	ID
27	Deep	20th	158	4	6.90	63	1	0	32	9	0	70	0.00	12	0.100	0.010	0.000	0.000	0.010	3.93	1.15	ID
27	Deep	50th	210	8	7.50	91	2	1	45	12	0	103	0.00	13	0.200	0.040	0.010	0.010	0.010	7.70	1.64	ID
27	Deep	80th	297	24	7.90	151	7	1	68	36	2	142	0.50	14	0.300	0.245	0.030	0.020	0.030	10.34	2.35	ID
27	Shallow	20th	177	4	7.13	79	1	0	38	7	0	94	0.00	11	0.159	0.007	0.007	0.000	0.003	4.80	1.50	ID
27	Shallow	50th	215	5	7.40	99	2	0	45	8	1	120	0.00	12	0.200	0.010	0.010	0.005	0.010	8.20	1.76	ID
27	Shallow	80th	284	24	7.97	144	9	1	66	10	2	170	0.50	14	0.238	0.023	0.013	0.010	0.024	9.25	2.00	ID
28	Deep	20th	308	24	7.10	74	5	3	28	32	0	85	0.00	13	0.100	0.010	0.010	0.010	0.030	1.89	0.83	ID
28	Deep	50th	425	45	7.80	156	9	5	73	45	2	186	0.50	15	0.200	0.010	0.010	0.020	0.030	4.60	2.25	ID
28	Deep	80th	723	66	8.20	219	16	9	128	74	5	257	0.50	17	0.230	0.040	0.210	0.030	0.045	9.73	3.54	ID

Zone[1]	Depth[2] (±30m)	Percentile[3]	EC[4] (μScm^{-1})	Hardness (mgL^{-1} as $CaCO_3$)[4]	pH	Alkalinity (mgL^{-1})	Ca[4] (mgL^{-1})	Mg[4] (mgL^{-1})	Na[4] (mgL^{-1})	Cl[4] (mgL^{-1})	SO_4[4] (mgL^{-1})	HCO_3[4] (mgL^{-1})	NO_3[4] (mgL^{-1})	SiO_2[4] (mgL^{-1})	F[4] (mgL^{-1})	Fe[4] (mgL^{-1})	Mn[4] (mgL^{-1})	Zn[4] (mgL^{-1})	Cu[4] (mgL^{-1})	SAR[4]	RAH[4] (meqL-1)	EH[4] (mV)
28	Shallow	20th	300	22	7.10	73	4	3	28	42	0	85	0.00	15	0.114	0.000	0.010	0.000	0.000	2.20	0.19	ID
28	Shallow	50th	615	51	7.70	196	9	6	128	57	2	230	0.50	17	0.200	0.020	0.010	0.010	0.005	5.50	2.80	ID
28	Shallow	80th	1644	261	8.20	416	30	32	252	241	11	495	0.50	25	0.400	0.093	0.096	0.019	0.019	13.50	4.91	ID
29	Deep	20th	689	8	7.60	187	2	0	186	115	0	136	0.00	12	0.100	0.000	0.000	0.000	0.000	13.52	2.13	ID
29	Deep	50th	1200	17	8.10	301	5	1	286	178	5	317	0.00	15	0.300	0.000	0.010	0.000	0.010	32.30	4.92	ID
29	Deep	80th	2205	108	8.60	500	29	8	568	600	23	568	1.00	18	1.000	0.068	0.030	0.010	0.030	51.49	9.36	ID
29	Shallow	20th	890	9	7.60	231	3	0	201	129	0	252	0.00	12	0.100	0.000	0.000	ID	ID	15.60	2.62	ID
29	Shallow	50th	1565	25	8.30	358	8	2	348	220	16	347	0.60	14	0.400	0.000	0.010	ID	ID	30.40	5.82	ID
29	Shallow	80th	2515	138	8.50	517	35	11	530	653	38	586	7.28	18	0.917	0.040	0.040	ID	ID	48.21	9.58	ID
30	Deep	20th	530	15	7.85	164	4	1	95	45	2	179	0.00	ID	0.079	ID	ID	ID	ID	5.05	2.74	ID
30	Deep	50th	665	65	8.15	243	8	10	113	60	12	296	0.00	ID	0.200	ID	ID	ID	ID	9.30	3.16	ID
30	Deep	80th	960	106	8.70	290	19	16	173	75	66	354	0.09	ID	0.300	ID	ID	ID	ID	12.15	4.17	ID
30	Shallow	20th	536	17	7.56	232	5	1	119	25	9	269	0.00	21	0.009	ID	ID	ID	ID	5.37	3.99	ID
30	Shallow	50th	1030	45	8.30	309	8	6	169	81	16	350	0.80	26	0.100	ID	ID	ID	ID	11.30	4.25	ID
30	Shallow	80th	1689	242	8.71	454	31	40	298	278	41	549	6.70	46	0.264	ID	ID	ID	ID	18.83	8.25	ID
31	Deep	20th	2151	79	7.70	357	9	14	375	414	0	412	0.00	15	0.100	ID	0.000	0.000	0.000	9.10	2.86	ID
31	Deep	50th	3150	198	7.95	575	27	28	589	554	10	683	0.50	17	0.105	ID	0.005	0.015	0.015	20.10	5.85	ID
31	Deep	80th	3540	610	8.20	632	70	106	734	954	64	763	2.44	47	0.380	ID	0.010	0.382	0.103	25.59	9.87	ID
31	Shallow	20th	874	107	7.51	342	13	18	200	34	12	406	0.50	54	0.187	0.000	0.000	0.000	0.000	5.23	0.72	ID
31	Shallow	50th	2450	296	8.00	594	37	55	481	565	72	710	2.50	71	0.450	0.010	0.010	0.010	0.010	11.55	4.67	ID
31	Shallow	80th	4200	649	8.30	805	80	107	805	951	152	956	8.19	90	0.715	0.050	0.030	0.033	0.030	17.20	9.90	ID
32	Deep	20th	0	14	7.60	165	3	1	360	185	0	0	0.00	13	0.200	0.000	0.000	0.007	0.000	32.07	2.43	ID
32	Deep	50th	2050	49	8.10	351	11	4	700	830	4	284	0.10	16	0.600	0.035	0.010	0.010	0.010	51.90	6.48	ID
32	Deep	80th	5165	156	8.60	605	46	12	1802	2476	34	628	2.64	19	1.195	0.200	0.033	0.230	0.033	77.96	11.56	ID
32	Shallow	20th	371	26	7.40	172	7	2	144	130	0	100	0.00	10	0.165	0.000	0.000	ID	0.000	5.67	1.17	ID
32	Shallow	50th	1440	105	7.95	237	28	8	508	385	6	275	0.00	15	0.400	0.060	0.000	ID	0.005	40.55	3.90	ID
32	Shallow	80th	6040	277	8.40	493	74	30	1868	2780	21	590	1.00	20	0.769	2.350	0.020	ID	0.010	61.89	9.14	ID
33	Deep	20th	0	247	7.27	144	53	0	401	405	2	0	0.11	9	0.100	0.007	0.000	ID	ID	8.27	0.00	ID
33	Deep	50th	6310	469	7.60	233	114	30	1420	2181	11	174	1.05	13	0.300	0.055	0.010	ID	ID	27.50	0.02	ID
33	Deep	80th	8712	734	8.22	574	263	62	2095	3286	96	391	8.70	33	0.601	0.292	0.050	ID	ID	38.70	4.12	ID
33	Shallow	20th	878	221	7.30	256	46	22	126	135	2	307	0.00	23	0.100	0.010	0.000	0.010	0.030	3.60	0.00	ID

Zone[1]	Depth[2] (±30m)	Percentile[3]	EC[4] (μScm^{-1})	Hardness (mgL^{-1} as $CaCO_3$)[4]	pH	Alkalinity (mgL^{-1})	Ca[4] (mgL^{-1})	Mg[4] (mgL^{-1})	Na[4] (mgL^{-1})	Cl[4] (mgL^{-1})	SO_4[4] (mgL^{-1})	HCO_3[4] (mgL^{-1})	NO_3[4] (mgL^{-1})	SiO_2[4] (mgL^{-1})	F[4] (mgL^{-1})	Fe[4] (mgL^{-1})	Mn[4] (mgL^{-1})	Zn[4] (mgL^{-1})	Cu[4] (mgL^{-1})	SAR[4]	RAH[4] (meqL-1)	EH[4] (mV)
33	Shallow	50th	3700	645	7.80	499	97	94	610	1169	62	600	2.00	29	0.200	0.030	0.045	0.020	0.050	8.70	0.93	ID
33	Shallow	80th	12158	1964	8.20	785	345	293	2944	4061	416	933	5.25	40	0.395	0.200	0.970	0.035	0.090	25.22	3.64	ID
34	Deep	20th	3419	359	7.40	156	46	35	480	753	25	188	0.01	16	0.020	0.000	0.000	0.010	0.017	10.50	0.00	ID
34	Deep	50th	6100	919	7.80	275	145	115	1100	1900	138	330	2.15	25	0.155	0.050	0.050	0.025	0.030	15.60	0.24	ID
34	Deep	80th	16000	3208	8.03	536	442	491	2565	5905	398	650	14.92	36	0.400	0.246	0.291	0.317	0.030	24.65	6.25	ID
34	Shallow	20th	498	163	7.10	154	18	27	135	171	12	187	0.00	21	0.100	0.000	0.000	0.000	0.000	4.37	0.00	ID
34	Shallow	50th	2150	674	7.75	435	84	108	747	1309	140	536	0.95	36	0.280	0.030	0.010	0.015	0.010	10.85	0.00	ID
34	Shallow	80th	8910	2228	8.10	752	215	389	1500	3185	318	878	5.30	52	0.500	0.140	0.160	0.060	0.030	18.21	2.30	ID
35	Deep	20th	4103	401	7.37	92	33	45	465	1079	0	126	0.00	9	0.060	0.000	0.010	0.010	0.000	16.51	0.00	ID
35	Deep	50th	9375	1216	7.60	189	146	204	1750	3316	20	268	0.10	18	0.300	0.010	0.040	0.140	0.005	21.20	0.05	ID
35	Deep	80th	13604	1905	8.01	311	366	226	2555	5368	122	376	0.50	76	0.500	0.047	2.495	0.270	0.010	28.31	1.91	ID
35	Shallow	20th	84	37	7.59	122	6	3	59	54	5	42	0.15	43	0.100	ID	ID	ID	ID	1.99	0.48	ID
35	Shallow	50th	870	124	7.60	320	14	27	113	86	11	333	1.40	68	0.200	ID	ID	ID	ID	4.15	2.40	ID
35	Shallow	80th	1983	430	7.93	556	81	58	256	392	25	646	9.60	72	0.500	ID	ID	ID	ID	9.72	4.92	ID
36	Deep	20th	3475	288	8.21	460	23	44	520	793	84	541	0.65	32	0.310	0.020	0.020	ID	ID	9.39	4.34	ID
36	Deep	50th	4150	354	8.30	572	45	74	830	1000	115	640	2.00	43	0.400	0.020	0.020	ID	ID	19.20	13.40	ID
36	Deep	80th	7255	619	8.66	1322	75	106	1748	1945	210	1549	2.90	81	1.120	0.047	0.047	ID	ID	45.12	22.45	ID
36	Shallow	20th	3100	323	7.70	316	42	46	590	610	2	372	1.00	25	0.285	0.020	0.020	ID	ID	13.00	1.83	ID
36	Shallow	50th	6300	363	7.80	600	53	56	1404	1885	5	732	4.25	43	0.300	0.020	0.045	ID	ID	26.80	6.84	ID
36	Shallow	80th	7410	528	8.35	843	105	72	1511	2373	120	1021	7.50	60	0.390	0.020	0.070	ID	ID	34.95	10.60	ID
37	Shallow	20th	544	169	7.53	154	27	22	82	83	15	186	0.15	41	0.219	0.000	0.007	ID	ID	3.53	0.00	ID
37	Shallow	50th	3400	428	8.00	318	57	64	430	300	92	380	0.80	59	0.600	0.020	0.010	ID	ID	6.20	1.35	ID
37	Shallow	80th	4418	841	8.10	680	114	137	807	1110	293	811	37.77	79	1.547	0.335	0.029	ID	ID	13.95	3.32	ID
38	Deep	20th	1333	217	7.66	273	21	38	125	133	17	332	0.00	19	0.200	0.005	0.000	0.010	0.010	2.60	0.00	ID
38	Deep	50th	1675	430	8.10	540	50	74	246	314	31	630	0.50	27	0.400	0.020	0.010	0.015	0.020	4.95	0.95	ID
38	Deep	80th	2450	561	8.57	580	61	105	355	423	70	695	3.23	39	0.710	0.035	0.015	0.020	0.030	9.55	2.94	ID
38	Shallow	20th	693	230	7.30	135	48	24	53	130	20	165	0.23	18	0.100	0.000	0.000	0.000	0.000	1.40	ID	ID
38	Shallow	50th	1050	357	7.70	187	72	41	81	200	36	225	0.80	26	0.160	0.015	0.010	0.030	0.010	1.95	ID	ID
38	Shallow	80th	1610	491	8.10	295	97	58	156	320	106	352	1.97	33	0.250	0.030	0.020	0.314	0.050	3.30	ID	ID
39	Deep	20th	665	437	7.85	427	7	89	31	66	8	513	1.20	79	0.045	0.000	ID	0.000	0.000	0.50	0.00	ID
39	Deep	50th	1270	710	8.30	693	7	169	32	69	10	817	1.40	80	0.080	0.000	ID	0.060	0.030	0.50	0.00	ID

Zone[1]	Depth[2] (±30m)	Percentile[3]	EC[4] (μScm^{-1})	Hardness (mgL^{-1} as $CaCO_3$)[4]	pH	Alkalinity (mgL^{-1})	Ca[4] (mgL^{-1})	Mg[4] (mgL^{-1})	Na[4] (mgL^{-1})	Cl[4] (mgL^{-1})	SO_4[4] (mgL^{-1})	HCO_3[4] (mgL^{-1})	NO_3[4] (mgL^{-1})	SiO_2[4] (mgL^{-1})	F[4] (mgL^{-1})	Fe[4] (mgL^{-1})	Mn[4] (mgL^{-1})	Zn[4] (mgL^{-1})	Cu[4] (mgL^{-1})	SAR[4]	RAH[4] (meqL-1)	EH[4] (mV)
39	Deep	80th	1422	773	8.55	705	31	182	59	143	20	819	5.30	87	0.285	0.030	ID	0.120	0.060	1.40	0.14	ID
39	Shallow	20th	1314	515	7.45	456	14	114	63	129	16	540	0.50	61	0.100	0.000	0.000	0.000	0.010	1.10	0.00	ID
39	Shallow	50th	1646	679	7.90	493	31	135	126	247	26	581	2.10	71	0.155	0.005	0.000	0.030	0.020	2.25	0.00	ID
39	Shallow	80th	2725	889	8.40	579	61	190	255	653	41	701	3.61	86	0.300	0.010	0.020	0.088	0.020	3.85	0.02	ID
40	Deep	20th	805	185	4.05	0	30	24	58	76	256	0	0.00	15	0.139	0.000	0.462	ID	ID	1.51	ID	ID
40	Deep	50th	1363	438	4.45	62	86	54	85	147	473	0	0.25	16	0.265	0.000	1.200	ID	ID	2.35	ID	ID
40	Deep	80th	1616	556	6.81	123	112	69	128	188	505	104	1.27	27	0.398	0.018	1.209	ID	ID	2.77	ID	ID
41	Deep	20th	974	251	7.15	206	46	33	74	53	18	251	0.85	12	0.160	0.000	0.000	0.010	0.000	1.42	0.02	ID
41	Deep	50th	1356	434	7.50	417	92	49	129	132	91	502	1.45	40	0.330	0.000	0.010	0.030	0.015	2.55	0.22	ID
41	Deep	80th	1656	574	8.13	451	132	60	152	216	192	543	24.06	45	0.403	0.000	0.041	0.491	0.058	3.19	1.55	ID
41	Shallow	20th	1611	611	7.30	111	116	74	100	193	252	132	0.50	30	0.100	0.010	0.000	0.010	0.000	1.70	ID	ID
41	Shallow	50th	2020	797	7.70	159	160	98	150	335	465	190	1.60	34	0.100	0.040	0.010	0.010	0.010	2.30	ID	ID
41	Shallow	80th	2600	979	7.90	246	205	120	205	520	580	293	5.23	43	0.200	0.070	0.010	0.045	0.030	3.10	ID	ID
42	Deep	20th	8080	1239	7.01	320	176	189	1376	2517	181	383	2.50	40	0.100	0.037	0.100	ID	ID	14.50	ID	ID
42	Deep	50th	11500	2310	8.00	369	315	312	1610	4020	185	450	3.75	43	0.200	0.190	0.105	ID	ID	16.30	ID	ID
42	Deep	80th	12220	2401	8.18	403	437	364	1781	4227	325	477	5.00	45	0.300	0.208	0.110	ID	ID	17.47	ID	ID
42	Shallow	20th	465	101	6.66	108	19	13	40	57	15	132	0.00	30	0.100	0.000	0.007	ID	ID	1.50	0.01	ID
42	Shallow	50th	560	133	7.00	134	22	19	157	219	34	162	0.20	33	0.130	0.000	0.120	ID	ID	6.00	0.16	ID
42	Shallow	80th	1738	2552	7.61	400	294	424	2473	5005	332	485	0.71	37	0.195	0.029	0.260	ID	ID	18.95	2.82	ID
43	Deep	20th	3460	511	7.70	393	48	96	617	690	58	474	0.00	14	0.047	0.019	0.000	ID	ID	7.30	0.00	ID
43	Deep	50th	5500	1360	8.20	442	184	217	748	1510	181	527	0.00	16	0.100	0.190	0.000	ID	ID	9.65	3.04	ID
43	Deep	80th	7720	3050	8.40	954	368	436	1259	3616	362	1113	0.94	46	0.310	0.856	0.054	ID	ID	14.40	12.38	ID
43	Shallow	20th	2725	307	7.09	291	29	56	537	446	60	351	0.00	23	0.194	0.000	0.000	0.010	0.000	9.77	0.00	ID
43	Shallow	50th	6300	978	7.80	544	118	123	712	960	121	633	3.00	56	0.350	0.010	0.010	0.030	0.010	14.40	0.00	ID
43	Shallow	80th	15495	5051	8.20	841	480	856	2628	6492	387	989	25.89	94	0.910	0.115	3.755	0.115	0.090	18.73	10.37	ID
44	Deep	20th	7380	1706	7.50	146	114	268	962	2385	207	176	4.61	17	0.056	0.100	0.000	ID	ID	9.64	ID	ID
44	Deep	50th	13500	2505	7.70	345	358	438	2075	4875	395	418	12.40	27	0.100	0.155	0.100	ID	ID	14.40	ID	ID
44	Deep	80th	17350	5443	7.90	663	1250	567	3450	6430	833	792	18.50	44	0.200	0.240	0.815	ID	ID	21.10	ID	ID
44	Shallow	20th	3900	736	7.47	270	37	142	438	996	67	322	0.00	10	0.100	0.000	0.000	0.020	0.000	6.80	ID	ID
44	Shallow	50th	7235	1287	7.80	540	110	280	1200	2140	223	645	1.30	35	0.200	0.050	0.060	0.340	0.015	14.30	ID	ID
44	Shallow	80th	12175	2558	8.30	813	288	435	2250	4000	478	960	10.00	45	0.400	0.260	0.413	2.688	0.063	20.35	ID	ID

Source: Regional chemistry of the Fitzroy Basin groundwater. (Raymond, M. A. A. and V. H. McNeil, 2011).

Notes:

1. Refer to plan WQ1310 to locate the relevant chemistry zone.
2. Within each chemistry zone, groundwater quality values are provided for two depths (shallow <30m, and deep >30m).
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, ID: insufficient data to perform statistical summaries, or the parameter was not tested.