Environmental Protection (Water and Wetland Biodiversity) Policy 2019

Johnstone River Basin
Environmental Values and Water Quality Objectives

basins 112 and adjacent coastal waters

Queensland Government

Prepared by: Environmental Policy and Planning Division, Department of Environment and Science

October 2020

Addendum Contents

Addendum Tables

October 2020 Amendments: Johnstone River Basin

1 Introduction

This amendment document (October 2020) is made pursuant to the Environmental Protection (Water and Wetland Biodiversity) Policy 2019, and applies to all Wet Tropics schedule 1 documents, scheduled in 2014.

Section 13 (2) (b) of the EPP (Water and Wetland Biodiversity), and section 1.6 (Matters for amendment) of the respective schedule documents outline permissible amendment types. These include changes to water quality objectives (WQOs); changes to water type boundaries/descriptions; updates to information/data sources, websites and email contact details, agency/departmental names, other institutional names, references.

Table 1 summarises the 2020 amendments. Table 2 provides updated aquatic ecosystem WQOs. Section 3 provides updated human use WQOs. Aside from the changes below, the content from 2014 remains applicable.

Table 1 Summary of amendments

2014 content	2020 amended content
Table 2.1 Water quality objectives for physico-chemical, nutrient, algal and water clarity indicators to protect the aquatic ecosystems EVs under baseflow conditions (Coastal, Midshelf and Offshore Waters only)	Table 2 Aquatic ecosystem water quality objectives: coastal and marine waters, replaces Table 2.1 for coastal and marine waters.
Table 2.3 Water quality objectives for specific pesticides and biocides to protect aquatic ecosystem EVs	ANZG, 2018, replaces Table 2.3
Table 2.4 Water quality objectives for other ions, metals and chemical indicators in surface waters	Wet Tropics basins schedule documents (excluding Barron River Basin): ANZG, 2018, replaces Table 2.4
AWQG or ANZECC guidelines Australian and New Zealand Guidelines for Fresh and Marine Water Quality (October 2000)	Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018), as amended.
Monitoring and Sampling Manual 2009	Monitoring and Sampling Manual 2018, as amended. Published on the department's website.
All legislative references	Refer to the latest version under the *Acts Interpretation Act, 1954*, as amended
Wet Tropics Coastal waters plan WQ1082	Revised coastal waters plan WQ1082 (available from the department's website)
Section 3.3 Water quality objectives for human use environmental values (including tables 3.1-3.10)	Section 3 Water quality objectives for human use environmental values (including tables 3-12)

2 Amendments

WET TROPICS COASTAL WATERS - AQUATIC ECOSYSTEM WQOs AMENDMENTS 2020

Applying to enclosed coastal, open coastal, midshelf and offshore marine waters of all Wet Tropics basins. Refer accompanying plan, WQ1082.

Table 2 Aquatic ecosystem water quality objectives: coastal and marine waters

Water area/type (Source: s1–s6) (refer plan WQ1082)	Management intent /Level of protection	WET TROPICS - COASTAL AND MARINE WATERS (refer plan WQ1082) Aquatic Ecosystem water quality objectives [1–7]															
		Note: WQGs for indicators are shown as a range of 20th, 50th and 80th percentiles to be maintained or achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value (e.g. <15). For single value WQOs, medians (or means where specified) of test data are compared against the WQO (refer to 'Note 7: comparison of test data with WQOs' for more details). HEV – high ecological value; SD – slightly disturbed; MD – moderately disturbed. Refer to accompanying plans for details; ID – insufficient data Sources: S1: Local datasets/reporting; S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or AIMS Long Term Monitoring Program datasets; S5: ANZG (2018); S6: CSIRO aluminium studies (Golding et al., 2015)														
		Amm N[1] (µg/L)	**Oxid N[1]** (µg/L)	**Partic N[5]** (µg/L)	**Total Diss N** (µg/L)	**Total N** (µg/L)	**FRP** (µg/L)	**Partic P[5]** (µg/L)	**Total Diss P** (µg/L)	**Total P** (µg/L)	**Chl-a[5]** (µg/L)	**Silicate** (µg/L)	**DO[3]** (% sat)	**Turb** (NTU)	**Secchi** (m)	**SS[2, 5]** (mg/L)	**pH**
WET TROPICS ENCLOSED COASTAL/LOWER ESTUARY WATERS – All WET TROPICS BASINS																	
WET TROPICS HEV and SD enclosed coastal/ lower estuary waters HEV3001, HEV3041, HEV3061, HEV3081, HEV3121 SD3041, SD3081, SD3121 (s2)	**HEV**	7–10–15 (s2)	2–3–10 (s2)	ID	na	95–115–160 (s2)	2–3–5 (s2)	ID	na	9–13–20 (s2)	0.7–1.1–2.0 (s2)	na	85–105 (s2)	1–4–10 (s2)	1–1.6–2.2 (s2)	ID	7.5–8.4 (s2)
WET TROPICS MD enclosed coastal/ lower estuary waters not identified as HEV or SD (s2)	**MD**	<15 (s2)	<10 (s2)	ID	na	<160 (s2)	<5 (s2)	ID	na	<20 (s2)	<2 (s2)	na	85–105 (s2)	<10 (s2)	>1 (s2)	ID	7.5–8.4 (s2)

Water area/type (Source: s1–s6) (refer plan WQ1082)	Management intent /Level of protection	WET TROPICS - COASTAL AND MARINE WATERS (refer plan WQ1082) Aquatic Ecosystem water quality objectives [1–7]															
		Note: WQGs for indicators are shown as a range of 20th, 50th and 80th percentiles to be maintained or achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value (e.g. <15). For single value WQOs, medians (or means where specified) of test data are compared against the WQO (refer to 'Note 7: comparison of test data with WQOs' for more details). HEV – high ecological value; SD – slightly disturbed; MD – moderately disturbed. Refer to accompanying plans for details; ID – insufficient data Sources: S1: Local datasets/reporting; S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or AIMS Long Term Monitoring Program datasets; S5: ANZG (2018); S6: CSIRO aluminium studies (Golding et al., 2015)														
		Amm N[1] (µg/L)	**Oxid N[1]** (µg/L)	**Partic N[5]** (µg/L)	**Total Diss N** (µg/L)	**Total N** (µg/L)	**FRP** (µg/L)	**Partic P[5]** (µg/L)	**Total Diss P** (µg/L)	**Total P** (µg/L)	**Chl-a[5]** (µg/L)	**Silicate** (µg/L)	**DO[3]** (% sat)	**Turb** (NTU)	**Secchi** (m)	**SS[2, 5]** (mg/L)	**pH**
WET TROPICS OPEN COASTAL WATERS – ALL BASINS EXCEPT HERBERT RIVER BASIN (refer separate row below)																	
WET TROPICS HEV and SD open coastal waters HEV3121, SD3121 (EXCLUDES Herbert Palm Island Group) (s2, s3, s4)	**HEV**	≤2 (s4)	0.07–0.35– 1.15 (s4)	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet:≤25 (Nov-Apr) (s3, s4)	50–80–100 (s4)	65-100-125 (s4)	0–2–3 (s4)	≤2.8 (ann. mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	3–6–10 (s4)	5–11–20 (s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3, s4)	90–165–260 (s4)	95–105 (s2)	0.6–0.9–1.8 (s3, s4)	≥10 (ann. mean) (s3)	≤2 (ann. mean) Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3, s4)	8.1–8.4 (s2)
WET TROPICS Open coastal waters not identified as HEV or SD (EXCLUDES Herbert Palm Island Group) (s2, s3, s4)	**SMD mapped as MD**	≤2 (s4)	≤0.35 (s4)	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet:≤25 (Nov-Apr) (s3, s4)	≤80 (s4)	≤100 (s4)	≤2 (s4)	≤2.8 (ann. mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	≤6 (s4)	≤11 (s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3, s4)	≥165 (s4)	95–105 (s2)	≤1 (s3, s4)	≥10 (ann. mean) (s3)	≤2 (ann. mean) Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3, s4)	8.1–8.4 (s2)
WET TROPICS OPEN COASTAL WATERS – HERBERT RIVER BASIN (Palm Island Group)																	
HERBERT - PALM ISLAND GROUP HEV and SD open coastal waters HEV3124, SD3124 (s2, s3, s4)	**HEV/SD**	≤3 (s4)	0.14–0.28–1.70 (s4)	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet: ≤25 (Nov-Apr) (s3, s4)	55–75–95 (s4)	70–100–125 (s4)	0–2–4 (s4)	≤2.8 (ann. mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	3–6–10 (s4)	7–11–20 (s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3,s4)	90–165–260 (s4)	95–105 (s2)	0.6–0.8–1.3 (s3, s4)	≥10 (ann. mean) (s3)	≤2 (ann. mean) Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3, s4)	8.1–8.4 (s2)

Water area/type (Source: s1–s6) (refer plan WQ1082)	Management intent /Level of protection	WET TROPICS - COASTAL AND MARINE WATERS (refer plan WQ1082) Aquatic Ecosystem water quality objectives [1–7]															
		Note: WQGs for indicators are shown as a range of 20th, 50th and 80th percentiles to be maintained or achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value (e.g. <15). For single value WQOs, medians (or means where specified) of test data are compared against the WQO (refer to 'Note 7: comparison of test data with WQOs' for more details). HEV – high ecological value; SD – slightly disturbed; MD – moderately disturbed. Refer to accompanying plans for details; ID – insufficient data Sources: S1: Local datasets/reporting; S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or AIMS Long Term Monitoring Program datasets; S5: ANZG (2018); S6: CSIRO aluminium studies (Golding et al., 2015)														
		Amm N[1] (µg/L)	**Oxid N[1]** (µg/L)	**Partic N[5]** (µg/L)	**Total Diss N** (µg/L)	**Total N** (µg/L)	**FRP** (µg/L)	**Partic P[5]** (µg/L)	**Total Diss P** (µg/L)	**Total P** (µg/L)	**Chl-a[5]** (µg/L)	**Silicate** (µg/L)	**DO[3]** (% sat)	**Turb** (NTU)	**Secchi** (m)	**SS[2, 5]** (mg/L)	**pH**
HERBERT - PALM ISLAND GROUP **Open coastal waters not identified as HEV or SD** **(s2, s3, s4)**	**SMD** **mapped as MD**	≤3 (s4)	≤0.28 (s4)	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet: ≤25 (Nov-Apr) (s3, s4)	≤75 (s4)	≤100 (s4)	≤2 (s4)	≤2.8 (ann. mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	≤6 (s4)	≤11 (s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	≥165 (s4)	95–105 (s2)	≤1 (s3, s4)	≥10 (ann. mean) (s3)	≤2 (ann. mean) Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3, s4)	8.1–8.4 (s2)
WET TROPICS MIDSHELF WATERS – ALL WET TROPICS BASINS EXCEPT HERBERT RIVER BASIN (refer separate row below)																	
WET TROPICS **HEV3121 midshelf waters** **EXCLUDES Herbert Palm Island Group** **(s2, s3, s4)**	**HEV**	≤2 (s4)	0.14–0.31–0.78 (s4)	10–14–18 Dry: ≤16 (May-Oct) Wet:≤25 (Nov-Apr) (s3, s4)	60–80–105 (s4)	75-100-130 (s4)	0–2–3 (s4)	1.5–2.0–3.0 Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	3–6–10 (s4)	6–8–15 (s4)	0.2–0.3–0.46 Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3, s4)	50–95–165 (s4)	95–105 (s2)	0.4–0.6–0.8 (s3, s4)	6–9–14 (s4)	0.6–1.1–1.8 Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3, s4)	8.1–8.4 (s2)
WET TROPICS MIDSHELF WATERS – HERBERT RIVER BASIN (Palm Island Group)																	
HERBERT PALM ISLAND GROUP **HEV3124 midshelf waters** **(s2, s3, s4)**	**HEV**	≤3 (s4)	0.14–0.31–2.08 (s4)	10–14–20 Dry: ≤16 (May-Oct) Wet: ≤25 (Nov-Apr) (s3, s4)	55–75–95 (s4)	70–100–115 (s4)	0–1–4 (s4)	1.5–2.0–2.8 Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	3–6–10 (s4)	5–10–15 (s4)	0.18–0.33–0.57 Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3,s4)	40–85–150 (s4)	95–105 (s2)	0.4–0.5–0.7 (s3, s4)	9–13–17 (s3, s4)	0.5–0.8–1.6 Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3, s4)	8.1–8.4 (s2)

Water area/type (Source: s1–s6) (refer plan WQ1082)	Management intent /Level of protection	WET TROPICS - COASTAL AND MARINE WATERS (refer plan WQ1082) Aquatic Ecosystem water quality objectives [1–7] **Note:** WQGs for indicators are shown as a range of 20th, 50th and 80th percentiles to be maintained or achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value (e.g. <15). For single value WQOs, medians (or means where specified) of test data are compared against the WQO (refer to 'Note 7: comparison of test data with WQOs' for more details). HEV – high ecological value; SD – slightly disturbed; MD – moderately disturbed. Refer to accompanying plans for details; ID – insufficient data Sources: S1: Local datasets/reporting; S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or AIMS Long Term Monitoring Program datasets; S5: ANZG (2018); S6: CSIRO aluminium studies (Golding et al., 2015)															
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WET TROPICS OFFSHORE WATERS – ALL WET TROPICS BASINS																	
WET TROPICS **HEV3122 offshore waters** **(s2, s3, s4)**	**HEV**	≤2 (s4)	0–0.6–2 (s4)	10–12–16 Dry: ≤14 (May-Oct) Wet: ≤20 (Nov-Apr) (s3, s4)	55–75–95 (s4)	70–95–120 (s4)	0–2–3 (s4)	1.2–1.7–2.4 Dry: ≤1.5 (May-Oct) Wet: ≤2.3 (Nov-Apr) (s3, s4)	2–5–8 (s4)	4–6–9 (s4)	0.2–0.3–0.5 Dry: ≤0.28 (May-Oct) Wet: ≤0.56 (Nov-Apr) (s3, s4)	25–50–100 (s4)	95–105 (s2)	≤1 (s2, s4)	13–18–23 (s3, s4)	0.3–0.6–1.0 Dry: ≤0.6 (May-Oct) Wet: ≤0.8 (Nov-Apr) (s3, s4)	8.1–8.4 (s2)

Water area/type (Source: s1–s6) (refer plan WQ1082)	Management intent /Level of protection	WET TROPICS - COASTAL AND MARINE WATERS (refer plan WQ1082) Aquatic Ecosystem water quality objectives [1–7]															
		Note: WQGs for indicators are shown as a range of 20th, 50th and 80th percentiles to be maintained or achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value (e.g. <15). For single value WQOs, medians (or means where specified) of test data are compared against the WQO (refer to 'Note 7: comparison of test data with WQOs' for more details). HEV – high ecological value; SD – slightly disturbed; MD – moderately disturbed. Refer to accompanying plans for details; ID – insufficient data Sources: S1: Local datasets/reporting; S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or AIMS Long Term Monitoring Program datasets; S5: ANZG (2018); S6: CSIRO aluminium studies (Golding et al., 2015)														
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WET TROPICS COASTAL AND MARINE WATERS – TOXICANTS (INCLUDING METALS, BIOCIDES)																	
Coastal (including lower estuary) and marine waters outside ports, marinas, spoil grounds: toxicants (s1, s3, s5, s6)	**all**	• Toxicants (including metals, biocides) in water: refer to 99% species protection values contained in: o ANZG (2018) 'toxicant default guideline values for water quality in aquatic ecosystems', as amended o The following sources, where their guideline values post-date the specified ANZG guideline value, or where there is no ANZG value specified for a toxicant (Note: the ANZG specifies the date of guideline development for each toxicant): ▪ Biocides: - GBRMPA (2010) *Water quality guidelines for the Great Barrier Reef Marine Park 2010* - King et al (2017, as amended) (vol 1 and 2) *Proposed aquatic ecosystem protection guideline values for pesticides commonly used in the Great Barrier Reef catchment area* (available from Queensland Government publications) ▪ Aluminium: <2.1 µg/L (99% species protection. Applies to the measured concentration in seawater that passes through a 0.45 µm filter) [Source: Golding et al. (2015)] • Toxicants in sediments: refer to ANZG 'toxicant default guideline values for sediment quality' • Ship-sourced pollutants (including sewage): Discharge of ship-sourced pollutants (including sewage) to be controlled in accordance with requirements of the *Transport Operations (Marine Pollution) Act 1995* and Regulation 2018. (Refer to Maritime Services Queensland website for further information.) • Anti-fouling: Comply with *Anti-fouling and in-water cleaning guidelines* (2015, as amended)														

<table>
<tr><th rowspan="3">Water area/type

(Source: s1–s6)

(refer plan WQ1082)</th><th rowspan="3">Management intent /Level of protection</th><th colspan="15">WET TROPICS - COASTAL AND MARINE WATERS
(refer plan WQ1082)
Aquatic Ecosystem water quality objectives [1–7]</th></tr>
<tr><td colspan="15">Note: WQGs for indicators are shown as a range of 20th, 50th and 80th percentiles to be maintained or achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value (e.g. <15). For single value WQOs, medians (or means where specified) of test data are compared against the WQO (refer to 'Note 7: comparison of test data with WQOs' for more details).

HEV – high ecological value; SD – slightly disturbed; MD – moderately disturbed. Refer to accompanying plans for details; ID – insufficient data

Sources: S1: Local datasets/reporting; S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or AIMS Long Term Monitoring Program datasets; S5: ANZG (2018); S6: CSIRO aluminium studies (Golding et al., 2015)</td></tr>
<tr><td>Amm N[1]
(µg/L)</td><td>Oxid N[1]
(µg/L)</td><td>Partic N[5]
(µg/L)</td><td>Total Diss N
(µg/L)</td><td>Total N
(µg/L)</td><td>FRP
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(µg/L)</td><td>DO[3]
(% sat)</td><td>Turb
(NTU)</td><td>Secchi
(m)</td><td>SS[2, 5]
(mg/L)</td><td>pH</td></tr>
<tr><td>Coastal (including lower estuary) and marine waters in ports, marinas, spoil grounds: toxicants (s1, s3, s5, s6)</td><td>all</td><td colspan="15">• Toxicants (excluding biocides – see below) in water: refer to 95% species protection values (or 99% species protection values for those toxicants identified in ANZG as having bioaccumulation potential) contained in:
○ ANZG (2018) 'toxicant default guideline values for water quality in aquatic ecosystems', as amended
○ The following sources, where their guideline values post-date the specified ANZG guideline value, or where there is no ANZG value specified for a toxicant (Note: the ANZG specifies the date of guideline development for each toxicant):
▪ Aluminium: <24 µg/L (95% species protection. Applies to the measured concentration in seawater that passes through a 0.45 µm filter) [Source: Golding et al. (2015)]
• Biocides in water: refer to 99% species protection values (tributyltin: apply 95% species protection values) contained in:
○ ANZG (2018) 'toxicant default guideline values for water quality in aquatic ecosystems', as amended
○ The following sources, where their guideline values post-date the specified ANZG guideline value, or where there is no ANZG value specified for a toxicant (Note: the ANZG specifies the date of guideline development for each toxicant):
▪ GBRMPA (2010) Water quality guidelines for the Great Barrier Reef Marine Park 2010
▪ King et al (2017, as amended) (vol 1 and 2) Proposed aquatic ecosystem protection guideline values for pesticides commonly used in the Great Barrier Reef catchment area (available from Queensland Government publications)
• Toxicants in sediments: refer to ANZG 'toxicant default guideline values for sediment quality'
• Ship-sourced pollutants (including sewage): Discharge of ship-sourced pollutants (including sewage) to be controlled in accordance with requirements of the Transport Operations (Marine Pollution) Act 1995 and Regulation 2018. (Refer to Maritime Services Queensland website for further information.)
• Anti-fouling: Comply with Anti-fouling and in-water cleaning guidelines (2015, as amended)</td></tr>
<tr><td colspan="17">COASTAL AND MARINE WATERS – TEMPERATURE, BIOLOGICAL</td></tr>
<tr><td>Coastal and marine waters</td><td>all</td><td colspan="15">Temperature (s3): Increases of no more than 1°C above long-term (20 year) average maximum. (GBRMPA, 2010)</td></tr>
<tr><td>Coastal waters: biological (s1)</td><td>All (where applicable)</td><td colspan="15"><u>Seagrass</u>
Light requirements are specified as a photosynthetic active radiation (PAR) moving average, depending on seagrass species. Levels specified here are derived to support the health of all species present either as the dominant species or as one of a suite of species that are known to occur in the region. It does not reflect requirements for macroalgae or other organisms.
• Deep water areas (>10m) 2.5 mol m^{-2} day^{-1} over a rolling 7 day average # (Collier et al 2016; Chartrand et al 2014; Rasheed et al 2014; York et al 2015)</td></tr>
</table>

Water area/type (Source: s1–s6) (refer plan WQ1082)	Management intent /Level of protection	WET TROPICS - COASTAL AND MARINE WATERS (refer plan WQ1082) Aquatic Ecosystem water quality objectives [1–7]															
		Note: WQGs for indicators are shown as a range of 20th, 50th and 80th percentiles to be maintained or achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value (e.g. <15). For single value WQOs, medians (or means where specified) of test data are compared against the WQO (refer to 'Note 7: comparison of test data with WQOs' for more details). HEV – high ecological value; SD – slightly disturbed; MD – moderately disturbed. Refer to accompanying plans for details; ID – insufficient data Sources: S1: Local datasets/reporting; S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or AIMS Long Term Monitoring Program datasets; S5: ANZG (2018); S6: CSIRO aluminium studies (Golding et al., 2015)														
		Amm N[1] (µg/L)	**Oxid N[1]** (µg/L)	**Partic N[5]** (µg/L)	**Total Diss N** (µg/L)	**Total N** (µg/L)	**FRP** (µg/L)	**Partic P[5]** (µg/L)	**Total Diss P** (µg/L)	**Total P** (µg/L)	**Chl-a[5]** (µg/L)	**Silicate** (µg/L)	**DO[3]** (% sat)	**Turb** (NTU)	**Secchi** (m)	**SS[2, 5]** (mg/L)	**pH**
		• Shallow inshore areas (<10m): 6 mol m^{-2} day^{-1} over a rolling 14 day average # (Collier et al 2016; Chartrand et al, 2012) Note: # Absolute light requirements for seagrass may vary between sites. Values described here provide a conservative guide to the levels of light likely to support seagrass growth. Locally derived absolute thresholds ideally should be obtained for management of specific activities likely to impact on the light environment.															

Abbreviations: ANZG – Australian and New Zealand guidelines for fresh and marine water quality; QWQG – Queensland water quality guidelines; ID – insufficient data. Will be updated if information becomes available; na – not applicable; * – limited data. To be used as interim value until further data is available.

Indicators: FRP – filterable reactive phosphorus; Chl-a – chlorophyll-a; DO – dissolved oxygen; SS – total suspended solids;

Units: µg/L – micrograms per litre; % sat – percent saturation; NTU – nephelometric turbidity units; m – metres; mg/L – milligrams per litre;

Management intent: Waters for which all physico-chemical WQOs (e.g. nutrients, toxicants) have been set corresponding to HEV management intent are identified in columns 1 and 2 of Table 2. Each of these waters is given a specific label in the table (e.g. 'HEV1234') which links to the accompanying plans. Slightly disturbed (SD) waters are similarly identified.

The management intent (level of protection) for most waters other than HEV or SD is to achieve a 'moderately disturbed' (MD) condition, for which corresponding WQOs have been derived. Where local WQOs are derived for MD areas these are also identified with specific labels (e.g. 'MD1234'). For some indicators and water types, WQOs correspond with a 'slightly to moderately disturbed' (SMD) level of protection, based on management intent categories specified in source technical guidelines, in particular the ANZG (2018). For ease of interpretation, this document and accompanying mapping include these within the MD level of protection. For some MD waters a higher level of protection may be provided for toxicants (e.g. pesticides).

Notes to Table (where applicable):

1. Nutrients:
Oxidised N = NO_2 + NO_3. Dissolved inorganic N (DIN) = Amm N + oxidised N.
Except where specified for event conditions, nutrient guidelines do not apply during high flow events in fresh and estuarine waters. 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 WQGs. 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 WQGs, provided this is due to natural causes. See QWQG (section 5 and Appendix D) for more information on applying guidelines under high flow conditions.

2. Suspended solids: Suspended solids (and hence turbidity and Secchi depth) levels in coastal waters are naturally highly variable depending on wind speed/wave height and in some cases on tidal cycles. The values in this table provide guidance on what the long term values of turbidity, Secchi depth or TSS should comply with. However, these values will often be naturally exceeded in the short term during windy weather or spring tides. They therefore should not be used for comparison with short term data sets. Where assessable coastal developments are proposed, proponents should

carry out site specific intensive monitoring of these indicators (or equivalent light penetration indicators) and use these as a baseline for deriving local guidelines and for comparison with post development conditions.

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

4. Open coastal/marine waters – GBR plume line: The GBR plume discharge area is derived from a smoothed version of the 'high' and 'very high' risk classes of modelled outputs from the risk assessment element of the Reef Plan Scientific Consensus Statement 2013 (Waterhouse et al. 2013).

5. Open coastal/marine waters - seasonal splits: Dry season is generally between May to November, however will vary annually and should be assessed based on rainfall and discharge. Wet season is generally December to April, however will vary annually and should be assessed based on discharge and antecedent rainfall. While seasonal means are estimated based on biotic responses the relationship is not as strong as it is for annual mean values. They are provided here as indicative objectives to allow comparison with single season collected data sets. Wet and dry seasons can start and end at different times of the year. Seasonal dates indicated are generally applicable. Applying these values for any management action should take both of these matters into account.

6. Open coastal/marine waters – Secchi depth. For waters shallower than the specified Secchi depth of ≥10m the depth to seafloor is the WQO.

7. Comparison of test data with WQOs: The following protocols are recommended when comparing fresh, estuarine or coastal/marine water quality (at a 'test' site) with the corresponding aquatic ecosystem water quality objective (WQO). For concentration-based indicators (e.g. nutrients) and turbidity (NTU), the intent is for test site water quality value to be less than or equal to the corresponding WQO. For WQO indicators where a range is specified (e.g. pH, DO), the intent is that the test site water quality median value falls within the specified WQO range. For Secchi measurements (typically used in estuarine, coastal and marine waters), the intent is for the test site water quality value to be greater than or equal to the stated WQO. Further detail is provided in the QWQG.

For HEV and SD waters:

- Where the WQO is expressed as a 20^{th}–50^{th}–80^{th} percentile range of values (e.g. Total N: 65–100–125 ug/L), the 20^{th}–50^{th}–80^{th} percentile distributions of the test data should meet the specified range of values. The sample number is a minimum of 24 test values over the relevant period (12 months if a continuous activity or alternatively a shorter period for activities where discharge occurs for only part of the year).
- For DO and pH, test sample median values are compared with, and should fall within, the specified percentile range.
- Where a single WQO value is provided, the median value of preferably five or more independent samples at a monitoring (test) site should be compared against the corresponding aquatic ecosystem WQO.

For MD and HD waters:

- The median value (e.g. concentration) of preferably five or more independent samples at a monitoring (test) site should be compared against the corresponding aquatic ecosystem WQO (WQOs in these waters are typically expressed as a single figure).
- For DO and pH, test sample median values are compared with, and should fall within the specified range.

For toxicants in water: unless otherwise stated, WQOs for toxicants are derived from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) default guideline values for the corresponding level of species protection. The ANZG recommends that the 95^{th} percentile of test data is compared against the default guideline value. As the proportion of test values that is required to be less than the default guideline value is high, the ANZG indicates that a single observation greater than the default guideline value is considered an exceedance.

For comparisons of toxicants in sediments, refer to ANZG.

Great Barrier Reef coastal/marine waters: Further to the above, some parameters in Great Barrier Reef waters have WQO values specified as an annual (or seasonal) mean, rather than as a median or percentile range. For these waters, the mean water quality value of a number of independent samples at a particular monitoring ('test') site should be compared against the applicable WQO. The sample number is preferably five or more samples for within season comparison, and five or more samples taken during each of the wet and dry seasons for annual mean comparisons. However, more samples may be required depending on the inherent variability in the measurement data (Queensland Monitoring and Sampling Manual; Section 1.9.1).

Further information: Refer to the QWQG, the Queensland Monitoring and Sampling Manual (2018), and ANZG for more details.

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Unpublished water quality datasets

3 Water quality objectives for human use environmental values

This section outlines water quality objectives (WQOs) to protect human use environmental values (EVs), which comprise those EVs (e.g. recreation, stock watering, aquaculture and crop irrigation) other than the aquatic ecosystem EV. Where a human use EV has been identified, the following tables can be used to identify the WQOs to support that EV. Where 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 ANZG (2018, as amended) and the Australian Drinking Water Guidelines (ADWG). 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.

3.1 Human use EVs water quality objectives

The following table summarises WQOs for human use EVs. More details are provided in subsequent sections by human use EV.

Table 3 Human use EVs water quality objectives

Environmental value	Water type/area	Water quality objective to protect EV (refer to specified codes and guidelines for full details)
Suitability for drinking water supply	All fresh waters including groundwaters	The Australian Drinking Water Guidelines (NHMRC, 2011, as amended) provides a framework for catchment management and source water protection for drinking water supplies. Quality of raw water (prior to treatment) should consider the requirements of water supply operators, and their capacity to treat the water to make it safe for human consumption. Also refer to Table 4. Note: For water quality after treatment or at point of use refer to legislation and guidelines, including: • *Public Health Act 2005* and Regulation • *Water Supply (Safety and Reliability) Act 2008*, including any approved drinking water quality management plan under the Act • *Water Fluoridation Act 2008* and Regulation • *Australian Drinking Water Guidelines* (ADWG, 2011, as amended). • Safe Water on Rural Properties guideline (Queensland Health, 2015) Whether water is drawn from surface catchments or underground sources, it is important that the local catchment or aquifer is understood, and that the activities that could lead to water contamination are identified and managed. Effective catchment management and source water protection include development of a catchment management plan, with the commitment of land use planning authorities to prevent inappropriate development and to enforce relevant planning regulations.
Protection of the human consumer for oystering	Estuarine and coastal waters	As per ANZG and Australia New Zealand Food Standards Code, Food Standards Australia New Zealand, as amended. (refer Food Standards Australia New Zealand website)
Protection of the human consumer	Fresh waters, estuarine and coastal waters	As per ANZG and Australia New Zealand Food Standards Code, Food Standards Australia New Zealand, as amended.
Protection of cultural and spiritual values	Fresh waters (including groundwaters), estuarine and coastal waters	Protect or restore indigenous and non-indigenous cultural heritage consistent with relevant policies and plans.

Environmental value	Water type/area	Water quality objective to protect EV (refer to specified codes and guidelines for full details)
Suitability for industrial use	Fresh waters, estuarine and coastal waters	None provided. Water quality requirements for industry vary within and between industries. The ANZG 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, estuarine and coastal waters	As per: • Tables 5–7 • ANZG and Australia New Zealand Food Standards Code, Food Standards Australia New Zealand, as amended
Suitability for irrigation	All fresh waters including groundwaters	Pathogens and metal WQOs are provided in Tables 8 and 9 (based on ANZG). For all other indicators, such as salinity, sodicity, sodium adsorption ratio (SAR), and herbicides, refer ANZG.
Suitability for stock watering	All fresh waters including groundwaters	As per ANZG, including median faecal coliforms <100 organisms per 100 mL. For total dissolved solids and metals, refer Tables 10 and 11, based on ANZG. For other indicators, such as cyanobacteria and pathogens, see ANZG.
Suitability for farm supply/use	All fresh waters including groundwaters	As per ANZG.
Suitability for primary contact recreation	Fresh waters, estuarine and coastal waters	Note: at time of publication the NHMRC guidelines for recreational water quality were under review, and updates may supersede the following. Refer to NHMRC website for latest information and updated guidelines. As per NHMRC (2008 – refer NHMRC website) including: • water free of physical (floating and submerged) hazards. Where permanent hazards exist (e.g. rips and sandbars), appropriate warning signs should be clearly displayed. • 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. • direct contact with venomous or dangerous aquatic organisms should be avoided. Recreational water bodies should be reasonably free of, or protected from, venomous organisms (e.g. box jellyfish and bluebottles) • waters contaminated with chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreational purposes.
Suitability for primary contact recreation	Fresh waters	Note: at time of publication the NHMRC guidelines for recreational water quality were under review, and updates may supersede the following. Refer to NHMRC website for latest information and updated guidelines. • 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 - where *Cylindrospermopsis caciborskii* is the dominant species present, advice should be sought for an appropriate guideline for

Environmental value	Water type/area	Water quality objective to protect EV (refer to specified codes and guidelines for full details)
		cylindrospermopsin or - cyanobacterial scums consistently present. Further details are contained in NHMRC (2008) and Table 12.
	Estuarine, coastal waters	• cyanobacteria/algae: Recreational water bodies should not contain ≥ 10 cells/mL *Karenia brevis* and/or have *Lyngbya majuscula* and/or *Pfiesteria* present in high numbers[2]. Further details are contained in NHMRC (2008) and Table 12.
Suitability for secondary contact recreation	Fresh waters, estuarine and coastal waters	As per NHMRC (2008), including: • intestinal enterococci: refer primary recreation above • cyanobacteria/algae—refer primary recreation, NHMRC (2008) and Table 12.
Suitability for visual recreation	Fresh waters, estuarine and coastal waters	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—see, NHMRC (2008) and Table 12.

Notes:

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

Sources:

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

- Technical review and advice from Queensland Health and Department of Natural Resources, Mines and Energy (2020)
- Australian Drinking Water Guidelines (NHMRC, 2011 as updated 2016), available from NHMRC website
- Australia New Zealand Food Standards Code (Australian Government: Food Standards Australia New Zealand), available from Food Standards Australia New Zealand website
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality *(ANZG, 2018, as amended)*
- Guidelines for Managing Risks in Recreational Water (NHMRC, 2008), available from NHMRC website. At time of publication the NHMRC guidelines were under review. Refer to NHMRC website for latest information and updated guidelines.
- Safe Water on Rural Properties Guideline (Queensland Health, 2015)

3.2 Drinking water EV water quality objectives

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

Indicator	Water quality objective [1]
Giardia	No guideline value set (ADWG) If *Giardia* is detected in drinking water then the Water Supply Regulator, DNRME and Queensland Health should be notified immediately and an investigation of the likely source of contamination undertaken.
Cryptosporidium	No guideline value set (ADWG) If *Cryptosporidium* is detected in treated drinking water then the Water Supply Regulator, DNRME and Queensland Health should be notified immediately and an investigation of the likely source of contamination undertaken.
E. coli	Well designed treatment plants with effective treatment 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). <1 cfu/100ml (Public Health Regulation 2018) and upstream sewage effluent discharges need to be known (catchment management).
Algal toxin	<1.3 µg/L Microcystin (ADWG)
pH	6.5–8.5 (ADWG)
Total dissolved solids (TDS)	<600mg/L The concentration of total dissolved solids in treated drinking water should not exceed 600 mg/L (ADWG, based on taste considerations).
Sodium	General [2]: The concentration of sodium in reticulated drinking water supplies should not exceed 180 mg/L (ADWG, based on threshold at which taste becomes appreciable). At-risk groups (medical) [2]: The concentration of sodium in water supplies for at-risk groups should not exceed 20 mg/L (ADWG).
Sulfate	The concentration of sulfate in drinking water should not exceed 250 mg/L (ADWG 2011, based on taste/aesthetic considerations). ADWG 2011 health guideline: <500mg/L
Dissolved oxygen	>85% saturation (ADWG)
Pesticides	Raw supplies: Below detectable limits. Treated drinking water: Refer to ADWG.
Other indicators (including physico-chemical indicators) e.g. turbidity	Refer to ADWG. <1 NTU is the target to facilitate for effective disinfection of drinking water (as turbidity of ≥ 1 NTU inhibits the performance of chlorination (ADWG))

Source: Australian Drinking Water Guidelines (NHMRC, 2011 as updated 2018). Technical review and advice from Queensland Health and Department of Natural Resources, Mines and Energy (2020).

Notes:

1. This table outlines WQOs for water **before treatment**, unless otherwise stated (e.g. ADWG). For water quality after treatment or at the point of use, refer to relevant legislation and guidelines, including *Public Health Act 2005* and Regulation, *Water Supply (Safety and Reliability) Act 2008 and Regulation*, including any approved drinking water management plan under the Act, *Water Fluoridation Act 2008*, the Australian Drinking Water Guidelines (ADWG, 2011 updated December 2013), and the Safe Water on Rural Properties guideline (Queensland Health, 2015).
2. The ADWG notes that 50 mg/L is a '*typical value*' in reticulated supplies. The ADWG value for sodium is 180 mg/L (based on level at which taste become appreciable) however '*sodium salts cannot be easily removed from drinking water*' and '*any steps to reduce sodium concentrations are encouraged*'. 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).

3.3 Aquaculture EV water quality objectives

The following tables outline WQOs for aquaculture, depending on water type and species.

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

Indicator: psu – practical salinity unit, NTU - nephelometric turbidity units, ID – Insufficient data

Note: The table provides indicative water requirements for a range of aquaculture species (fresh and/or marine), recognising that not all listed species will occur in a given area, and that potential exists for changes in species under culture.

Source: Department of Primary Industries and Fisheries—Water Quality in Aquaculture—DPI Notes April 2004 (as amended) and DAF 2019-2020 technical review and advice.

Table 6 Aquaculture EV: Water quality objectives for optimal growth of particular freshwater species

WATER QUALITY TARGET VALUES FOR AQUACULTURE						
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	26–32˚C	23–28˚C	23–28˚C	23–28˚C	22–31˚C	23–31˚C
pH	7.5–8.5	7.0–8.5	6.5–8.5	6.5–8.5	7.0–8.5	7.0–8.5
Ammonia (TAN, Total ammonia–nitrogen)	ID	<1.0 mg/L	ID	ID	<1.0 mg/L	<1.0 mg/L
Ammonia (NH_3, un–ionised form)	<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)	ID	ID	<100 mg/L	ID	ID	ID
Nitrite (NO_2)	<1.5 mg/L	<1.0 mg/L	<0.1 mg/L	ID	<1.0 mg/L	<1.0 mg/L
Salinity (extended periods)	0–35 psu	ID	<5 psu	<5 psu	ID	<4 psu
Salinity bath (short term treatment)	0–35 psu	ID	5–10 psu for 1 hour	ID	max. 20 psu for 1 hour	ID
Hardness ($CaCO_3$)	50-100 mg/L	ID	>50 mg/L	>50 mg/L	>40 mg/L	>40 mg/L
Alkalinity	>50 mg/L	ID	100–400 mg/L	100–400mg/L	>40 mg/L	>40 mg/L
Chlorine	<0.04 mg/L	ID	ID	ID	<0.04 mg/L	ID
Hydrogen sulphide	<0.3 mg/L	ID	ID	ID	<0.3 mg/L	ID
Iron	<0.1 mg/L	ID	<0.5 mg/L	<0.5 mg/L	<0.1 mg/L	<0.1 mg/L
Spawning temperature	marine	ID	23–28	23–28	>24 for more than 3 days	ID

Indicator: psu – practical salinity unit, ID – Insufficient data

Note: The table provides indicative water requirements for a range of aquaculture species (fresh and/or marine), recognising that not all listed species will occur in a given area, and that potential exists for changes in species under culture.

Source: Department of Primary Industries and Fisheries—Water Quality in Aquaculture—DPI Notes April 2004 (as amended) and DAF 2019-2020 technical review and advice.

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

Water parameter	Barramundi		Giant Tiger prawn (*Penaeus monodon*)	
	Hatchery	**Grow out**	**Hatchery**	**Grow out**
Dissolved oxygen	saturation	>4 mg/L	>4 mg/L	>3.5 mg/L
Temperature	28–30˚C optimum 25–31˚C range	28–30˚C optimum	28-30˚C	26–32˚C
pH	approx. 8	approx. 8	7.8-8.2	7.5–8.5
Ammonia (TAN, total ammonia-nitrogen)	ID	0.1–0.5 mg/L	ID	<3 mg/L
Ammonia (NH_3, un-ionised form)	<0.1 mg/L	<0.1 mg/L	<0.1 mg/L	<0.1 mg/L
Nitrate (NO_3)	<1.0 mg/L	<1.0 mg/L	<1.0 mg/L	<1.0 mg/L
Nitrite (NO_2)	<0.2 mg/L	<1.0 mg/L	<0.2 mg/L	<0.2 mg/L
Salinity	28–31psu	0–35psu	30-35psu	10–25 psu optimum
Alkalinity	ID	105–125 mg/L $CaCO_3$	ID	>80 mg/L
Clarity	ID	<10mg/L	ID	30–40cm secchi disk
Hydrogen sulphide	ID	<0.3 mg/L	<0.1 mg/L	<0.1 mg/L
Iron	ID	<0.02 mg/L	<1 mg/L	<1.0 mg/L
Spawning temperature	ID	28–32˚C	ID	27–32˚C

Indicator: psu – practical salinity unit, ID – Insufficient data

Note: The table provides indicative water requirements for a range of aquaculture species (fresh and/or marine), recognising that not all listed species will occur in a given area, and that potential exists for changes in species under culture.

Source: Department of Primary Industries and Fisheries—Water Quality in Aquaculture—DPI Notes April 2004 (as amended) and DAF 2019-2020 technical review and advice.

3.4 Irrigation EV water quality objectives

The following tables outline WQOs for irrigation, based on relevant national guidelines.

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, such as cattle, sheep and goats)	<1000 cfu/100 mL
Silviculture, turf, cotton, etc. (restricted public access)	<10 000 cfu/100 mL

Notes:

1. Adapted from ARMCANZ, ANZECC and NHMRC (1999).

2. Refer to AWQG, Volume 1, Section 4.2.3.3 for advice on testing protocols. Source: AWQG, Volume 1, Section 4.2.3.3, Table 4.2.2.

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

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

Notes:

1. Concentrations in irrigation water should be less than the trigger values. Trigger values should only be used in conjunction with information on each individual element and the potential for off-site transport of contaminants (refer AWQG, Volume 3, Section 9.2.5).

2. ND = Not determined; insufficient background data to calculate CCL.

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

3.5 Stock watering EV water quality objectives

The following tables outline WQOs for stock watering, according to stock type (cattle, sheep etc.).

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

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

Notes:

1. From ANZECC (1992), adapted to incorporate more recent information.

2. Sheep on lush green feed may tolerate up to 13 000 mg/L TDS without loss of condition or production.

Source: ANZECC, ARMCANZ (2000), Volume 1, Section 4.3.3.5, Table 4.3.1. Note that a review of stock watering tolerances under the ANZG (2018) may lead to revised values from those in this table. Refer to ANZG (2018) for further details.

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

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

Notes:

1. Higher concentrations may be tolerated in some situations (further details provided in ANZECC, ARMCANZ (2000), Volume 3, Section 9.3.5).

2. ND = not determined, insufficient background data to calculate.

3. May be tolerated if not provided as a food additive and natural levels in the diet are low.

Source: ANZECC, ARMCANZ (2000), Volume 1, Section 4.3.4, Table 4.3.2. Note that a review of stock watering tolerances under the ANZG (2018) may lead to revised values from those in this table. Refer to ANZG (2018) for further details.

3.6 Recreation EV water quality objectives - cyanobacteria

When cyanobacteria are present in large numbers they can present a significant hazard, particularly to primary contact users of waters. Water quality guidelines for cyanobacteria in recreational waters are provided below. Monitoring and 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.

Note: at time of publication the NHMRC guidelines for recreational water quality were under review, and updates may supersede the following. Refer to NHMRC website for latest information and updated guidelines.

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

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

Notes:

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

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

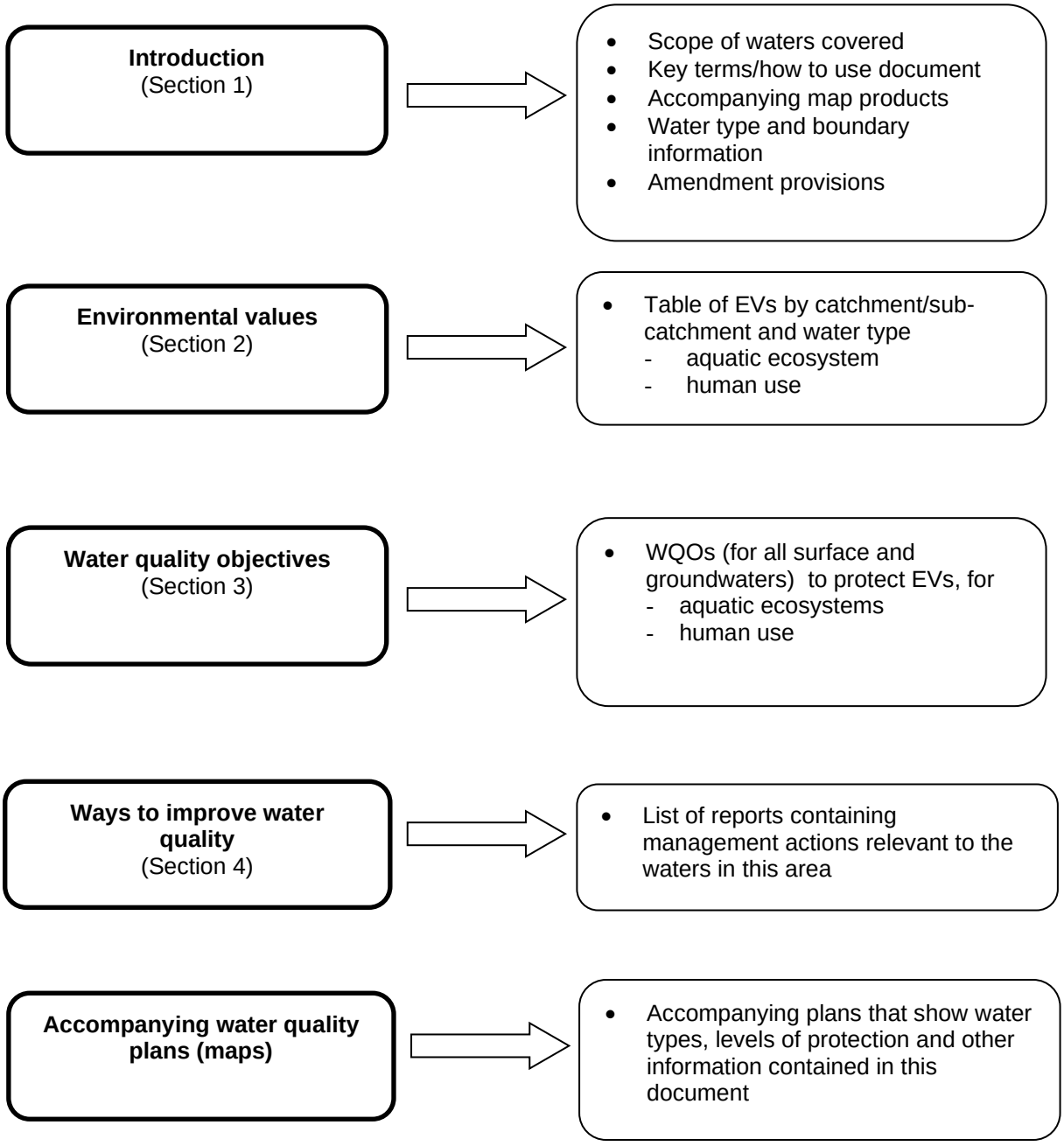
   b. **Amber**: Notify agencies as appropriate. Increase sampling frequency to twice weekly at representative locations in the water body where toxigenic species (above) are dominant within the alert level definition (i.e. total biovolume) to establish population growth and spatial variability in the water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

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

2. The definition of 'dominant' is where the known toxin producer comprises 75 per cent or more of the total biovolume of cyanobacteria in a representative sample.
3. This applies where high cell densities or scums of 'non toxic' cyanobacteria are present i.e. where the cyanobacterial population has been tested and shown not to contain known toxins (mycrocystins, nodularian, cylindrospermopsin or saxitoxin).
4. Health risks and levels: Level 1 is developed to protect against short-term health effects of exposure to cyanobacterial toxins ingested during recreational activity, whereas the Level 2 applies to the circumstance where there is a probability of increased likelihood of non-specific adverse health outcomes, principally respiratory, irritation and allergy symptoms, from exposure to very high cell densities of cyanobacterial material irrespective of the presence of toxicity or known toxins (NHMRC, 2008;114).
5. This refers to the situation where scums occur at the recreation site each day when conditions are calm, particularly in the morning. Note that it is not likely that scums are always present and visible when there is a high population as the cells may mix down with wind and turbulence and then reform later when conditions become stable.

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

Main parts of this document and what they contain



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Introduction and guidance on using this document

1 Introduction

This document is made under the provisions of the Environmental Protection (Water) Policy 2009 (EPP Water), which is subordinate legislation under the *Environmental Protection Act 1994* (EP Act).

The EPP Water and the EP Act provide a framework for:

- establishing environmental values (EVs) and management goals for Queensland waters, and deciding the water quality objectives (WQOs) to protect or enhance those EVs
- listing the identified EVs, management goals and WQOs under Schedule 1 of the EPP (Water).

This document contains the EVs, management goals, WQOs and map products for the waters of the Johnstone River basin (112)[1] and the adjacent coastal waters, to the limit of Queensland waters.

The document is listed under Column 2 of Schedule 1 of the EPP Water for the Column 1 entry of the Johnstone River basin (112) and adjacent coastal waters.

1.1 Purpose

The purpose of this document is to identify locally relevant environmental values and water quality objectives for the region, based on local historical data and in close consultation with the local community. These water quality objectives are used to help set development conditions, influence local government planning schemes and underpin report card grades for ecosystem health monitoring programs. These water quality objectives have been refined from national and state water quality guidelines and present a truer picture of the values and water quality of local waterways. This ensures the values the community holds for its waterways can be maintained and improved into the future, without imposing unrealistic standards from national guidelines that may be inappropriate for local conditions.

1.2 Waters to which this document applies – project waters

This document applies to all surface waters and groundwaters of the Johnstone River basin and adjacent coastal waters, as indicated in the accompanying maps WQ1121—surface waters, WQ1082—coastal waters and WQ1083—groundwaters.

The surface waters and groundwaters include the:

- North Johnstone River catchment
- South Johnstone River catchment
- All tributaries of the above catchments including Bamboo Creek, Ithica River, Beatrice River and Downey Creek
- Moresby River catchment, including tributaries of the catchment
- Liverpool Creek catchment, including tributaries of the catchment
- Maria Creek catchment, including tributaries of the catchment
- Lakes and drinking water storages
- Moresby and Cowley Area wetlands, Etty Bay conservation park, Maria Creek and Kurramine wetlands
- Basin groundwaters

[1] Queensland Drainage Division number and river basin names are published at Geoscience Australia's website <www.ga.gov.au>.

- Enclosed coastal and open coastal waters, to the limit of Queensland waters including seagrass meadows of Mourilyan Harbour

The geographical extent of waters shown in the accompanying maps is:

- north to the Mulgrave-Russell River basin (111)
- northwest to the Barron River basin (110)
- south to the Tully River basin (113)
- west to the Herbert River basin (116)
- east to the jurisdictional limit of Queensland waters.

1.3 Guidance on using this document

1.3.1 List of acronyms and terms

ADWG means the Australian Drinking Water Guidelines (2011)-updated December 2013, prepared by the National Health and Medical Research Council (NHMRC)[2].

AWQG or ANZECC guidelines 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)[3].

Aquatic ecosystem means the animals, plants and micro-organisms that live in water, and the physical and chemical environment and climatic regime in which they interact. The physical components (e.g. light, temperature) and chemical components (e.g. oxygen, nutrients), and to a lesser extent biological interactions, determine what lives and breeds in the aquatic ecosystem and the food web structure.

Basin means hydrologic drainage basin. Refer to the Geoscience Australia website www.ga.gov.au.

Catchment means the land area draining into a watercourse. The limits of a catchment are the heights of land (watershed) separating it from neighbouring catchments.

Developed fresh waters (or waters in developed areas) are waters in areas impacted through some form of development e.g. urban, industrial, rural residential or agricultural development and land uses. These waters are generally assigned the Moderately Disturbed (MD) level of protection.

Ecological health or condition of an aquatic ecosystem means the ability to 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. There are four levels of aquatic ecosystems protection—High Ecological Value (HEV), Slightly Disturbed (SD), Moderately Disturbed (MD) and Highly Disturbed (HD). See **Management intent** for waters under the EPP Water (section 14).

Environmental values means the EVs at Section 2. EVs for waters are the qualities of water that make it suitable for supporting aquatic ecosystems and human uses. EVs under the EPP Water are shown below.

[2] The Australian Drinking Water Guidelines are available on the National Health and Medical Research Council website at www.nhmrc.gov.au.

[3] The ANZECC guidelines are available on the Australian Government's National Water Quality Management Strategy website.

Environmental values (EVs)	Potentially applicable to:	
	Tidal waters	Fresh (non-tidal) waters, including ground water
Aquatic ecosystem EV		
Environmental values may be stated for four levels of aquatic ecosystems protection	✓	✓
• high ecological value waters (effectively unmodified)		
• slightly disturbed waters (slightly modified)		
• moderately disturbed waters (adversely affected to a relatively small but measurable degree)		
• highly disturbed waters (measurably degraded).		
Human use EVs		
Suitability of the water for agricultural use (e.g. crop irrigation, stock watering, farm use)		✓
Suitability of the water for aquaculture (e.g. prawns, barramundi)	✓	✓
Suitability of the water for producing aquatic foods (e.g. fish, crustaceans) for human consumption	✓	✓
Suitability of the water for supply as drinking water (i.e. raw water, before treatment)		✓
Suitability of the water for industrial use (e.g. mining, minerals refining/processing)		✓
Suitability of the water for recreation:		
• primary contact (e.g. swimming)	✓	✓
• secondary contact recreation (e.g. boating)	✓	✓
• visual (no contact) recreation	✓	✓
The cultural and spiritual values of the water	✓	✓

GBRMPA guidelines means the *Water Quality Guidelines for the Great Barrier Reef Marine Park, Great Barrier Reef Marine Park Authority 2010*, published at the GBRMPA website.

Management goals means the goals stated in Section 2.2 of this document. Management goals are used to assess whether the corresponding environmental value is being maintained. They reflect the desired levels of protection for the aquatic system and any relevant environmental problems.

M**anagement intent** for waters—see Section 2.2.

Monitoring and Sampling Manual 2009 means the protocol document under the EP Act published on the department's website at www.ehp.qld.gov.au

Queensland waters means waters within the state (i.e. headwaters to the three nautical mile jurisdiction limit).

QWQG means the Queensland Water Quality Guidelines, published at www.ehp.qld.gov.au

Soil degradation, for the purposes of the objective for irrigation water in section 2.2.3, means reduced permeability and soil structure breakdown caused by the level of sodium in the irrigation water, assessed using the sodium adsorption ratio.

Undeveloped fresh waters (or waters in undeveloped areas) are waters within protected areas such as National Park, Regional Park and forest reserves or in other undisturbed states. These waters are given High Ecological Value (HEV) or Slightly Disturbed (SD) levels of protection.

Water quality indicator for an environmental value, under the EPP Water, means a physical, chemical, biological or other property that can be measured or decided in a quantitative way. For example:

- the concentration of nutrients and pH value are examples of chemical indicators
- Secchi disc water clarity measure is an example of a physical indicator
- seagrass depth range, macro-invertebrate family richness are examples of biological indicators.

Water quality guidelines under the EPP Water means the quantitative measures (expressed as contaminant concentrations, loads or narrative statements) for indicators which protect a stated EV. For a particular water, the indicators and water quality guidelines for an EV are decided using the following documents (in order of priority):

- site specific documents for the water,
- the QWQG
- the AWQG
- other relevant documents published by a recognised entity.

Water quality guidelines may be modified by economic and social impact assessments of protecting the EVs for waters.

Water quality objectives (WQOs) means the WQOs at Section 3 which protect the EVs at Section 2.

WQOs are the quantitative measures of the various water quality indicators that protect receiving waters aquatic ecosystem and human use EVs. WQOs are:

- numerical concentration levels, sustainable loads measures or narrative statements of indicators
- based on water quality guidelines, but may be modified by economic and social inputs
- receiving water quality objectives—not individual point source objectives or emission standards
- long-term goals for water quality management.

WQOs compliance assessment means the compliance assessment at Appendix D of the QWQG.

Water type means the grouping of waters within which water quality is sufficiently consistent that a single guideline value can be applied to all waters within each group (or water type). See section 1.5.

1.3.2 Use of this document

Section 1 – Introduction and guidance on using this document.

Section 2 – lists the identified EVs for protection for particular waters.

Section 3 – lists the WQOs to protect the corresponding aquatic ecosystems and human use EVs for each water type, including both surface waters and groundwaters.

This document refers to a number of water quality guidelines, codes and other reference sources. In particular, the QWQG provide detailed information on water types, water quality indicators, derivation of local water quality guidelines, monitoring and assessing compliance. ANZECC guidelines contain national level water quality guidelines, for example water quality guidelines for toxicants.

Section 4 – lists documents relevant to the improvement of water quality in the Johnstone River basin.

1.4 Information about mapped areas and boundaries

The boundaries in the accompanying pdf plans are indicative only. The corresponding GIS datasets are available as part of the Wet Tropics Environmental Values Schedule 1 Geodatabase November 2014—held at the department's offices at Level 10, 400 George Street Brisbane.

The GIS datasets may be downloaded free of charge from the Queensland Spatial Catalogue (QSpatial) at http://qldspatial.information.qld.gov.au/catalogue/custom/index.page

For further information, please email the department at epa.ev@ehp.qld.gov.au

1.5 Water types and basis for boundaries

1.5.1 **Water types**

Water types in this document are identified in Section 3 and the accompanying plans. Water types include (see the QWQG and GBRMPA guidelines):

- upland fresh waters—smaller upper catchments freshwater streams, above 150 metres altitude, moderate to fast flowing with steeper gradients than lowland fresh waters, downstream limit—lowland fresh waters
- lowland fresh waters—larger slow moving freshwater streams and rivers, below 150 metres altitude, downstream limit—upper estuary
- freshwater lakes/reservoirs—deep water habitat situated in dammed river channels
- upper/mid estuary waters:
  - upstream tidal limit—determined from EHP wetland mapping, declared downstream freshwater limit, mean high water springs or limiting structure
  - downstream limit—lower estuary
- enclosed coastal/lower estuary waters—occur at the downstream end of estuaries and include shallow coastal waters (<6m depth) in enclosed bays
- open coastal waters—extend from the seaward limit of the enclosed coastal water body to the jurisdictional limit of Queensland waters[4]

  groundwaters—sub-artesian waters that occur in an aquifer
- wetlands—palustrine, lacustrine and estuarine – see EHP mapping at Wetlandsinfo website.
- marinas, boat harbours, tidal canals and constructed estuaries

1.5.2 **Water type boundaries**

The boundaries of different water types are mapped in the accompanying plans using the following attributes, see QWQG for definitions, including:

- altitude (from Australian Height Datum, Geoscience Australia)
- catchment or sub catchment boundaries
- coastline mapping
- downstream or tidal limit—structure (limiting), declared downstream limit or mean high water springs
- enclosed coastal waters (GBRMPA 2014)
- geographic coordinates
- highest/lowest astronomical tide

[4] Beyond the jurisdictional limit of Queensland waters, mid-shelf marine waters extend from the limit of open coastal waters to 24 km offshore and offshore marine waters extend from the limit of mid-shelf waters to 170 km offshore. See GBRMPA guidelines.

- jurisdiction or defined coastal waters limits
- maritime mapping conventions
- plume line—seaward limit of detection of terrestrial impact—chlorophyll-a mapping (GBRMPA 2014)
- surveyed terrestrial and maritime boundaries.

1.6 Matters for amendment

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

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

Environmental values for waters of the Johnstone River basin and adjacent coastal waters

2 Environmental values

2.1 Environmental values

The EVs for the surface waters and groundwaters of the Johnstone River basin and adjacent coastal waters are listed at table 1 and mapped in the accompanying plans and the GIS datasets.

The EVs were established during stakeholder consultation undertaken by the department and Terrain NRM – see Consultation Report: Environmental Values for Wet Tropics Basins, (Terrain NRM, September 2012).

2.2 Management goals

2.2.1 **Management intent for waters – under the EPP Water**

It is the management intent for waters that the decision to release waste water or contaminants to the waters must ensure the following:

- for high ecological value (HEV) waters—the measures for the indicators for all EVs are maintained
- for slightly disturbed (SD) waters—the measures for the slightly modified physical or chemical indicators are progressively improved to achieve the WQOs for HEV waters
- for moderately disturbed (MD) waters:
    - if the measures for indicators of the EVs achieve the water quality objectives for the water—the measures for the indicators are maintained at levels that achieve the WQOs for the water or
    - if the measures for indicators of the EVs do not achieve the water quality objectives for the water—the measures for indicators of the EVs are improved to achieve the WQOs for the water
- for highly disturbed (HD) waters—the measures for the indicators of all environmental values are progressively improved to achieve the water quality objectives for the water.

The mapping of HEV waters, SD waters and HD waters in the accompanying plans (or GIS datasets) informs the determination of Management Intent for particular waters.

Note 1 – All other waters in the accompanying plans are moderately disturbed (MD).

Note 2 – See the Environmental Protection Regulation 2008, section 51.

Note 3 – See the Environmental Protection (Water) Policy 2009, section 14.

2.2.2 **Raw water for treatment for human consumption**

- Minimise the risk that the quality of raw water taken for treatment for human consumption results in adverse human health effects
- Maintain the palatability rating of water taken for treatment for human consumption at the level of good, as set out in the Australian Drinking Water Guidelines (ADWG).
- Minimise the risk that the quality of raw water taken for treatment for human consumption results in the odour of drinking water being offensive to consumers.

2.2.3 **Irrigation water**

The management goal for irrigation water is that the quality of surface water, when used in accordance with the best irrigation and crop management practices and principles of ecologically sustainable development, does not result in crop yield loss or soil degradation.

2.2.4 **Recreational water quality**

The management goal for recreational water quality is to achieve a low risk to human health from water quality threats posed by exposure through ingestion or contact during recreational use of water resources.

Table 1 Environmental values for the waters of the Johnstone River basin (112) and adjacent coastal waters

Johnstone River basin (112)	Environmental values[1, 2, 3]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation [4]	Secondary recreation[4]	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
												
Surface fresh waters (rivers, creeks, streams) in developed areas (e.g. urban, industrial, rural residential, agriculture, farmlands)												
Peeramon	✓	✓	✓	✓		✓	✓			✓		✓
Malanda Creek	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Cleminson and Williams	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓
Ithaca, Short and Glen Allyn South	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓
Gillies	✓		✓	✓		✓	✓		✓	✓	✓	✓
Five Mile	✓		✓	✓		✓	✓		✓	✓		✓
Dirran Creek	✓	✓	✓	✓	✓	✓	✓			✓		✓
Theresa Creek	✓	✓	✓	✓		✓	✓		✓	✓		✓
Elinjaa and Mungalli	✓	✓	✓	✓		✓	✓		✓	✓		✓
Topaz	✓			✓						✓		✓
Topaz South	✓	✓	✓	✓		✓				✓		✓
Coolamon Creek	✓			✓						✓		✓
Beatrice River	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Granite	✓	✓	✓	✓		✓	✓		✓	✓		✓

Johnstone River basin (112)	Environmental values[1, 2, 3]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation [4]	Secondary recreation[4]	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
												
Clancys Overflow	✓	✓		✓			✓		✓	✓	✓	✓
Mid North Johnstone including Rankin, Fisher, Waraker, Tregothanaan, Pin Gin, Polly and Victory sub-catchments	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mid South Johnstone including Utchee west, Meingan, Mena, Wangan, Bamboo and Mourilyan sub-catchments	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
South Coastal fresh waters including West Liverpool, South Liverpool, Little Liverpool, Scindah, Kittabah, Cowley, Brown, Taringabah, Meuribah, Jingu, Big Maria, Silkwood, Bombeeta, Moresby and Boundary sub-catchments	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Surface fresh waters in undeveloped areas (e.g. National Parks, forest reserves)												
North Johnstone including Badgery, Henrietta, Mystery, Poorka and Lower Badgery sub-catchments	✓					✓	✓	✓	✓	✓		✓
Upper South Johnstone including Charappa, Maple, Downey, Lower Downey, McNamee, Egan, Mitcha, Lower McNamee and Kaarru sub-catchmetns	✓					✓	✓	✓	✓			✓
Karang Garee Creek	✓						✓		✓	✓		✓
Groundwaters	✓	✓	✓	✓						✓	✓	✓
Estuaries/bays, coastal and marine waters												
Estuarine waters including Johnstone River main channel and tributary estuaries, Moresby and Mourilyan estuaries.	✓				✓	✓		✓	✓		✓	✓

Johnstone River basin (112)	Environmental values[1, 2, 3]											
	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation [4]	Secondary recreation[4]	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
												
Johnstone coastal waters	✓					✓	✓	✓	✓		✓	✓
Offshore marine waters	✓					✓	✓	✓	✓			✓

Notes:

1. ✓ means the EV is selected for protection.
2. Refer to the accompanying maps for the spatial locations of the EVs.
3. Blank indicates that the EV is not chosen for protection.
4. The selection of recreational EVs for waters does not mean that these waters are free of dangerous aquatic organisms, for example venomous organisms (e.g. marine stingers including box jellyfish, irukandji jellyfish), crocodiles, and sharks. Direct contact with dangerous aquatic organisms should be avoided. Refer to EHP CrocWatch, council, www.health.qld.gov.au, www.beachsafe.org.au, www.marinestingers.com.au and other information sources for further details on swimming safety and information on specific waters.

Water quality objectives to protect environmental values

3 Water quality objectives to protect environmental values

This section provides WQOs to protect the EVs for the waters at Section 2.

- Section 3.1 information for reference to the State Planning Policy: state interest – water quality.
- Section 3.2 states the surface waters WQOs to protect the aquatic ecosystem EV.
- Section 3.3 states the surface waters WQOs to protect the human use EVs.
- Section 3.4 states the groundwater WQOs to protect the groundwater EVs.

3.1 State planning policy: state interest – water quality

The State Planning Policy (SPP) defines the Queensland Government's policies about matters of state interest in land use planning and development. (A state interest is defined under the *Sustainable Planning Act 2009.*)

Water quality is a state interest. The SPP (state interest – water quality) seeks to ensure that 'the environmental values and quality of Queensland waters are protected and enhanced'. It includes provisions relating to planning schemes, acid sulfate soils and water supply buffer areas.

The provisions of the SPP are operationalised through the SPP code – water quality (Appendix 3 of the SPP). The purpose of the code is to 'ensure development is planned, designed, constructed and operated to manage stormwater and wastewater in ways that support the protection of environmental values identified in the Environmental Protection (Water) Policy 2009'. The code contains detailed performance objectives for planning schemes, development and land use activities to implement the code's purpose. These include stormwater management design objectives by climatic region (construction and post-construction phases).

The SPP (state interest – water quality) is supported by the State Planning Policy—state interest guideline – water quality. The SPP (including SPP code) and supporting guideline are available from the DSDIP website.

3.2 Water quality objectives to protect aquatic ecosystems environmental values

This section lists the WQOs for the various water types to protect the aquatic ecosystems environmental values stated for the Johnstone River basin at Section 2.

Procedures for the application of WQOs for aquatic ecosystem protection, and compliance assessment protocols can be found in Section 5 and Appendix D of the QWQG. For the comparison of test site monitoring data against WQOs, the median water quality value (e.g. concentration) of a number (preferably five or more) of independent samples at a particular monitoring ('test') site should be compared against the water quality objective of the same indicator, water type and level of aquatic ecosystem protection, as listed in table 2 below. For WQOs based on GBRMPA data, where single value WQOs are given for specified indicators (e.g. particulate N, Secchi depth), these should be compared to annual mean (rather than median) values. Relevant seasonal adjustments can be referenced in GBRMPA (2010) Water Quality Guidelines for the Great Barrier Reef Marine Park 2010. Also refer to notes after the tables.

WQOs for metals and other toxicants in sediments, in all cases reference is made to the ANZECC guidelines.

WQOs for metals and other toxicants in waters, where not stated in this document, are referred to the ANZECC guidelines. In the case of aluminium, reference is made to a recent peer reviewed study of toxicity of aluminium in marine waters by Golding et al. (2014). This study used ANZECC protocols to derive a marine guideline value of 24 µg/L of aluminium (that applies to the measured concentration in seawater that passes through an 0.45 µm filter) to protect 95% of species that applies to slightly to moderately disturbed waters, and 2.1 µg/L to protect 99% of species which applies to HEV waters. This supersedes the existing low reliability guideline of 0.5 µg/L that was derived using conservative safety margins from limited data.

- Golding, L.A., Angel, B.M., Batley, G.E., Apte, S.C., Krassoi, R. and Doyle, C.J. 2014. Derivation of a water quality guideline for aluminium in marine waters. Environmental Toxicology and Chemistry (Accepted) (DOI: 10.1002/etc.2771).

Water quality objectives for surface waters to protect the aquatic ecosystem environmental values

3.2.1 Surface water quality objectives

Tables 2.1 to 2.5 include the following information for the surface waters for the various catchments and adjacent coastal waters:

- Water quality objectives for physico-chemical, nutrient, algal and water clarity indicators under baseflow conditions—Table 2.1
- Water quality objectives for nutrients and suspended solids during high flow periods – Table 2.2
- Water quality objectives for specific pesticides and biocides – Table 2.3
- Water quality objectives for other ions, metals and chemical indicators in surface waters—Table 2.4
- Freshwater macroinvertebrate objectives for moderately disturbed waters—Table 2.5

Note: Event flow WQOs are provided in table 2.2. Unless otherwise stated all other WQOs provided are for application only during baseflow conditions.

Table 2.1 Water quality objectives for physico-chemical, nutrient, algal and water clarity indicators to protect the aquatic ecosystems EVs under baseflow conditions

Level of protection	Water type	Water quality objectives													
		Physico-chemical		Nutrients								Algal growth	Water clarity		
		DO	pH	Ammonia N	Oxidised N	Particulate N	Organic N	Total N	FRP	Particulate P	Total P	Chl-a	Turbidity	Secchi	TSS
		% Saturation		µg/L									NTU	m	mg/L
Table notes		**Water quality objectives** shown as 20th, 50th and 80th percentiles (i.e. 3-4-5) or as a single value of median or 80th percentile (i.e. 15). DO and pH may be shown as a range of 20th and 80th percentiles (i.e. 85–105). **Seagrass:** Local seagrass distribution and composition is maintained as measured by extent of seagrass, species diversity and depth limit. Minimum light requirement for seagrass is a PAR two week moving average of greater than 6 mol m^{-2} day^{-1}. This is minimum requirement only for seagrass health and is generally below average harbour conditions. It does not include potential impacts on benthic microalgae and phytoplankton at this light level. Objective based on Chartrand et al. *(2012) Development of a Light-Based Seagrass Management Approach for the Gladstone Western Basin Dredging Program.* **Mangroves:** Objective of no net loss of mangrove area. The Queensland Herbarium conducts biennial mapping of mangrove cover and this could be used as an assessment tool. Mapping is available from EHP. **Wetlands:** for high impact earthworks within Great Barrier Reef wetland protection areas, refer to the guideline 'Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments', and the Queensland wetland buffer planning guideline, available from the department's website. Also refer to Section 3.2.3.													
High ecological value waters/ slightly disturbed waters	Undeveloped upland fresh water (HEV3061)	90-95-100[1]	6-6.5-7.5[1]	3-4-6[1]	10-15-30[1]	nd	75-100-125[1]	90-120-150[1]	3-4-5[1]	nd	5-7-10[1]	<0.5[1]	<1-2-5[1]	nd	2[3]
	Undeveloped lowland fresh water (HEV3061/ HEV3123)	85-120[1]	6.0-8.0[1]	10[1]	30[1]	nd	200[1]	240[1]	4[1]	nd	10[1]	1.5[1]	15[1]	nd	2[3]
	Freshwater lakes/ reservoirs (HEV3061)	90-120[1]	6.0-8.0[1]	10[1]	10[1]	nd	330[1]	350[1]	5[1]	nd	10[1]	3[1]	2-200[1]	nd	nd
	Wetlands (HEV3061)	90-120[1]	6.0-8.0[1]	10[1]	10[1]	nd	330-1180[1]	350-1200[1]	5-25[1]	nd	10-50[1]	10[1]	2-200[1]	nd	nd
	Mid estuarine and tidal canals, constructed estuaries, marinas and boat harbours (HEV3061)	80-85-105[1]	6.5-7.3-8.4[1]	5-10-15[1]	2-15-30[1]	nd	100-100-200[1]	110-130-250[1]	2-3-5[1]	nd	10-15-20[1]	1-2-3[1]	2-5-10[1]	2-1.5-1[1]	nd
	Enclosed coastal/lower estuary (HEV3061/ SD3121)	85-105[1]	6.5-7.3-8.4	<15	nd	nd	135[1]	160[1]	5[1]	nd	20[1]	2.0[1]	10[1]	1.0[1]	nd

Level of protection	Water type	Water quality objectives													
		Physico-chemical		Nutrients								Algal growth	Water clarity		
		DO	pH	Ammonia N	Oxidised N	Particulate N	Organic N	Total N	FRP	Particulate P	Total P	Chl-a	Turbidity	Secchi	TSS
		% Saturation		µg/L									NTU	m	mg/L
High ecological value waters/ slightly disturbed waters	Open coastal[2] (HEV3121/ SD3121)	95-100-105[2]	8.1-8.3-8.4[2]	1-3-7[2]	0-0-1[2]	≤20[2]	nd	76-105-140[2]	0-2-3[2]	≤2.8[2]	8-14-22[2]	<0.45[2]	0.6-0.9-1.8[2]	≥10[2]	≤2[2]
		Total dissolved N: 57-80-110 µg/L **Total dissolved P**: 4-8-18 µg/L **Silicate**: 90-165-260 µg/L **Temperature**: <1°C increase above long term (20 year) average maximum													
	Offshore waters[2] (HEV3122)	95-105[2]	8.1-8.3-8.4[2]	1-4-10[2]	0-1-2[2]	10-13-17[2]	nd	71-96-122[2]	0-1-3[2]	1.2-1.9-2.6[2]	4-6-9[2]	0.2-0.3-0.5[2]	<1[2]	10-13-16[2]	0.3-0.6-1.1[2]
		Total dissolved N: 54-74-97 µg/L **Total dissolved P**: 2-4-8 µg/L **Silicate**: 28-52-104 µg/L **Temperature**: <1°C increase above long term (20 year) average maximum													
Moderately disturbed waters	Developed fresh water	85-120[1]	6.0-8.0[1]	<10[3]	<50[3]	nd	nd	<340[3]	<8[3]	nd	<25[3]	<1.5[1]	<15[1]	nd	<8[3]
	Freshwater lakes/ reservoirs	90-120[1]	6.0-8.0[1]	<10[1]	<10[1]	nd	<330[1]	<350[1]	<5[1]	nd	<10[1]	<3[1]	2-200[1]	nd	nd
	Wetlands	90-120[1]	6.0-8.0[1]	<10[1]	<10[1]	nd	330-1180[1]	350-1200[1]	5-25[1]	nd	10-50[1]	<10[1]	2-200[1]	nd	nd
	Mid estuarine and tidal canals, constructed estuaries, marinas and boat harbours	80-105[1]	6.5-8.4[1]	<15[1]	<30[1]	nd	<200[1]	<250[1]	<5[1]	nd	<20[1]	<3[1]	<10[1]	>1[1]	nd
	Enclosed coastal/lower estuary	85-105[1]	6.5-8.4[1]	<15[1]	<10[1]	nd	<135[1]	<160[1]	<5[1]	nd	<20[1]	<2[1]	<10[1]	>1[1]	nd
Slightly – moderately disturbed waters	Open coastal[2]	95-105[2]	8.1-8.4[2]	≤3[2]	≤1[2]	≤20[2] (annual mean)	nd	≤105[2]	≤2[2]	≤2.8[2] (annual mean)	≤14[2]	≤0.45[2] (annual mean)	≤1[2]	≥10[2] (annual mean)	≤2[2] (annual mean)

Level of protection	Water type	Water quality objectives												
		Physico-chemical		Nutrients								Algal growth	Water clarity		
		DO	pH	Ammonia N	Oxidised N	Particulate N	Organic N	Total N	FRP	Particulate P	Total P	Chl-a	Turbidity	Secchi	TSS
		% Saturation		µg/L									NTU	m	mg/L
Slightly – moderately disturbed waters	Open coastal[2]	**Total dissolved N**: ≤80 µg/L **Total dissolved P**: ≤8 µg/L **Silicate**: ≥165 µg/L **Temperature**: <1^{o}C increase above long term (20 year) average maximum													
Highly disturbed waters		Assess existing water quality at the highly disturbed test site. Initial objective is to ensure no deterioration from this. Long-term objective is to attain the moderately disturbed objective value. Intermediate objectives can be set based on (a) 95th percentile of reference values from a slightly disturbed reference site or (b) on references values from another site that is highly disturbed but that is nevertheless in measurably better condition than the test site[1].													

Notes:

- DO: dissolved oxygen, FRP: filterable reactive phosphorus, Chl-a: chlorophyll-a, TSS: total suspended solids. nd: no (or insufficient) data.
- Units % saturation: percent saturation, µg/L: micrograms per litre, NTU: nephelometric turbidity units, m: metres, mg/L: milligrams per litre.

Sources:

1. Queensland Water Quality Guidelines 2009.
2. GBRMPA analysis of Reef Rescue Marine Monitoring Program and/or Long Term Monitoring Program datasets.
3. Analysis of DSITIA water quality monitoring data and Great Barrier Reef Catchment Loads Monitoring Program.

Table 2.2 Water quality objectives for nutrients and suspended solids to protect aquatic ecosystem EVs during high flow periods

Water Quality Objectives	Ammonia N	Oxidised N	Particulate N	DON	TN	FRP	Particulate P	DOP	TP	TSS
Units	**µg/L**									**mg/L**
	WQOs apply to all fresh waters during high flow periods where discharge is above local baseflow. WQO are presented as 20^{th}-50^{th}-80^{th} percentiles.									
20^{th}-50^{th}-80^{th} percentiles	4-8-13	5-66-101	50-153-384	72-106-148	229-370-668	1-3-4	5-10-45	5-5-10	10-20-70	4-20-52

Notes:

1. High flow WQOs are based on measured data from high flow periods at a reference site on the Tully River in Tully Gorge National Park (gauging station 113015A).
2. DON: dissolved organic nitrogen, TN: total nitrogen, FRP: filterable reactive phosphorous, DOP: dissolved organic phosphorous, TP: total phosphorous, TSS: total suspended solids.

Source:

Orr, D., Turner, R.D.R., Huggins, R., Vardy, S., Warne, M. St. J. 2014. Wet Tropics water quality statistics for high and base flow conditions. Great Barrier Reef Catchment Loads Monitoring Program, Department of Science, Information Technology, Innovation and the Arts, Brisbane.

Table 2.3 Water quality objectives for specific pesticides and biocides to protect aquatic ecosystem EVs

Level of aquatic ecosystems protection	Water quality objectives											
	Water type	Pesticides										Biocide
		Diuron	Atrazine	Chlor-pyrifos	Endo-sulfan	Ametryn	Simazine	Hexa-zinone	2,4-D	Tebu-thiuron	MEMC	Diazinon	Tributlyltin (as Sn)
		µg/l											
High ecological value waters	All (HEV3061/ HEV3121/ HEV3122/ HEV3123)	No detection of anthropogenic toxicants											
Slightly disturbed waters	Undeveloped fresh water	nd	0.7	0.00004	0.03	nd	0.2	75	140	0.2	nd	0.00003	nd
	Freshwater lakes/ reservoirs	nd	0.7	0.00004	0.03	nd	0.2	75	140	0.2	nd	0.00003	nd
	Wetlands	nd	0.7	0.00004	0.03	nd	0.2	75	140	0.2	nd	0.00003	nd
	Mid estuarine and tidal canals, constructed estuaries, marinas and boat harbours	nd	0.7	0.00004	0.03	nd	0.2	75	140	0.2	nd	0.00003	nd
	Enclosed coastal/lower estuary (SD3121)	0.9	0.6	0.0005	0.005	0.5	0.2	1.2	0.8	0.02	0.002	0.00003	0.0004
	Open coastal (SD3121)	0.9	0.6	0.0005	0.005	0.5	0.2	1.2	0.8	0.02	0.002	0.00003	0.0004

Level of aquatic ecosystems protection	Water quality objectives											
	Water type	Pesticides										Biocide
		Diuron	Atrazine	Chlor-pyrifos	Endo-sulfan	Ametryn	Simazine	Hexa-zinone	2,4-D	Tebu-thiuron	MEMC	Diazinon	Tributlyltin (as Sn)
		µg/l											
Moderately disturbed and highly disturbed waters	Developed fresh water	nd	13	0.01	0.03	nd	3.2	75	280	2.2	nd	0.01	nd
	Freshwater lakes/ reservoirs	nd	13	0.01	0.03	nd	3.2	75	280	2.2	nd	0.01	nd
	Wetlands	nd	13	0.010	0.03	nd	3.2	75	280	2.2	nd	0.01	nd
	Mid estuarine and tidal canals, constructed estuaries, marinas and boat harbours	nd	13	0.01	0.03	nd	3.2	75	280	2.2	nd	0.01	nd
	Enclosed coastal/lower estuary	1.6	1.4	0.009	0.005	1.0	3.2	1.2	30.8	2	0.002	0.01	0.006
	Open coastal	1.6	1.4	0.009	0.005	1.0	3.2	1.2	30.8	2	0.002	0.01	0.006

Notes:

1. nd = no data
2. For all other contaminants in waters, including **metals** —see ANZECC guidelines. For aluminium, refer to: Golding, L.A., Angel, B.M., Batley, G.E., Apte, S.C., Krassoi, R. and Doyle, C.J. 2014. Derivation of a water quality guideline for aluminium in marine waters. Environmental Toxicology and Chemistry (Accepted) (DOI: 10.1002/etc.2771).
3. Comply with the Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance, ANZECC (Re Tributyltin and Dibutyltin)

Source:

Freshwater and Mid estuarine WQOs derived from ANZECC (2000). Enclosed coastal/Lower estuary and Open coastal WQOs derived from GBRMPA (2010)

Table 2.4 Water quality objectives for other ions, metals and chemical indicators in surface waters

Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		EC	Hardness (mg· L^{-1})	Alkalinity (mg· L^{-1})	SiO_2 (mg· L^{-1})	F (mg· L^{-1})	Fe (mg· L^{-1})	Mn (mg· L^{-1})	Zn (mg· L^{-1})	Cu (mg· L^{-1})	SAR
	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	µS· cm^{-1}									
20th	5	40	2	16	1	17	14	47	6	28	1	2	47	8	11	10.1	0.010	0.010	0.000	0.000	0.00	0.60
50th	7	51	3	22	2	26	25	59	9	36	1	3	72	17	20	14.1	0.060	0.050	0.000	0.010	0.01	0.70
80th	11	66	5	28	4	34	40	68	14	48	2	6	106	29	33	21.1	0.110	0.200	0.010	0.020	0.03	0.95

Note:

1. These values are based on local data collected across the Wet Tropics region. ANZECC guidelines apply for some elements, however these locally observed data are below the guideline values and should be maintained.
2. EC = electrical conductivity; SAR = sodium adsorption ratio.

Source:

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

3.2.2 Riparian and groundcover water quality objectives

The clearing of native vegetation in Queensland is regulated by the *Vegetation Management Act 1999* the *Sustainable Planning Act 2009* and associated policies and codes. This includes the regulation of clearing in water and drainage lines.

For vegetation management relating to waterways, reference should be made to:

- State Development Assessment Provisions (SDAP) Module 8: Native vegetation clearing. This module includes performance requirements relating to clearing of native vegetation and a table relating to watercourse buffer areas and stream order. To review the SDAP modules, contact the Department of State Development, Infrastructure and Planning website.
- SDAP Module 11: Wetland protection area.
- Relevant self-assessable codes under the *Vegetation Management Act 1999*. These codes are activity based, some applying to different regions, and 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 self-assessable code (and other explanatory information), contact the Department of Natural Resources and Mines website.

To review the current vegetation management laws contact the Queensland Government website or Department of Natural Resources and Mines website.

To review the SDAP Modules, contact the Department of State Development, Infrastructure and Planning website.

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

The **riparian vegetation** target up to 2018 in the Reef Water Quality Protection Plan (Reef Plan) 2013 is that ‘The extent of riparian vegetation is increased’ and the **groundcover target** is for a ‘Minimum 70 per cent late dry season groundcover on grazing lands’.

3.2.3 Wetlands water quality objectives

The Environmental Protection Regulation section 81A defines Environmental values for wetlands.

The State assesses impacts from earth works that may have impacts on freshwater wetlands of High Ecological Significance in Great Barrier Reef Catchments against State Development Assessment Provisions (SDAP) Module 11: Wetland protection area.

This module includes performance requirements to ensure:

- adverse effects on hydrology, water quality and ecological processes of a wetland are avoided or minimised
- any significant adverse impacts on matters of state environmental significance and on riparian areas or wildlife corridors in strategic environmental areas are avoided.

Note: refer to the guideline 'Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments', and the Queensland wetland buffer planning guideline, available from the department’s website.

3.2.4 Freshwater macroinvertebrate objectives

Locally derived objectives for freshwater macroinvertebrate indices are listed in table 2.5 based, on reference sites shown at Figure 1. Aquatic macroinvertebrates are common and widespread throughout many aquatic ecosystems, are easily sampled and can provide an integrated measure of stream condition. Specific sampling protocols have been used and their training and accreditation requirements (see http://ausrivas.ewater.com.au/training-and-accreditation3) mean that sample results from a number of programs can be combined for use in derivation of objective values. In determining macroinvertebrate objectives, 10m of either edge or riffle habitats were sampled with standard protocols. Indices included in these macroinvertebrates objectives are:

- SIGNAL index (Stream Invertebrate Grade Number – Average Level) was developed for the bioassessment of water quality in rivers in Australia. A SIGNAL score is calculated by grading each detected macroinvertebrate family based upon its sensitivity to pollutants from 1 (tolerant) to 10 (sensitive) and averaging the grades. These guidelines used SIGNAL version 2.iv (Chessman 2003, available at www.environment.gov.au).
- Taxa richness is the number of different aquatic macroinvertebrate taxa collected in a sample.
- PET taxa richness is the number of aquatic macroinvertebrate families collected from three orders of aquatic insects; Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). These orders are considered to be sensitive to changes in their environment and therefore useful to assess stream condition.
- % sensitive taxa in an index based on the proportion of taxa with ‘sensitive’ SIGNAL grades of 8-10 (SIGNAL version 2.iv).
- % tolerant taxa in an index based on the proportion of taxa with ‘tolerant’ SIGNAL grades of 1-3 (SIGNAL version 2.iv).

Samples for the macroinvertebrate objectives were identified in the laboratory to family level, except Chironimidae (non-biting midges) that are identified to sub-family, and lower Phyla (Porifera, Nematoda, Nemertea, etc.), Oligochaeta (freshwater worms), Acarina (mites), and microcrustacea (Ostracoda, Copepoda, Cladocera) that are not identified further. The taxonomy used to calculate the objective indices are based on those used in SIGNAL version 2.iv.

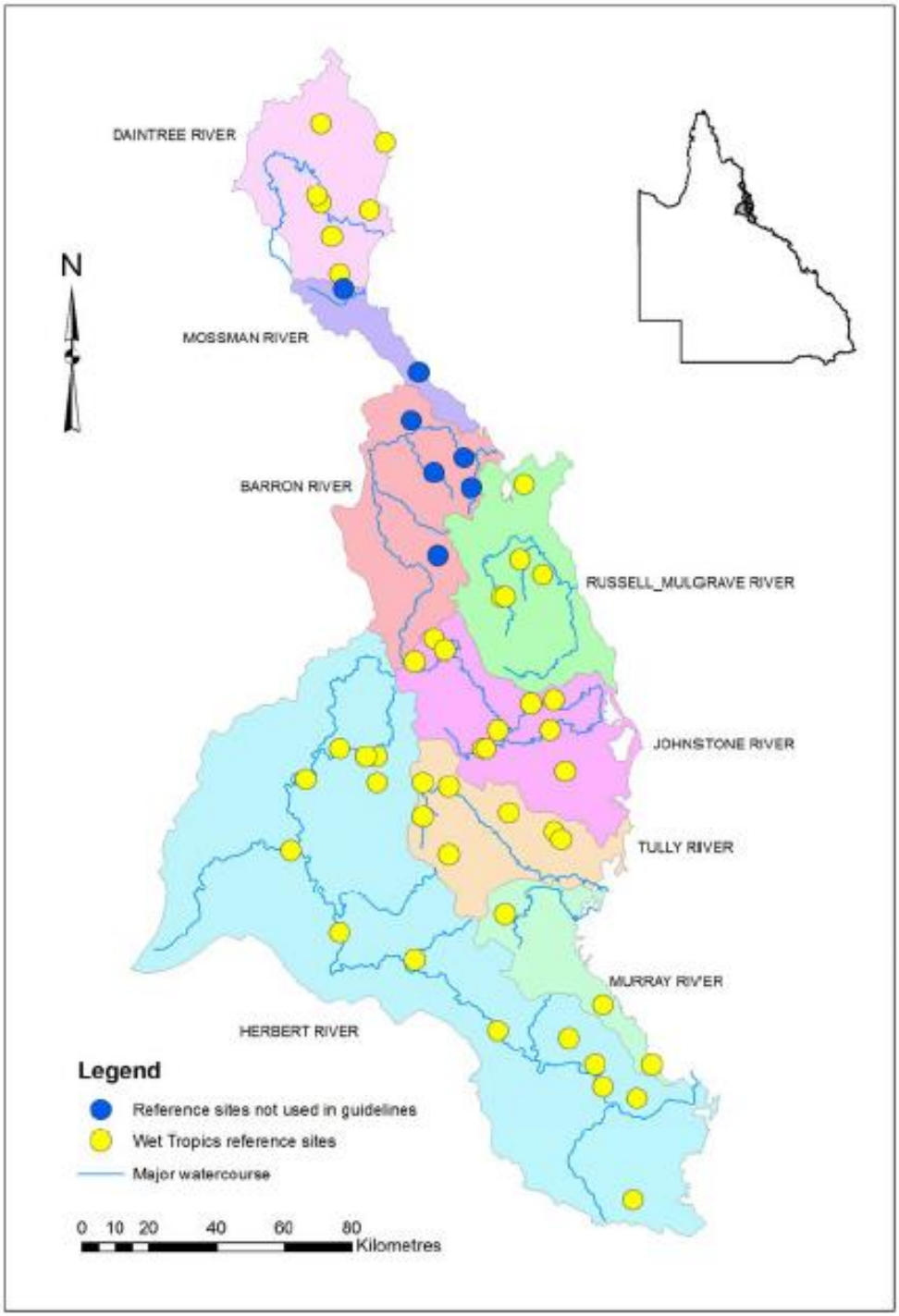

Figure 1 Reference sites (yellow circles) with samples considered or used for development of macroinvertebrate objectives in the Wet Tropics of Queensland

Table 2.5 Freshwater macroinvertebrate objectives for moderately (MD) disturbed waters of the Johnstone River basin

Index	Johnstone River basin			
	Edge habitat[1]		Riffle habitat[2]	
	20th percentile	80th percentile	20th percentile	80th percentile
SIGNAL index	4.12	4.79	5.06	5.94
Taxa richness	16	26	18	27
PET taxa richness	4	6	6	10
% sensitive taxa	3.85	10.34	14.29	27.78
% tolerant taxa	24.57	35.50	12.50	21.88

Notes:

1. Edge Habitat is located along the stream bank.
2. Riffle Habitat is characterised as a reach with relatively steep, shallow (<0.3m), fast flowing (>0.2m/s) and broken water over stony beds.

Source:

Negus P, Steward A & Blessing J. 2013. Queensland interim biological guidelines for Wet Tropics coastal streams: Aquatic macroinvertebrates, April 2013 – Draft for Comment. Brisbane: Department of Science, Information Technology, Innovation and the Arts, Queensland Government.

Water quality objectives to protect the human use environmental values

3.3 Water quality objectives for human use environmental values

This section outlines the WQOs to protect human use EVs, e.g. recreation, stock watering, aquaculture and crop irrigation. Tables 3.1 to 3.10 list the WQOs to protect the human use EVs for the waters of the Johnstone River basin and adjacent coastal waters.

The WQOs in these tables are based on national water quality guidelines, including ANZECC (2000), the National Health and Medical Research Council Guidelines for managing risks in recreational water, the Food Standards Australia New Zealand and the Australian Drinking Water Guidelines[5].

Where national guidelines are the source for the stated WQOs, reference is necessary to obtain comprehensive listings of all indicators, corresponding WQOs and up-to-date information.

Table 3.1 Water quality objectives to protect human use environmental values

Environmental value	Water type—refer attached pdf mapping or GIS datasets	Water quality objectives to protect the stated EV
Suitability for raw drinking water supply (before treatment)	Fresh waters and groundwaters	WQOs for drinking water supply are at table 3.2. Note: For water quality after treatment or at point of use refer to legislation and guidelines, including: • *Public Health Act 2005* and Regulations • *Water Supply (Safety and Reliability) Act 2008*, including any approved drinking water quality management plan under the Act • Australian Drinking Water Guidelines 2011—updated December 2013
Protection of the human consumer (oysters, fish crustaceans)	All fresh, estuarine and coastal waters	WQOs as per ANZECC guidelines and Australia New Zealand Food Standards Code[6], Food Standards Australia New Zealand, 2007 and updates.
Protection of cultural and spiritual values	All waters	Protect or restore indigenous and non-indigenous cultural heritage consistent with any relevant policies and plans.
Suitability for industrial use (includes mining, minerals processing, chemical process industries etc.)	Fresh waters, estuarine and coastal waters	No WQOs are stated for industrial uses of water. Water quality requirements for industry vary within and between industries. Where there are specific intake water quality requirements e.g. power station cooling water, the EV is protected by WQOs for other EVs, such as the aquatic ecosystem requirements.

[5] The AWQG are available on the National Water Quality Management Strategy website.
The ADWG are available on the NHMRC website.

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

Environmental value	Water type—refer attached pdf mapping or GIS datasets	Water quality objectives to protect the stated EV
Suitability for aquaculture	Fresh waters, estuarine and coastal waters	WQOs as per: • tables 3.3 to 3.5 • ANZECC guidelines and Australia New Zealand Food Standards Code, Food Standards Australia New Zealand, 2007 and updates
Suitability for irrigation	Fresh waters and groundwaters	WQOs for pathogens and metals are provided in tables 3.6 and 3.7 For other indicators, such as salinity, sodicity and herbicides, see ANZECC guidelines
Suitability for stock watering	Fresh waters and groundwaters	WQOs as per ANZECC guidelines, including median faecal coliforms <100 organisms per 100 mL WQOs for total dissolved solids and metals are provided in tables 10 and 11 For other objectives, such as cyanobacteria and pathogens, see ANZECC guidelines
Suitability for farm supply/use	All fresh waters including groundwaters	WQOs as per ANZECC guidelines
Suitability for primary contact recreation	Fresh waters, estuarine and coastal waters	Objectives as per NHMRC (2008)[7], 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 100mL (for healthy adults) (NHMRC, 2008; table 5.7) • direct contact with venomous or dangerous aquatic organisms should be avoided. Recreational water bodies should be reasonably free of, or protected from, venomous organisms (e.g. box jellyfish and bluebottles) • waters contaminated with chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreational purposes

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

Environmental value	Water type—refer attached pdf mapping or GIS datasets	Water quality objectives to protect the stated EV
Suitability for primary contact recreation – continued	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 3.10.
	Estuarine, coastal waters	cyanobacteria / algae: Recreational water bodies should not contain ≥ 10 cells/mL *Karenia brevis* and/or have *Lyngbya majuscula* and/or *Pfiesteria* present in high numbers[2]. Further details are contained in NHMRC (2008) and table 3.10.
Suitability for secondary contact recreation	Fresh waters, 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 3.10.
Suitability for visual recreation	Fresh waters, estuarine and coastal waters	Objectives as per NHMRC (2008), including: • recreational water bodies should be aesthetically acceptable to recreational users. The water should be free from visible materials that may settle to form objectionable deposits; floating debris, oil, scum and other matter; substances producing objectionable colour, odour, taste or turbidity; and substances and conditions that produce undesirable aquatic life. • Cyanobacteria / algae—refer objectives for primary recreation, NHMRC (2008) and table 3.10.

Notes:

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

Sources:

The WQOs were determined from:

- 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).

Table 3.2 Drinking water EV – Water quality objectives for raw drinking water supply in the vicinity of off-takes, including groundwater, before treatment

WQOs for drinking water **before treatment** are derived from the Office of the Water Supply Regulator (Department of Energy and Water Supply) and Queensland Health.

Note: 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, *Water Fluoridation Act 2008*, and the Australian Drinking Water Guidelines (ADWG (2011), 2013 update).

Indicator	Water quality objective
Giardia	0 cysts (Office of Water Supply Regulator) If *Giardia* is detected in drinking water then the health authorities should be notified immediately and an investigation of the likely source of contamination undertaken (ADWG).
Cryptosporidium	0 cysts (Office of Water Supply Regulator) If *Cryptosporidium* is detected in drinking water then the health authorities should be notified immediately and an investigation of the likely source of contamination undertaken (ADWG).
E. coli	<50 cfu/100mL Treatment plants with effective barriers and disinfection are designed to address faecal contamination. *E. coli* or thermotolerant coliforms should not be present in any 100 mL sample of (treated) drinking water (ADWG).
Blue-green algae (cyanobacteria)	<100 cells/mL
Algal toxin	<1 µg/L Microcystin
pH	5.5–8
Total dissolved solids	<600mg/L The concentration of total dissolved solids in treated drinking water should not exceed 600 mg/L (ADWG 2011, based on taste considerations).
Sodium	<180mg/L The concentration of sodium in reticulated drinking water supplies should not exceed 180 mg/L (ADWG, based on threshold at which taste becomes appreciable).
Sulfate	<250mg/L The concentration of sulfate in drinking water should not exceed 250 mg/L (ADWG 2011, based on taste/aesthetic considerations). ADWG 2011 health guideline: <500mg/L
Dissolved oxygen	5.5–7 mg/L

Indicator	Water quality objective
Pesticides	Raw supplies: Below detectable limits. Treated drinking water: Refer to ADWG.
Other indicators (including physico-chemical indicators)	Refer to ADWG.

Table 3.3 Aquaculture EV – Water quality objectives for tropical aquaculture

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

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

Table 3.4 Aquaculture EV – Water quality objectives for optimal growth of freshwater species

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

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

Table 3.5 Aquaculture EV – Water quality objectives for optimal growth of particular marine species

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

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

Table 3.6 Irrigation EV – Water quality objectives for thermotolerant (faecal) coliforms in irrigation water used for food and non-food crops[1]

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

Notes:

1. Adapted from ARMCANZ, ANZECC and NHMRC (1999).
2. Refer to Australian Drinking Water Guidelines 2000 (AWQG), Volume 1, Section 4.2.3.3 for advice on testing protocols.

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

Table 3.7 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

Notes:

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

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

Table 3.8 Stock watering EV – Water quality objectives for tolerances of livestock to total dissolved solids (salinity) in drinking water[1]

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

Notes:

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

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

Table 3.9 Stock watering EV – Water quality objectives (low risk trigger values) for heavy metals and metalloids in livestock drinking water

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

Notes:

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

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

Table 3.10 Recreational waters – Alert levels and corresponding actions for management of cyanobacteria

The water quality objectives for water used for recreational purposes are that the values for cyanobacteria cell counts or biovolume meet the guideline values set out in Chapter 6 of the Guidelines for Managing Risks in Recreational Water.

When cyanobacteria are present in large numbers they can present a significant hazard, particularly to primary contact users of waters. Monitoring/action requirements relative to cyanobacteria 'alert' levels are summarised below the table, and are explained more fully in the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008).

Further details on the process to determine suitability of waters for recreation, relative to historical cyanobacterial levels and susceptibility to cyanobacterial contamination, are contained in sections 6 and 7 of the NHMRC guidelines.

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

Notes:

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

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

Water quality objectives to protect groundwater environmental values

3.4 Water quality objectives to protect groundwater environmental values

This section lists WQOs for the various groundwater types to protect the aquatic ecosystems environmental values stated for the groundwaters of the Johnstone River basin at Section 2.

WQOs are provided according to their chemistry zone and depth category in tables 4.1 to 4.8.

Where groundwaters interact with surface waters, groundwater quality should not compromise identified EVs and WQOs for those waters.

The AWQG recommends that the highest level of protection should be provided to underground aquatic ecosystems, given their high conservation value.

Where groundwaters are in good condition the intent is to maintain existing water quality (20th, 50th and 80th percentiles).

3.4.1 **Wet Tropics groundwater chemistry groups**

The Groundwater Chemistry Zones in the Johnstone River basin are shown at Plan WQ1083.

The major groups include:

Wet tropical alluvial:

- ID No. 18 – Barron Mulgrave Johnstone metamorphics (Table 4.1)
- ID No. 21 – Herbert Johnstone volcanics (Table 4.2)
- ID No. 22 – Maadi Bingle (Table 4.3)
- ID No. 23 – Basalt uplands and slopes (Table 4.4)
- ID No. 24 – Mundoo (Table 4.5)

Sodic:

- ID No. 10 – Granitic uplands and slopes (Table 4.6)

Coastal and floodplain:

- ID No. 9 – Low salinity coastal floodplains (Table 4.7)

High nitrate:

- ID No. 27 – Innisfail (Table 4.8)

Table 4.1 Water quality objectives to protect aquatic ecosystem EVs for Groundwater Chemistry Group (refer to Plan WQ1083) – Wet Tropical Alluvial – 18 Barron Mulgrave Johnstone metamorphics

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC	Hardness	pH	Alkalinity	SiO_2	F	Fe	Mn	Zn	Cu	SAR	RAH	eH
		mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	µS· cm^{-1}	(mg· L^{-1})		(mg· L^{-1})	(mg· L^{-1})	(mg· L^{-1})	(mg· L^{-1})	(mg· L^{-1})	(mg· L^{-1})	(mg· L^{-1})		(meqL^{-1})	(mV)
shallow	20th	8	45	2	12	1	11	23	41	5	19	-	-	-	-	66	8	6.4	19	12.0	0.003	0.000	0.000	0.000	0.00	0.80	0.10	-
	50th	10	59	4	24	2	13	32	68	7	25	-	-	2	2	105	18	6.7	26	18.0	0.100	0.010	0.020	0.015	0.01	0.90	0.22	-
	80th	13	75	9	35	3	21	55	75	19	44	2	3	7	13	144	34	7.1	45	36.0	0.119	1.026	0.401	0.030	0.01	1.59	0.32	-
moderate	20th	8	40	3	12	1	9	18	34	6	13	-	-	-	-	90	12	6.5	16	14.9	0.043	0.000	0.000	0.000	0.00	0.80	0.00	-
	50th	13	56	6	19	3	21	52	62	9	25	2	2	2	2	143	28	7.3	47	24.0	0.200	0.000	0.000	0.000	0.00	1.10	0.33	-
	80th	97	76	25	35	13	29	173	78	61	51	6	6	7	12	570	115	7.9	151	40.1	0.500	0.020	0.030	0.010	0.01	2.98	1.36	-
deep	20th	8	47	1	8	1	11	16	38	5	12	-	-	-	-	71	6	6.5	13	17.0	0.010	0.000	0.000	0.000	0.00	0.81	0.12	-
	50th	13	57	3	16	3	26	42	66	7	26	1	1	1	0	110	20	7.0	35	23.0	0.110	0.000	0.000	0.008	0.00	1.35	0.30	-
	80th	38	82	8	24	8	31	106	85	25	45	3	3	4	9	305	51	7.7	88	33.9	0.362	0.049	0.181	0.024	0.02	2.39	0.70	-
very deep	20th	15	77	2	8	1	9	22	38	11	25	0	0	0	0	98	9	6.4	18	22.0	0.524	0.000	0.000	0.000	0.00	2.20	0.10	-
	50th	17	80	2	10	1	10	35	57	12	32	1	4	5	4	119	10	7.2	29	22.5	0.620	0.015	0.000	0.000	0.00	2.25	0.33	-
	80th	20	84	8	12	4	11	50	63	17	34	4	9	15	22	166	37	7.8	41	24.8	0.695	0.700	0.063	0.000	0.00	2.40	0.40	-

Table 4.2 Water quality objectives to protect aquatic ecosystem EVs for Groundwater Chemistry Group (refer to Plan WQ1083) – Wet tropical alluvial – 21 Herbert Johnstone volcanics

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC	Hardness (mg· L^{-1})	pH	Alkalinity (mg· L^{-1})	SiO_2 (mg· L^{-1})	F (mg· L^{-1})	Fe (mg· L^{-1})	Mn (mg· L^{-1})	Zn (mg· L^{-1})	Cu (mg· L^{-1})	SAR	RAH (meqL^{-1})	eH (mV)
		mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	µS· cm^{-1}												
moderate		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
deep	20th	6	23	7	29	6	32	62	72	6	13	-	-	1	1	113	42	7.0	51	37.2	0.000	-	-	-	-	0.40	0.06	-
	50th	6	26	11	40	6	37	67	80	8	14	-	-	3	3	135	53	7.0	55	39.0	0.000	-	-	-	-	0.40	0.18	-
	80th	8	27	13	43	6	44	82	83	14	26	0	1	5	6	160	57	7.2	68	42.6	0.072	-	-	-	-	0.49	0.29	-

Table 4.3 Water quality objectives to protect aquatic ecosystem EVs for Groundwater Chemistry Group (refer to Plan WQ1083) – Wet tropical alluvial – 22 Maadi Bingle

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC	Hardness (mg· L^{-1})	pH	Alkalinity (mg· L^{-1})	SiO_2 (mg· L^{-1})	F (mg· L^{-1})	Fe (mg· L^{-1})	Mn (mg· L^{-1})	Zn (mg· L^{-1})	Cu (mg· L^{-1})	SAR	RAH (meqL^{-1})	eH (mV)
		mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	µS· cm^{-1}												
shallow	Samples	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Insufficient data for Water Quality Objectives																												

Table 4.4 Water quality objectives to protect aquatic ecosystem EVs for Groundwater Chemistry Group (refer to Plan WQ1083) – Wet tropical alluvial – 23 Basalt uplands and slopes

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC	Hardness (mg· L^{-1})	pH	Alkalinity (mg· L^{-1})	SiO_2 (mg· L^{-1})	F (mg· L^{-1})	Fe (mg· L^{-1})	Mn (mg· L^{-1})	Zn (mg· L^{-1})	Cu (mg· L^{-1})	SAR	RAH (meqL^{-1})	eH (mV)
		mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	µS· cm^{-1}												
shallow	20th	4	32	1	10	2	22	11	39	6	20	-	-	1	1	58	9	5.9	10	10.0	0.000	0.000	0.000	0.000	0.00	0.50	0.00	466.3
	50th	9	43	3	23	3	30	29	55	11	32	1	1	5	8	75	18	6.6	28	32.0	0.020	0.005	0.000	0.010	0.01	0.85	0.11	566.5
	80th	16	64	11	29	9	40	89	76	17	47	2	3	9	18	202	61	7.5	74	54.5	0.256	0.030	0.019	0.021	0.02	1.60	0.84	575.7
moderate	20th	6	26	3	17	3	29	16	49	7	15	-	-	-	0	79	18	6.2	15	16.0	0.000	0.000	0.000	0.010	0.00	0.50	0.00	425.5
	50th	9	36	7	26	5	37	54	74	10	22	-	-	2	2	128	38	6.8	50	37.5	0.000	0.000	0.000	0.020	0.01	0.60	0.12	526
	80th	14	50	13	32	10	43	100	81	14	39	2	3	5	10	200	73	7.5	85	51.1	0.100	0.010	0.010	0.060	0.02	0.80	0.33	564.3
deep	20th	7	25	3	18	3	26	30	62	7	11	-	-	0	0	97	20	6.4	26	22.3	0.000	0.000	0.000	0.000	0.00	0.50	0.00	397.8
	50th	9	31	8	28	7	39	69	76	10	20	-	-	2	2	159	48	7.0	59	41.5	0.010	0.000	0.000	0.010	0.01	0.60	0.08	519.5
	80th	16	53	17	32	11	45	137	86	14	30	2	3	5	6	257	89	7.6	114	53.0	0.100	0.010	0.010	0.050	0.01	0.90	0.38	549
very deep	20th	10	24	6	23	4	29	56	70	8	12	-	-	-	-	136	35	6.7	47	30.5	0.000	0.000	0.000	0.000	0.00	0.50	0.07	332.3
	50th	11	30	12	30	9	40	91	80	11	16	-	-	3	2	196	69	7.3	79	46.0	0.000	0.000	0.000	0.020	0.01	0.60	0.16	449
	80th	17	45	16	33	11	44	123	85	14	23	4	4	6	5	257	80	8.0	107	52.0	0.070	0.021	0.000	0.050	0.02	1.00	0.44	532.1

Table 4.5 Water quality objectives to protect aquatic ecosystem EVs for Groundwater Chemistry Group (refer to Plan WQ1083) – Wet tropical alluvial – 24 Mundoo

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC	Hardness (mg· L^{-1})	pH	Alkalinity (mg· L^{-1})	SiO_2 (mg· L^{-1})	F (mg· L^{-1})	Fe (mg· L^{-1})	Mn (mg· L^{-1})	Zn (mg· L^{-1})	Cu (mg· L^{-1})	SAR	RAH (meqL^{-1})	eH (mV)
		mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	µS· c m^{-1}												
shallow	20th	4	53	1	10	1	15	-	-	8	54	-	-	4	14	48	6	4.4	0	3.0	0.000	0.000	0.030	0.010	0.01	0.65	0.00	-
	50th	5	64	1	13	1	22	2	10	9	65	-	-	6	26	55	7	4.8	2	3.0	0.000	0.000	0.030	0.020	0.02	0.80	0.00	-
	80th	6	71	1	17	2	29	5	20	10	69	1	2	8	31	59	10	5.8	4	5.5	0.050	0.005	0.096	0.078	0.02	1.05	0.00	-
moderate	20th	4	42	1	11	2	23	6	18	6	31	-	-	3	10	53	12	5.4	5	7.1	0.000	0.000	0.000	0.020	0.01	0.50	0.00	-
	50th	5	45	2	16	3	34	16	44	7	38	1	2	6	18	57	16	6.3	13	12.0	0.000	0.000	0.000	0.030	0.01	0.60	0.00	-
	80th	7	53	3	25	3	44	18	55	9	45	4	16	10	26	75	17	6.5	15	15.0	0.000	0.001	0.018	0.040	0.01	0.76	0.00	-
deep	20th	4	38	1	11	1	16	6	25	7	15	-	-	-	-	48	9	5.8	6	7.2	0.000	0.000	0.000	0.000	0.00	0.70	0.02	-
	50th	11	47	8	24	6	30	78	75	10	19	1	1	0	1	162	47	6.9	64	33.5	0.065	0.010	0.050	0.005	0.01	1.05	0.36	-
	80th	20	72	9	30	7	33	90	82	11	48	4	5	5	10	192	52	7.8	74	50.9	0.140	0.289	0.607	0.015	0.02	1.29	0.49	-

Table 4.6 Water quality objectives to protect aquatic ecosystem EVs for Groundwater Chemistry Group (refer to Plan WQ1083) – Sodic – 10 Granitic uplands and slopes

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

Table 4.7 Water quality objectives to protect aquatic ecosystem EVs for Groundwater Chemistry Group (refer to Plan WQ1083) – Coastal and Floodplain – 9 Low salinity coastal floodplains

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC	Hardness (mg· L^{-1})	pH	Alkalinity (mg· L^{-1})	SiO_2 (mg· L^{-1})	F (mg· L^{-1})	Fe (mg· L^{-1})	Mn (mg· L^{-1})	Zn (mg· L^{-1})	Cu (mg· L^{-1})	SAR	RAH (meqL^{-1})	eH (mV)
		mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	µS· cm^{-1}												
shallow	20th	6	57	1	6	1	10	7	18	8	39	-	-	-	-	51	7	5.8	6	9.0	0.000	0.000	0.000	0.010	0.00	1.00	0.00	-
	50th	13	67	2	11	2	18	18	32	17	54	2	4	1	2	96	14	6.6	15	19.5	0.050	0.008	0.018	0.020	0.01	1.50	0.02	-
	80th	24	81	5	21	4	27	41	52	28	70	6	11	4	8	156	26	7.3	34	30.0	0.150	0.040	0.094	0.075	0.02	2.90	0.28	-
moderate	20th	6	50	1	6	1	14	6	12	8	32	-	-	1	0	64	8	6.0	5	11.1	0.000	0.000	0.000	0.010	0.00	0.70	0.00	-
	50th	10	67	2	12	2	21	14	27	12	46	1	2	7	12	85	15	6.5	12	18.0	0.020	0.000	0.010	0.020	0.01	1.20	0.00	-
	80th	25	75	7	22	4	28	62	50	28	64	5	10	13	29	199	34	7.2	52	27.0	0.200	0.020	0.040	0.039	0.02	2.10	0.22	-
deep	20th	6	53	1	8	1	12	6	19	8	22	-	-	-	0	59	6	5.5	5	11.0	0.000	0.000	0.000	0.005	0.00	0.90	0.00	-
	50th	9	65	2	14	2	18	16	35	10	43	1	2	3	5	82	12	6.5	14	17.0	0.050	0.002	0.010	0.010	0.01	1.30	0.10	-
	80th	18	76	6	25	3	24	64	68	15	65	4	5	9	22	163	34	7.2	52	35.0	0.180	0.030	0.060	0.030	0.02	1.65	0.49	-
very deep	20th	7	54	1	10	1	10	13	21	7	20	1	2	1	0	64	9	6.1	11	16.0	0.010	0.000	0.000	0.000	0.00	0.70	0.00	-
	50th	9	59	3	15	3	16	29	46	9	39	1	4	4	9	95	19	6.9	24	23.0	0.100	0.005	0.005	0.010	0.02	1.30	0.13	-
	80th	78	74	18	26	8	25	103	65	65	60	16	8	8	16	511	67	7.5	85	43.7	0.610	0.020	0.020	0.030	0.02	5.25	1.47	-

Table 4.8 Water quality objectives to protect aquatic ecosystem EVs for Groundwater Chemistry Group (refer to Plan WQ1083) – High nitrate – 27 Innisfail

Depth	Percentile	Na		Ca		Mg		HCO_3		Cl		SO_4		NO_3		EC	Hardness (mg· L^{-1})	pH	Alkalinity (mg· L^{-1})	SiO_2 (mg· L^{-1})	F (mg· L^{-1})	Fe (mg· L^{-1})	Mn (mg· L^{-1})	Zn (mg· L^{-1})	Cu (mg· L^{-1})	SAR	RAH (meqL^{-1})	eH (mV)
		mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	mg· L^{-1}	%	µS· c m^{-1}												
shallow	20th	4	34	1	7	2	30	5	15	7	40	-	-	8	16	58	12	5.0	4	9.1	0.000	0.000	0.010	0.005	0.00	0.50	0.00	-
	50th	6	44	1	11	3	47	7	21	11	47	0	1	10	22	73	18	5.9	6	10.5	0.005	0.005	0.010	0.010	0.01	0.60	0.00	-
	80th	7	58	2	14	6	52	20	41	16	58	1	7	13	33	102	29	6.5	17	16.9	0.050	0.010	0.030	0.030	0.02	0.70	0.02	-
moderate	20th	5	30	1	10	2	15	5	17	7	19	-	-	2	2	76	12	5.2	7	10.0	0.000	0.000	0.000	0.001	0.00	0.41	0.00	-
	50th	7	48	2	17	4	25	15	36	10	41	1	2	9	13	101	22	6.8	14	14.0	0.020	0.010	0.008	0.010	0.02	0.65	0.00	-
	80th	12	67	19	35	6	45	93	72	16	49	5	12	15	33	231	70	7.8	80	18.0	0.100	0.020	0.136	0.040	0.02	1.39	0.47	-
deep	20th	17	42	3	10	3	13	69	1	10	19	0	2	-	-	197	25	6.7	57	17.3	0.075	0.000	0.015	0.013	0.00	0.90	0.00	-
	50th	748	46	346	26	226	28	76	2	2,083	86	321	9	-	0	6,500	1,807	7.5	63	25.0	0.120	0.010	2.265	0.025	0.01	7.70	0.09	-
	80th	898	51	463	27	289	31	111	76	2,627	89	388	10	4	3	8,112	2,345	7.8	92	29.0	0.200	0.116	4.351	0.212	0.01	7.90	1.19	-
very deep	20th	6	49	3	5	2	4	47	42	7	7	1	1	-	-	85	16	7.0	38	13.0	0.037	0.000	0.000	0.000	0.00	0.79	0.14	-
	50th	70	68	6	11	2	14	135	76	9	15	1	2	4	1	330	31	7.6	111	18.0	0.150	0.005	0.000	0.000	0.00	3.50	0.95	-
	80th	76	90	11	38	13	23	199	91	80	47	4	5	15	13	498	80	8.1	170	21.0	0.242	0.020	0.010	0.020	0.01	8.10	3.04	-

Notes:

1. Refer to Plan WQ1083 to locate relevant groundwater chemistry zones.
2. Within each chemistry zone, groundwater quality values are provided for different depths (Shallow: <15m, Moderate: 15–40m, Deep: 40–65m, Very deep: >65m, Artesian: all artesian).
3. The management intent is to maintain 20th, 50th and 80th percentile values. Values are provided for each of these percentiles.
4. Abbreviations: EC: Electrical conductivity, $CaCO_3$: Calcium carbonate, Ca: Calcium, Mg: Magnesium, Na: Sodium, Cl: Chloride, SO_4: Sulfate, HCO_3: Bicarbonate, NO_3: Nitrate, SiO_2: Silica, F: Fluoride, Fe: Iron, Mn: Manganese, Zn: Zinc, Cu: Copper, SAR: Sodium adsorption ratio, RAH: Residual alkali hazard, EH: Redox (oxidation/reduction) potential, '-': insufficient data to perform statistical summaries, or the parameter was not tested.

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

Ways to improve water quality

4 Ways to improve water quality

The following documents are relevant in considering ways to improve water quality in the Johnstone River basin.

Regional plans

- Wet Tropics Water Quality Improvement Plan, Terrain NRM 2015, in publication. See Terrain website.

Queensland and Australian Government plans

- Reef Water Quality Protection Plan 2013
- Reef 2050 Long-Term Sustainability Plan
- Reef Program–The Australian Government Reef Program will be delivered as a component of the National Landcare Program and will build on the success of the first phase of Reef Rescue. More about the Australian Government Reef Program