Department of Science, Information Technology and Innovation

Draft environmental values and water quality guidelines:

Don and Haughton River basins, Mackay-Whitsunday estuaries, and coastal/marine waters

Draft for consultation – March 2017

Queensland Government

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March 2017

Cover photo courtesy of Queensland Government. Haughton River estuary.

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Definitions and abbreviations

AIMS	Australian Institute of Marine Science
ANZECC, ARMCANZ	Australian and New Zealand Environment and Conservation Council; Agriculture and Resources Management Council of Australia and New Zealand
AWQG	Australian water quality guidelines
DNRM	Department of Natural Resources and Mines
DO	Dissolved oxygen
DPA	Dugong protection area
DSITI	Department of Science, Information Technology and Innovation
EC	Electrical conductivity: is the measure of the ability of a solution to conduct an electric current.
EHP	Department of Environment and Heritage Protection
EPP (Water)	Environmental Protection Policy (Water)
EV	Environmental value: the qualities of water that make it suitable for supporting aquatic ecosystems and human water uses, e.g. irrigation, recreation, and cultural and spiritual values. EVs need to be protected from the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe and healthy for human use.
FHA	Fish habitat area
GBR, GBRMPA	Great Barrier Reef; Great Barrier Reef Marine Park Authority
Guideline – water quality	Quantitative measures or statements for indicators, including contaminant concentrations or sustainable load measures of water to protect a stated EV.
HD	Highly disturbed waters
HEV	High ecological value (effectively unmodified) waters
MD	Moderately disturbed waters
mg/L	Milligrams per Litre
PAR	Photosynthetic available radiation. Used in relation to light availability for photosynthesis by primary producers such as seagrass. Insufficient PAR can lead to loss of seagrass.
Percentile	This is the value of a variable below which a certain percent of observations fall. So the 75th percentile is the value (or score) below which 75 percent of the observations may be found.
pH	A measure of the acidity or basicity of a solution, commonly ranging from 0 (acid) to 14 (basic).
Queensland Waters	All waters that are within the limits of the State, including coastal/marine waters to 3 nautical miles.
QWQG	Queensland water quality guidelines
SD; SMD	Slightly disturbed waters; slightly-moderately disturbed waters
TSS	Total suspended solids
µg/L	Micrograms per Litre
WQG	Water quality guideline – a technically derived guideline to support particular environmental values, e.g. aquatic ecosystem. Refer to full definition under ‘guideline’
WQIP	Water quality improvement plan
WQO	Water quality objective: the set of water quality guidelines for all indicators that will protect all environmental values selected for the water. WQOs may be the same as technically derived WQGs, or may be altered by consideration of the social and economic impacts of protecting the EVs.

Summary

This report presents environmental values and water quality guidelines for Queensland surface waters in the Don-Haughton and Mackay-Whitsunday regions. The report covers fresh, estuarine and coastal/marine surface waters to the limit of Queensland waters, and forms part of the water quality planning process under the *Environmental Protection Policy (Water) 2009 [EPP Water]*. Guidelines presented in this report are draft, and may be revised in response to stakeholder comments or additional water quality data. Water quality guidelines form a technical basis for water quality objectives under schedule 1 of the EPP Water. To date, there are no waters in the Burdekin, Don or Haughton basins included in schedule 1 of the EPP Water.

Water quality guidelines are provided in this report for both aquatic ecosystems and human uses (e.g. recreation, irrigation, stock watering), based on relevant sources. A key component of this report is the development of draft aquatic ecosystem water quality guidelines from local monitoring. Aquatic ecosystem guidelines are primarily focussed on physico-chemical indicators; nutrients, dissolved oxygen, pH, water clarity parameters, and chlorophyll-a. Seagrass light guidelines have also been included. Guidelines have been derived for annual application, ambient conditions and, where sufficient information is available, separate dry and wet season conditions.

Water quality guidelines have been developed for the following waters and are provided in Section 5 (Tables 1 – 4) of the report:

- Don and Haughton river basins: new guidelines for fresh, estuarine and coastal/marine waters including Bowling Green, Upstart, Abbot and Edgecumbe bays, midshelf waters around Holbourne Island

- Mackay-Whitsunday region: updated guidelines for mid-estuarine waters in Proserpine, O'Connell, Pioneer and Plane Creek basins; and coastal/marine waters. These are based on additional water quality monitoring and analysis.

Datasets used in the derivation of aquatic ecosystem water quality guidelines have been sourced from government, ports, research institute, university and private sector sources. Information in water quality improvement plans (WQIPs) for the Burdekin and Mackay-Whitsunday regions has also been reviewed. State or national guidelines have been applied for those parameters where insufficient local data was available to derive local guidelines or where guidelines are based on biological effects (e.g. toxicants). Human use guidelines are derived from the relevant national sources (e.g. National Health and Medical Research Council, ANZECC) and are provided in Appendix 3. Information on waterway uses and values ('environmental values') has been obtained from work undertaken for WQIPs and other sources (e.g. landuse mapping, marine park zoning).

The Reef Water Quality Protection Plan, Reef 2050 Long-Term Sustainability Plan and related policies provide a further impetus to this report and are briefly outlined. Further work is being undertaken to develop basin-specific load targets for Great Barrier Reef catchments, including the Don and Haughton basins. When available, results of this work will be reviewed and addressed in the finalisation of EPP Water materials, including water quality objectives.

Mackay-Whitsunday region waters were scheduled under the EPP Water in 2013, (available from http://www.ehp.qld.gov.au/water/policy/index.html). Since scheduling, DSITI has undertaken further estuarine water quality monitoring and analysis, and the Great Barrier Reef Marine Park Authority (GBRMPA) has updated analyses of marine water quality data

and water type mapping. The resulting updated estuarine and coastal guidelines and mapping are included in this report. No changes are proposed in fresh waters.

Following consultation and any amendment, a final set of water quality objectives will be prepared for consideration by Government for inclusion in schedule 1 of the EPP Water.

1 Introduction

1.1 Scope

This report forms part of the process to localise water quality guidelines (WQGs) throughout Queensland, in accordance with recommendations in the *Australian and New Zealand Water Quality Guidelines* (ANZECC & ARMCANZ 2000). The first step of this process in Queensland was the complementary development of the *Queensland Water Quality Guidelines (*QWQG 2009) and the *Water quality guidelines for the Great Barrier Reef Marine Park* (GBRMPA 2010). Other projects in Central Queensland to localise WQGs have been conducted for the Fitzroy and Capricorn-Curtis Coast regions. The need for local guidelines is outlined in Section 3 of this report.

The report establishes local water quality guidelines for the protection of the 'aquatic ecosystem' environmental value in:

- Don and Haughton river basins fresh and estuarine waters and adjacent coastal and marine waters.
- Mackay-Whitsunday region mid estuarine waters covering Proserpine River, O'Connell and Pioneer River Basins and Plane Creek Basin, and open coastal and marine waters of the region.

The report includes:

- overview of the study area (Section 2, including landuse and other catchment features)
- national framework for developing water quality guidelines (Section 3)
- methodology for deriving guidelines (Section 4)
- water quality guidelines by region/water type/indicator (Section 5 - tables)
- details on freshwater, estuary and marine water quality data sources (Appendices 1, 2)
- human use water quality guidelines (Appendix 3)

Data sources used in the development of aquatic ecosystem guidelines are outlined in Section 4, and include government, university, private sector and research institutes. State or national guidelines have been applied for parameters where insufficient local data was available to derive local guidelines or where guidelines are based on biological effects data (e.g. toxicants). Human use guidelines are largely derived from national sources (e.g. National Health and Medical Research Council, ANZECC).

Under the ANZECC water quality framework and the *Environmental Protection Policy (Water*) *2009,* properly developed and approved local guidelines hold higher precedence over state or national guidelines. Water quality guidelines form a technical basis for development of water quality objectives under the EPP Water. Following consultation and any amendment, a final set of water quality objectives will be prepared for consideration by Government for inclusion in schedule 1 of the EPP Water.

1.2 Reef planning policies and actions

The Reef 2050 Long-Term Sustainability Plan, prepared by Australian and Queensland governments, is the overarching framework for protecting and managing the Great Barrier Reef from 2015 to 2050. The Plan is a key component of the Australian Government's response to the recommendations of the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Committee. At the core of the Plan is an outcomes framework that will drive progress towards an overarching vision:

'*To ensure the Great Barrier Reef continues to improve on its Outstanding Universal Value every decade between now and 2050 to be a natural wonder for each successive generation to come*.'

The Reef 2050 Plan and supporting information is available from http://www.environment.gov.au/marine/gbr/long-term-sustainability-plan.

The Reef 2050 Plan was drafted with government, community, industry and science and presents an opportunity for everyone involved with the Reef to take part in building its resilience. It sets out shared targets, objectives and outcomes across seven different themes – ecosystem health, biodiversity, water quality, heritage, community benefits, economic benefits and governance. A summary of Reef 2050 Plan priorities and actions as they relate to water quality guidelines is provided below.

Localising water quality guidelines

- *Water quality action (WQA) 7: Finalise and implement plans (e.g. Water Quality Improvement Plans and Healthy Waters Management Plans) for Reef catchments and key coastal areas, identifying implementation priorities for protection of the Reef.*

- *WQA9: Review and update water quality objectives and Great Barrier Reef Marine Park Authority Water Quality Guidelines at Reef-wide and regionally relevant scales based on scientifically verified monitoring and research.*

These commitments build upon the ANZECC framework for localising guidelines as outlined in section 3 of this document. The Burdekin water quality improvement plan (WQIP) and supporting water quality atlas (prepared by NQ Dry Tropics) are directly relevant to these actions.

Note: In response to recommendations of the Great Barrier Reef Water Science taskforce in May 2016 (http://www.gbr.qld.gov.au/taskforce/), further work is being undertaken to develop basin specific load targets for the 35 basins of the Great Barrier Reef catchment. Results of this work will be reviewed and addressed in the finalisation of EPP Water materials, including water quality objectives.

Water quality condition

- *Water quality target (WQT) 4: Water quality in the Great Barrier Reef has a stable or positive trend.*

- *Water quality objective (WQO) 1: Over successive decades the quality of water entering the Reef from broadscale land use has no detrimental impact on the health and resilience of the Great Barrier Reef.*

- *WQO2: Over successive decades the quality of water in or entering the Reef from all sources including industrial, aquaculture, port (including dredging), urban waste and*

stormwater sources has no detrimental impact on the health and resilience of the Great Barrier Reef.

- *2050 outcome: Reef water quality sustains the Outstanding Universal Value, builds resilience and improves ecosystem health over each successive decade.*

These commitments identify the overall intent for water quality entering and within the reef.

Community and economic benefit

- *Community benefit objective (CBO) 3: Community benefits provided by the Reef, including its superlative natural beauty and the sense of place, are maintained for current and future generations.*

- *Economic benefit objective (EBO) 4: Reef-dependent industries are productive and profitable based on a healthy Reef and are ecologically sustainable.*

These recognise how a healthy reef supports reef-dependent economic and community activities such as tourism and recreation.

1.3 Environmental values and management intent

Draft environmental values (EVs) and management intent for Don-Haughton waters are derived from work undertaken for the Burdekin WQIP, including Lankester et al. (2007), and NQ Dry Tropics (Kerr, 2013). Draft EVs/management intent mapping for these areas was included in the Burdekin WQIP (WQIP section 4) made available via the NQ Dry Tropics, and has been reviewed/updated in this document. Environmental values include aquatic ecosystems and human use values (e.g. irrigation, stock watering, recreation). Further information is provided in Section 2.

The AWQG, QWQG and EPP Water outline the management framework applying to different aquatic ecosystems. The framework provides threshold levels of change that are acceptable for each of the different aquatic ecosystem conditions. The main categories are listed below and further detail on these is provided in section 3.

- High ecological value (HEV) – maintain natural condition
- Slightly disturbed (SD) – maintain/improve to natural condition
- Moderately disturbed (MD) – maintain/achieve the relevant water quality guidelines
- Highly disturbed (HD) – improve progressively over time

The following have been applied in identifying HEV and SD management intent/level of protection, but may vary according to local information:

- National parks (HEV)
- Wet Tropics World Heritage Area (zones A, B)
- High ecological significance wetlands/wetland protection areas (HEV or SD)
- Ramsar (HEV or SD)
- Fish habitat areas (A) (SD)
- Dugong protection areas (A) (SD)
- Conservation parks (SD)
- State forests (SD)
- Nature refuges (SD)

In coastal and marine waters all waters seaward of the GBRMPA plume line receive HEV management intent. Landward of the plume line, recognised conservation areas were

generally given SD management intent. These are draft and may change following feedback or further information.

2 Study area

2.1 Overview

Queensland waters covered by this report are shown in Figures 1 and 2, and comprise:

- Surface fresh and estuarine waters of the Don and Haughton basins (basins 121 and 119)[1]
- coastal and marine waters of Don and Haughton coasts, including Bowling Green, Upstart, Abbot and Edgecumbe bays, and midshelf waters around Holbourne Island.
- Mackay-Whitsunday region estuarine waters and coastal/marine waters of the following river basins (basin numbers); Proserpine (122), Whitsunday (123), O'Connell (124), Pioneer (125) and Plane Creek (127).

Note: This report does not cover aquatic ecosystem water quality objectives for groundwaters or Burdekin River Basin fresh and estuarine waters. These will be addressed in separate reporting. Mackay-Whitsunday freshwater WQOs are already scheduled and this report proposes no changes to those WQOs.

Considerable detail on landuses, catchment, waterway and wetland condition is provided in publicly available reporting including the Burdekin and Mackay-Whitsunday WQIPs and other sources below. This section therefore provides an overview of landuse and catchment features.

- Great Barrier Reef Report Card 2014: available from http://www.reefplan.qld.gov.au/measuring-success/report-cards/2014/assets/gbr-2014report-card.pdf
- Burdekin water quality improvement plan and catchment atlas - http://wiki.bdtnrm.org.au/index.php?title=Burdekin_Water_Quality_Improvement_Plan (Note: plan completed in 2009. New plan under development 2016)
- Don and Haughton basin assessments – http://elibrary.gbrmpa.gov.au/jspui/bitstream/11017/2895/2/Don-basin-assessment-2013.pdf http://elibrary.gbrmpa.gov.au/jspui/bitstream/11017/2898/2/Haughton-Basin-Assessment-2013.pdf
- Mackay Whitsunday water quality improvement plan (Note: plan completed in 2008. New plan under development 2016) http://reefcatchments.com.au/
- Wetlands - http://wetlandinfo.ehp.qld.gov.au/wetlands/facts-maps/

[1] Queensland Drainage Division number and river basin names are published at Geoscience Australia's website www.ga.gov.au. Refer Australia's River Basins 1997—Product User Guide. Published by Geoscience Australia. Canberra, ACT (3rd edition, 2004).

The largest land use throughout the project region is cattle grazing. Sugarcane production is another significant land use in the project area, particularly in the Haughton and Mackay-Whitsunday regions, concentrated in lowlands and floodplains. Other land use in the region includes horticultural uses along the Don River lowlands, port development at Abbot Point, Mackay and Hay Point, aquaculture, and urban land use in the regional centres of Bowen, Ayr, Mackay and Proserpine. There are several areas of significant coastal wetlands linking to the Great Barrier Reef, discussed in sections below.

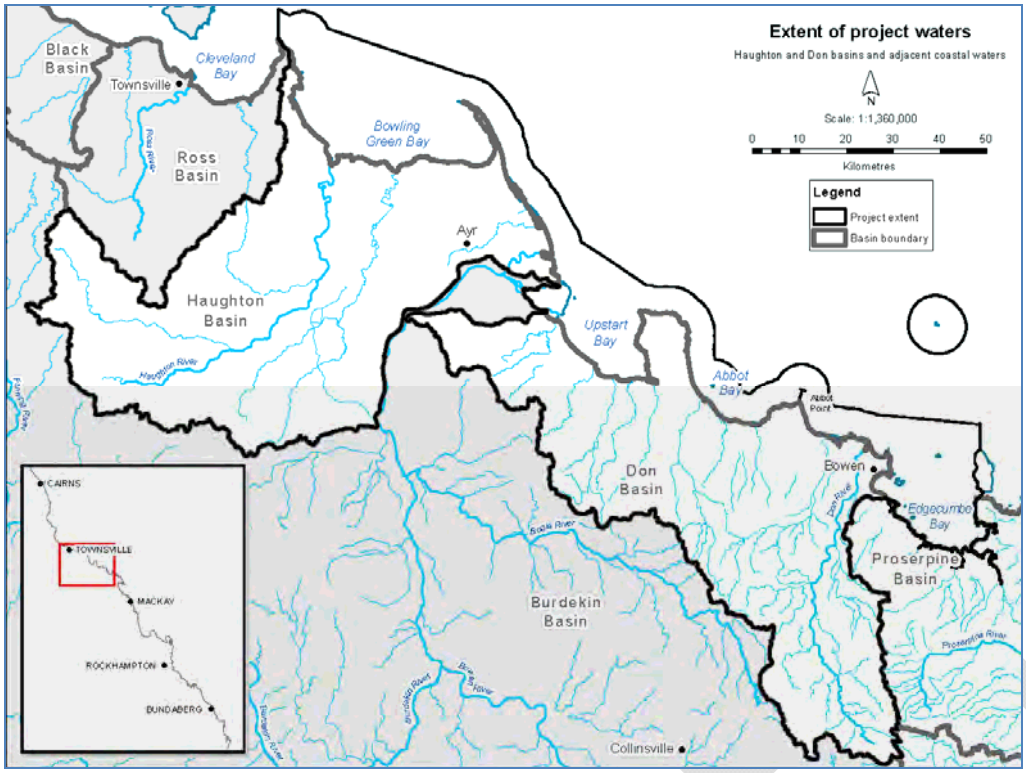

Figure 1 Don-Haughton project waters (fresh, estuarine and coastal/marine waters)

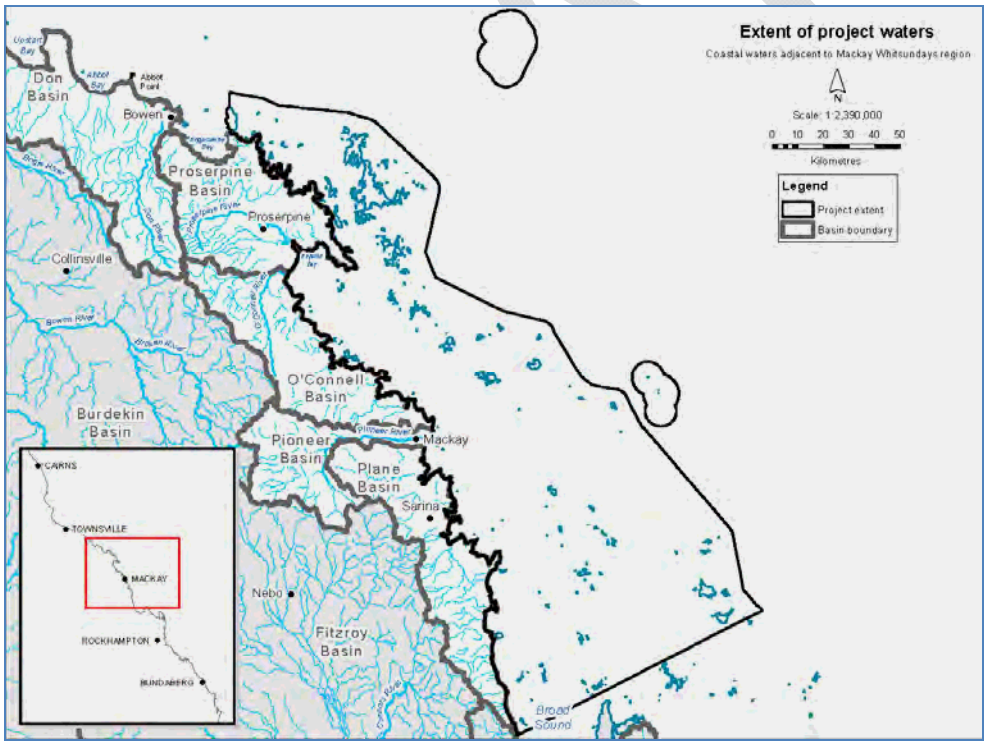

Figure 2 Mackay-Whitsunday project waters (estuaries and coastal/marine waters)

2.2 Fresh and estuarine waters of the Don and Haughton river basins

2.2.1 Don River Basin

Details on the condition of reef catchments, and actions being taken by industry, government, regional NRM and other stakeholders to address reef water quality are provided in the Burdekin WQIP, report cards and best management practice materials available from the Reef Plan web site at http://www.reefplan.qld.gov.au.

The Don River Basin is considered here in three parts (north to south): Upstart Bay catchments, Abbot Bay catchments and the Don River catchment (Figure 3). The Upstart Bay sub-catchment is dominated by grazing with more than 70% of land under pasture. Irrigated sugarcane makes up only 4% of land area, mainly adjacent to the Burdekin Delta. More than 14% of land area is used for conservation or minimal use, including Cape Upstart National Park (Figure 4; Burdekin WQIP 2009). Upstart Bay sub-catchment also contains the Southern Upstart Bay wetlands listed in the Directory of Important Wetlands in Australia (Figure 5).

Creek systems draining to Upstart Bay are mostly ephemeral, flowing only after intense rain events. The wetlands of the area are not well studied and their ecology and condition is not well understood. Large permanent waterholes are not known, but smaller waterholes are likely present and vulnerable to disturbance (Burdekin WQIP 2009).

Land use in the Abbot Bay sub-catchment is dominated by grazing with extensive areas of wetlands along the coast. Horticulture is an important land-use in the south-east area of the sub-catchment bordering the Don River sub-catchment. Areas of conservation exist in the upland areas including Mount Aberdeen National Park (Figure 4).

The Abbot Bay sub-catchment also hosts the Port of Abbot Point, a coal loading facility. Land around the port is identified as a State Development Area (SDA), to facilitate large-scale industrial development of regional, state and national significance. The SDA has its own development scheme, governing landuse activities in the SDA. SDA boundaries are shown on Figure 3. The Caley Valley wetlands are within the SDA. Further details on the SDA are available at: http://www.statedevelopment.qld.gov.au/coordinator-general/abbot-point-state-development-area.html.

Considerable technical reporting on the Port of Abbot Point expansion is provided in environmental studies available from the Queensland Government (Department of State Development) website at: http://www.statedevelopment.qld.gov.au/major-projects/abbot-point-growth-gateway-project.html.

The creek systems of the Abbot Bay sub-catchment are ephemeral, flowing only after significant rainfall events. Coastal freshwater wetlands are also ephemeral or seasonal filling following rainfall events. Large areas of coastal estuarine wetlands are also present (Burrows et al. 2007, GBRMPA 2013). The Caley Valley Wetlands at Abbot Point (Figure 5) are listed in the Directory of Important Wetlands in Australia (GBRMPA 2013a). More details are provided on the Wetland*Info* web page at: http://wetlandinfo.ehp.qld.gov.au/wetlands/facts-maps/diwa-wetland-abbot-point-caley-valley/.

The Don River sub-catchment is also dominated by grazing land use with horticultural use along lower reaches of the Don River (Burrows et al. 2007). The urban centre of Bowen is a

concentrated area of urban land use on the coast of Edgecumbe Bay. Only small areas of conservation exist in this sub-catchment (Figure 4).

The Don River is an ephemeral system, flowing only for short periods after significant rainfall events. No large permanent waterholes are known, though small waterholes are likely and vulnerable to disturbance (Burrows et al. 2007).

Proposed environmental values (EVs) for surface waters in the above areas are shown on Figure 3. These reflect the uses and values of water including for consumptive use, aquatic ecosystem, and cultural and spiritual values, and have largely been based on work from the NQ Dry Tropics NRM, with local updates undertaken for this report. Key EVs reports are NQ Dry Tropics NRM (2013), Lankester et al. (2007), and Dight (2009). Water quality guidelines in later sections of this report are derived to protect the aquatic ecosystem EV.

2.2.2 Haughton River Basin

Details on the condition of reef catchments, and actions being taken by industry, government, regional NRM and other stakeholders to address reef water quality are provided in the Burdekin WQIP, report cards and best management practice materials available from the Reef Plan web site at http://www.reefplan.qld.gov.au .

The Haughton River Basin includes the Haughton, Barratta and Burdekin Delta catchments (Figure 6). The basin falls largely within the Burdekin Shire and Charters Towers Shires. The Burdekin Shire produces Australia's largest quantity of sugarcane, mainly due to the abundance of water resources supplied by the Burdekin River (Burdekin Shire Council, 2015). In the early 1950s, the Burdekin River Irrigation Area was established on 7500ha of land in the Burdekin Shire (SunWater, n.d), enabling the distribution of irrigation water to cropping farms. This was expanded in 1980 to supply an area of 48000ha, with the construction of the Burdekin Falls Dam and irrigation channels and canals (Queensland Competition Authority, 2003). The Burdekin Shire estimated resident population in 2014 was 17916 persons (Qld Government Statistician's Office, 2015).

The largest landuse by area is grazing of natural and modified vegetation (59%) (GBRMPA, 2013b; Haughton Basin Assessment). This occurs predominantly in the upper basin (refer Figure 4).

Irrigated cropping of sugarcane is the second largest land use (20%), (GBRMPA, 2013b), occurring in mid to lower reaches of the basin (Figure 4). Sugarcane production is expanding yearly and is expected to continue expanding (GBRMPA, 2013b).

The construction of channels, canals and weirs, along with alterations to floral diversity has resulted in large modifications to the hydrological system. Inputs of nutrients into the aquatic environment have increased, a result of fertiliser use associated with this land use change.

Urban landuse covers a small proportion of the basin and is concentrated around Ayr, which had an estimated resident population in 2011 of 8885 (ABS, 2013). Other towns within the Haughton River Basin include Brandon, Mt Kelly, Giru, Jarvisfield and Airdmillam (Figure 4).

Both the Haughton River and Barratta Creek discharge into the nationally and internationally significant Ramsar-listed, Bowling Green Bay coastal wetland. This coastal wetland directly contributes to support the outstanding universal value of the World and National Heritage listed Great Barrier Reef Marine Park. Bowling Green Bay National Park also occurs in this basin (Figure 7). Refer to Wetland*Info* web site for more details on Bowling Green Bay: http://wetlandinfo.ehp.qld.gov.au/wetlands/facts-maps/ramsar-wetland-bowling-green-bay/

The area also contains several wetlands listed in the Directory of Important Wetlands of Australia including Burdekin Delta, Barratta Channels Aggregation, Bowling Green Bay,

Jerona Aggregation, Wongaloo Fans Aggregation, Wongaloo Swamps Aggregation (EHP, 2015). Further information on these is available from the Wetland*Info* web site.

Proposed environmental values (EVs) for Haughton Basin surface waters covering Haughton River, Barratta Creek and Burdekin Delta catchments are shown on Figure 6. These reflect the uses and values of water including for consumptive use, aquatic ecosystem, and cultural and spiritual values. These have largely been based on work for the Burdekin water quality improvement plan (WQIP), with local updates undertaken for this report. Key EVs reports are NQ Dry Tropics NRM (2013) and Lankester et al. (2007). Water quality guidelines in later sections of this report are derived to protect the aquatic ecosystem EV.

2.3 Queensland marine waters – Haughton and Don coasts

Marine waters of the Haughton and Don coast include Bowling Green Bay, Upstart Bay, Abbot Bay and Edgecumbe Bay to the limit of Queensland waters, and midshelf waters surrounding Holbourne Island (Figure 8).

All of the bays in this planning area primarily fall within the one non-reef bioregion: the high nutrient coastal strip. This bioregion is characterised by terrigenous muds and high levels of nutrients from the adjacent land. It is known generally to include sponges, solitary corals, soft corals, shallow and deep water seagrass, sea urchins, sea stars, sea lilies, feather stars, sea cucumbers, jellyfish, foraminifera, and bryozoans. (GBRMPA 2002a)

Some of the bays exhibit examples of the coastal southern reef bioregion, with some fringing reefs around islands (e.g. Holbourne Island) and the coast, as well as some reef patches, and submerged reef or shoals.

Proposed environmental values (EVs) for coastal and marine waters are shown on Figure 8. These reflect the uses and values of water for consumptive use, aquatic ecosystem, cultural and spiritual values, and have largely been based on work for the Burdekin water quality improvement plan (WQIP), with local updates undertaken for this report. Key EVs reports for the WQIP are NQ Dry Tropics NRM (2013) and Lankester et al. (2007). Water quality guidelines in later sections of this report are derived to protect the aquatic ecosystem EV.

2.3.1 Bowling Green Bay

The waters of Bowling Green Bay include important feeding grounds for threatened species of dugongs, estuarine crocodiles and green turtles and nursery grounds for many fish and crustacean species. The area has some of the richest coastal wetland habitat, typical of the coastal wet-dry tropics of north-east Australia. It is an extremely important bait fish, finfish and crustacean nursery. There are “pristine” mangrove habitats important for mud crab and fish and also as breeding grounds for grunter (Dobbs 2011).

The adjacent coast includes Bowling Green Bay National Park, and one of only two Ramsar--listed internationally significant wetlands in the Great Barrier Reef World Heritage Area, namely Bowling Green Bay - refer to Wetland*Info* for more details (Figure 9). Substantial numbers of all Australian waterbird groups are regularly supported here (e.g.: 4000 individuals, making 1% of the Australian brolga population, 10,000 magpie geese). The beaches on the western shore of the bay host low density nesting by flatback turtles. There is also some turtle nesting on Cape Bowling Green sand spit (Dobbs 2011).

The bay is a Dugong Protection Area (DPA) ‘B’ Zone with aerial survey information indicating that when the habitat is ‘good’, the bay can support large numbers of dugongs.

Indo-Pacific Humpback dolphins have also been sighted in the bay. It also contains the Bowling Green Bay Fish Habitat Area (FHA) A (Figure 9; GBRMPA 2005). For more information on FHAs, see the Department of National Parks, Sport and Racing (DNPSR) website: www.nprsr.qld.gov.au/managing/habitat-areas/area-plans.html .

There are incipient fringing reefs and non-reefal habitat in the bay (GBRMPA 2005).

2.3.2 Upstart Bay

This bay has extensive seagrass beds, which are important as dugong and green turtle foraging habitat, and as a fish and crustacean nursery. Upstart Bay is a DPA 'A' Zone in recognition of these features (Figure 9). Substantial sections of the bay are zoned Marine National Park and Conservation Park zone. These run adjacent to the Cape Upstart National Park and Southern Upstart Bay Directory of National Wetlands Australia listings (refer Wetland*Info* for more details). Most of Upstart Bay also lies within the Burdekin Fish Habitat Area, recognised as having a high fisheries and habitat value, (refer http://www.nprsr.qld.gov.au/managing/area-summaries/burdekin.html)

Important commercial fishery species for these waters have included spanish mackerel, barramundi, mullet and blue-salmon. Additional fish species include flathead, trevally, whiting, queenfish, cod, grunter, bream, king salmon, and mackerel (QFS log book data as reported in GBRMPA et al. 2002). Prawn fisheries in these waters include tiger, banana, king, endeavour and coral prawns. Scallops, mud crabs, Moreton Bay bugs, squid and blue swimmer crabs are also caught in these waters (QFS log book data as reported in GBRMPA et al. 2002)

The bay has wide intertidal flats in the south and east, but the remainder is mostly shallow (<10m) subtidal to deep subtidal in depth. The mouth of the Burdekin River system is located at the north western entrance to the bay and most of its run-off is taken north by the prevailing currents.

There are several areas of cultural heritage significance to the Traditional Owners of the Cape Upstart area (GBRMPA 2005). Large populations of waterbirds use the area for breeding and as a drought refuge (Environment Australia 2001).

2.3.3 Abbot Bay and Abbot Point

Abbot Bay has a diversity of inshore marine habitats including seagrass, soft bottom habitats, beaches and estuarine areas. (Eco Logical and Open Lines Australia 2013).

The marine environment within Abbot Point is mainly a heterogeneous habitat of soft-sediment, seagrass and algae (Rasheed et al. 2005), with some shoals and channels (GHD 2009b). The marine environment to the south-east and north-west of Abbot Point is shallow and contains creek mouths, beaches, mud flats and mangrove habitats (GHD 2009a; NQBP 2010).

Both dugongs and marine turtles forage in local seagrass and algal communities in the bay. (GBRMPA 2005). Seagrass distribution is naturally variable and whilst the majority of seagrass meadows are patchy, and variable in density, at times extensive areas of coastal and offshore seagrass meadows have been present in the region from Branch Creek to Bowen to a distance of approximately 10 km offshore (McKenna et al. 2008, 2011, 2013). Work has been undertaken to identify light requirements of seagrasses in the bay, and outcomes are included in this report (e.g. McKenna et al, 2015).

Higher order predators are present in the area e.g. sharks, dolphins, indicating functioning food webs.

Abbot Point is one of four Priority Port Development Areas in the Great Barrier Reef World Heritage Area (State of Queensland 2014). The port has a throughput of 10-14 million tonnes annually (Ports Australia 2012 and Department of Transport and Main Roads (Qld) 2014), making an important contribution to the national economy (GBRMPA 2014). See website for Port of Abbot Point at: www.nqbp.com.au/abbot-point/. Considerable technical reporting on the bay and port is provided in environmental studies available from the Queensland Government (Department of State Development) website at http://www.statedevelopment.qld.gov.au/major-projects/abbot-point-growth-gateway-project.html .

Land around the port is identified as a State Development Area (SDA), to facilitate large-scale industrial development of regional, state and national significance. The SDA has its own development scheme, governing landuse activities in the SDA. SDA boundaries are shown on Figure 3. Further details on the SDA are available at: http://www.statedevelopment.qld.gov.au/coordinator-general/abbot-point-state-development-area.html . The Caley Valley wetlands are within the SDA. More details are provided on the Wetland*Info* web page at http://wetlandinfo.ehp.qld.gov.au/wetlands/facts-maps/diwa-wetland-abbot-point-caley-valley/ .

The bay also forms part of the broader Abbot Point port limits/pilotage area under the *Transport Operations (Marine Safety) Regulation 2004.*

2.3.4 Edgecumbe Bay

The bay has a declared Dugong Protection Area B and a Fish Habitat Area (Edgecumbe Bay, Cape Gloucester to Adelaide Point Fish Habitat Area A and B) (Figure 9). Incipient reefs and shoals occur within the bay as well as fringing coral reefs and seagrass beds on the western and southern aspects of Gloucester Island. The area is identified as important to the Bowen and Whitsunday communities for fishing (GBRMPA 2005). The bay also forms part of the broader Abbot Point port limits/pilotage area under the *Transport Operations (Marine Safety) Regulation 2004.*

2.3.5 Waters surrounding Holbourne Island

Holbourne Island is a National Park and the zoning of waters adjacent to the island protects fringing coral reefs and bird nesting habitats. The area is an important recreational and commercial line fishing area (GBRMPA 2005).

Its surrounding non-reefal bioregion is classified as mid shelf lagoon. The general description for this bioregion is of a mud-dominated substrate with minimal algae or seagrass. Mobile sand dunes in the region are influenced by strong East Australian Currents (GBRMPA 2002b). It is known generally to include a similar suite of species to the waters inshore of this region including sponges, solitary corals, soft corals, sea urchins, sea stars, sea lilies, feather stars, sea cucumbers, jellyfish, foraminifera, deep water seagrass and bryozoans.

2.4 Mackay-Whitsunday estuaries

This section summarises the landuse context dealing with the new estuarine water quality sampling and analysis. Information on landuse in the Mackay-Whitsunday region is available from the Mackay-Whitsunday WQIP, available from Reef Catchments website:

http://reefcatchments.com.au/. Details on the condition of reef catchments, and actions being taken by industry, government, regional NRM and other stakeholders to address reef water quality are provided in report cards and best management practice materials available from the Reef Plan web site at: http://www.reefplan.qld.gov.au.

EVs and WQOs for Mackay-Whitsunday region waters, including estuaries, were scheduled under the EPP Water in 2013. Mapping of these areas is shown in Figure 10. Due to limited local information, most estuarine WQOs scheduled in the EPP Water were based on Queensland water quality guideline default regional values. Since that time more detailed water quality information has been obtained.

In the Mackay-Whitsunday region (Proserpine, O'Connell, Pioneer and Plane Creek basins) the Dividing Range lies fairly close to the coast with relatively steep inclines inland from the coast in most areas. The proximity of the range means that most catchments are quite small. As a result, the estuaries in the region tend to be relatively small and short. Many are only a few kilometres long and none are more than 20kms. Despite their restricted length, there are numerous estuaries in the region and they are an important feature of the region's aquatic ecosystems. Their extensive mangrove and saltmarsh areas (Reef Catchments 2013) are a key component of the region's fisheries habitats.

Tide height ranges in the region vary from south to north. In the southern part of the region tides are very large (typical spring tides ~ 6.0m) but decrease significantly northwards towards Bowen (typical spring tides ~ 3.0m). This has implications for estuary water quality, particularly for suspended sediment loads and resultant turbidity, as estuaries further south in the large tidal range zone would be expected to have higher resuspension rates, and thus higher turbidity and particulate nutrient concentrations than those estuaries further north in the region.

The predominant agricultural land use in the lower catchment areas of the region is sugarcane production (refer Figures 11, 12). There are very few catchments that do not have at least some areas under cane. Many of the estuaries run through intensively farmed cane areas but there are some exceptions.

Apart from some very small estuaries in steep national park areas (Figures 13, 14), the least disturbed estuary is the Gregory River estuary. It has a small area of sugar cane in its mid-catchment but the estuary is surrounded by low intensity grazing. This low level of disturbance is reflected in its having the highest water quality of any of the estuaries which have been monitored in recent times.

For this reason, the Gregory estuary has been adopted as the best estuary site available in the region and the water quality data from the Gregory has been used as a basis for setting water quality guidelines for Mackay-Whitsunday mid estuarine waters. However, being in the northern part of the region, the Gregory estuary has much smaller tides than estuaries to the south of Mackay and therefore adjustment of some indicator guidelines has been required for these more turbid estuaries.

2.5 Mackay-Whitsunday coastal and marine waters

EVs and WQOs for Mackay-Whitsunday coastal and marine waters were scheduled under the EPP Water in 2013. GBRMPA zoning plans outline allowable uses in marine park zones. Figures 15 and 16 summarise the main marine park zones, and other coastal water designations. Information on the process to update WQGs in coastal and marine waters is included in Section 4 of this report.

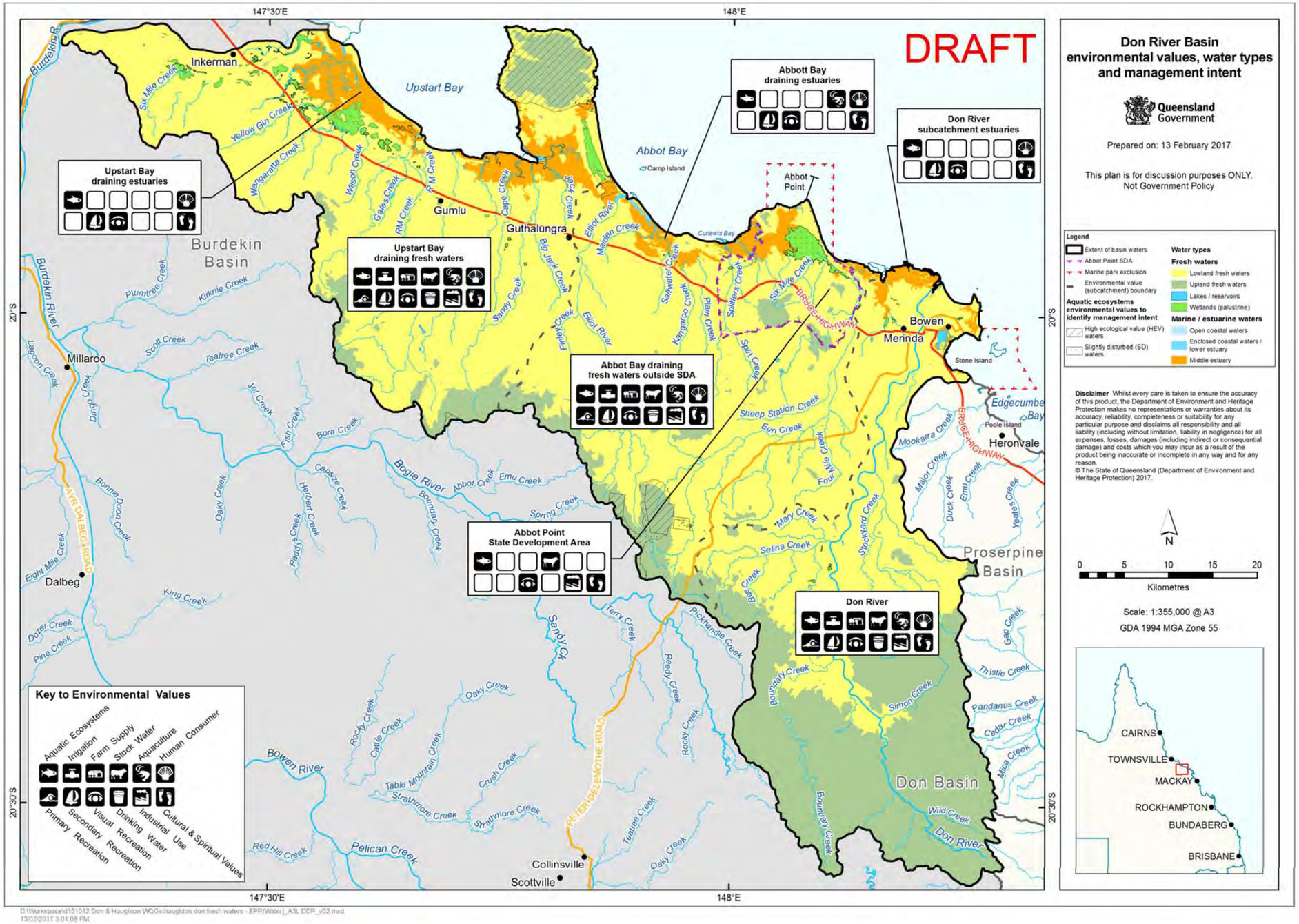

Figure 3 Don River Basin waters environmental values, water type and management intent

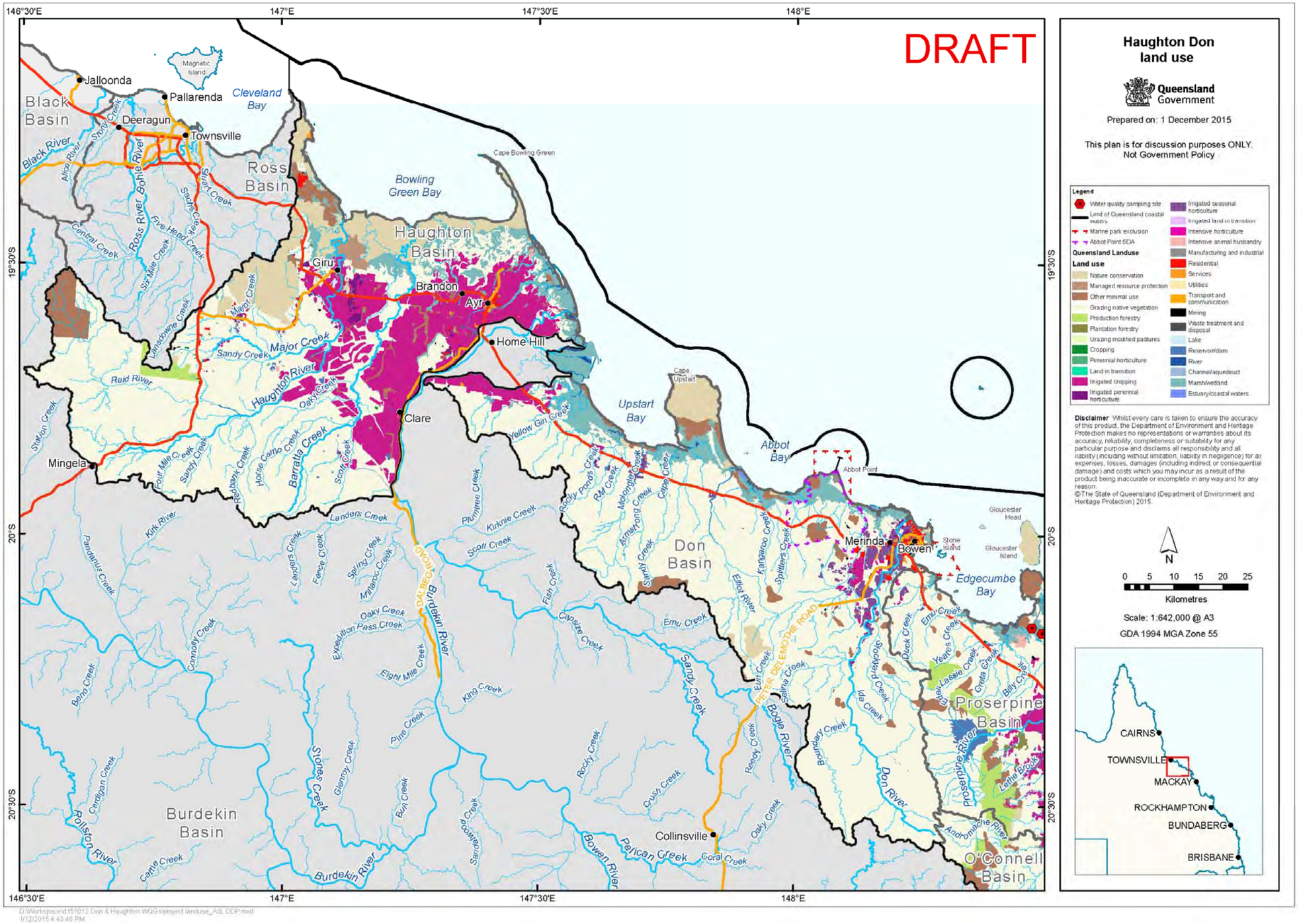

Figure 4 Don and Haughton river basins landuse

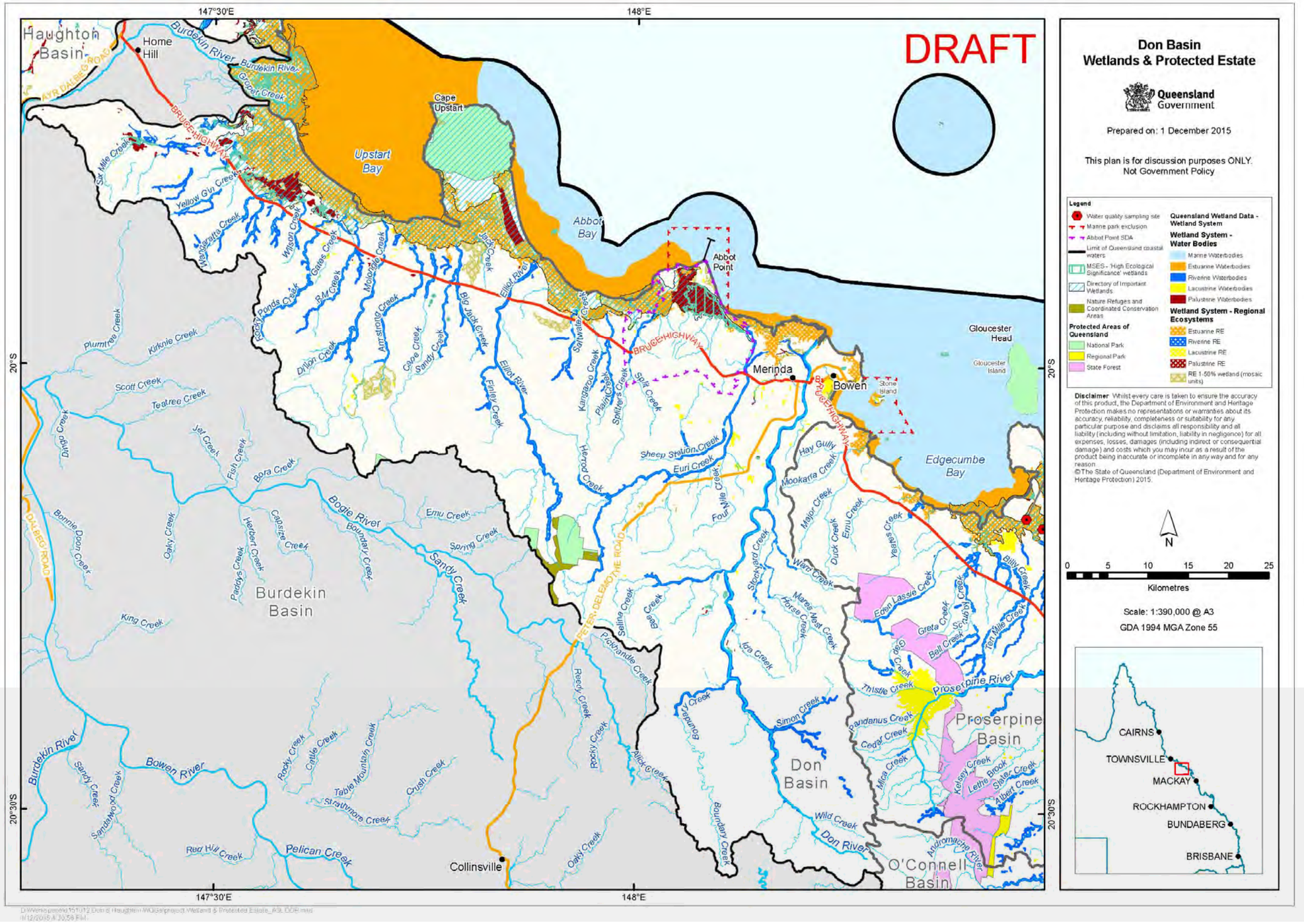

Figure 5 Don River Basin wetlands and protected estate

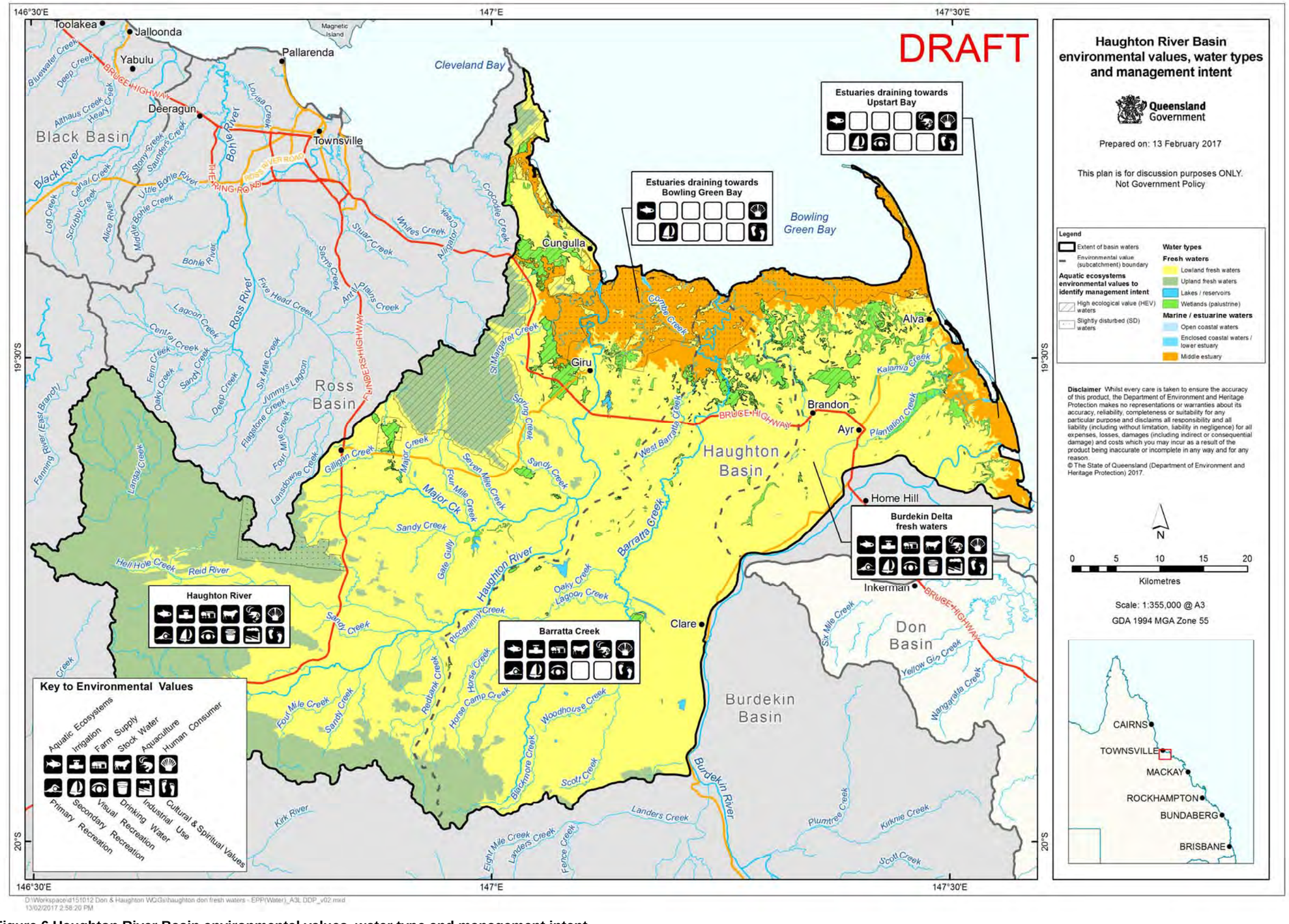

Figure 6 Haughton River Basin environmental values, water type and management intent

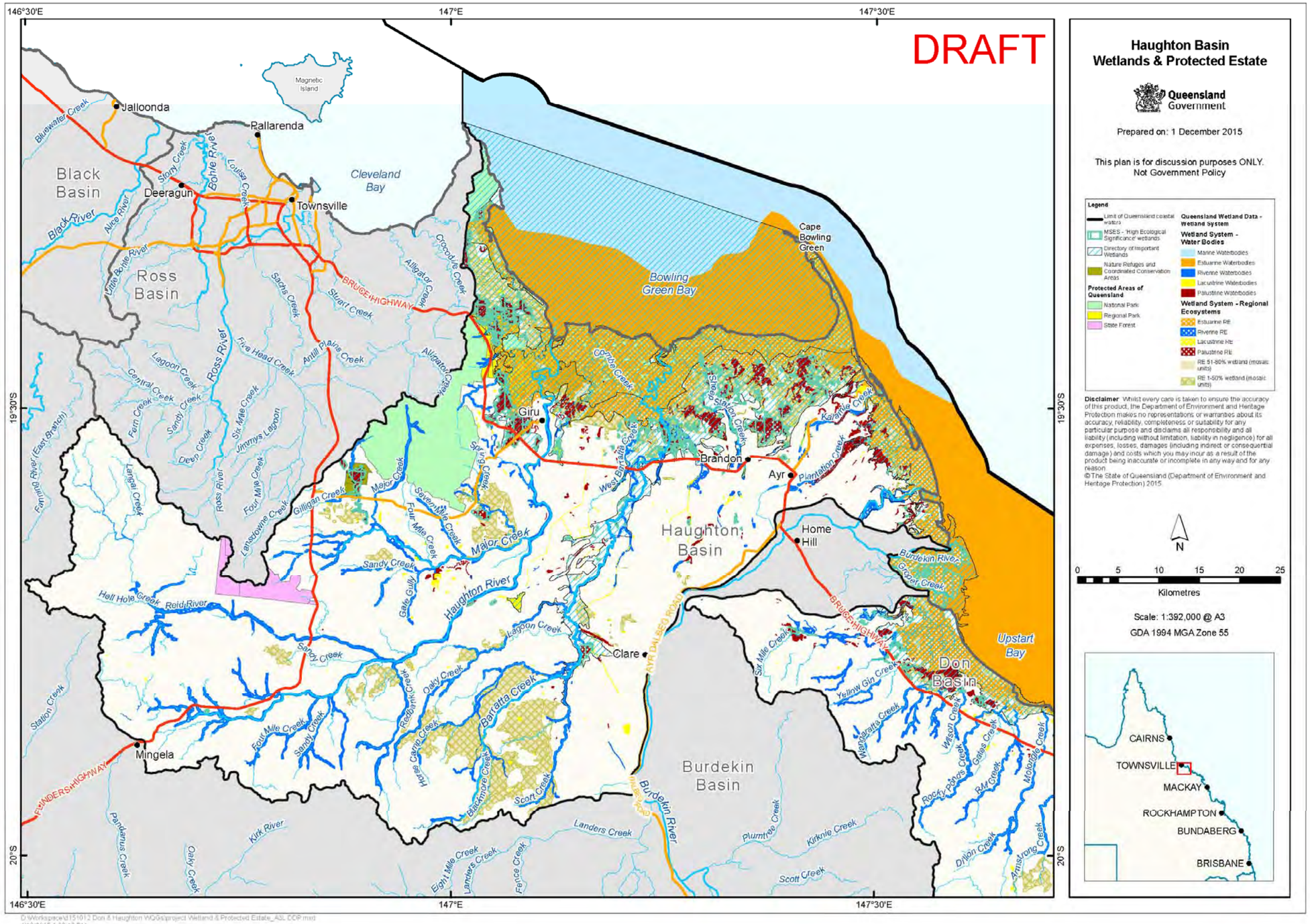

Figure 7 Haughton River Basin wetlands and protected estate

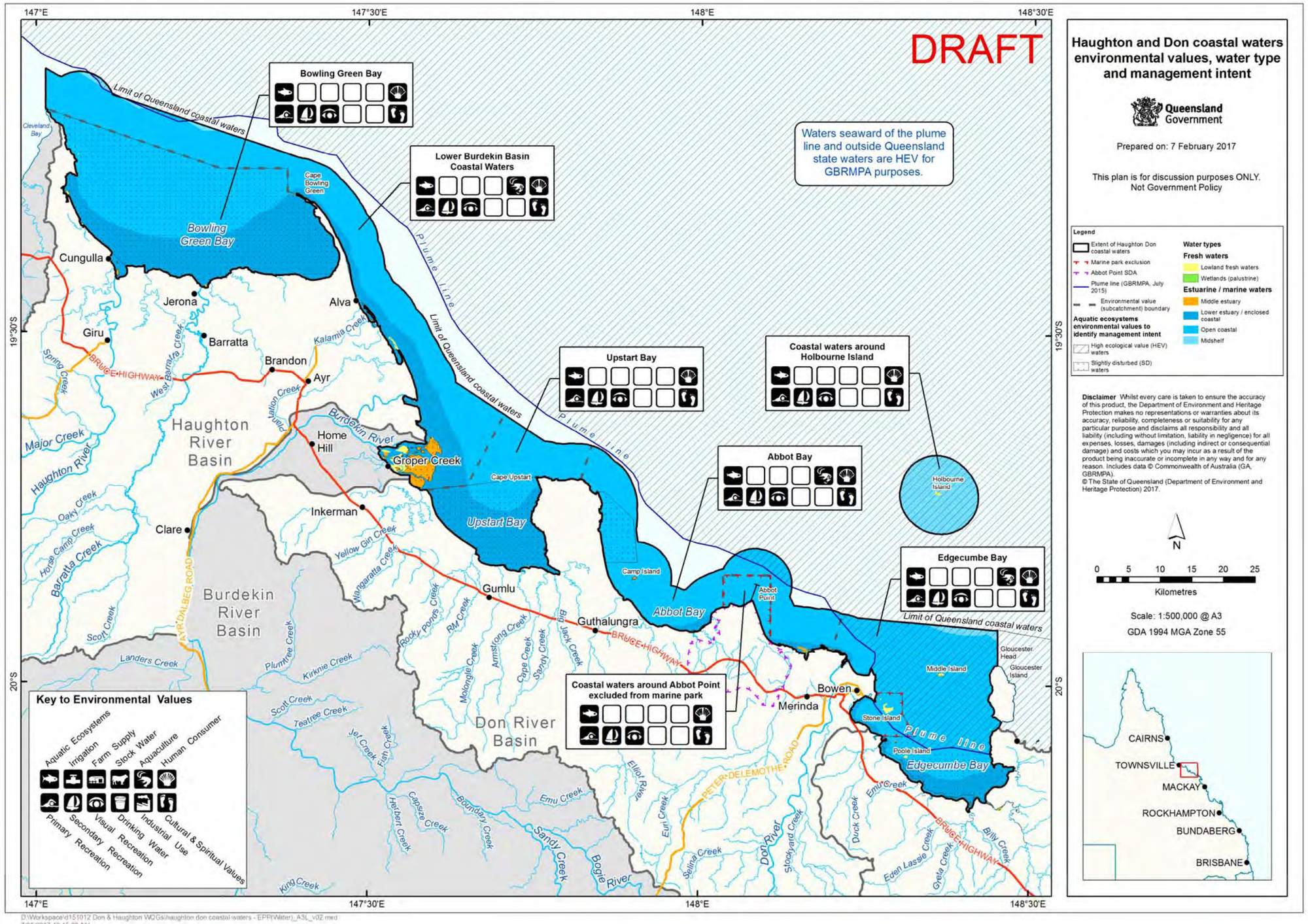

Figure 8 Don and Haughton coastal water environmental values, water type and management intent

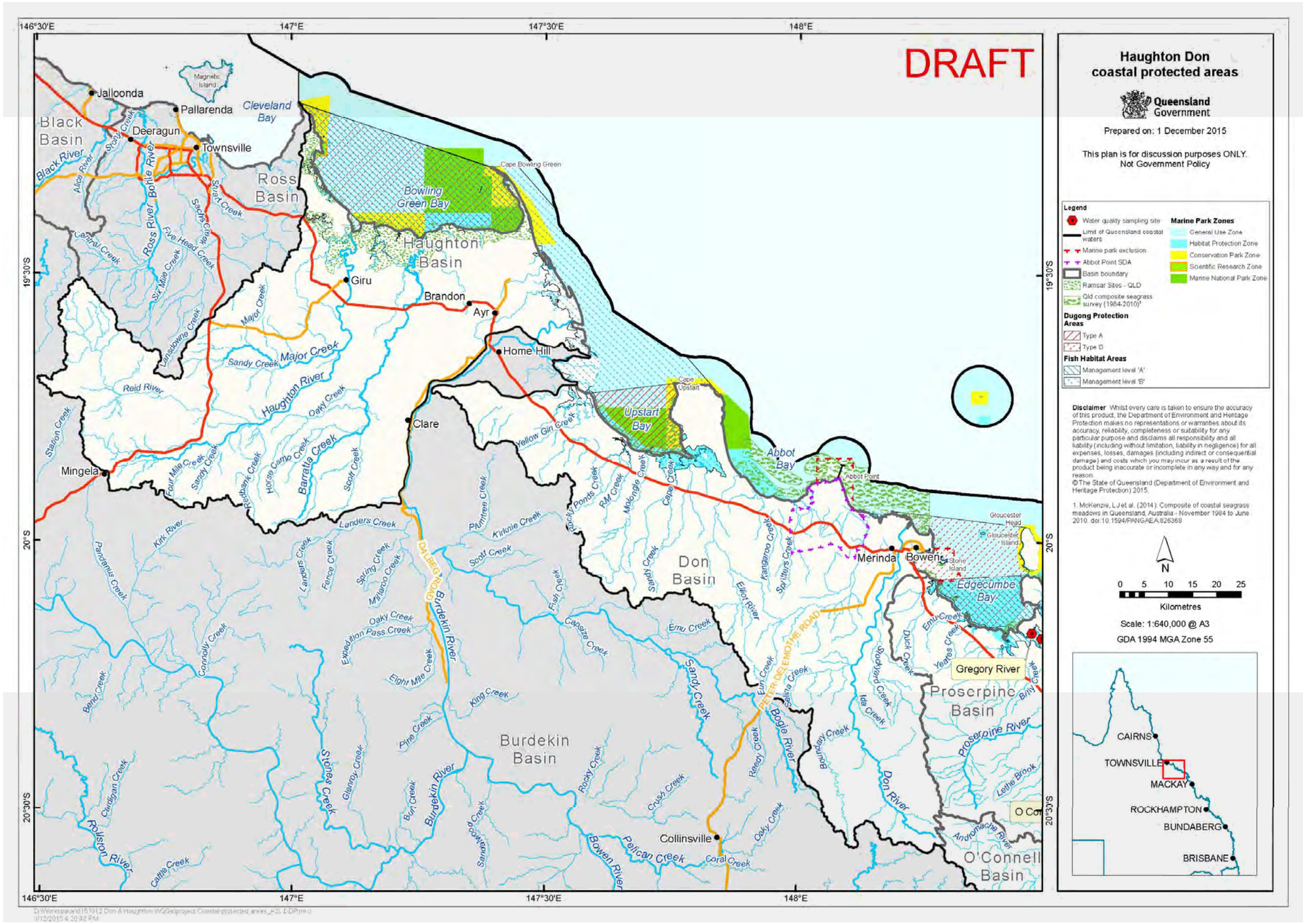

Figure 9 Don and Haughton coastal waters protected areas (Marine Park, Fish Habitat Area, Dugong Protection Area)

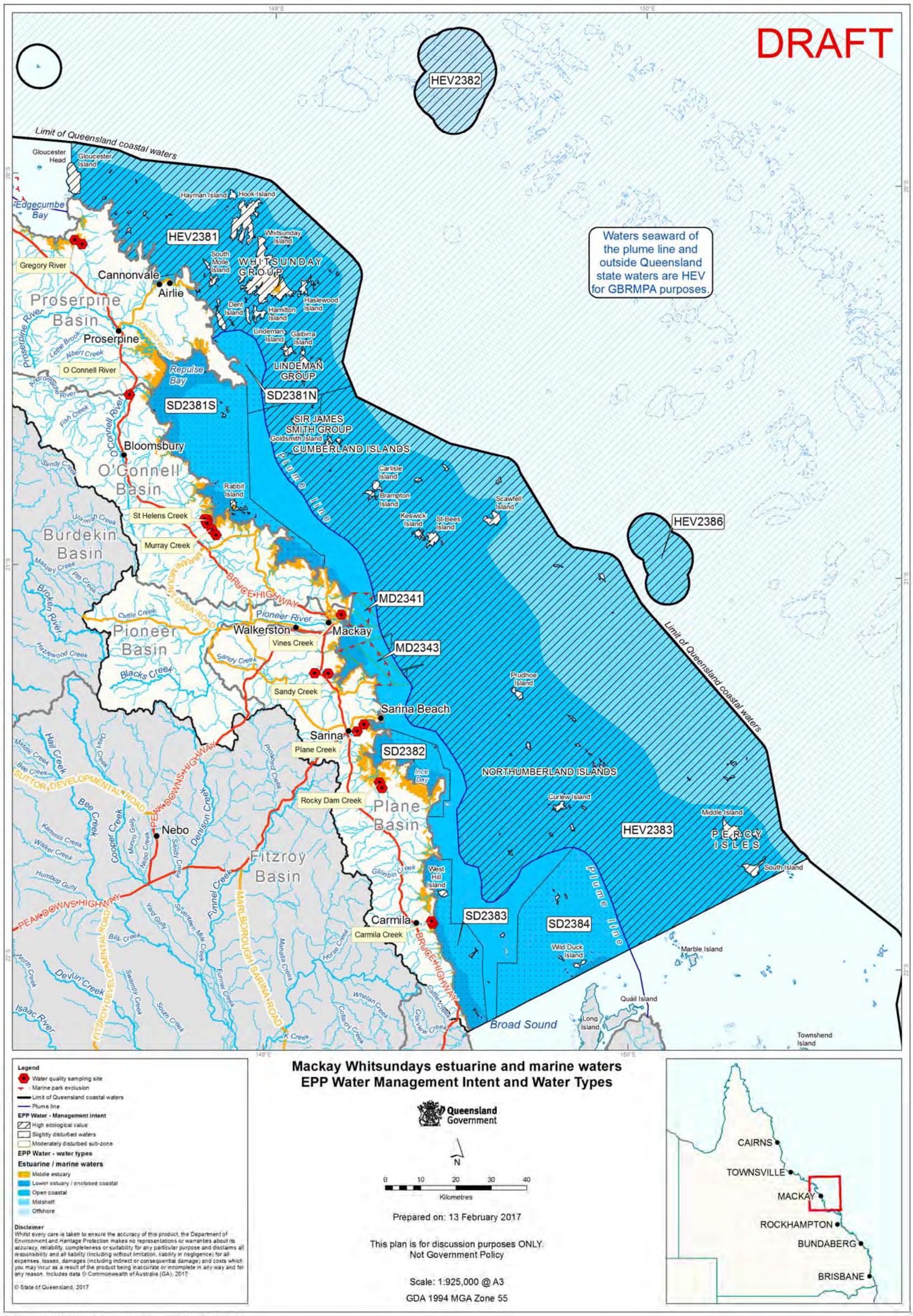

Figure 10 Mackay Whitsunday estuarine and marine water types and management intent

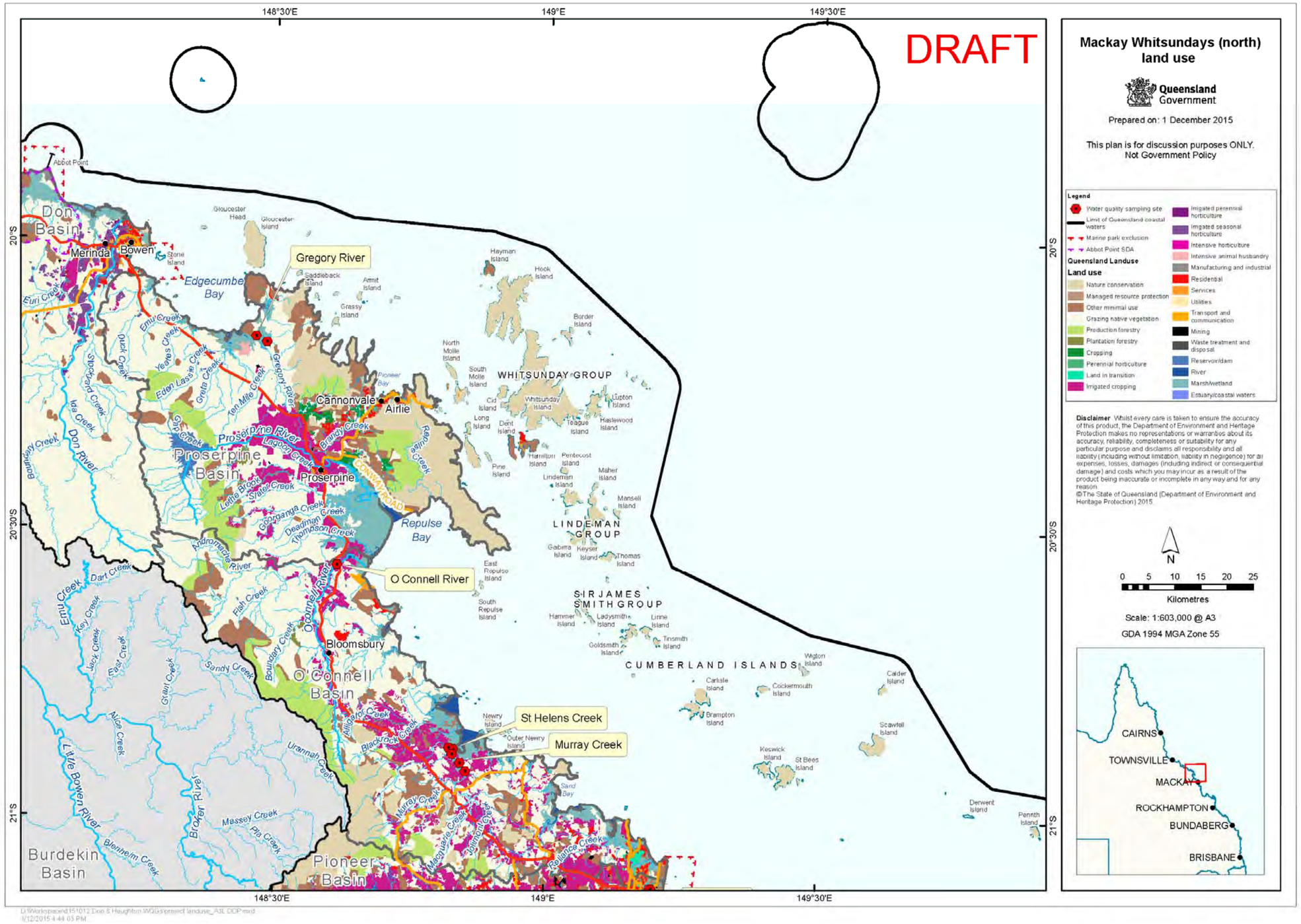

Figure 11 Mackay-Whitsunday (north) landuse

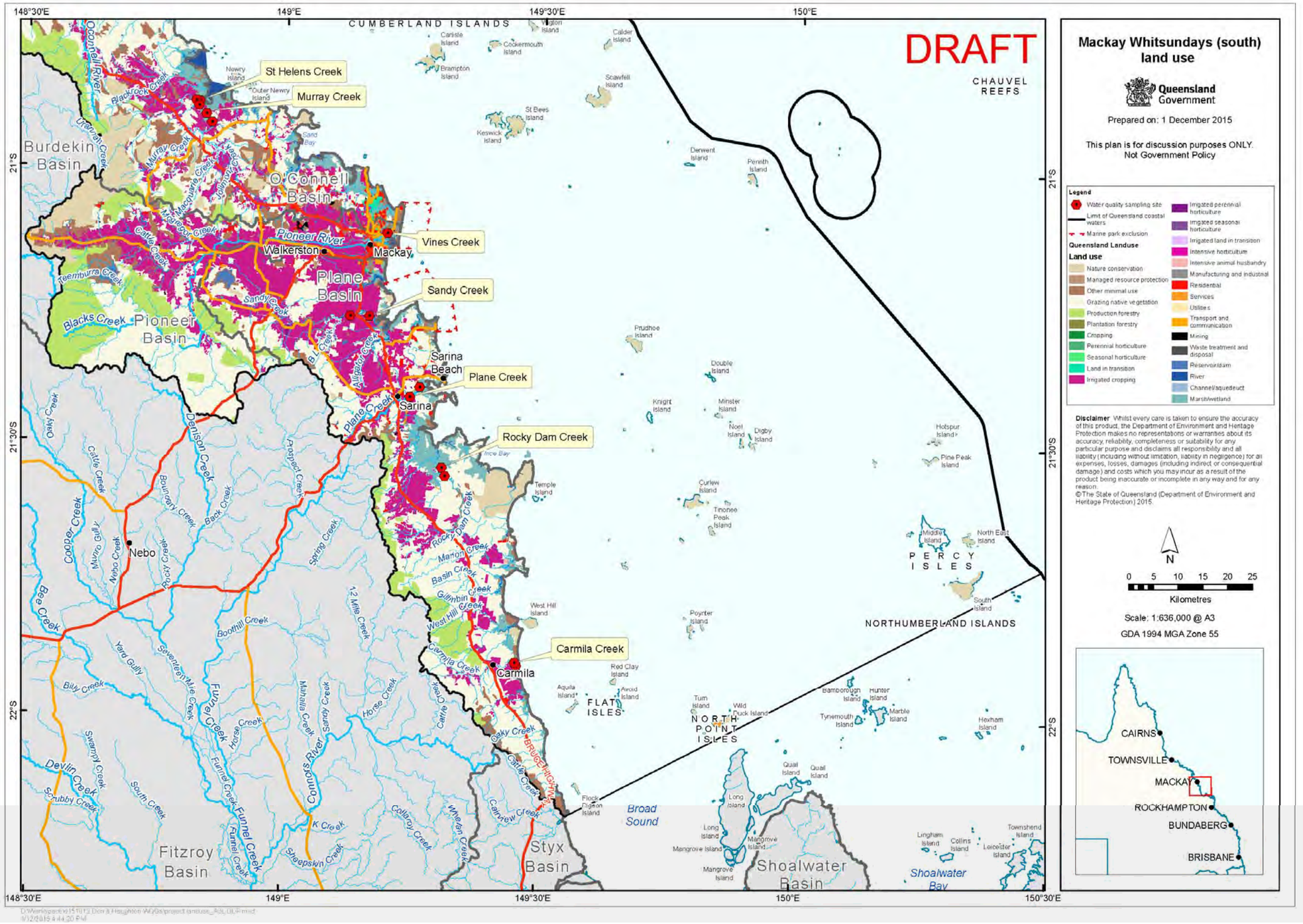

Figure 12 Mackay-Whitsunday (south) landuse

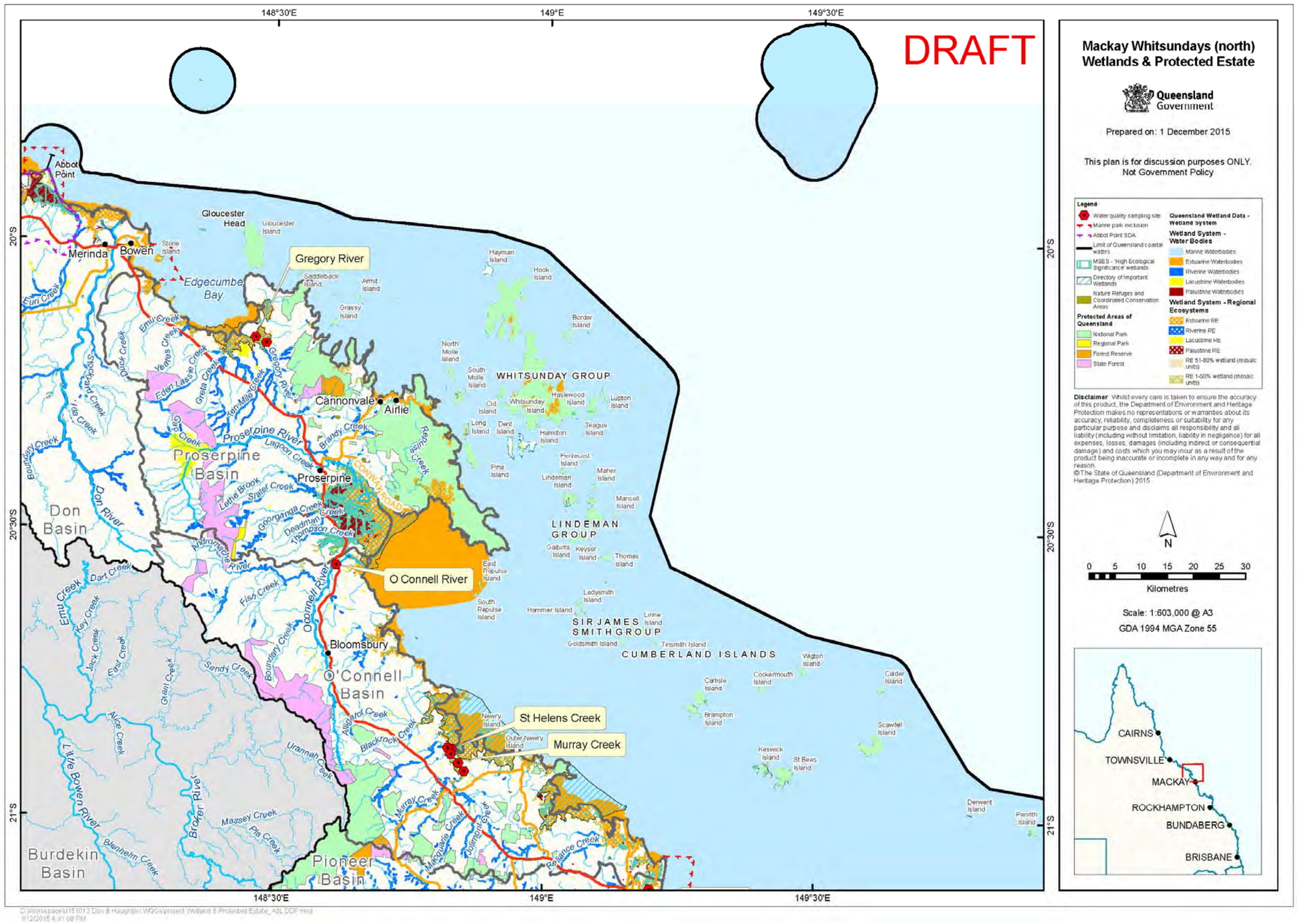

Figure 13 Mackay-Whitsunday (north) wetlands and protected estate

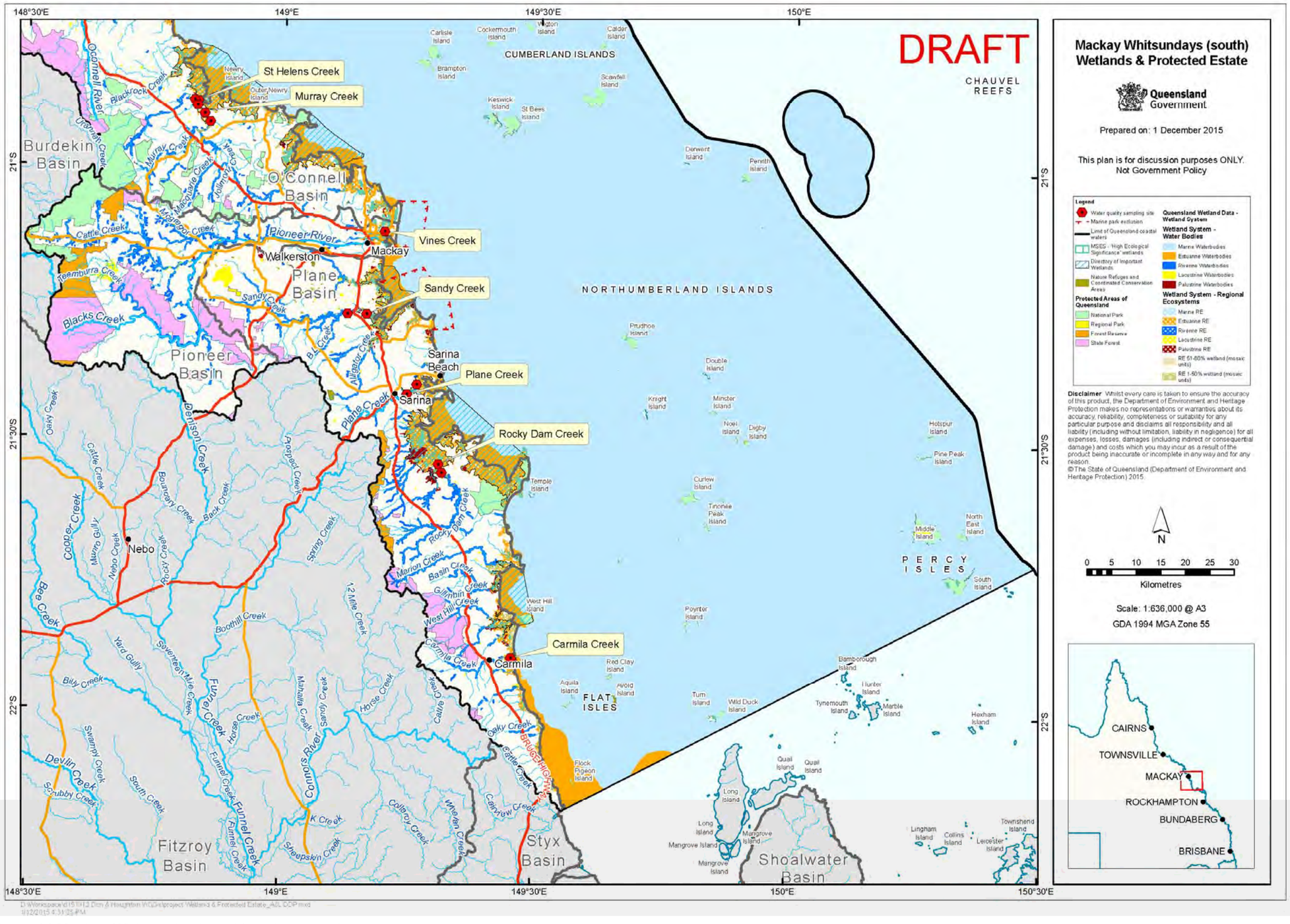

Figure 14 Mackay-Whitsunday (south) wetlands and protected estate

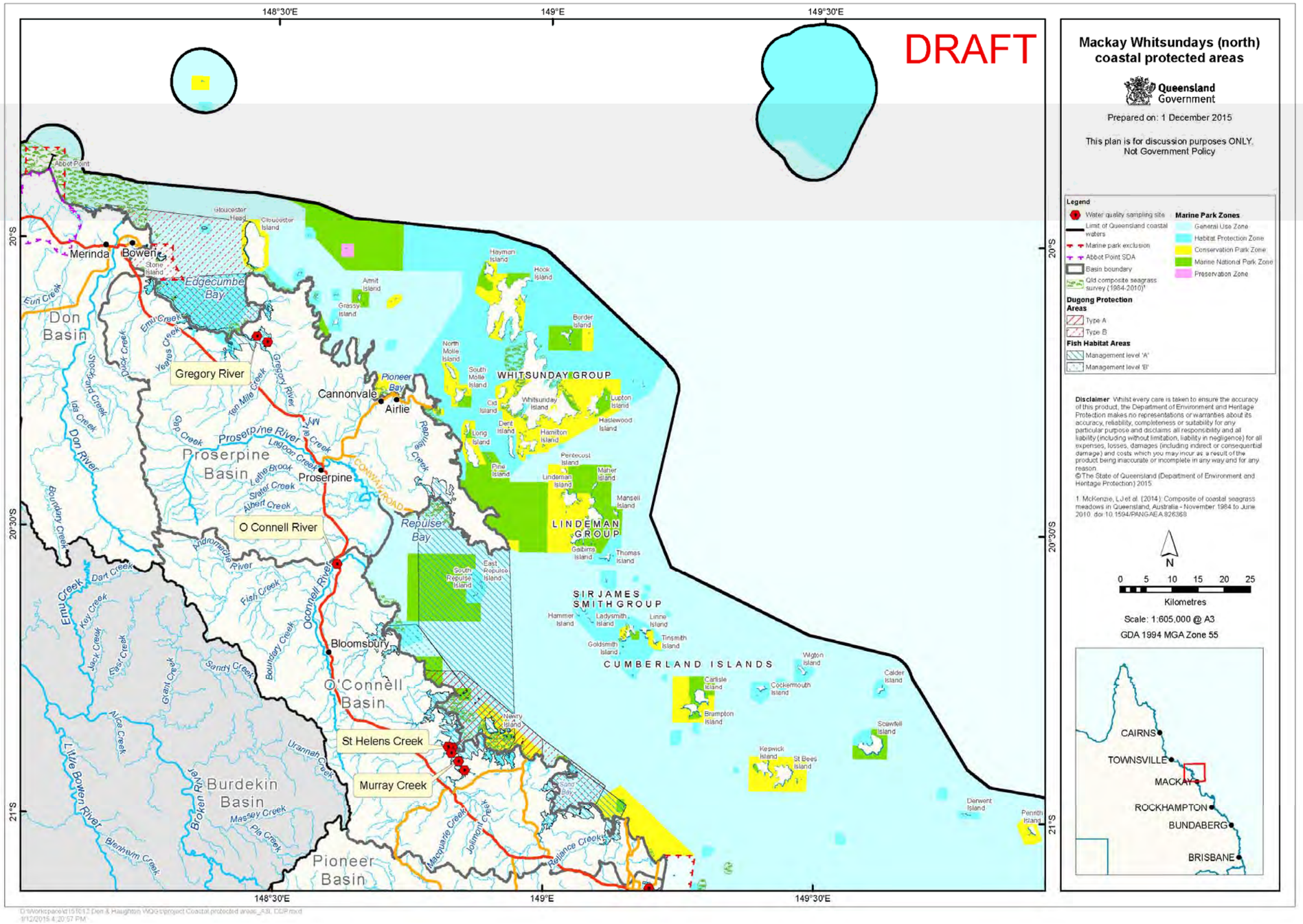

Figure 15 Mackay-Whitsunday coastal waters (north) protected areas (Marine Park, Fish Habitat Area, Dugong Protection Area)

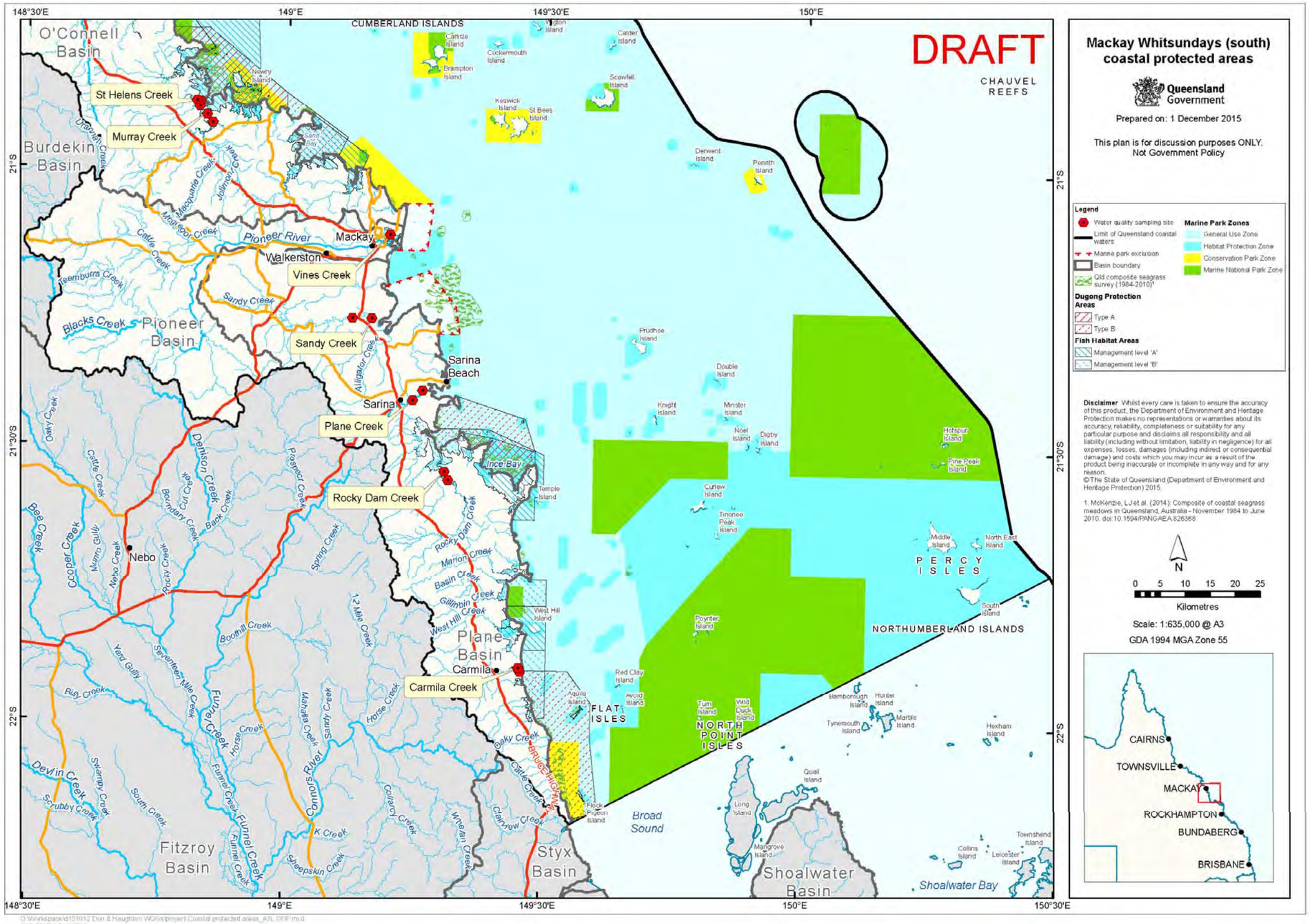

Figure 16 Mackay-Whitsunday coastal waters (south) protected areas (Marine Park, Fish Habitat Area, Dugong Protection Area)

3 Deriving local water quality guidelines for aquatic ecosystem protection

3.1 Default ANZECC regions and water types

The *Australian and New Zealand Water Quality Guidelines* (ANZECC & ARMCANZ 2000) refer to four large regions of Australia (Figure 17), and derive 'default' WQGs for water types in each region. The split between the 'Tropical' region and more southern regions is the Tropic of Capricorn. The study area lies to the north of the Tropic of Capricorn and falls under the ANZECC 'Tropical' region, which includes all Australian waters north of the Tropic of Capricorn from waters of north Queensland, Northern Territory and Western Australia.

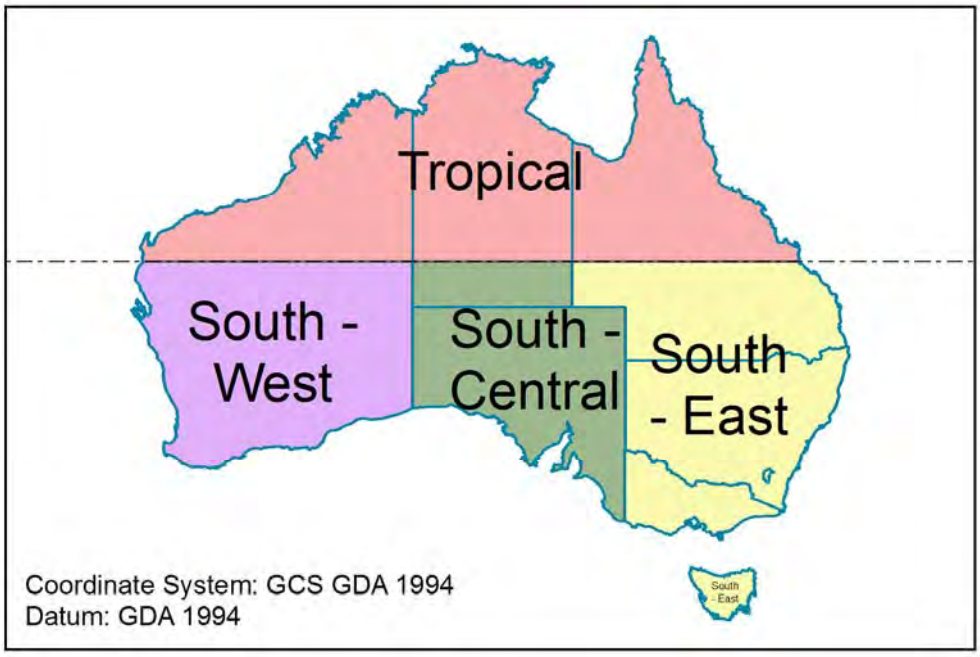

Figure 17 ANZECC water type regions. The project area is located in the 'Tropical' water type.

The default water types outlined in the ANZECC guidelines are also 'generic' in their characterisation. For example, in ANZECC there is a single 'estuarine' water type and only two broad marine water types (inshore, offshore).

Consequently, the direct application of the default ANZECC values may not necessarily reflect local water types or water quality characteristics, and potentially offers insufficient protection or imposes excessive constraints relative to the local characteristics of the water, particularly for physico-chemical indicators.

3.2 National framework – the need for local water quality guidelines

While the ANZECC water quality guidelines provide default aquatic ecosystem water quality guideline values for a range of broad water types and indicators, they strongly emphasise the need to develop more locally relevant guidelines:

"It is not possible to develop a universal set of specific guidelines that apply equally to the very wide range of ecosystem types or production systems, in varying degrees of health, in Australia and New Zealand. Environmental factors can reduce or increase the effects of physical and chemical parameters at a site and these factors can vary considerably across the two countries. A framework is provided that allows the user to move beyond single-number, necessarily conservative values, to guidelines that can be refined according to local environmental conditions — that is, to developing site-specific guidelines. This is a key message of the Water Quality Guidelines…."

"This can produce values more appropriate to a particular water resource. Although tailoring guidelines to local conditions requires more work in some cases, it results in much more realistic management goals. It therefore has the potential to reduce costs for industry." (ANZECC, 2000 Introduction to the guidelines, 8 - 9)

Under the ANZECC water quality framework and the *Environmental Protection Policy (Water),* properly developed and approved local guidelines hold higher precedence over state or national guidelines. State (or national) guidelines apply when local guidelines do not exist, and are used for any parameters that are not included in the most locally relevant guidelines.

The ANZECC guidelines set out the policy framework for water quality guideline and management. Core to this is the concept of 'continual improvement', where management of waters should always be aiming towards better water quality and ecological health:

"*An overriding principle that should guide management should be continual improvement. This is more obvious where water or sediment quality does not match the water quality objectives. In badly polluted waters it might even be necessary to set intermediate levels of water quality to be achieved in well defined stages, each subsequent target closer to the required water quality objective, until it is finally met."* (ANZECC, 2000, Section 2.2.1.7)

3.3 Developing local water quality guidelines in Queensland

The first step towards developing local water quality guidelines for Queensland waters was taken with the development of the *Queensland Water Quality Guidelines* (QWQG) (EHP 2009, updated 2013) and the corresponding *Water Quality Guidelines for the Great Barrier Reef Marine Park* (GBRMPA 2010). The QWQG divides Queensland's river basins into a number of regions and water types, and then defines WQGs for each water type within each region. Under the QWQG framework, waters in the study area fall within the 'central coast'

region (applying to river basins from the Burnett River near Bundaberg to the Black River near Townsville). The QWQG also identifies water types in a more detailed level of disaggregation. For example, 'estuary' is sub divided into lower, middle and upper estuary sub-types with different WQGs. The QWQG also 'calls up' a more detailed split of coastal waters based on the GBRMPA guidelines, including open coastal, midshelf and offshore waters within State limits. Guideline values are provided for each of these water types.

While the QWQG and GBRMPA guidelines provide a regional level of water quality guidelines, there is still the opportunity to review local water quality data and, if sufficient data exists, to further refine guideline values at the local level.

For these reasons, and in accord with the recommendations of the ANZECC guidelines, this report derives local aquatic ecosystem water quality guidelines for the study area where sufficient information exists to do so. The guidelines are primarily focused on physico-chemical indicators. Where there is insufficient information to derive local guidelines for particular indicators, reference will be made back to the relevant Queensland, GBRMPA or ANZECC water quality guidelines.

For toxicants (metals, pesticides etc.) the intent is to use the WQGs from relevant over-arching guideline sources (ANZECC, GBRMPA), using their recommended species protection guideline values. This means that all waters within the GBRMP and waters with 'slightly disturbed' or 'high ecological value' levels of protection have a species protection level of 99% of species. MD waters outside the GBRMP have a species protection level of 95% of species. Where ANZECC advises bioaccumulation risk occurs, or where GBRMPA recommends a higher level of protection, e.g. for agricultural pesticides in marine waters, the 99% of species protection is used in these waters.

Some toxicant guidelines are currently under review as part of the ANZECC water quality guidelines review process. Pending approval/endorsement by government/ANZECCC, updated values would subsequently be included.

Similarly, for human use environmental values (recreation, irrigation, etc.) the intent is to use the most appropriate (e.g. NHMRC, ANZECC) guidelines (refer Appendix 3).

3.4 Management intent/level of protection

The AWQG, QWQG and EPP Water outline the management framework applying to different aquatic ecosystems. The framework provides threshold levels of change that are acceptable for each of the different aquatic ecosystem conditions. In summary this involves maintaining the condition of waters in good condition and seeking to sustainably manage water quality in modified waters.

High conservation/ecological value systems (HEV) are defined as:

"effectively unmodified or other highly valued systems, typically (but not always) occurring in national parks, conservation reserves or in remote and/or inaccessible locations... The ecological integrity of high conservation/ecological value systems is regarded as intact." (ANZECC 2000; 3.1-10)

According to the AWQG:

"…these (HEV) waters are afforded a high degree of protection by ensuring that there is no reduction in the existing water quality, irrespective of the water quality guidelines."

"Where there are few biological assessment data available for the system, the management objective should be to ensure no change in the concentrations of the physical and chemical water quality variables beyond natural variation" (ANZECC 2000;3.1-11)

The ANZECC Guidelines does not specify how "no change" should be assessed but a statistical method is presented in the Queensland Water Quality Guidelines (2009), available from the EHP website. This proposes that "no change" should be assessed as no change to the 20/50/80th percentiles of existing water quality.

For modified systems, the concept of 'continual improvement' is relevant, where management of waters should aim towards better water quality and ecological health:

"An overriding principle that should guide management should be continual improvement. This is more obvious where water or sediment quality does not match the water quality objectives. In badly polluted waters it might even be necessary to set intermediate levels of water quality to be achieved in well-defined stages, each subsequent target closer to the required water quality objective, until it is finally met." (ANZECC & ARMCANZ 2000, Section 2.2.1.7, p2 16).

For slightly disturbed systems ('waters that have the biological integrity of high ecological value waters with slightly modified physical or chemical indicators but effectively unmodified biological indicators': EPPW), the management intent is to improve their physico-chemical water quality back towards HEV levels.

For moderately disturbed systems disturbed waters ('waters in which the biological integrity of the water is adversely affected by human activity to a relatively small but measurable degree' EPPW), the intent is to achieve specified water quality objectives.

For highly disturbed waters ('significantly degraded by human activity and have lower ecological value than high ecological value waters or slightly or moderately disturbed waters': EPPW), the framework recognises that progressive improvement will be required.

Further details on the approach used to derive guidelines in Don-Haughton waters are provided in section 4.

4 Approach used to derive aquatic ecosystem guidelines

This section summarises the approach used in deriving aquatic ecosystem water quality guidelines for the study area. Main water types, management intent and water type sub-regions for which WQGs are derived are shown in Figure 3 - Don, Figure 6 – Haughton, Figure 8 – Don-Haughton coastal, Figure 10 – Mackay-Whitsunday.

Note: In response to recommendations of the Great Barrier Reef Water Science taskforce in May 2016 (http://www.gbr.qld.gov.au/taskforce/), further work is being undertaken to develop basin specific load targets for the 35 basins of the Great Barrier Reef catchment including the Don, Haugton and Mackay-Whitsunday basins. Results of this work will be reviewed and addressed in the finalisation of EPP Water materials, including water quality objectives.

4.1 Water types

The study team has used water type definitions described in the QWQG and *Water Quality Guidelines for the Great Barrier Reef Marine Park* (GBRMPA, 2010) for this project. The following water types occur within the study area, and are the starting point for development of water quality guidelines in the tables:

- Fresh waters
- Estuarine waters
    - Mid estuary
    - Lower estuary/enclosed coastal
- Open coastal waters
- Midshelf and offshore waters
- wetlands
- groundwaters

Note: local WQGs have not been developed for wetlands or groundwaters at this stage.

For estuaries that flow directly into open coastal waters, the seaward limit of the water type (enclosed coastal water) is close to the mouth of the waterway. For Bowling Green Bay and Upstart Bay which are much more enclosed, the seaward extent of the enclosed coastal water type is further from shore (Figure 8).

4.2 Don and Haughton river basins fresh waters

Water quality guidelines for freshwaters derived from local data have not previously been developed for the Don and Haughton river basins. In the past, default guidelines from the QWQG Central Coast Region and the AWQG would be applied. The project team have collated available data from multiple sources to develop locally based guidelines for the first time. The method used to derive these local guidelines is outlined in this section.

4.2.1 Use of referential approach to derive water quality guidelines

A reference site is a site whose condition is considered to be a suitable baseline or benchmark for assessment and management of sites in similar water bodies. Most commonly reference condition refers to sites that are subject to minimal disturbance. The QWQG includes a list of criteria for reference sites to make them suitable for physico-chemical indicators (QWQG 2009, Table 4.4.1). The criteria seek that sites have minimal impact from human activities such as intensive agriculture and wastewater discharges. The QWQG notes however that:

'Although the criteria…are recommended, there are some regions and some water types where it may be difficult to find any sites that fully comply with these criteria. In this situation it may be necessary to use lesser quality or best available sites' (QWQG 2009, Section 4.4.2, available from the DEHP website).

Much of the Don and Haughton basins have been impacted to some degree during a history of clearing for grazing, sugarcane and agriculture and suffers discharge impacts from mining, industry and urban development. This severely limits the availability of data from minimally disturbed reference condition sites in the basins. For the purposes of developing water quality guidelines for aquatic ecosystems, the use of moderately disturbed sites as best available reference sites allows for a more comprehensive dataset to be used than would otherwise be available. However, this necessitates an alternative percentile approach, rather than using 20th or 80th percentiles of reference sites to set guideline values at the MD level of protection, as would be used for minimally impacted reference sites.

The proposed alternative percentile approach is to use the 40th percentile of data from moderately disturbed, best available sites to set water quality guidelines for similar moderately disturbed waters. The traditional referential method uses an 80th percentile of data from minimally impacted sites, and a median of data from test sites in moderately disturbed areas is tested against this. This allows moderately disturbed sites to deviate from the reference condition within limits that should protect the aquatic ecosystem EV at the moderately disturbed level of protection. The proposed alternative percentile approach uses a percentile less than the median of best available moderately disturbed site data, aiming to both protect the aquatic ecosystem EV and guide improvements in water quality towards an uncertain reference condition. The 40th percentile is suggested as a modest goal for improvement on condition where no specific management goals are defined which may require more ambitious guidelines.

There is little guidance available in the national and state water quality frameworks for developing guidelines in catchments with limited availability of undisturbed reference sites. This alternative percentile approach has the potential to be widely applied in moderately disturbed catchments, and can be methodically repeated to review guidelines as improvements in water quality progress through management actions. The steps used in the development of local water quality guidelines in the Don and Haughton basins, using the alternative percentile method, are further explained below.

4.2.1 Data sources and quality control

For freshwaters in Don and Haughton basins, DSITI reviewed available data from the Department of Natural Resources and Mines Water Monitoring Information Portal, Hydstra Project Sciences database and data provided by James Cook University from local studies. Local stakeholders within the Don Basin also provided data under terms of data sharing agreements. Samples targeted at event sampling were removed and baseflow guidelines were derived.

Quality coding of DNRM and Hydstra data provided indication of data quality for those data points. James Cook University provided quality assured data and inspection and analysis by DSITI proved the compatibility with the government data.

Where there was insufficient information to derive WQGs based on local data, values defaulted to the Central Coast Region WQGs specified in the Queensland Water Quality Guidelines (2009).

Appendix 2 provides a detailed statement of methods, monitoring sites and sample sizes. Figure 18 shows locations of water quality monitoring in the Don-Haughton region.

4.2.2 Sub-basin scale of draft water quality objectives

For the purposes of water quality guidelines development the basins have been separated into sub-basin scale units as in the Burdekin WQIP. Refer to Figure 1 for map of the sub-basins.

4.2.3 Flow separation

Certain indicators, including electrical conductivity and suspended solids, can vary considerably with flow regime (Jones & Moss 2011) and therefore separate guidelines are ideal to account for these differences between flow conditions. High flows and also very low and nil flow conditions can produce highly variable water quality, dependent on the time since the last flow and the amount of water in the system.

After quality assurance and data screening, samples from both the Queensland government and external datasets were categorised by flow condition using historical discharge data for local gauges. Discharge data was accessed from the DNRM online water monitoring information portal. Discharge was reported at a daily timestep as Daily Mean Discharge (m^3 $second^{-1}$, cumecs). This enabled separation of 'high flow' samples from 'low/no flow' samples. At present, high flow condition guidelines have not been developed due to insufficient data, but these could be developed in the future as more data becomes available.

Flow condition was estimated based on flow exceedance curves of discharge data from the basins. Flow exceedance curves were plotted from the historical data of a number of gauges in the catchment. The approximate 'inflection point' for each curve was identified and used as an indicator to separate 'high flow' and 'low flow'. Generally, high flow was identified as discharges above the 90^{th} percentile of daily mean discharge (i.e. the 10% of recorded days with the greatest daily mean discharge). Low flow was defined as discharges below the 90^{th} percentile of daily mean discharge.

For each water quality sample, discharge (cumecs) at the sample site was estimated from discharge reported at the nearest gauge, and attributed to 'low flow' or 'high flow' conditions if below or above the calculated high flow threshold for that gauge.

4.2.4 Derivation of freshwater water quality guidelines for moderately disturbed waters

These water quality guidelines are derived to protect or enhance the aquatic ecosystem environmental value. This protection is related to general goals of protecting integrity of ecosystem functions and general biological health. These goals can be achieved by maintaining the water quality of moderately disturbed reaches, or in some cases aiming for improvements where necessary. More specific management intent, for example related to

protection of a specific species, may require more stringent water quality guidelines than those presented here.

The aim in deriving these water quality guidelines was to protect aquatic ecosystems by maintaining or improving current water quality. Freshwater WQGs reported in the Burdekin WQIP 2009 have been based on the QWQG 2009 for the Central Coast region, which in turn are largely based on ANZECC guidelines. These WQGs may be inconsistent with the systems of the Don and Haughton river basins, and may either not provide sufficient protection or impose inappropriate limits on water quality. The guideline values derived in this report are, depending on location and indicator, higher or lower than the current applicable water quality guidelines. Using the process outlined below they nonetheless provide for maintenance of, or an improvement on, current water quality.

4.2.4.1 Method of WQG review:

1. Sample sites and data were reviewed as outlined in sections 4.2.1.
2. Data points were separated at sub-basin scale as outlined in section 4.2.2.
3. Flow condition was applied to samples as outlined in section 4.2.3.
4. A range of percentiles of the data for each parameter were calculated for each sub-basin and flow condition.
5. The median of the recorded data was compared to the Central Coast guidelines from the QWQG.
    a. Where the median of the recorded data represented a better water quality than the Central Coast guideline, the median of the data was adopted as the updated WQG. The 20th and 80th percentiles are also defined to provide the water quality range. This method seeks to at least maintain water quality at current condition.
    b. Where the median of the recorded data represented a poorer water quality than the Central Coast guideline, a lower percentile (representing an improvement of current water quality) of the recorded data was adopted as the updated WQG. The 40th percentile of recorded data was chosen as the updated WQG. The 20th and 70th percentiles are also defined to provide the water quality range. This method seeks an improvement over current water quality, but within a practicable range.
    c. From part b), if the 40th percentile of recorded data represents a better water quality than the Central Coast guideline (where the Central Coast guideline is between the median and 40th percentile) the Central Coast guideline is retained, as this still provides a goal of improved water quality. The 20th and 70th percentiles of recorded data are also defined to provide the water quality range.

To assess against these water quality guidelines, the median of test data would be assessed against the guideline, and 20th and 80th percentiles of test data compared to the provided water quality range. For more information on monitoring condition relative to water quality guidelines, see Section 5 of this report and the QWQG 2009, Section 5.

The methods outlined above for developing and reviewing the water quality guidelines for the Don and Haughton basin fresh waters poses a methodical and repeatable process. The updated WQGs seek to protect the aquatic ecosystem EV by, at a minimum, maintaining water quality, and improving water quality in impacted catchments.

This review provides for the first time in the Don and Haughton rivers, sub-basin specific water quality guidelines for a range of parameters derived from locally collected data. In some areas, this has resulted in higher guideline values than the earlier QWQG values

which are derived largely from the AWQG. In other areas, guideline values are lower. As these guidelines are now based on local data, and the policy framework aims for continual improvement in water quality to protect EVs, future reviews of the guidelines should only seek to maintain or improve on the water quality values provided here.

4.3 Don and Haughton river basins estuarine waters

Insufficient local data was available for mid estuarine waters in the Don and Haughton river basins to derive guidelines from local data. For the Don River, data collected by DSITI from the nearby Gregory River mid estuary has been used as reference to develop guidelines for mid estuary waters at the MD level of protection. Although the Gregory River is in the Mackay-Whitsunday region it is a suitable surrogate site for the Don Basin, having similar land use and climate conditions. Data collected by DSITI is collected in accordance with the Queensland Monitoring and Sampling Manual 2009 (DEHP 2010 ver.2). Data then undergoes quality assurance procedures before being entered to the Queensland Waterways Database. The data set from the Gregory River is currently limited to about seven months of results which would not normally be considered to be sufficient to derive guidelines. However, for the purposes of this consultation document, draft guideline values have been developed. These will be updated as more data becomes available, although major changes are not anticipated.

For the Haughton River estuary, there was no suitably similar estuary to use as a reference site. Instead WQGs will default to the Central Queensland region QWQG values.

4.4 Don and Haughton river basins coastal and marine waters

For enclosed coastal waters and waters within core port zones (outside the Great Barrier Reef Marine Park), DSITI reviewed water quality data collected both by discrete sampling efforts and data recorded by continuous loggers. This data was made available by local stakeholders under terms of data sharing agreements. Data was checked for anomalous values and datasets from different providers compared for consistency. Data was then combined for purposes of developing WQGs.

For open coastal and midshelf marine waters, GBRMPA reviewed AIMS data (including continuous logger data) from the Marine Monitoring Program (MMP) and the Long Term Monitoring Program (LTMP). All data are collected and analysed in accordance with an approved Quality Assurance and Quality Control manual available at the GBRMPA website (http://elibrary.gbrmpa.gov.au/jspui/handle/11017/2875).

GBRMPA also reviewed ocean site data published in the Environmental Impact Statement for a proposed aquaculture development at Guthalungra (Abbot Bay). Data was checked for anomalous values and compared with other datasets for consistency.

Where condition of marine waters did not meet desired ecosystem state objectives, or it was not feasible to derive marine water WQGs based on local data, values are sourced from the GBRMPA guidelines. This was the case for all open coastal sites adjacent to the Don and Haughton Basins. The GBRMPA guidelines are derived to protect a desired ecosystem state. Long term annual means should meet the GBRMPA guidelines. If there is a need or desire to assess shorter term (seasonal) data sets, means of those datasets should meet seasonal guidelines.

Guidelines for seagrass light requirements around Abbot Point were based on research reported by McKenna et al. (2015) for inshore (sub-tidal) and offshore (deeper water) seagrasses. McKenna et al. (2015) states that “Seagrass biomass and irradiance (light) data

was collected from the established Abbot Point seagrass program. Five inshore seagrass meadows and four offshore areas have been monitored approximately quarterly for seagrass presence, biomass, area (inshore meadows only) and species composition since 2008".

Guidelines for seagrass light requirements in the broader coastal and marine waters including Bowling Green and Edgecumbe Bays, are based on research by TropWater (James Cook University). These data sources and reports are available from the Trop Water website: https://research.jcu.edu.au/tropwater .

Appendix 1 provides a detailed statement of methods, monitoring sites, and sample sizes. Figure 18 (provided at end of this section) shows locations of water quality monitoring in Don-Haughton coastal waters.

4.5 Mackay-Whitsunday estuarine waters

There is very limited historical data for estuaries in the Mackay-Whitsunday region. Consequently, when Mackay-Whitsunday region estuaries were scheduled in 2013, QWQG default values were applied in most cases. However, in October 2014 DSITI commenced a program of monthly monitoring in eight estuaries across the Mackay-Whitsunday region. These estuaries are the Gregory River, O'Connell River, St Helens/Murray Creeks, Vines Creek, Sandy Creek, Plane Creek, Rocky Dam Creek and Carmila Creek. Monitoring locations are shown in Figure 20.

Data is collected by DSITI in accordance with the Queensland Monitoring and Sampling Manual 2009 (DEHP 2010 ver.2). Data then undergoes quality assurance procedures before being entered to the Queensland Waterways Database.

To date about seven months of water quality data, collected from one or two sites in each estuary, has been used in this analysis. Of the estuaries monitored, only the Gregory River estuary could be considered a good quality reference site, although some of the others were impacted to only a limited degree and data from these were used for some indicators. The Gregory River is the most northern of the Mackay-Whitsunday estuaries being monitored and has a much smaller tidal range compared to estuaries south of Mackay. This meant that for the southern catchments, guidelines for indicators such as turbidity could not be based on Gregory River data and needed to be based on data from these more southern estuaries despite the level of disturbance. Where there was insufficient information to derive WQGs based on local data, values default to the applicable WQGs specified in the Queensland Water Quality Guidelines (2009).

4.6 Mackay-Whitsunday coastal and marine waters

Coastal and marine waters were scheduled under the EPP Water in 2013. In this review, the GBRMPA has added seasonal guidelines for a number of parameters, and updated analyses of marine water quality data, water type and plume line mapping in the region.

For open coastal, midshelf and offshore marine waters, GBRMPA reviewed AIMS data (including continuous logger data) from the Marine Monitoring Program (MMP) and the Long Term Monitoring Program (LTMP) as well as AIMS and GBRMPA data from the long term chlorophyll monitoring program. Since last being scheduled an additional two years of monitoring data was available from the MMP and included in re-analysis. All data are collected and analysed in accordance with an approved Quality Assurance and Quality Control manual available at the GBRMPA website (http://elibrary.gbrmpa.gov.au/jspui/handle/11017/2875).

Following analysis, waters around Tern, Bushy-Redbill and Sandpiper reefs (HEV2386 in Figure 10) have been re-classified as 'midshelf' water type (rather than 'offshore' as initially scheduled).

Grouped site data from a joint AIMS and GBRMPA long term chlorophyll monitoring program was considered as reference quality, and percentiles from this data have been set as the WQGs for northern open coastal waters. Details are provided in Appendix 1. Figure 19 shows locations of sites used in the updated Mackay-Whitsunday coastal waters analysis.

Guidelines for seagrass light requirements in the broader Mackay-Whitsunday region coastal waters of the Proserpine & Pioneer Basins, are based on research by TropWater (James Cook University).

4.7 Indicators

The study team reviewed potential indicators against available water quality data and the parameters currently used in QWQG (2009) and GBRMPA guidelines (2010). The indicators for which guidelines have been developed are listed below and include nutrients, dissolved oxygen, pH, water clarity parameters, and chlorophyll-a. These indicators are important and often there is at least some data on which guidelines can be based. At present there is limited data available for biological indicators. However, seagrass light guidelines have been included for estuarine and marine waters. In the longer term it is considered desirable to include guidelines for additional biological indicators. Toxicant guidelines (e.g. metals, pesticides) are sourced from AWQG (except where otherwise noted, e.g. Aluminium).

4.7.1 Marine waters

WQG indicators used for coastal and marine waters include the following:

- ammonia nitrogen (µg/L)
- oxidised nitrogen (µg/L)
- particulate nitrogen (µg/L)
- total dissolved nitrogen (µg/L)
- total nitrogen (µg/L)
- filterable reactive phosphorus (FRP: µg/L)
- particulate phosphorus (µg/L)
- total dissolved phosphorus (µg/L)
- total phosphorus (µg/L)
- chlorophyll-a (µg/L)
- silicate (µg/L)
- dissolved oxygen (% saturation)
- turbidity (NTU)
- Secchi depth (m)
- suspended solids (mg/L)
- pH
- temperature: (˚C)
- toxicants (µg/L)
- seagrass light requirements

Refer to Appendix 1 for further details on indicators and source datasets.

4.7.2 Fresh and estuarine waters

For fresh and estuarine waters of the Don and Haughton river basins and estuarine waters of the Mackay-Whitsunday region, indicators for which WQGs have been derived are:

- ammonia nitrogen (µg/L)
- oxidised nitrogen (µg/L)
- total nitrogen (µg/L)
- filterable reactive phosphorus (FRP: µg/L)
- total phosphorus (µg/L)
- chlorophyll-a (µg/L)
- dissolved oxygen (% saturation)
- turbidity (NTU)
- Secchi depth (m) (estuarine waters only)
- suspended solids (mg/L)
- pH
- specific conductivity (µS/cm) (fresh waters only)
- toxicants (µg/L)

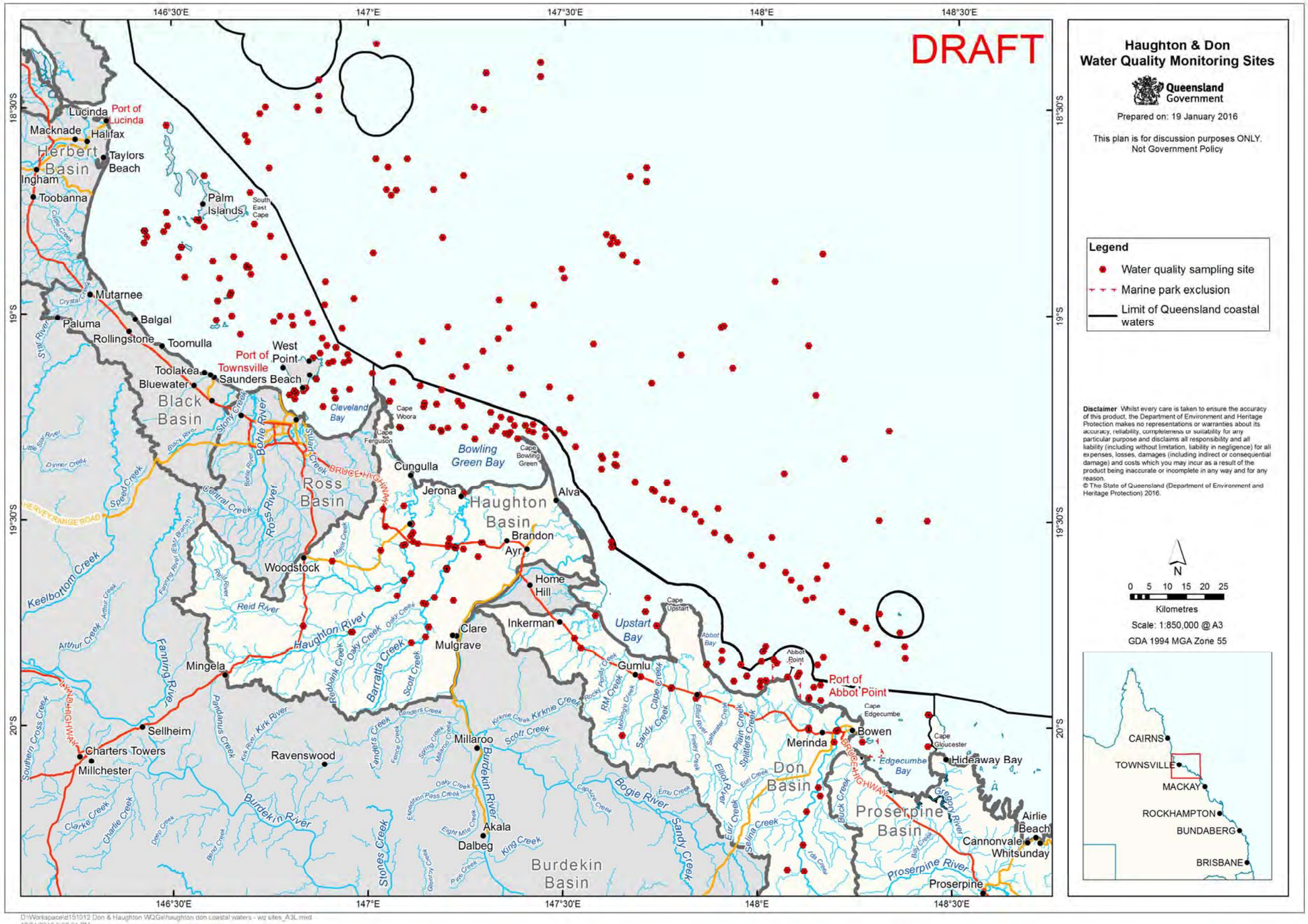

Figure 18 Don-Haughton fresh, estuary, coastal/marine water quality monitoring sites

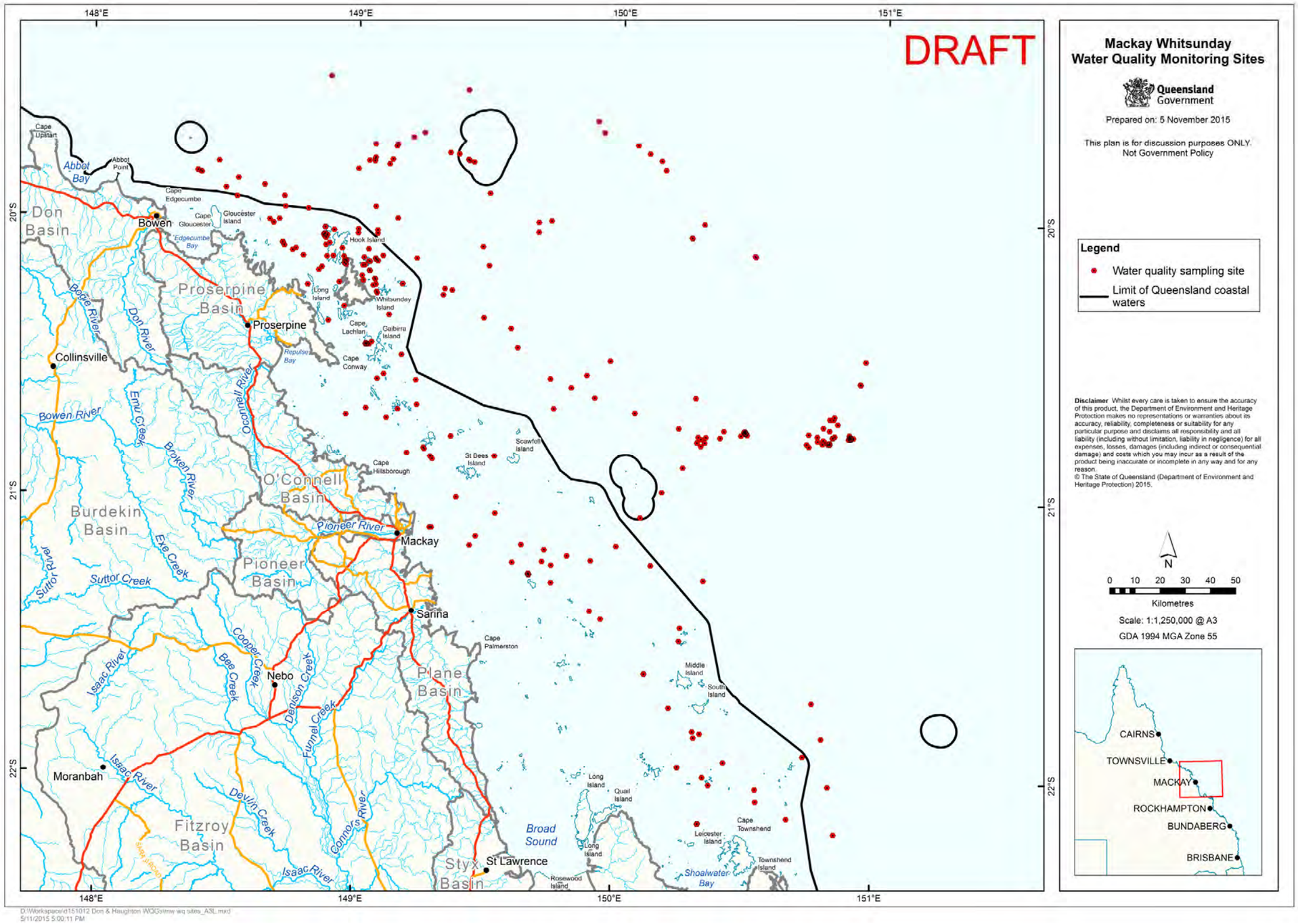

Figure 19 Mackay-Whitsunday coastal/marine water quality monitoring sites

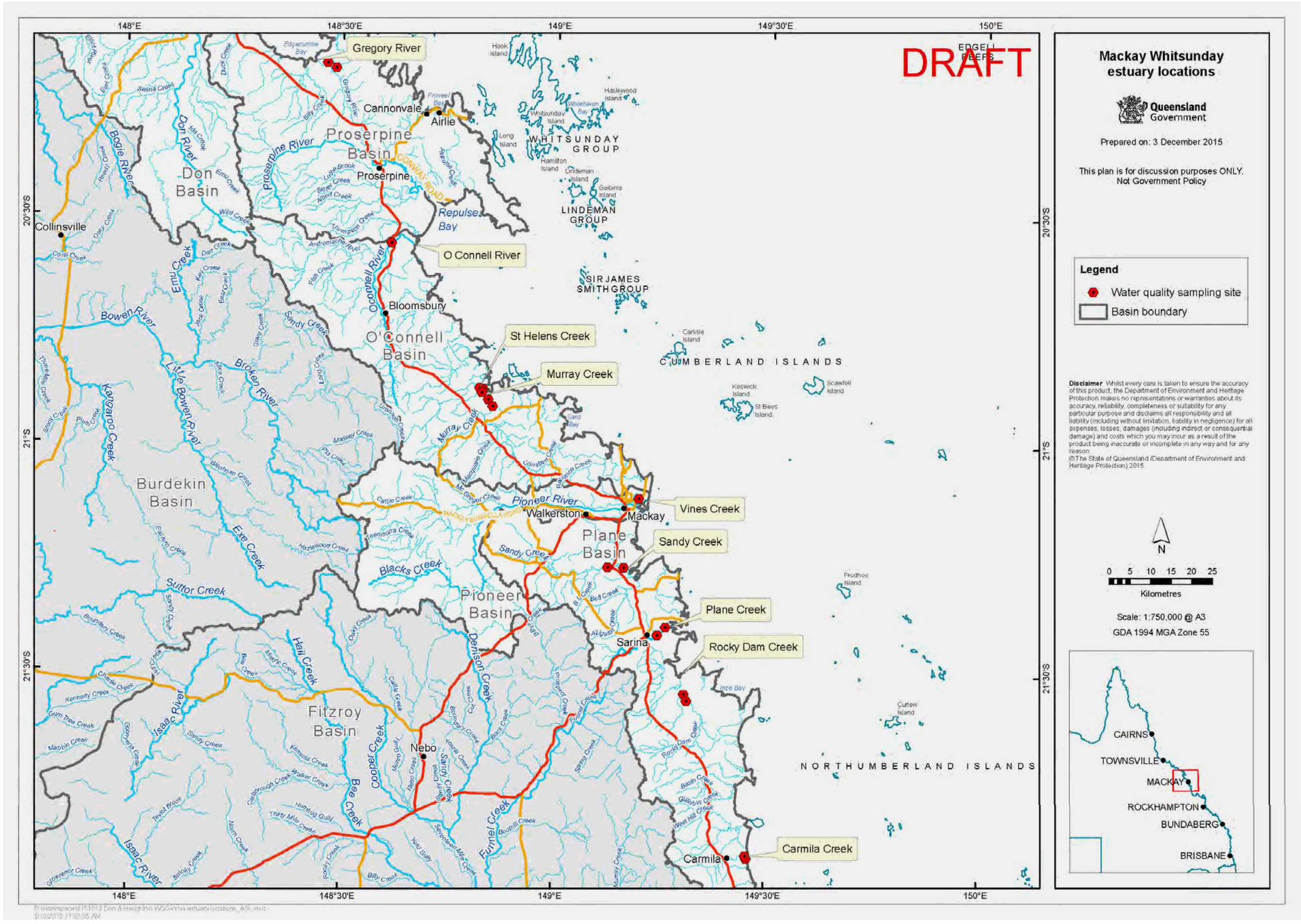

Figure 20 Mackay-Whitsunday estuary water quality monitoring sites

5 Water quality guidelines to protect aquatic ecosystems

5.1 WQGs tables information

The aquatic ecosystem water quality guidelines are presented in:

- Table 1: Don-Haughton region marine/coastal waters, including Abbot Point port
- Table 2: Mackay-Whitsunday region marine/coastal waters (updates)
- Table 3: Don, Haughton estuarine/fresh waters
- Table 4: Mackay-Whitsunday mid estuarine waters (updates).

Guidelines for the Don-Haughton region waters are newly derived. Those for Mackay-Whitsunday region are proposed amendments to existing EPP Water scheduled WQOs (based on further data collation and analysis, including derivation of seasonal guidelines). Updated Mackay-Whitsunday WQGs are shown in the tables. Only those Mackay-Whitsunday waters with proposed changes in WQG values are shown in the table.

The columns of each table identify:

- 1st column: water type (e.g. enclosed coastal) or water type sub-region (e.g. Abbot Bay catchments lowland freshwaters), and main data source for the guidelines (e.g. 's2')
- 2nd column: management intent/level of protection for that water (e.g. MD – moderately disturbed, HEV – high ecological value). For more information about management intent of waters, refer to the EPP (Water) 2009.
- Other columns: these identify the water quality guidelines (WQGs) proposed to achieve the management intent for specified indicators (TN, TP, pH, etc.).

Data sources, references and notes are listed after the tables, and further details are provided in appendices.

For some parameters and locations, guidelines are as specified in the QWQG and the GBRMPA guidelines because there was minimal difference between local data and QWQG, there were insufficient data to derive appropriate guidelines for the local area, or no suitable reference site existed. For other parameters (e.g. toxicants) the guidelines are primarily sourced from ANZECC and (for a number of agricultural pesticides) GBRMPA guidelines.

5.2 Monitoring condition relative to aquatic ecosystem water quality guidelines

The following protocols are recommended for monitoring condition (at a 'test' site) relative to the aquatic ecosystem water quality guidelines. More details are provided in the QWQG (section 5, Appendix D) and the AWQG (ANZECC & ARMCANZ, 2000). In general (e.g. for nutrients) the intent is for test site water quality to be less than or equal to the stated guidelines:

- HEV waters (and SD waters): The management intent is no change from natural condition (HEV waters) and to achieve HEV condition (SD waters). Where a range of three values is provided for waters identified for HEV level of protection (e.g. Total N:65-100-125), the 75 percent confidence intervals around sampled 20th-50th-80th 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, a range of two values typically applies, and the test sample values should fall within the specified range. Also see comments for coastal/marine waters below.

- For the comparison of test site monitoring data against single value guidelines with an MD level of protection, 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 applicable water quality guideline/objective.

- Where a range of three values is provided for waters with an MD level of protection (e.g. Total N: 165-200-225) the median water quality value of test samples is compared with the middle value of the stated range. The 20th and 80th percentiles are compared with the outside values of the range provided, which are the desired 20th – median – 80th percentile range of test values.

- Where a range of two values is provided for water with an MD level of protection, as for parameters DO and pH, the median water quality values of test samples should fall within this range.

- Coastal/marine waters: Some parameters in marine waters have single values specified as an annual (or seasonal) mean, rather than median. The mean water quality value of a number of independent samples at a particular monitoring ('test') site should be compared against the applicable water quality guideline. The sample number is preferably five or more samples for within season comparison, and five or more [preferably 24 or more over two years] samples taken during wet and dry seasons for annual mean comparisons. 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 values 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.

- For assessing monitoring data against toxicant guidelines/objectives (in waters and sediments), the QWQG refers to the AWQG protocols (e.g. AWQG vol. 1 sections 3.5.5, 7.4.4.2 and 7.4.4.4). For toxicants in water, the AWQG recommends the comparison of the 95th percentile of monitoring data against the default toxicant trigger values.

5.3 Coastal and marine waters

5.3.1 Don-Haughton coastal and marine waters

WQGs for Don-Haughton coastal/marine waters are provided in Table 1 as listed below (broadly north – south) and shown in Figure 8:

1. Bowling Green Bay – enclosed/open coastal waters
2. Lower Burdekin – enclosed/open coastal waters
3. Upstart Bay – enclosed/open coastal waters
4. Abbot Bay – enclosed/open coastal waters
5. Abbot Point – enclosed/open coastal waters
6. Edgecumbe Bay – enclosed/open coastal waters
7. Holbourne Island – midshelf waters adjacent to island

All guidelines are 'new', and no Don-Haughton waters have previously been scheduled under the EPP Water.

The tables include marine water quality guidelines for both long term annual and, where possible, shorter term seasonal conditions. These guidelines protect a desired ecosystem state. Long term annual means should meet the guidelines. If there is a need or desire to assess shorter term (seasonal) data sets, means of those datasets should meet seasonal guidelines where specified.

Refer to Appendix 1 for details on marine water quality analyses.

5.3.2 Mackay-Whitsunday coastal and marine waters

WQGs for Mackay-Whitsunday region coastal/marine waters are provided in Table 2 and listed broadly north – south. Water unit names are based on those used in the Proserpine and Pioneer EPP Water schedule 1 documents and maps. Those WQGs that differ from current scheduled WQOs are underlined. These include specification of seasonal (dry season, wet season) guidelines. Refer to Figure 10 for coastal/marine water types and sub-regions. Further details are provided in Appendix 1.

5.4 Fresh and estuarine waters

5.4.1 Don-Haughton fresh and estuarine waters

WQGs for Don-Haughton estuarine and fresh waters are shown in Table 3. Additional information on related plans and policies for riparian and wetlands values is provided in Section 5.5 after the tables. Waters are listed as follows (refer Figures 3 and 6 for Don and Haughton water types, sub-regions and EVs):

<u>Don River Basin</u>

1. Upstart Bay catchments - mid estuarine/lowland/upland fresh waters
2. Abbot Bay catchments - mid estuarine/lowland/upland fresh waters
3. Don River catchment - mid estuarine/lowland/upland fresh waters

<u>Haughton River Basin</u>

4. Haughton catchment - mid estuarine/lowland/upland fresh waters
5. Barratta catchment - mid-estuarine/lowland/upland freshwaters
6. Burdekin delta - mid-estuarine/lowland/upland freshwaters

The table is separated on the basis of drainage patterns and land use. Each sub-basin has been given different water quality guidelines based on locally derived data. Data has been collected by state government agencies, researchers of James Cook University and local stakeholders.

Fresh and estuarine waters of the Don and Haughton basins have proposed levels of protection, namely High Ecological Value (HEV), slightly disturbed (SD) or Moderately Disturbed (MD). Waters identified for HEV level of protection are based on existing legislative information regarding protected estate (e.g. National Parks, fish habitat areas) and occur mainly in protected upland areas, but also in some lowland areas and valuable coastal estuarine wetland systems. Fresh and estuarine HEV waters are not represented in the water quality sampling data and as such have not been assigned local guideline values here. Monitoring of these waters is required to develop suitable local guideline values.

Guidelines aim to maintain and improve the current condition of the MD waters, and achieve the specified values for HEV management intent waters.

5.4.2 Mackay-Whitsunday estuarine waters

WQGs for Mackay-Whitsunday region mid estuarine waters are shown in Table 4. These are primarily based on DSITI water quality monitoring of Gregory estuary and other estuaries in the region. Additional information on related plans and policies for riparian and wetlands values is provided in Section 5.3 after the tables.

Guidelines aim to maintain and improve the current condition of the MD waters, and achieve the specified values for HEV management intent waters.

Table 1 Water quality guidelines for coastal and marine waters of the Don and Haughton coasts

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5]															
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)														
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Particulate N** (µg/L)	**Total Dissolved N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Particulate P** (µg/L)	**Total Dissolved P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Silicate** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**
BOWLING GREEN BAY (refer to map Figure 8)																	
BOWLING GREEN BAY SD Lower estuary/ enclosed coastal waters (s1, s2)	**HEV**	2–2–5 (s1)	1–4–8 (s1)	na	na	80–90–125 (s1)	1–1–3 (s1)	na	na	10–12–13 (s1)	≤1 (s1)	na	90–100 (s2)	2–4–14 (s1)	≥1.5 (s2)	≤2 (s1)	8–8.4 (s2)
BOWLING GREEN BAY Lower estuary/ enclosed coastal waters (s1, s2)	**MD**	≤2 (s1)	≤4 (s1)	na	na	≤90 (s1)	≤1 (s1)	na	na	≤12 (s1)	≤1 (s1)	na	90–100 (s2)	≤4 (s1)	≥1.5 (s2)	≤2 (s1)	8–8.4 (s2)
BOWLING GREEN BAY SD Open coastal waters (landward of GBR plume line) (s1, s2,s3,s4)	**HEV**	0–1–6 (s1, s4)	0–1–2 (s4)	8–13–20 Dry: ≤16 (May-Oct) Wet:≤25 (Nov-Apr) (s3, s4)	50–70–90 (s4)	65–100–125 (s1, s4)	0–2–4 (s1, s4)	1.5–2.1–3.2 Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	2–6–11 (s4)	8–12–20 (s1, s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	60–110–320 (s4)	95–105 (s2)	≤2 (s1, s4)	≥10 (ann. mean) (s3)	0.5–1.2–2.5 Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s1, s3, s4)	8.1–8.3–8.4 (s2)

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5]															
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)														
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Particulate N** (µg/L)	**Total Dissolved N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Particulate P** (µg/L)	**Total Dissolved P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Silicate** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**
BOWLING GREEN BAY All coastal waters: temperature (s3)	**all**	**Temperature**: increases of no more than 1°C above long-term (20 year) average maximum. (GBRMPA, 2010)															
BOWLING GREEN BAY All coastal waters: toxicants (s1, s3, s5, s6))	**all**	**Toxicants and Pesticides**: WQOs for all pesticides in these waters as per GBRMPA and AWQG water quality guidelines, to protect marine species at the HEV level of protection (except where noted). Pesticides/biocides specified in GBR water quality guidelines include (but not limited to): • Ametryn: <0.5 µg/L; Atrazine: <0.6 µg/L; Diuron: <0.9 µg/L; Hexazinone: <1.2 µg/L; Simazine: <0.2 µg/L; Tebuthiuron: <0.02 µg/L; 2,4-D: <0.8 µg/L ; Tributyltin: <0.006 µg/L (95% species protection) For other toxicants not listed in GBRMPA guidelines, refer to AWQG and sources below: • Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the MD level of protection typically correspond to protection of 95% species (in a small number of cases where bioaccumulation may occur, the AWQG recommends 99% species protection level). • Aluminium: <24 µg/L (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 AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)														
BOWLING GREEN BAY All coastal waters: biological (s1, s5)	**All**	**Seagrass**: 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) • 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 from acute water quality impacts. Locally derived absolute thresholds ideally should be obtained for management of specific activities likely to impact on the light environment. Higher light requirements may be needed for the management of longer term chronic impacts.														

Water area/type (Sources: s1–s6)	Management intent /Level of protection	**Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5]** **Note:** WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)														
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Particulate N** (µg/L)	**Total Dissolved N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Particulate P** (µg/L)	**Total Dissolved P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Silicate** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**
LOWER BURDEKIN COASTAL WATERS (extending up to boundary with Bowling Green Bay) (refer to map Figure 8)																	
LOWER BURDEKIN Lower estuary/ enclosed coastal waters (s1, s2)	**MD**	≤2 (s1)	≤4 (s1)	na	na	≤90 (s1)	≤1 (s1)	na	na	≤12 (s1)	≤1 (s1)	na	90–100 (s2)	≤4 (s1)	≥1.5 (s2)	≤2 (s1)	8–8.4 (s2)
LOWER BURDEKIN Open coastal waters (s1,s2,s3,s4)	**SMD**	≤1 (s1, s4)	≤1 (s4)	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet: ≤25 (Nov-Apr) (s3)	≤70 (s4)	≤100 (s1, s4)	≤2 (s1, s4)	≤2.8 (ann. mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3)	≤6 (s4)	≤12 (s1, s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	≥110 (s4)	95–105 (s2)	≤2 (s1, s4)	≥10 (ann. mean) (s3)	≤2 (ann. mean) Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3)	8.1–8.4 (s2)
LOWER BURDEKIN All coastal waters: temperature (s3)	**all**	**Temperature**: increases of no more than 1°C above long-term (20 year) average maximum. (GBRMPA, 2010)															

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5]

Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines.

HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed

Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)

Ammonium N (µg/L)	Oxidised N (µg/L)	Particulate N (µg/L)	Total Dissolved N (µg/L)	Total N (µg/L)	Filterable Reactive P (µg/L)	Particulate P (µg/L)	Total Dissolved P (µg/L)	Total P (µg/L)	Chlorophyll-a (µg/L)	Silicate (µg/L)	Dissolved Oxygen (% saturation)	Turbidity (NTU)	Secchi (m)	Suspended Solids (mg/L)	pH

LOWER BURDEKIN All coastal waters: toxicants (s1, s3, s5, s6)	**all**	**Toxicants and Pesticides**: WQGs for all toxicants and pesticides in these waters (except aluminium – specified below) as per GBRMPA (2010) and ANZECC (2000) water quality guidelines, to protect marine species at the HEV (99% of species protection) level of protection. Where pesticide values are specified in both the GBRMPA and ANZECC guidelines, the lower value will be adopted. Pesticides/biocides specified in GBR water quality guidelines include: • Ametryn: <0.5 µg/L; Atrazine: <0.6 µg/L; Diuron: <0.9 µg/L; Hexazinone: <1.2 µg/L; Simazine: <0.2 µg/L; Tebuthiuron: <0.02 µg/L; 2,4-D: <0.8 µg/L; Tributyltin: <0.0004 µg/L For other toxicants not listed in GBRMPA guidelines, refer to AWQG and sources below: • Toxicants in water: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). • Aluminium: <2.1 µg/L (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 AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)
LOWER BURDEKIN All coastal waters: biological (s1, s3)	**All**	**Seagrass**: 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) • 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 from acute water quality impacts. Locally derived absolute thresholds ideally should be obtained for management of specific activities likely to impact on the light environment. Higher light requirements may be needed for the management of longer term chronic impacts.

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5]															
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)														
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Particulate N** (µg/L)	**Total Dissolved N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Particulate P** (µg/L)	**Total Dissolved P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Silicate** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**
UPSTART BAY (refer to map Figure 8)																	
UPSTART BAY SD Lower estuary/ enclosed coastal waters (s1, s2)	**HEV**	2–2–5 (s1)	1–4–8 (s1)	na	na	80–90–125 (s1)	1–1–3 (s1)	na	na	10–12–13 (s1)	≤1 (s1)	na	90–100 (s2)	2–4–14 (s1)	≥1.5 (s2)	≤2 (s1)	8–8.4 (s2)
UPSTART BAY Lower estuary/ enclosed coastal waters (s1, s2)	**MD**	≤2 (s1)	≤4 (s1)	na	na	≤90 (s1)	≤1 (s1)	na	na	≤12 (s1)	≤1 (s1)	na	90–100 (s2)	≤4 (s1)	≥1.5 (s2)	≤2 (s1)	8–8.4 (s2)
UPSTART BAY SD Open coastal waters (landward of GBR plume line) (s1, s2, s3,s4)	**HEV**	0–1–6 (s1, s4)	0–1–2 (s4)	8–13–20 Dry: ≤16 (May-Oct) Wet: ≤25 (Nov-Apr) (s3, s4)	50–70–90 (s4)	65–100–125 (s1, s4)	0–2–4 (s1, s4)	1.5–2.1–3.2 Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	2–6–11 (s4)	8–12–20 (s1, s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	60–110–320 (s4)	95–105 (s2)	≤2 (s1, s4)	≥10 (ann. mean) (s3)	0.5–1.2–2.5 Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s1, s3, s4)	8.1–8.3–8.4 (s2)
UPSTART BAY Open coastal waters (s1, s2,s3,s4)	**SMD**	≤1 (s1, s4)	≤1 (s4)	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet: ≤25 (Nov-Apr) (s3)	≤70 (s4)	≤100 (s1, s4)	≤2 (s1, s4)	≤2.8 (ann. mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3)	≤6 (s4)	≤12 (s1, s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	≥110 (s4)	95–105 (s2)	≤2 (s1, s4)	≥10 (ann. mean) (s3)	≤2 (ann. mean) Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3)	8.1–8.4 (s2)

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5]

Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines.

HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed

Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Ammonium N (µg/L)	Oxidised N (µg/L)	Particulate N (µg/L)	Total Dissolved N (µg/L)	Total N (µg/L)	Filterable Reactive P (µg/L)	Particulate P (µg/L)	Total Dissolved P (µg/L)	Total P (µg/L)	Chlorophyll-a (µg/L)	Silicate (µg/L)	Dissolved Oxygen (% saturation)	Turbidity (NTU)	Secchi (m)	Suspended Solids (mg/L)	pH
UPSTART BAY All coastal waters: temperature (s3)	**all**	**Temperature**: increases of no more than 1°C above long-term (20 year) average maximum. (GBRMPA, 2010)															
UPSTART BAY All coastal waters: toxicants (s1, s3, s5,s6)	**all**	**Toxicants and Pesticides**: WQGs for all toxicants and pesticides in these waters (except aluminium – specified below) as per GBRMPA (2010) and ANZECC (2000) water quality guidelines, to protect marine species at the HEV (99% of species protection) level of protection. Where pesticide values are specified in both the GBRMPA and ANZECC guidelines, the lower value will be adopted. Pesticides/biocides specified in GBR water quality guidelines include: • Ametryn: <0.5 µg/L; Atrazine: <0.6 µg/L; Diuron: <0.9 µg/L; Hexazinone: <1.2 µg/L; Simazine: <0.2 µg/L; Tebuthiuron: <0.02 µg/L; 2,4-D: <0.8 µg/L; Tributyltin: <0.0004 µg/L For other toxicants not listed in GBRMPA guidelines, refer to AWQG and sources below: • Toxicants in water: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). • Aluminium: <2.1 µg/L (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 AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)														
UPSTART BAY All coastal waters: biological (s1, s3)	**all**	**Seagrass**: 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) • 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 from acute water quality impacts. Locally derived absolute thresholds ideally should be obtained for management of specific activities likely to impact on the light environment. Higher light requirements may be needed for the management of longer term chronic impacts.														

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5] **Note:** WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)															
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Particulate N** (µg/L)	**Total Dissolved N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Particulate P** (µg/L)	**Total Dissolved P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Silicate** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**
ABBOT POINT PORT (core port waters outside GBR Marine Park) (refer to map Figure 8)																	
ABBOT POINT PORT Lower estuary/ enclosed coastal core port waters outside GBR Marine Park (s1, s2)	**MD**	≤2 (s1)	≤4 (s1)	na	na	≤90 (s1)	≤1 (s1)	na	na	≤12 (s1)	≤1 (s1)	na	90–100 (s2)	1–3–7 (dry) 2–4–14 (wet) (s1)	≥1.5 (s2)	≤2 (s1)	8–8.4 (s2)
ABBOT POINT PORT Open coastal core port waters outside GBR Marine Park (s1, s2,s3,s4)	**MD**	2–2–4 (s1 port)	1–3–7 (s1 port) QWQG: <3	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet: ≤25 (Nov-Apr) (s3)	50–70–90 (s4)	80–100–125 (s1 port)	1–2–3 (s1 port)	≤2.8 (ann. mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3)	2–6–11 (s4)	10–12–13 (s1 port)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	60–110–320 (s4)	95–105 (s2)	1–2–4 (dry) 1–2–5 (wet) (s1 port)	≥10 (ann. mean) (s3)	1–1–1 (dry) 1–1–2 (wet) (s1 port)	8.1–8.4 (s2)
ABBOT POINT PORT Coastal core port waters in area outside GBR Marine Park; marinas; approved spoil grounds: temperature (s3)	**all**	**Temperature**: increases of no more than 1°C above long-term (20 year) average maximum. (GBRMPA, 2010)															
ABBOT POINT PORT Coastal core port waters in area outside GBR Marine Park; marinas;	**all**	**Toxicants and Pesticides**: WQGs for all pesticides in these waters as per GBRMPA and AWQG water quality guidelines, to protect marine species at the HEV level of protection (except where noted). Pesticides/biocides specified in GBR water quality guidelines include (but not limited to):															

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5]

Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines.

HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed

Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Ammonium N (µg/L)	Oxidised N (µg/L)	Particulate N (µg/L)	Total Dissolved N (µg/L)	Total N (µg/L)	Filterable Reactive P (µg/L)	Particulate P (µg/L)	Total Dissolved P (µg/L)	Total P (µg/L)	Chlorophyll-a (µg/L)	Silicate (µg/L)	Dissolved Oxygen (% saturation)	Turbidity (NTU)	Secchi (m)	Suspended Solids (mg/L)	pH
approved spoil grounds: toxicants (s1, s3, s5, s6)		• Ametryn: <0.5 µg/L; Atrazine: <0.6 µg/L; Diuron: <0.9 µg/L; Hexazinone: <1.2 µg/L; Simazine: <0.2 µg/L; Tebuthiuron: <0.02 µg/L; 2,4-D: <0.8 µg/L ; Tributyltin: <0.006 µg/L (95% species protection) For other toxicants not listed in GBRMPA guidelines, refer to AWQG and sources below: • Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the MD level of protection typically correspond to protection of 95% species (in a small number of cases where bioaccumulation may occur, the AWQG recommends 99% species protection level). • Aluminium: <24 µg/L (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 AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)														
ABBOT POINT PORT Coastal core port waters in area outside GBR Marine Park; marinas; approved spoil grounds: biological (s1, s3)	**all**	**Seagrass** Light requirement is a photosynthetic active radiation (PAR) moving average, as specified below, depending on seagrass species. This requirement is based on the listed species, from work by McKenna et al. (2015) *Initial light thresholds for modelling impacts to seagrass from the Abbot Point growth gateway project.* It does not reflect requirements for macroalgae or other organisms. • Deep water areas (>10m) dominated by *Halophila* species: 1.5 mol m^{-2} day^{-1} over a rolling 7 day average. * • Shallow inshore areas (<10m) dominated by *Halodule uninervis*: 5 mol m^{-2} day^{-1} over a rolling 7 day average (until further data is available) * Note: * These requirements are set as an initial threshold. Ongoing data collection on site is aimed at increasing certainty that these levels are sufficient to maintain seagrass at the desired level. Application of the thresholds should remain flexible to allow additional information from the ongoing data collection on site, or any additional new studies to be incorporated in refinement.														

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5]															
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)														
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Particulate N** (µg/L)	**Total Dissolved N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Particulate P** (µg/L)	**Total Dissolved P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Silicate** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**
ABBOT BAY (waters within GBR Marine Park – outside of core port area) (refer to map Figure 8)																	
ABBOT BAY Lower estuary/ enclosed coastal waters in GBR Marine Park outside core port waters: (s1, s2)	**MD**	≤2 (s1)	≤4 (s1)	na	na	≤90 (s1)	≤1 (s1)	na	na	≤12 (s1)	≤1 (s1)	na	90–100 (s2)	1–3–7 (dry) 2–4–14 (wet) (s1)	≥1.5 (s2)	≤2 (s1)	8–8.4 (s2)
ABBOT BAY Open coastal waters in GBR Marine Park outside core port waters: landward of GBR plume line (s1, s2, s3,s4)	**SMD**	≤1 (s1, s4)	≤1 (s4)	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet: ≤25 (Nov-Apr) (s3)	≤70 (s4)	≤100 (s1, s4)	≤2 (s1, s4)	≤2.8 (ann. mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3)	≤6 (s4)	≤12 (s1, s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	≥110 (s4)	95–105 (s2)	1–2–4 (dry) 1–2–5 (wet) (s1 port)	≥10 (ann. mean) (s3)	1–1–1 (dry) 1–1–2 (wet) (s1 port)	8.1–8.4 (s2)
ABBOT BAY Open coastal waters in GBR Marine Park outside core port waters: seaward of GBR plume line (s1, s2, s3,s4)	**HEV**	0–1–6 (s1, s4)	0–1–2 (s4)	8–13–20 Dry: ≤16 (May-Oct) Wet: ≤25 (Nov-Apr) (s4)	50–70–90 (s4)	65–100–125 (s1, s4)	0–2–4 (s1, s4)	1.5–2.1–3.2 Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	2–6–11 (s4)	8–12–20 (s1, s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	60–110–320 (s4)	95–105 (s2)	1–2–4 (dry) 1–2–5 (wet) (s1)	≥10 (ann. mean) (s3)	0.5–1.2–2.5 Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s1, s3, s4)	8.1–8.3–8.4 (s2)
ABBOT BAY Coastal waters in GBR Marine Park outside core port waters; marinas; approved spoil grounds: temperature (s3)	**all**	**Temperature**: increases of no more than 1°C above long-term (20 year) average maximum. (GBRMPA, 2010)															

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5]															
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)														
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Particulate N** (µg/L)	**Total Dissolved N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Particulate P** (µg/L)	**Total Dissolved P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Silicate** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**
ABBOT BAY Coastal waters in GBR Marine Park outside core port waters; marinas; approved spoil grounds: toxicants (s1, s3, s5, s6)	**all**	**Toxicants and Pesticides**: WQGs for all toxicants and pesticides in these waters (except aluminium – specified below) as per GBRMPA (2010) and ANZECC (2000) water quality guidelines, to protect marine species at the HEV (99% of species protection) level of protection. Where pesticide values are specified in both the GBRMPA and ANZECC guidelines, the lower value will be adopted. Pesticides/biocides specified in GBR water quality guidelines include: • Ametryn: <0.5 µg/L; Atrazine: <0.6 µg/L; Diuron: <0.9 µg/L; Hexazinone: <1.2 µg/L; Simazine: <0.2 µg/L; Tebuthiuron: <0.02 µg/L; 2,4-D: <0.8 µg/L; Tributyltin: <0.0004 µg/L For other toxicants not listed in GBRMPA guidelines, refer to AWQG and sources below: • Toxicants in water: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). • Aluminium: <2.1 µg/L (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 AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)														
ABBOT BAY Coastal waters in GBR Marine Park outside core port waters; marinas; approved spoil grounds: biological (s1, s3)	**all**	**Seagrass**: 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) • 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 from acute water quality impacts. Locally derived absolute thresholds ideally should be obtained for management of specific activities likely to impact on the light environment. Higher light requirements may be needed for the management of longer term chronic impacts.														

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5]															
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)														
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Particulate N** (µg/L)	**Total Dissolved N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Particulate P** (µg/L)	**Total Dissolved P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Silicate** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**
PORT DENISON - BOWEN PORT (core port waters outside GBR Marine Park) (refer to map Figure 8)																	
PORT DENISON Lower estuary/ enclosed coastal core port waters outside GBR Marine Park (s1, s2)	**MD**	≤2 (s1)	≤4 (s1)	na	na	≤90 (s1)	≤1	na	na	≤12 (s1)	≤1 (s1)	na	90–100 (s2)	1–3–7 (dry) 2–4–14 (wet) (s1)	≥1.5 (s2)	≤2 (s1)	8–8.4 (s2)
PORT DENISON Open coastal core port waters outside GBR Marine Park (s1, s2,s3,s4)	**MD**	2–2–4 (s1)	1–3–7 (s1)	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet: ≤25 (Nov-Apr) (s3)	50–70–90 (s4)	80–100–125 (s1)	1–2–3 (s1)	≤2.8 (ann. mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3)	2–6–11 (s4)	10–12–13 (s1)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	60–110–320 (s4)	95–105 (s2)	1–2–4 (dry) 1–2–5 (wet) (s1)	≥10 (ann. mean) (s3)	≤2 (ann. mean) (s3)	8.1–8.4 (s2)
PORT DENISON Coastal core port waters outside GBR Marine Park; marinas; approved spoil grounds: temperature (s3)	**all**	**Temperature**: increases of no more than 1°C above long-term (20 year) average maximum. (GBRMPA, 2010)															

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5]

Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines.

HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed

Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Ammonium N (µg/L)	Oxidised N (µg/L)	Particulate N (µg/L)	Total Dissolved N (µg/L)	Total N (µg/L)	Filterable Reactive P (µg/L)	Particulate P (µg/L)	Total Dissolved P (µg/L)	Total P (µg/L)	Chlorophyll-a (µg/L)	Silicate (µg/L)	Dissolved Oxygen (% saturation)	Turbidity (NTU)	Secchi (m)	Suspended Solids (mg/L)	pH
PORT DENISON Coastal core port waters outside GBR Marine Park; marinas; approved spoil grounds: toxicants (s1, s3, s5, s6)	**all**	**Toxicants and Pesticides**: WQGs for all pesticides in these waters as per GBRMPA and AWQG water quality guidelines, to protect marine species at the HEV level of protection (except where noted). Pesticides/biocides specified in GBR water quality guidelines include (but not limited to): • Ametryn: <0.5 µg/L; Atrazine: <0.6 µg/L; Diuron: <0.9 µg/L; Hexazinone: <1.2 µg/L; Simazine: <0.2 µg/L; Tebuthiuron: <0.02 µg/L; 2,4-D: <0.8 µg/L ; Tributyltin: <0.006 µg/L (95% species protection) For other toxicants not listed in GBRMPA guidelines, refer to AWQG and sources below: • Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the MD level of protection typically correspond to protection of 95% species (in a small number of cases where bioaccumulation may occur, the AWQG recommends 99% species protection level). • Aluminium: <24 µg/L (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 AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)															
PORT DENISON Coastal core port waters outside GBR Marine Park; marinas; approved spoil grounds: biological (s1, s3)	**all**	**Seagrass** Light requirement is a photosynthetic active radiation (PAR) moving average, as specified below, depending on seagrass species. This requirement is based on the listed species, from work by McKenna et al. (2015) *Initial light thresholds for modelling impacts to seagrass from the Abbot Point growth gateway project.* It does not reflect requirements for macroalgae or other organisms. • Deep water areas (>10m) dominated by *Halophila* species: 1.5 mol m^{-2} day^{-1} over a rolling 7 day average. * • Shallow inshore areas (<10m) dominated by *Halodule uninervis*: 5 mol m^{-2} day^{-1} over a rolling 7 day average (until further data is available) * Note: * These requirements are set as an initial threshold. Ongoing data collection on site is aimed at increasing certainty that these levels are sufficient to maintain seagrass at the desired level. Application of the thresholds should remain flexible to allow additional information from the ongoing data collection on site, or any additional new studies to be incorporated in refinement.															

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5]															
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)														
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Particulate N** (µg/L)	**Total Dissolved N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Particulate P** (µg/L)	**Total Dissolved P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Silicate** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**
EDGECUMBE BAY (waters within GBR Marine Park – outside of core port area) (refer to map Figure 8) **MIDSHELF WATERS NEAR HOLBOURNE ISLAND**																	
EDGECUMBE BAY Lower estuary/ enclosed coastal waters in GBR Marine Park outside core port waters (s1, s2)	**SMD**	2–2–5 (s1)	1–4–8 (s1)	–	–	80–90–125 (s1)	1–1–3 (s1)	–	–	10–12–13 (s1)	≤1 (s1)	–	90–100 (s2)	2–4–14 (s1)	≥1.5 (s2)	≤2 (s1)	8–8.4 (s2)
EDGECUMBE BAY SD Open coastal waters in GBR Marine Park outside core port waters (landward of GBR plume line) (s1, s2, s3, s4)	**HEV**	0–1–6 (s1, s4)	0–1–2 (s4)	8–13–20 Dry: ≤16 (May-Oct) Wet: ≤25 (Nov-Apr) (s3, s4)	50–70–90 (s4)	65–100–125 (s1, s4)	0–2–4 (s1, s4)	1.5–2.1–3.2 Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	2–6–11 (s4)	8–12–20 (s1, s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	60–110–320 (s4)	95–105 (s2)	1–2–4 (dry) 1–2–5 (wet) (s1 port)	≥10 (ann. mean) (s3)	0.5–1.2–2.5 Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s1, s3, s4)	8.1–8.3–8.4 (s2)
EDGECUMBE BAY HEV Open coastal waters in GBR Marine Park outside core port waters (seaward of GBR plume line) (s1, s2, s3, s4)	**HEV**	0–1–6 (s1, s4)	0–1–2 (s1, s4)	8–13–20 Dry: ≤16 (May-Oct) Wet: ≤25 (Nov-Apr) (s3, s4)	50–70–90 (s4)	65–100–125 (s1, s4)	0–2–4 (s1, s4)	1.5–2.1–3.2 Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	2–6–11 (s4)	8–12–20 (s1, s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	60–110–320 (s4)	95–105 (s2)	1–2–4 (dry) 1–2–5 (wet) (s1 port)	≥10 (ann. mean) (s3)	0.5–1.2–2.5 Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s1, s3, s4)	8.1–8.3–8.4 (s2)

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5]															
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)														
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Particulate N** (µg/L)	**Total Dissolved N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Particulate P** (µg/L)	**Total Dissolved P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Silicate** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**
MIDSHELF WATERS HEV waters adjacent to Holbourne Island (s2, s4)	**HEV**	0–4–8 (s4)	0–0–1 (s4)	9–14–20 (s4)	40–65–90 (s4)	50–90–110 (s4)	0–1–3 (s4)	1.5–2.0–2.8 (s4)	2–6–10 (s4)	5–10–15 (s4)	0.18–0.33–0.57 (s4)	30–50–120 (s4)	95–105 (s2)	0.4–0.5–0.7 (s4)	7–11–17 (s4)	0.5–0.8–1.6 (s4)	8.1–8.3–8.4 (s2)
EDGECUMBE BAY and MIDSHELF coastal waters in GBR Marine Park outside core port waters; marinas; approved spoil grounds: temperature (s1, s3, s5, s6)	**all**	**Temperature**: increases of no more than 1°C above long-term (20 year) average maximum. (GBRMPA, 2010)															
EDGECUMBE BAY and MIDSHELF coastal waters in GBR Marine Park outside core port waters; marinas; approved spoil grounds: toxicants (s1, s3, s5, s6)	**all**	**Toxicants and Pesticides**: WQGs for all toxicants and pesticides in these waters (except aluminium – specified below) as per GBRMPA (2010) and ANZECC (2000) water quality guidelines, to protect marine species at the HEV (99% of species protection) level of protection. Where pesticide values are specified in both the GBRMPA and ANZECC guidelines, the lower value will be adopted. Pesticides/biocides specified in GBR water quality guidelines include: • Ametryn: <0.5 µg/L; Atrazine: <0.6 µg/L; Diuron: <0.9 µg/L; Hexazinone: <1.2 µg/L; Simazine: <0.2 µg/L; Tebuthiuron: <0.02 µg/L; 2,4-D: <0.8 µg/L; Tributyltin: <0.0004 µg/L For other toxicants not listed in GBRMPA guidelines, refer to AWQG and sources below: • Toxicants in water: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). • Aluminium: <2.1 µg/L (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 AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)														
EDGECUMBE BAY and MIDSHELF coastal waters in GBR Marine Park outside core port waters; marinas;	**all**	**Seagrass – Edgecumbe Bay:** Light requirement is a photosynthetic active radiation (PAR) moving average, as specified below, depending on seagrass species. This requirement is based on the listed species, from work by McKenna et al. (2015) *Initial light thresholds for modelling impacts to seagrass from the Abbot Point growth gateway project.* It does not reflect requirements for macroalgae or other organisms. • Deep water areas (>10m) dominated by *Halophila* species: 1.5 mol m^{-2} day^{-1} over a rolling 7 day average. * • Shallow inshore areas (<10m) dominated by *Halodule uninervis*: 5 mol m^{-2} day^{-1} over a rolling 7 day average (until further data is available) *														

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 1: DON AND HAUGHTON COASTAL AND MARINE WATERS: Water quality guidelines[1–5]

Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines.

HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed

Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)

Ammonium N (µg/L)	Oxidised N (µg/L)	Particulate N (µg/L)	Total Dissolved N (µg/L)	Total N (µg/L)	Filterable Reactive P (µg/L)	Particulate P (µg/L)	Total Dissolved P (µg/L)	Total P (µg/L)	Chlorophyll-a (µg/L)	Silicate (µg/L)	Dissolved Oxygen (% saturation)	Turbidity (NTU)	Secchi (m)	Suspended Solids (mg/L)	pH
approved spoil grounds: biological (s1, s3, s5, s6)		Note: * These requirements are set as an initial threshold. Ongoing data collection on site is aimed at increasing certainty that these levels are sufficient to maintain seagrass at the desired level. Application of the thresholds should remain flexible to allow additional information from the ongoing data collection on site, or any additional new studies to be incorporated in refinement. **Seagrass – Midshelf:** 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) • 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 from acute water quality impacts. Locally derived absolute thresholds ideally should be obtained for management of specific activities likely to impact on the light environment. Higher light requirements may be needed for the management of longer term chronic impacts.														

Abbreviations: id: insufficient data; na: not applicable.

Notes to Tables 1 and 2 (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: 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.

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Table 2 Water quality guidelines for Mackay-Whitsunday region coastal and marine waters

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 2: MACKAY-WHITSUNDAY COASTAL AND MARINE WATERS: Water quality guidelines[1–5]															
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed **Sources:** S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015) **Underline** = new and revised values														
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Particulate N** (µg/L)	**Total Dissolved N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Particulate P** (µg/L)	**Total Dissolved P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Silicate** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**
PROSERPINE COASTAL/MARINE WATERS (NORTH-SOUTH) (refer to map Figure 10)																	
HEV2381 open coastal waters (Whitsundays – south to Thomas island) seaward of Plume line shown in WQ1222) (s3,s4)	**HEV**	0–1–6 (s4)	0–1–2 (s4)	10–14–20 Dry: ≤16 (May-Oct) Wet: ≤24 (Nov-Apr) (s3, s4)	50–70–95 (s4)	75–95–125 (s4)	0–1–3 (s4)	1.6–2.3–3.0 Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	3–6–9 (s4)	8–11–14 (s4)	0.25–0.36–0.54 Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3, s4)	30–50–90 (s4)	95–105 (s2)	0.7–1.1–2.1 (s4)	≥10 (ann. mean) (s3)	0.9–1.4–2.2 Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3, s4)	8.1–8.3–8.4 (s2)
HEV2382 offshore waters (around Circular Quay Reef), shown in WQ1222 (s3,s4)	**HEV**	0–2–6 (s4)	0–1–3 (s4)	11–14–18 Dry: ≤14 (May-Oct) Wet: ≤20 (Nov-Apr) (s3, s4)	45–65–85 (s4)	70–85–120 (s4)	0–1–3 (s4)	1.4–1.8–2.4 Dry: ≤1.6 (May-Oct) Wet: ≤2.3 (Nov-Apr) (s3, s4)	3–5–9 (s4)	6–10–15 (s4)	≤0.4 (ann. mean) Dry: ≤0.24 (May-Oct) Wet: ≤0.56 (Nov-Apr) (s3, s4)	20–35–90 (s4)	95–105 (s2)	≤1 (ann. mean) (s3, s4)	≥17 (ann. mean) (s3)	0.4–0.6–1.1 Dry: ≤0.6 (May-Oct) Wet: ≤0.8 (Nov-Apr) (s3, s4)	8.1–8.3–8.4 (s2)
HEV2383 open coastal waters (southern Cumberland region – south of Thomas Island), seaward of plume line shown in WQ1222 (s3,s4)	**HEV**	1–2–6 (s4)	0–0–1 (s4)	14–18–24 Dry: ≤16 (May-Oct) Wet: ≤24 (Nov-Apr) (s3, s4)	45–75–95 (s4)	55-90-115 (s4)	1–2–4 (s4)	1.6–2.1–3.0 Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	4–9–17 (s4)	6–12–20 (s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	40–60–100 (s4)	95–105 (s2)	≤1 (ann. mean) (s3, s4)	≥10 (ann. mean) (s3)	1.1–1.6–2.4 Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3, s4)	8.1–8.3–8.4 (s2)

Table 2: MACKAY-WHITSUNDAY COASTAL AND MARINE WATERS: Water quality guidelines[1–5]

Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines.

HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed

Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)

Underline = new and revised values

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Ammonium N (µg/L)	Oxidised N (µg/L)	Particulate N (µg/L)	Total Dissolved N (µg/L)	Total N (µg/L)	Filterable Reactive P (µg/L)	Particulate P (µg/L)	Total Dissolved P (µg/L)	Total P (µg/L)	Chlorophyll-a (µg/L)	Silicate (µg/L)	Dissolved Oxygen (% saturation)	Turbidity (NTU)	Secchi (m)	Suspended Solids (mg/L)	pH
SD2381N open coastal waters, landward of the plume line shown in WQ1222 (s3,s4)	**HEV**	0–1–6 (s4)	0–1–2 (s4)	10–14–20 Dry: ≤16 (May-Oct) Wet: ≤24 (Nov-Apr) (s3, s4)	50–70–95 (s4)	75–95–125 (s4)	0–1–3 (s4)	1.6–2.3–3.0 Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	3–6–9 (s4)	8–11–14 (s4)	0.25–0.36–0.54 Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3, s4)	30–50–90 (s4)	95–105 (s2)	0.7–1.1–2.1 (s4)	≥10 (ann. mean) (s3)	0.9–1.4–2.2 Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3, s4)	8.1–8.4 (s2)
SD2381S (Repulse Bay south open coastal waters, landward of the plume line) (s3, s4)	**HEV**	1–2–6 (s4)	0–0–1 (s4)	14–18–24 Dry: ≤16 (May-Oct) Wet: ≤24 (Nov-Apr) (s3, s4)	45–75–95 (s4)	55-90-115 (s4)	1–2–4 (s4)	1.6–2.1–3.0 Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	4–9–17 (s4)	6–12–20 (s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	40–60–100 (s4)	95–105 (s2)	≤2 (ann. mean) (s3, s4)	≥10 (ann. mean) (s3)	1.1–1.6–2.4 Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3, s4)	8.1–8.4 (s2)
Open coastal waters landward of the plume line, shown in WQ1222 Includes OC waters outside of port sub-zones and not identified as SD or HEV (s3, s4)	**SMD, mapped as MD**	≤2 (s4)	≤1 (s4)	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet: ≤24 (Nov-Apr) (s3)	≤75 (s4)	≤90 (s4)	≤2 (s4)	≤2.8 (ann. mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3)	≤9 (s4)	≤12 (s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	≥60 (s4)	95–105 (s2)	≤2 (ann. mean) (s3, s4)	≥10 (ann. mean) (s3)	≤2.0 (ann. mean) Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3)	8.1–8.4 (s2)
Enclosed coastal waters	**MD, SD, HEV**	No changes to existing scheduled values for these indicators. Refer to seagrass and toxicant guidelines below.															

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 2: MACKAY-WHITSUNDAY COASTAL AND MARINE WATERS: Water quality guidelines[1–5]															
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed **Sources:** S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015) **Underline** = new and revised values														
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Particulate N** (µg/L)	**Total Dissolved N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Particulate P** (µg/L)	**Total Dissolved P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Silicate** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**
Marinas, boat harbours – including Abel Point and Hamilton Point marinas, Laguna Quays, Shute harbour	**MD**	No changes to existing scheduled values for these indicators. Refer to seagrass and toxicant guidelines below.															
Coastal waters: temperature (s5)	**all**	**Temperature**: increases of no more than 1°C above long-term (20 year) average maximum. (GBRMPA, 2010)															
Coastal waters outside ports, marinas, approved spoil grounds: toxicants (s1, s3, s5, s6)	**all**	**Toxicants and Pesticides**: WQGs for all toxicants and pesticides in these waters (except aluminium – specified below) as per GBRMPA (2010) and ANZECC (2000) water quality guidelines, to protect marine species at the HEV (99% of species protection) level of protection. Where pesticide values are specified in both the GBRMPA and ANZECC guidelines, the lower value will be adopted. Pesticides/biocides specified in GBR water quality guidelines include: • Ametryn: <0.5 µg/L; Atrazine: <0.6 µg/L; Diuron: <0.9 µg/L; Hexazinone: <1.2 µg/L; Simazine: <0.2 µg/L; Tebuthiuron: <0.02 µg/L; 2,4-D: <0.8 µg/L; Tributyltin: <0.0004 µg/L For other toxicants not listed in GBRMPA guidelines, refer to AWQG and sources below: • Toxicants in water: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). • Aluminium: <2.1 µg/L (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 AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)														

Table 2: MACKAY-WHITSUNDAY COASTAL AND MARINE WATERS: Water quality guidelines[1–5]

Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines.

HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed

Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)

Underline = new and revised values

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Ammonium N (µg/L)	Oxidised N (µg/L)	Particulate N (µg/L)	Total Dissolved N (µg/L)	Total N (µg/L)	Filterable Reactive P (µg/L)	Particulate P (µg/L)	Total Dissolved P (µg/L)	Total P (µg/L)	Chlorophyll-a (µg/L)	Silicate (µg/L)	Dissolved Oxygen (% saturation)	Turbidity (NTU)	Secchi (m)	Suspended Solids (mg/L)	pH
Coastal waters in ports, marinas, approved spoil grounds (outside GBR Marine Park): toxicants (s3, s5, s6)	**all**	**Toxicants and Pesticides**: WQGs for all pesticides in these waters as per GBRMPA and AWQG water quality guidelines, to protect marine species at the HEV level of protection (except where noted). Pesticides/biocides specified in GBR water quality guidelines include (but not limited to): • Ametryn: <0.5 µg/L; Atrazine: <0.6 µg/L; Diuron: <0.9 µg/L; Hexazinone: <1.2 µg/L; Simazine: <0.2 µg/L; Tebuthiuron: <0.02 µg/L; 2,4-D: <0.8 µg/L ; Tributyltin: <0.006 µg/L (95% species protection) For other toxicants not listed in GBRMPA guidelines, refer to AWQG and sources below: • Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the MD level of protection typically correspond to protection of 95% species (in a small number of cases where bioaccumulation may occur, the AWQG recommends 99% species protection level). • Aluminium: <24 µg/L (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 AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)															
Coastal waters: biological (s1, s3)	**all**	**Seagrass**: 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) • 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 from acute water quality impacts. Locally derived absolute thresholds ideally should be obtained for management of specific activities likely to impact on the light environment. Higher light requirements may be needed for the management of longer term chronic impacts.															

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 2: MACKAY-WHITSUNDAY COASTAL AND MARINE WATERS: Water quality guidelines[1–5]															
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed **Sources:** S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015) **Underline** = new and revised values														
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Particulate N** (µg/L)	**Total Dissolved N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Particulate P** (µg/L)	**Total Dissolved P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Silicate** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**
MACKAY and HAY POINT PORTS (NORTH-SOUTH) (refer to map Figure 10)																	
Ports: MD2341: Mackay Port enclosed coastal waters	**MD**	No changes to existing scheduled values for these indicators. Refer to seagrass and toxicant guidelines below.															
Ports: MD2341: Mackay Port open coastal waters (including approved dredge spoil grounds)	**MD**	id	id	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet: ≤24 (Nov-Apr) (s3)	id	id	id	≤2.8 (ann. mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3)	id	id	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	id	95–105 (s2)	Dry: 1–2–8 Wet: 5–12–33 (s1 port)	≥10 (ann. mean) (s3)	≤2.0 (ann. mean) Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3)	8.1–8.4 (s2)
Ports: MD2342 Sandringham Bay sub-zone enclosed coastal waters	**MD**	No changes to existing scheduled values for these indicators. Refer to seagrass and toxicant guidelines below.															
Ports: MD2343 Hay Point sub-zone enclosed coastal waters	**MD**	No changes to existing scheduled values for these indicators. Refer to seagrass and toxicant guidelines below.															

Table 2: MACKAY-WHITSUNDAY COASTAL AND MARINE WATERS: Water quality guidelines[1–5]

Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines.

HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed

Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)

Underline = new and revised values

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Ammonium N (µg/L)	Oxidised N (µg/L)	Particulate N (µg/L)	Total Dissolved N (µg/L)	Total N (µg/L)	Filterable Reactive P (µg/L)	Particulate P (µg/L)	Total Dissolved P (µg/L)	Total P (µg/L)	Chlorophyll-a (µg/L)	Silicate (µg/L)	Dissolved Oxygen (% saturation)	Turbidity (NTU)	Secchi (m)	Suspended Solids (mg/L)	pH
Ports: MD2343 Hay Point sub-zone open coastal waters (including approved dredge spoil grounds)	**MD**	id	id	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet: ≤24 (Nov-Apr) (s3)	id	id	id	≤2.8 (ann. mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3)	id	id	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	id	95–105 (s2)	Dry: 1–2–8 Wet: 5–12–33 (s1 port)	≥10 (ann. mean) (s3)	≤2.0 (ann. mean) Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3)	8.1–8.4 (s2)
Coastal waters in ports MD2341, MD2342, MD2343, marinas, approved spoil grounds: temperature (s3)	**all**	**Temperature**: increases of no more than 1°C above long-term (20 year) average maximum. (GBRMPA, 2010)															
Coastal waters in ports MD2341, MD2342, MD2343, marinas, approved spoil grounds (s1, s3, s5, s6)	**all**	**Toxicants and Pesticides**: WQGs for all pesticides in these waters as per GBRMPA and AWQG water quality guidelines, to protect marine species at the HEV level of protection (except where noted). Pesticides/biocides specified in GBR water quality guidelines include (but not limited to): • Ametryn: <0.5 µg/L; Atrazine: <0.6 µg/L; Diuron: <0.9 µg/L; Hexazinone: <1.2 µg/L; Simazine: <0.2 µg/L; Tebuthiuron: <0.02 µg/L; 2,4-D: <0.8 µg/L ; Tributyltin: <0.006 µg/L (95% species protection) For other toxicants not listed in GBRMPA guidelines, refer to AWQG and sources below: • Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the MD level of protection typically correspond to protection of 95% species (in a small number of cases where bioaccumulation may occur, the AWQG recommends 99% species protection level). • Aluminium: <24 µg/L (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 AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)															

Table 2: MACKAY-WHITSUNDAY COASTAL AND MARINE WATERS: Water quality guidelines[1–5]

Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines.

HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed

Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)

Underline = new and revised values

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Ammonium N (µg/L)	Oxidised N (µg/L)	Particulate N (µg/L)	Total Dissolved N (µg/L)	Total N (µg/L)	Filterable Reactive P (µg/L)	Particulate P (µg/L)	Total Dissolved P (µg/L)	Total P (µg/L)	Chlorophyll-a (µg/L)	Silicate (µg/L)	Dissolved Oxygen (% saturation)	Turbidity (NTU)	Secchi (m)	Suspended Solids (mg/L)	pH
Coastal waters in ports MD2341, MD2342, MD2343, marinas, approved spoil grounds (s1, s3)	**all**	**Seagrass**: 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) • 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 from acute water quality impacts. Locally derived absolute thresholds ideally should be obtained for management of specific activities likely to impact on the light environment. Higher light requirements may be needed for the management of longer term chronic impacts.															

Table 2: MACKAY-WHITSUNDAY COASTAL AND MARINE WATERS: Water quality guidelines[1–5]

Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines.

HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed

Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)

Underline = new and revised values

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Ammonium N (µg/L)	Oxidised N (µg/L)	Particulate N (µg/L)	Total Dissolved N (µg/L)	Total N (µg/L)	Filterable Reactive P (µg/L)	Particulate P (µg/L)	Total Dissolved P (µg/L)	Total P (µg/L)	Chlorophyll-a (µg/L)	Silicate (µg/L)	Dissolved Oxygen (% saturation)	Turbidity (NTU)	Secchi (m)	Suspended Solids (mg/L)	pH
PIONEER COASTAL/MARINE WATERS OUTSIDE PORTS (NORTH-SOUTH) (refer to map Figure 10)																	
HEV2383 open coastal waters seaward of plume line shown in WQ1222 (s3,s4)	**HEV**	1–2–6 (s4)	0–0–1 (s4)	14–18–24 Dry: ≤16 (May-Oct) Wet: ≤24 (Nov-Apr) (s3, s4)	45–75–95 (s4)	55-90-115 (s4)	1–2–4 (s4)	1.6–2.1–3.0 Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, 4)	4–9–17 (s4)	6–12–20 (s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	40–60–100 (s4)	95–105 (s2)	≤1 (ann. mean) (s3, s4)	≥10 (ann. mean) (s3)	1.1–1.6–2.4 Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3, s4)	8.1–8.3–8.4 (s2)
HEV2386 midshelf waters (Tern, Bushy-Redbill and Sandpiper reefs) (s3,s4)	**HEV**	0–2–6 (s4)	0–1–2 (s4)	11–15–20 Dry: ≤16 (May-Oct) Wet: ≤24 (Nov-Apr) (s3, s4)	50–65–90 (s4)	70–85–115 (s4)	0–1–3 (s4)	1.4–2.0–2.8 Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3, s4)	3–5–9 (s4)	6–10–15 (s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	25–40–90 (s4)	95–105 (s2)	≤1 (ann. mean) (s3, s4)	11–13–17 (s4)	0.6–1.1–1.7 Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3, s4)	8.1–8.3–8.4 (s2)
SD2382 open coastal waters, landward of the plume line, shown in WQ1222 (s3)	**HEV**	id	id	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet: ≤24 (Nov-Apr) (s3)	id	id	id	≤2.8 (ann. mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3)	id	id	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	id	95–105 (s2)	≤2 (ann. mean) (s3, s4)	≥10 (ann. mean) (s3)	≤2.0 (ann. mean) Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3)	8.1–8.4 (s2)

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Table 2: MACKAY-WHITSUNDAY COASTAL AND MARINE WATERS: Water quality guidelines[1–5] **Note:** WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed **Sources:** S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015) **Underline** = new and revised values																
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Particulate N** (µg/L)	**Total Dissolved N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Particulate P** (µg/L)	**Total Dissolved P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Silicate** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**
SD2383 and SD2384 open coastal waters (including macro tidal) in areas landward of the plume line, shown in WQ1222 **(note: these link to SD2421 Broadsound waters to the south –refer Styx schedule document/plan) (s3,s4)**	**HEV**	1–2–6 (s4)	0–0–1 (s4)	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet: ≤24 (Nov-Apr) (s3)	45–75–95 (s4)	55-90-115 (s4)	1–2–4 (s4)	≤2.8 (ann.mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3)	4–9–17 (s4)	6–12–20 (s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	40–60–100 (s4)	95–105 (s2)	id	≥8 (ann. mean) (s3)	≤2.4 (ann.mean) Dry: ≤1.9 (May-Oct) Wet: ≤2.9 (Nov-Apr) (s3)	8.1–8.3–8.4 (s2)
Open coastal waters landward of the plume line, shown in WQ1222 Includes OC waters outside of port sub-zones and not identified as SD or HEV (s1,s3, s4)	**SMD, mapped as MD**	≤2 (s4)	≤1 (s4)	≤20 (ann. mean) Dry: ≤16 (May-Oct) Wet: ≤24 (Nov-Apr) (s3)	≤75 (s4)	≤90 (s4)	≤2 (s4)	≤2.8 (ann. mean) Dry: ≤2.3 (May-Oct) Wet: ≤3.3 (Nov-Apr) (s3)	≤9 (s4)	≤12 (s4)	≤0.45 (ann. mean) Dry: ≤0.32 (May-Oct) Wet: ≤0.63 (Nov-Apr) (s3)	≥60 (s4)	95–105 (s2)	Between port sub-zones and south of Hay Point to lat 21° 27′ south Dry: 0.5–1–4 (s1) Other areas: ≤2 (ann. mean) (s1, s3,	≥10 (ann. mean) (s3)	≤2.0 (ann. mean) Dry: ≤1.6 (May-Oct) Wet: ≤2.4 (Nov-Apr) (s3)	8.1–8.4 (s2)

Table 2: MACKAY-WHITSUNDAY COASTAL AND MARINE WATERS: Water quality guidelines[1–5]

Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines.

HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed

Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)

Underline = new and revised values

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Ammonium N (µg/L)	Oxidised N (µg/L)	Particulate N (µg/L)	Total Dissolved N (µg/L)	Total N (µg/L)	Filterable Reactive P (µg/L)	Particulate P (µg/L)	Total Dissolved P (µg/L)	Total P (µg/L)	Chlorophyll-a (µg/L)	Silicate (µg/L)	Dissolved Oxygen (% saturation)	Turbidity (NTU)	Secchi (m)	Suspended Solids (mg/L)	pH
														s4)			
Enclosed coastal waters in SD2384 (note: these link to SD2421 Broadsound waters to the south –refer Styx schedule document/plan)	**HEV**	2–3–8	2–2–3	na	na	100–130–200	2–2–6	na	na	6–9–20	0.5–1.0–2.0	na	90–95–100	id	id	id	8.0–8.4 (s2)
Enclosed coastal waters (where not specified above)	**MD, SD, HEV**	No changes to existing scheduled values for these indicators. Refer to seagrass and toxicant guidelines below.															
Coastal waters outside ports, marinas, approved spoil grounds: temperature (s3)	**all**	**Temperature**: increases of no more than 1°C above long-term (20 year) average maximum. (GBRMPA, 2010)															
Coastal waters outside ports, marinas, approved spoil grounds: toxicants (s1, s3, s5, s6)	**all**	**Toxicants and Pesticides**: WQGs for all toxicants and pesticides in these waters (except aluminium – specified below) as per GBRMPA (2010) and ANZECC (2000) water quality guidelines, to protect marine species at the HEV (99% of species protection) level of protection. Where pesticide values are specified in both the GBRMPA and ANZECC guidelines, the lower value will be adopted. Pesticides/biocides specified in GBR water quality guidelines include: • Ametryn: <0.5 µg/L; Atrazine: <0.6 µg/L; Diuron: <0.9 µg/L; Hexazinone: <1.2 µg/L; Simazine: <0.2 µg/L; Tebuthiuron: <0.02 µg/L; 2,4-D: <0.8 µg/L; Tributyltin: <0.0004 µg/L For other toxicants not listed in GBRMPA guidelines, refer to AWQG and sources below: • Toxicants in water: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). • Aluminium: <2.1 µg/L (applies to the measured concentration in seawater that passes through a 0.45 µm filter) [Source: Golding et al. (2015)]															

Table 2: MACKAY-WHITSUNDAY COASTAL AND MARINE WATERS: Water quality guidelines[1–5]

Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines.

HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed

Sources: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG; s6: CSIRO aluminium studies (Golding et al., 2015)

Underline = new and revised values

Water area/type (Sources: s1–s6)	Management intent /Level of protection	Ammonium N (µg/L)	Oxidised N (µg/L)	Particulate N (µg/L)	Total Dissolved N (µg/L)	Total N (µg/L)	Filterable Reactive P (µg/L)	Particulate P (µg/L)	Total Dissolved P (µg/L)	Total P (µg/L)	Chlorophyll-a (µg/L)	Silicate (µg/L)	Dissolved Oxygen (% saturation)	Turbidity (NTU)	Secchi (m)	Suspended Solids (mg/L)	pH
		• Toxicants in sediments: refer to AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)															
Coastal waters outside ports, marinas, approved spoil grounds: biological (s1, s3)	**all**	**Seagrass**: 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) • 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 from acute water quality impacts. Locally derived absolute thresholds ideally should be obtained for management of specific activities likely to impact on the light environment. Higher light requirements may be needed for the management of longer term chronic impacts.														

Abbreviations: id: insufficient data; na: not applicable

Notes, references: refer notes and references after Table 1.

Table 3 Water quality guidelines for fresh and estuarine waters of the Don and Haughton river basins

Water area/type (Sources: s1–s4)	Management intent /Level of protection	**Table 3: DON AND HAUGHTON RIVER BASINS - Fresh and estuarine waters: Water quality guidelines [1–3]** **Note:** WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed **Sources**: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: Best available reference condition data; S4: ANZECC (2000) AWQG											
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**	**Conductivity** (µS/cm)
DON RIVER BASIN (refer to map Figure 3)													
Sub-basin: UPSTART BAY CATCHMENTS													
Mid estuarine waters of Upstart Bay catchments (e.g. national park)	**HEV**	Insufficient data. Refer to QWQG for details on how to establish local WQGs.											
Mid estuarine waters of Upstart Bay catchments (s3, s2)	**MD**	4–7–10 (s3)	5–6–8 (s3)	250–260–400 (s3)	13–17–30 (s3)	25–35–40 (s3)	0.8–1.0–1.5 (s3)	85–100 (s2)	3–4–5 (s3)	1.4–1.5–1.6 (s3)	id	7–8.4 (s2)	na
Lowland freshwaters of Upstart Bay catchments (e.g. national park)	**HEV**	Insufficient data. Refer to QWQG for details on how to establish local WQGs.								na			
Lowland freshwaters of Upstart Bay catchments (s1, s2)	**MD**	2–3–8 (s1)	5–22–46 (s1)	240–350–625 (s1)	20–35–60 (s1)	40–60–100 (s1)	<5 (s2)	85–110 (s2)	2–4–7 (s1)	na	5–6–13 (s1)	6.5–8.0 (s2)	290–490–1020 (s1)
Upland freshwaters of Upstart Bay catchments (e.g. national park)	**HEV**	Insufficient data. Refer to QWQG for details on how to establish local WQGs								na			

Water area/type (Sources: s1–s4)	Management intent /Level of protection	Table 3: DON AND HAUGHTON RIVER BASINS - Fresh and estuarine waters: Water quality guidelines [1–3]											
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed **Sources**: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: Best available reference condition data; S4: ANZECC (2000) AWQG											
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**	**Conductivity** (µS/cm)
Upland freshwaters of Upstart Bay catchments (s2)	**MD**	<10	<15	<250	<15	<30	na	90–110	<25	na	id	6.5–7.5	<680
Sub-basin: ABBOT BAY CATCHMENTS (including State Development Area)													
Mid estuarine waters of Abbot Bay catchments (e.g. national park)	**HEV**	Insufficient data. Refer to QWQG for details on how to establish local WQGs.											
Mid estuarine waters of Abbot Bay catchments (s3, s2)	**MD**	4–7–10 (s3)	5–6–8 (s3)	250–260–400 (s3)	13–17–30 (s3)	25–35–40 (s3)	0.8–1.0–1.5 (s3)	85–100 (s2)	3–4–5 (s3)	1.4–1.5–1.6 (s3)	id	7–8.4 (s2)	na
Lowland freshwaters of Abbot Bay catchments	**HEV**	Insufficient data. Refer to QWQG for details on how to establish local WQGs.								na			
Lowland freshwaters of Abbot Bay catchments (s1, s2)	**MD**	2–3–8 (s1)	5–22–46 (s1)	240–350–625 (s1)	20–35–60 (s1)	40–60–100 (s1)	<5 (s2)	85–110 (s2)	2–4–7 (s1)	na	5–6–13 (s1)	6.5–8.0 (s2)	290–490–1020 (s1)

Water area/type (Sources: s1–s4)	Management intent /Level of protection	Table 3: DON AND HAUGHTON RIVER BASINS - Fresh and estuarine waters: Water quality guidelines [1–3]											
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed **Sources**: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: Best available reference condition data; S4: ANZECC (2000) AWQG											
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**	**Conductivity** (µS/cm)
Upland freshwaters of Abbot Bay catchments (e.g. national park)	**HEV**	Insufficient data. Refer to QWQG for details on how to establish local WQGs								na			
Upland freshwaters of Abbot Bay catchments (s2)	**MD**	<10	<15	<250	<15	<30	na	90–110	<25	na	-	6.5–7.5	<680
Sub-basin: DON RIVER CATCHMENT													
Mid estuarine waters of Don River catchment (s3, s2)	**MD**	4–7–10 (s3)	5–6–8 (s3)	250–260–400 (s3)	13–17–30 (s3)	25–35–40 (s3)	0.8–1.0–1.5 (s3)	85–100 (s2)	3–4–5 (s3)	1.4–1.5–1.6 (s3)	id	7–8.4 (s2)	na
Lowland freshwaters of Don River (s1, s2)	**MD**	3–5–19	16–25–64	165–200–295	35–45–70	80–100–135	<5 (s2)	85–110 (s2)	1–2–5	na	4–5–10	6.5–8.0 (s2)	405–590–840
Upland freshwaters of Abbot Bay catchments (s2)	**MD**	<10	<15	<250	<15	<30	na	90–110	<25	na	-	6.5–7.5	<680

Water area/type (Sources: s1–s4)	Management intent /Level of protection	Table 3: DON AND HAUGHTON RIVER BASINS - Fresh and estuarine waters: Water quality guidelines [1–3]											
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed **Sources**: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: Best available reference condition data; S4: ANZECC (2000) AWQG											
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**	**Conductivity** (µS/cm)
HAUGHTON RIVER BASIN (refer to map Figure 6)													
Sub-basin: HAUGHTON RIVER CATCHMENT													
Mid estuarine waters of Haughton River catchments (e.g. national park)	**HEV**	Insufficient data. Refer to QWQG for details on how to establish local WQGs.											
Mid estuarine waters of Haughton River catchment (s2)	**MD**	<10	<10	<300	<8	<25	<4.0	85–100	<8	>1	<20	7.0–8.4	na
Lowland freshwaters of Haughton River catchment (e.g. national park)	**HEV**	Insufficient data. Refer to QWQG for details on how to establish local WQGs.								na			
Lowland fresh waters of Haughton River catchment (s1, s2)	**MD**	3–5–8 (s1)	3–6–18 (s1)	159–228–303 (s1)	8–10–13 (s1)	22–28–34 (s1)	<5 (s2).	85–110 (s2)	4–7–18 (s1)	na	5.0–8.0–16.1 (s1)	6.5–8.0 (s2)	127–176–237 (s1)

Water area/type (Sources: s1–s4)	Management intent /Level of protection	Table 3: DON AND HAUGHTON RIVER BASINS - Fresh and estuarine waters: Water quality guidelines [1–3]											
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed **Sources**: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: Best available reference condition data; S4: ANZECC (2000) AWQG											
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**	**Conductivity** (µS/cm)
Upland fresh waters of Haughton River catchment (e.g. national park)	**HEV**	Insufficient data. Refer to QWQG for details on how to establish local WQGs.								na			
Upland freshwaters of Haughton River catchments (s2)	**MD**	<10	<15	<250	<15	<30	na	90–110	<25	na	id	6.5–7.5	<270
Sub-basin: BARRATTA CREEK CATCHMENT													
Mid estuarine waters of Barratta Creek catchment (e.g. national park)	**HEV**	Insufficient data. Refer to QWQG for details on how to establish local WQGs.											
Mid estuarine waters of the Barratta Creek catchment (s2)	**MD**	<10	<10	<300	<8	<25	<4.0	85–100	<8	>1	<20	7.0–8.4	na
Lowland freshwaters of Barratta Creek catchment	**HEV**	Insufficient data. Refer to QWQG for details on how to establish local WQGs.								na			
Lowland fresh waters of Barratta Creek catchment (s1, s2)	**MD**	10–16–27 (s1)	15–90–240 (s1)	370-540-900 (s1)	10–20–30 (s1)	27–55–85 (s1)	<5 (s2)	85–110 (s2)	10–35–70 (s1)	na	4–10–24 (s1)	6.5–8.0 (s2)	170–240–320 (s1)

Water area/type (Sources: s1–s4)	Management intent /Level of protection	Table 3: DON AND HAUGHTON RIVER BASINS - Fresh and estuarine waters: Water quality guidelines [1–3]											
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed **Sources**: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: Best available reference condition data; S4: ANZECC (2000) AWQG											
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**	**Conductivity** (µS/cm)
Upland freshwaters of Barratta Creek catchments (s2)	**MD**	<10	<15	<250	<15	<30	na	90–110	<25	na	id	6.5–7.5	<270
Sub-basin: BURDEKIN DELTA													
Mid estuarine waters of Burdekin Delta catchment	**HEV**	Insufficient data. Refer to QWQG for details on how to establish local WQGs.											
Mid estuarine waters of the Burdekin Delta catchment (s2)	**MD**	<10	<10	<300	<8	<25	<4.0	85–100	<8	>1	<20	7.0–8.4	na
Lowland freshwaters of Burdekin Delta catchment (e.g. national park)	**HEV**	Insufficient data. Refer to QWQG for details on how to establish local WQGs.								na			
Lowland fresh waters of Burdekin Delta catchment (s1, s2)	**MD**	10–16–27 (s1)	15–90–240 (s1)	370-540-900 (s1)	10–20–30 (s1)	27–55–85 (s1)	<5 (s2)	85–110 (s2)	10–35–70 (s1)	na	4–10–24 (s1)	6.5–8.0 (s2)	170–240–320 (s1)

Water area/type (Sources: s1–s4)	Management intent /Level of protection	Table 3: DON AND HAUGHTON RIVER BASINS - Fresh and estuarine waters: Water quality guidelines [1–3]											
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed **Sources**: S1: Local datasets (e.g. DSITI, key stakeholder); S2: QWQG guidelines and /or data; S3: Best available reference condition data; S4: ANZECC (2000) AWQG											
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**	**Conductivity** (µS/cm)
Lakes, reservoirs (s2)	**MD**	10	10	350	5	10	5	90–110	1–20	nd	nd	6.5–8.0	Refer QWQG Appendix G
Fresh waters: Toxicants (s4)	**HEV and SD**	WQGs for all toxicants and pesticides in these waters as per ANZECC AWQG, to protect species at the HEV level of protection. • Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the HEV level of protection typically correspond to protection of 99% of species. • Toxicants in sediments: refer to AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)											
Fresh waters: Toxicants (s4)	**MD**	WQGs for all toxicants and pesticides in these waters as per ANZECC AWQG, to protect species at the MD level of protection (except where noted). • Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the MD level of protection typically correspond to protection of 95% species (in a small number of cases where bioaccumulation may occur, the AWQG recommends 99% species protection level). • Toxicants in sediments: refer to AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)											
Fresh waters: Temperature (s2)	**all**	Temperature varies daily and seasonally, is depth-dependent and highly site specific. Refer to QWQG for details on how to establish a range (20^{th} – 80^{th} percentiles) of temperature. From an ecological effects perspective, daily maximum temperature and daily variation in temperature are key indicators, and seasonal variations also need to be identified.											
		STATE PLANNING POLICY, RIPARIAN, WETLANDS, GROUNDWATERS											
State Planning Policy	**all**	Refer to section 5.5											
Riparian	**all**	Refer to section 5.5											
Wetlands, mangroves	**all**	Refer to section 5.5. Mangroves: No loss of mangrove area. DEHP/ Queensland Herbarium conducts biennial mapping of mangrove cover and this could be used as an assessment tool. Note: there is insufficient information available to establish local guidelines for wetlands. Refer to QWQG for details on how to establish a minimum water quality data set for deriving local 20th, 50th and 80th percentiles. In the absence of local information, the AWQG provides default values for wetlands.											
Groundwaters	**HEV**	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. Where groundwaters interact with surface waters, groundwater quality should not compromise identified EVs and WQGs for those waters.											

Abbreviations: id: insufficient data; na: not applicable.

Notes to Table 3:

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 and tidal estuarine 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.

References:

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Australian Government (2013) *Anti-fouling and in-water cleaning guidelines* (June 2013), Department of Agriculture, Fisheries and Forestry, Canberra.

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

Table 4 Water quality guidelines for estuarine waters of the Mackay-Whitsunday region

Water area/type (Sources: s1–s4)	Management intent /Level of Protection	Table 4: MACKAY-WHITSUNDAY MID ESTUARINE WATERS: Water quality guidelines [1–5]											
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed **Sources:** S2: QWQG guidelines and /or data; S3: data collected by DSITI from Gregory River mid estuarine reaches. Data collection is ongoing and these WQGs will be updated as more data becomes available; S4: ANZECC (2000) AWQG; s5: DSITI data from Gregory River, adjusted with data from Rocky Dam and Carmila creeks										
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**	**Conductivity** (µS/cm)
MACKAY-WHITSUNDAY MID ESTUARINE WATERS (refer to map Figure 10)													
Mid estuarine waters of Mackay Whitsunday	**HEV**	Insufficient data. Refer to QWQG for details on how to establish local WQOs.											
SD Mid estuarine waters of Mackay Whitsunday (e.g. fish habitat areas) (s2, s3)	**HEV**	2–4–9 (s3)	4–6–7 (s3)	180–250–355 (s3)	11–13–28 (s3)	19–24–40 (s3)	0.4–0.8–1.2 (s3)	70–100 (s3)	3–4–5 (s3)	1.4–1.5–1.6 (30-60-80 percentiles) (s3)	id	7–8.4 (s2)	na
Mid estuarine waters (moderate tidal estuaries from Mackay north) [4] (s2,s3,s5)	**MD**	<10 (s3)	<8 (s3)	<400 (s3)	<30 (s3)	<40 (s3)	<2 (s3)	70–105 (s5)	<10 (s3)	>1.5m (s3)	id	7–8.4 (s2)	na
Mid estuarine waters (macro-tidal estuaries south of Mackay) [5] (s2,s3,s5)	**MD**	<10 (s3)	<8 (s3)	<400 (s3)	<60 (s5)	<130 (s5)	<5 (s5)	70–105 (s5)	Too variable to derive guideline	Too variable to derive guideline	id	7–8.4 (s2)	na
Temperature	**all**	Temperature varies daily and seasonally, is depth-dependent and highly site specific. Refer to QWQG for details on how to establish a range (20^{th} – 80^{th} percentiles) of temperature. From an ecological effects perspective, daily maximum temperature and daily variation in temperature are key indicators, and seasonal variations also need to be identified.											
Toxicants	**all**	WQGs for all toxicants and pesticides in these waters as per ANZECC AWQG: • Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). • Toxicants in sediments: refer to AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)											

Water area/type (Sources: s1–s4)	Management intent /Level of Protection	Table 4: MACKAY-WHITSUNDAY MID ESTUARINE WATERS: Water quality guidelines [1–5]											
		Note: WQGs for indicators are shown as a range of 20-50-80 percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value to be achieved by median of test data (e.g. <15). See Section 5.2 for details on applying guidelines. HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed **Sources:** S2: QWQG guidelines and /or data; S3: data collected by DSITI from Gregory River mid estuarine reaches. Data collection is ongoing and these WQGs will be updated as more data becomes available; S4: ANZECC (2000) AWQG; s5: DSITI data from Gregory River, adjusted with data from Rocky Dam and Carmila creeks										
		Ammonium N (µg/L)	**Oxidised N** (µg/L)	**Total N** (µg/L)	**Filterable Reactive P** (µg/L)	**Total P** (µg/L)	**Chlorophyll-a** (µg/L)	**Dissolved Oxygen** (% saturation)	**Turbidity** (NTU)	**Secchi** (m)	**Suspended Solids** (mg/L)	**pH**	**Conductivity** (µS/cm)
		STATE PLANNING POLICY, RIPARIAN, WETLANDS, GROUNDWATERS											
State Planning Policy	**all**	Refer to section 5.5											
Riparian	**all**	Refer to Section 5.5											
Wetlands, mangroves	**all**	Refer to section 5.5. Mangroves: No loss of mangrove area. DEHP/ Queensland Herbarium conducts biennial mapping of mangrove cover and this could be used as an assessment tool. Note: there is insufficient information available to establish local guidelines for wetlands. Refer to QWQG for details on how to establish a minimum water quality data set for deriving local 20th, 50th and 80th percentiles. In the absence of local information, the AWQG provides default values for wetlands.											
Groundwaters	**HEV**	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. Where groundwaters interact with surface waters, groundwater quality should not compromise identified EVs and WQGs for those waters.											

Abbreviations: id: insufficient data; na: not applicable.

Notes:

1-3: As applicable from Table 3.

4. MD mid estuarine waters from Mackay north include MD reaches of Pioneer River, Proserpine River, O'Connell River, Murray estuaries.

5. MD mid estuarine waters south of Mackay include MD reaches of Sandy, Plane, Rocky Dam, Carmilla Creek estuaries. Note that local WQOs were scheduled for Cabbage Tree and Louisa Creek sub-catchments (TSS, Copper), and no change is proposed to them.

5.5 Planning and management links

5.5.1 Riparian vegetation

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, refer to the Department of Infrastructure Local Government and Planning website http://www.dilgp.qld.gov.au/planning/development-assessment/state-development-assessment-provisions.html .
- 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), view the Department of Natural Resources and Mines website. https://www.dnrm.qld.gov.au/

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

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

5.5.2 Wetlands

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.

5.5.3 Marine plants (including mangroves)

Marine plants grow on or adjacent to tidal lands. They include mangroves, seagrass, saltcouch, algae, samphire (succulent) vegetation and adjacent plants, such as melaleuca (paper barks) and casuarina (coastal she-oaks).

Marine plants support local fish populations, fish catches and general aquatic health, and for this reason they are protected under the Fisheries Act 1994. The destruction, damage or disturbance of marine plants without prior approval from Fisheries Queensland is prohibited.

Activities that disturb fish habitats may require fisheries development approval under the Sustainable Planning Act 2009 (SPA). A resource allocation authority (a form of resource entitlement) may also be required under the Fisheries Act 1994. The Department of Agriculture and Fisheries website contains further information on approvals, self-assessable codes and other aspects relating to marine plants. Refer to link below for more details.
https://www.daf.qld.gov.au/fisheries/habitats/fisheries-development/approvals-required

5.5.4 State Planning Policy (state interest – water quality)

Note: As part of Queensland's planning reform process, the new Planning Act 2016 is planned to commence in July 2017. The State Planning Policy (SPP) and State Development Assessment Procedures (SDAP) modules are currently being updated. Please refer to the DILGP website for the most current information http://dilgp.qld.gov.au/planning-reform.html

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 receiving waters, acid sulfate soils and water supply buffer areas.

The provisions of the SPP are operationalised through their 'integration' into local government planning schemes. Planning schemes adopt measures prescribed in the SPP including the SPP code – water quality (Appendix 3 of the SPP) or alternative measures considered more locally appropriate. 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 for the construction phase (Table A of the code) and the post-construction phase of development (Table B). The stormwater quality design objectives for the post-construction phase include minimum percentage pollution load reductions (compared with unmitigated development) for key pollutants by climatic region.

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 Department of Infrastructure Local Government and Planning website
http://www.dilgp.qld.gov.au/planning/state-planning-instruments/state-planning-policy.html

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 Department of Infrastructure Local Government and Planning website http://www.dilgp.qld.gov.au/planning/state-planning-instruments/state-planning-policy.html .

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7 Appendix 1 Marine Water Quality Guidelines

This appendix provides further information pertaining to marine water data sets, marine water type classification and derivation of guidelines for different water types and sub-regions. The general approach has been to use locally applicable data, where available, as a basis for deriving WQGs for marine water sub-regions. In the absence of local data, or where local data fail to meet relevant ecosystem protection thresholds expressed in the Water Quality Guidelines for the Great Barrier Reef Marine Park (GBRMPA 2010), the WQGs default back to the values in the GBRMPA guidelines.

7.1 Water types and water type sub-regions

Water types in the planning area include enclosed coastal, open coastal, midshelf and offshore waters. Water type delineations are based on refined mapping of the general 'relative distance' descriptions and approach outlined in the GBRMPA guidelines.

7.1.1 Enclosed coastal

The enclosed coastal water type is defined in words in the QWQG as the seaward part of the estuary which is defined as the cut-off between shallow, enclosed waters near the estuary mouth and deeper, more oceanic waters further out (the full definition includes further details).

Areas of enclosed coastal waters were delineated under remote sensing work for the Marine Monitoring Program. The Commonwealth Scientific and Industrial Research Organisation analysed temporal patterns in the chlorophyll variability across the shelf from ten years of MODIS data (Brando et al. 2011). The K-means clustering technique (Wilks 2006) was applied to group waters within which concentrations displayed similar magnitude over time and space (Brando et al., 2011). Initially the analysis was run as a case study, and was later expanded to delineate the enclosed coastal water type for the entire GBR. Colour dissolved organic matter (CDOM) was selected as the cluster parameter rather than chlorophyll to remove confounding biological effect influences on the clustering (Brando et al. 2014).

7.1.2 Open coastal

The GBRMPA guidelines generally describe a buffer distance from the coast and at time of publication this was used as the surrogate for relative distance to the edge of the shelf as coverage was not available at the time for the eastern edge of the shelf. Use of the average for buffering was found, during assessment of cluster analysis for enclosed coastal waters delineation, to not take sufficient account of changes in shelf width that were in some cases substantial across a region. Adjustments have been made using the eastern reef edge as a proxy for shelf width, considering the clustering of more seaward waters from the CSIRO work and manually editing water bodies. This pushes the inner-midshelf water body seaward where the change in width of the shelf is substantial within a region (e.g. southern Mackay and Fitzroy section) and narrows it in some northern areas where the shelf edge is close to the coast.

Don-Haughton coastal/marine waters

Generally, considering the similar hydrodynamics of the region, the clustering of the waters according to remote sensing analysis, and the spread of samples collected in the region, the open coastal portion of the waters in this region is considered sufficiently similar to have the same

guidelines applied. The Abbot Bay coastal waters landward of GBR plume line were given an SMD level of protection and corresponding WQGs (refer Figure 8 for spatial extent). It is acknowledged that periodic large flood flows from the Burdekin are likely to exceed these guidelines.

The coastal waters of this region are adjacent to the dry savannah climate region and are subject to SE trade winds that prevail for over 8 months of the year (Apr-Nov) across thousands of kilometres along the GBR. The coastal orientation is NW-SE along this section with capes protruding 15-20kms onto the shelf regularly along this 270km stretch. These embayments tend to cause recirculation in the bays in the lee of the SE winds and smaller tidal eddies tend to peel off when strong tidal ebbs and floods are experienced. The continental shelf is ~80km wide along this stretch with gentle slopes to the shelf break and the vast majority of reefs on the outer portion.

A lagoonal branch of the East Australian Current flows along the outer shelf toward the SE, however a wind-driven NW coastal boundary current dominates the long shore flows in the region of interest. Tides provide significant energy in concert with the wind to assist in resuspension of coastal sediments creating often turbid coastal boundary layers. The maximum spring tidal range is ~4m along this section.

Ocean colour imagery characterises these waters with having similar optical properties that are proxies for turbidity, chlorophyll a and CDOM. Independent eReefs modelling of optical properties also confirms this result. Climatologies from satellite derived Sea Surface Temperature imagery also show a strong cross shelf gradient with a smaller latitudinal gradient of warming to the North.

Stratification can occur in late spring to summer though this will often be moderated through the fortnightly tidal cycle if winds are absent. There may be some seasonal dense shelf water cascades across the shelf in autumn as the saline coastal waters cool and flow away from shore along the bottom slope. In winter cooling is enhanced in the shallow embayments and residence times can be increased with any bay recirculation.

Given the Burdekin is the largest source of episodic run-off along the entire Australian coast there are occasions where this can dominate the water characteristics of the coastal water to the north of its delta. Freshwater river plumes tend to follow the coast and turn northwest in response to Coriolis forcing. Exceptions can occur when northerly winds dominate. A stronger than normal NW monsoon can see plumes move SW and offshore.

Some overlap of the defined midshelf water type intrudes into State coastal waters at their seaward extent (other than those adjacent to Holbourne Island). The guidelines of the open coastal water type have been retained for these waters as the intrusions are small and there is considered to be little ecological or management benefit in complicating the derivation of WQGs by recognising these nuances. Water quality exhibits a gradient moving seaward from the mainland due to a range of factors that change over space and time (e.g. currents, tides, winds, waves, upwellings and seasons/time of year) and no boundary line will represent the full range of conditions that influence water movement.

Mackay Whitsunday coastal/marine waters

There are two distinct water bodies in the Mackay Whitsunday open coastal region. These are a consequence of the hydrodynamics and in particular of the high tidal regime of the southern waters adjacent to the Pioneer Basin and extending up into Repulse Bay. For waters with >5m tidal range a third delineation is recognised and classified as ‘macro tidal’.

7.1.3 Midshelf

Waters adjacent to Holbourne Island are classified as midshelf waters. Waters surrounding Tern, Bushy-Redbill and Sandpiper reefs are classified as midshelf waters.

7.1.4 Offshore

Waters surrounding Circular Quay Reef are classified as offshore waters.

7.1.5 Plume line and derivation of guidelines

Plume line

As an indication of where the disturbed waters are, the GBRMPA uses the ‘high’ and ‘very high’ risk classes of the modelled output of the risk assessment of the Scientific Consensus Statement 2013 (Waterhouse et al. 2013), with some modification. The line where this falls is named the ‘plume line’.

The ‘simplify’ function was initially applied with a 5000m and 5 hectare tolerance followed by manual smoothing to counteract impressions of accuracy in angular polygons. The resulting polygons were then extended beyond the GBRMPA coastline dataset and an ‘erase’ with the GBRMPA coastline was applied to remove the GBRMPA mainland and island areas from the dataset.

The plume line, or area, can only ever be an indication of disturbance as at any one time the waters may or may not reach particular parts of the marine park depending on conditions, and may or may not carry above natural levels of pollutants.

GBRMPA and state agency staff reviewed water quality monitoring data in GBR waters relative to the plume line to corroborate the plume line modelling. Some local modification has been applied where local information supported such a change. For example, Shoalwater Bay (outside the current project area) was identified as a high risk area under Waterhouse et al. (2013). Following review of local catchment conditions (small flow, naturally vegetated, good catchment water quality condition), and the natural influence of the high tidal regime on the resuspension of sediments in the area (likely causing high reflectance in remote sensing analysis), the bay was removed from the high risk area report.

Guidelines relative to plume line

GBR waters seaward of the plume line are generally expected to be in high ecological value condition in terms of their water quality. If local water quality condition was better than the GBRMPA guidelines, and there was sufficient data to do so, percentiles were set to maintain this condition. If GBRMPA guidelines were not met, they were set as desired condition for relevant indicators covered by the GBRMPA guidelines, and local data were used to set WQGs for other indicators.

Waters landward of the plume line are generally found to not meet GBRMPA guidelines. For these waters the intent is to improve water quality over time to achieve the GBRMPA water quality guidelines. If GBRMPA guidelines were not met, they were set as desired condition, and local data were used for other indicators that would otherwise have defaulted to QWQG. Further details are provided in the following sections.

7.2 Marine data sources

Tables 5 and 6 below summarise data sources used in deriving marine water quality guidelines for different water type sub-regions (listed numerically).

7.2.1 Don-Haughton coastal waters

Open coastal waters

GBRMPA has two Marine Monitoring Program (MMP) water quality sites in the open coastal waters of the Burdekin NRM region (Pandora and Geoffrey Bay).

The Pandora site is in Halifax Bay to the north of the bays in this planning area. It is within the open coastal water body which is clustered by the CSIRO k-mean clustering analysis as similar to the bays within this planning area (Cape Bowling Green, Upstart, Abbot Bay: Wilks 2006; Brando et al. 2011, 2014). The site is landward of the plume equating to the influence area of high to very high risk of receiving poor water quality.

Cleveland Bay samples (including Geoffrey Bay) have been excluded from analysis to derive guidelines for the open coastal waters of the more southern bays of the Burdekin region. Cleveland Bay is a depositional bay, is shallow, often experiences wind-driven resuspension and the circulation of waters in this area keeps material within the bay for some time (Walker 1981). Bottom resuspension shows a strong correlation between both TSS and phytoplankton concentration and it may be that enrichment in these waters is contributed to by the release of the interstitial nutrients from the deposited sediments (detected as high chlorophyll concentrations due to take up by planktonic organisms). High loads of dissolved nutrients however are known to contribute to poor water quality in the area, and the sediments are understood to transport higher concentrations of nutrients than was naturally available due to changes in the adjacent catchment landscape.

AIMS LTMP data has between 80 and 130 samples taken in this region's open coastal waters (depending on parameter) over a period spanning 1988-2006 across wet and dry seasons.

Water quality guidelines for Abbot Bay have been developed from local data sources. The network of sites in Abbot Bay was located within the plume line. The majority of sites were in open coastal waters, and two sites in the lee of Abbot Point represented enclosed coastal waters. Turbidity percentiles have been derived from Abbot Bay logger data provided by local stakeholders under a data agreement and reviewed by DSITI. Guidelines for turbidity are based on the current distribution (20^{th}-50^{th}-80^{th} percentiles) from the datasets. The management intent is that the median of samples in the future stay at or below the current values recorded in local datasets. Outside port limits, the WQG adopts the 50th percentile of local data. This 50^{th} percentile is also protective of the desired ecosystem state derived from the relationship between TSS and turbidity. The management intent is that the median of samples in the future stay at or below the median of current data.

The combination of stakeholder and agency collected data enabled development of water quality guidelines for open coastal waters landward of plume line across Upstart Bay, Abbot Bay and Edgecumbe Bay.

Existing condition of marine waters did not meet the GBRMPA guidelines for all parameters in the Don-Haughton open coastal water body. GBRMPA guidelines were adopted for chlorophyll-a. WQGs for dissolved nutrient parameters and suspended solids have been adopted from reduced

percentiles (10-40-70th) of local data and are set to be achieved as 20-50-80th percentiles for these waters. Rounding has also been applied where appropriate.

Midshelf

There is one MMP site at Pelorus/Orpheus West with 97 samples spanning wet and dry season from 2005 to 2013. AIMS LTMP data has between 62 and 74 samples taken in the midshelf waters (depending on parameter) over a period spanning 1988-2006 across wet and dry seasons.

Apart from NOx, dissolved nitrogen concentrations, and in particular ammonia, did not meet desired state in this water body. The guidelines selected for these parameters have been adopted from lower percentiles (10-40-70th) and scheduled to be achieved as 20-50-80th percentiles for these waters. Chlorophyll-a, TSS and phosphorus parameter percentiles met the GBRMPA guideline and were adopted at their 20-50-80th percentile ranges.

7.2.2 Mackay Whitsunday region (Proserpine and Pioneer Basins)

Open coastal waters

Oceanography and hydrodynamics of Mackay-Whitsunday region open coastal waters vary from north to south and east to west (CSIRO, 2008). Waters north of a line of latitude approximately -20.5 degrees are generally within the 2-3 metre tidal range, while waters to the south fall within the 3-4m tidal range, and further south, closer to shore, the >5m (macro-tidal) tidal range (CSIRO 2008).

Scheduled marine water WQOs seaward of the plume reflected the north-south variance (unit HEV2381 in the north, and HEV2383 in the south), but WQOs for SD waters landward of the plume line were not separated into north/south zones. As part of this report, open coastal water quality data was grouped and analysed by northern and southern sections, as outlined below. Following further review of the data, it is now proposed to also extend the north-south grouping to SD waters in this region (as per HEV waters).

Northern

Samples north of a line of latitude approximately -20.5 degrees (immediately south of Lindeman Island) were used to derive the Proserpine Basin open coastal water quality objectives. Data from three monitoring programs was reviewed.

There are three marine monitoring program (MMP) sites in the Proserpine Basin open coastal waters region: Double Cone, Daydream and Pine Island. A total of 281 samples has been collected across wet and dry seasons from the three sites over 2005-2013. Long term monitoring program (LTMP) data have between 75 and 145 samples (depending on parameter) taken from LTMP sites (see Attachment C) in the open coastal waters over a period spanning 1988-2006 across wet and dry seasons. Data from a joint AIMS and GBRMPA long term chlorophyll monitoring program was also analysed, providing a further 127 samples collected between 1996 and 2008.

Analysis of the full data set (i.e. the three programs) reveals that the current condition of the waters does not meet all of the GBRMPA guidelines derived to support the desired state of ecosystems of the marine park and world heritage area. Pooled data from the long term chlorophyll monitoring program met chlorophyll guidelines, and was considered as reference quality. Percentiles from this data were the basis for WQGs for northern open coastal waters. Seasonal guidelines have been added to allow for comparisons with smaller data sets should that be required. A minor downward adjustment of the 80th percentile for total suspended solids was made as the annual mean is

slightly above the GBRMPA guideline and this recognises the desire to improve the condition of these waters. Particulate N and P had minor changes as a result of the larger data set and guidelines protective of desired state were still met for these parameters.

In recognition of the different hydrodynamics described above, it is proposed to update open coastal water mapping and WQ guidelines to reflect the north-south split. The separation proposed is an extension of the vertical segment of the existing SD2381 polygon northward to intersect with the mainland at Cape Conway. (refer Figure 10 of this document). For the northern portion of SD2381 the WQGs are to achieve the open coastal WQOs scheduled for the adjacent northern HEV waters (HEV2381) seaward of the plume line.

Southern

Samples south of a line of latitude approximately -20.5 degrees are grouped within the approximate area of the 3.1-4m tidal range (CSIRO 2008). This tidal range continues south into the Fitzroy region to approximately -23.5 degrees latitude. The Mackay and the Fitzroy region midshelf data sets from the LTMP that fit this tidal range water body were merged for analysis. Sample size was between 41-60 samples (depending on parameter).

Existing condition of marine waters did not meet the GBRMPA guidelines for all parameters in this water body. WQGs for open coastal waters landward of the plume have been set recognising the need for improvement in water quality. The guidelines for these waters are set to achieve the corresponding open coastal WQOs scheduled for the adjacent HEV waters (HEV2383), or GBRMPA guidelines, depending on location (in some instances where water quality was considered adequate, WQGs were set to maintain current condition - according to area).

For SD2381 south open coastal waters (continuing south of Repulse Bay to Sand Bay) the intent is to attain the same values as adjacent HEV2383 waters. Seasonal guidelines have also been provided for these waters (means of those datasets should meet seasonal guidelines).

Existing scheduled SD waters 2382, 2383 and 2384 landward of the plume line in the Pioneer Basin also fall landward of the 3.1-4m tidal range waters. There were no sample sites within these waters to inform setting of WQGs. For SD2382 there is no change to the GBRMPA annual guidelines as previously scheduled, except that turbidity has been rounded upwards instead of downwards in recognition of the higher tidal regime in the region. Seasonal GBRMPA guidelines have been added for these waters (means of those datasets should meet seasonal guidelines). For SD 2383 and 2384 however, since scheduling, a further area of particularly high tidal regime has been mapped (macro tidal waters described below). The macro tidal waters cover parts of the SD areas and adjustments to the sediment related guidelines have been made accordingly. WQGs for other waters in this area (outside HEV/SD areas) have been updated accordingly. Seasonal GBRMPA guidelines have been added for these waters (means of those datasets should meet seasonal guidelines).

Additional monitoring has commenced in these southern waters in 2015. GBRMPA will provide further advice as it becomes available in the future.

<u>Macro tidal</u>

Waters with >5m tidal range are delineated as ‘macro tidal’ waters. The main macro-tidal waters in the Mackay-Whitsunday region occur in the far south of the project area towards and including the Broadsound (majority of Broadsound WQOs are included as part of the separate Styx Basin schedule document). As there are no additional monitored sites in these waters to provide local water quality data, WQGs are based on the GBRMPA (2010) guidelines. Water clarity is strongly driven by the high tidal ranges leading to intense resuspension, while chlorophyll and many of the nutrient concentrations remain low (Fabricius et al. 2013). In recognition of this, in the area with >5m tidal range (i.e. the Broad Sound water body) the guideline values for water clarity parameters

(Secchi depth and total suspended solids) (GBRMPA 2010) are reduced by a value of 20 per cent for the WQO. This approach emanates from De'ath G, Fabricius KE (2008) who stated:

"It is therefore advisable to decrease the guideline values for water clarity for areas with >5 m tidal ranges, and an (arbitrary) value of 20% may serve this purpose. In the longer term, local tides and wave height might be included as additional factors in the models to assess ecosystem responses"

Some values have been rounded.

Midshelf

Waters surrounding the Tern, Bushy-Redbill and Sandpiper Reefs (HEV2386) lie close to the boundary of the midshelf and offshore waters. Initial scheduling of these waters applied offshore derived percentiles as the WQOs. Upon further review, the mean of the offshore and the midshelf data sets has been adopted as the basis for most indicator percentiles. Particulate nitrogen midshelf values did not meet guideline and reduced percentiles were used with the offshore values to generate the mean.

The combined long term monitoring program (LTMP) data have between 180 and 380 samples collected over a period spanning 1988-2006 across wet and dry seasons.

Offshore (Circular Quay)

Long term monitoring program (LTMP) data have between 82 and 200 samples taken in the offshore waters (depending on parameter) over a period spanning 1988-2006 across wet and dry seasons. Chlorophyll did not meet the GBRMP guideline so the default values were set as the guideline. In initial scheduling the midshelf (rather than the offshore value) was applied for chlorophyll-a. The offshore value has now been adopted. Turbidity is not measured in this suite of data, and the turbidity relationship for these offshore waters is not known so an NTU value cannot be deduced from this data set. An ecosystem health guideline was not derived for turbidity in these waters so the default QWQG is applied for these waters: median <1 NTU.

Further reductions in dissolved nutrient parameters may be desirable for these waters.

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Table 5 Don Haughton marine water quality data sources

Sub-regions (refer Figures 8, 18)	Indicators	Site source	Number of samples	Dates (years) of samples
1.Lower estuary/ enclosed coastal waters	ammonia N oxidised N total N total P FRP chlorophyll suspended solids	1 site of enclosed coastal waters in Abbot Bay	N=13	2013-2014
	turbidity	2 sites of Abbot Bay	continuous logger	1 site 2011-2012 1 site 2013-2014
2. Open coastal waters Bowling Green Bay, Upstart Bay, Edgecumbe Bay	total dissolved N total dissolved P particulate N particulate P silicate	Multiple open coastal sites Refer Attachment A	N= 82-192 depending on parameter	1988-2006 AIMS LTMP 2005-2013 RRMMP
	ammonia N oxidised N total N total P FRP chlorophyll suspended solids	6 sites of Abbot Bay	Nutrients: 86 TSS: 124 Chl-a: 85	2013-2014
	Secchi	Refer GBRMPA guidelines	Secchi >2000	1988-2006 AIMS GBRMPA
	turbidity	11 sites of Abbot Bay	continuous logger	5 sites 2011-2012 6sites 2013-2014
3. Midshelf waters	ammonia N oxidised N total N total P total dissolved N FRP total dissolved P particulate N particulate P chlorophyll silicate suspended solids secchi	Multiple midshelf sites Refer Attachment B	N= 62-168 depending on parameter	1988-2006 AIMS LTMP 2005-2013 RRMMP
	turbidity	Pelorus Island: Latitude -18.54 Longitude 146.49	continuous logger	2007-2011 RRMMP

Table 6 Mackay Whitsunday coastal and marine water quality sources

Sub-regions (refer Figures 10, 19)	Indicators	Site source	Number of samples	Dates (years) of samples
1.Lower estuary/ enclosed coastal waters	ammonia N oxidised N total N total P FRP chlorophyll suspended solids	QWQG		
	turbidity – port and adjacent areas	Port areas: Based on coastal water quality monitoring (continuous turbidity logger data) 2010 to 2012 from sites within and around the ports, including Hay Point, Dudgeon Point, Round Top Island, and analysis by DSITIA	continuous logger	2010-2012
2. Open coastal waters northern (north of lat -20.5)	ammonia N oxidised N total N total P total dissolved N FRP total dissolved P particulate N particulate P silicate suspended solids	Multiple open coastal sites Refer Attachment C	N= 75-356 depending on parameter	1988-2006 AIMS LTMP 2005-2013 MMP
	chlorophyll	Joint AIMS and GBRMPA long term chlorophyll monitoring program. Hook Passage, Cid, Henning, Dent Passage, and West of Lindeman	N= 127	1996-2008
	Secchi	Refer GBRMPA guidelines	Secchi >2000	1988-2006 AIMS
	turbidity	Double Cone Island	continuous logger	2005-2013
3. Open coastal waters southern (south of lat -20.5)	ammonia N oxidised N total N total P total dissolved N FRP total dissolved P	Multiple open coastal sites Refer Attachment D	N=41-60 depending on parameter	1988-2006 AIMS LTMP

Sub-regions (refer Figures 10, 19)	Indicators	Site source	Number of samples	Dates (years) of samples
	particulate N particulate P silicate suspended solids			
	secchi chlorophyll	Refer GBRMPA guidelines	>2000	1988-2006 AIMS GBRMPA
	turbidity	Port areas: Based on coastal water quality monitoring from sites within and around the ports, including Hay Point, Dudgeon Point, Round Top Island, and analysis by DSITI	continuous logger	2010-2012
4. Midshelf waters	ammonia N oxidised N total N total P total dissolved N FRP total dissolved P particulate N particulate P silicate suspended solids	Multiple midshelf sites Refer Attachment E	N=48-67 depending on parameter	1988-2006 AIMS LTMP
	Chlorophyll secchi	Refer GBRMPA guidelines	>2000	1988-2006 AIMS GBRMPA
	turbidity	No site data. Guideline based on relationship to TSS	>100	2005-2010 MMP
5. Offshore waters	ammonia N oxidised N total N total P total dissolved N FRP total dissolved P particulate N particulate P silicate suspended solids	Multiple offshore sites Refer Attachment F	N=82-200 depending on parameter	1988-2006 AIMS LTMP
	chlorophyll secchi	Refer GBRMPA guidelines	>2000	1988-2006 AIMS GBRMPA
	turbidity	No site data. Guideline based on relationship to TSS	>100	2005-2010 MMP

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7.4 Attachment A - Reference sites for open coastal waters of Bowling Green Bay, Upstart Bay, Edgecumbe Bay

station	lat	long	TWN127	-18.970	146.617	WQS083	-19.725	147.710
TWN084	-18.800	146.430	TWN154	-18.970	146.617	TWN061	-18.828	146.430
TWN143	-18.800	146.430	CNS611	-19.097	146.878	TWN062	-18.828	146.430
TWN146	-18.800	146.430	TWN087	-19.083	146.918	TWN063	-18.800	146.430
WQN070	-18.800	146.432	TWN131	-19.083	146.918	TWN064	-18.800	146.430
CNS800	-18.864	146.518	TWN148	-19.083	146.918	HAL001	-19.017	146.613
WQN072	-18.840	146.525	TWN005	-18.800	146.430	HAL002	-19.017	146.613
TWN147	-18.970	146.617	TWN006	-18.800	146.430	HAL003	-19.017	146.613
TOR001	-18.957	146.648	TWN007	-18.828	146.430	TWN065	-18.970	146.617
CNS801	-18.951	146.651	TWN008	-18.828	146.430	TWN066	-18.970	146.617
CNS364	-19.007	146.775	TWN009	-18.800	146.430	TWN069	-19.083	146.918
GIL002	-19.029	146.809	TWN010	-18.800	146.430	TWN070	-19.083	146.918
TSV001	-19.000	146.847	TWN011	-18.828	146.430	SAT025	-19.759	147.739
FSH001	-19.062	146.883	TWN012	-18.828	146.430	Pandora	-18.814	146.437
GIL001	-19.122	146.900	TWN078	-18.800	146.430	BGB002	-19.278	147.165
CNS610	-19.101	146.949	WQN026	-18.800	146.431	BGB008	-19.278	147.165
TSV014	-19.147	147.011	CNS749	-18.802	146.480	BGB020	-19.278	147.165
POM138	-19.169	147.063	NWA004	-18.788	146.490	BGB030	-19.278	147.165
WQS080	-19.228	147.142	WQN027	-18.839	146.524	POM188	-19.280	147.204
BGB001	-19.280	147.083	NWA003	-18.913	146.533	BGB015	-19.277	147.247
BGB007	-19.280	147.083	TWN077	-18.970	146.617	BGB023	-19.277	147.247
BGB013	-19.280	147.083	CNS748	-18.916	146.622	BGB028	-19.277	147.247
BGB019	-19.280	147.083	WQN028	-19.006	146.653	POM186	-19.287	147.317
BGB024	-19.280	147.083	NWA002	-19.052	146.675	BGB009	-19.275	147.327
BGB029	-19.280	147.083	CNS747	-19.021	146.759	BGB016	-19.275	147.327
WQS073	-19.555	147.622	CNS644	-19.007	146.805	BGB021	-19.275	147.327
WQS072	-19.691	147.716	WQN034	-19.108	146.860	WQS075	-19.199	147.395
TWN095	-18.828	146.430	WQN033	-19.079	146.895	BGB005	-19.273	147.402
TWN096	-18.800	146.430	CNS746	-19.118	146.911	BGB010	-19.273	147.402
TWN097	-18.800	146.430	TWN003	-19.083	146.918	BGB022	-19.273	147.402
TWN098	-18.828	146.430	TWN004	-19.083	146.918	BGB033	-19.273	147.402
TWN126	-18.800	146.430	TWN041	-19.083	146.918	WQS074	-19.270	147.422
TWN129	-18.800	146.430	TWN042	-19.083	146.918	POM185	-19.282	147.452
TWN156	-18.828	146.430	CNS643	-19.120	146.939	AIV001	-19.225	147.240
TWN157	-18.800	146.430	CNS560	-19.115	146.952	POM227	-19.307	147.273
TWN158	-18.828	146.430	CNS745	-19.215	147.055	AIV013	-19.242	147.313
TWN159	-18.800	146.430	POM405	-19.277	147.081	AIV002	-19.258	147.363
CNS614	-18.756	146.487	WQS082	-19.569	147.624	POM226	-19.290	147.422
CNS613	-18.874	146.605	WQS021	-19.569	147.624	POM404	-19.220	147.144
TWN094	-18.970	146.617	WQS020	-19.725	147.710	POM270	-19.285	147.186

POM041	-19.296	147.359	POM272	-19.222	147.175	WQS071	-20.038	148.268
POM269	-19.290	147.363	POM273	-19.253	147.339	WQS070	-19.971	148.438
WQS022	-19.307	147.382	POM274	-19.283	147.488	WQS085	-19.971	148.436
POM228	-19.300	147.453	WQS018	-20.048	148.436			

7.5 Attachment B – Reference sites for midshelf waters of Don and Haughton coasts

station	**lat**	**long**	WQS077	-19.063	147.332	CNS530	-18.568	146.688
POM178	-19.835	148.376	WQN079	-19.037	146.934	POM263	-19.727	148.309
POM146	-19.806	148.374	TSV017	-19.034	147.204	POM264	-19.642	148.150
POM195	-19.761	148.276	WQN078	-18.965	146.964	POM266	-19.487	147.836
POM179	-19.748	148.245	FSH054	-18.925	146.892	POM267	-19.409	147.682
POM145	-19.723	148.213	GIL003	-18.906	146.702	POM229	-19.378	147.596
POM194	-19.688	148.139	CNS608	-18.885	146.692	POM268	-19.326	147.530
POM180	-19.664	148.106	FSH002	-18.863	146.658	POM403	-19.154	147.215
POM144	-19.628	148.068	WQN077	-18.854	147.014	POM402	-19.092	147.293
POM193	-19.611	148.009	WQN035	-18.814	146.752	CNS559	-18.890	146.697
POM181	-19.587	147.979	WQN073	-18.784	146.711	CNS645	-18.889	146.691
POM143	-19.543	147.919	FSH125	-18.583	146.694	TWN013	-18.667	146.583
POM192	-19.532	147.886	POM221	-19.746	148.241	TWN014	-18.667	146.583
POM182	-19.505	147.851	POM222	-19.646	148.082	TWN039	-18.667	146.583
POM127	-19.476	147.808	POM223	-19.550	147.925	TWN040	-18.667	146.583
POM142	-19.456	147.776	POM224	-19.432	147.732	POM279	-19.611	148.172
POM191	-19.452	147.755	POM225	-19.353	147.599	POM278	-19.543	148.033
POM183	-19.428	147.726	AIV012	-19.207	147.517	POM277	-19.474	147.895
POM141	-19.370	147.635	AIV003	-19.180	147.463	POM276	-19.410	147.764
POM190	-19.367	147.630	CNS711	-19.024	146.859	POM275	-19.344	147.633
POM184	-19.347	147.595	CNS531	-18.980	146.890	POM271	-19.178	147.133
WQS079	-19.187	147.188	CNS712	-18.863	146.787	TWN059	-18.667	146.583
WQS076	-19.133	147.363	CNS713	-18.707	146.700	TWN060	-18.667	146.583
WQS078	-19.130	147.251	TWN099	-18.667	146.583	Pelorus	-18.544	146.487
TSV015	-19.101	147.079	TWN160	-18.667	146.583			
TSV016	-19.069	147.139	TWN161	-18.667	146.583			

7.6 Attachment C – Reference sites for Mackay Whitsunday open coastal waters north of Latitude -20.5

station	**lat**	**long**	POM147	-19.8685	148.5442	KAT233	-19.9685	149.0667
POM262	-19.8075	148.4705	POM261	-19.8932	148.6438	SWA053	-19.9715	148.7233
POM128	-19.842	148.3898	POM177	-19.9042	148.4975	POM260	-19.9772	148.8105
POM220	-19.8457	148.3993	POM148	-19.9333	148.7197	POM176	-20.0153	148.701
POM196	-19.8485	148.405	POM197	-19.9355	148.5397	POM219	-20.0167	148.664

POM198	-20.029	148.6787	WHT071	-20.1067	148.8783	WHT117	-20.2167	149.0167
SWA052	-20.0432	148.875	WHT106	-20.1067	148.8783	WHT129	-20.2167	149.0167
WHT025	-20.045	148.875	WHT112	-20.1067	148.8783	WHT130	-20.2167	149.0167
WHT026	-20.045	148.875	WHT167	-20.1067	148.8783	WHT145	-20.2167	149.0167
WHT027	-20.045	148.875	WHT169	-20.1067	148.8783	WHT146	-20.2167	149.0167
WHT028	-20.045	148.875	KAT043	-20.1185	148.9402	POM328	-20.2278	149.0653
WHT043	-20.045	148.875	POM129	-20.1202	148.764	POM327	-20.2295	149.0673
WHT105	-20.045	148.875	POM333	-20.1213	149.0413	POM329	-20.234	149.0215
WHT109	-20.045	148.875	POM331	-20.1445	149.096	WQS066	-20.2407	148.9303
WHT147	-20.045	148.875	SWA048	-20.1467	148.9067	KAT202	-20.2448	149.1715
WHT150	-20.045	148.875	KAT218	-20.1483	148.9472	KAT206	-20.2448	149.1715
POM125	-20.0497	149.0017	WQS016	-20.1483	148.8823	KAT213	-20.2448	149.1715
POM150	-20.0533	149.0747	KAT220	-20.1515	149.024	KAT232	-20.2455	149.1708
SWA051	-20.0533	148.9098	POM151	-20.1532	149.225	KAT230	-20.248	149.0695
POM316	-20.064	149.0008	KAT244	-20.1538	149.0675	WQS063	-20.2515	149.0592
KAT241	-20.0643	149.0748	KAT221	-20.1577	149.0685	POM315	-20.2613	149.3325
POM080	-20.0667	148.8733	KAT207	-20.1602	149.0715	POM152	-20.2657	149.3605
WHT023	-20.0667	148.875	KAT212	-20.1602	149.0715	POM326	-20.2737	149.0725
WHT024	-20.0667	148.875	KAT234	-20.1613	148.9507	KAT239	-20.2788	149.0742
WHT029	-20.0667	148.875	KAT228	-20.1617	148.956	POM124	-20.2838	149.3268
WHT030	-20.0667	148.875	POM330	-20.164	149.0767	SWA041	-20.3283	148.95
WHT044	-20.0667	148.875	POM332	-20.1648	149.0425	SAT019	-20.3573	149.121
WHT070	-20.0667	148.875	KAT211	-20.165	148.9568	POM153	-20.3653	149.4825
WHT108	-20.0667	148.875	KAT219	-20.165	148.9568	SAT018	-20.4563	149.0557
WHT110	-20.0667	148.875	WHT048	-20.1667	149.0465	KAT203	-20.4607	149.0332
WHT122	-20.0667	148.875	WHT120	-20.1667	149.0465	KAT214	-20.4607	149.0332
WHT148	-20.0667	148.875	WHT121	-20.1667	149.0465	WQS092	-20.4632	149.038
WHT149	-20.0667	148.875	WHT141	-20.1667	149.0465	WQS011	-20.4633	149.0355
POM040	-20.0677	148.8745	WHT144	-20.1667	149.0465	KAT223	-20.4637	149.032
POM081	-20.0678	148.8733	POM336	-20.1732	148.9492	WQS059	-20.4643	149.036
POM175	-20.0695	148.8692	WQS065	-20.1762	148.9538	POM320	-20.4648	149.0455
SWA050	-20.0717	148.8833	WQS087	-20.1778	148.9552	KAT237	-20.4653	149.0353
POM259	-20.0775	148.8733	WQS064	-20.1787	149.027	KAT243	-20.5	149.1703
WHT031	-20.0817	148.8783	WHT047	-20.18	149.02	POM203	-20.57	149.1028
WHT032	-20.0817	148.8783	WHT118	-20.18	149.02	POM204	-20.57	149.1028
WHT035	-20.0817	148.8783	WHT119	-20.18	149.02	SWA047	-20.1982	148.8515
WHT036	-20.0817	148.8783	WHT142	-20.18	149.02	POM199	-20.1453	148.793
WHT107	-20.0817	148.8783	WHT143	-20.18	149.02	SAT012	-20.1262	148.7518
WHT111	-20.0817	148.8783	POM337	-20.1867	148.8635	WQS069	-20.0988	148.713
WHT166	-20.0817	148.8783	POM042	-20.1982	149.045	WQS086	-20.0983	148.714
WHT168	-20.0817	148.8783	POM001	-20.199	149.045	Double Cone Island	-20.11	148.72
SWA049	-20.1	148.8917	POM082	-20.2	149.0465	Daydream Island	-20.25	148.81
WHT033	-20.1067	148.8783	WHT039	-20.2167	149.0167	Pine Island	-20.38	148.89
WHT034	-20.1067	148.8783	WHT040	-20.2167	149.0167			
WHT037	-20.1067	148.8783	WHT045	-20.2167	149.0167			
WHT038	-20.1067	148.8783	WHT046	-20.2167	149.0167			

7.7 Attachment D – Reference site for Mackay-Whitsunday open coastal waters south of latitude -20.5

station	lat	long
POM301	-21.5133	150.2467
WQS053	-21.6328	150.1152
WQS097	-21.6345	150.115
WQS032	-21.7285	150.7605
POM352	-21.7537	150.2122
WQS052	-21.8382	150.305
POM135	-21.8453	150.3337
WQS033	-21.8555	150.8005
POM353	-21.8598	150.31
POM302	-21.9203	150.731
POM354	-21.9468	150.4258
MAC003	-21.9667	150.25
MAC004	-21.9667	150.25
MAC012	-21.9667	150.25
POM074	-21.9667	150.25
POM088	-21.9682	150.25
WQS098	-22.0025	150.3467
WQS034	-22.0283	150.83
WQS051	-22.0295	150.3713
POM355	-22.0422	150.55
POM136	-22.0858	150.553
POM356	-22.1447	150.6738
MAC001	-22.1667	150.3333
MAC002	-22.1667	150.3333
MAC011	-22.1667	150.3333
POM073	-22.1667	150.3333
POM033	-22.1672	150.3325
POM089	-22.1682	150.3315
WQS035	-22.1975	150.8562
POM203	-20.57	149.1028
SWA033	-20.6783	149.23
WQS058	-20.6918	149.0363
SAT017	-20.6947	149.1578
SAT016	-20.715	148.9602
POM341	-20.7262	149.1147
SWA032	-20.79	149.3617
POM255	-20.8322	149.2578
POM133	-20.8363	149.2608
SWA031	-20.8598	149.5298
WQS093	-20.8632	149.2843
WQS057	-20.8722	149.2918
POM344	-21.0093	149.3852
WQS056	-21.0647	149.5353
POM253	-21.1473	149.4617
POM252	-21.1762	149.6367
POM300	-21.1773	150.0002
POM251	-21.1925	149.725
POM250	-21.2133	149.8125
POM249	-21.2292	149.9033
POM134	-21.2348	149.7167
POM347	-21.239	149.6028
SWA030	-21.2433	150.1333
WQS055	-21.2477	149.7522
POM087	-21.2783	149.665
POM075	-21.2815	149.665
POM035	-21.2823	149.6677
MAC005	-21.2833	149.6667
MAC006	-21.2833	149.6667
MAC013	-21.2833	149.6667
POM348	-21.3107	149.7525
POM349	-21.4107	149.9023
WQS054	-21.4388	149.9453
POM034	-21.4667	150.25
station	lat	long
POM342	-20.8517	149.1945
POM254	-21.1182	149.2855
POM345	-21.1178	149.2923
POM346	-21.1805	149.4387

7.8 Attachment E – Reference sites for Mackay-Whitsunday midshelf waters

station	lat	long
POM262	-19.8075	148.4705
POM128	-19.842	148.3898
POM220	-19.8457	148.3993
POM196	-19.8485	148.405
POM147	-19.8685	148.5442
POM261	-19.8932	148.6438
POM177	-19.9042	148.4975
POM148	-19.9333	148.7197
POM197	-19.9355	148.5397
KAT233	-19.9685	149.0667
SWA053	-19.9715	148.7233
POM260	-19.9772	148.8105
POM176	-20.0153	148.701
POM219	-20.0167	148.664
POM198	-20.029	148.6787
SWA052	-20.0432	148.875
WHT025	-20.045	148.875
WHT026	-20.045	148.875
WHT027	-20.045	148.875
WHT028	-20.045	148.875
WHT043	-20.045	148.875
WHT105	-20.045	148.875
WHT109	-20.045	148.875
WHT147	-20.045	148.875
WHT150	-20.045	148.875
POM125	-20.0497	149.0017
POM150	-20.0533	149.0747
SWA051	-20.0533	148.9098
POM316	-20.064	149.0008
KAT241	-20.0643	149.0748
POM080	-20.0667	148.8733
WHT023	-20.0667	148.875

WHT024	-20.0667	148.875	KAT234	-20.1613	148.9507	KAT239	-20.2788	149.0742
WHT029	-20.0667	148.875	KAT228	-20.1617	148.956	POM124	-20.2838	149.3268
WHT030	-20.0667	148.875	POM330	-20.164	149.0767	SWA041	-20.3283	148.95
WHT044	-20.0667	148.875	POM332	-20.1648	149.0425	SAT019	-20.3573	149.121
WHT070	-20.0667	148.875	KAT211	-20.165	148.9568	POM153	-20.3653	149.4825
WHT108	-20.0667	148.875	KAT219	-20.165	148.9568	SAT018	-20.4563	149.0557
WHT110	-20.0667	148.875	WHT048	-20.1667	149.0465	KAT203	-20.4607	149.0332
WHT122	-20.0667	148.875	WHT120	-20.1667	149.0465	KAT214	-20.4607	149.0332
WHT148	-20.0667	148.875	WHT121	-20.1667	149.0465	WQS092	-20.4632	149.038
WHT149	-20.0667	148.875	WHT141	-20.1667	149.0465	WQS011	-20.4633	149.0355
POM040	-20.0677	148.8745	WHT144	-20.1667	149.0465	KAT223	-20.4637	149.032
POM081	-20.0678	148.8733	POM336	-20.1732	148.9492	WQS059	-20.4643	149.036
POM175	-20.0695	148.8692	WQS065	-20.1762	148.9538	POM320	-20.4648	149.0455
SWA050	-20.0717	148.8833	WQS087	-20.1778	148.9552	KAT237	-20.4653	149.0353
POM259	-20.0775	148.8733	WQS064	-20.1787	149.027	KAT243	-20.5	149.1703
WHT031	-20.0817	148.8783	WHT047	-20.18	149.02	POM203	-20.57	149.1028
WHT032	-20.0817	148.8783	WHT118	-20.18	149.02	POM204	-20.57	149.1028
WHT035	-20.0817	148.8783	WHT119	-20.18	149.02	SWA034	-20.5867	149.0782
WHT036	-20.0817	148.8783	WHT142	-20.18	149.02	POM216	-20.5902	149.226
WHT107	-20.0817	148.8783	WHT143	-20.18	149.02	SWA033	-20.6783	149.23
WHT111	-20.0817	148.8783	POM337	-20.1867	148.8635	POM215	-20.6867	149.7533
WHT166	-20.0817	148.8783	POM042	-20.1982	149.045	WQS058	-20.6918	149.0363
WHT168	-20.0817	148.8783	POM001	-20.199	149.045	SAT017	-20.6947	149.1578
SWA049	-20.1	148.8917	POM082	-20.2	149.0465	SAT016	-20.715	148.9602
WHT033	-20.1067	148.8783	WHT039	-20.2167	149.0167	POM341	-20.7262	149.1147
WHT034	-20.1067	148.8783	WHT040	-20.2167	149.0167	SWA032	-20.79	149.3617
WHT037	-20.1067	148.8783	WHT045	-20.2167	149.0167	POM255	-20.8322	149.2578
WHT038	-20.1067	148.8783	WHT046	-20.2167	149.0167	POM133	-20.8363	149.2608
WHT071	-20.1067	148.8783	WHT117	-20.2167	149.0167	SWA031	-20.8598	149.5298
WHT106	-20.1067	148.8783	WHT129	-20.2167	149.0167	WQS093	-20.8632	149.2843
WHT112	-20.1067	148.8783	WHT130	-20.2167	149.0167	WQS057	-20.8722	149.2918
WHT167	-20.1067	148.8783	WHT145	-20.2167	149.0167	POM344	-21.0093	149.3852
WHT169	-20.1067	148.8783	WHT146	-20.2167	149.0167	WQS056	-21.0647	149.5353
KAT043	-20.1185	148.9402	POM328	-20.2278	149.0653	POM253	-21.1473	149.4617
POM129	-20.1202	148.764	POM327	-20.2295	149.0673	POM252	-21.1762	149.6367
POM333	-20.1213	149.0413	POM329	-20.234	149.0215	POM300	-21.1773	150.0002
POM331	-20.1445	149.096	WQS066	-20.2407	148.9303	POM251	-21.1925	149.725
SWA048	-20.1467	148.9067	KAT202	-20.2448	149.1715	POM250	-21.2133	149.8125
KAT218	-20.1483	148.9472	KAT206	-20.2448	149.1715	POM249	-21.2292	149.9033
WQS016	-20.1483	148.8823	KAT213	-20.2448	149.1715	POM134	-21.2348	149.7167
KAT220	-20.1515	149.024	KAT232	-20.2455	149.1708	POM347	-21.239	149.6028
POM151	-20.1532	149.225	KAT230	-20.248	149.0695	SWA030	-21.2433	150.1333
KAT244	-20.1538	149.0675	WQS063	-20.2515	149.0592	WQS055	-21.2477	149.7522
KAT221	-20.1577	149.0685	POM315	-20.2613	149.3325	POM087	-21.2783	149.665
KAT207	-20.1602	149.0715	POM152	-20.2657	149.3605	POM075	-21.2815	149.665
KAT212	-20.1602	149.0715	POM326	-20.2737	149.0725	POM035	-21.2823	149.6677

MAC005	-21.2833	149.6667	POM348	-21.3107	149.7525	POM034	-21.4667	150.25
MAC006	-21.2833	149.6667	POM349	-21.4107	149.9023			
MAC013	-21.2833	149.6667	WQS054	-21.4388	149.9453			

7.9 Attachment F – Reference Sites for offshore waters

station	lat	long	POM114	-20.0667	150.2708	POM248	-21.2953	150.3357
KAT208	-19.7997	149.4208	POM115	-20.1767	149.5	POM280	-20.7617	150.4857
KAT209	-19.8155	149.1178	POM116	-20.1083	149.4758	POM287	-20.7723	150.4692
KAT225	-19.7982	149.1297	POM117	-20.7962	150.7803	POM288	-20.7723	150.8885
KAT226	-19.7437	149.148	POM118	-20.7758	150.8843	POM291	-20.7772	150.8795
KAT227	-19.7922	149.064	POM120	-20.7973	150.8067	POM295	-20.7822	150.39
KAT240	-19.8047	149.0615	POM121	-20.7873	150.762	POM296	-20.7998	150.3312
KAT242	-19.7437	149.064	POM122	-20.7605	150.4812	POM297	-20.8923	150.2495
MAC007	-20.5132	149.9667	POM123	-20.611	149.8192	POM298	-20.9813	150.171
MAC008	-20.5132	149.9667	POM126	-20.0125	149.7352	POM299	-21.0737	150.0907
MAC009	-20.0167	150.3167	POM149	-19.5	148.8938	POM309	-20.7625	150.4882
MAC010	-20.5132	149.9667	POM154	-20.4705	149.6128	POM311	-20.7745	150.8897
MAC014	-20.0167	150.3167	POM155	-20.5807	149.7393	POM312	-20.6412	150.2947
MAC015	-20.5132	149.9667	POM156	-20.6458	149.9093	POM313	-20.5658	149.8777
MAC016	-20.5132	149.9667	POM157	-20.698	150.0632	POM314	-20.402	149.5863
MAC017	-20.0167	150.3167	POM158	-20.75	150.2315	POM334	-19.796	149.0622
MAC018	-20.7733	150.8182	POM159	-20.7572	150.4038	POM335	-19.803	149.041
MAC019	-20.7733	150.8182	POM160	-20.7567	150.4842	POM377	-20.7742	150.8885
MAC020	-20.5132	149.9667	POM162	-20.776	150.8888	POM378	-20.7752	150.8832
POM003	-20.065	150.2702	POM163	-20.7965	150.8078	POM379	-20.7618	150.4868
POM004	-20.13	150.5132	POM164	-20.7962	150.8075	POM380	-20.7582	150.4812
POM006	-20.5798	150.92	POM165	-20.7828	150.7833	SAT011	-20.0102	149.151
POM007	-20.7382	150.7833	POM166	-20.8075	150.7292	SWA020	-19.545	149.4148
POM044	-20.065	150.27	POM167	-20.789	150.7897	WHT007	-19.8333	149
POM045	-20.13	150.5132	POM168	-20.7727	150.8208	WHT008	-19.8333	149
POM047	-20.5798	150.92	POM169	-20.7685	150.8265	WHT009	-19.7	149.25
POM048	-20.7382	150.7833	POM170	-20.7253	150.8375	WHT010	-19.7	149.25
POM049	-20.7917	150.8075	POM205	-20.7625	150.488	WHT011	-19.75	149.1448
POM050	-20.8	150.3017	POM206	-20.7738	150.8897	WHT012	-19.75	149.1448
POM051	-20.7083	150.8215	POM207	-20.7692	150.8837	WHT013	-19.7167	149.2083
POM052	-20.7983	150.7203	POM209	-20.7632	150.8825	WHT014	-19.7167	149.2083
POM053	-20.7483	150.8067	POM210	-20.7807	150.3353	WHT015	-19.75	149.1448
POM054	-20.7	150.825	POM211	-20.7802	150.3065	WHT016	-19.75	149.1448
POM107	-20.7708	150.7608	POM212	-20.8125	150.317	WHT017	-19.7167	149.2083
POM108	-20.7965	150.8015	POM213	-20.8125	150.317	WHT018	-19.7167	149.2083
POM109	-20.7765	150.8848	POM214	-20.7878	150.3175	WHT019	-19.7965	149.4167
POM110	-20.7083	150.8075	POM230	-20.761	150.4872	WHT020	-19.7965	149.4167
POM111	-20.5817	150.9223	POM232	-20.7635	150.7275	WHT021	-19.8048	149.4382
POM113	-20.1275	150.5102	POM235	-20.5	150.9393	WHT022	-19.8048	149.4382

WHT041	-20.0183	149.6867	WHT113	-20.0533	149.6867
WHT042	-20.0183	149.6867	WHT114	-20.0533	149.6867
WHT049	-19.8333	149	WHT132	-19.75	149.1448
WHT050	-19.7	149.25	WHT133	-19.7167	149.2083
WHT051	-19.7715	149.3482	WHT134	-19.75	149.1448
WHT052	-19.7765	149.3815	WHT135	-19.7167	149.2083
WHT053	-19.7965	149.4167	WHT136	-19.7	149.25
WHT054	-19.8048	149.4382	WHT137	-19.8048	149.4382
WHT055	-19.9167	149.5	WHT138	-19.7965	149.4167
WHT056	-19.9167	149.5	WHT139	-19.7965	149.4167
WHT057	-19.7367	150.0598	WHT140	-19.8048	149.4382
WHT058	-19.7667	150.105	WHT151	-19.6515	149.9083
WHT059	-19.7917	150.15	WHT152	-19.6917	149.9317
WHT060	-19.825	150.1667	WHT153	-19.6515	149.9083
WHT061	-20.0533	149.6867	WHT154	-19.6917	149.9317
WHT062	-20.0183	149.6867	WHT155	-19.7667	150.105
WHT072	-19.8333	149	WHT156	-19.7367	150.0598
WHT073	-19.75	149.1448	WHT157	-19.7667	150.105
WHT074	-19.75	149.1448	WHT158	-19.7367	150.0598
WHT075	-19.7167	149.2083	WHT159	-19.7367	150.0598
WHT076	-19.7	149.25	WHT160	-19.825	150.1667
WHT077	-19.7	149.25	WHT161	-19.7917	150.15
WHT078	-19.7715	149.3482	WHT162	-19.7917	150.15
WHT079	-19.7765	149.3815	WHT163	-19.825	150.1667
WHT080	-19.7965	149.4167	WHT173	-20.0533	149.6867
WHT081	-19.8048	149.4382	WHT174	-20.0183	149.6867
WHT082	-19.7765	149.3815	WHT175	-20.0533	149.6867
WHT083	-19.7715	149.3482	WHT176	-20.0183	149.6867
WHT084	-19.8048	149.4382	WHT177	-19.7765	149.3815
WHT085	-19.7965	149.4167	WHT178	-19.7715	149.3482
WHT086	-19.9167	149.5	WHT179	-19.7715	149.3482
WHT087	-19.9167	149.5	WHT180	-19.7765	149.3815
WHT088	-19.825	150.1667	WQS023	-20.7648	150.486
WHT089	-19.825	150.1667	WQS025	-20.774	150.8885
WHT090	-19.7917	150.15	WQS026	-20.7733	150.8983
WHT091	-19.7917	150.15	WQS094	-20.7693	150.4932
WHT092	-19.7667	150.105	WQS095	-20.7628	150.4845
WHT093	-19.7667	150.105	WQS096	-20.7633	150.4867
WHT094	-19.7367	150.0598			
WHT095	-19.7367	150.0598			
WHT096	-19.6917	149.9317			
WHT097	-19.6917	149.9317			
WHT098	-19.6515	149.9083			
WHT099	-19.6515	149.9083			
WHT100	-20.0183	149.6867			
WHT101	-20.0183	149.6867			

8 Appendix 2 Fresh and Estuarine Water Quality Guidelines

This appendix provides further information pertaining to fresh and estuarine water data sets, fresh and estuarine water type classification and derivation of guidelines for different water types and sub-regions. The general approach has been to use locally applicable data where available as a basis for deriving WQGs for water sub-regions. In the absence of sufficient local data, water quality guidelines will default back to Queensland Water Quality Guidelines (2009) for Central Coast region.

8.1 Water types and water type sub-regions

Fresh and estuarine water types in the planning area include mid estuary, lowland freshwater, upland freshwater, and wetlands.

Water types are defined in the Queensland Water Quality Guidelines (2009) Appendix B and the ANZECC guidelines.

The ephemeral nature of the waterways of much of the project area means that there are no 'upper estuary' reaches and 'mid estuary' reaches are short or present only while flows are occurring. The study catchments consist mainly of coastal lowlands and floodplains, so 'lowland freshwaters' are a dominant feature of the catchments. 'Upland freshwaters' occur mainly in the western areas of the catchments. Few samples (n=4) have been collected from 'upland freshwater' reaches, so further monitoring would be required in these areas before local water quality guidelines can be developed for this water type.

8.2 Fresh water and estuarine data sources

Publicly available data for fresh and estuarine waters for the region was provided from government sources and James Cook University. Details are provided below and in Table 7.

8.2.1 Upland fresh waters

In both the Don and Haughton basins there was insufficient local water quality data to derive local guideline values. More monitoring of upland water will need to occur before locally derived water quality guidelines can be developed. Until such time, water quality guidelines will default to Queensland Water Quality Guidelines for Central Coast upland freshwaters.

8.2.2 Lowland fresh waters

Details of data sources are provided in Table 7.

In the Don River Basin, data for lowland fresh waters was obtained from the DNRM online Water Monitoring Portal and by request from the Hydstra Project database. Data was collected from five sites in the Upstart and Abbot Bay sub-catchments and from six sites in the Don River sub-catchment. Data collection spanned from 1968 to 2015 for physico-chemical parameters and from 1996 to 2015 for nutrients, though sampling frequency was low.

James Cook University also provided data for lowland freshwaters of the project area. Sampling occurred at seven sites in the Upstart and Abbot Bay sub-catchments and two sites in the Don

River sub-catchment. Samples were collected between 2006 and 2009. Sampling conducted by JCU targeted high flow events, and therefore much of the provided data was not suitable for use in deriving baseflow guidelines. High flow samples were separated and not used in developing baseflow guidelines.

In the Haughton River Basin, data from 35 sites was obtained from the DNRM online Water Monitoring Portal, covering the period 1970–2015. JCU also provided sampling data targeting high flows in the Haughton Basin from 2006-2009, however this data was not used for development of low flow guidelines.

8.2.3 Mid estuary waters

There was insufficient data collected from mid estuarine reaches of the Don Basin to develop local water quality guidelines. Instead, guidelines were calculated using data collected from the Gregory River estuary which drains to Edgecumbe Bay. The Gregory River has similar land use dominated by grazing and climate to the Don River catchment, so is more appropriate as a surrogate than using the Burdekin Delta or Haughton Basin data which have lower reaches dominated by irrigated sugarcane.

Data from the Gregory River mid estuary reaches is continuing to be collected and these guidelines will be updated as more data becomes available.

In the Haughton River Basin there was insufficient data collected from mid-estuarine waters to develop local guidelines. Accordingly, QWQG regional guideline values are retained.

8.2.4 Gregory River mid estuary waters

Data collected in the Gregory River mid estuary was part of a larger sampling effort across eight estuaries of the Mackay-Whitsunday region being conducted by DSITI. Of the sampled estuaries, the Gregory River showed the best available data for developing water quality guidelines. Data from this estuary was used in developing most guidelines for the Mackay-Whitsunday estuaries.

For the estuaries south of Mackay with a large tidal range, local data was used to develop guidelines for FRP, TP and Chl-a, which are all influenced by increased suspended sediments. No guideline is provided for turbidity in the southern estuaries as the results obtained to date are too variable to meaningfully interpret for guideline development.

8.3 Derivation of draft Water Quality Guidelines

8.3.1 Lowland Freshwaters

In developing these draft water quality guidelines the aim was to define a water quality that seeks to maintain or improve upon the current condition of waterways. These guidelines move away from the ‘reference condition’ approach and use an adjustment of ambient water quality condition. The default guidelines in the QWQG for the Central Coast region may not be appropriate for these relatively small and naturally ephemeral systems and impose inappropriate limits on water quality. While some of the proposed draft guidelines may be less strict that the default guidelines, they still represent maintenance of or improvement on current water quality.

To derive the draft guidelines, the collated monitoring data was separated by sub-catchments. In the Don Basin these sub-catchments were the Don River sub-catchment, Abbot Bay sub-catchment and Upstart Bay sub-catchment. For derivation of guidelines, data from Abbot Bay and Upstart Bay sub-catchments were combined. The landscape and land-uses for these sub-catchments are similar and combining them provided sufficient data to derive local guidelines. In

the Haughton River basin, the Haughton River sub-catchment and Barratta Creek sub-catchments were analysed separately. Draft guidelines derived for the Barratta Creek sub-catchment were also applied to the lowland freshwaters of the Burdekin Delta sub-catchment, which had only limited data available.

Data from each sub-catchment was collated and the water quality guidelines were derived as the 40th percentile of the data for each water quality parameter. The 20th and 70th percentiles are also provided as the desired water quality range.

This method recognises the lack monitoring data from high quality reference sites in the catchments, yet provides locally appropriate guidelines for water quality improvement in these moderately disturbed catchments. The method for derivation of guidelines provides a methodical and repeatable process for deriving and reviewing water quality guidelines. These guidelines seek to improve upon current water quality, and can be reviewed in the future with updated monitoring data and further refined as water quality improves.

8.3.2 Mid estuary waters

For mid estuary waters of the Don River Basin, the reference site approach was used to derive draft water quality guidelines. The Gregory River mid estuary was used as the reference site, and the 20th, 50th and 80th percentiles of monitored data is provided here as draft guidelines. The Gregory River was not considered a suitable reference site for use in the Haughton River Basin, and with limited local estuary data, guidelines will default to the QWQG Central Coast region.

The Gregory River mid estuary was also used as a reference site for the Mackay-Whitsunday region mid estuary guidelines. The small tidal range of the Gregory River, compared to the catchments south of Mackay, mean that some parameters at Gregory could not be applied to these catchments. Gregory River mid-estuary was used as a reference for catchments from Mackay and north. For catchments south of Mackay draft guidelines for TP, FRP and chlorophyll-a were adjusted with data from local Carmila and Rocky Dam creeks as these parameters are impacted by the higher suspended sediment concentrations in these southern catchments. Turbidity and suspended solids were deemed too variable to derive guidelines from the present dataset.

Table 7 Mid estuarine and fresh water quality data sources

Sub-regions (refer Figures 3, 6, 10, 18)	Indicators	Site source	Number of samples	Dates (years) of samples
1. Mid estuary waters – Don Basin	ammonia N oxidised N total N total P FRP chlorophyll turbidity secchi suspended solids	Dept of Science, Information Technology and Information, Queensland Waters Database – 2 sites in Gregory River mid estuary	8 sample occasions N=16 (as at July 2015)	2014-2015
2. Mid estuary waters – Haughton Basin	All	Insufficient data for derivation of local WQGs – monitoring required to develop local WQGs. Apply QWQG regional WQGs until local WQGs developed	-	-
3. Lowland freshwaters – Don Basin	ammonia N oxidised N total N total P FRP chlorophyll turbidity suspended solids conductivity	Dept of Natural Resources and Mines, Online Water Monitoring Portal database – 13 sites James Cook University – 10 sites	470 sample occasions N=45-420 depending on parameter	Hydstra: 1968-2014
4. Lowland freshwaters – Haughton Basin	ammonia N oxidised N total N total P FRP turbidity suspended solids conductivity	Dept of Natural Resources and Mines, Online Water Monitoring Portal database – 35 sites JCU: 4 sites	Haughton River: 943 sample occasions N= 44 - 201 depending on parameter. Barratta Creek: 2579 sample occasions N= 55 – 646 depending on parameter.	Hydstra: 1970-2015 JCU: 2006-2009
5. Upland freshwaters – Don and Haughton basins	All	Insufficient data for derivation of local WQGs – monitoring required to develop local WQGs. Apply QWQG regional WQGs until local WQGs developed	-	-
6. Mid estuarine	ammonia N	Dept of Science,	8 sample occasions	2014-2015

Sub-regions (refer Figures 3, 6, 10, 18)	Indicators	Site source	Number of samples	Dates (years) of samples
waters – Mackay-Whitsunday region	oxidised N total N total P FRP chlorophyll turbidity secchi suspended solids	Information Technology and Information, Queensland Waters Database – 2 sites in Gregory River mid estuary	N=16 (as at July 2015)	
7. Wetlands – Don and Haughton basins	All	Insufficient data for derivation of local WQGs – monitoring required to develop local WQGs.	-	-
8. Groundwaters – Don and Haughton basins	All	Outside scope of project. Groundwater WQGs to be considered separately	-	-

9 Appendix 3 Human use EV water quality guidelines

This section outlines WQGs to protect human use EVs, which comprise EVs other than the aquatic ecosystem EV, such as recreation, stock watering, aquaculture and crop irrigation. Where a human use EV has been identified, the following tables can be used to identify the WQGs 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 WQG for each water quality indicator will then protect all identified EVs.

WQGs in this section are, unless otherwise specified, based on relevant national water quality guidelines including AWQG and the ADWG. Reference to those national guidelines or codes is necessary to obtain comprehensive listings of all indicators and corresponding WQGs. Table 8 outlines human use EVs, applicable water types, and a selection of more commonly used WQGs to support those EVs. Tables 9 to 17 provide further guidelines to protect particular human use EVs (based on national guidelines or other more local studies).

Table 8 Human use EVs – summary of guidelines and sources

Environmental value	Water type/area	Water quality guideline to protect EV (refer to specified codes and guidelines for full details)
Suitability for drinking water supply	All fresh waters including groundwaters	Quality of raw water (prior to treatment) to meet requirements of water supply operators. Local WQGs for drinking water supply are provided in Table 9. 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, updated 2016.
Protection of the human consumer for oystering	Estuarine and coastal waters	As per AWQG and Australia New Zealand Food Standards Code, Food Standards Australia New Zealand, as amended.
Protection of the human consumer	Fresh waters, estuarine and coastal waters	As per AWQG 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.
Suitability for industrial use	Fresh waters, estuarine and coastal waters	None provided. Water quality requirements for industry vary within and between industries. The AWQG do not provide guidelines to protect industries, and indicate that industrial water quality requirements need to be considered on a case-by-case basis. This EV is usually protected by other values, such as the aquatic ecosystem EV.

Environmental value	Water type/area	Water quality guideline to protect EV (refer to specified codes and guidelines for full details)
Suitability for aquaculture	Fresh waters, estuarine and coastal waters	As per: • Tables 10–12 • AWQG and Australia New Zealand Food Standards Code, Food Standards Australia New Zealand, 2007 and updates.
Suitability for irrigation	All fresh waters including groundwaters	AWQG values for pathogens and metals are provided in Tables 13 and 14. For other indicators, such as salinity, sodicity and herbicides, see AWQG.
Suitability for stock watering	All fresh waters including groundwaters	As per AWQG, including median faecal coliforms <100 organisms per 100 mL. For total dissolved solids and metals, refer to Tables 15 and 16, based on AWQG. For other indicators, such as cyanobacteria and pathogens, see AWQG.
Suitability for farm supply/use	All fresh waters including groundwaters	As per AWQG.
Suitability for primary contact recreation	Fresh waters, estuarine and coastal waters	As per NHMRC (2008), 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. • direct contact with venomous or dangerous aquatic organisms should be avoided. Recreational water bodies should be reasonably free of, or protected from, venomous organisms (e.g. box jellyfish and bluebottles) • waters contaminated with chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreational purposes.
Suitability for primary contact recreation	Fresh waters	• cyanobacteria/algae: Recreational water bodies should not contain: - level 1[1]: ≥ 10 µg/L total microcystins; or ≥ 50 000 cells/mL toxic *Microcystis aeruginosa*; or biovolume equivalent of ≥ 4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume or - level 2[1]: ≥ 10 mm^3/L for total biovolume of all cyanobacterial material where known toxins are not present or - cyanobacterial scums consistently present. Further details are contained in NHMRC (2008) and Table 17.
	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 17.
Suitability for secondary contact recreation	Fresh waters, estuarine and coastal waters	As per NHMRC (2008), including: • faecal contamination • cyanobacteria/algae (refer above and Table 17)
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;

Environmental value	Water type/area	Water quality guideline to protect EV (refer to specified codes and guidelines for full details)
		substances producing objectionable colour, odour, taste or turbidity; and substances and conditions that produce undesirable aquatic life. • cyanobacteria/algae—refer NHMRC (2008) and Table 17.

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 water quality guideline source documents include:

Australian Drinking Water Guidelines (NHMRC, 2011, as updated 2016).

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

This table outlines WQGs for water before and following treatment for use as noted. 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*, and the Australian Drinking Water Guidelines (ADWG, 2011, updated 2016). Information sources are provided in the table.

Indicator	Water quality guideline
Giardia	0 cysts (Queensland Water Supply Regulator) No guideline value set (ADWG, 2011) If *Giardia* is detected in drinking water then the health authorities should be notified immediately and an investigation of the likely source of contamination undertaken (ADWG).
Cryptosporidium	0 cysts (Queensland Water Supply Regulator) No guideline value set (ADWG, 2011) 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	Well designed treatment plants with effective barriers and disinfection are designed to address faecal contamination. *E. coli* or thermotolerant coliforms should not be present in any 100 mL sample of (treated) drinking water (ADWG).
Algal toxin	<1.3 µg/L Microcystins (ADWG 2011)
pH	6.5–8.5 (ADWG 2011)
Total dissolved solids (TDS)	<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	General [1]: The concentration of sodium in reticulated drinking water supplies should not exceed 180 mg/L (ADWG, based on threshold at which taste becomes appreciable). At-risk groups (medical): The concentration of sodium in water supplies for at-risk groups should not exceed 20 mg/L (ADWG).
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, 2011)
Pesticides	Raw supplies: Below detectable limits. Treated drinking water: Refer to ADWG.
Other indicators (including physico-chemical indicators)	Refer to ADWG.

Source: Australian Drinking Water Guidelines (NHMRC, 2011 as updated 2016).

Notes:

1. 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).

Table 10 Aquaculture EV: Water quality guidelines 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 11 Aquaculture EV: Water quality guidelines for optimal growth of particular species in fresh water

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

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

Table 12 Aquaculture EV: Water quality guidelines 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 13 Irrigation EV: Water quality guidelines for thermotolerant (faecal) coliforms in irrigation waters used for food and non-food crops

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

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

Table 14 Irrigation EV: Water quality guidelines 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) (kg/ha)	Long-term trigger value (LTV) in irrigation water (up to 100 years) (mg/L)	Short-term trigger value (STV) in irrigation water (up to 20 years) (mg/L)
Aluminium	ND[2]	5	20
Arsenic	20	0.1	2.0
Beryllium	ND	0.1	0.5
Boron	ND	0.5	Refer to AWQG, Vol 3, Table 9.2.18
Cadmium	2	0.01	0.05
Chromium	ND	0.1	1
Cobalt	ND	0.05	0.1
Copper	140	0.2	5
Fluoride	ND	1	2
Iron	ND	0.2	10
Lead	260	2	5
Lithium	ND	2.5 (0.075 for citrus crops)	2.5 (0.075 for citrus crops)
Manganese	ND	0.2	10
Mercury	2	0.002	0.002
Molybdenum	ND	0.01	0.05
Nickel	85	0.2	2
Selenium	10	0.02	0.05
Uranium	ND	0.01	0.1
Vanadium	ND	0.1	0.5
Zinc	300	2	5

Notes:

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

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

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

Table 15 Stock watering EV: Water quality guidelines for tolerances of livestock to salinity, as total dissolved solids, in drinking water

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[1]
Horses	0–4000	4000–6000	6000–7000
Pigs	0–4000	4000–6000	6000–8000
Poultry	0–2000	2000–3000	3000–4000

Notes:

1. 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 16 Stock watering EV: Water quality guidelines (low risk trigger values) for heavy metals and metalloids in livestock drinking water

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

Notes:

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

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

Table 17 Recreational waters: Alert levels and corresponding actions for management of cyanobacteria

When cyanobacteria are present in large numbers they can present a significant hazard, particularly to primary contact users of waters. Water quality guidelines for cyanobacteria in recreational waters are provided in Table 8. 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.

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).