Results Report

Townsville Dry Tropics 2017-18 Pilot Report Card

Released 24th of May, 2019

dry tropics partnership
for healthy waters

Authorship statement

The technical report of the results of the Townsville Dry Tropics 2017-2018 Pilot Report Card (released in 2019) was compiled by the Partnership's Technical Officer, Dr. Tegan Whitehead.

Input was received from the Regional Report Cards Technical Working Group (TWG) members. Some content was also based on technical reports from the Wet Tropics and Mackay-Whitsunday regional report cards.

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Executive Summary

The Dry Tropics Partnership for Healthy Waters (referred to as the Partnership) was formed in November 2017 and launched in January 2019. The Townsville Dry Tropics 2017-2018 Pilot Report Card (henceforth referred to as the Pilot Report Card) will be released in April 2019, which will mainly report on data from the 2017-2018 financial year. The Partnership aims to produce a holistic report card that provides information on the ecological condition of waterways (Biodiversity and Water) and the Community (social) and Economic benefits provided by waterways. To reflect this, the results of the report card are separated into these four reporting components (Biodiversity, Water, Community and Economy). The Pilot Report Card will provide a baseline against which future report cards can be compared.

The results presented in this document include assessments of the condition of the freshwater, estuarine/coastal, inshore marine and offshore marine environments, the value the community derives from and their perception of the condition of the Great Barrier Reef (GBR) and the non-monetary economic benefits from waterways, such as the ability to attract tourism to the region. The scores and grades for freshwater, estuarine/coastal, inshore marine and offshore marine zones are provided for the financial year of July 2017 to June 2018. Results from multiple indicators are aggregated into results for indicator categories, which are aggregated into results for indices. Confidence levels associated with the results are also provided. The indicators selected are affected by a wide range of impacts, including weather (e.g. rainfall), and these influencing impacts are briefly examined within this report.

This document is intended to be read in conjunction with the Townsville Dry Tropics Program Design.

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Terms and Acronyms

AIMS	Australian Institute of Marine Science
Artificial barriers (as an indicator)	Artificial barriers relate to any barriers which prevent or delay connectivity between key habitats which has the potential to impact migratory fish populations, decrease the diversity of aquatic species and communities and reduce the condition of aquatic ecosystems (Moore, 2016).
Basin	An area of land where surface water runs into smaller channels, creeks or rivers and discharges into a common point and may include many sub-basins or sub-catchments. For the purpose of this report card, a basin will refer to only the freshwater waterways. This is to differentiate between the freshwater waters and both freshwater and estuarine waters (which are referred to as a catchment).
Catchment	An area of land where surface water runs into smaller channels, creeks or rivers and discharges into a common point and may include many sub-basins or sub-catchments. For the purpose of this report card a catchment will refer to both freshwater and estuarine waters.
Chlorophyll *a*	Chlorophyll-*a* is an estimate of phytoplankton biomass. It is widely considered a useful proxy to measure nutrient availability and the productivity of a system.
Climate	In the context of the report card, climate refers to both natural climate variability and climate change.
CVA	Conservation Volunteers Australia
DES	Department of Environment and Science
DIN	Dissolved Inorganic Nitrogen
DO	Dissolved Oxygen
DSITI	Department of Science Information Technology and Innovation Queensland
DTPHW	Dry Tropics Partnership for Healthy Waters
Ecosystem	A dynamic complex of animal (including humans), plant and microorganism communities and their non-living environment interacting as a functional unit.
Enclosed Coastal (EC)	An enclosed coastal (EC) water body includes shallow, enclosed waters near an estuary mouth and extends seaward towards deeper, more oceanic waters further out. The seaward limit of the enclosed coastal water body is the cut-off between shallow, enclosed waters near the estuary mouth and deeper, more oceanic waters further out (Great Barrier Reef Marine Park Authority (GBRMPA), 2010)..
FRP	Filterable Reactive Phosphorus
GBR	Great Barrier Reef
GBR Report Card	Great Barrier Reef Report Card developed under the Reef Water Quality Protection Plan (2013).
GBRMPA **GBRMP**	Great Barrier Reef Marine Park Authority Great Barrier Reef Marine Park
GV	Guideline Value
Impoundment	An indicator used in the 'in-stream habitat modification' indicator for

length	freshwater basins in the region. This index reports on the proportion (%) of the linear length of the main river channel when inundated at the Full Supply Level of artificial in-stream structures, such as dams and weirs.
Index	Is generated by one or more indicator categories (e.g. coral, seagrass and fauna are indicator categories of the index flora and fauna).
Indicator	A measure of one component of an indicator category (e.g. coral composition (indicator) is a measure of coral (indicator category).
Indicator category	Is generated by one or more indicators (e.g. coral is comprised of coral composition, change in coral cover, juvenile density, macroalgae cover and coral cover).
Inshore marine environment	Includes enclosed coastal (EC), open coastal (OC) and midshelf (MS) waters, extending east to the boundary with the offshore waters **Invalid source specified.**. The boundary is based on the delineation guidelines for the Burdekin (which includes the Townsville Dry Tropics region) and the Wet Tropics region. Waters north of Pelorus Island are based on the guidelines for the inshore boundary for the Wet Tropics region.
Inshore marine zone	Inshore marine zone is a reporting zone in the Townsville Dry Tropics report card that includes enclosed coastal, midshelf and open coastal waters.
ISP	Independent Science Panel
JCU	James Cook University
Midshelf waters	Midshelf waters are from 12 to 48 km offshore in the Burdekin region (waters south of approximately Pelorus Island) and 6 to 24 km offshore in the Wet Tropics region (waters north of Pelorus Island) (GBR, 2010).
NQDT	North Queensland Dry Tropics
NRM	Natural resource management
OGBR	Office of the Great Barrier Reef
Open coastal (OC)	Open coastal waterbodies being at the seaward limit and extends 12 km offshore in the Burdekin region (waters south of approximately Pelorus Island) and 6 km offshore in the Wet Tropics region (waters north of Pelorus Island) (GBR, 2010).
Physical-chemical properties (phy-chem)	The physical-chemical indicator category that includes two indicators: dissolved oxygen (DO) and turbidity.
QA/QC	Quality Assurance / Quality Control
RIMREP	Reef 2050 Integrated Monitoring and Reporting Program
Riparian Extent (as an indicator)	An indicator used in the assessments of both freshwater and estuarine zones. This indicator uses mapping resources to determine the extent of the vegetated interface between land and waterways in the region.
SF	Scaling factor
Standardised condition score	The transformation of indictor scores into the Wet Tropics Report Card scoring range of 0 to 100.
TN	Total nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids

Flow (as an indicator)	Flow relates to the degree that the natural river flows have been modified in the region's waterways.
LTMP	Long Term Monitoring Program
Macroalgae (cover)	An indicator used in part to assess coral health. Macroalgae is a collective term used for seaweed and other benthic (attached to the bottom) marine algae that are generally visible to the naked eye.
MMP	Marine Monitoring Program: the Great Barrier Reef Marine Park Authority's Marine Monitoring Program.
NOx	Oxidised Nitrogen
Offshore waters	Offshore waters extend 48 to 180 km in the Burdekin region (waters south of approximately Pelorus Island) and 24 to 170 km offshore in the Wet Tropics region (waters north of Pelorus Island) (GBR, 2010).
Offshore zone	Offshore is a reporting zone in the Townsville Dry Tropics report card that includes offshore waters.
Overall Score	The overall scores for each reporting zone used in the report card are generated by an index or an aggregation of indices.

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1 Introduction

1.1 Overview

The Dry Tropics Partnership for Healthy Waterways (referred to as the Partnership) was founded in November 2017, with technical work beginning in late May 2018 and the Partnership launched in January 2019. A focus of the Partnership is to produce an annual report card on the condition of Water and Biodiversity. Water and biodiversity are two main ecological components of waterways (Cork, et al., 2007). The report card also presents information on the state of the social and economic benefits that the community derives from waterways. 'Water' comprises indicators of water quality and quantity, whilst 'Biodiversity' refers to all ecological components that are directly associated with or supported by waterways (e.g. wetlands, riparian habitat, wader birds etc.). Community benefits are the social and cultural benefits derived from waterways, excluding economic benefits. Economic benefits are the monetary benefits industries derive from healthy waterways and also non-monetary economic benefits, such as the ability to attract tourists to the region. Different indicators are measured and reported on to provide the overall scores for Water, Biodiversity, Community and Economy. It is noted that not all indicators will be scored in the Pilot Report Card due to data gaps or no current methodology for scoring indicators.

1.2 Pilot Report Card reporting zones

The results presented in the Pilot Report Card are divided into four environments (freshwater, estuarine/coastal, inshore marine and offshore marine). These four environments collectively cover seven zones. The zones are:

- two freshwater zones, called Ross Basin and Black Basin
- two estuary/coastal zones, called Ross estuary/coastal zone and Black estuary/coastal zone
- two inshore marine zones, called Cleveland Bay inshore marine zone (referred to as Cleveland Bay) and Halifax Bay inshore marine zone (referred to as Halifax Bay)
- one offshore marine zone

The reporting area for the Townsville Dry Tropics is shown in Figure 1.

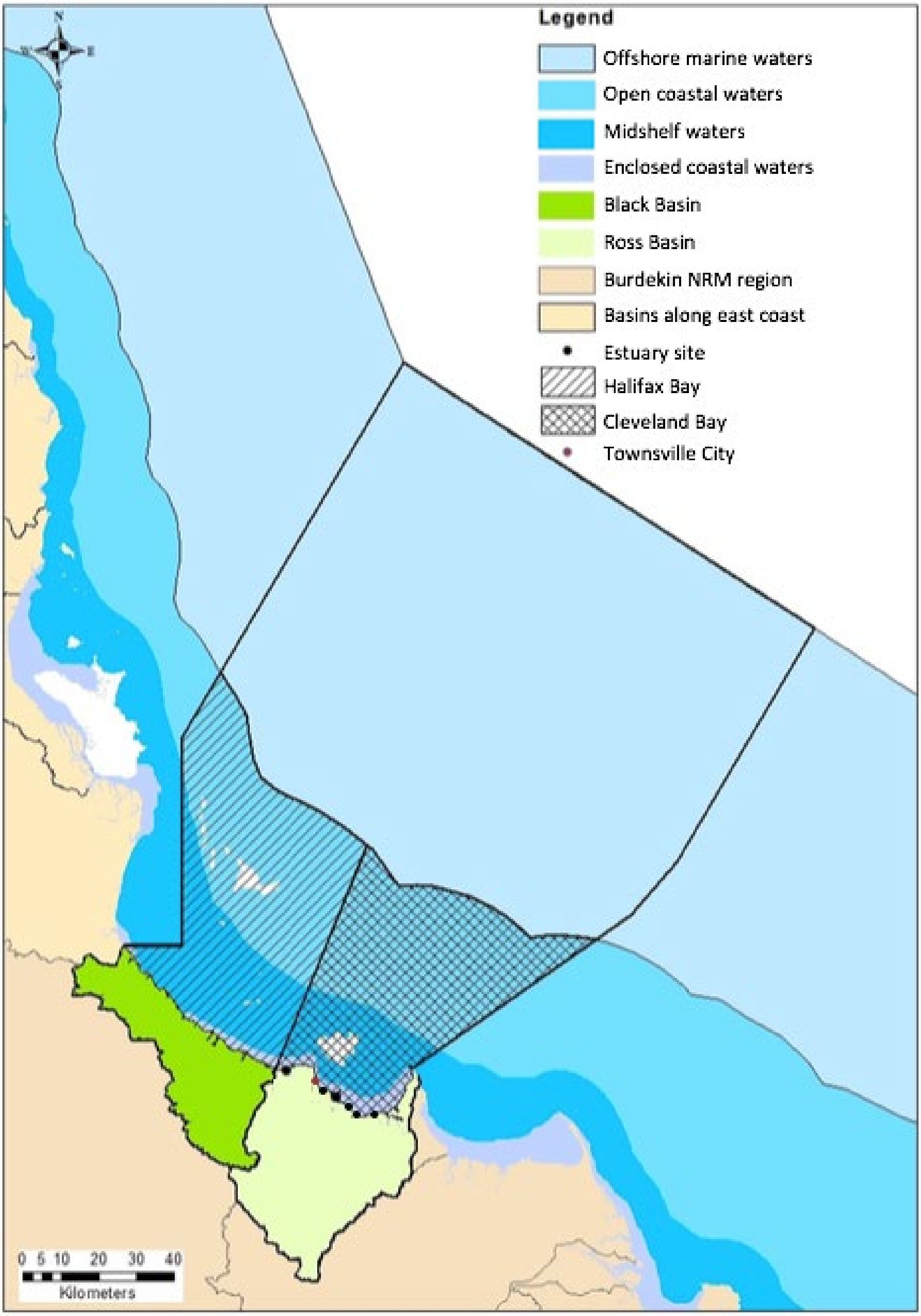


Figure 1. Geographic boundary reported upon by the Dry Tropics Partnership, comprising the Ross and Black basins, estuarine/coastal zones, Cleveland Bay and Halifax Bay inshore marine zones and the offshore marine zone. The inshore marine zones comprise open coastal, midshelf and enclosed coastal waters. The right angle in the offshore marine zone is the boundary of the Hinchinbrook Planning area.

1.3 Purpose of this document

The purpose of this document is to provide detailed results on the condition of freshwater basins, estuarine/coastal, inshore marine and offshore marine environments within the Townsville Dry Tropics region. This document presents scores and grades for indicators, indicator categories, indices, and overall scores for Water, Biodiversity, Community and Economy within each zone. The associated confidence scores with the results are also presented.

This document supports the Pilot Report Card, which will be released in April 2019 and will provide a summary of the results. For further details on the design of the Pilot Report Card program, including reporting zones and reasoning for selecting the indicators, refer to the Townsville Dry Tropics Program Design.

2 Methods

Unless otherwise specified, the methods used are the same as those used by the Wet Tropics and Mackay-Whitsunday regional report cards. The methods used by these regions are outlined in Wet Tropics Healthy Waterways Partnership (2018) (https://wettropicswaterways.org.au/wp-content/uploads/2017/11/WTHWP-Program-design-Report-Card-2017.pdf) and Mackay-Whitsunday Healthy Rivers to Reef Partnership (2017). A brief overview of the scoring methods and confidence measures are outlined below. A report detailing the methods for the Townsville Dry Tropics will be finalised later in 2019.

2.1 Terminology

Different indicators are measured to assess water quality, the condition of biodiversity and the state of community and economic benefits. The indicators that measure a similar aspect of the condition of the environment are grouped together and their scores are aggregated multiple times to produce an overall score for Water, Biodiversity, Community and Economy.

The levels of aggregation are:

- **Indicator** is a measured variable (e.g. coral cover)
- **Indicator category** is a group of similar indicators (e.g. coral, which is aggregated from indicators of coral). Where an indicator category is represented by a single indicator, the indicator category score is equal to the indicator
- **Index or indices** is an aggregation of indicator categories (e.g. freshwater habitat is an aggregation of wetland and riparian extent)
- **Overall score** is generated by the aggregation of indices (Water and Biodiversity) or benefit (Community and Economic)

The score for indices of Biodiversity, Water, Community and Economy will be presented in the coaster, as shown in Figure 2. Presentation of the coasters in the report card can be with or without the two outer rings (indicators and indicator categories). The results for each environmental and benefit will be presented in one coaster for each zone. This ensures the results are succinctly presented and Biodiversity, Water, Community and Economy are given equal representation in the report card. However environmental, social and economic scores will not be aggregated.

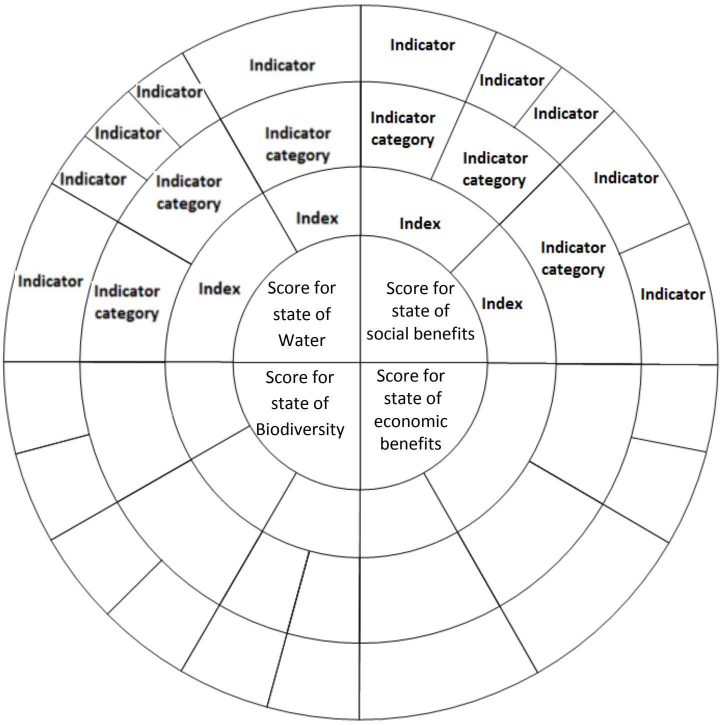


Figure 2. Terminology for defining the levels of aggregation for indicators and how they are displayed in the report card.

2.2 Data used in the Pilot Report Card

The Pilot Report Card mainly reports on data collected during the 2017-2018 financial year (1 July 2017 to 30 June 2018). However, there are a few exceptions. Within the Biodiversity index, the remote sensing data for the indicators of riparian, wetland, mangrove and saltmarsh extent is only updated every four years (due for updating in the 2018-19 Report Card). For these indicators the results presented in this document are from July 1st 2013 to June 30th 2014. Additionally, the results for offshore coral indicators are averaged using a four-year rolling mean (although indicators of coral condition are measured each year).

3 Drivers impacting upon the Townsville Dry Tropics

Climate change and extreme weather, land use, consumerism, urban lifestyles and economic growth are the key drivers that impact upon the condition of the waterways within the Townsville Dry Tropics region. Climatic and extreme weather events that occurred between July 1 2017 and June 30 2018 are outlined below.

3.1 Rainfall

The amount of rainfall within a catchment can influence the amount of nutrients and sediments washed into waterways (Department of Environment and Science, 2018). This is especially applicable to the urban environment, where stormwater drains channel water straight into the waterways (Department of Environment and Science, 2018). As seen in Figure 3, during 2017-18, the Black and Ross catchments respectively received 102% and 92% of the mean long-term rainfall for the Townsville region (Bureau of Meteorology (BOM), 2018b). However, there were only four months (October and November 2017 and February and March 2018) where the region experienced higher than average monthly rainfall (see Figure 4 and Figure 5) (BOM, 2018b). The region was in drought (which started in 2013-14) until March 2018 (BOM, 2018b), with level 3 water restrictions in place throughout the region (level 3 water restrictions only allow hand watering between 6-7am and 6-7pm twice a week) (Townsville City Council, 2018). The Ross River Dam (major drinking water supply) fell to 15% in early March 2018 and water from the Burdekin River was pumped into the Dam (Townsville City Council, 2018). In March 2018, the region experienced heavy rains, with some regions (e.g. Rollingstone) recording over 200 mm in 24 hours (BOM, 2018b). The Dam levels rose to above 90% in April 2018 and water restrictions were eased to level 2 (sprinklers allowed for 2 hours twice a week) (Townsville City Council, 2018).

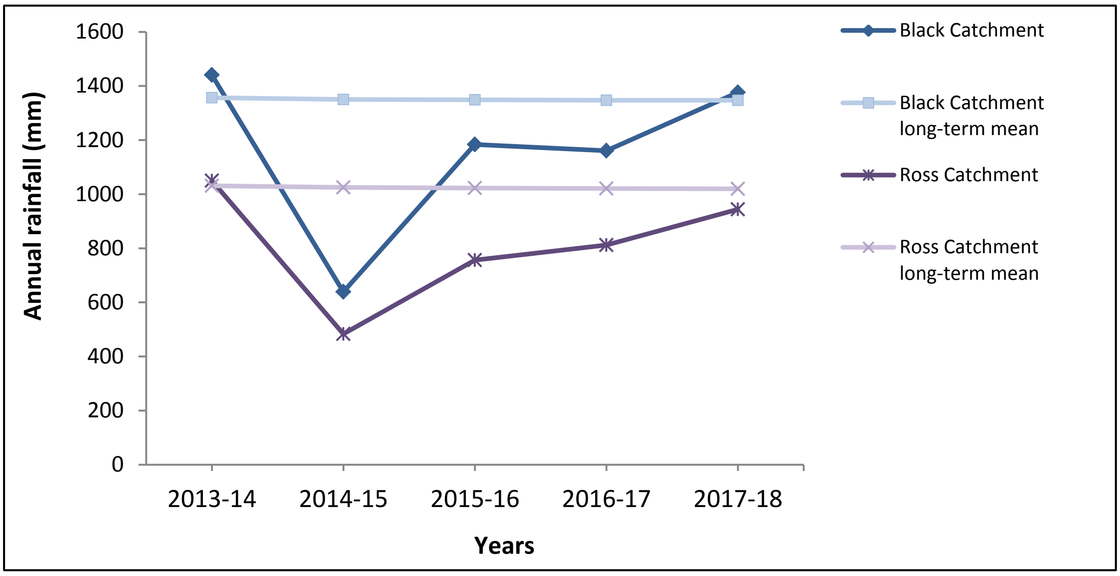


Figure 3. Total annual rainfall across the Townsville Dry Tropics during the 2017-18 reporting period compared to the previous four years and the long-term mean.
Source: Graph compiled from data sourced from the Bureau of Meteorology (2018a).

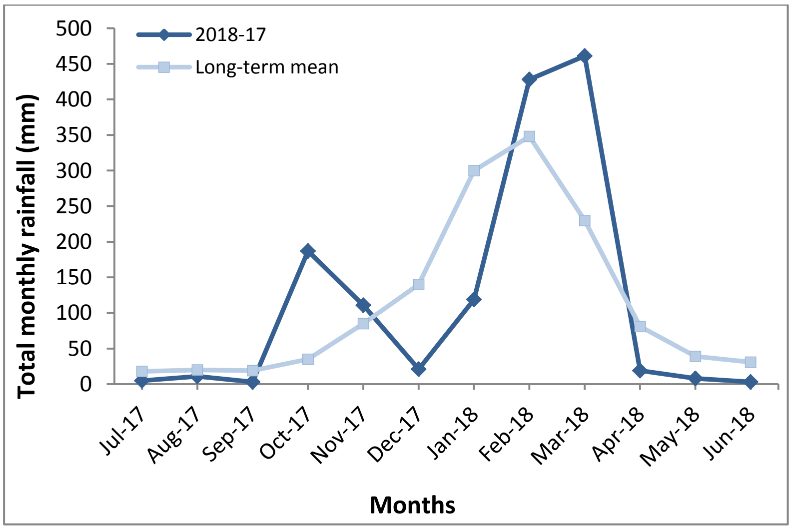


Figure 4. Total monthly rainfall across the Black Catchment during the 2017-18 reporting period compared to the long-term mean.
Source: Graph compiled from data sourced from the Bureau of Meteorology (2018a).

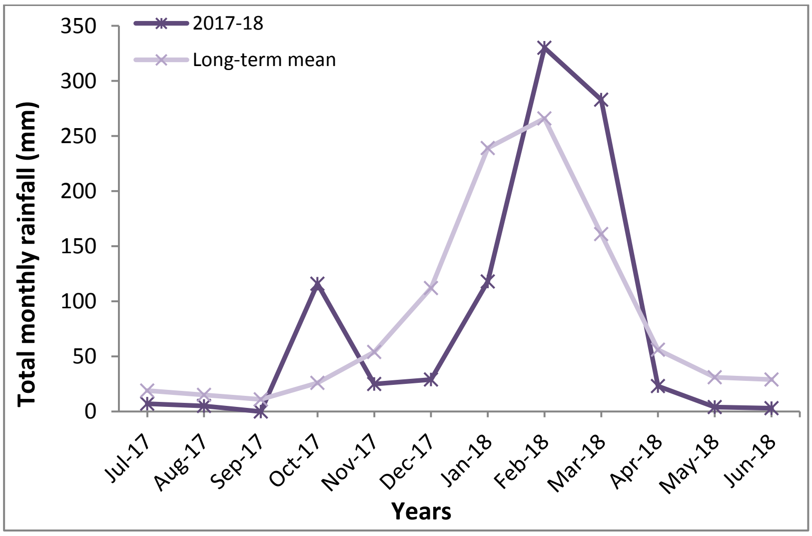


Figure 5. Total monthly rainfall across the Ross Catchment during the 2017-18 reporting period compared to the long-term mean.
Source: Graph compiled from data sourced from the Bureau of Meteorology (2018a).

3.2 Ground cover within grazing/forested areas in the late dry season

Ground cover can have a substantial impact upon water quality, with poorly vegetated areas often having higher erosion and runoff rates than vegetated areas (Zuazo & Pleguezuelo, 2008). As of 2016, in the late dry season grazing areas had over 80% groundcover which was similar cover to the long-term average (see Table 1). In 2016, the amount of ground cover that met the minimum target level of >70% cover during the dry season had reduced from 10% (26 year mean) to 4% (2016) in the Black Basin and from 15% (26 year mean) to 7% (2016) within the Ross Basin. This change is shown in Table 1 and Figure 6. (Note that the urban/developed areas are not included in calculation of mean ground cover in Table 1 or reported in Figure 6).

Table 1. Ground cover within grazing/forested areas in the late dry season in the Black and Ross catchments (including the freshwater basins and estuarine areas). The minimum target level for ground cover is >70% cover.

Basin	29-year-mean ground cover (%)	2016 mean ground cover (%)	Area (%) that met the minimum target level for ground cover averaged over the last 29 years.	Area (%) that met the minimum target level for ground cover in 2016.
Black	87	89	10	4
Ross	83	86	15	7

Source: Department of Science, Information Technology and Innovation (DSITI), (2017).

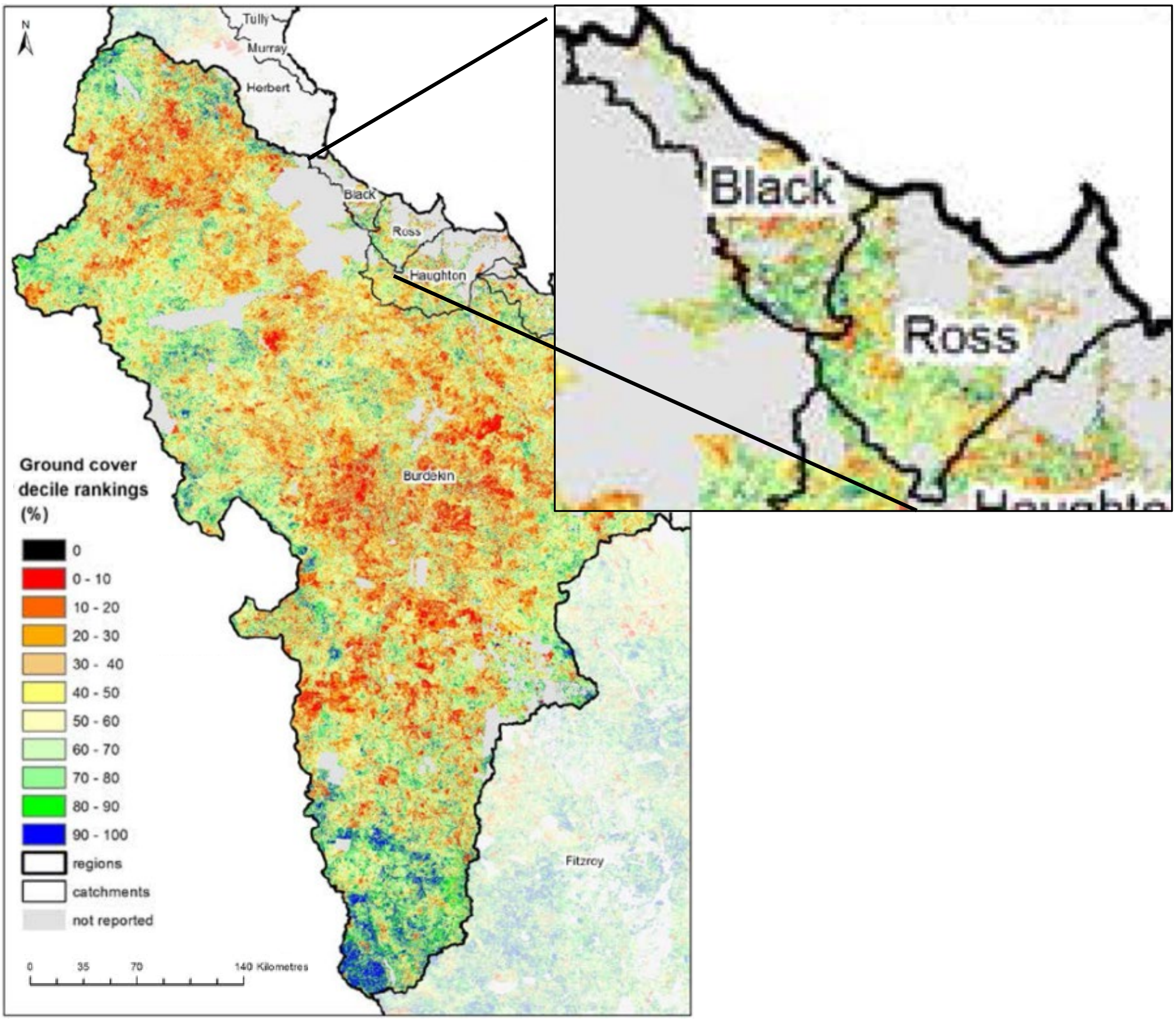


Figure 6. Burdekin region ground cover decile rankings, with a highlight of the Black and Ross catchments. This map shows spring 2016 ground cover in comparison to the long-term spring cover (1988–2012 baseline). The lowest decile (red) indicates where ground cover was at the lowest level relative to the baseline period, and the highest decile (blue) indicates where ground cover was at the highest level relative to the baseline period.

Source: Graph adapted from the Department of Science, Information Technology and Innovation (DSITI), (2017).

3.3 Runoff

A large proportion of the Ross and Black catchments are developed as urban or peri-urban (NQ Dry Tropics, n.d.). Urban areas often have high runoff due to much of the catchment comprising impermeable surfaces (Miller, et al., 2014). This increases the quantity of surface flows, the peak flows within rivers, flood duration and flood height (Miller, et al., 2014). Surface runoff is a key component of the terrestrial hydrological cycle (Kuchment, 2004) and thus an important aspect to assess.

Runoff from the Black Catchment was 112% above the long-term mean, with the catchment experiencing runoff totals of more than 500 mm (BOM, 2018a). In contrast, the Ross Catchment was 72% below the long-term annual mean average (BOM, 2018a), with 43.1% of the Ross Catchment having less than 200 mm runoff (BOM, 2018a). As seen in Figure 7 and Figure 8, the five-year trend in runoff from the Black and Ross catchments reflects the trend in rainfall, with most of the runoff coinciding with the high rainfall events in October 2017 and February and March 2018.

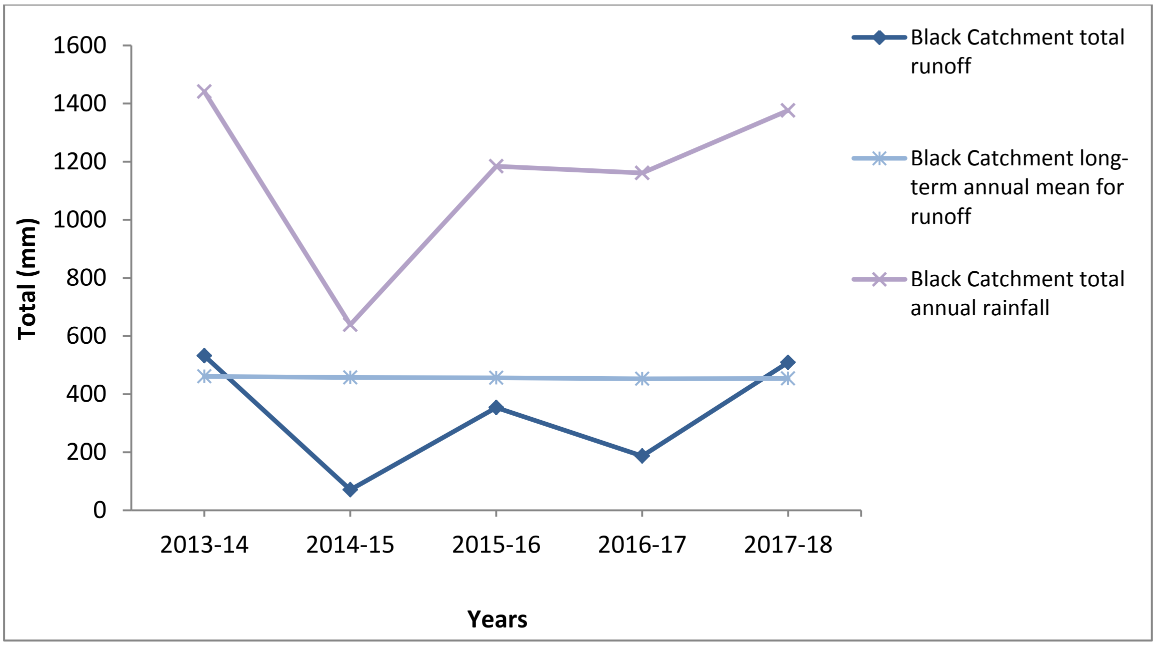


Figure 7. Total annual runoff across the Black Catchment during the 2017-18 reporting period compared to the previous four years, the long-term annual mean for runoff and the total annual rainfall.
Source: Graph compiled from data sourced from the Bureau of Meteorology (BOM) (2018a).

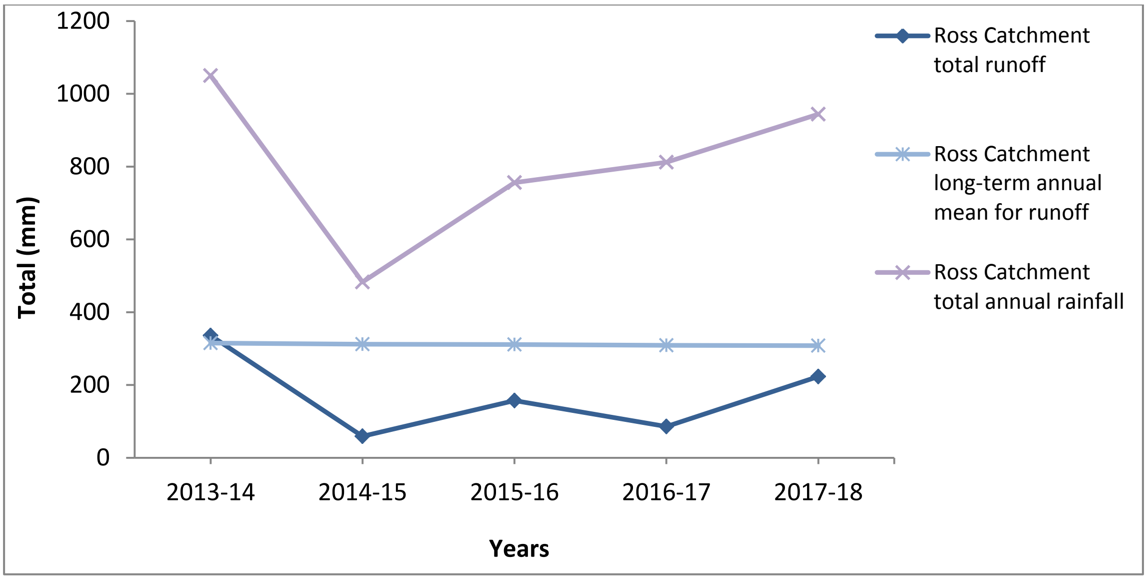


Figure 8. Total annual runoff across the Ross Catchment during the 2017-18 reporting period compared to the previous four years, the long-term annual mean for runoff and the total annual rainfall.
Source: Graph compiled from data sourced from the Bureau of Meteorology (BOM) (2018a).

3.4 Climate change

Climate change is one of the major factors driving the current condition of the environment (Jackson & Rankin, 2016). The interactions between climate change and UV radiation can have large, substantially negative impacts upon the health of certain species within freshwater and marine ecosystems (Häder, et al., 2011) due to feedback between temperature, UV radiation and greenhouse gas concentrations (Häder, et al., 2015). Between 2014 and 2017 there was a three-year global coral bleaching event, where some reefs experienced bleaching each year (National Oceanic and Atmospheric Administration, 2018). Mass bleaching was caused by extended periods of extreme sea surface temperatures and coincided with a strong El Nino in 2015-16, which spread and worsened the bleaching (Eakin, et al., 2016). Globally this resulted in more than 75% of all tropical reefs experiencing bleaching, with bleaching being fatal for almost 30% of reefs (NOAA, 2018). Bleaching occurred in several reef regions that had never bleached before, including reefs in the northernmost Great Barrier Reef (GBR) (NOAA, 2018).

Since 2014, sea surface temperatures in Australia have been ≥0.49^{o} above the long-term average (BOM, 2018c). Between July 1st 2015 and June 30th 2016, sea temperatures were the highest on record (0.78^{o} above the average) (BOM, 2018c). Consistently high sea surface temperatures within the GBR Marine Park resulted in widespread and severe bleaching (Australian Institute of Marine Science (AIMS), 2018). In 2016, coral mortality (as of June 2016) was estimated at 22% of the entire GBR (AIMS, 2016). Bleaching was more widespread and intense between Cape York and Port Douglas, with more than 60% coral communities bleaching within this area, as shown in Figure 9 (AIMS, 2016). The intensity of the bleaching declined along a southerly gradient, with bleaching intensity varying from 10% to 90% (AIMS, 2016). In 2017, the spatial pattern of bleaching shifted, with bleaching focused on the central reefs between Port Douglas and Ayr, as shown in Figure 9. The back-to-back bleaching events of 2016 and 2017 affected two-thirds of the GBR (AIMS, 2016). Although the coral bleaching is outside of the 2017-18 reporting period, the bleaching is likely to impact the results for inshore and offshore coral.

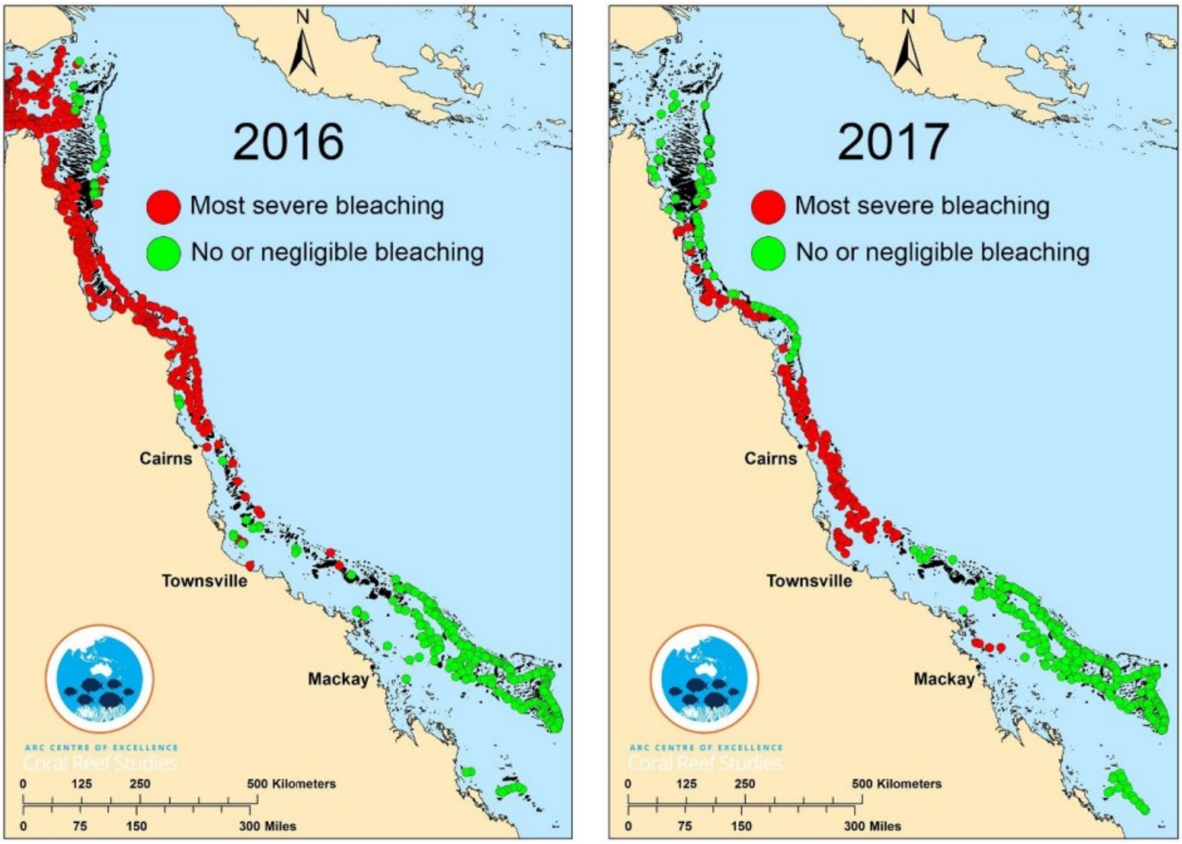


Figure 9. Composite map of coral reefs surveyed across the 2016 and 2017 bleaching events. Only reefs at either end of the bleaching spectrum are shown. Red circles indicate reefs undergoing the most severe bleaching (≥60% of corals visible to aerial surveys bleaching), whilst green circles indicate reefs with no or only minimal bleaching (10% or less of corals bleaching).

Source: Thompson, et al., (2018)

4 Methods for scoring Biodiversity and Water indicators

4.1 Scoring categories

Indicators are scored using five ordinal values commonly used in report cards:

'A' (Very Good), 'B' (Good), 'C' (Moderate), 'D' (Poor) and 'E' (Very Poor) (as shown in Table 2).

Each indicator is scored on a specific scale that is appropriate for the variable being measured. Hence, different indicators may have different scoring ranges. To ensure results for all indicators are comparable, all scores are converted (if required) into a 'standardised' score. The standardised score has a scoring range of between 0 and 100, as shown in Table 2. The standardised scores include decimal places to allow grades to be differentiated. For example, 80.9 is classified as Good, whilst 81 is Very Good). In the summary tables and in the report cards, the scores are presented as integers for simplicity of results.

Scores for each indicator are aggregated into an indicator category, then into an index and an overall score. Scores can only be aggregated to the next level (i.e. from an indicator category to an index) if they meet the 'minimum information rules for aggregating data'. These rules are:

1. ≥50% of indicators are required to aggregate to an indicator category
2. ≥60% of indicator categories are required to aggregate to an index

The grades for each indicator category and index are presented in a coaster to visually show which components contribute to the overall grade.

The scores of indicators, indicator categories, indices and the overall scores are represented by colours (dark green indicates a "Very Good" score, light green indicates "Good", yellow indicates "Moderate", orange indicates "Poor" and red indicates "Very Poor"). The standardised scoring range for Water and Biodiversity indicators and indicator categories are shown in Table 2.

Table 2. Standardised scoring range and corresponding grade for Water and Biodiversity indicators and indicator categories.

Scoring range	Grade and colour code
81 to 100	Very Good
61 to <81	Good
41 to <61	Moderate
21 to <41	Poor
0 to <21	Very Poor

The detailed methods to convert the raw habitat data to standardised scores are outlined in Wet Tropics Healthy Waterways Partnership (2018) (https://wettropicswaterways.org.au/wp-content/uploads/2017/11/WTHWP-Program-design-Report-Card-2017.pdf) and Mackay-Whitsunday Healthy Rivers to Reef Partnership (2017). The methods document for the Dry Tropics is currently being compiled.

4.2 Confidence measure

The Pilot Report Card includes a qualitative confidence measure for each score for the indicator categories within Water and Biodiversity. The confidence is based on the accuracy of the data used in the analysis. Confidence scores range from 4.5 to 13.5, with the score calculated using five criteria, which are listed in Table 3. Each category is weighted according to its importance, with this weighting also shown in Table 3. Each criterion is assigned a confidence ranking from 1 (low) to 5 (high). The definitions for each criterion and more detailed methods for measuring confidence are presented in page 99 of the Methods for the Mackay-Whitsunday 2016 Report Card (Mackay-Whitsunday Healthy Rivers to Reef Partnership, 2017).

Table 3. Criteria and weighting used to generate the confidence score for the indicator categories within Water and Biodiversity.

Criteria	Weighting
Maturity of Methodology	0.36
Validation	0.71
Representativeness	2
Directness	0.71
Measured error	0.71

The weighting for each criterion may change from the weighting listed in Table 3. A review of the weighting for the representativeness criterion is being undertaken. The Townsville Dry Tropics is a smaller area than the other regions, with each monitoring site thus representing a greater proportion of each reporting zone compared to monitoring sites within the other regions. The high weighting of 2 for the representativeness criterion is likely to be inappropriate for the Townsville Dry Tropics region. Additionally, it is proposed that an additional criterion is developed based on the proportion of indicators scored. This would make the confidence scores more transparent in acknowledging how many indicators are scored.

5 Biodiversity results

The score for Biodiversity is based on indicators that are grouped into the following indicator categories:

- Flora and fauna, artificial barriers and gross pollutants for the two freshwater basins (Ross and Black Basin) and two estuarine/coastal zones (Ross and Black estuarine/coastal zone)
- Flora and fauna and gross pollutants for Cleveland Bay and Halifax Bay inshore marine zones and one marine offshore zone.

For the Pilot Report Card, one or two indicator categories of the flora and fauna index could be scored for each zone (as shown in Table 4). The indicator categories and indices aggregated in the Pilot Report Card are highlighted in Table 4. Due to the minimum rules for aggregating, an overall score for Biodiversity could not be generated.

There was no data and/or scoring method for the other indicators of flora and fauna or for the indicators of artificial barriers and gross pollutants. Data will be collected and scoring methods for these indicators will be developed for future reports.

Table 4. Indices and indicator categories aggregated to generate an overall score for Biodiversity. The indices and indicator categories that are scored in the Piot Report Card are highlighted.

Zone	Index	Indicator category
Freshwater	Flora & fauna	Riparian vegetation
		Wetlands
		Fauna
	Artificial barriers	Fish barriers
		Impoundment length
	Gross pollutants	Plastic bottles and drink bottles
		Straws and plastic cutlery
		Plastic
		Cigarette butts
		Total rubbish (excluding previous categories)
Estuary/coast	Flora & fauna	Saltmarsh
		Mangroves
		Fauna
	Artificial barriers	Fish barriers
	Gross pollutants	Plastic bottles and drink bottles
		Straws and plastic cutlery
		Plastic
		Cigarette butts
		Total rubbish (excluding previous categories)
Inshore marine	Flora & fauna	Coral
		Seagrass
		Fauna
	Gross pollutants	Plastic bottles and drink bottles
		Straws and plastic cutlery
		Plastic
		Cigarette butts
		Total rubbish (excluding previous categories)
Offshore marine	Flora & fauna	Coral
		Fish
	Gross pollutants	Plastic bottles and drink bottles
		Straws and plastic cutlery
		Plastic
		Cigarette butts
		Total rubbish (excluding previous categories)

5.1 Freshwater basins

5.1.1 Data source

Data on riparian extent and wetland extent were prepared by the Queensland Herbarium, using data obtained through Google Earth and the Queensland Herbarium's Regional Ecosystem (version 9) mapping (Neldner, et al., 2017). These data are updated every four years, with the latest available data comparing pre-European levels with 2013 (Neldner, et al., 2017). The next available update will be released in 2019 and will be reported on for the 2018-19 Report Card.

Mapping of pre-clearing vegetation is based on the interpretation of landscape primarily as depicted on aerial photographs, with a range of other information including satellite imagery and other land resources survey and mapping. The imagery has been ground-truthed at a number of known points, which although may be representative at a state (Queensland) scale, is not representative at a local scale. "Where vegetation has already been cleared on these aerial photographs, the pre-clearing vegetation may be reconstructed by the botanist using landform, soils, geology, field data and ecological knowledge. Field data from adjacent or nearby remnant vegetation and isolated trees, and patches of remnant vegetation and regrowth within cleared areas are collected and also used to attribute the vegetation types occurring in cleared areas. In addition, historical survey records of vegetation types and older aerial photographs (if they exist) are used extensively in this reconstruction. Experience has shown that wherever investigations by Herbarium officers have assessed surveyors' records from the early 1920s and earlier, the vegetation boundaries shown in these records have been the same as, or very similar to, the vegetation boundaries that exist on the 1960s and current aerial photography" (Neldner, et al., 2017).

Although this method is applicable across broad areas (e.g. state level), within highly urbanised and relatively small regions, such as the Townsville Dry Tropics, this method may not be appropriate. Additionally, large areas of land have been cleared in Queensland (and throughout Australia) pre-1960 (Bradshaw, 2012). For example, in the 1920s, large developments occurred within Townsville, including bulk iron ore being exported from Townsville and the construction of major roads, the Hubert's Well Power Station and Aplins weir (Townsville City Council, n.d.). The area of pre-European habitat extent within the Townsville Dry Tropics would therefore be higher than the area based on the 1960s maps (as the 1960s maps include areas of substantial development and clearing). This means that the proportion of current habitat remaining compared to pre-European extent levels are likely to be higher than actual. This will result in the habitat extent scores being better (a higher score) than appropriate. It is proposed that in future report cards, the current habitat extent will be compared to a more recent baseline to resolve this problem.

5.1.2 Results

Riparian extent and wetland extent are the two indicators measured within the freshwater zone for the flora and fauna index. Riparian extent is vegetation with a 50 m buffer from a watercourse. Palustrine wetlands are vegetated, non-riverine or non-channel systems that include billabongs, swamps, bogs, springs, soaks etc. and have more than 30% emergent vegetation (Department of Environment and Science, 2013). The results and confidence scores are presented below. The scores for riparian extent and wetland extent were aggregated to produce an overall score for the flora and fauna index.

Overall, the flora and fauna index for Ross Basin was in a moderate state, whilst the Black Basin was in good state. The riparian extent in the Black Basin was in a very good state, however riparian extent scored very poorly in the Ross Basin, as shown in Table 5. This is unsurprising given the high level of urban development along waterways within the Ross Basin (as seen in Figure 10 in section 6.3). Wetland extent was classified as good within the Ross Basin and moderate within the Black Basin (Table 5).

Table 5. Scores and grades for riparian vegetation, wetlands and flora and fauna for the Ross and Black basins. The percent (%) loss and remaining based on 2013 levels is compared to pre-European levels. Flora and fauna scores are averages of the scores for riparian and wetland extent.

Freshwater zone	Raw data (2013 data)		Standardised score			Grade for indicator categories		
	Riparian extent (2013 data)	Wetland extent (2013 data)	Riparian extent	Wetland extent	**Flora & fauna index**	Riparian vegetation	Wetlands	**Flora & fauna index**
Ross Basin	61% lost 39% remaining	10% lost 90% remaining	16	71	**44**	E	B	**C**
Black Basin	5% lost 95% remaining	21% lost 79% remaining	81	53	**67**	A	C	**B**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good = 81 – 100 | ■ No score/data gap.

5.1.3 Confidence scores

There was a very low confidence in the results for riparian and wetland extent respectively. The scores used to generate this ranking are presented in Table 6. Riparian and wetland extent is based on GIS mapping, with no ground truthing/field surveying occurring to verify these results. Additionally, the data used is from 2013. The four year lag in results potentially impacting upon the results, especially given that clearing continues to occur within both the Ross and Black basins. Riparian and wetland extent as of 2018 will be included in the results of the 2018-19 Report Card.

Table 6. Confidence scores for riparian and wetland extent for both the Ross and Black basins. Confidence criteria are scored 1-3, weighted by the value identified in parenthesis and summed to produce a final (weighted) score (4.5 – 13.5). Final scores rank from 1 to 5 (very low to very high).

	Maturity (0.36)	Validation (0.71)	Representa-tiveness (2)	Directness (0.71)	Measured error(0.71)	Final score	Rank
Riparian extent	1	2	1	1.5	2	6.2	Very low (1)
Wetland extent	1	2	1	1.5	2	6.2	Very low (1)

Rank based on final score: Very low (1): 4.5 – 6.3; Low (2): >6.3 – 8.1; Moderate (3): >8.1 – 9.9; High (4): >9.9 – 11.7; Very high (5): >11.7 – 13.5.

5.2 Estuary/coastal zone

5.2.1 Data source

Data on mangrove extent and saltmarsh extent were prepared by the Queensland Herbarium, using data obtained through Google Earth and the Queensland Herbarium's Regional Ecosystem (version 9) mapping. These data are updated every four years, with the latest available data comparing pre-European levels with 2013. The next available update will be released in 2019 and will be reported on for the 2018-19 Report Card. As discussed in section 5.1.1, habitat extent is based on 1960 maps and scores are likely to be higher than accurate.

5.2.2 Results

Mangrove extent and saltmarsh extent are the two indicators measured within the estuarine/coastal zone. The score for mangrove and saltmarsh extent were aggregated to produce an overall score for the flora and fauna index.

Overall, flora and fauna received a good score within the Ross estuarine/coastal zone, as shown in Table 7. Mangrove and saltmarsh extent were in a good and very good state respectively. Flora and fauna within the Black estuarine/coastal zone was in a very good state, mangrove extent was very good and saltmarsh extent was good.

Table 7. Scores and grades for mangrove, saltmarsh and flora and fauna for the Ross and Black estuarine/coastal zones. Flora and fauna scores are averages of the scores for mangrove and saltmarsh extent.

Estuarine/ coastal zone	Raw data		Standardised score			Grade for indicator categories		
	Mangrove extent	Saltmarsh extent	Mangrove extent	Saltmarsh extent	**Flora & fauna index**	Mangrove	Saltmarsh	**Flora & fauna index**
Ross estuarine/ coastal zone	6% loss 94% remaining	5% loss 95% remaining	79	81	**80**	B	A	**B**
Black estuarine/ coastal zone	1% loss 99% remaining	8% loss 92% remaining	96	75	**86**	A	B	**A**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good = 81 – 100 | ■ No score/data gap.

5.2.3 Confidence scores

There was a moderate confidence in the results for mangrove and saltmarsh extent, with the overall rank and the scores for each confidence criterion presented in Table 8. Mangrove and saltmarsh scores are based on GIS mapping, with no field verification, resulting in the measured error and maturity of method criteria receiving a low rank (1) (Table 8).

Table 8. Confidence scores for mangrove and saltmarsh extent for both the Ross and Black estuary/coastal zone. Confidence criteria are scored 1-3, weighted by the value identified in parenthesis and summed to produce a final (weighted) score (4.5 – 13.5). Final scores rank from 1 to 5 (very low to very high).

	Maturity (0.36)	Validation (0.71)	Representativeness (2)	Directness (0.71)	Measured error (0.71)	Final score	Rank
Mangrove extent	1	2	2	2	1	7.9	Moderate (3)
Saltmarsh extent	1	2	2	2	1	7.9	Moderate (3)

Rank based on final score: Very low (1): 4.5 – 6.3; Low (2): >6.3 – 8.1; Moderate (3): >8.1 – 9.9; High (4): >9.9 – 11.7; Very high (5): >11.7 – 13.5.

5.3 Inshore marine

Coral and seagrass are the two indicator categories that comprise the flora and fauna index for Cleveland Bay and Halifax Bay inshore marine zones.

5.3.1 Data source

5.3.1.1 Coral

Inshore coral data within the Dry Tropics inshore marine zone was collected from eight reefs by the MMP. MMP has a biennial sampling design, meaning all reefs are sampled over a two year period (not every monitored reef is sampled every year). Since some reefs will have been surveyed last in the preceding year, the values for each reporting year are effectively a 2-year rolling mean. The data included in the Pilot report card was collected over the period May 2016 to July 2018. Coral community structure and exposure to disturbances differ markedly with depth (Bridge, et al., 2013). This influence of depth is most apparent in inshore areas where the turbidity of waters causes a rapid attenuation of light (Bridge, et al., 2013; Marshall & Baird, 2000). To minimise the differences in depth, the MMP stratifies sampling by depth including transects at both 2 m and 5 m below lower astronomical tide (LAT).

5.3.1.2 Seagrass

Data on seagrass condition was obtained from the Port of Townsville monitoring program, with monitoring conducted by James Cook University (JCU). Ten monitoring meadows were sampled in September 2017, using a helicopter to survey intertidal areas at low tide and diving to survey shallow sub-tidal areas (Bryant & Rasheed, 2018). The locations of the monitored seagrass meadows are shown in Figure Appendix B 1. The methods for scoring seagrass are explained in Bryant & Rasheed, 2018. Each indicator for seagrass (biomass, area and species composition) is compared against a baseline to create the score (Bryant & Rasheed, 2018). The baseline was developed in 2007/2008 and updated in 2013 and 2016. Both the Wet Tropics and Mackay-Whitsunday report cards rely upon the methods devised by Bryant & Rasheed, 2018. Using the same method aligns with the other report cards.

No data was available on seagrass condition within Halifax Bay and this will be grey in the Pilot Report Card. One site is monitored within Halifax Bay as part of the marine monitoring program (MMP). However the results for the 2017-2018 surveys had not been publically released at the time this report was compiled and therefore could not be incorporated into the Pilot Report Card. Additionally, MMP and the Port of Townsville seagrass monitoring program use different methods to score seagrass indicators, making comparisons between the two difficult. The lack of data availability, difference in methods and monetary costs associated with standardising the MMP and JCU methods means the MMP data will not be used in the Pilot Report Card. It is hoped that the difference in methods will be resolved as part of the Reef 2050 Integrated Monitoring and Reporting Program (RIMReP) program design. The method chosen for RIMReP will be used in future report cards.

5.3.2 Results

Both coral and seagrass comprise multiple indicators, with the scores for coral and seagrass presented below.

5.3.2.1 Inshore coral

Average scores and grades for coral indicators and the indicator category are presented in Table 9. It is noted that the coral change indicator is estimated over a two-year rolling mean. This indicator estimates the recovery potential of the reef. There will be a slight lag in response due to the biennial sampling design, with this most evident in offshore coral results. In case of a disturbance, the marine monitoring program (MMP) conducts additional sampling. Table Appendix A 1 presents the unstandardised and standardised scores for each coral indicator at each site and for the two depths (2 m and 5 m) in which coral was measured.

Overall, Cleveland Bay inshore marine zone was in a poor condition, with all indicators, except juvenile density, scoring poorly or very poorly (Table 9). Halifax Bay inshore marine zone was in a moderate condition, with three out of five indicators being in a moderate, good or very good condition (Table 9). There was a greater variability in the indicator scores for reefs within Halifax Bay inshore marine zone compared to Cleveland Bay inshore marine zone. Grade ranged from very high to very poor within Halifax Bay inshore marine zone.

Of note, three-quarters of the monitoring sites (6 out of 8) had very poor scores for macroalgae, as shown in Table 9. Cleveland Bay and Halifax Bay inshore marine zones scored very poorly and poorly respectively for this indicator (Table 9). High macroalgae cover (as represented by a low macroalgae score) indicates there may be high nutrient availability within inshore waters at Magnetic Island, Middle Reef, Havannah Reef North, Palms Reef East, Pandora Reef and Pandora Reef North. Within Halifax Bay, half (3 of the 6) of the monitoring sites had very good composition of hard corals (Table 9).

A score of zero for macroalgae means that the proportion of algal cover classified as macroalgae is less than the lower thresholds of macroalgae required for that specific reef to be healthy and also above the highest threshold required by that specific reef. "The biological significance of a zero score for macro algae will vary from reef to reef. Where the reefs are in turbid and nutrient rich settings (closer to the coast) the threshold are capped at levels that are likely to cause reduced resilience of communities in terms of limiting juvenile density, coral growth, and coral cover. As you move further from the coast, the threshold for a zero score declines as there is less expectation for high cover of macroalgae in these conditions. Here, higher than threshold levels can be interpreted as the processes that limit macroalgae have been weakened. These process may influenced by higher availably of nutrient and reduced herbivory" (A. Thompson 2019, pers. comm., 25th February).

Table 9. Scores and grades for coral indicators and the coral indicator category for Cleveland Bay and Halifax Bay inshore marine zones*. The scores for the coral indicator category are averages of each indicator score.

	Standardised score						Grade					
	Juvenile density	Macro-algae	% Coral cover	% Change hard corals	Composition of hard corals	Coral indicator category	Juvenile density	% Macro-algae	% Coral cover	% Change hard corals	Composition of hard corals	Coral indicator category
Magnetic Island Reef (Geoffrey Bay)	44	0	30	32	25	26	C	E	D	D	D	D
Middle Reef	53	0	51	NA^	50	38	C	E	C	NA^	C	D
Cleveland Bay inshore marine zone	**49**	**0**	**41**	**33**	**38**	**33**	**C**	**E**	**C**	**D**	**D**	**D**
Havannah Reef	21	50	49	75	100	59	D	C	C	B	A	C
Havannah Reef North	100	0	9	58	100	53	A	E	E	C	A	C
Palms Reef East	58	10	20	59	100	49	C	E	E	C	A	C
Palms Reef West	29	100	40	83	50	60	D	A	D	A	C	C
Pandora Reef	45	2	11	39	75	34	C	E	E	D	B	D
Pandora Reef North	58	0	72	8	0	27	C	E	B	E	E	D
Halifax Bay inshore marine zone	**52**	**27**	**33**	**54**	**70**	**47**	**C**	**D**	**D**	**C**	**B**	**C**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good = 81 – 100 | ■ No score/data gap.

*Results are based on a two year rolling mean.

^The percent change in hard coral cover has not been sampled on Middle Reef since 2014.

5.3.2.2 Seagrass

Overall seagrass was in a good condition within Cleveland Bay inshore marine zone. Overall, all indicators were in a moderate to very good condition, with the results and the associated grades for each indicator and the indicator category presented in Table 10.

Table 10. Scores and grades for seagrass indicators and the seagrass indicator category for Cleveland Bay inshore marine zone. At each site, the two lowest scores are used to calculate the average for the indicator category. The overall score for the Cleveland Bay inshore marine zone is averaged from the seagrass indicator category scores for each site.

	Standardised score				Grade			
Site (meadow)	Biomass	Area	Species composition	Seagrass indicator category	Biomass	Area	Species composition	Seagrass indicator category
3	82	95	79	80	A	A	B	B
4	84	87	85	84	A	A	A	A
5	86	84	100	84	A	A	A	A
6	86	53	96	53	A	C	A	C
10	93	57	92	57	A	C	A	C
12	90	100	80	85	A	A	B	A
14	82	89	98	82	A	A	A	A
15	89	92	89	89	A	A	A	A
16	95	79	97	79	A	B	A	B
17/18	86	86	96	86	A	A	A	A
Cleveland Bay inshore marine zone				**78**	**A**	**A**	**A**	**B**

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100 | No score/data gap.

5.3.3 Overall inshore marine score

Within the inshore marine zone, the flora and fauna index is comprised of coral, seagrass and fauna. However data was only available for the coral and seagrass indicator categories for the Pilot Report Card, with the scores for these indicator categories presented in Table 11. Flora and fauna (and the overall Biodiversity score) was moderate for both Cleveland Bay and Halifax Bay.

Table 11. Scores and grades for coral, seagrass and overall flora and fauna for Cleveland Bay and Halifax Bay. Flora and fauna scores are averages of the scores for coral and seagrass.

	Score			Grade		
Site	Coral	Seagrass	Flora and fauna index	Coral	Seagrass	Flora and fauna index
Cleveland Bay	33	78	55	D	B	C
Halifax Bay	47		47	C		C

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100 | No score/data gap.

5.3.4 Confidence scores

As shown in Table 12, there was a high and moderate confidence in the results for the overall habitat index for Cleveland Bay and Halifax Bay respectively. The score for each confidence criterion is shown in Table 12. The majority of seagrass beds within Cleveland Bay are monitored, resulting in a good score (3) for representativeness (Table 12).

Table 12. Confidence score for the habitat index for Cleveland Bay and Halifax Bay. Confidence criteria are scored 1-3, weighted by the value identified in parenthesis and summed to produce a final (weighted) score (4.5 – 13.5). Final scores rank from 1 to 5 (very low to very high).

Indicator category	Maturity of method (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final score	Rank
Coral	1.5	3	1.5	3	2	9.2	Moderate (3)
Seagrass	2	3	3	3	2	12.4	Very high (5)
Cleveland Bay						**10.8**	**High (4)**
Coral	1.5	3	1.5	3	2	9.2	Moderate (3)
Halifax Bay						**9.2**	**Moderate (3)**

Rank based on final score: Very low (1): 4.5 – 6.3; Low (2): >6.3 – 8.1; Moderate (3): >8.1 – 9.9; High (4): >9.9 – 11.7; Very high (5): >11.7 – 13.5.

5.4 Offshore marine

5.4.1 Data source

Coral is the only indicator category within the flora and fauna index within the offshore marine zone. Coral is measured as part of the long-term monitoring program (LTMP), which has a biennial sampling design. Since some reefs will have been surveyed last in the preceding year, the values for each reporting year are effectively a 2-year rolling mean. The data included in the Pilot Report Card was collected over the period May 2016 to July 2018. The LTMP samples sites at 6-9 m depth.

5.4.2 Results

As shown in Table 13, the overall condition of coral within the offshore marine zone was in a good condition. The percentage change in coral cover was moderate, whilst coral cover was poor and juvenile density (recruitment) was very good.

Table 13. Integer score and grade for coral indicators and the coral indicator category for the offshore marine zone*. The score for the coral indicator category are averages of each indicator score.

	Standardised score				Grade			
	% Change in coral cover (2017-18)	% coral cover	Juvenile density	**Coral indicator category**	% Change in coral cover (2017-18)	% coral cover	Juvenile density	**Coral indicator category**
Offshore marine zone	51	34	97	**61**	C	D	A	**B**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good = 81 – 100 | ■ No score/data gap.

*Results are based on a two year rolling mean.

5.4.3 Confidence scores

As shown in Table 14, there was a low confidence in the results of the offshore coral indicators and the overall coral indicator category score (Table 14). Low confidence was mainly attributed to a low (1) rank in representativeness and measured error criteria. The representativeness was low as sites were only measured once every two years, with only a fraction of all the offshore reefs measured.

Table 14. Confidence scoring of offshore coral for the offshore marine zone. Confidence criteria are scored 1-3, weighted by the value identified in parenthesis and summed to produce a final (weighted) score (4.5 – 13.5). Final scores rank from 1 to 5 (very low to very high).

	Maturity (0.36)	Validation (0.71)	Represent-ativeness (2)	Directness (0.71)	Measured error (0.71)	Final score	Rank
Offshore coral	3	3	1	3	1	8.1	Low (2)

Rank based on final score: Very low (1): 4.5 – 6.3; Low (2): >6.3 – 8.1; Moderate (3): >8.1 – 9.9; High (4): >9.9 – 11.7; Very high (5): >11.7 – 13.5.

6 Water results

The overall score for Water is based on indicators and indicator categories that are grouped into the following indices:

- Hydrology, nutrients, physical and chemical parameters (phys-chem) and contaminants for the two freshwater and two estuarine/coastal zones (Black and Ross)
- Nutrients, phys-chem, chlorophyll *a* and contaminants for Cleveland Bay and Halifax Bay
- Phys-chem properties and chlorophyll *a* for the one offshore marine zone.

Groundwater is also included as a separate zone, with the score for this zone being derived from indicators within the hydrology and contaminants indicator categories. For the Pilot Report Card, phys-chem will be referred to as 'water clarity' as the indicators scored in the pilot mainly relate to water clarity. In future report cards, pH and temperature will be scored. Both these indicators are within the phys-chem indicator category but not scored in the pilot due to a lack of data).

The indicator categories and indices aggregated into an overall score for the Pilot Report Card are highlighted in Table 15. For the Pilot Report Card, aspiration indices (indicated by an asterisk in Table 15) were excluded when aggregating scores. This allowed an overall score for Water to be produced when the minimum information rules for aggregating data are applied. It was important to the Partnership that an overall water quality score was produced.

In the freshwater and estuarine/coastal environments, indicators of nutrients and physical-chemical (phys-chem) properties were reported and an overall score generated. There is currently no data and/or scoring method for the other indicator categories. In the future, it is aimed that data to score these categories will become available and methods for scoring indicators will be developed. In the inshore marine zones (Cleveland Bay and Halifax Bay), indicators of nutrients, phys-chem properties and chlorophyll *a* are reported and an overall score for water quality generated. No scores are generated for the offshore marine environment due to a lack of data and time constraints.

Table 15. Indices and indicator categories that are aggregated to generate an overall score for Water. The indices and indicator categories aggregated into an overall score for Water for the Pilot Report Card are highlighted.

Zone	Index	Indicator category
Freshwater and estuary/coastal	Hydrology	% catchment impervious/developed
		% native land cover
		Flow
	Nutrients	Phosphorus (P)
		Dissolved inorganic nitrogen (DIN)
	Phys-chem	Dissolved Oxygen (DO)
		Turbidity
		pH
	Contaminants*	Pesticides
		Metals
		PFAS (freshwater only)
Inshore marine	Nutrients	Phosphorus
		Oxidised nitrogen (NOx)
		Particulate Nitrogen (PN)
	Phys-chem	Total suspended solids (TSS)
		Turbidity
		Secchi depth
		Temperature
		pH
	Chlorophyll *a*	Chlorophyll *a*
	Contaminants*	Metals
Offshore marine	Phys-chem*	Turbidity/TSS
		Temperature
	Chlorophyll a	Chlorophyll a
Groundwater	Hydrology*	Quantity/recharge rates
	Contaminants*	Salinity/Conductivity

*Index is aspirational (unlikely to be developed within the next two years) and not included when aggregating scores using the minimum information rules for aggregating data.

6.1 Guideline values

Scheduled environmental protection policy water quality objectives (guideline values) for the freshwater, estuarine/coastal, marine inshore and offshore marine zones were sourced from four regionally specific documents. Different guidelines apply for specific aquatic ecosystems. Guideline values that are applicable to the Ross and Black freshwater and estuarine waters within the Townsville Dry Tropics regions are listed in Table 16. Guideline values applicable to Cleveland Bay (offshore of Ross Basin), Halifax Bay (offshore of Black Basin) and the offshore marine zone are presented in Table 17. Guideline values have only been listed for the zones where data is available.

Guidelines values for the Ross freshwater (basin) and estuarine zones, and Cleveland Bay and Halifax Bay were sourced from ‘Environmental Protection (Water) Policy 2009: Ross River Basin and Magnetic Island Environmental Values and Water Quality Objectives, Basin 118 including all waters of the Ross River Basin, and adjacent coastal waters (including Magnetic Island) (Environmental Policy and Planning Division, 2013).

Guideline values for waters within the Black Basin and estuarine/coastal zone were sourced from ‘Environmental Protection (Water) Policy 2009 Black River Basin Environmental Values and Water Quality Objectives Basin No. 117, including all waters of the Black River Basin and adjacent coastal waters’ (Environmental Policy and Planning Division, 2013). There were two monitoring sites within Halifax Bay (offshore of the Black estuarine/coastal zone), which were Pandora Reef and Palms West Reef (off Pelorus/Orpheus Island). Guideline values for waters at Pandora Reef were sourced from ‘Environmental Protection (Water) Policy 2009 Tully, Murray and Hinchinbrook Is. River Basins - Environmental Values and Water Quality Objectives - Basins Nos. 113, 114 and 115 and adjacent coastal (Division, Environmental Policy and Planning, 2014). The Wet Tropics Report Card also reports on Palms West Reef. To ensure consistency with the Wet Tropics, the same guideline values were used, which are sourced from the Marine Monitoring Program Annual report for inshore water quality monitoring 2014-2015 (Lønborg, et al., 2016).

Table 16. Scheduled environmental protection policy water quality objectives for water quality indicators for the Ross and Black basins and estuarine/coastal environments. NOx indicates oxidised nitrogen and Total P indicates total phosphorus. Guideline values are only listed for the areas where monitoring occurred. Values for dissolved oxygen (DO) and turbidity for freshwater lakes/reservoirs are presented as lower-upper boundary values. MD indicates that the guideline values are written for moderately disturbed areas.

			Ross Basin		Ross estuary/coastal			Black Basin
Indicator category	**Indicator**	**Unit**	**Bohle River freshwaters (MD)**	**Freshwater lakes/ reservoirs (MD)**	**Mid-estuary waters (Ross Creek & Ross River) (MD)**	**Estuary waters of Bohle River & Sandfly Creek (MD)**	**Mid estuary waters within Stuart Creek estuary north of Townsville State Development Area (MD)**	**Freshwater lakes/ reservoirs (MD)**
Nutrients	DIN	µg/L	<80	<20	<20	<20	<20	<20
	Total P	µg/L	<50	<10	<25	<50	<25	<10
Physical-chemical	Turbidity	NTU	<22	1-20 (upper value used)	<8	<20	<20	1-20 (upper value used)
	DO	% sat.	60-90	90-110	85-100	85-100	85-100	90-110
Monitoring sites			Bohle River	Black (School) Weir, Gleeson's weir, Aplins weir , Ross River Dam	Ross River Estuary, Ross Creek Estuary, Alligator Creek Estuary, Keyatta Lakes, Fairfield Lakes	Louisa Creek and Bohle River Estuary (Bohle) Estuary), Sandfly Creek Estuary	Stuart Creek Estuary	Paluma Dam

Table 17. Scheduled environmental protection policy water quality objectives for water quality indicators for Cleveland Bay, Halifax Bay and the offshore marine environment. Where a range of three values are listed, the middle value is used. However, when the middle value is zero, the upper value is used. MD indicates that the guideline values are written for moderately disturbed areas, SD represents the guideline values are for slightly disturbed areas, whilst HEV means the area is of high ecological value.

			Cleveland Bay			Halifax Bay
Indicator category	**Indicator**	**Unit**	**Townsville Port sub-zone waters (MD)**	**Cleveland Bay enclosed coastal/lower estuary waters, & Breakwater Marina (MD)**	**SD2245 enclosed coastal waters (Geoffrey Bay is within SD2244 but there are no guidelines for that zone). HEV**	**Wet Tropics Open coastal (HEV3121/ SD3121)**
Nutrients	NOx	µg/L	<9	<9	2-4-9	<2
	Particulate N	µg/L	<20 (using MD2242 Cleveland Bay open coastal waters guidelines)		20 (using MD2242 Cleveland Bay open coastal waters guidelines)	<20
	Total P	µg/L	<30	<30	15-20-30	8-14-22
	Particulate P	µg/L	2.8 (using MD2242 Cleveland Bay open coastal waters guidelines)		2.8 (using MD2242 Cleveland Bay open coastal waters guidelines)b	<2.8
Physical-chemical	Turbidity	NTU	<4.9	<4.9	0.4-1.0-4.9	<1.5
	TSS	mg/L	13-22-34	<15	7-10-15	<2
	Secchi depth	m	<1	<1	1.0-1.4-1.9	<10
Chlorophyll *a*	Chlorophyll *a*	µg/L	<2.6	<2.6	1.0-1.6-2.6	<0.45
Monitoring sites			Midshelf Cleveland Bay	Enclosed coastal Cleveland Bay	Geoffrey Bay	Palms West Island, Pandora

6.2 Overview of rivers and monitoring sites within the reporting region

There are three main rivers within the reporting extent. These rivers are the Black River, within the Black catchment, and the Ross River and Bohle River, both of which are within the Ross catchment. Across the two catchments there are six freshwater sites, six estuarine/coastal sites and two man-made lakes sites. However, the majority of monitoring occurs within the Ross catchment. Five freshwater monitoring sites (one on the Bohle River and four on the Ross River) and all estuarine/coastal monitoring sites and man-made lake sites are located within the Ross catchment. Only one freshwater monitoring site is located within the Black catchment, with no estuarine/coastal monitoring sites. There are five inshore marine monitoring sites within Cleveland Bay (offshore of the Ross catchment), but none within Halifax Bay (offshore of Black catchment). Figure 10 shows the location of monitoring sites in relation to the main rivers and land use in the Townsville Dry Tropics region.

The Ross River has four major impoundments: Ross River Dam and three weirs, Black School weir (referred to as Black weir), Gleeson's weir, and Aplins weir. During the wet season, heavy rainfall can result in flow overtopping the impoundments, providing connectivity from the headwaters to the coast. However, throughout most of the year, water doesn't overtop the impoundment walls. This results in the weirs and Ross River Dam essentially being separate waterbodies. Overtopping of Ross River Dam occurred during the 2017-2018 wet season, although it lasted only for a brief period (< 2 weeks). During the dry season, when the Ross River Dam falls below 15% capacity, water is diverted from the Haughton Balancing Storage (Burdekin water) into the Ross River Dam until the dam reaches 30% capacity (Department of Natural Resources, Mines and Energy (DNRME) 2019, pers. comm., 25 January). During 2017-2018, water was diverted from the Haughton Balancing Storage into the Ross River Dam from 14/11/2017 until 28/02/2018 (Department of Natural Resources, Mines and Energy 2019, pers. comm., 25 January). When water is not being pumped from the Burdekin into the Ross River Dam, the interim resource operations licence (iROL) conditions require water to be released from Ross River Dam as necessary to maintain Black Weir. The Black Weir has to be maintained at a level ≥ 2.5metres (below its full supply level (FSL)) (i.e. existing level 11.31m AHD) (Department of Natural Resources and Water, 2009). However, no releases from Ross River Dam occurred to meet this requirement due to groundwater inputs maintaining the weir water levels. This licence condition is cancelled when pumping from the Haughton Balancing Storage is activated (DNRME 2019, pers. comm., 25 January).

6.3 Position of monitoring sites in relation to land use

In general water quality in a watercourse is influenced by upstream catchment land use activities (Huan, et al., 2013). The positions of these monitoring sites in relation to land use in the Townsville Dry Tropics region are shown in Figure 10. This is the case for monitoring along the Bohle River, with the sample likely affected by activities directly upstream. For example, the water quality at the Bohle River water quality monitoring site is influenced by runoff from conservation area, agricultural (irrigated and non-irrigated), rural residential and urban land uses. Rainfall, groundwater inputs and retention in standing water bodies can also affect water quality (DNRME 2019, pers. comm., 25 January). Water quality monitoring samples within the Ross River weirs are influenced by inflow from upstream sources, direct rainfall, localised catchment runoff (including runoff from irrigated areas) and groundwater (DNRME 2019, pers. comm., 25 January). The Ross River is also influenced by storm water inputs, with stormwater drains collecting water from nearby urban areas and transferring it directly into the Ross River. Water quality within the Ross River Dam is also affected by the occasional supplementation from the Haughton Balancing Storage.

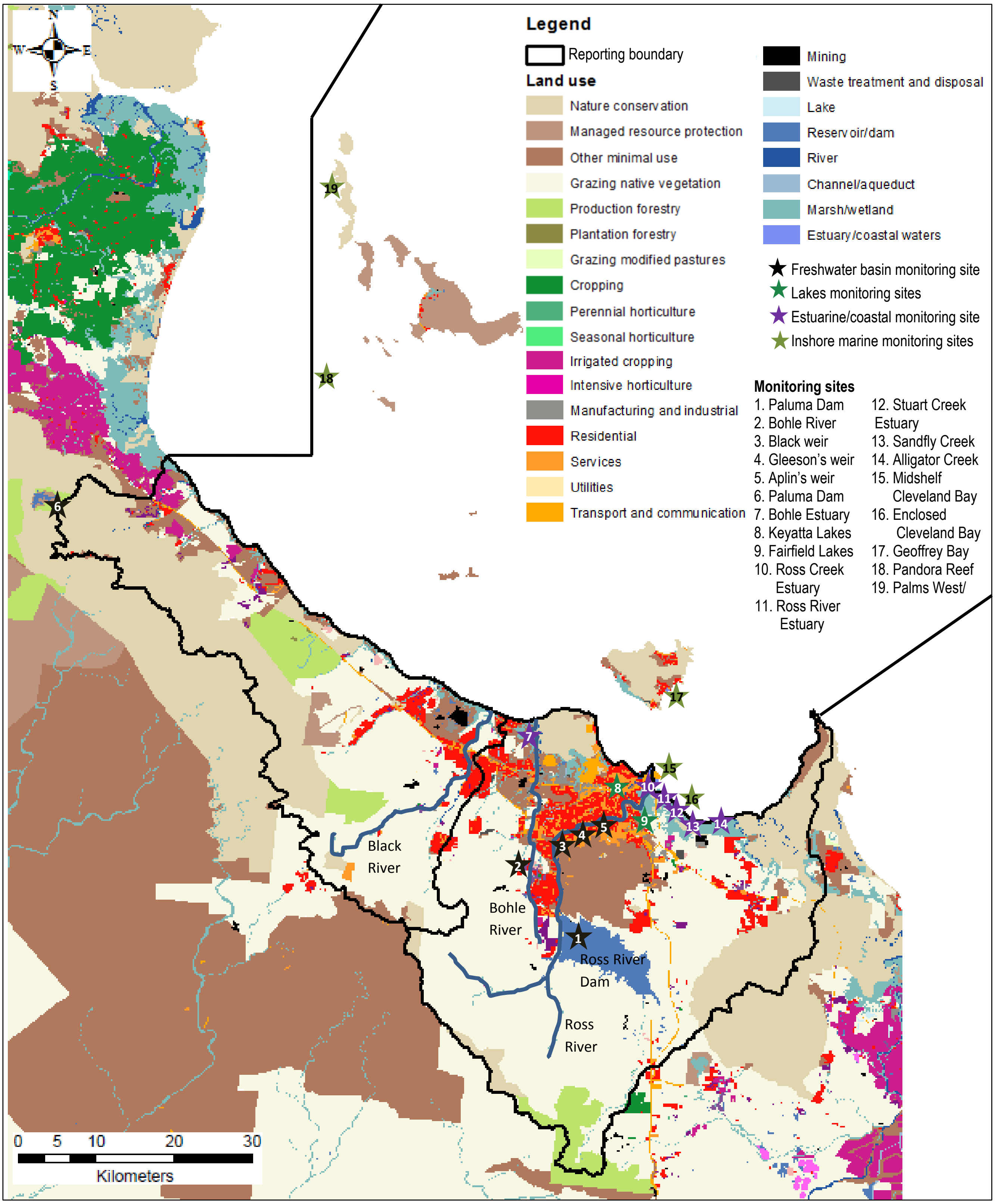


Figure 10. Location of monitoring sites in relation to the main rivers and land use in the Townsville Dry Tropics region.
Source: Adapted from maps from Department of Science, Information Technology and Innovation (DSITI) (2017).

6.4 Freshwater basins

6.4.1 Overview of monitoring sites

Water quality scores were derived from two indices (nutrients and phys-chem properties). Monitoring occurred at five sites within the Ross Basin and one site within the Black Basin. All sites are monitored monthly using grab samples. At Ross River Dam, Bohle River and Paluma Dam, samples were collected at multiple locations at the site. At all other sites, only one sample was taken from approximately the same location each month. (A monitoring location refers to where a sample was specifically taken, whilst a monitoring site refers to the collective of one or more monitoring locations).

The freshwater monitoring sites within Ross Basin are:

- Ross River Dam, comprising seven monitoring locations (Figure Appendix B 2)
- Black Weir, comprising of one monitoring location beside the weir (Figure Appendix B 3)
- Gleeson's Weir, comprising of one monitoring location beside the weir (Figure Appendix B 3)
- Aplins Weir, comprising of one monitoring location beside the weir (Figure Appendix B 3)
- Bohle River monitoring site, comprising three monitoring locations (near-field location above the sewage treatment plant (control site), mid-field and far-field locations), as shown in Figure Appendix B 4. This site comprises of the receiving end monitoring from Condon Sewage Treatment Plant (STP). A proportion of the water treated at Condon STP is discharged into the Bohle River, whilst the remainder is used for irrigation on a nearby golf course and re-used for service on site.

The freshwater monitoring sites within Black Basin are:

- Paluma Dam (within the Black Basin), comprising of monitoring location beside the Dam wall.

Note: The result for Paluma Dam is presented, however this grade will not be used to represent the score for the entire Black Basin. This is because the site is located in the upper part of the catchment, with access to the site restricted (as the area is used as a drinking water supply). Water within Paluma Dam is thus likely to be in better condition than most rivers within the Black Basin, especially compared to developed areas. Basing scores on only one upstream monitoring location is also not scientifically robust and likely to be unrepresentative of water quality across the zone. For the Pilot Report Card, Black Basin will be left as a grey area until there is sufficient data to provide a more accurate indication of water quality within the Basin.

6.4.2 Method for scoring multiple locations within the same site

At sites within multiple monitoring locations, the results from each location are averaged to generate one score for the site.

6.4.3 Method for scoring multiple sites within the same basin

There are five monitoring sites within the Ross Basin. Neither the Wet Tropics nor Mackay-Whitsunday regional report cards currently generate a score for a basin using data from multiple monitoring sites. A method was thus required to generate a single score for Ross Basin based on data from the five monitoring sites. The method devised treats monitoring sites within the same river and spatially close to each other as replicates and averages their scores. Black, Gleeson's and Aplins weirs are all located along the lower reaches of the Ross River and are geographically close to each other, as seen in Figure Appendix B 3. Results from these three sites were averaged to produce a score for the Lower Ross River. The Ross River Dam, which is located in the upper part of Ross River, was treated as a separate site. Dividing the Ross River into the Upper and Lower Ross River also aligns with the Water Quality Improvement Plan (WQIP) (Gunn, 2010). This meant there were three overall sites for the Ross Basin; the Lower Ross River, Upper Ross and Bohle River. The results from these sites were averaged to provide an overall score for the Ross Basin.

Equally weighting the freshwater sites may not be the most appropriate approach. Weighting the sites based on the proportion of the catchment that each monitoring site represents may be a more appropriate method, as this would account for differences in the size of each monitoring area. For future reports, a method will be developed to weight each freshwater monitoring zone.

6.4.4 Results

The results for the indicators and indicator categories of freshwater water quality are presented in the following sections. The distributions of data for each indicator are presented as boxplots in Appendix C.

6.4.4.1 Nutrients

The score for nutrients was derived from two indicator categories; total phosphorus (TP) and dissolved inorganic nitrogen (DIN). The results for TP and DIN are presented in Table 18.

Both the Ross Basin and Paluma Dam received an overall score of moderate and poor respectively for nutrient concentrations. There were high concentrations of total phosphorus in both systems resulting in a very poor score for this indicator, whilst DIN ranged from moderate to very good. The low concentrations of DIN within the weirs (which resulted in good and very good scores) may be attributed to high levels of aquatic weed within the weirs. Aquatic plants uptakes DIN within waterways, with DIN from sediment quickly fixated into plant biomass (Ribaudo, et al., 2018).

Although high total phosphorus levels are a concern, these levels are similar to historic levels (C. Cuff 2019, pers. comm., 4th March). Future investigation is required to estimate the source for these historically high levels.

Table 18. Integer scores and grades for total phosphorus (TP), dissolved inorganic nutrients (DIN) and nutrients for freshwater sites. The scores for nutrients were averaged from the scores for TP and DIN. Scores for the Lower Ross River are the average of scores for the Black, Gleeson's and Aplins weirs (shown in dark purple writing). Scores for Ross Basin were averaged from the scores for Upper Ross River, Lower Ross River and Bohle River.

Site	Standardised score			Grade		
	TP	DIN	Nutrients	TP	DIN	Nutrients
Upper Ross River (Ross River Dam)	12	54	33	E	C	D
Lower Ross River	12	82	47	E	A	C
Black Weir	12	90	51	E	A	C
Gleeson's Weir		67	67		B	B
Aplins Weir		90	90		A	A
Bohle River	24	62	43	D	B	C
Overall Ross basin	**16**	**66**	**41**	**E**	**B**	**C**
Paluma Dam	**12**	**54**	**33**	**E**	**C**	**D**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = assigned 90 | ■ No score/data gap

6.4.4.2 Physical-Chemical (water clarity for Pilot Report Card)

The results for the phys-chem index were derived from two indicator categories, turbidity and dissolved oxygen (DO). The results for these indicators and the phys-chem index are presented in Table 19.

Overall both Ross Basin and Paluma Dam were in a moderate and good condition respectively with respect to phys-chem properties. Scores for all indicators ranged from moderate to very good, except for turbidity within the Bohle River, which received a very poor score. This very poor score for turbidity resulted in the Bohle River receiving a poor score for the phys-chem category. No recent study has been undertaken determine the direct cause of the high turbidity levels within the Bohle River. As shown in Figure 10, the dominate land use above the monitoring sites is grazing in native vegetation, with a small proportion of the above stream land use being residential and mining. A Sewage Treatment Plant (STP) is also above the monitoring sites, with the monitoring locations being the mid and far field monitoring from the STP. In the future it is planned that trends in report card scores can be compared with land use changes to determine the most probable land use/s contributing to the scores.

For the weirs (and the overall Lower Ross score), the results for turbidity are not aggregated into an overall score for phys-chem. Turbidity is generally caused by water movement (either from wind or water flow). For the majority of the year, water does not naturally flow within the weirs and therefore turbidity levels are low (resulting in the very good score). Dissolved oxygen levels are a greater environmental issue than turbidity within Townsville weirs. There was no data on dissolved oxygen within the weirs and therefore this indicator could not be scored. Basing the overall phys-chem result only on the scores for turbidity is thus unlikely to accurately represent the condition of the phys-chem properties within the weirs.

The very poor turbidity scores within the Bohle River are unsurprising given the surrounding region mainly comprises sodic soils (C. Cuff 2019, pers. comm., 4th March). Sodic soils tend to have higher runoff and erosion rates than other soils due to their dispersive nature (particles disperse rather than aggregate when in contact with water) (Lemon & Hall, 2019). This can result in highly turbid waters (Cay, et al., 2001).

Table 19. Integer scores for turbidity, dissolved oxygen (DO) and phys-chem properties for freshwater sites. Phys-chem scores were averaged from the scores for turbidity and DO (using the numerically lesser of the two DO scores). Scores for the Lower Ross River are the average of scores for the Black, Gleeson's and Aplins weirs (shown in dark purple writing). Scores for Ross Basin were averaged from the scores for Upper Ross, Lower Ross and Bohle River.

Site	Standardised score				Grade			
	Turbidity	Lower DO	Upper DO	Phys-chem	Turbidity	Lower DO	Upper DO	Phys-Chem.
Upper Ross (Ross River Dam)	57	81	90	69	C	A	A	B
Lower Ross	90*				A			
Black Weir	90*				A			
Gleeson's Weir	90*				A			
Aplins Weir	90*				A			
Bohle River	0.0	54	90	27	E	C	A	D
Overall Ross basin	**49**	**68**	**90**	**48**	**C**	**B**	**A**	**C**
Paluma Dam	**90**	**55**	**90**	**72**	**A**	**C**	**A**	**B**

Scoring range: Very Poor (E) = 0 to <21 | Poor (D) = 21 to <41 | Moderate (C) = 41 to <61 | Good (B) = 61 to <81 | Very Good (A) = assigned 90 | No score/data gap

6.4.4.3 Overall water quality

As shown in Table 20, water quality was in a moderate condition both within the Ross Basin and at Paluma Dam, with the Upper Ross and Bohle River being in a moderate condition.

Table 20. Water quality scores and grades for freshwater sites. Scores for water quality are averaged from the scores for nutrients and physical-chemical parameters. Scores for the Lower Ross River are the average of scores for the Black, Gleeson's and Aplins weirs (shown in dark purple writing). Scores for Ross Basin were averaged from the scores for Upper Ross, Lower Ross and Bohle River.

	Score			Grade		
Site	Nutrients	Phys-chem	Water quality	Nutrients	Phys-chem	Water quality
Upper Ross (Ross River Dam)	33	69	51	D	B	C
Lower Ross	47			C		
Black Weir	51			C		
Gleeson's Weir	67			B		
Aplins Weir	90			A		
Bohle River	43	27	45	C	D	C
Overall Ross basin	**41**	**48**	**48**	**C**	**C**	**C**
Paluma Dam	**33**	**72**	**53**	**D**	**B**	**C**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = assigned 90 | ■ No score/data gap

6.4.4.4 Confidence scores

There was low confidence in the scores for water quality for the Ross and Black Basins. The score for each criterion is shown in Table 21. The low confidence is due to limited spatial sampling within both the Ross and Black Basins. Maturity of method was scored two (out of three) because the method for averaging spatially close sites (Lower Ross) is a new method that needs improvement. The method for sampling nutrients and phys-chem properties is standard and hence the method received a two rather than a lower score.

Table 21. Confidence scores for nutrients, physical-chemical parameters and water quality for the Ross Basin and Paluma Dam*. Confidence criterion were scored 1-3 and weighted by the value identified in parenthesis. Weighted scores were summed to produce a final score (4.5 – 13.5). Final scores were ranked from 1 to 5 (very low to very high).

Indicator category	Maturity of method (x0.36)	Validation (x0.71)	Represe-ntativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final score	Rank
Nutrients	2	3	1	3	1	7.6	Low (2)
Phys-chem	2	3	1	3	1	7.6	Low (2)
Water quality index						**8.1**	**Low (2)**

Rank based on final score: Very low (1): 4.5 – 6.3; Low (2): >6.3 – 8.1; Moderate (3): >8.1 – 9.9; High (4): >9.9 – 11.7; Very high (5): >11.7 – 13.5.

6.5 Estuary/Coastal

Within the estuary/coastal zone there are two different types of estuarine waters, which are natural estuaries and estuarine man-made lakes. Given the urban nature of the report card and the importance of the lakes within the Townsville region, it is important to score the lakes. Separate scores were produced for the estuaries and lakes. For the Pilot Report Card, the scores and grades for the lakes will be presented only as contextual information. Information and results for estuaries and lakes are presented separately.

6.5.1 Overview of estuarine monitoring sites

Water quality scores for estuary/coastal zones were derived from two indices, nutrients and phys-chem properties. There are six estuarine/coastal monitoring sites, all located within the Ross estuarine/coastal zone. No sampling occurred within the Black estuarine/coastal zone. Water samples were collected using grab samples, with samples taken monthly at one to five locations per estuary.

The six estuarine monitoring sites are:

- Bohle Estuary, comprising of five monitoring locations within Louisa Creek and Bohle River, as shown in Figure Appendix B 5
- Ross Creek Estuary, comprising three estuarine/coastal monitoring locations, as shown in Figure Appendix B 6 and Figure Appendix B 7
- Ross River Estuary, comprising one estuarine/coastal monitoring location, as shown in Figure Appendix B 6 and Figure Appendix B 7
- Stuart Creek Estuary, comprising one estuarine/coastal monitoring location, as shown in Figure Appendix B 7
- Sandfly Creek Estuary, comprising two estuarine/coastal monitoring location, as shown in Figure Appendix B 7
- Alligator Creek Estuary, comprising one estuarine/coastal monitoring location within a tributary of Alligator Creek, as seen in Figure Appendix B 7

6.5.2 Weighting of estuarine/coastal sites

The overall score for Ross estuarine/coastal zone was calculated by averaging the results from each estuary, with all estuaries equally weighted. However, equally weighting the estuaries may not be the most appropriate approach as all estuaries are different sizes; however, it is noted that all estuaries are relatively small within the region. Future reports will investigate the aggregation and weighting of estuarine scores.

6.5.3 Results for estuarine/coastal sites

The results for the indicator categories are presented in the following sections. The distributions of scores for each indicator are presented as boxplots in Appendix C.

6.5.3.1 Nutrients

The scores for nutrients were derived from two indicator categories, total phosphorus (TP) and dissolved inorganic nitrogen (DIN). DIN was calculated by summing oxidised nitrogen (NOx) and Ammonium (i.e. NOx-N + Ammonia-N).

Overall, the estuarine monitoring sites within the Ross estuarine/coastal zone received a good score for nutrients. The results for total phosphorus, DIN and nutrients are presented in Table 22. The Ross River and Ross Creek estuaries achieved a very good score, which was attributed to total phosphorus concentrations being very good, but it is noted there was no corresponding data for DIN. Bohle Estuary and Sandfly Creek Estuary were both in a moderate condition for nutrients, with low to median concentrations of total phosphorus. However, both estuaries had high (poor) DIN concentrations. Stuart Creek and Alligator Creek Estuary were in a poor condition for nutrients.

There were high total phosphorus concentrations within Alligator Creek, resulting in a very poor result. However, the Partnership considered this result to be unusual, considering that Alligator Creek is relatively unmodified compared to the other estuaries and thus would be expected to have good scores for TP. Therefore, the results for Alligator Creek estuary will be excluded when rolling up the score.

Table 22. Integer scores and grades for total phosphorus (TP), dissolved inorganic nutrients (DIN) and nutrients for the Ross estuarine/coastal zone. The scores for nutrients were averaged from the scores for TP and DIN.

	Score			Grade		
Site	TP	DIN	Nutrients	TP	DIN	Nutrients
Ross Creek Estuary	90		90	A		A
Ross River Estuary	90		90	A		A
Bohle Estuary	61	36	49	B	D	C
Stuart Creek Estuary	20	56	38	E	C	D
Sandfly Creek Estuary	61	31	46	B	D	C
Alligator Creek Estuary	20	41	31	E	C	D
Overall Ross estuarine/coastal zone (Cleveland Bay discharge)	**64**	**41**	**62**	**B**	**C**	**B**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = assigned 90 | ■ No score/data gap

6.5.3.2 Physical-Chemical parameters (water clarity for Pilot Report Card)

The score for the phys-chem indicator category was derived from two indicator categories, turbidity and dissolved oxygen (DO). Overall, the Ross estuarine/coastal zone was in a good condition for phys-chem parameters, as shown in Table 23. The scores for all indicator categories and the index ranged from moderate to very good. Bohle and Stuart Creek estuaries received very good scores for all categories. Overall, Ross Creek, Sandfly Creek and Alligator Creek estuaries were in a good condition, whilst Ross River was in moderate condition.

Table 23. Integer scores and grades for turbidity, dissolved oxygen (DO) and overall phys-chem properties for the Ross estuarine/coastal zone. Phys-chem scores were averaged from the scores for turbidity and lower DO score (the numerically lesser of the two DO scores).

	Score				Grade			
Site	Turbidity	Lower DO	Upper DO	Phys-chem	Turbidity	Lower DO	Upper DO	Phys-chem
Ross Creek Estuary	75	49	90	62	B	C	A	B
Ross River Estuary	69	48	90	58	B	C	A	C
Bohle Estuary	90	90	90	90	A	A	A	A
Stuart Creek Estuary	90	90	90	90	A	A	A	A
Sandfly Creek Estuary	90	57	90	73	A	C	A	B
Alligator Creek Estuary	62	67	90	65	B	B	A	B
Overall Ross estuarine/coastal zone (Cleveland Bay discharge)	**79**	**67**	**90**	**73**	**B**	**B**	**A**	**B**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = assigned 90 | ■ No score/data gap

6.5.3.3 Overall water quality

As seen in Table 24, overall water quality within the Ross estuarine/coastal zone was in a good condition, Sandfly Creek and Alligator Creek estuaries were in a moderate condition whilst all other estuaries were in a good condition.

Table 24. Water quality scores and grades for Ross estuarine/coastal zone. Scores for water quality are averaged from the scores for nutrients and physical-chemical parameters.

	Score			Grade		
Site	Nutrients	Phys-chem	Water quality	Nutrients	Phys-chem	Water quality
Ross Creek Estuary	90	62	76	A	B	B
Ross River Estuary	90	58	74	A	C	B
Bohle Estuary	49	90	69	C	A	B
Stuart Creek Estuary	38	90	64	D	A	B
Sandfly Creek Estuary	46	73	60	C	B	C
Alligator Creek Estuary	31	65	48	D	B	C
Overall Ross estuarine/coastal zone (Cleveland Bay discharge)	**62**	**73**	**67**	**B**	**B**	**B**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = assigned 90 | ■ No score/data gap

6.5.3.4 Confidence scores

There was a moderate confidence in the water quality scores for the Ross estuarine/coastal zone. The score for each criterion is shown in Table 25. Data were available for all indicators within the nutrient indicator category and therefore this category received a higher 'representativeness' rank than for the phy-chem indicator category. In the phy-chem indicator category, pH is an indicator that will be included in future reports. Since it was not included within this report it meant only two out of the three indicators were scored and therefore representativeness was given a lower score.

Maturity of method was scored two (out of three) because the method of generating the overall score needs improvement (the overall score is currently generated based on averaging all estuarine sites, with estuaries not weighted). The method for sampling nutrients and phy-chem properties is standard and this is the reason for method received a two rather than a lower score.

Table 25. Confidence score for nutrients, physical-chemical parameters and water quality for the Ross estuarine/coastal zone. Confidence criterion were scored 1-3 and weighted by the value identified in parenthesis. Weighted scores were summed to produce a final score (4.5 – 13.5). Final scores were ranked from 1 to 5 (very low to very high).

Indicator category	Maturity of method (x0.36)	Validation (x0.71)	Representa-tiveness (x2)	Directness (x0.71)	Measured error (x0.71)	Final score	Rank
Nutrients	2	3	2	3	1	9.6	Moderate (3)
Phys-chem	2	3	1.5	3	1	8.6	Moderate (3)
Water quality index						**8.6**	**Moderate (3)**

Rank based on final score: Very low (1): 4.5 – 6.3; Low (2): >6.3 – 8.1; Moderate (3): >8.1 – 9.9; High (4): >9.9 – 11.7; Very high (5): >11.7 – 13.5.

6.6 Overview of man-made lakes

Within the Ross estuarine/coastal zone, there are two man-made lakes, which are:

- Fairfield Lakes, comprising five monitoring locations, as shown in Figure Appendix B 8
- Keyatta Lakes, comprising three monitoring locations, as shown in Figure Appendix B 9

These lakes receive both freshwater and saltwater inputs (via pipes) and are classified as estuarine waters. Water from Ross River is pumped into and circulated through the lakes, with outflow from the lakes discharged (via canals) into Ross River. Samples were collected weekly at Keyatta and Fairfield lakes.

6.6.1 Weighting of man-made lakes

The scores for the two lakes were averaged together. The results for the lakes will only be presented as contextual information in the Pilot Report Card. Given the urban nature of the report card, future reports will investigate weighting and aggregating the scores for estuary sites and artificial lakes.

6.6.2 Results for man-made lakes

6.6.2.1 Nutrients

Different nutrients were measured within the two lakes, resulting in DIN being scored at Keyatta lakes and TP at Fairfield Lakes. Overall, nutrients within the lakes exceeded guideline values, resulting in them receiving a poor score, as shown in Table 26. DIN concentrations within Keyatta Lakes exceeded the guideline values, with the site being classified as being in a moderate condition with respect to nutrient concentrations. Fairfield Lakes had high phosphorus concentrations, resulting in the site receiving a very poor score.

Table 26. Integer scores and grades for total phosphorus (TP), dissolved inorganic nutrients (DIN) and nutrients for man-made lakes within the Ross estuarine/coastal zone. The scores for nutrients were averaged from the scores for TP and DIN.

	Score			Grade		
Site	TP	DIN	Nutrients	TP	DIN	Nutrients
Keyatta Lakes		41	41		C	C
Fairfield Lakes	20		20	E		E
Man-made lakes	**20**	**41**	**31**	**E**	**C**	**D**

Scoring range: Very Poor (E) = 0 to <21 | Poor (D) = 21 to <41 | Moderate (C) = 41 to <61 | Good (B) = 61 to <81 | Very Good (A) = assigned 90 | No score/data gap

6.6.2.2 Physical-Chemical parameters (water clarity for Pilot Report Card)

Overall, the man-made lakes within Townsville were in a moderate condition with respect to turbidity and dissolved oxygen, with these scores aggregated into a phys-chem score. The results for phys-chem properties are presented in Table 27. Keyatta Lake received a very good score, whilst Fairfield lakes were in a poor condition, mainly due to high DO concentrations.

Table 27. Integer scores and grades for turbidity, dissolved oxygen (DO) and overall phys-chem for man-made lakes within the Ross estuarine/coastal zone. Phys-chem scores were averaged from the scores for turbidity and DO (using the numerically lesser of the two DO values).

	Score				Grade			
Site	Turbidity	Lower DO	Upper DO	Phys-chem	Turbidity	Lower DO	Upper DO	Phys-chem
Keyatta Lakes	90	90	90	90	A	A	A	A
Fairfield Lakes	39	90	6.8	23	D	A	E	D
Man-made lakes	**64**	**90**	**48**	**56**	**B**		**C**	**C**

Scoring range: Very Poor (E) = 0 to <21 | Poor (D) = 21 to <41 | Moderate (C) = 41 to <61 | Good (B) = 61 to <81 | Very Good (A) = assigned 90 | No score/data gap

6.6.2.3 Overall water quality

As presented in Table 28, overall water quality within man-made lakes was in a moderate condition, with Keyatta Lakes being in good condition, whilst Fairfield Lakes was in a poor condition.

Table 28. Water quality scores and grades for man-made lakes within Ross estuarine/coastal zone. Scores for water quality are averaged from the scores for nutrients and physical-chemical parameters.

	Score			Grade		
Site	Nutrients	Phys-chem	Water quality	Nutrients	Phys-chem	Water quality
Keyatta Lakes	41	90	65	C	A	B
Fairfield Lakes	20	23	21	E	D	D
Man-made lakes	**31**	**56**	**43**	**D**	**C**	**C**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = assigned 90 | ■ No score/data gap

6.6.2.4 Confidence scores

There was a moderate confidence in the scores for the man-made lakes, with the scores for each criterion shown in Table 29. At each lake, data were only available for one of the two indicators of nutrients (TP for Keyatta Lakes and DIN for Fairfield Lakes). Therefore, representativeness was only given a 1.5 out of 3, with an overall confidence rank of moderate for nutrients. In the phys-chem indicator category, pH is an indicator that will be included in future reports. Since it was not included within this report it meant only two out of the three indicators were scored and therefore representativeness for phys-chem properties was also given a score of 1.5 and an overall confidence of moderate.

Table 29. Confidence score for nutrients, physical-chemical parameters and water quality for man-made lakes within the Ross estuarine/coastal zone. Confidence criterion were scored 1-3 and weighted by the value identified in parenthesis. Weighted scores were summed to produce a final score (4.5 – 13.5). Final scores were ranked from 1 to 5 (very low to very high).

Indicator category	Maturity of method (x0.36)	Validation (x0.71)	Representa-tiveness (x2)	Directness (x0.71)	Measured error (x0.71)	Final score	Rank
Nutrients	3	3	1.5	3	1	9.1	Moderate (3)
Phys-chem	3	3	1.5	3	1	9.1	Moderate (3)
Water quality index						**9.1**	**Moderate (3)**

Rank based on final score: Very low (1): 4.5 – 6.3; Low (2): >6.3 – 8.1; Moderate (3): >8.1 – 9.9; High (4): >9.9 – 11.7; Very high (5): >11.7 – 13.5.

6.7 Inshore marine

6.7.1 Overview of monitoring sites

In total there were three monitoring sites within Cleveland Bay and two within Halifax Bay.

The three monitoring sites within Cleveland Bay are:

- Enclosed coastal Cleveland Bay, comprising three inshore marine locations, as shown in Figure Appendix B 10. This site is situated within enclosed coastal waters and thus 'enclosed coastal' is used to differentiate between monitoring that occurs within open coastal waters within Cleveland Bay.

- Midshelf Cleveland Bay, comprising seven inshore marine locations, as shown in Figure Appendix B 6.
- Geoffrey Bay

The two monitoring sites within Halifax Bay are:

- Pandora Reef
- Palms West Reef (off Pelorus/Orpheus Island)

6.7.2 Overview of indicators measured at each site

Water quality scores for inshore zones were derived from three indices (nutrients, phys-chem parameters and chlorophyll *a*). The indicators measured varied between sites due to the sites being monitored by different programs. Table 30 presents the indicators measured at each inshore site, the type of sampling used (either grab sample or continuous loggers), frequency of sampling and the monitoring program/organisation undertaking the sampling.

Of note, loggers (recording chlorophyll *a* and turbidity) were only deployed between 1st July 2017 and the 4th January 2018. Loggers were deployed at Geoffrey Bay, Pandora Reef and Palms West Reef as part of the MMP. Results for these indicators at these three sites thus do not include the 2018 wet season. This may positively bias the data (higher water quality scores), as high rainfall generally occurs between December and March. Higher rainfall generally results in more nutrients and sediments being flushed into the inshore zone.

Table 30. Indicators sampled at each monitoring site. The indicators measured at each site are shaded in dark grey. TP represents Total phosphorus, NOx indicates oxidised nitrogen, Chl-*a* indicates Chlorophyll *a*, TSS indicates total suspended solids (TSS), PP indicates particulate phosphorus and PN indicates particulate nitrogen.

Zone	Site	Monitoring program	Type of sample	Frequency	TP	NOx	Turbidity	Chl-*a*	Secchi depth	TSS	PP	PN
Cleveland Bay inshore marine zone	Enclosed coastal Cleveland Bay	TCC	Grab	Monthly								
	Midshelf Cleveland Bay	Port of Townsville	Grab	Monthly								
		MMP	Grab	9 times over 6-7 months								
	Geoffrey Bay	MMP	Grab	9 times over 6-7 months								
			Logger	Continuous*								
Halifax Bay inshore marine zone	Palms West	MMP	Grab	9 times over 6-7 months								
			Logger	Continuous*								
	Pandora Reef	MMP	Grab	9 times over 6-7 months								
			Logger	Continuous*								

*Hourly reads were produced from continuous logging data. Sampling only occurred between 01/07/2017 and 04/01/2018 instead of the full financial year.

6.7.3 Weighting of inshore marine sites

All sites were given equal weighting. It is noted that this method may not be appropriate as monitoring at each site occurred at different spatial and temporal scales. For example, the seven monitoring locations at the midshelf Cleveland Bay site were spaced further apart than the seven locations within enclosed coastal Cleveland Bay site. At Pandora Reef and Palms West Reef, sampling only occurred at one location, with data indicating water quality at that specific monitoring location. The frequency of sampling also differs between sites, as seen in Table 30. A more robust method that accounts for these differences will be explored for future reports.

6.7.4 Removal of outliers

The Pilot Report Card is designed to report on the ambient condition of waterways. Scores were produced with and without outliers, with outliers determined to have a substantial impact upon the scores of some indicators. Outliers were therefore removed from the inshore marine data sets. Scores were derived by standardising the annual mean against the guideline values (following the method outlined on page 57 in the Methods for the Mackay-Whitsunday 2016 Report Card (Mackay-Whitsunday Healthy Rivers to Reef Partnership, 2017). In the freshwater and estuarine zones the median (instead of mean) is standardised and outliers thus have less of an impact on the results.

6.7.5 Results

The results for inshore marine water quality are presented in the following sections. The distributions of scores for each indicator are presented as boxplots in Appendix C.

6.7.5.1 Nutrients

The scores for nutrients were derived from the average of total phosphorus (TP), particulate phosphorus (PP), particulate nitrogen (PN) and oxidised nitrogen (NOx). The results for these indicators are presented in Table 31.

Cleveland Bay and Halifax Bay were in a moderate condition. The midshelf Cleveland Bay site was the only site in a very good condition with respect to nutrients, with all other sites being in a poor or moderate condition. Particulate nitrogen concentrations were graded as poor at all sites, whilst particulate phosphorus levels were good at all sites except Geoffrey Bay.

Table 31. Integer scores and grades for nutrients within Cleveland Bay and Halifax Bay inshore marine zone. The scores for nutrients were averaged from the scores for total phosphorus (TP), particulate phosphorus (PP), particulate nitrogen (PN) and oxidised nitrogen (NOx).

	Score					Grade				
Site	TP	PP	PN	NOx	Nutrients	TP	PP	PN	NOx	Nutrients
Enclosed coastal Cleveland Bay	16			52	34	E			C	D
Midshelf Cleveland Bay		65		97	81		B		A	A
Geoffrey Bay		43	24	39	35		C	D	D	D
Overall Cleveland Bay	**16**	**54**	**24**	**63**	**50**	**E**	**C**	**D**	**B**	**C**
Pandora Reef		70	23	45	46		B	D	C	C
Palms West		79	34	39	51		B	D	D	C
Overall Halifax Bay		**75**	**28**	**42**	**48**		**B**	**D**	**C**	**C**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81-100 | ■ No score/data gap

6.7.5.2 Physical-Chemical parameters (water clarity for Pilot Report Card)

As seen in Table 32, Cleveland Bay and Halifax Bay were in a good condition with respect phys-chem parameters. Turbidity values exceeded guideline values at the enclosed coastal Cleveland Bay site and Geoffrey Bay, whilst secchi depth also scored very poorly for sites within Halifax Bay (Pandora Reef and Palms West Reef).

However, it is noted that these results are driven by the guidelines values (see Figure Appendix C 17-20). The guideline values become progressively stricter the further offshore the sites are. This means that even if offshore sites have lower turbidity and TSS levels, the sites will receive a poorer score as they are being compared against stricter guideline values. As seen from the boxplots in Figure Appendix C 17-20, the further the monitoring sites were offshore, the lower the turbidity and TSS concentrations and the higher the secchi depth. Lower turbidity and TSS levels and higher secchi depths indicate better water quality than sites with high turbidity and TSS and low secchi depth. Thus, offshore sites had higher water quality than inshore sites (but not in relation to the guideline values derived for them).

Secchi depth was excluded when calculating the overall score for phys-chem. Secchi depth, turbidity and TSS all measure similar aspects of water clarity. Turbidity was kept as it was the only indicator that was measured across all the sites and also used continuous logger data. TSS and secchi depth were collected at the same time (same number and frequency of sampling). The Wet Tropics do not score secchi depth and therefore secchi depth was excluded when aggregating the data to align with the Wet Tropics report card. Mackay-Whitsunday aggregate their score based on all three indicators.

Therefore, the results for secchi depth are presented in Table 32 to enable comparisons between regions (but the score is not used in the calculations).

Table 32. Integer scores and grades for turbidity, total suspended solids (TSS), secchi depth and the overall phys-chem index within Cleveland Bay and Halifax Bay inshore marine zone. Phys-chem scores are averaged from turbidity and TSS (secchi depth is excluded as delineated by the asterisk).

	Score				Grade			
Site	Turbidity	TSS	Secchi depth*	Phys-chem	Turbidity	TSS	Secchi depth	Phys-chem
Enclosed coastal Cleveland Bay	2				E			
Midshelf Cleveland Bay	57	100	100*	78	C	A	A	B
Geoffrey Bay	20	100	100*	60	E	A	A	C
Overall Cleveland Bay	**26**	**100**	**100***	**69**	**D**	**A**	**A**	**B**
Pandora Reef	81	28	0.0*	55	A	D	E	C
Palms West Reef	100	53	7*	76	A	C	E	B
Overall Halifax Bay	**90**	**41**	**3***	**65**	**A**	**C**	**E**	**B**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81-100 | ■ No score/data gap

6.7.5.3 Chlorophyll *a*

Chlorophyll *a* levels were good overall within Halifax Bay, with waters at Pandora Reef and Palms West Reef having good and moderate chlorophyll *a* concentrations (

Table 33). Chlorophyll *a* concentrations in Geoffrey Bay were below the guideline values, resulting in a very good score.

Table 33. Integer scores and grades for Chlorophyll *a* within Cleveland Bay and Halifax inshore marine zone.

	Score	Grade
Site	Chlorophyll *a*	Chlorophyll *a*
Enclosed coastal Cleveland Bay		
Midshelf Cleveland Bay		
Geoffrey Bay	100	A
Overall Cleveland Bay	100	A
Pandora Reef	75	B
Palms West Reef	59	C
Overall Halifax Bay	**67**	**B**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81-100 | ■ No score/data gap

6.7.5.4 Overall water quality

Overall, Cleveland Bay and Halifax Bay had good and moderate water quality respectively. The summary scores and grades for the water quality are presented in Table 34. The midshelf Cleveland Bay site and Geoffrey Bay had very good and good water quality respectively, whilst Pandora Reef and Palms West Reef had moderate water quality.

The results for Halifax Bay may be influenced by discharge from the Burdekin River. Lewis et al., (2015) studied sediment and nutrient discharge from the Burdekin River and determined that nutrients bound to the fine-grained fraction can travel vast distances from the Burdekin River and form organic-rich floc aggregates. This turbidity can impact on coral reefs and sea meadows offshore of Palm Island (Palms West monitoring site) and Magnetic Island (Geoffrey Bay monitoring site).

Lewis et al., (2015) also found that the majority of the particulate nutrient bound to the coarse-grained sediment fraction drops out in nearshore receiving waters. The timing of particulate dissociation is unknown though may occur from days to months once delivered to coastal waters. Monitoring within the enclosed coastal Cleveland Bay site was likely to be impacted by discharge from rivers within the Ross Basin.

Table 34. Water quality scores and grades for Cleveland Bay and Halifax Bay inshore marine zone. Scores for water quality are averaged from the scores for nutrients, physical-chemical parameters and chlorophyll *a*.

	Score				Grade			
Site	Nutrients	Phys-chem	Chloro-phyll *a*	Water quality	Nutrients	Phys-chem	Chloro-phyll *a*	Water quality
Enclosed coastal Cleveland Bay	34				D			
Midshelf Cleveland Bay	81	78		79	A	A		B
Geoffrey Bay	35	60	100	65	D	C	A	B
Overall Cleveland Bay	50	**69**	**100**	**73**	**C**	**B**	**A**	**B**
Pandora Reef	46	55	75	59	C	C	B	C
Palms West Reef	51	76	59	62	C	B	C	B
Overall Halifax Bay	48	**65**	**67**	50	**C**	**B**	**B**	**C**

Scoring range: Very Poor (E) = 0 to <21 | Poor (D) = 21 to <41 | Moderate (C) = 41 to <61 | Good (B) = 61 to <81 | Very Good (A) = 81-100 | No score/data gap

6.7.5.5 Confidence scores

There was a low confidence in the scores for water quality indices for both Cleveland Bay and Halifax Bay. The score for each criterion is shown in Table 35. The confidence score is low due to limited spatial sampling, with only three monitoring locations within each inshore zone.

Within Cleveland Bay, monitoring within both the open and enclosed coastal site was within 3 km of the mainland coastline. The site at Geoffrey Bay was approximately 10 km from the Townsville mainland and approximately 500 m offshore from Magnetic Island. The inshore area extends to approximately 60 km offshore and sampling only close to the coastline is unlikely to accurately represent water quality within the entirety of the area. However, sampling close to the coastline is likely to capture the majority of the pollutant discharge for terrestrial sources

Table 35. Confidence scores for water quality indices for Cleveland Bay and Halifax Bay inshore marine zone. Confidence criterion were scored 1-3 and weighted by the value identified in parenthesis. Weighted scores were summed to produce a final score (4.5 – 13.5). Final scores were ranked from 1 to 5 (very low to very high).

Indicator category	Maturity of method (x0.36)	Validation (x0.71)	Representat-iveness (x2)	Directness (x0.71)	Measured error (x0.71)	Final	Rank
Phys-chem	3	3	1	3	1	8.1	Low (2)
Nutrients	3	3	1	3	1	8.1	Low (2)
Chlorophyll *a*	3	3	1	3	1	8.1	Low (2)
Water quality index						**8.1**	**Low (2)**

Rank based on final score: Very low (1): 4.5 – 6.3; Low (2): >6.3 – 8.1; Moderate (3): >8.1 – 9.9; High (4): >9.9 – 11.7; Very high (5): >11.7 – 13.5.

6.8 Offshore marine

No data is presented for offshore marine zones in the Pilot Report Card. This is due to limited data availability and time constraints.

7 Community and Economy methods

7.1 Data source

Data was drawn from the GBR Social and Economic Long Term Monitoring Program (SELTMP), 2017 (Marshall, et al., 2017). Data was collected between June and August 2017 from coastal population centres between Cooktown and Bundaberg (referred to as the GBR coastal region). This data set is based on a series of survey questions, with the results designed to be used to describe conditions and trends of the social aspects of waterways and the GBR (Marshall, et al., 2016). The results for community indicators were sourced from questions relating to the perceived health, condition and management of waterways. Questions relating to the non-monetary economic values and industry sustainability were used to score the economic benefits to the community.

7.2 Methods

7.2.1 Scoring indicators, indicator categories and indices

Survey questions acted as the indicators, with similar themed questions forming indicator categories. The survey questions (within their respective indicator categories) that were used to generate the scores for Community and Economy are listed in Table Appendix D 1 and Table Appendix E 1 respectively. The survey questions listed in Table Appendix D 1 and Table Appendix E are indicative only and questions will be further refined so scores can be produced for each zone. This high resolution will enable comparisons between social perceptions and the state of environment. This information is useful as it enables management and education programs to target specific areas if required. For example, if there is a substantial difference between perceptions and condition, education campaigns can be undertaken to rectify this discrepancy.

Survey respondents ranked each question from 1 (lowest/strongly disagree) to 10 (highest/strongly agree). The score for each question was averaged into indicator categories, with indicator categories then averaged to generate a score for an index and then the overall score for Community and Economy. An overall Community score could only be generated for the offshore zone. The minimum information rules for aggregating data meant there was insufficient data to support an overall Community score for the other zones. No overall score for Economy could be produced for any zone.

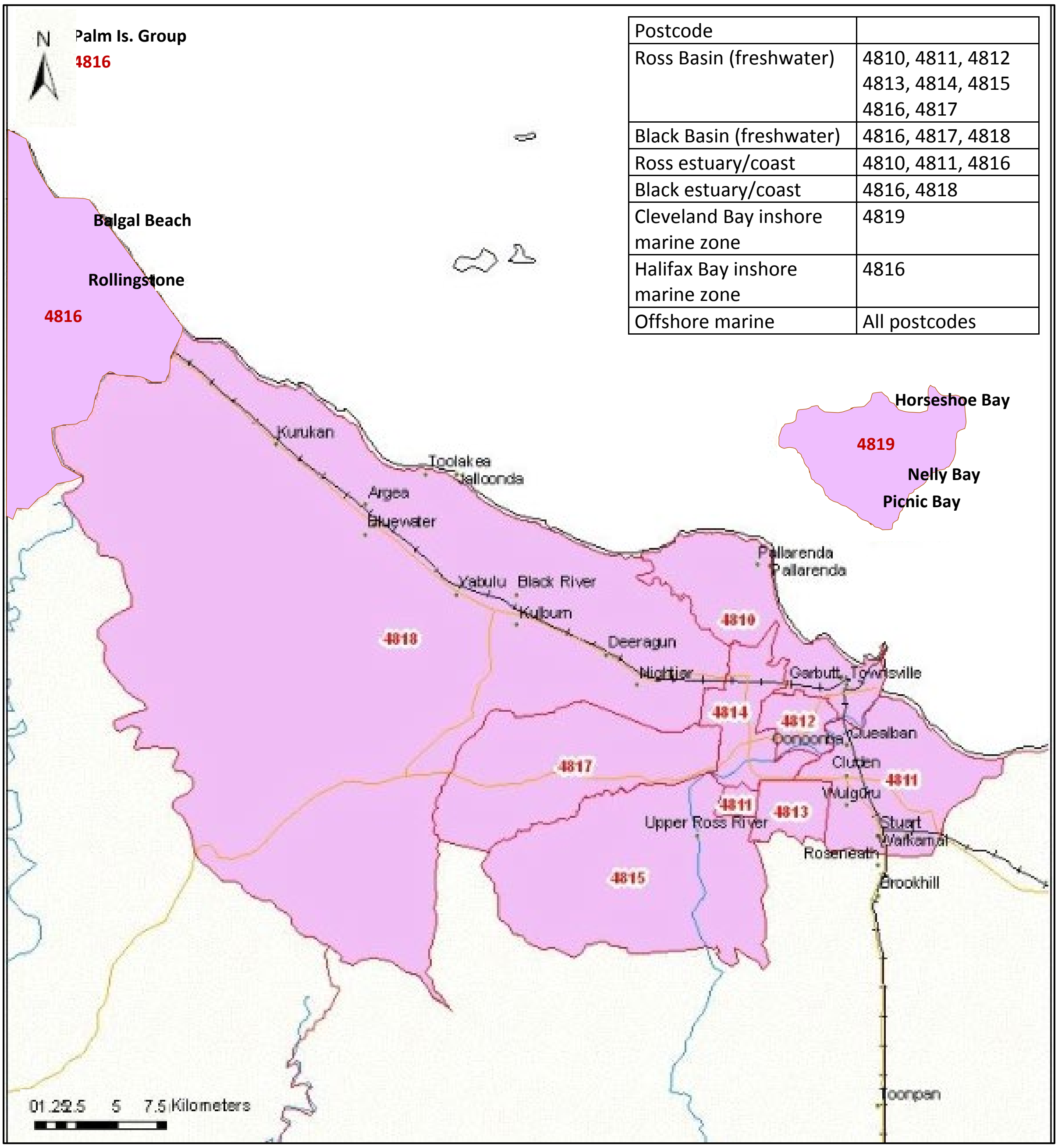
7.2.2 Scores for each reporting zone

SELTMP survey data contain postcodes and basic demographic details of respondents. This meant the survey responses could be filtered based on postcodes within the Townsville Dry Tropics reporting zones. Figure 11 shows the postcodes within the reporting region.
The SELTMP survey was primarily designed to determine the social value of the GBR. Although there were some survey questions relating to freshwater, estuarine/coastal and marine waters, these questions were framed towards the whole Townsville region (for questions relating to freshwater and estuarine/coastal areas) and the entire GBR region, rather than specific waterways. This meant that scores could not be produced for most indices for the freshwater, estuarine/coastal or inshore marine zones (Cleveland Bay and Halifax Bay). It is intended that surveys for future reports will include survey data using questions tailored to the specific reporting region, so that appropriate management responses can be provided.

There was one exception, with scores able to be produced for the community stewardship index. Stewardship rating scores were generated for each zone by grouping postcode responses to the Townsville Dry Tropics reporting areas. Questions on stewardship related to the activities people undertook within their specific region (homes). This enabled scores to be generated at a finer-scale than for the other indicators.

A limitation of this approach is that some overlap occurs in postcodes across the Townsville region. For example, the postcodes for Alligator Creek, Palm Island and Balgal Beach are the same (4816). This limitation should be acknowledged and carefully considered in any further analysis and caution should be taken when interpreting the results. For some postcodes, the sample size was non-representative and inadequate to generate a score for a zone. For example, there were only six survey respondents from Magnetic Island residents (postcode 4819), from a total of 2,335 residents (as of 2016 Census data). Magnetic Island residents are the only residents within the Cleveland Bay inshore marine zone. Therefore a community stewardship score for the Cleveland Bay zone was not generated. Increasing survey sizes within areas where there are small sample sizes will improve the accuracy of the data and representativeness of the results.

The score for all indicator categories were generated for the offshore marine zone. The score for the offshore marine zone was derived from questions relating to the GBR. The answers from all survey respondents within the reporting postcodes were averaged to generate the score for each indicator. For these questions, it is acknowledged that the responses are reflective of the entire GBR, rather than parts of the GBR within the offshore marine zone. In future, the intent is to develop specific survey questions to identify values and perceptions for the offshore marine zone (rather than the whole GBR). A total of 1,191 people in Townsville participated in the survey from a total population of approximately 192,988.



Postcode	
Ross Basin (freshwater)	4810, 4811, 4812 4813, 4814, 4815 4816, 4817
Black Basin (freshwater)	4816, 4817, 4818
Ross estuary/coast	4810, 4811, 4816
Black estuary/coast	4816, 4818
Cleveland Bay inshore marine zone	4819
Halifax Bay inshore marine zone	4816
Offshore marine	All postcodes

Figure 11. Postcode areas within the Townsville Dry Tropics region, shaded in pink and including Magnetic Island.

7.2.3 Positive wording survey questions

Some survey questions were positively worded, whilst others were negatively worded to minimise systematic bias in the survey responses. For the Pilot Report Card, all negative questions were changed to be written so they were positively worded and the scores inverted (e.g. a score of 1 for a negatively worded question is inverted to a 10 to represent the equivalent positively worded question). For example, a question such as "Thinking about coral bleaching makes me feel depressed" was changed to "Thinking about coral bleaching does not make me feel depressed". This was done so that all answers were on the same scale (e.g. a 10 meant the highest positive response, whilst 1 was the lowest score).

7.2.4 Method for grading Community and Economy data

Similar to the grading methods used for the environmental condition assessments, the Community and Economic benefits were graded using a five-point scale ranging from A (Very Good) to E (Very Poor). The distributions of rating scores from each survey question were assessed for normality. Whilst most questions had normally distributed responses, the responses for the Community Stewardship indicator category were highly skewed (more positive scores). This reflects the majority of respondents self-rating their stewardship behaviour at the top end of the scale. To account for this positivity (or virtue) bias, the A-E scoring range has been shifted upwards for this indicator category (so that a higher mean score is required to achieve a Very Good score). The scores and the corresponding grades for the indicator categories and indices for Community and Economic are shown in Table 36.

In contrast to the environmental condition assessments, a "C (moderate)" grade does not necessarily indicate passing or failing a guideline. Instead it indicates that the community derives moderate benefits from waterways.

Table 36. Scoring range and corresponding grade for Community and Economic indicator categories and indices and for the Community Stewardship indicator category.

Scoring range for Community and Economic indicator categories and indices*	Scoring range for Community stewardship indicator category	Grade and colour code
8 to 10	9 to 10	Very Good (A)
7 to <8	8 to <9	Good (B)
6 to <7	7 to <8	Moderate (C)
5 to <6	6 to <7	Poor (D)
<5	<6	Very Poor (E)

*Scoring range for all indicator categories and the overall Community and Economic indices except the Community Stewardship indicator category.

7.2.5 Confidence score for Community and Economy

There is currently no method to score confidence for Community and Economic indices. Therefore the standard error associated with each score and the percentage of the population that was

sampled was presented with the results. The standard error was calculated for each question and then averaged for each indicator category and the overall Community and Economic index. The standard error represents the variability in survey responses. This variability does not provide a measure of how accurate the data is, only a reflection of the variability of responses.
The percentage of the population was calculated based on the number of survey respondents and the number of people living within the reporting zone. The number of survey respondents, population within each zone and percentage of the population surveyed for each zone is presented in Table 37. The population within each zone was calculated by summing the population for each suburb (and postcode) within that zone. Population data was based on the 2016 Census data (Australian Bureau of Statistics, 2016). The population for each suburb is listed in Table Appendix D 2.

Table 37. Percentage of population surveyed within the Townsville region.

Zone	Population	Population surveyed	Percentage (%) of the population surveyed
Ross Basin (freshwater)	138,538	596	0.43
Black Basin (freshwater)	4,015	112	2.79
Ross estuarine/coastal zone	39,730	306	0.77
Black estuarine/coastal zone	6,484	58	0.89
Cleveland Bay (inshore marine zone)	2,335	6	0.26
Halifax Bay (inshore marine zone)	2,455	0	0.00
Offshore marine zone	193,557	1,191	0.62

8 Community results

8.1 Overview of Community indicator indices

The overall score for Community is based on indicators grouped into the following indices:

- Value and Wellbeing of waterways (referred to as Value and wellbeing)
- Perception of waterway management and environmental condition (referred to as perceptions)
- Community stewardship

Indices and indicator categories aggregated to produce an overall score for community within each zone are highlighted in Table 39. There are currently no data (and therefore score) for the first two indices within the freshwater, estuarine/coastal or inshore marine environment. It is intended that survey questions will be developed to address these gaps and results for these indices will be reported upon in future reports. Minimum information rules for aggregating data meant that no overall score for Community can be produced.

Table 38. Indices and indicator categories that are aggregated to generate an overall score for Community. The indices and indicator categories aggregated into an overall score for Community for the Pilot Report Card are highlighted.

Zone	Index	Indicator category
Freshwater, estuarine/coastal and inshore marine zones	Value & wellbeing from waterways	Values of waterways
		Wellbeing from waterways
	Perception of waterways	Perception of waterway management
		Perception of environmental condition
	Stewardship	Stewardship
Offshore marine	Value & wellbeing	Values of waterways
		Wellbeing from waterways
	Perceptions	Perception of waterway management
		Perception of environmental condition
	Community stewardship	Community stewardship

8.2 Freshwater

Community stewardship by residents within the Ross and Black basins was moderate and poor respectively (Table 39). No overall score for Community could be generated due to the minimum information rules.

Table 39. Scores (with standard errors) and grades of community stewardship by residents within Ross and Black freshwater basins. The number of people surveyed is indicated by N, whilst Pop indicates the percentage of the population surveyed.

	Score		Grade	
	Community stewardship	Community score	Community stewardship	Community score
Ross Basin	7.2 ± 0.090 (N = 596, Pop. = 0.43%)		C	
Black Basin	6.9 ± 0.21 (N = 112, Pop. = 2.8%)		D	

Scoring range for Community Stewardship: ■ Very Poor (E) = ≤5 | ■ Poor (D) = 6 to <7 | ■ Moderate (C) = 7 to <8 | ■ Good (B) = 8 to <9 | ■ Very Good (A) = 9 to 10 | ■ No score/data gap

8.3 Estuary/Coastal

8.3.1 Overall Community index

Community stewardship scores were graded as moderate and poor for residents within the Ross and Black coastal zones respectively (Table 40). There was insufficient data to generate an overall score for Community in the Ross or Black estuarine/coastal zones.

Table 40. Scores (with standard errors) and grades for community stewardship by residents within Ross and Black freshwater basins. The number of people surveyed is indicated by N, whilst Pop indicates the percentage of the population surveyed.

	Score		Grade	
	Community stewardship	Community score	Community stewardship	Community score
Ross estuarine/coastal zone	7.0 ± 0.13 (N = 306; Pop. = 0.77%)		C	
Black estuarine/coastal zone	6.4 ± 0.31 (N = 58; Pop. = 0.89%)		D	

Scoring range for Community Stewardship: ■ Very Poor (E) = ≤5 | ■ Poor (D) = 6 to <7 | ■ Moderate (C) = 7 to <8 | ■ Good (B) = 8 to <9 | ■ Very Good (A) = 9 to 10 | ■ No score/data gap

8.4 Inshore marine

8.4.1 Overall Community index

Magnetic Island residents are the only residents within Cleveland Bay and there were only 6 survey respondents. Thus, there was insufficient data to produce a score for any indicator within Cleveland Bay (inshore marine zone).

8.5 Offshore marine

8.5.1 Value and wellbeing index

As seen in Table 41, the community received good benefits from the offshore marine zone (entire GBR) in relation to the value and wellbeing.

Table 41. Scores (with standard errors) and grades for the value and wellbeing that Townsville residents received from the Great Barrier Reef. The number of people surveyed is indicated by N, whilst Pop indicates the percentage of the population surveyed.

	Score			Grade		
	Value	Wellbeing	Value and wellbeing index	Value	Wellbeing	Value and wellbeing index
Offshore marine zone (GBR) N = 1191, Pop. = 0.62%	7.3 ± 0.068	7.7 ± 0.068	7.5 ± 0.068	B	B	B

Scoring range: ■ Very Poor (E) = 0 to <5 | ■ Poor (D) = 5 to <6 | ■ Moderate (C) = 6 to <7 | ■ Good (B) = 7 to <8 | ■ Very Good (A) = 8 to 10 | ■ No score/data gap

8.5.2 Perception index

As shown in Table 42, community perceptions of the health and condition of the offshore marine environment (entire GBR) were graded as very poor, and perceptions of management were poor. It is noted that surveys were conducted immediately after the second mass bleaching event on the GBR (M. Curnock 2019, pers. comm., 30 January). This event is considered to have had a strong influence on the community perception of the GBR health (M. Curnock 2019, pers. comm., 30 January).

Table 42. Scores (with standard errors) and grades for the perception Townsville residents have of the management and the environmental condition of the Great Barrier Reef. The number of people surveyed is indicated by N, whilst Pop indicates the percentage of the population surveyed.

	Score			Grade		
	Perception of waterway management	Perception of environmental condition	Perception index	Perception of waterway management	Perception of environmental condition	Perception index
Offshore marine zone (GBR) N = 1191, Pop. = 0.62%	5.6 ± 0.075	4.6 ± 0.067	5.1 ± 0.071	D	E	D

Scoring range: ■ Very Poor (E) = 0 to <5 | ■ Poor (D) = 5 to <6 | ■ Moderate (C) = 6 to <7 | ■ Good (B) = 7 to <8 | ■ Very Good (A) = 8 to 10 | ■ No score/data gap

8.5.3 Community stewardship index

As presented in Table 43, community stewardship by Townsville residents was graded as poor.

Table 43. Score (with standard error) and grade for community stewardship by Townsville residents. The number of people surveyed is indicated by N, whilst Pop indicates the percentage of the population surveyed.

	Score	Grade
	Community stewardship	Community stewardship
Offshore marine zone (GBR) N = 1191, Pop. = 0.62%	6.7 ± 0.069	D

Scoring range for Community Stewardship: ■ Very Poor (E) = ≤5 | ■ Poor (D) = 6 to <7 | ■ Moderate (C) = 7 to <8 | ■ Good (B) = 8 to <9 | ■ Very Good (A) = 9 to 10 | ■ No score/data gap

8.5.4 Overall Community index

Overall, the community received moderate benefits from the offshore marine zone (entire GBR) (Table 44), with good value and wellbeing benefits but poor perceptions of the GBR (both condition and management) and poor stewardship by residents.

Table 44. Scores (with standard errors) and grades for the indices that comprise the Community index and overall score for the Community index for the offshore marine zone. The number of people surveyed is indicated by N, whilst Pop indicates the percentage of the population surveyed.

	Value and Wellbeing	Perceptions	Community stewardship	Community index
Score (N = 1191, Pop. = 0.62%)	7.5 ± 0.068	4.6 ± 0.067	6.7 ± 0.069	6.6 ± 0.070
Grade	B	E	D	C

Scoring range (ex. Community Stewardship): ■ Very Poor (E) = 0 to <5 | ■ Poor (D) = 5 to <6 | ■ Moderate (C) = 6 to <7 | ■ Good (B) = 7 to <8 | ■ Very Good (A) = 8 to 10 | ■ No score/data gap

Scoring range for Community Stewardship: ■ Very Poor (E) = ≤5 | ■ Poor (D) = 6 to <7 | ■ Moderate (C) = 7 to <8 | ■ Good (B) = 8 to <9 | ■ Very Good (A) = 9 to 10 | ■ No score/data gap

9 Economic results

The score for Economy is based on the scores of indicators that are grouped into two indices for all zones, which are:

- Non-monetary economic values
- Industry sustainability (ecological and economic)

For the Pilot Report Card, only indicators of non-monetary economic values are reported upon and only within the offshore marine zone. Indices and indicator categories aggregated to produce an overall score for community within each zone are highlighted in Table 45. Only one index is scored and the aim is to generate data and develop a scoring method for the other index for future report cards. The minimum information rules for aggregating data meant that no overall score for Economy can be produced.

There was no available data on economics relating to the freshwater, estuarine/coastal or inshore marine waters. In the future it is hoped that surveys can be tailored to include questions on the economic values of these three environments. There is currently no scoring method to score indicators within the industry sustainability index. A scoring method will be developed and the results for this indicator category will be presented in future reports. The number of indices or indicator categories may be increased as more data become available.

Table 45. Indices and indicator categories that are aggregated to generate an overall score for Economy. The indices and indicator categories aggregated into an overall score for Economy for the Pilot Report Card are highlighted.

Zone	Index	Indicator category
Freshwater, estuarine/coastal, inshore marine and offshore marine zones	Non-monetary economic value	Tourism attraction value
		Science and education value
		Fresh local seafood
		Perception of economic value
	Industry Sustainability	Ecological sustainability
		Economic sustainability

9.1 Offshore marine zone

9.1.1 Overall Economic Index

Overall, the community received very high non-monetary economic benefits from the offshore marine zone for the entire GBR. The scores for each indicator category are presented in Table 46. All categories received a very good score, except for the benefits of fresh local seafood, which the community scored as being a moderate benefit (Table 46).

Table 46. Scores (with standard errors) and grades for the indicatory categories that comprise the Economy index and overall Economy score for the offshore marine zone. The number of people surveyed is indicated by N, whilst Pop indicates the percentage of the population surveyed.

	Tourism attraction value	Science and education value	Fresh local seafood	Perception of economic value	Non-monetary economic index
Score (N = 644, Pop = 0.33%)	8.5 ± 0.079	8.5 ± 0.073	6.7 ± 0.12	9.2 ± 0.054	8.2 ± 0.080
Grade	A	A	C	A	A

Scoring range: ■ Very Poor (E) = 0 to <5 | ■ Poor (D) = 5 to <6 | ■ Moderate (C) = 6 to <7 | ■ Good (B) = 7 to <8 | ■ Very Good (A) = 8 to 10 | ■ No score/data gap

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Appendix A. Detailed results of coral indicators

The unstandardised and standardised scores for indicators of inshore coral for each monitoring site are presented in Table Appendix A 1. At most monitoring sites, indicators were measured at two depths, with the results from these two depths averaged for the site. The overall score for coral indicator category within Cleveland Bay and Halifax Bay was calculated by averaging the scores for each site.

Table Appendix A 1. Unstandardised and standardised scores for indicators of inshore coral and the overall coral index for Cleveland Bay and Halifax Bay. The standardised score for Cleveland Bay and Halifax Bay are presented as integers to conform to the grading system.

	Raw scores							Standardised scores					
Site (Reef)	Depth (m)	Juvenile density	Macro-algae	% Coral cover	% Change hard corals	Composition of hard corals	**Coral indicator category**	Juvenile density	Macro-algae	% Coral cover	% Change hard corals	Composition of hard corals	**Coral indicator category**
Magnetic Is.	2	0.18	0	0.22	0.31	0.50	0.24	17.8	0.0	21.7	31.5	50.0	24.2
Magnetic Is.	5	0.71	0	0.39	0.34	0.00	0.29	70.5	0.0	39.3	33.8	0.0	28.7
Magnetic Is.	Average	0.44	0	0.31	0.33	0.25	0.26	44.2	0.0	30.5	32.6	25.0	26.5
Middle Reef	2	0.54	0	0.52	NA*	0.50	0.39	54.0	0.0	51.9	NA*	50.0	39.0
Cleveland Bay	**Average**	**0.49**	**0.00**	**0.41**	**0.33**	**0.38**	**0.33**	**49**	**0**	**41**	**33**	**38**	**33**
Havannah	2	0.11	1.00	0.52	0.50	1.00	0.63	10.8	100.0	51.8	50.0	100.0	62.5
Havannah	5	0.33	0.00	0.47	1.00	1.00	0.56	33.0	0.0	47.0	100.0	100.0	56.0
Havannah	**Average**	**0.22**	**0.50**	**0.49**	**0.75**	**1.00**	**0.59**	**21.9**	**50.0**	**49.4**	**75.0**	**100.0**	**59.3**
Havannah North	5	1.00	0.00	0.09	0.59	1.00	0.54	100.0	0.0	9.5	58.8	100.0	53.7
Palms East	2	0.53	0.21	0.23	0.50	1.00	0.49	52.8	20.9	22.8	50.0	100.0	49.3
Palms East	5	0.65	0.00	0.18	0.69	1.00	0.50	65.1	0.0	17.8	69.0	100.0	50.4
Palms East	**Average**	**0.59**	**0.10**	**0.20**	**0.59**	**1.00**	**0.50**	**58.9**	**10.5**	**20.3**	**59.5**	**100.0**	**49.8**
Palms West	2	0.18	1.00	0.33	1.00	0.00	0.50	18.1	100.0	32.8	100.0	0.0	50.2
Palms West	5	0.40	1.00	0.48	0.67	1.00	0.71	40.3	100.0	47.6	66.7	100.0	70.9
Palms West	**Average**	**0.29**	**1.00**	**0.40**	**0.83**	**0.50**	**0.61**	**29.2**	**100.0**	**40.2**	**83.3**	**50.0**	**60.5**
Pandora	2	0.26	0.00	0.08	0.26	0.50	0.22	25.9	0.0	8.3	25.7	50.0	22.0
Pandora	5	0.65	0.05	0.14	0.54	1.00	0.48	65.3	4.8	14.2	53.8	100.0	47.6
Pandora	**Average**	**0.46**	**0.02**	**0.11**	**0.40**	**0.75**	**0.35**	**45.6**	**2.4**	**11.3**	**39.8**	**75.0**	**34.8**
Pandora North	5	0.59	0.00	0.73	0.08	0.00	0.28	58.5	0.0	72.5	8.2	0.0	27.8
Halifax Bay	**Average**	**0.52**	**0.27**	**0.34**	**0.54**	**0.71**	**0.48**	**52**	**27**	**33**	**54**	**70**	**47**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = assigned 90 | ■ No score/data gap

*The percent change in hard coral cover has not been sampled on Middle Reef since 2014.

Appendix B. Freshwater, estuarine/coastal and inshore marine monitoring sites and locations

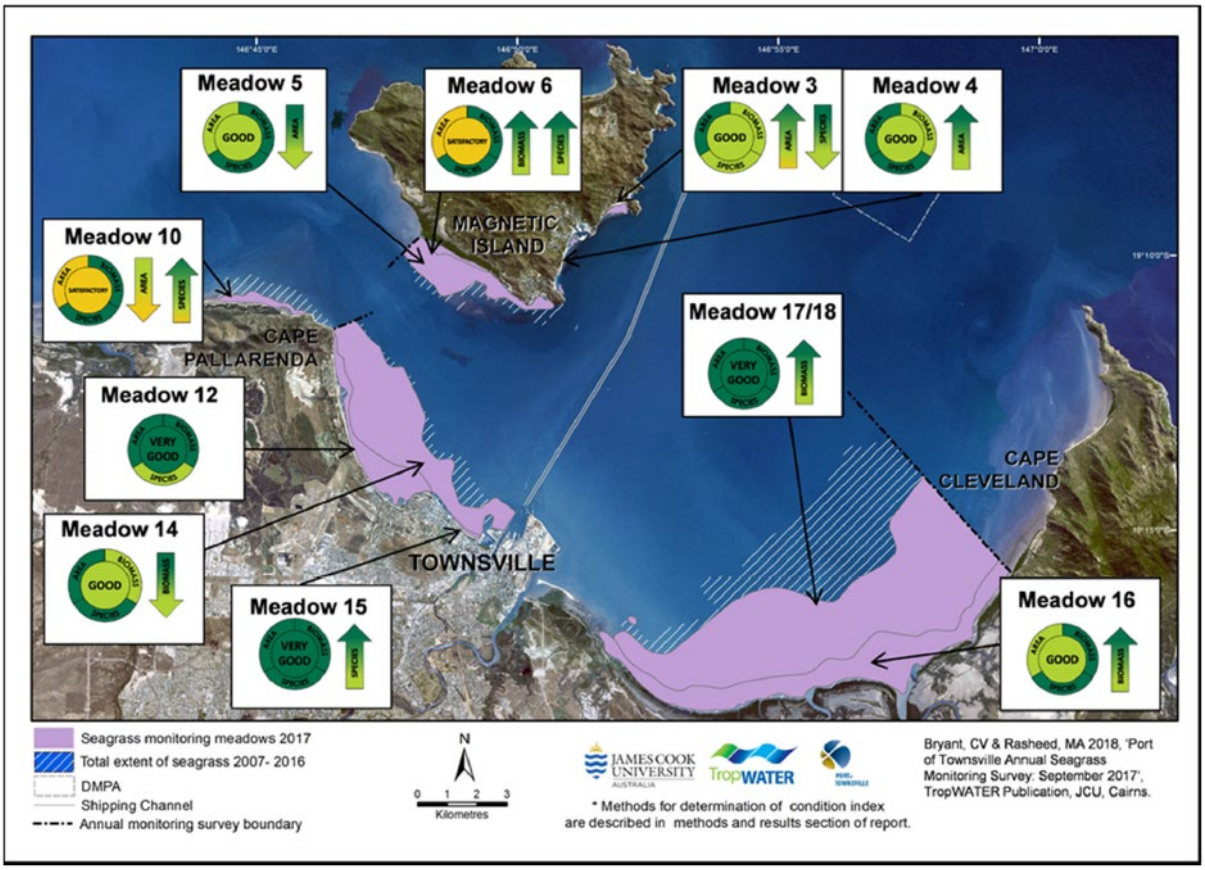

Figure Appendix B 1. Seagrass condition for Townsville seagrass monitoring meadows.
Source: (Bryant & Rasheed, 2018)

Figure Appendix B 2. Seven monitoring locations within the Ross River Dam.
Image source: Google Earth ©, 2018

Figure Appendix B 3. Black Weir, Gleeson's Weir and Aplins Weir monitoring sites along the Ross River.
Image source: Google Earth ©, 2018

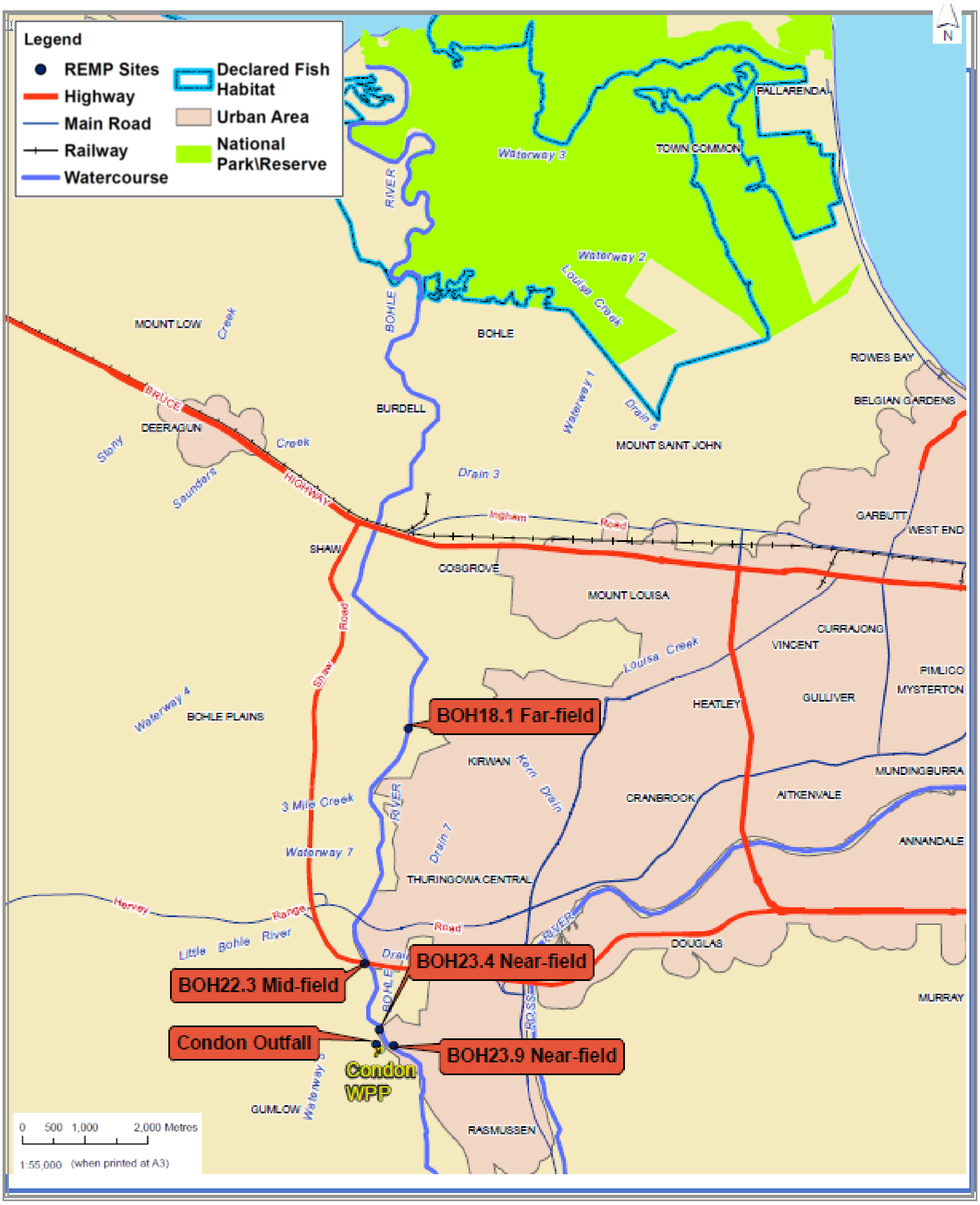

Figure Appendix B 4. Freshwater monitoring locations along the Bohle River (BOH) in relation to the Condon Sewage Treatment Plant (Condon WPP in figure). Data from BOH22.3 mid-field, BOH18.1 far-field and BOH23.9 near-field (which is above the sewage treatment plant) sites were included in analysis. Data from the outfall location and BOH23.4 (near-field location) were excluded as the Report Card focuses on the ambient monitoring.

Source: (AECOM Australia Pty Ltd, 2013).

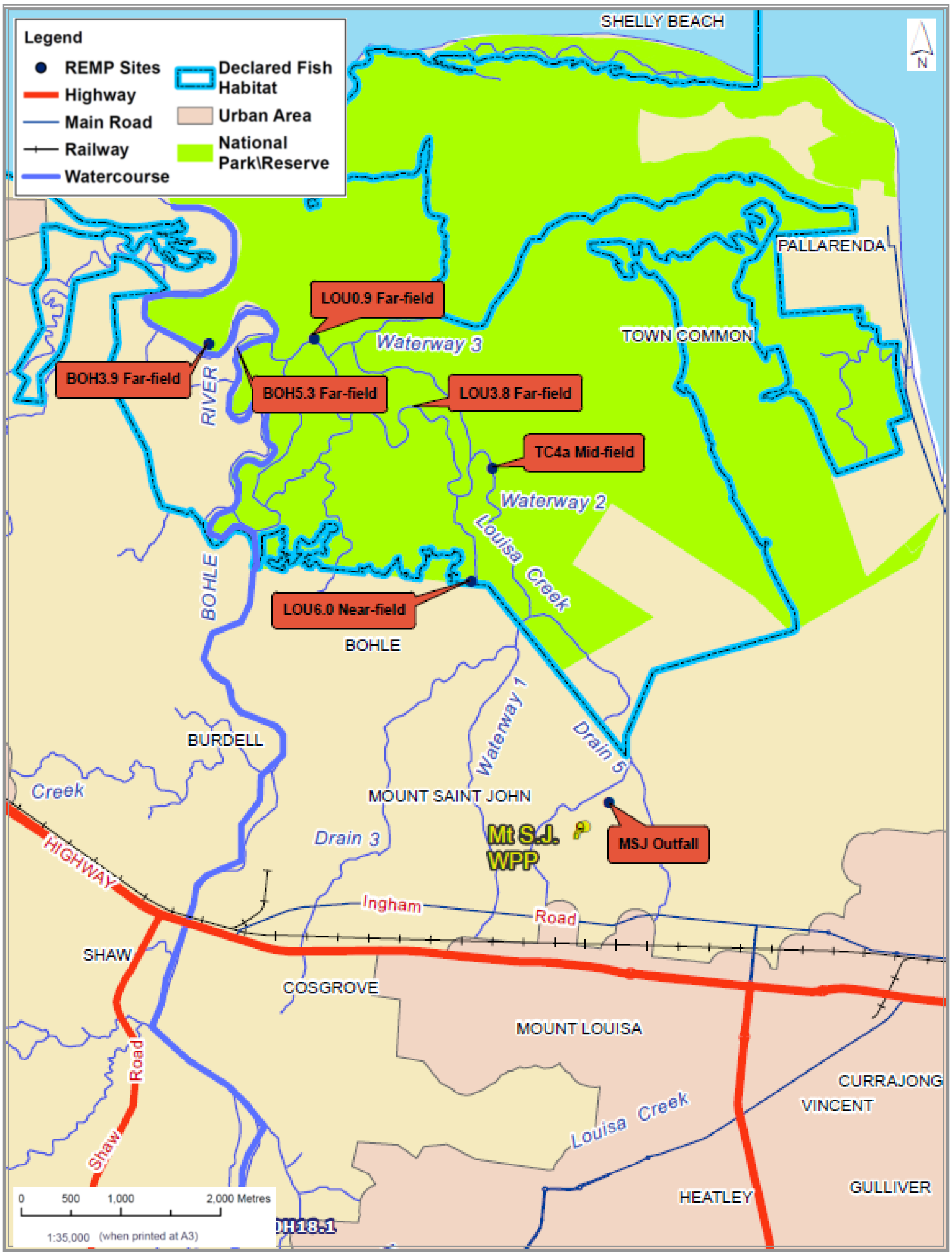

Figure Appendix B 5. Location of estuarine/coastal outfall, near, mid and far-field monitoring sites in relation to Mt. St. John's (MTS) Sewage Treatment Plant. Monitoring occurred along Louisa Creek (LOU) within the Town Common (TC) wetland and along the Bohle River (BOH). Monitoring was not undertaken at BOH5.3 far-field or LOU 3.8 Far-field.

Source: (AECOM Australia Pty Ltd, 2013).

Figure Appendix B 6. Estuarine/coastal monitoring locations along the Ross Creek (purple dots) and Ross River (pink dot) and inshore marine monitoring locations (yellow dots indicating grab samples and a red dot indicating logger sample) at the midshelf Cleveland Bay site.

Image source: Google Earth ©, 2018

Figure Appendix B 7. Location of monitoring sites at Ross Creek Estuary (purple dots), Ross River Estuary (pink dot), Stuart Creek Estuary (red dot), Sandfly Creek (yellow dots) and Alligator Creek Estuary (orange dot).

Image source: Google Earth ©, 2018

Figure Appendix B 8. Estuarine/coastal monitoring locations within Fairfield Lakes.
Image source: Google Earth ©, 2018

Figure Appendix B 9. Estuarine/coastal monitoring locations within Keyatta Lakes.
Image source: Google Earth ©, 2018

Figure Appendix B 10. Townsville City Council (TCC) Cleveland Bay water quality monitoring sites.

Appendix C. Distribution of water quality data

The following figures are box and whisker plots (boxplots) of water quality indicators at all sites within the freshwater, estuarine/coastal and inshore marine zones. The mid-line is the median and the box depicts the upper and lower quartiles. The whiskers are the lowest and highest datum within 1.5 interquartile range (IQR) and outliers are datum above or below 1.5 IQR. Analysis was conducted on all data points collected during the reporting period (not only on the monthly values used for generating scores).

Boxplots for freshwater water quality data

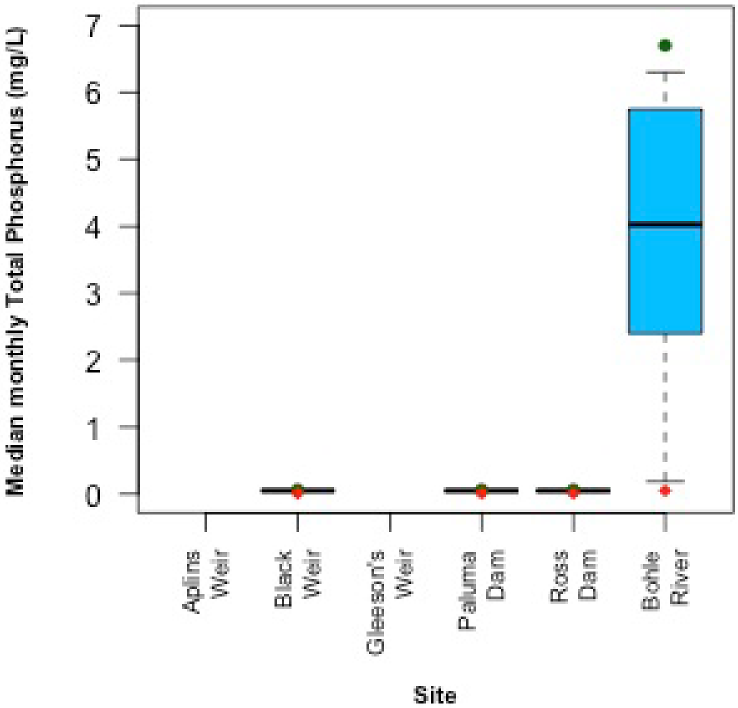

Figure Appendix C 1. Boxplot of total phosphorus concentrations at each freshwater monitoring site. The red circles indicate the guideline values and the green circles show the scaling factors.

Note the GV for the Bohle River is 5 times higher than for the other sites within the Ross Basin (weirs and Ross Dam). This difference in GVs has a substantial impact upon the final scores. For example the Bohle River received a 'poor' grade, which is a grade better than all the other sites which received very poor grades. This was despite the data showing the Bohle River had substantially higher concentrations of total phosphorus than all the other freshwater sites.

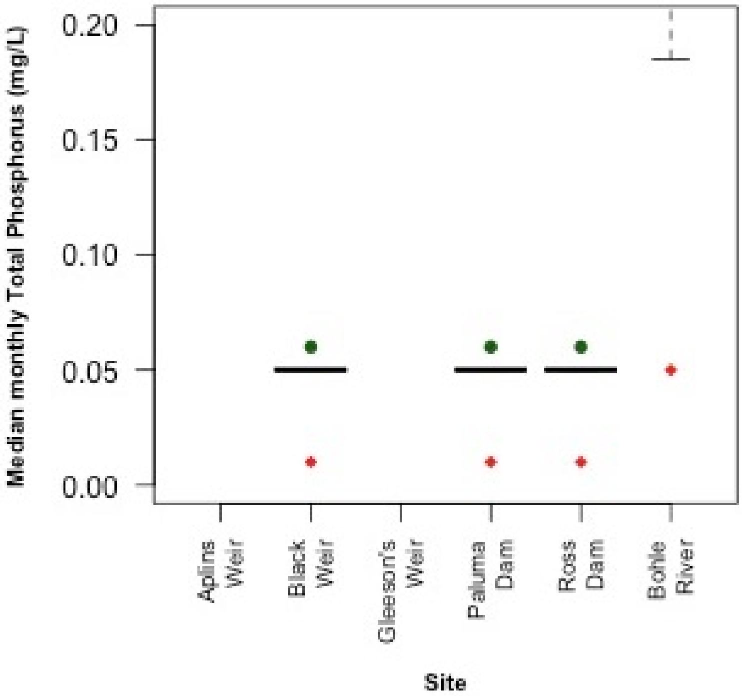

Figure Appendix C 2. Boxplot of total phosphorus concentrations at each freshwater monitoring site. The higher values from the Bohle River site have been excluded to allow a closer examination of the boxplots. The red circles indicate the guideline values (GVs) and the green circles show the scaling factors.

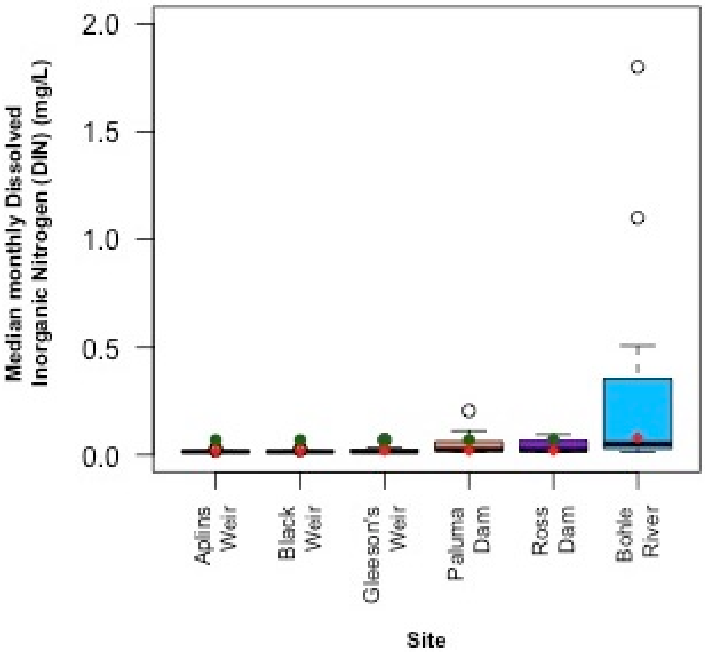

Figure Appendix C 3. Boxplot of dissolved inorganic nitrogen (DIN) concentrations at each freshwater monitoring site. The red circles indicate the guideline values and the green circles show the scaling factors. Outliers are shown as clear circles.

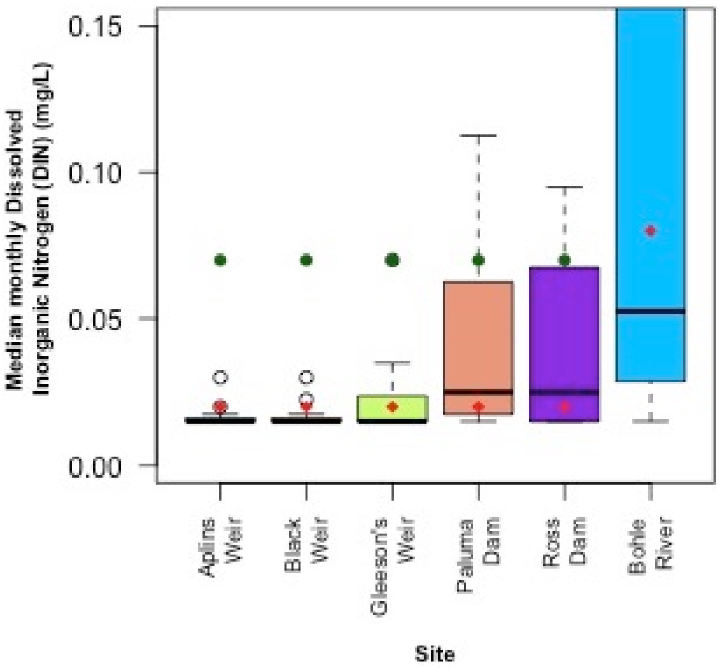

Figure Appendix C 4. Boxplot of dissolved inorganic nitrogen (DIN) concentrations at each freshwater monitoring site. The uppermost data from the Bohle River site has been excluded to allow a closer examination of the boxplots. The red circles indicate the guideline values (GVs) and the green circles show the scaling factors. Outliers are shown as clear circles.

Note that the GV for the Bohle River is 4 times higher than the GVs for the other freshwater sites within the Ross Basin (weirs and Ross Dam). This difference in GVs has a substantial impact upon the final scores. For example the Bohle River received a 'good' grade, which is a grade better than Ross Dam and similar to the other sites. This was despite the data showing the Bohle River had higher concentrations of DIN than all the other freshwater sites.

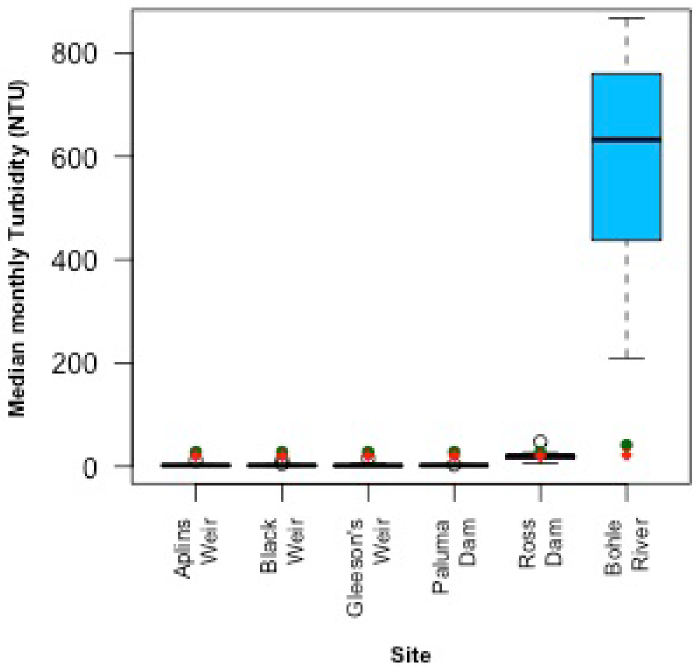

Figure Appendix C 5. Boxplot of turbidity levels at each freshwater monitoring site. The red circles indicate the guideline values and the green circles show the scaling factors. Outliers are shown as clear circles.

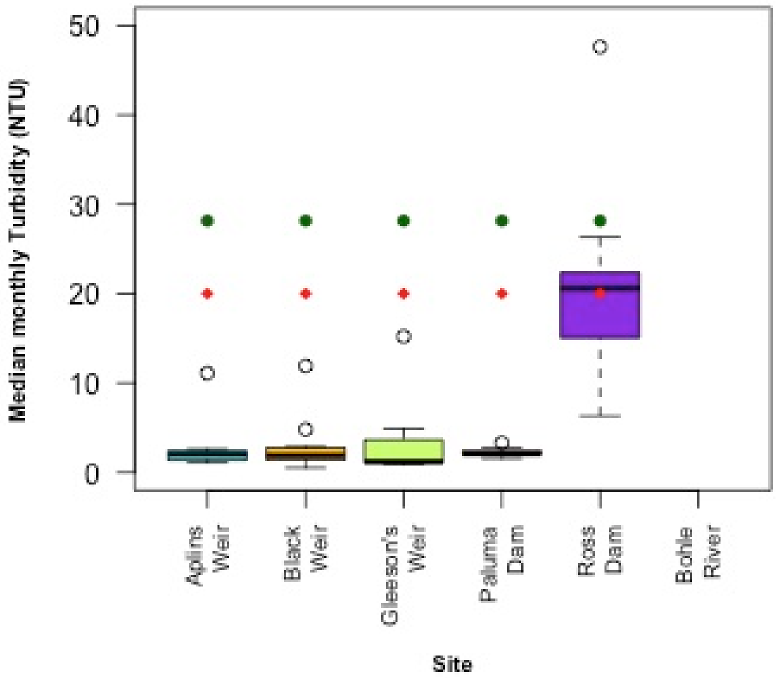

Figure Appendix C 6. Boxplot of turbidity levels at each freshwater monitoring site. The Bohle River site has been excluded to allow a closer examination of the boxplots. The red circles indicate the guideline values and the green circles show the scaling factors. Outliers are shown as clear circles.

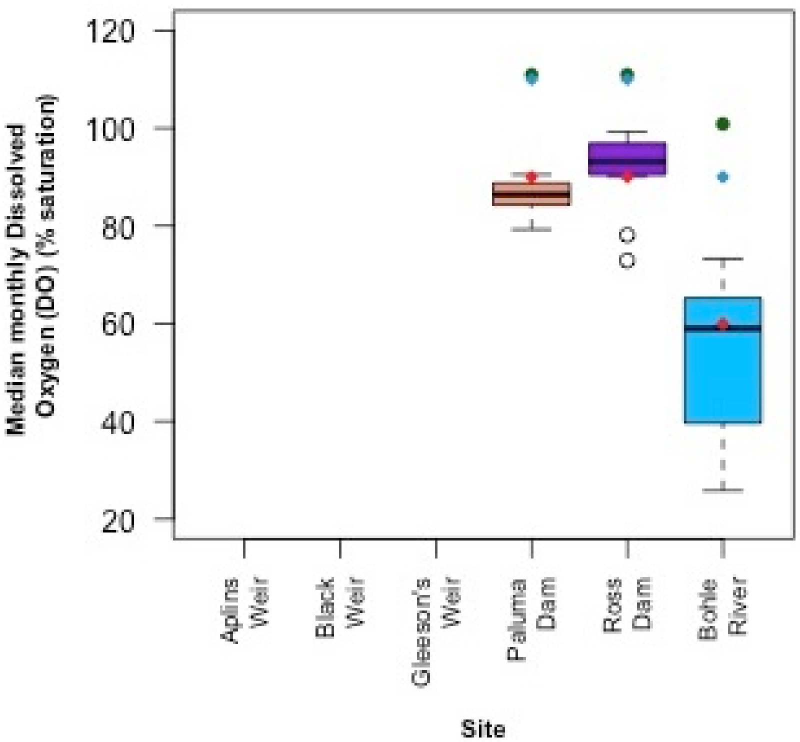

Figure Appendix C 7. Boxplot of dissolved oxygen (DO) concentrations at each freshwater monitoring site. The red and blue circles indicate the guideline values for the lower and upper DO limit respectively and the green circles show the scaling factors. Outliers are shown as clear circles.

Boxplots for estuarine/coastal water quality data

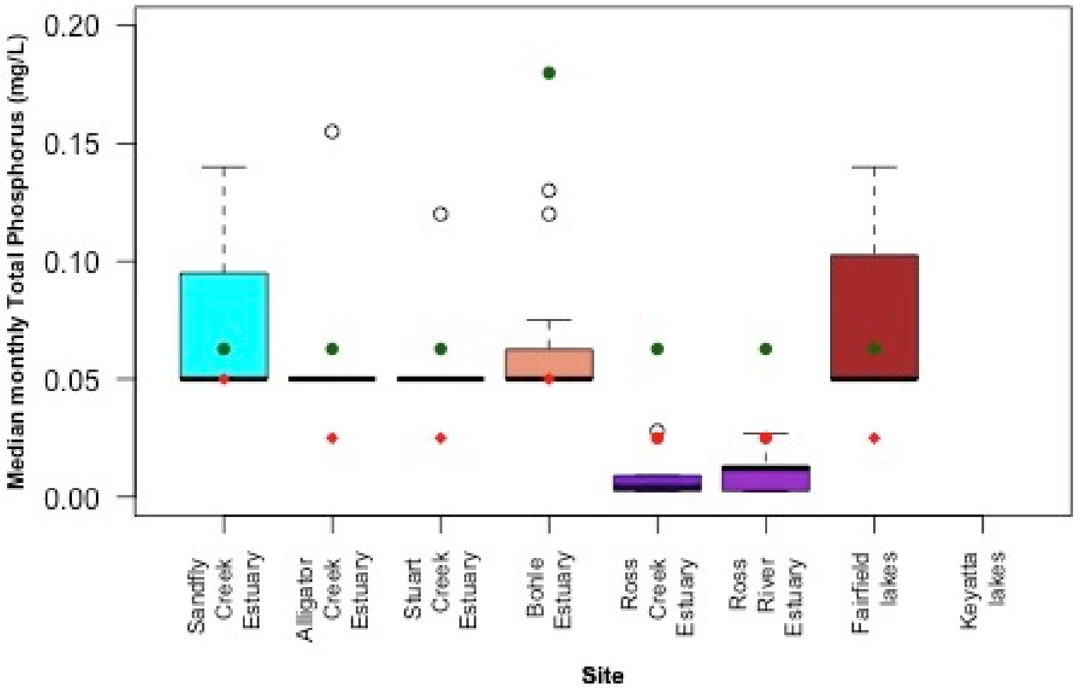

Figure Appendix C 8. Boxplot of total phosphorus concentrations at each estuarine/coastal monitoring site. The red circles indicate the guideline values (GVs) and the green circles show the scaling factors. Outliers are shown as clear circles.

Note that the GV for the Bohle Estuary is twice as higher as the GVs for the other estuarine sites within the Ross Basin (weirs and Ross Dam). This difference in GVs has a substantial impact upon the final scores. For example the Bohle River received a 'good' grade, whilst Alligator Creek and Stuart Creek estuaries received poor scores despite the Bohle Estuary having substantially higher concentrations of total phosphorus.

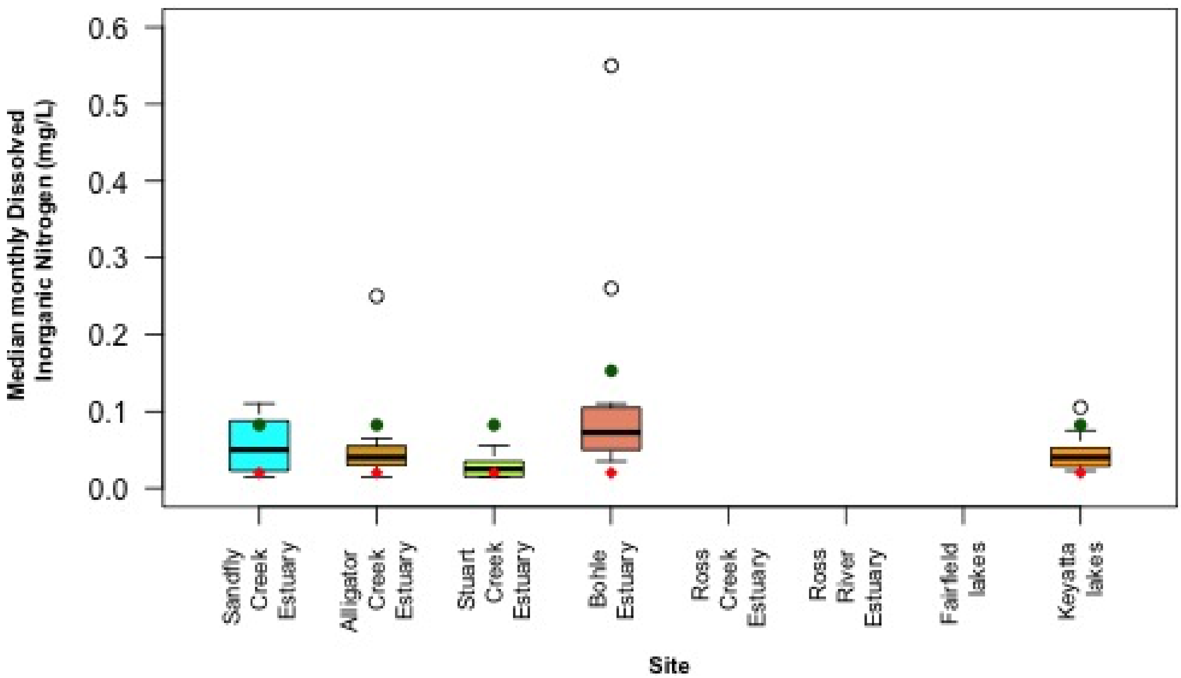

Figure Appendix C 9. Boxplot of dissolved inorganic nitrogen (DIN) concentrations at each estuarine/coastal monitoring site. The red circles indicate the guideline values and the green circles show the scaling factors. Outliers are shown as clear circles.

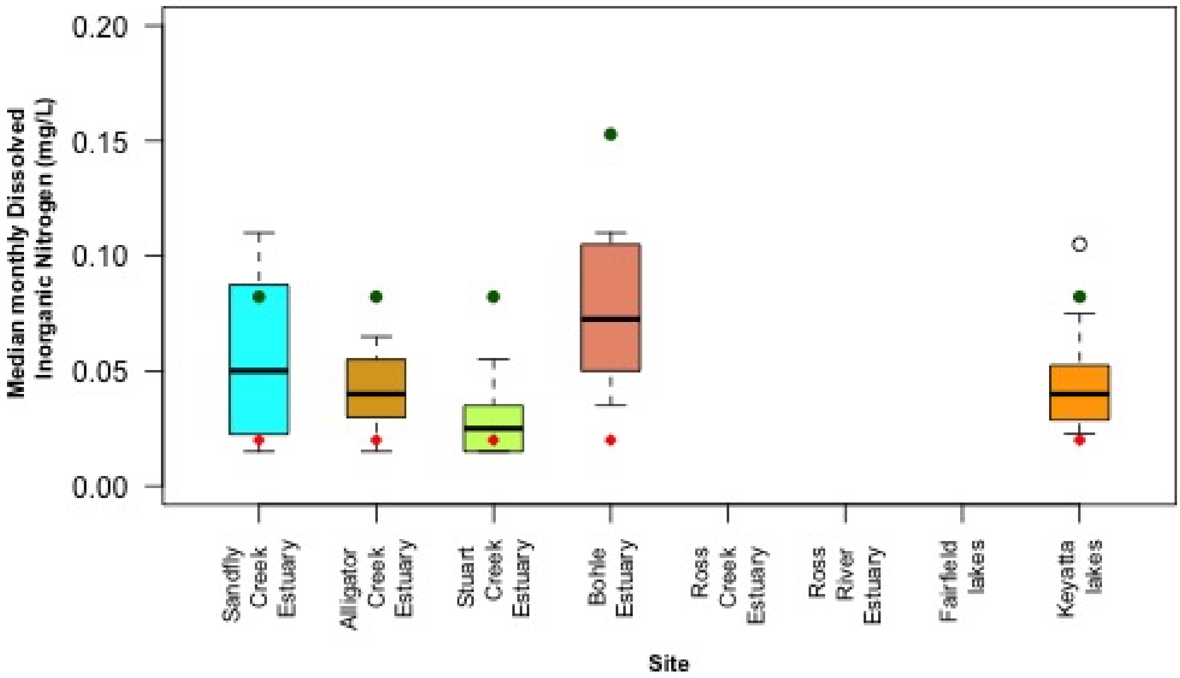

Figure Appendix C 10. Boxplot of dissolved inorganic nitrogen (DIN) concentrations at each estuarine/coastal monitoring site. The two outliers at Bohle Estuary have been excluded to allow a closer examination of the boxplots. The red circles indicate the guideline values and the green circles show the scaling factors. Outliers are shown as clear circles.

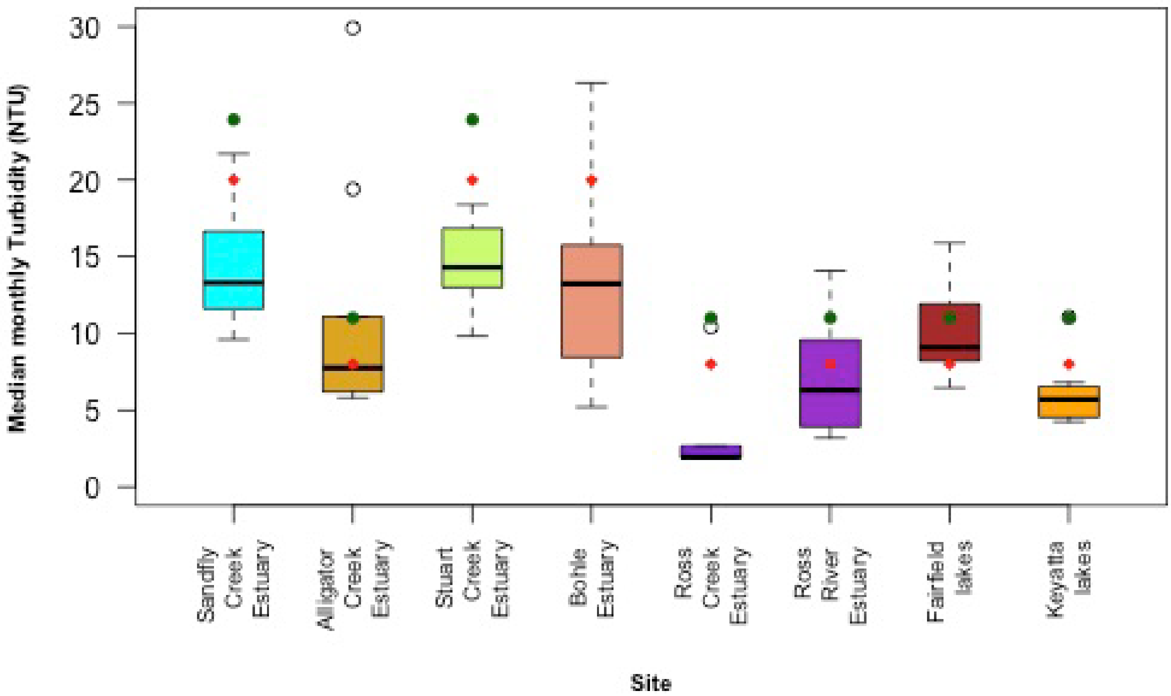

Figure Appendix C 11. Boxplot of turbidity levels at each estuarine/coastal monitoring site. The red circles indicate the guideline values and the green circles show the scaling factors. Outliers are shown as clear circles. The SF for the Bohle Estuary is 38 NTU but has been excluded to allow a closer examination of the boxplots.

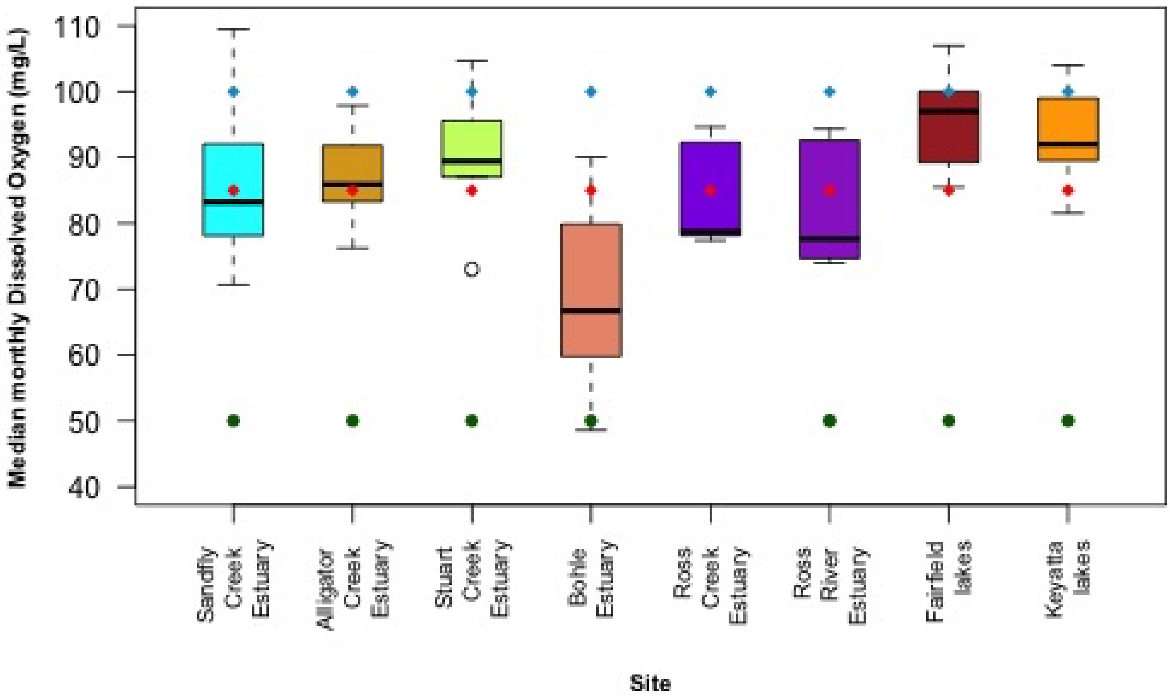

Figure Appendix C 12. Boxplot of dissolved oxygen (DO) concentrations at each estuarine/coastal monitoring site. The red and blue circles indicate the guideline values for the lower and upper DO limit respectively and the green circles show the scaling factors. Outliers are shown as clear circles.

Boxplots for inshore marine water quality data

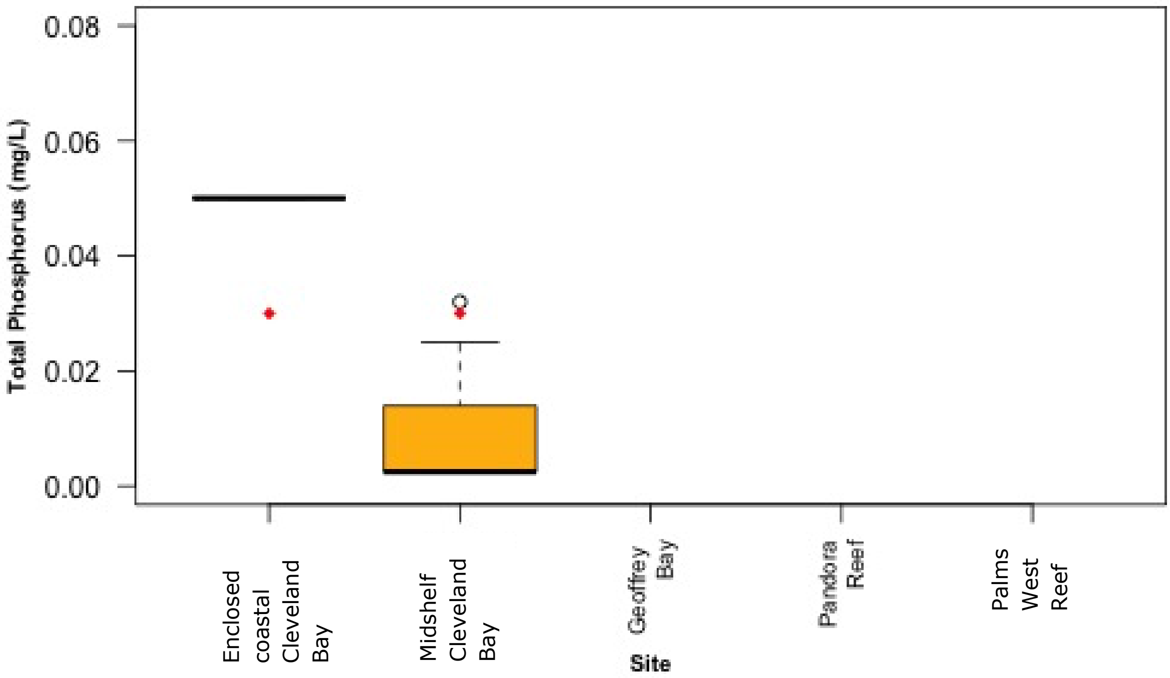

Figure Appendix C 13. Boxplot of total phosphorus concentrations at each inshore marine monitoring site. The red circles indicate the guideline values. Outliers are shown as clear circles.

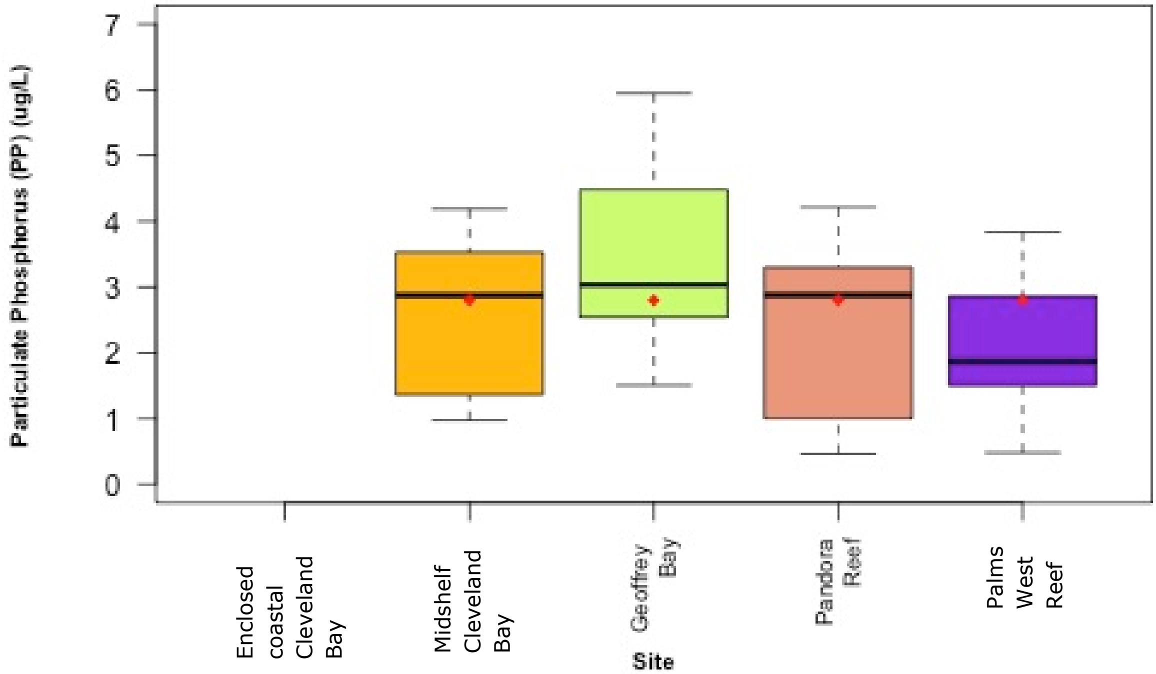

Figure Appendix C 14. Boxplot of particulate phosphorus concentrations at each inshore marine monitoring site. The red circles indicate the guideline values.

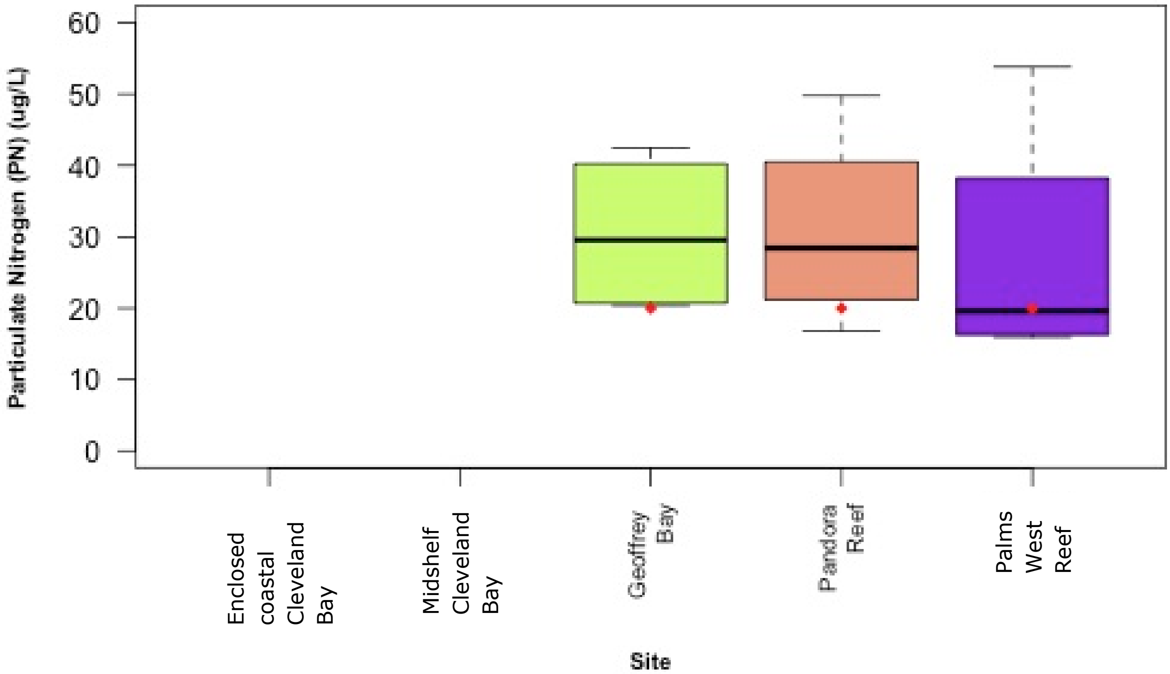

Figure Appendix C 15. Boxplot of particulate nitrogen concentrations at each inshore marine monitoring site. The red circles indicate the guideline values.

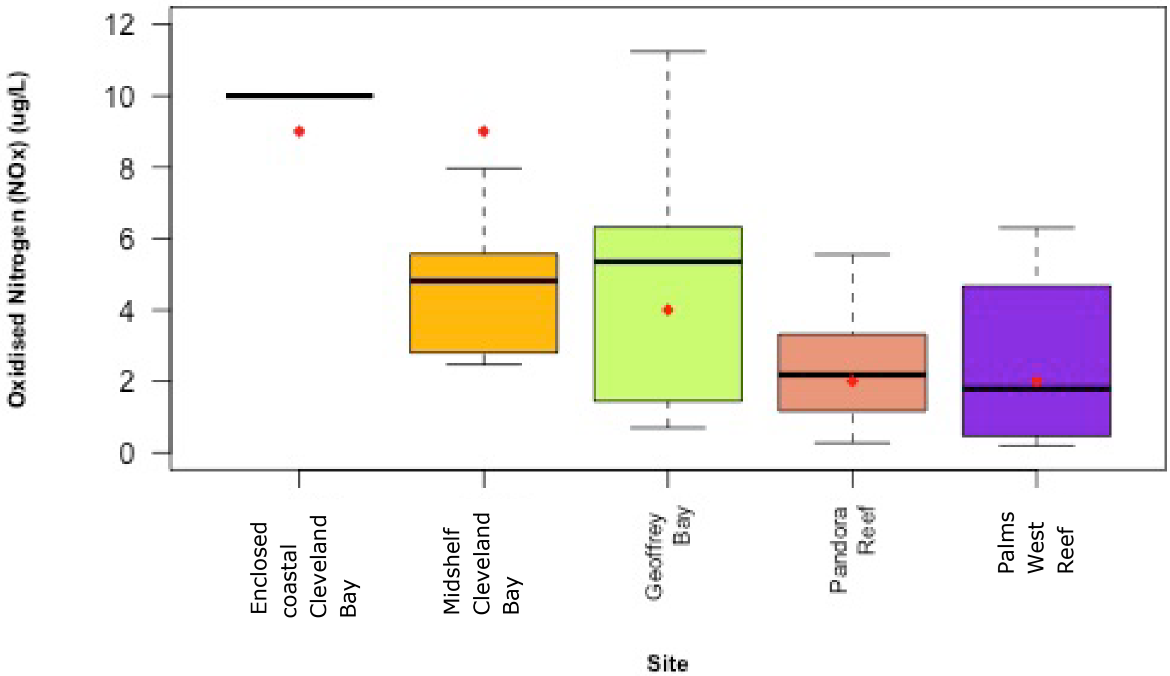

Figure Appendix C 16. Boxplot of oxidised nitrogen concentrations at each inshore marine monitoring site. The red circles indicate the guideline values (GVs).

Note that the GVs for the Cleveland Bay sites are 2.5 times higher than the GV for Geoffrey Bay and 4.5 times higher than the GVs for Pandora Reef and Palms West Reef. The grades for each site do not reflect the differences in concentrations. Instead, the difference in GVs has the greatest influence on the grades. Both the Cleveland Bay sites and Geoffrey Bay had higher concentrations yet received very good or moderate scores, whilst Pandora Reef and Palms West Reef had lower concentrations but where graded as being in a poor condition.

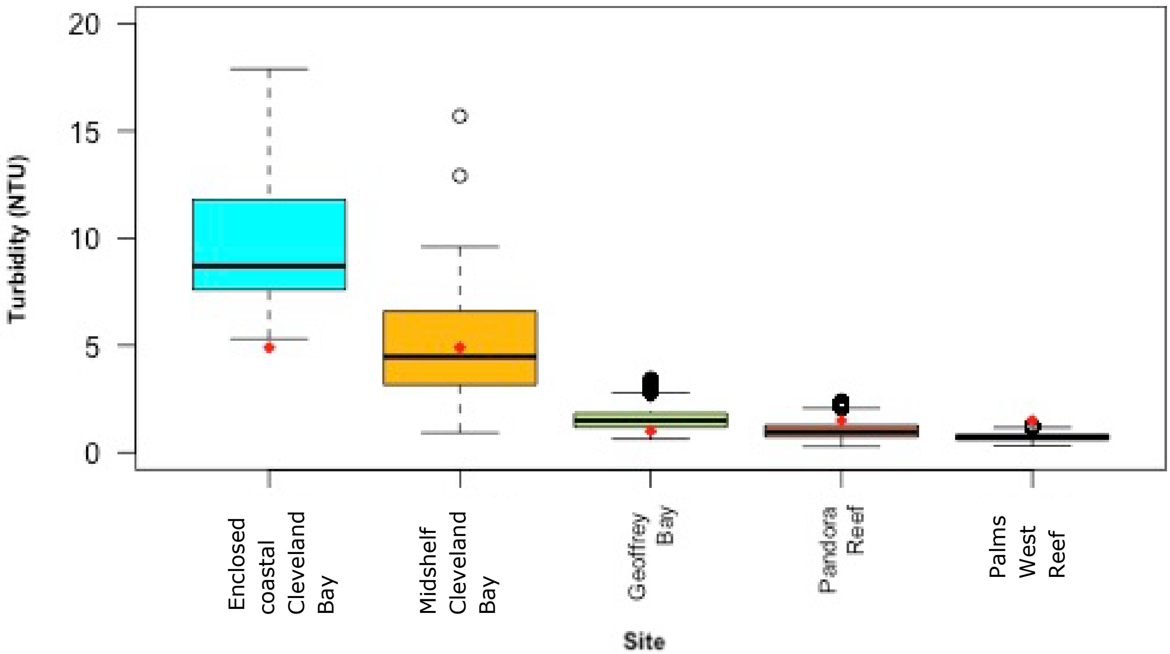

Figure Appendix C 17. Boxplot of turbidity levels at each inshore marine monitoring site, with data collected using grab samples and hourly loggers. The red circles indicate the guideline values (GVs). Outliers are shown as clear circles.

Note that the GVs for the Cleveland Bay sites are 4.9 times higher than the GV for Geoffrey Bay and 3.2 times higher than the GVs for Pandora Reef and Palms West Reef. The difference in GVs greatly influenced the grades at some sites. For example, the midshelf Cleveland Bay site was graded as moderate despite having higher turbidity levels substantially higher than at Geoffrey Bay, which was graded as very poor.

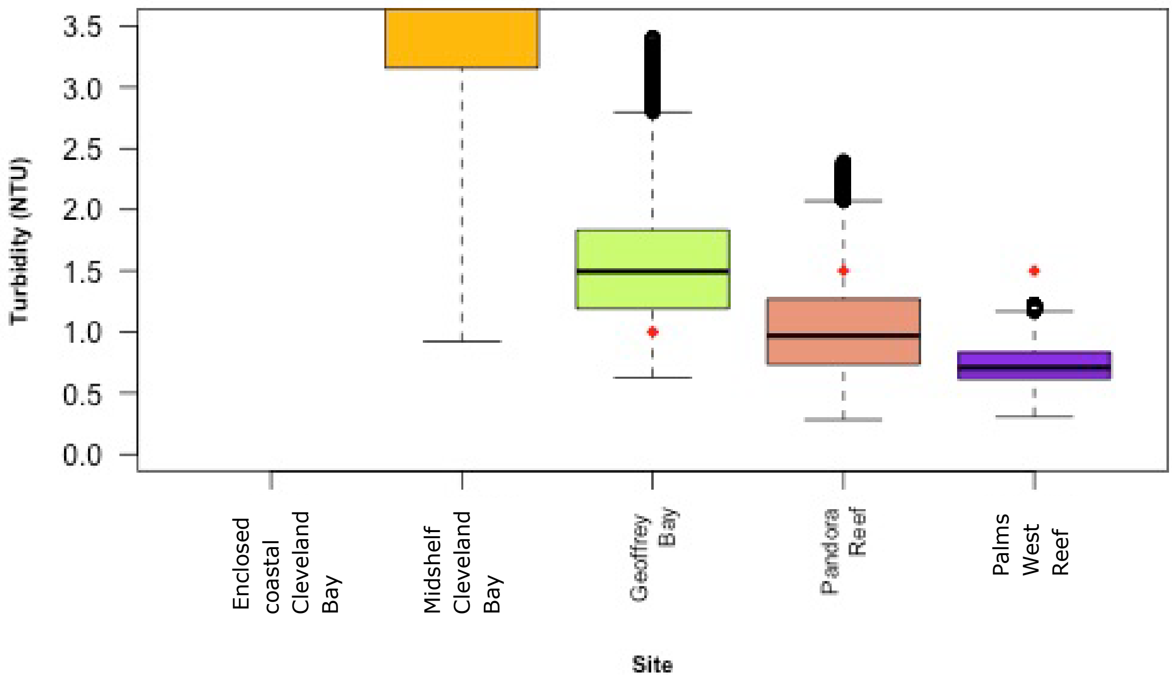

Figure Appendix C 18. Boxplot of turbidity levels at each inshore marine monitoring site. Data from the enclosed coastal Cleveland Bay site and the uppermost data from the midshelf Cleveland Bay site were excluded to allow a closer examination of the boxplots.

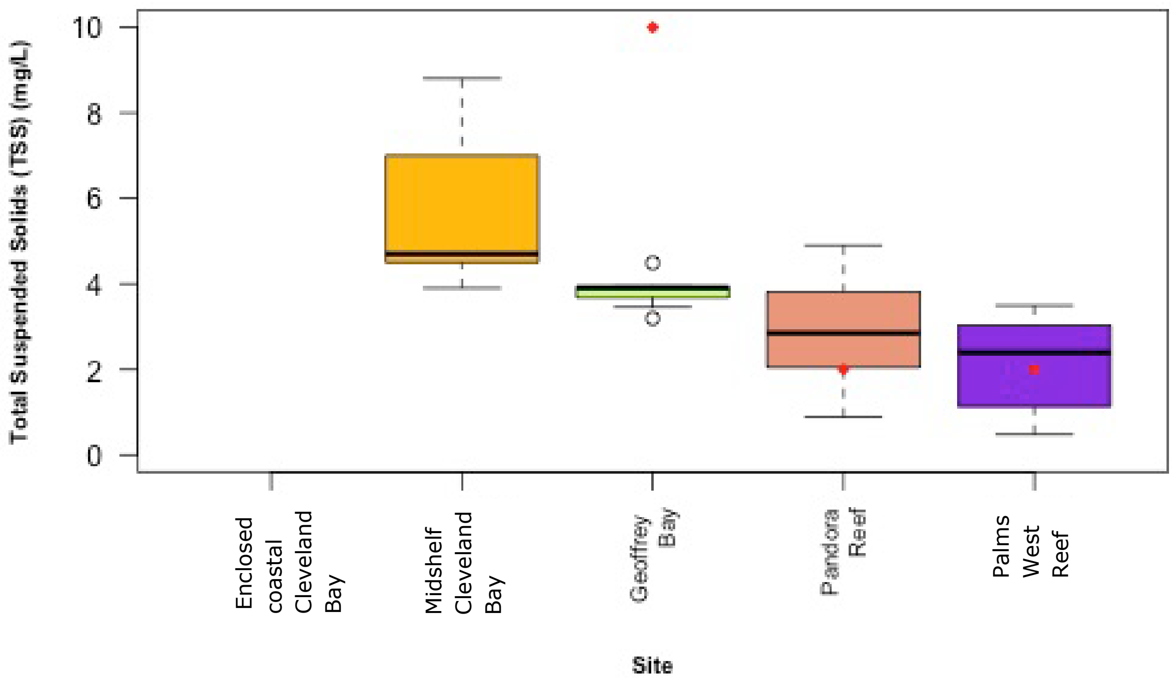

Figure Appendix C 19. Boxplot of total suspended solids concentrations at each inshore marine monitoring site. The red circles indicate the guideline values (GVs). The GV for TSS at the midshelf Cleveland Bay site is 22 mg/L, but has been excluded to allow a closer examination of the boxplots. Outliers are shown as clear circles.

Note the GVs for midshelf Cleveland Bay is over double the GV for Geoffrey Bay and 11 times higher than the GVs for Pandora Reef and Palms West Reef. The GV for Geoffrey Bay is 5 times higher than for Pandora Reef and Palms West Reef. The difference in GVs resulted in Cleveland Bay and Geoffrey Bay receiving a very good score whilst Pandora was poor and Palms West Reef was moderate. This was despite Cleveland Bay and Geoffrey Bay having substantially higher TSS concentrations.

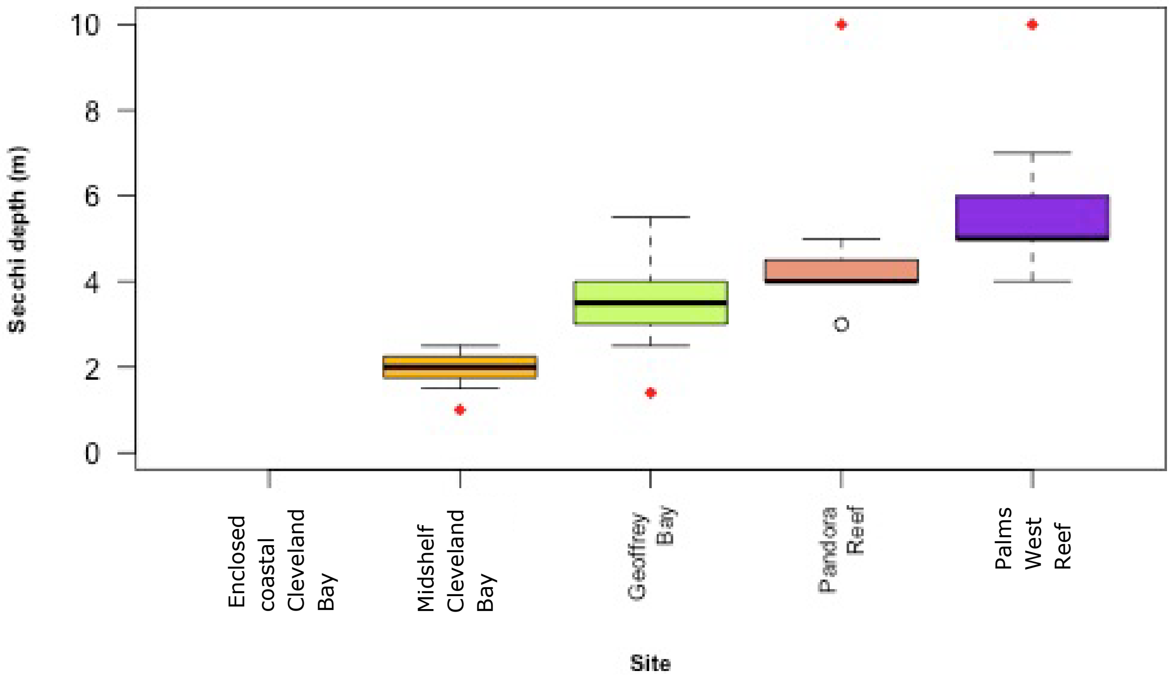

Figure Appendix C 20. Boxplot of secchi depth levels at each inshore marine monitoring site. The red circles indicate the guideline values (GVs). Outliers are shown as clear circles.

Note the GVs for the midshelf Cleveland Bay site are 10 times lower and for Geoffrey Bay, 7 times lower than the GVs for Pandora Reef and Palms West Reef. Lower secchi readings indicate poorer condition. The results for secchi depth are driven by the differences in the GVs. Secchi depth improves further from the coast, but this is not reflected in the scores (worse in the midshelf Cleveland Bay (closest to the coast) and best at Palms West Reef (furthest from the coast)). For example, Pandora Reef and Palms West Reef both received very poor scores despite having better secchi depth than the midshelf Cleveland Bay site and Geoffrey Bay, which both received very good scores.

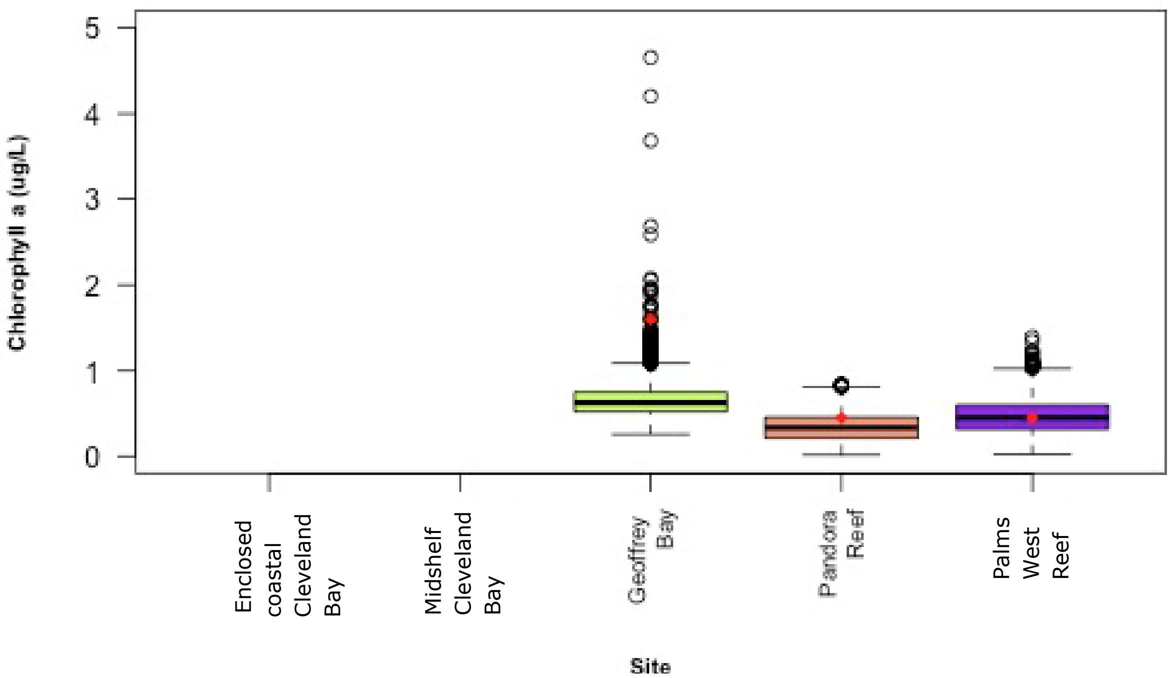

Figure Appendix C 21. Boxplot of chlorophyll *a* concentrations at each inshore marine monitoring site. The red circles indicate the guideline values (GVs). Outliers are shown as clear circles.

Note the GVs for Geoffrey Bay are 3.5 times higher than for Pandora Reef and Palms West Reef, resulting in Geoffrey Bay receiving a very good score despite having higher concentrations than Pandora and Palms West reefs, which received a good and moderate score respectively.

Appendix D. Community survey questions and indicator categories

Table Appendix D 1. Indicators used to determine the score of Community for the freshwater, estuarine/coastal and inshore and offshore marine zones. The indices and indicator categories scored for the Pilot Report Card are highlighted. The postcodes of survey respondents that were used to generate the score for each zone are also shown. An asterisk (*) indicates the question was changed so they were positively worded. Survey questions not included in the Pilot Report Card will be used in future surveys and are indicative only. Questions in future surveys will be tailored so scores can be produced for each zone.

Zone	Index	Indicator category	Indicator	Frequency of reporting	Included in Pilot Report Card
Freshwater	Value & wellbeing from waterways	Values of waterways	I value our freshwater waterways because they support a desirable and active way of life	TBD	No
			I value our freshwater waterways because we can learn about the environment through scientific discoveries	TBD	No
			The aesthetic beauty of our freshwater waterways is outstanding	TBD	No
			I value the our freshwater waterways because they inspire me in artistic or thoughtful ways	TBD	No
			I value our freshwater waterways because they are an important part of my culture.	TBD	No
		Wellbeing from waterways	I love that I live in proximity to our freshwater waterways	TBD	No
			Thinking about pollution in our freshwater waterways does not make me feel depressed	TBD	No
			I value our freshwater waterways because they make me feel better physically and/or mentally	TBD	No
			Our freshwater waterways are a part of my identity	TBD	No
			Our freshwater waterways contribute to my quality of life and well-being	TBD	No
	Perception of waterways	Perception of waterway management	I feel confident that the freshwater areas in my region are well managed	4 years	Yes
			I support the current rules and regulations that affect access and use of freshwater areas (rivers and creeks) in my region	4 years	Yes
		Perception of environmental condition	I am not worried about the status of freshwater fish in my region	4 years	Yes
			The freshwater areas (e.g. rivers, creeks) in my region are in good condition	4 years	Yes
Ross = 4810, 4811, 4812, 4813, 4814, 4815, 4816, 4817 Black == 4816, 4817, 4818	Stewardship	Stewardship	I would like to do more to improve water quality in my waterways (including rivers, creeks)	4 years	Yes
			I make every effort to use energy efficiently in my home and workplace -	4 years	Yes
			I often consider the environmental impact of the production process for goods and services that I purchase	4 years	Yes
			I usually make any extra effort to reduce the waste I generate	4 years	Yes
			I re-use or recycle most goods and waste	4 years	Yes
Estuary/coast	Value & wellbeing from	Values of waterways	I value our beaches and estuaries because they supports a desirable and active way of life	TBD	No
			I value our beaches and estuaries because we can learn about the environment through scientific discoveries	TBD	No

Zone	Index	Indicator category	Indicator	Frequency of reporting	Included in Pilot Report Card
	waterways		The aesthetic beauty of our beaches and estuaries are outstanding	TBD	No
			I value our beaches and estuaries because they inspire me in artistic or thoughtful ways	TBD	No
			I value our beaches and estuaries because they are an important part of my culture	TBD	No
		Wellbeing from waterways	I love that I live in proximity to our beaches and estuaries	TBD	No
			Thinking about pollution in our beaches and estuaries does not make me feel depressed	TBD	No
			I value our beaches and estuaries because they make me feel better physically and/or mentally	TBD	No
			Our beaches and estuaries are part of my identity	TBD	No
			Our beaches and estuaries contribute to my quality of life and well-being	TBD	No
	Perception of waterways	Perception of waterway management	I do have fair access to our beaches and estuaries compared to other user groups	TBD	No
			I feel confident that our beaches and estuaries are well managed	TBD	No
			I support the current rules and regulations that affect access and use of our beaches and estuaries	TBD	No
			I feel like I can contribute to the management of our beaches and estuaries	TBD	No
			I think enough is being done to effectively manage our beaches and estuaries	TBD	No
			I do have fair access to our beaches and estuaries compared to other user groups	TBD	No
		Perception of environmental condition	There is not much rubbish (plastics and bottles) on the beaches in my region	4 years	Yes
			The mangroves in my region are in good health	4 years	Yes
			The estuarine and marine fish in my region are in good condition	4 years	Yes
			I like the colour/clarity of the water along the beaches in my region	4 years	Yes
Ross = 4810, 4811, 4816 Black = 4816, 4818	Stewardship	Stewardship	I make every effort to use energy efficiently in my home and workplace	4 years	Yes
			I often consider the environmental impact of the production process for goods and services that I purchase	4 years	Yes
			I usually make any extra effort to reduce the waste I generate	4 years	Yes
			I re-use or recycle most goods and waste	4 years	Yes
			I would like to do more to help protect the GBR	4 years	Yes
			I have the necessary knowledge and skills to reduce any impact that I might have on the GBR	4 years	Yes
			I would like to learn more about the condition of the GBR	4 years	Yes
Inshore marine	Value & wellbeing from waterways	Values of waterways	I value inshore islands, reefs and marine life because it supports a desirable and active way of life	TBD	No
			I value inshore islands, reefs and marine life because we can learn about the environment through scientific discoveries	TBD	No
			The aesthetic beauty of the inshore islands, reefs and marine life is outstanding	TBD	No
			I value the inshore islands, reefs and marine life because it inspires me in artistic or thoughtful ways	TBD	No
			I value the inshore islands, reefs and marine life because it is an important part of my culture.	TBD	No
		Wellbeing from waterways	I love that I live in close proximity to inshore islands and reefs.	TBD	No
			Thinking about pollution within the inshore marine area does not make me feel depressed	TBD	No

Zone	Index	Indicator category	Indicator	Frequency of reporting	Included in Pilot Report Card
			I value the inshore islands, reefs and marine life because it makes me feel better physically and/or mentally	TBD	No
			Inshore islands and reefs contributes to my quality of life and well-being	TBD	No
	Perception of waterways	Perception of waterway management	I do have fair access to the inshore islands and reefs compared to other user groups	TBD	No
			I feel confident that the inshore islands and reefs is well managed	TBD	No
			I support the current rules and regulations that affect access and use of the inshore islands and reefs	TBD	No
			I feel like I can contribute to inshore islands and reefs management	TBD	No
			I think enough is being done to effectively manage the inshore islands and reefs	TBD	No
		Perception of environmental condition	There is not much rubbish (plastics and bottles) on the beaches in my region	4 years	Yes
			I like the colour/clarity of water along the beaches in my region	4 years	Yes
			The mangroves in my region are in good health	4 years	Yes
			The estuarine and marine fish in my region are in good condition	4 years	Yes
			The coral reef in my region is in good condition	4 years	Yes
Cleveland Bay (Magnetic Island residents) = 4819 Halifax Bay (Palm Island residents) = 4816	Stewardship	Stewardship	I have the necessary knowledge and skills to reduce any impact that I might have on the GBR	4 years	Yes
			I can make a personal difference in improving the health of the great barrier reef	4 years	Yes
			I make every effort to use energy efficiently in my home and workplace	4 years	Yes
			I often consider the environmental impact of the production process for goods and services that I purchase	4 years	Yes
			I usually make any extra effort to reduce the waste I generate	4 years	Yes
			I re-use or recycle most goods and waste	4 years	Yes
			I would like to learn more about the condition of the GBR	4 years	Yes
			I would like to do more to help protect the GBR	4 years	Yes
Offshore marine All Townsville postcodes	Value & wellbeing from waterways	Values of waterways	I value the GBR because it supports a desirable and active way of life	4 years	Yes
			I value the GBR because we can learn about the environment through scientific discoveries	4 years	Yes
			The aesthetic beauty of the GBR is outstanding	4 years	Yes
			I value the GBR because it inspires me in artistic or thoughtful ways	4 years	Yes
			I value the GBR because it is an important part of my culture	4 years	Yes
		Wellbeing from waterways	I love that I live beside the GBR	4 years	Yes
			Thinking about coral bleaching does not make me feel depressed	4 years	Yes
			I value the GBR because it makes me feel better physically and/or mentally	4 years	Yes
			I feel proud that the GBR is a World Heritage Area	4 years	Yes
			The GBR is part of my identity	4 years	Yes
			The GBR contributes to my quality of life and well-being	4 years	Yes

Zone	Index	Indicator category	Indicator	Frequency of reporting	Included in Pilot Report Card
	Perception of waterways	Perception of waterway management	I do have fair access to the GBR compared to other user groups	4 years	Yes
			I feel confident that the GBR is well managed	4 years	Yes
			I support the current rules and regulations that affect access and use of the GBR	4 years	Yes
			I feel like I can contribute to GBR management	4 years	Yes
			I think enough is being done to effectively manage the GBR	4 years	Yes
		Perception of environmental condition	The coral reefs in my region are in good condition	4 years	Yes
	Stewardship	Stewardship	I have the necessary knowledge and skills to reduce any impact that I might have on the GBR	4 years	Yes
			I can make a personal difference in improving the health of the great barrier reef	4 years	Yes
			I make every effort to use energy efficiently in my home and workplace	4 years	Yes
			I often consider the environmental impact of the production process for goods and services that I purchase	4 years	Yes
			I usually make any extra effort to reduce the waste I generate	4 years	Yes
			I re-use or recycle most goods and waste	4 years	Yes
			I would like to learn more about the condition of the GBR	4 years	Yes
			I would like to do more to help protect the GBR	4 years	Yes

Table Appendix D 2. Population of Townsville suburbs used to calculate the population for each zone. The population for each suburb is based on 2016 Australian Bureau of Statistics Census data.

Zone	Suburb	Postcode	Population
Ross Basin (freshwater)	Aitkenvale	4814	10,065
	Annandale	4814	8574
	Cluden	4811	427
	Cosgrove	4818	285
	Cranbrook	4814	5908
	Currajong	4812	2548
	Douglas	4814	7744
	Gulliver	4812	2825
	Heatley	4814	4038
	Hermit Park	4812	3414
	Idalia	4811	4438
	Mount Louisa	4814	8825
	Mount St John	4818	62
	Mount Stuart	4811	0
	Mundingburra	4812	3620
	Murray	4814	1491
	Mysterton	4812	809
	North Ward	4810	5065
	Pimlico	4812	2460
	Rosslea	4812	1732
	Stuart	4811	1386
	Vincent	4814	2357
	Wulguru	4811	4570
	Alligator Creek	4816	1353
	Barringha	4816	62
	Brookhill	4816	76
	Calcium	4816	21
	Gumlow	4815	167
	Julago	4816	113
	Mount Elliot	4816	8
	Oak Valley	4811	487
	Rangewood	4817	1057
	Roseneath	4811	154
	Ross River	4816	0
	Toonpan	4816	
	Bohle	4818	85
	Bohle Plains	4817	3205
	Condon	4815	5779
	Deeragun	4818	4250
	Kelso	4815	10538
	Kirwan	4817	21418
	Pinnacles	4815	93
	Rasmussen	4815	4456
	Thuringowa Central	4817	2023
	Shaw	4818	550

	Total Ross Basin		**138,538**
Black Basin (freshwater)	Clemant	4816	0
	Crystal Creek	4816	10
	Granite Vale	4815	0
	Hervey Range	4817	279
	Alice River	4817	2425
	Bluewater Park	4818	992
	Mutarnee	4816	116
	Paluma	4816	68
	Rollingstone	4816	125
	Total Black Basin		**4,015**
Ross estuarine/coastal zone	Townsville City	4810	2910
	Belgian Gardens	4810	2069
	Castle Hill	4810	941
	Garbutt	4814	2396
	Hyde Park	4812	1387
	Oonoonba	4811	1675
	Pallarenda	4810	791
	Railway Estate	4810	2852
	Rowes Bay	4810	573
	South Townsville	4810	2353
	Town Common	4810	71
	Townsville West	4810	0
	West End	4810	4046
	Nome	4816	1016
	Bushland Beach (beach)	4818	6181
	Burdell (beach)	4818	5814
	Mount Low (beach)	4818	4655
	Total Ross estuarine/coastal zone		**39,730**
Black estuarine/ coastal zone	Beach Holm (beach)	4818	32
	Bluewater (beach)	4818	1040
	Balgal Beach	4816	966
	Black River (beach)	4818	1476
	Jensen (beach)	4818	1476
	Saunders Beach (beach)	4818	409
	Toolakea (beach)	4818	205
	Toomulla	4816	183
	Yabulu (beach)	4818	697
	Total Black estuarine/coastal zone		**6,484**
Cleveland Bay (inshore marine zone)	**Magnetic Island**	4819	**2,335**
Halifax Bay (inshore marine zone)	**Palm Island**	4816	**2,446**
Offshore marine zone	**All postcodes**		**193,557**

Appendix E. Economic survey questions, indicators and indicator categories

Table Appendix E 1. Indicator categories and indicators used to determine the score of Economy for the freshwater, estuarine/coastal and inshore and offshore marine zones. The indices and indicator categories scored for the Pilot Report Card are highlighted. The postcodes of survey respondents that were used to generate the score for each zone are also shown. Survey questions not included in the Pilot Report Card will be used in future surveys and are indicative only. Questions in future surveys will be tailored so scores can be produced for each zone.

Region	Index	Indicator categories	Indicator	Frequency of reporting	Included in Pilot Report Card
Freshwater	Non-monetary economic value	Tourism attraction value	I value our freshwater waterways because they attract visitors to our region	TBD	No
		Science and education value	I value our freshwater waterways because we can learn about the environment through scientific discoveries	TBD	No
		Fresh local seafood	I value our freshwater waterways for the fishing opportunities they provide	TBD	No
		Perception of economic value	Our freshwater waterways are a great asset for the economy of this region	TBD	No
	Industry Sustainability	Ecological Sustainability	I always consider the environmental impact of the production process for goods and services that my business uses	TBD	No
			I usually make any extra effort to reduce the waste my business generates	TBD	No
			My business re-uses or recycles most goods and waste	TBD	No
		Economic Sustainability	Freshwater water sports or other freshwater dependant business	TBD	No
			Dependency of waterfront business on healthy waters	TBD	No
Estuary/ coastal	Non-monetary economic values	Tourism attraction value	I value our beaches and estuaries because they attract visitors to our region	TBD	No
		Science and education value	I value our beaches and estuaries because we can learn about the environment through scientific discoveries	TBD	No
		Fresh local seafood	I value our beaches and estuaries for the fresh seafood they provide	TBD	No
		Perception of economic value	Our beaches and estuaries are a great asset for the economy of this region	TBD	No
	Industry Sustainability	Ecological Sustainability	I always consider the environmental impact of the production process for goods and services that my business uses	TBD	No
			I usually make any extra effort to reduce the waste my business generates	TBD	No
			My business re-uses or recycles most goods and waste	TBD	No
		Economic Sustainability	Waterfront business	TBD	No
			Income generated from coastal water sports	TBD	No
Inshore marine	Non-monetary economic values	Tourism attraction value	I value the inshore islands, reefs and marine life because they attracts people from all over the world	TBD	No
		Science and education value	I value the inshore islands, reefs and marine life because we can learn about the environment through scientific discoveries	TBD	No
		Fresh local seafood	I value the inshore marine area for the fresh seafood it provides	TBD	No
		Economic value	The inshore islands and reefs are a great asset for the economy of this region	TBD	No

Region	Index	Indicator categories	Indicator	Frequency of reporting	Included in Pilot Report Card
	Industry Sustainability	Ecological Sustainability	I always consider the environmental impact of the production process for goods and services that my business uses	TBD	No
			I usually make any extra effort to reduce the waste my business generates	TBD	No
			My business re-uses or recycles most goods and waste	TBD	No
		Economic Sustainability	How long have you been involved in the GBR tourism industry?	TBD	No
			How long has your current business been operating?	TBD	No
			What proportion of your household income came from tourism in the last financial year?	TBD	No
			How many employees (FTE) did your operation employ over the previous 12 months	TBD	No
			Do you have insurance for your business assets?	TBD	No
			Could you please indicate (approximately) your business turnover (entire revenue) for the past 12 months, in broad categories?	TBD	No
Offshore Marine All postcodes and industry specific data	Non-monetary economic values	Tourism attraction value	I value the GBR because it attracts people from all over the world	4 years	Yes
		Science and education value	I value the GBR because we can learn about the environment through scientific discoveries	4 years	Yes
		Fresh local seafood	I value the GBR for the fresh seafood it provides	4 years	Yes
		Perception of economic value	The GBR is a great asset for the economy of this region	4 years	Yes
	Industry Sustainability	Ecological Sustainability	Does your operation have fuel efficient engines	4 years	No
			Does your operation use Carbon offsets to counter emissions	4 years	No
			Does your operation have green energy, such as solar panels, for your vessel	4 years	No
			Does your operation participate in industry best practices via a code of practice, or memorandum of understanding (MOU)	4 years	No
			Does your operation use alternative fuels such as biodiesel and ethanol	4 years	No
			Does your operation employ formally trained guides providing interpretation about the Reef	4 years	No
			I am optimistic about the future of my business in the GBR	4 years	No
			My business has performed this year as well as last year	4 years	No
		Economic Sustainability	Does your operation use an emissions calculator to plan your business operations	4 years	No
			How many employees (FTE) did your operation employ over the previous 12 months	4 years	No
			Do you have insurance for your business assets?	4 years	No
			Could you please indicate (approximately) your business turnover (entire revenue) for the past 12 months, in broad categories?	4 years	No
			I am optimistic about the future of my business in the GBR	4 years	No
			My business has performed this year as well as last year	4 years	No