Program Design

Townsville Dry Tropics 2017-18 Pilot Report Card

Released 24th of May, 2019

dry tropics partnership for healthy waters

Acknowledgements

The 2018 Program Design was prepared by the Technical Officer of the Dry Tropics Partnership for Healthy Rivers and was reviewed by the Regional Report Cards Technical Working Group. It was reviewed and endorsed by the Reef Independent Science Panel and endorsed by the Dry Tropics Partnership for Healthy Waters.

Suggested citation: Whitehead, T (2019). *Program Design for the Townsville Dry Tropics 2017-2018 Pilot Report Card (released in 2019).* Dry Tropics Partnership for Healthy Waters, Townsville.

Executive Summary

Report cards are an effective tool for documenting, evaluating and communicating the health of an ecosystem. As a result, they are becoming an increasingly popular method for assessing aquatic ecosystems and changes in ecosystems over time. They are particularly useful for enabling large quantities of complex scientific data from multiple sources to be summarised and presented in a way that is easy to understand by a broad audience. Additionally, if there is consistency of approaches between regions, report cards can enable different regions to be easily compared. This enables managers to identify and prioritise management actions based on the scores for the different zones.

To maximise the expertise and scope of information within a report card, they are often created using partnerships. These partnerships involve collaborations between multiple sectors, including government organisations, non-government organisations, research institutions, industries (e.g. agriculture, ports, tourism and fisheries), community groups and traditional owners.

The Dry Tropics Partnership for Healthy Waters (referred to as the Partnership) was established in November 2017 to create a report card that provides a broad-scale overview of the condition of waterways within the region, the condition of the environment supported by waterways and the social and economic benefits the community derives from waterways. The initial scope is the catchments in the Townsville region, from Crystal Creek in the north to Cape Cleveland in the south, and includes all the groundwater, freshwater, estuarine/coastal and marine environments within this region. Multiple organisations and groups collect a suite of scientific data on the health of waterways within this region. The Dry Tropics Partnership aims to collate and integrate this data and communicate the results so they are easily understood by community members and Partnership stakeholders.

This document has been created to support the development of the report card and ensure the objectives of the Partnership are met. The Partnership established the vision for the program, and a series of workshops with experts and community members were undertaken to determine the goals and objectives of the report card. Guiding by the information from the workshops, the Partnership decided to report upon four components of waterways. These components are Biodiversity (flora and fauna dependent on waterways), Water (water quality and quantity) and the social and economic benefits to the community (Community and Economic benefits). Indicators to measure the state of these four reporting components were devised from the workshops and by reviewing the literature.

The report card has an urban focus, with half of the report card dedicated to the social and economic state within the Townsville region. Most environmental indicators are similar to those of the Wet Tropics and Mackay Whitsunday report card programs, meaning the Townsville Dry Tropics report card is comparable and consistent to other regions. It also means that the report card can

contribute to understanding the condition of the environment across Queensland, as well as within the Townsville Dry Tropics. Most indicators measured within the Wet Tropics and Mackay-Whitsunday reports are applicable to the urban environment (e.g. measuring nutrient runoff is applicable in both the urban and agricultural sector. However the sources of these nutrients are likely to differ between an agricultural and urban report and thus will be conveyed in the messaging and framing of the report card. Over time it is aimed that more indicators will be developed to measure how specific aspects of urban lifestyles impact upon environmental aspects of the region (e.g. measuring the amount of gross pollutants within the environment and the proportion of the catchment that comprises man-made impermeable surfaces).

The report card will be produced annually, allowing temporal changes and trends in the health of the catchment to be determined. Within the Townsville Dry Tropics there is limited freely available data. In contrast to the other regional reports, within the Townsville Dry Tropics there is no State or Federally funded government environmental long-term monitoring programs. For example, there are no end of catchment loads monitoring data within the freshwater or estuarine systems, no pesticide monitoring program, no fish monitoring programs and very limited flow data (two monitoring stations). Instead, the only available data is provided in kind by the Townsville Dry Tropics partners. Due to limited data availability, not all indicators are currently scored. It is aimed that as data becomes available and methods for scoring indicators are developed, the report cards will be able to include more data and indicators. Each time an indicator is added, or more data is added into an existing indicator (e.g. if a monitoring program expands) the baseline will change. This will limit the ability of the report card to track trends over time, as changes will be influenced by the addition of an indicator and not necessarily changes in the ecological, social or economic environment.

This document will be reviewed as necessary following the release of each report card. Any required changes or amendments to improve the program and the report card will be included, with this document then updated. A 5-year program design will also be completed to determine the long-term scope of the program.

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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	Great Barrier Reef Marine Park Authority
GBRMP	Great Barrier Reef Marine Park
GV	Guideline Value

Impoundment length	An indicator used in the 'in-stream habitat modification' indicator for 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 (Department of Environment and Science, 2018). 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.

Terminology

The term “waters” and “waterways” refers to all aquatic environments, including freshwater creeks, streams, rivers, lakes, waterbodies, freshwater environments (e.g. wetlands), estuarine environments (e.g. saltmarshes), and inshore and offshore marine environments within the nominated regions.

A healthy ecosystem is defined as “one that is sustainable – that is, it has the ability to maintain its structure (organisation) and function (vigour) over time in the face of external stress (resilience)” (Constanza & Mageau, 1999). Over the last two decades there has been a greater focus on including humans within the ecosystem, rather than solely focusing on the "impact" measures of humans, a strategy that puts humans outside the ecosystem as a permanent perturbation (Machlis, et al., 1997). According to the Ecological Society of America (n.d.) “An ecosystem is any geographic area that includes all of the organisms (including humans) and non-living parts of their physical environment. An ecosystem can be a natural wilderness area, a suburban lake or forest, or a heavily used area such as a city. The more natural an ecosystem is, the more ecosystem services it provides. These include cleansing the water (wetlands and marshes) and air (forests), pollinating crops and other important plants (insects, birds, bats), and absorbing and detoxifying pollutants (soils and plants).”

1 Introduction

1.1 Purpose of the Program Design

The Program Design document has been produced as a framework to guide the Partnership in the development of 2017-18 Pilot Report Card, which will be released in April 2019 (and is henceforth referred to as the Pilot Report Card). Separate technical reports with detailed methods and results will provide further support to this document.

This document contains the following information:

- Background on the region, linkages with other report cards and the guiding framework
- Development of the report card, including:
    - information on the Partnership
    - expert workshops
    - selection of reporting components
    - report card goals and objectives
    - development of the conceptual diagram
- Frequency, scope and reporting region for the report card
- Roles and responsibility for the development of the report card
- Method for developing report card scores

- Indicators used to report on Biodiversity, Water, Community and Economy
- Program management, including data management and sharing, and
- Future program

The Pilot Report Card Program Design provides a framework for establishing a baseline for future reporting, though is subject to change pending data availability and Partnership priorities. A review of this program design will form part of the evaluation process for amending and improving the design of future Report Cards.

1.2 Dry Tropics Partnership

The Partnership was established in November 2017 and is a collaborative partnership between community, government, science and industry. The Partnership works collectively to gather data and report on the health of waters and waterways and the social and economic benefits derived from waterways. The Partnership builds on and will complement previous efforts for improved catchment management within the Townsville region, including by the Townsville City Council's Creek to Coral program. The Partnership was established with seed funding by the Queensland and Australian Governments. Two staff members (Executive and Technical Officer) were employed in May 2018, with technical work beginning at this time. The Partnership continues to be supported by financial and in-kind support from all Partners. Current Partners are listed below.

Australian Government
Queensland Government
Townsville City Council
NQ Dry Tropics
Port of Townsville Ltd.
Veolia
C&R Consulting
CSIRO
Australian Institute of Marine Science
James Cook University
Conservation Volunteers Australia
Magnetic Island Nature Care Association
Coastal Dry Tropics Landcare Inc.
Reef Check Australia
Tangaroa Blue
Reef Citizen Science Alliance

1.3 Dry Tropics Partnership report card

The Partnership aims to develop a report card to inform the community and decision makers of the condition of waters and waterways, the condition of environments dependent waters and waterways and the social and economic benefits the community derives from waters and waterways. The report card will present information on the freshwater basins, estuaries/coasts, adjacent inshore marine areas and the offshore marine zone (outer Great Barrier Reef). Science from a variety of monitoring programs is integrated into the report card to develop a more complete understanding and measure of the environmental, social and economic health of the region (in relation to waterways). By using data from existing monitoring programs, it enables duplications and more importantly, gaps in the monitoring to be identified. This will help to guide the direction of future monitoring programs.

The report card is designed so that scientific information is presented in a way that is easily understood by industry, the community and local governments. Effective communication better enables these groups to recognise how they can contribute towards maintaining the health of waterways. This increases the chance of positive actions being undertaken and management recommendations being implemented.

1.4 Report cards

Reports cards are an increasingly popular tool to assess and communicate the health of aquatic ecosystems. Large quantities of systematically collected data from various sources are integrated and presented in the report card. This enables a more complete picture to be developed, as the information can then be used to determine the factors that influence the region at a landscape scale, rather than at a fine-scale. The information thus enables for a greater understanding of ecosystem health across a broad region.

1.5 Linkages and relevance to other programs

The Townsville Dry Tropics Report Card is relevant at a regional and a broader level across the Great Barrier Reef. The report is nested in a larger framework of federal, state, and local programs and aims to be consistent with the approach developed for other regional report cards. The report card aligns with goals and targets identified in the Black Ross Water Quality Improvement Plan (Gunn & Manning, 2010).

1.5.1 Other Regional Partnerships

In Queensland, many other regions produce annual report cards that assess the health of aquatic ecosystems. These include:

- Healthy Land and Water, who have released annual report cards for South East Queensland since 1999
- The Fitzroy Partnership for River Health who formed in 2012 and have released six report cards to date
- The Gladstone Healthy Harbours Partnership who formed in 2013 and have released four report

cards to date
- The Mackay-Whitsunday Healthy Rivers to Reef Partnership who formed in 2014 and have released three reports cards to date
- The Wet Tropics Healthy Waterways Partnership who formed in 2016 and have released two report cards to date
- The Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (Paddock to Reef program) reports progress towards Reef 2050 WQIP targets through the Great Barrier Reef Report Card. The program has released 7 report cards since 2009

Some aspects of the program for the Partnership have been modelled on the Mackay-Whitsunday and the Wet Tropics program design, although there are noticeable differences due to the different frameworks used to guide the programs. Nevertheless, sharing knowledge between the three Partnerships will increase the efficiency of developing and improving upon the report cards. The Partnership shares the Technical Working Group (TWG) with these two other Partnerships. This ensures consistency of methods and reporting across the regions.

1.5.2 National Waterway Report Card Network

The National Waterway Report Card Network (the Network) "is an informal group of waterway health practitioners and specialists involved in producing report cards on waterway, estuary, harbour, reef and marine health across Australia" (Fitzroy Partnership for River Health, 2018). All current Queensland regional report card partnerships are members of this national network.

1.5.3 Reef 2050 Long-Term Sustainability Plan

The Reef 2050 Long-Term Sustainability Plan (Reef 2050 Plan) has direct links to the Partnership. The Reef Plan 2050 specifies that regional action plans are required in order to address locally significant risks (Commonwealth of Australia, 2018). Regional plans will also encourage community engagement and action (Commonwealth of Australia, 2018). The Reef 2050 Plan covers all aspects of the Reef's environment including its natural and physical attributes, heritage values and social, economic and cultural aspects (Commonwealth of Australia, 2018). However the Reef 2050 Plan mainly focuses on the health of the Great Barrier Reef (GBR) at a Queensland wide scale. Regional plans (and Report Cards) can play a crucial role in strengthening the focus on the catchment and the links between the health of the catchment and the health of the GBR. Regional report card partnerships are considered foundational programs in promoting actions that improve ecosystem health, water quality and community and economic benefits within regional areas. Annual report cards are used to indicate progress towards achieving the Reef 2050 Water Quality Improvement Plan (2017-2022) targets.

1.5.4 Reef 2050 Water Quality Improvement Plan (2017-2022)

The Reef 2050 Water Quality Improvement Plan (the Reef 2050 WQIP) is a joint commitment of the Australian and Queensland Governments and builds upon previous water quality plans (developed in

2003, 2009 and 2013). The Reef 2050 WQIP is based on the best available independent scientific advice and was revised due to "scientists agree[ing] that current initiatives would not meet water quality targets and that on-ground changes in practices need to be accelerated and supported" (Department of Environment and Science, 2017). The Reef 2050 WQIP seeks to improve water quality that is discharging into the marine environment from the six regions along the Queensland Coast (Cape York, Wet Tropics, Burdekin, Mackay Whitsunday, Fitzroy and Burnett Mary). The Reef 2050 WQIP outlines the regional water quality targets for each of the catchments that are to be met by 2025 (Department of Environment and Science, 2017).

The Reef 2050 WQIP directly aligns with the Reef 2050 Plan to provide consistency in the targets and management actions for improving water quality and the overall health of the Great Barrier Reef (GBR). Similar to the Reef 2050 Plan, the Reef 2050 WQIP acknowledges the importance of Partnerships, stating "Partnerships across all sectors at all levels continue to be the key to success in reaching water quality targets" and that "Partnerships across government, industry, research, Traditional Owners, agriculture, business and community are required to coordinate projects to improve water quality in the Great Barrier Reef and adjacent catchments" (Department of Environment and Science, 2017).

For the first time, Reef 2050 WQIP includes a human dimensions target, recognising that actively engaging communities and landholders in water quality improvement programs is necessary to improve land and catchment management outcomes (Department of Environment and Science, 2019, pers. comm.). Understanding and measuring the human dimensions, including social and cultural factors, will be critical to achieving this target. In 2018, CSIRO undertook a project called 'Towards a Human Dimension Baseline' to develop and test indicators that help Reef managers track progress towards meeting human dimension objectives and targets. The indicator themes identified from the project included; attitudes towards practices, motivations, perceived barriers, perceived behavioural control, past and future behaviour, group norms, trust, cultural norms and cultural artefacts. Broadly speaking, these indicators reflect the social and cultural factors that influence whether practices to improve water-quality are adopted and maintained. The measurement of these indicators will commence in 2019, with the focus initially being in the agricultural sector. The project will be expanded to other sectors, including urban, over time.

1.5.5 Reef Integrated Monitoring, and Reporting Program (RIMReP)

The Reef Integrated Monitoring and Reporting Program (RIMReP) is a key part of the Reef 2050 Plan and is "a coordinated and integrated monitoring, modelling and reporting program for the Reef and its adjacent catchment" (Great Barrier Reef Marine Park Authority (GBRMPA) and Queensland Government, 2018). RIMReP will cover all aspects of the Reef's environment, including its natural and physical attributes, heritage values and social, economic and cultural aspects (GBRMPA and Queensland Government, 2018). RIMReP is designed to play a central role in ensuring management decisions regarding protecting the Great Barrier Reef are based on the best available science and are underpinned by a partnership approach (GBRMPA and Queensland Government, 2018).

The goals of RIMReP are to be:

- "Effective in enabling the early detection of trends and changes in the Reef's environment, inform the assessment of threats and risks, and drive resilience based management,
- Efficient in enabling management priorities and decisions to be cost effective, transparent and based on cost-benefit and risk analyses, and
- Evolving based on the findings of Great Barrier Reef Outlook reports, new technologies and priority management and stakeholder needs" (GBRMPA and Queensland Government, 2018).

RIMReP will help track progress towards the targets and objectives of the Reef 2050 Plan, and aims to "capitalise on existing program investment, provide value for money, improve efficiency and avoid duplication of effort" (GBRMPA and Queensland Government, 2018). The initial priority of RIMReP is to integrate existing monitoring programs and fill critical knowledge gaps (GBRMPA and Queensland Government, 2018).

1.5.6 Millennium Ecosystem Assessment

The Millennium Ecosystem Assessment (MEA) was initiated in 2001 by the United Nations Secretary-General and has the objective of determining how changes to environmental services will impact upon human well-being and to devise ways to conserve and sustainably use these services so they can continue to contribute to human health (DeFries, et al., 2005).

1.5.7 Social and Economic Long-Term Monitoring Program (SELTMP)

The Social and Economic Long-Term Monitoring Program (SELTMP) for the Great Barrier Reef (GBR) region describes the conditions and trends of the human dimension of the GBR social-ecological system. Designed in 2011 to address objectives of the MEA (DeFries, et al., 2005), SELTMP was modified in 2016–17 to provide additional indicators relevant to the Reef 2050 Long-Term Sustainability Plan. SELTMP provides data to help assess progress towards four of the seven themes within the Reef 2050 Plan, including community benefits, economic benefits, heritage and governance. SELTMP data includes surveys of GBR region residents, tourists, Reef-dependent industries, and Australian residents nationally. Regionally relevant results from SELTMP are used by the Partnership.

1.5.8 Black Ross Water Quality Improvement Plan

The Water Quality Improvement Plan (WQIP) was developed by the Townsville City Council, in partnership with the government and community (Gunn & Manning, 2010). The plan identifies the environmental values within the Townsville region and highlights potential pressures impacting upon the region (Gunn & Manning, 2010). It also outlines water quality objectives and targets and proposes management actions to reduce the decline of water quality within the region (Gunn & Manning, 2010). To ensure aspects of the report card and the WQIP align, the Partnership ensured that the environmental values identified in the WQIP were considered when developing the environment components that would be reported upon within the region. All water quality scores are benchmarked against the environmental protection policy water quality objectives (scheduled guideline values) developed in the WQIP.

Regional water quality and ecosystem health guidelines can underpin future management decisions and actions. The guideline values "are numerical concentration levels or statements for indicators that protect a stated environmental value" (Gunn & Manning, 2010). For example, in areas where guideline values are exceeded, management and industry can focus on ways to improve their practices so guideline values are not exceeded.

1.6 The Townsville Dry Tropics region

For the report card, the initial focus is the freshwater and estuarine/coastal environments associated with the Ross and Black basins, the inshore marine areas of Cleveland Bay and Halifax Bay and the area offshore of the Townsville Local Government Area. This region is outlined in Figure 1 and will be referred to as the Townsville Dry Tropics throughout the rest of the document. Focusing on this small area will highlight the state of urbanised catchments and adjacent marine areas. In future years, the Partnership anticipates extending the report card coverage to the entire Burdekin natural resource management (NRM) area, which is shown in Figure 1. However, for the purposes of this document, only the characteristics of the current reporting region will be described.

1.6.1 Rainfall

The Townsville Dry Tropics region is characterised by a distinctive wet-dry season, with around 80% of the region's rain falling during the wet season (November to April) (AECOM, 2014). The average annual rainfall is 1,143 mm over an average of 91 days (Woodward & Horm, 2017). However there is substantial variation in annual rainfall within the region, with low of 853 mm (for the year) at Woodstock on the western boundary and high of 2,571 mm (for the year) at Paluma in the north (Gunn, et al., 2009). Most rain falls in intense downpours or over several weeks of almost constant rain (Planning Services Special Projects Unit, n.d.).

1.6.2 Overview of main rivers within the Townsville Dry Tropics

The Townsville Dry Tropics region comprises two drainage basins, the Ross Basin and the Black Basin. Ross River is the main river within the Ross Basin, with Bohle River the second largest river. Bohle River historically ephemeral now contains flow for much of the year. This highly modified system is influenced by high levels of urban stormwater and waterwater treatment systems. . Historically, Ross River was also ephemeral and only flowed during heavy periods of rain (Lukacs, 1996). However, in 1908, Gleeson weir was constructed across Ross River, with two further weirs created

(Aplins Weir in 1928 and Black School Weir (referred to as Black Weir) in 1934) (Lukacs, 1996). In 1973 the Ross River Dam was constructed, with the Ross River now being a permanent water source. During heavy rainfall, the weirs and Ross River Dam overtop their walls, however for the majority of the year there is no natural flows between the water bodies. Releases from Ross River Dam are required under the licence conditions to ensure that the water levels in Black Weir do not fall below 2.5 m of its full supply level (FSL) (Department of Natural Resources and Water, 2009). However groundwater inputs maintain the water levels at Black Weir and thus no scheduled releases from the Ross River Dam have occurred to maintain the weir water level (Department of Natural Resources, Mines and Energy (DNRME) 2019, pers. comm., 25 January).

Black River is the main river within the Black Basin and is ephemeral, being dry for most of the year and only flowing for short periods of time during intense periods of rainfall from December to March (Gunn, et al., 2009).

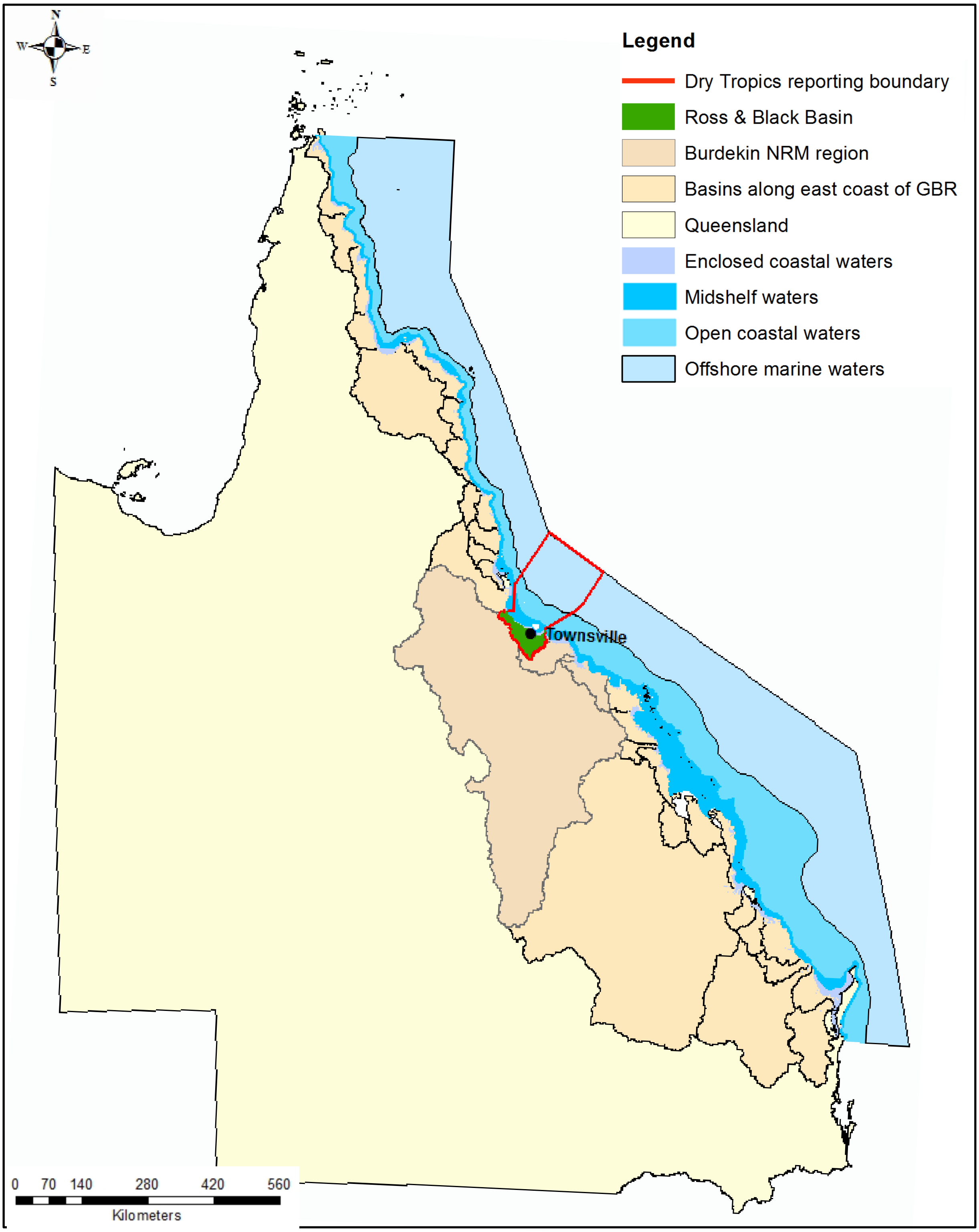

Figure 1. Townsville Dry Tropics reporting region within Queensland.

1.6.3 Land use

As of 2010, land use within the Ross Basin comprises of approximately 50% grazing within native vegetation, 25% conservation/natural areas or National Park, 15% urban or rural residential areas and 10% water (Ross River Dam) or wetlands (Gunn & Manning, 2010). However, between 2010 and 2018, an average of 207 ha of native vegetation was cleared each year within the Ross Basin (Queensland Government, 2018), as shown in Figure 2. The cumulative amount cleared between 2010 and 2018 is shown in Figure 3. Most clearing has occurred for residential development, with pasture the second largest cause (Queensland Government, 2018).

Within the Black Basin, in 2010 approximately 40% of the catchment was National Park or conservation/natural areas, with approximately 50% grazing (within native vegetation) and very little urban development or intensive agriculture (around 5% each) (Queensland Government, 2018). However between 2010 and 2018 an average of 150 ha of native vegetation has been cleared each year within the Black Basin, as shown in Figure 2. Land was mostly cleared for pasture, with infrastructure developed the second main factor.

The Townsville region supports ecological communities of significance (Ltd, Chenoweth Environmental Planning & Landscape Architecture Pty, 2011). One of the critical issues for vegetation clearing, especially associated with urban expansion, is the loss of wetlands. Studies conducted over 20 years ago determined that wetlands situated on the Ross River floodplain, such as the Idalia lagoons, have been disconnected from the river for decades and are reliant on surface runoff from their immediate catchments (and stormwater from developed areas) (Lukacs, 1996). Additionally, weeds, especially of paragrass (*Urochloa mutica*), were extensive throughout wetlands (Lukacs, 1996). Developments have detrimentally impacted upon wetlands and the rivers that feed into wetlands. For example, waterways feeding into the Ross wetlands were in poor condition, with large sections of riparian vegetation cleared, high soil erosion, extensive rubbish and pollutants resulting in eutrophication of the river (Lukacs, 1996). Most studies have focused on wetlands within the Townsville-Burdekin area, rather than specifically the Townsville Dry Tropics region. It is noted that these studies were conducted over 20 years ago, with a more recent study required to verify the state of wetlands.

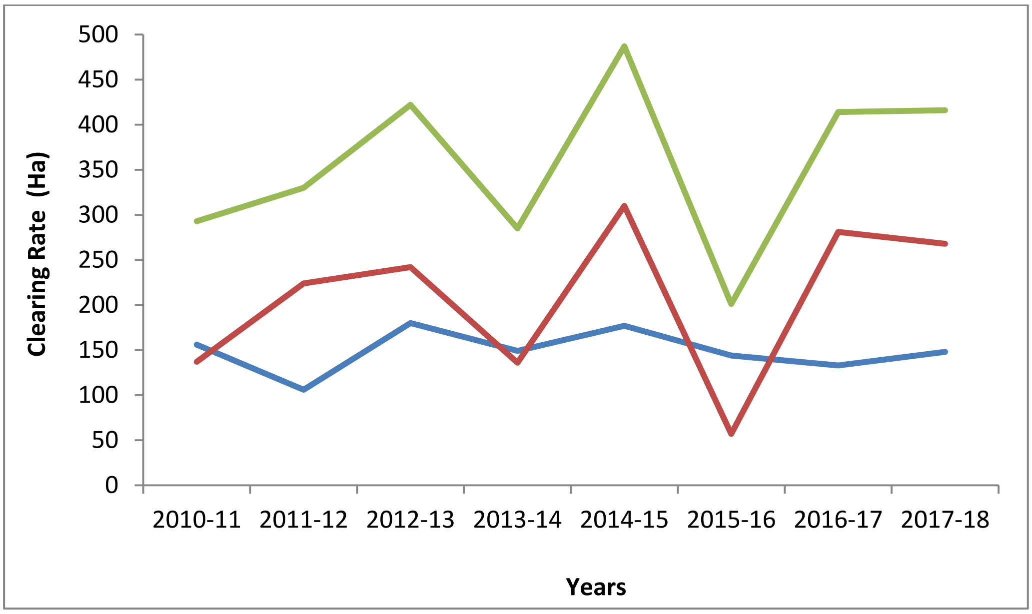

Figure 2. Annual clearing rates between 2010 and 2018 in the Ross Basin (red line), the Black Basin (blue line) and for both basins combined (green line).

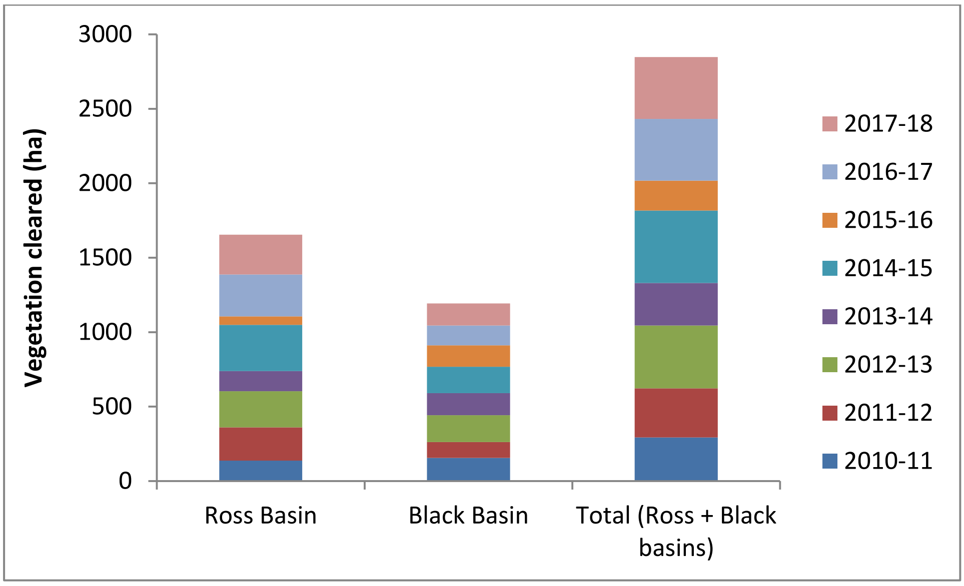

Figure 3. Cumulative annual rate of clearing between 2010 and 2018 in the Ross Basin, the Black Basin and for both basins combined.

1.6.4 Employment sectors and industries within the Townsville Dry Tropics

The Townsville Local Government Area (LGA) (including the Black and Ross basins and Magnetic Island) is the largest urban area located north of the Sunshine Coast (Population Australia, 2018). In June 2017, there were 192,988 people living in Townsville LGA, with the population growing annually by 1% over the last 5 years and 1.7% over the last 10 years (Queensland Government Statistician's Office, 2018). Based on data collected in 2016, the five main employment sectors in

Townsville are;

- Health Care and Social Assistance (14.6% of the working population)
- Public Administration and Safety (13.7%)
- Retail Trade (9.9%)
- Education and Training (9.6%), and
- Construction (8.2%) (Queensland Government Statistician's Office, 2018).

The main industries creating these jobs are;

- Defence
- Government education businesses, agencies (State and Federal) and research centres (James Cook University (JCU), Central Queensland University, TAFE Queensland North, Australian Institute of Marine Science (AIMS), Great Barrier Reef Marine Park Authority (GBRMPA)
- Health services (primarily the Townsville hospital), and
- Heavy industry (mainly the Port of Townsville) (Townsville Enterprise, 2018).

1.6.5 Management of the Townville Dry Tropics

Various organisations manage different areas within the Townsville Dry Tropics region. The Townsville City Council is responsible for determining and managing the policies and planning of the Local Government Area and ensuring community compliance with local council regulations (Corporate Governance, 2016). Council planning and policies are also strongly guided by state interests. State Parks and National Parks surrounding the Townsville region are managed by Queensland Parks and Wildlife Service, whilst GBRMPA is responsible for managing the Great Barrier Reef (GBR) Marine Park (GBRMPA, (2007). The Port of Townsville manages the marine area and shipping channel offshore of the Port, whilst Defence manages all land within its boundary. North Queensland (NQ) Dry Tropics is the regional natural resource management (NRM) body covering both Townsville and the Burdekin region (NQ Dry Tropics, 2017). Terrain NRM covers the northern most area of the Townsville Dry Tropics reporting region, including Crystal Creek sub-catchment in the north (Terrain NRM, 2017). Although the current focus of the report card is to report on the health of the urban area, broader pressures from activities in the greater NRM (Burdekin) region will also be considered.

2 Development of the annual report card

To develop the report card, the Partnership undertook a series of steps which are shown in Figure 4. Initially the Partnership established its vision and objectives. A series of workshops were then undertaken, including Walking the Landscape (WTL) workshops and workshops with local experts and community members. From these workshops the components of waterway health that were to be reported upon were determined and the drivers and pressures impacting these components were determined. Indicators for each of these components were then established, with the benchmark against which indicators would be scored were developed. Indicators (with sufficient data) were then scored. Although the Partnership does not undertake management actions, the report card scores can be used to guide management actions to areas of greatest concern (i.e. zones which received a low score).

Figure 4. Process the Partnership undertook to develop the report card.

2.1 Partnership vision and objectives

2.1.1 Partnership vision

The vision defines the Partnership's purpose and provides direction to Partners. The Partnership's vision is:

Partnering to improve the values of our catchments and Reef

The Partnership aims to establish collaborative approaches that seek to integrate environmental, social, economic and cultural information and catchment health knowledge. It builds upon and integrates existing monitoring, modelling, and reporting efforts at the catchment and Reef-wide scale, and will deliver products at a scale to which communities can relate.

2.1.2 Partnership objectives

The Partnership is committed to delivering the following objectives to meet its goals:

1. Establish and maintain a diverse membership including all levels of government, community, traditional owners, industries and research organisations committed to achieving the Partnership's vision.
2. Communicate information effectively and at a relevant scale to the broader community on waterway health issues to increase knowledge and empower the local community on Reef issues.
3. Develop an annual waterway health report card incorporating environmental, social, economic and cultural indicators, by building on existing monitoring and reporting programs, with scientific integrity, independence and transparency.
4. Initially the focus is on reporting on the Townsville region, and in the longer term extends to the entire North Queensland Dry Tropics region.
5. Coordinate and share data and information across a range of stakeholders to identify monitoring gaps and reduce duplication.
6. Provide scientific information that may assist in improving or maintaining the environmental, social and economic values, identify long-term trends, stimulate management action and drive positive change.
7. Recognise and support the efforts of Partners and others to improve regional waterway health by building upon, complementing and enhancing their efforts.

8. Identify waterway health related knowledge, identify priority activities, and advocate for them.

2.1.3 Commitment of the Partnership

In line with the vision and objectives of the Partnership, the Partners recognise that more can be achieved together than alone and acknowledge the value of collaboration in achieving greater outcomes than by any single agency or organisation. The Partners intend to cooperate and collaborate by:

1. Making a commitment to long-term monitoring and reporting to inform management responses.
2. Working together to pool resources and knowledge to maximise outcomes and underpin effective and efficient management actions.
3. Ensuring the nesting of this initiative within other whole of Reef monitoring, reporting and management activities.
4. Working towards ensuring alignment between different policy and reporting initiatives including the Reef 2050 Plan and Reef 2050 Water Quality Improvement Plan (Reef WQIP) [renamed (August 2017) and formerly known as the Reef Water Quality Protection Plan i.e. Reef Plan (2003, 2009 and 2013)], and associated integrated monitoring program and other reporting programs e.g. relevant components of the Paddock to Reef and broader Reef Integrated Monitoring Program.
5. Engaging with the local and broader communities by communicating waterway health issues and management responses in collaboration with the Partnership.

2.2 Walking the Landscape workshops

The Partnership undertook four 'Walking the Landscape' workshops in May 2018. The primary aim of the "Walking the Landscape" workshops was to obtain regional knowledge about the functioning of the landscape from local experts. Walking the Landscape is a participatory mapping method developed by the Wetlands team (Queensland Government) to enhance a shared understanding of environmental values, processes and threats. Participants virtually "walk" through the sub-catchments, mapping their knowledge on environmental, social and economic values in the context of the regionally important physical, geological and hydrological processes occurring in the landscape. Regional experts in geology, groundwater, hydrology, wetlands, natural resource management and urban water management and planning were invited to attend, as well as community members. During the workshops, participants virtually 'walked' through four Basins; Black, Ross, Bohle (sub-basin of Ross) and Magnetic Island. In the report card the Bohle Basin is included within the Ross Basin to align with the WQIP and other reports and Magnetic Island is excluded due to the basin being small and insufficient data available. For the purposes of the WTL workshops, the Basins were divided to maximise the information collected.

The workshops resulted in a shared understanding of the landscape features and processes that are important to the community. From the workshops, the environmental and social and economic values of the region were collated into a series of 'Catchment Stories' for each of the four Basins. The Catchment Stories are an interactive website containing maps and information pertaining to each Basin. They also provide a tool that people can use to better understand the environment and the social and economic benefits derived from the four catchments.

2.3 Selected reporting components

Based on the information from Walking the Landscape, the Partnership chose to report upon two environmental components of waterways, which were Biodiversity (flora and fauna dependent of waterways) and Water (water quality and quantity). It was also decided that waterways provided important social and economic benefits to the Townsville community, with these benefits reported as Community (social benefits) and Economy (economic benefits).

Reporting these four components in association with each other enables the community and decision makes to see the trade-offs between the condition of the environment and the community and economic benefits. It will also enable the community and managers to assess whether a decline in environmental conditions correlate with a decline in social and/or economic benefits. This leads to a better informed community and may lead to greater community effort in ensuring waterway health is maintained or improved (as this would in turn maintain community benefits). Over time, the Partnership aims to assess for trends between the four reporting areas (i.e. whether changes in environmental scores is reflected in the Community or Economy score). A range of key indicators representative of each component will be assessed in order to evaluate the region's ecosystem health and how this reflects the region's prosperity.

2.4 Report card goals and objectives

The Partnership established goals and objectives for each reporting component (Biodiversity, Water, Community and Economy).

2.4.1 Goals of the report card

In supporting the Partnership's vision, the main purpose of the report card is to bring together the best available information on the environmental health of the region's waterways and the social and economic benefits waterways provide to the community. In order to assess the region's ecosystem health and how this reflects the region's prosperity, the Partnership established goals for each reporting component.

The Partnership goals are:

- Biodiversity: Waterways are managed to sustain biodiversity for the benefit of local communities and dependant industries.
- Water: Waterways are managed to improve water quality, water flow and connectivity.
- Community: The community values and uses waterways and acts to reduce impacts on them.

- Economy: Waterways contribute to an enhanced economy that is underpinned by sustainable industries that provide employment and opportunities.

2.4.2 Objectives of the report card

The overarching objectives for the report card are:

a) Develop and implement a consistent approach to long-term monitoring and reporting on the region's waterway and marine issues
b) Communicate information effectively and at a relevant scale to the broader community on waterway health issues with scientific integrity, independence and transparency
c) Support decision making for management activities and interventions and report on the effectiveness of management decisions
d) Be specific to the Dry Tropics region, whilst maintaining consistency with other regional waterway report cards where appropriate.

To work towards meeting these objectives, the Partnership uses the annual report card to present information on the health of the waterways (condition of biodiversity and water) and the state of the community and economic benefits derived from waterways. The report card will be designed based on the best available information and will integrate a range of monitoring programs that measure waterway health and community and economic benefits.

The specific report card objectives (listed below) are focused around assessing the current state of Biodiversity, Water, Community benefits and Economic benefits within the region. The objectives (and associated indicators) were chosen so that the report card presents information that is of importance to the community with respect to the health of waterways.

Over time, the report card will assess whether ecosystem health is progressing towards or meeting regional targets, such as water quality targets. This will assist in evaluating the effectiveness of management responses. Additionally, after 3 to 5 years (depending on the data) the report card will be used to assess trends in the health of the environment and whether there is a correlation between the health of the environment and the social and economic benefits to the community. The report card will continue to evolve over time to incorporate new approaches to report card writing, data sources, or data analyses. As data gaps are filled in subsequent reports, the report card objectives may evolve from those listed below.

2.4.2.1 Biodiversity objectives

- Assess and report on habitat within freshwater, estuarine, and marine ecosystems using indicators of structure, function and resilience to track changes over time
- Assess and report on fauna that is important to waterways and track their changes over time

- Report upon the state of habitat and fauna against progress targets, and
- Report on the pressures to biodiversity, including the quantity of gross pollutants.

2.4.2.2 Water objectives

- Assess and report on the quality of water entering and within groundwater, freshwater, estuarine and marine ecosystems, against agreed water quality objectives to track changes over time
- Report upon the quality of water against progress targets
- Assess and report on pollutants entering and within the groundwater, freshwater, estuarine and marine ecosystems
- Assess and report on water quantity within groundwater, freshwater, estuarine and marine ecosystems using indicators of stream flow and stream height, whilst taking into consideration the effects of seasonality, and
- Report on the pressures to water quality and quantity.

2.4.2.3 Community objectives

- Report on the trends of the value placed on waterways and the Reef by the community, and their use
- Report on the trends associated with the wellbeing people derive from waterways
- Report on trends in the perception of environmental condition and waterway management by the community
- Report on the Indigenous and non-indigenous cultural importance of waterways, and
- Report on industry and community stewardship, including actions implemented to maintain healthy and sustainable waterways.

2.4.2.4 Economic objectives

- Report on the direct economic benefits of industries that depend upon healthy waterways in the region
- Assess and provide a baseline on the value that the community places on economic opportunities derived from waterways and the reef in the Townsville Dry Tropics region, and
- Monitor the ecological and economic sustainability associated with industries dependant on waterways and the Reef.

2.5 Conceptual diagram

Following the development of the vision and objectives for the Partnership and the selection of the four reporting components, a conceptual model was developed. Existing information and local knowledge of the region was used to develop a conceptual diagram. The conceptual diagram (Figure 5) incorporates the region's geography and the diversity of waterway environments. It also Illustrates the drivers and some of the main pressures (and pressure pathways) impacting upon the Ross and Black freshwater and estuarine zones and the inshore and offshore marine zones.

illustrates depicts

Figure 5. Draft conceptual diagram of the main drivers and pressures impacting upon key community values within waterways of the Dry Tropics. Drivers are human activities that exert pressure on the environment but occur at a sufficiently large scale that they cannot be solely managed at a regional scale. Pressures are human activities that affect the state of the environment and can be managed at a regional scale.

2.5.1 Current drivers and pressures and their resulting predicted impacts on the region

An objective of the report card is to assess and communicate the main drivers and pressures impacting upon the ecosystem (environmental, social and economic). For the purpose of the report card, drivers were defined using the Millennial Ecosystem Assessment definition of broad scale "natural or human-induced factor that directly or indirectly causes a change in an ecosystem. A direct driver unequivocally influences ecosystem processes. An indirect driver operates more diffusely, by altering one or more direct drivers" (Nelson, 2005). A contextual section of the report card will be dedicated to the influence of drivers.

For the purpose of the report card, threats and pressures were used collectively. A pressure was defined as "Any human activity or biophysical pattern of change that has the potential to impact the natural environment" (van Dam, et al., 2008), whilst a threat was defined as "any physical, chemical, or biological agent or process arising from a pressure, which can induce an adverse environmental response" (van Dam, et al., 2008). Identifying pressures is important as environmental managers can then prioritise actions that mitigate the main pressures impacting upon the environment (Carwardine, et al., 2012). It is also important to note that pressures may impact upon the environment in a non-linear way (i.e. cause rapid or abrupt changes in ecosystem health) (Maes, et al., 2012).

The drivers and regionally important pressures impacting upon the Ross and Black freshwater and estuarine environments were sourced from expert knowledge at the Walking the Landscape workshops, discussions with local experts and by conducting literature searches of the known current threats to the region. Drivers and pressures to the marine zone were sourced from discussions with experts and from the literature, namely the Great Barrier Reef Outlook Report (GBRMPA, 2014) and the AIMS websites.

A workshop was conducted in September 2018 and was attended by 34 experts, including marine ecologists, environmental managers, social scientists, government employees, economists and representatives from community groups. At the workshop, experts ranked the drivers and pressures to the freshwater and estuarine/coastal ecosystems for both the Black and Ross Basins and to the inshore and offshore marine zones. The main drivers and some of their associated impacts are listed in Table 1. The main pressures to the freshwater and estuarine/coastal zones are outlined in Table 2, whilst the pressures to the inshore and offshore marine zones are presented in Table 3. On the conceptual diagram (Figure 5), the main pressures to each reporting zone are included.

Table 1. Ranked main drivers, and some of their associated impacts, on the Townsville Dry Tropics. Drivers were ranked (from highest to lowest) by 34 experts. Note the descriptions are simplified so the survey responders could quickly read through the questions and answers.

Rank	Driver	Predicted impacts
1	Climate change & extreme weather events	Results in an increase in ocean acidification, sea levels and temperature and the frequency of intense floods and tropical cyclones. Increases the frequency, severity and scale of mass coral bleaching.
2	Land use	Contaminants from the catchment, such as sediments, nutrients and gross pollutants, wash into rivers and then discharge into the marine environment. At sufficient concentrations, contaminants can harm aquatic species, including corals, seagrass and marine fauna.
3	Consumable and urban lifestyle	The urban tropical lifestyle (e.g. large single-story buildings) and consumable lifestyle (e.g. upgrading products and throwing out resources) results in a high demand for resources and a high amount of waste produced.
4	Economic growth (including technology)	Increases the pressure on the environment as more resources are consumed and pollution increases.

Source of information: Government reports (e.g. Outlook report) and scientific websites (e.g. AIMS website).

Table 2. Ranked main pressures, and some of their associated impacts, on the Ross and Black freshwater and estuarine/coastal environments. Pressures were ranked (from highest to lowest) by 34 experts. Note the list of impacts is not exhaustive and the descriptions are simplified so the survey responders could quickly read the questions and answers.

Zone	Rank	Pressure	Impact from pressure
Ross freshwater	1	Urban & industrial contaminants	Contaminants flow into rivers and out to the marine environment, and at sufficient concentrations can harm aquatic life.
	2	Hardening of the catchment	Reduces infiltration rates and groundwater recharge and increases runoff rates. This increases erosion rates and the amount of contaminants that flow into waterways.
	3	Modification of waterways	Modification, including artificial barriers (e.g. dams) and armouring of rivers, disrupts connectivity and flow rates of waters, provides barriers to animal movements and results in the loss of aquatic environments, such as wetlands and saltmarshes.
	4	Gross pollutants	Can block storm water drains, which may increase localised flooding, and can harm aquatic species through ingestion and/or entanglement.
	5	Invasive & pest species	Can choke waterways and compete with other species for resources.
Ross estuary/coast	1	Modification/ development of coastal ecosystems	Modification, including the creation of seawalls and dredging of sand, changes the hydrology along the coast and can cause coastal erosion.
	2	Urban & industrial contaminants	Same as previous description
	3	Waste water discharge	Can alter the flow rates within an environment and change the salinity within wetlands.
	4	Personal care products	Products, such as shampoos, soaps, cosmetics, microplastics and pharmaceuticals, cannot be removed by waste water treatment plants and are discharged into waterways.
Black freshwater	1	Land clearing & urban development	Clearing and development, including of coastal and riparian vegetation, results in habitat loss, erosion and reduced water infiltration rates and groundwater recharge.
	2	Agricultural practices	Can lead to excess nutrients, sediments and chemicals (e.g. pesticides) flowing into waterways and then out to the reef.
	3	Groundwater extraction	Can result in the water table rising and may lead to saltwater intrusion. Saline water can result in infertile and barren land.

Zone	Rank	Pressure	Impact from pressure
Black estuary/ coast	1	Land clearing & urban development	Same as previous description
	2	Agricultural practices	Same as previous description
	3	Septic systems	If managed poorly, can provide a long term chronic source of nutrient pollution.

Source of information: Discussions with regional experts (including six days of 'Walking the Landscape' workshops) and government reports (e.g. 2014 GBR Outlook report) and scientific websites (e.g. AIMS website).

Table 3. Main pressures, and some their impacts, upon the inshore and offshore zones. Pressures were ranked (from highest to lowest) by 34 experts. Note the list of impacts is not exhaustive and the descriptions are simplified so the survey responders could quickly read through the questions and answers.

Zone	Rank	Pressure	Impact from pressure
Inshore	1	Catchment runoff	Runoff, including nutrients, sediments, chemicals and gross pollutants flow into the marine environment. At sufficient concentrations, these pollutants can harm aquatic life.
	2	Dredging	Can impact on the seabed and create plumes of suspended sediment that affect marine organisms and may contribute to chronic suspended sediments.
	3	Boating & shipping	Can threaten the environment through noise pollution, boats striking animals, ship groundings and anchor damage to the seabed or corals.
	4	Oil & chemical spills	Can harm aquatic species, including poisoning mammals and birds, and reducing the survival, development and reproduction rates of fish and corals.
	5	Overfishing	Can lead to population declines of species (both targeted and bycatch). This can result in trophic cascades and reduced ecosystem functioning.
	6	Poorly managed tourism & recreation	Can physically damage corals (e.g. whilst snorkelling or diving) and/or alter animals' behaviours (e.g. disturbing animals or feeding fish, turtles or birds).
	7	Invasive & pest species	Including crown of thorns starfish, compete with or predate upon other species and can reduce the health and diversity of species within ecosystems.
Offshore	1	Boating & shipping	Same as previous description
	2	Overfishing	Same as previous description
	3	Dredging	Same as previous description
	4	Oil & chemical spills	Same as previous description
	5	Poorly managed tourism & recreation	Same as previous description
	6	Invasive & pest species	Same as previous description

Source of information: Discussions with regional experts and government reports (e.g. Outlook report) and scientific websites (e.g. AIMS website).

2.5.2 Response to pressures

To address the pressures affecting the region's waterways, various development plans and water quality guidelines have been devised, with many reports also recommending further management actions be devised (Bainbridge, et al., 2008; Gunn & Manning, 2010).

The key management programs that operate within the Dry Tropics are;

- The Reef 2050 Plan (see section 1.5.3)
- Black Ross (Townsville) WQIP (Gunn & Manning, 2010) has been developed to identify the main issues impacting the Black and Ross waterways from land-based activities. The Black Ross WQIP

also lists management actions that are designed to minimise the decline in water quality within the Townsville Dry Tropics. The WQIP provides a regional focus and highlights issues, priorities and management actions that target specific outcomes for the region. It is hoped that the WQIP will be updated and its management actions implemented.

2.5.3 Guiding framework: Modified DPSIR model with human dimension emphasis

The Social and Economic Long-Term Monitoring Program (SELTMP) Conceptual Framework guided the development of the report card, which is shown in Figure 6. The SELTMP Conceptual Framework is based on the DPSIR framework and Millennium Ecosystem Assessment Framework. The Framework will be referred to as the 'modified framework' within this document. This is because the DPSIR framework is more universally recognised that the SLETMP Conceptual Framework, that is primarily used by social scientists.

The modified framework interlinks the environmental (ecosystem), community (social) and economic components together and positions community and economic benefits and drivers as key components of the framework. Reporting upon the triple bottom line will provide a holistic understanding of the state of the region. It also highlights how the health of the environment is interlinked with and directly influenced by the community and economy. The state of the ecosystem (Ecosystem State in Figure 6) comprises the components of the environment that people value and benefit (Marshall, et al., 2016). The ecosystem also needs to be healthy for the sake of the environment and for the socio-economic benefits it provides. People benefit from the environment by either using or depending upon the resource ('A' in Figure 6) or for personal wellbeing ('B' in Figure 6) (Marshall, et al., 2016). The value people place on the environment influences how much people impact the environment and also their willingness to change their impact ('C' in Figure 6) (Marshall, et al., 2016). Activities undertaken by the community and industry directly impact upon (pressure) and drive change in within the environment ('D' in Figure 6) (Marshall, et al., 2016). Drivers of change include management actions, political decisions, communication and media reporting and science and technology (Bohensky, et al., 2011; Marshall, et al., 2016). The amount of impact/change in turn affects the state of the environment.

For the report card, Biodiversity and Water translate as the ecosystem state ('A' of the framework), whilst section 'A', 'B' and 'C' of the modified framework is the Community and Economy components of the report card. For the report card, section D of the modified framework represents the pressures indicators of Biodiversity and Water.

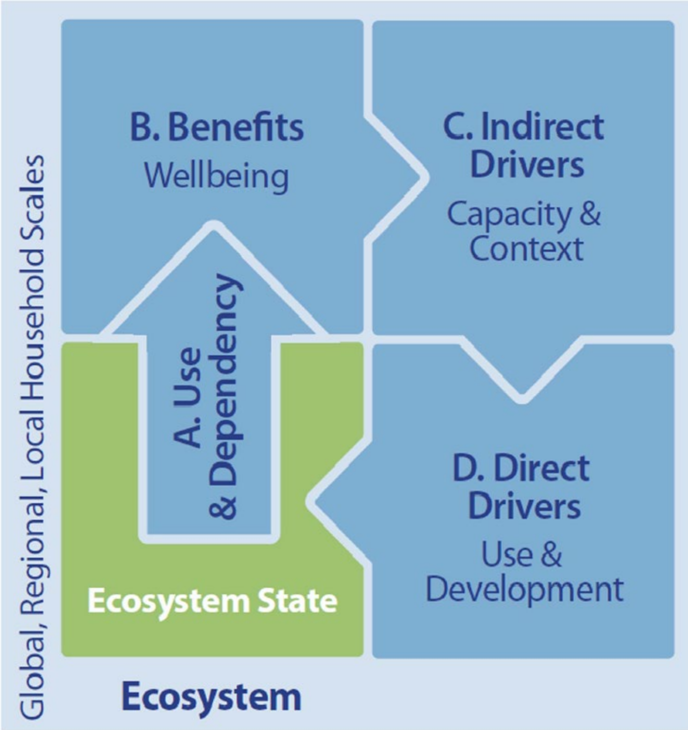

Figure 6. The modified framework based on the DPSIR framework and Millennium Ecosystem Assessment Framework. The human dimension is represented by the four components (in blue): A. Use and Dependency, B. Human Wellbeing, C. Capacity and Context, and D. Use and Development. It suggests that the level of human and community wellbeing is determined, in part, by how people use and depend on the region. Human and community wellbeing ('B') influences the environment (Ecosystem State) by influencing the social and economic context or indirect drivers within the system ('C'), within which direct drivers are allowed or not allowed to occur ('D'). Opportunities for strategies and interventions that can halt, reverse, or change a process exist at several points within the cycle.
Source: Marshall, et al., 2016

The modified framework is based on the Millennial Ecosystem Assessment and the Drivers Pressure State Impact Response (DPSIR) Framework (Marshall, et al., 2016). Additionally, the SELTMP Framework provides data for four of the seven Reef 2050 themes (Marshall, et al., 2016). The seven themes of the Reef 2050 Plan are shown in Figure 7 (Commonwealth of Australia, 2018). The environmental components of the system are described in the three following themes; Ecosystem health, Biodiversity and Water quality (see Figure 7) (Commonwealth of Australia, 2018). The remaining four describe the social-economic dimensions of the system, these themes being heritage, economic benefits, governance and community benefits (Figure 7) (Commonwealth of Australia, 2018).

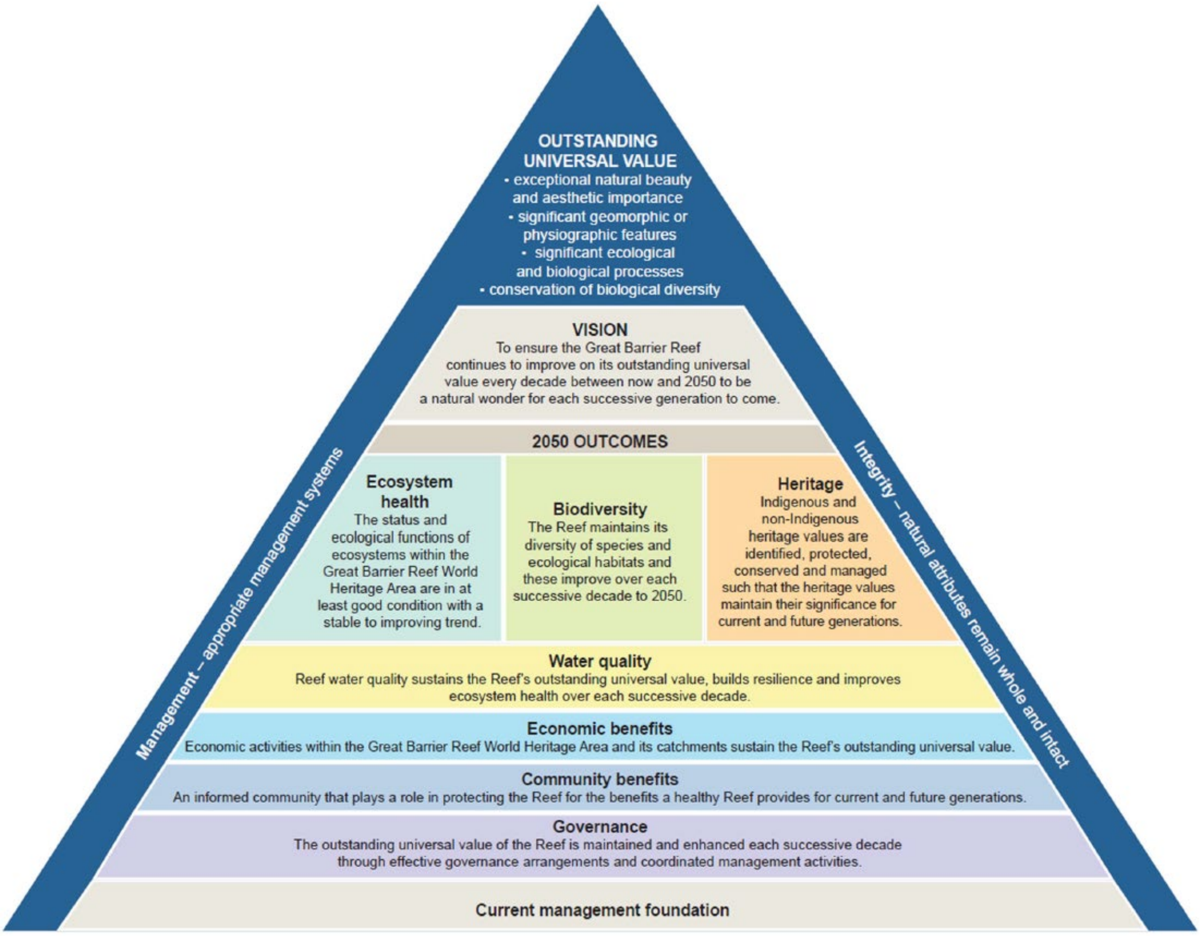

Figure 7. Seven themes of the Reef 2050 Long-Term Sustainability Plan.

Source: Commonwealth of Australia, 2018

The modified framework is different to that used by other Queensland regional report cards, which use the DPSIR Framework. The important difference between the modified framework and the DPSIR framework is that the social and economic benefits are explicitly integrated into the modified framework. This increases the relevance of the report card to the community and stakeholders. Additionally, by aligning environmental components with societal values, it enables management to implement social, economic and environmental changes to improve the state of the environment. Indicators can also be developed for any part of the Framework (environmental, social or economic). Table 4 below outlines how the conceptual framework aligns with the DPSIR model with example indicators included. Once indicators, targets and desired outcomes are identified, management interventions can be determined to respond to changing conditions identified through monitoring indicators. The Dry Tropics Partnership is the first report card within Queensland to adopt a framework that places social and economic benefits and drivers as key components of the Framework.

Table 4. Framework components mapped against the DPSIR model

Framework component	Corresponding DPSIR framework component	Example indicators	Comments
Ecosystem state	State (biophysical components and processes)	• Waterway health and water quality indicators • Riparian vegetation indicators • Inshore, mid shelf, offshore habitat and ecosystem health indicators	This category encompasses all environmental values and ecosystem processes. It excludes human-derived values and benefits. Most biophysical monitoring programs provide data and indicators for this category.
A. Use & dependency	Pressure • Human use levels and patterns of activity in the environment are categorized in DPSIR as a pressure	• Use levels and types of recreational and commercial activities in waterways. • Place attachment, lifestyle dependence, occupational attachment of regional residents and businesses.	"Dependency" on natural resources is an additional component not explicitly addressed within the standard DPSIR model. Dependency is an important characteristic of the human-environment relationship, which influences benefits (wellbeing) and pressures on natural resources. Understanding dependency provides contextual information that is vital for decision making.
B. Benefits (wellbeing)	State + Impact (human components)	• Economic values and benefits derived from waterways • Social, cultural and psychological (non-monetary) values and benefits derived from waterways	Human wellbeing derived from natural resources is an additional component not explicitly addressed within the standard DPSIR model (though it may sometimes be included under the *Impact* heading). All human-derived values and benefits extracted from the environment are included here.

C. Indirect Drivers (capacity & context)	Drivers + Response • *Drivers* are regarded as any natural or human-induced factor that directly or indirectly causes a change in the social-ecological system (e.g. climate change). • *Indirect drivers* are the environmental and socio-cultural drivers that influence human actions and responses (NB. *societal attitudes* are recognised in DPSIR as a *Driver).* • Raising community awareness of an environmental problem and support for corrective actions is categorised as a management *response* in the DPSIR framework.	• Community attitudes, aspirations, capacity and stewardship indicators • Community perceptions of management effectiveness • Community perceptions and awareness of environmental threats • Trust and confidence in management agencies • Regional, national and international economic indicators • Political, scientific, technological, communication and media trends	The standard DPSIR model does not distinguish between *direct* and *indirect* drivers of change. Human capacity to influence environmental change is an additional component not explicitly addressed within the standard DPSIR model. The social and cultural context in which environmental problems emerge plays an important role in the management *response* (e.g. social and cultural norms have a large influence on human attitudes and behaviour).
D. Direct Drivers (use and development)	Drivers + Response • *Direct drivers* are those that involve human actions and biophysical processes (i.e. they have a physical component). • Management interventions in the environment (e.g. wetland, riparian, waterway or coral restoration) would be categorised as a management *response* in the DPSIR framework.	Climate change and associated indicators (e.g. sea and land temperatures, weather and rainfall patterns, ocean salinity, sea level rise, ocean acidification) Land and waterway activity levels and changes (e.g. agricultural, residential, industrial). Levels of coastal development, land clearing, land use change.	The standard DPSIR model does not distinguish between *direct* and *indirect* drivers of change.

2.6 Roles and responsibilities during the report card production

Overall, the Townsville Dry Tropics Report Card program is managed through the Partnership. The Executive Officer and Technical Officer progress the day-to-day operation of the Partnership and report card development. The development of the report card is guided by the technical working group (TWG) and all aspects of the methodology and scoring approach is reviewed by the TWG and the Independent Science Panel (ISP).

2.6.1 Technical Working Group

The Technical Working Group (TWG) is comprised of experts and data custodians from different organisations. The main organisations involved are government departments and research institutions, including the Commonwealth Scientific and Industrial Research Organisation (CSIRO), AIMS, GBRMPA, JCU, CQU, the Department of Environment and Science (DES), the OGBR and other regional report card partnerships. Information is reviewed by the TWG at important stages during the report card development. TWG members may assist in developing methods to be used in the report card, such as methods for scoring indicators and devising report card scores. All substantial pieces of work require review by the TWG and the Independent Science Panel (ISP) (see below) before being published. This ensures the scientific rigour of the report card.

2.6.2 Independent Science Panel

The ISP is a group of independent scientists that review the report card at key stages along the report card development. The ISP operates within an established Terms of Reference.

The ISP reviews and makes recommendations on the following components of the report card:

- Partnership program design (this document)
- Selected indicators that will be scored within the report card
- Scoring methods to be used in the report card
- Synthesis of data results and the interpretation of the results, and
- Final report card and technical reports.

3 The Townsville Dry Tropics Report Card

3.1 Frequency of report cards

Initially the Partnership aims to benchmark agreed components of the Dry Tropics region in the Pilot Report Card. The state of the Dry Tropics waterways will then be assessed and the Partnership will produce a regional report card of the findings. The Pilot Report Card will be released in April 2019 and report upon data from 2013 to June 2018 (based on the reporting periods of the data available). The majority of data supporting the report is from the 2017-18 financial year. The Pilot Report Card will focus on the Townsville Dry Tropics reporting area. Subsequent report cards will be adaptable and expandable.

There will always be a lag period (up to 12 months) between when the data is collected and when the data can be used. This is due to validation and confirmation processes that are required before the data is released to the regional report cards. The Partnership is working with data providers to explore options for reducing lag time in publishing the report card. Currently, it is also necessary that the release date of the Townsville Dry Tropics Report Card takes into account the release date of other report cards (such as the annual GBR report card, which is released in September each year) (Department of Environment and Science, 2017).

3.2 Report card scope

The scope of the report card is considered in both the short and longer term, which is shown in Table 5. More detailed information on the short term indicators (which are scored in the Pilot Report Card) are outlined in section 5.4, 5.4, 5.5 and 5.6. As more information becomes available, the scope of the report card will be adapted. The current scope of the report card is presented in section 3.3.

Table 5. Short- and long-term scope for the Townsville Dry Tropics Report Card. For the long-term scope, the current barriers to including the indicators within the report are listed. If an indicator occurs in more than one zone, the explanation is only listed in the first zone.

<table>
<tr><th></th><th>Short term</th><th>Longer term</th></tr>
<tr><td rowspan="5">Extent</td><td>Two freshwater zones (Ross and Black)</td><td>Extend to the Dry Tropics NRM region and include the Haughton, Don and the Burdekin Catchment, comprising five major sub-catchments within the Burdekin (Upper Burdekin, Cape Campaspe, Bowen Bogle, Burdekin and Theresa Creek) (Queensland Government, 2018).</td></tr>
<tr><td>Two estuarine/ coastal zones (Ross and Black)</td><td>Extend to include the estuaries of the Dry Tropics NRM (Haughton, Don and the Burdekin).</td></tr>
<tr><td>Two inshore zones (discharge from the Ross and Black)</td><td>Extend to include three more inshore zones to reflect where rivers discharge:
• Bowling Green Bay, where the Haughton River, Major Creek and Barratta Creek discharge)
• Upstart Bay, where the Burdekin River and its tributaries discharge
• Abbott Bay and Queens Bay, where Menilden Creek and Euri Creek discharge (Queensland Government, 2018).</td></tr>
<tr><td>One offshore marine zone</td><td>Expand the offshore region to include the area offshore of the Burdekin. Remain with one offshore marine zone (not two) as discharge from the Burdekin impacts the current Townsville Dry Tropics offshore marine zone (Wolff, et al., 2018).</td></tr>
<tr><td>Groundwater</td><td>Expand to include groundwater indicators</td></tr>
<tr><td>Indicators</td><td>Freshwater basin:
• Riparian and wetland extent
• Total phosphorus (TP)
• Dissolved inorganic nutrients (DIN)
• Dissolved Oxygen (DO)
• Turbidity
• Community stewardship</td><td>Include:
• riparian and wetland condition (current monitoring would need to be expanded to include more sites within the Dry Tropics)
• fish (current monitoring would need to be expanded to include Dry Tropics)
• macroinvertebrates (citizen science data available, quality assurance/control is required)
• birds (citizen science data available, but requires a method to score the indicator)
• gross pollutant data (method to score indicator category is required)
• artificial barriers
• water quantity (flows) (monitoring would need to be expanded to include more sites)
• percent of the freshwater catchment that is developed (would require a method to score the indicator)
• metals, pesticides and per- and poly-fluoroalkyl substances (PFAS) (contaminants) (accessibility to data is an issue or current monitoring programs would need to be expanded to include the Dry Tropics region. For metals and PFAS a method to score the indicator would also be required.)
• social data sets (methods to score social indicators are required)
• economic data sets (methods to score economic indicators are required).
Expand:
• spatial and temporal data sets on water quality (limited data within Black Basin)
• water quality sampling to include dissolved inorganic phosphorus/filterable reactive phosphorus (FRP).</td></tr>
</table>

	Estuaries/coastal: • mangrove and saltmarsh extent • TP • DIN • DO • turbidity • stewardship	Include: • mangrove and saltmarsh condition (current monitoring would need to be expanded to include more sites within the Dry Tropics) • fish • birds • gross pollutants • water quantity (flows) • percent of the estuarine catchment that is developed • contaminants (metals and pesticides and PFAS) • pH Expand: • spatial and temporal data sets on water quality • water quality sampling to include dissolved inorganic phosphorus/FRP • increase the frequency of social and economic surveys
	Inshore marine: • coral indicators • seagrass indicators • TP/particulate phosphorus • oxidised nitrogen (NOx) • particulate nitrogen (PN) • TSS • turbidity • secchi depth • Chlorophyll *a* • stewardship	Include: • fish • birds • marine megafauna (current monitoring not suitable for a small region report and a method to score the indicator would also be required) • gross pollutants (current monitoring would need to be expanded to include the marine zones) • metals • light Expand: • spatial and temporal data sets on water quality • water quality sampling to include dissolved inorganic phosphorus/FRP and chlorophyll *a* • increase the frequency of social and economic surveys.
	Offshore marine: • coral indicators • values of waterways • wellbeing from waterways • perception of waterway management • perception of environmental condition • stewardship • Non-monetary economic values	Include: • Fish (reef fish are currently monitored as part of the long-term monitoring program) • water quality indicators, including turbidity/total suspended solids (TSS), chlorophyll a and light (there is no long term offshore marine water quality monitoring program measuring turbidity/TSS within the Dry Tropics) • increase the frequency of social and economic surveys
	Groundwater	Water quality/recharge rates/flow and quantity, including contaminants (PFAS, salinity, nutrients, etc.)
Context	Environmental	Include new information that is regionally relevant. Highlight and address knowledge gaps.
	Social	Build upon current social data sets and fill in data and knowledge gaps. Present ongoing data on the community values of waterways.
	Economic	Develop the economic value of waterways.

3.3 Townsville Dry Tropics reporting region

The spatial scope for the report card is currently restricted to the Townsville Dry Tropics region, comprising of the Black and Ross basins (Figure 8). It also includes the islands from Pelorus (North Palm) Island in the north to Magnetic Island in the south and the adjacent marine zones and inshore and offshore reef habitats (Figure 8). For the report card, the Townsville Dry Tropics region is differentiated into reporting zones that align with related initiatives such as the Reef 2050 Plan and the Townsville WQIP. This provides consistency in the presentation between reports.

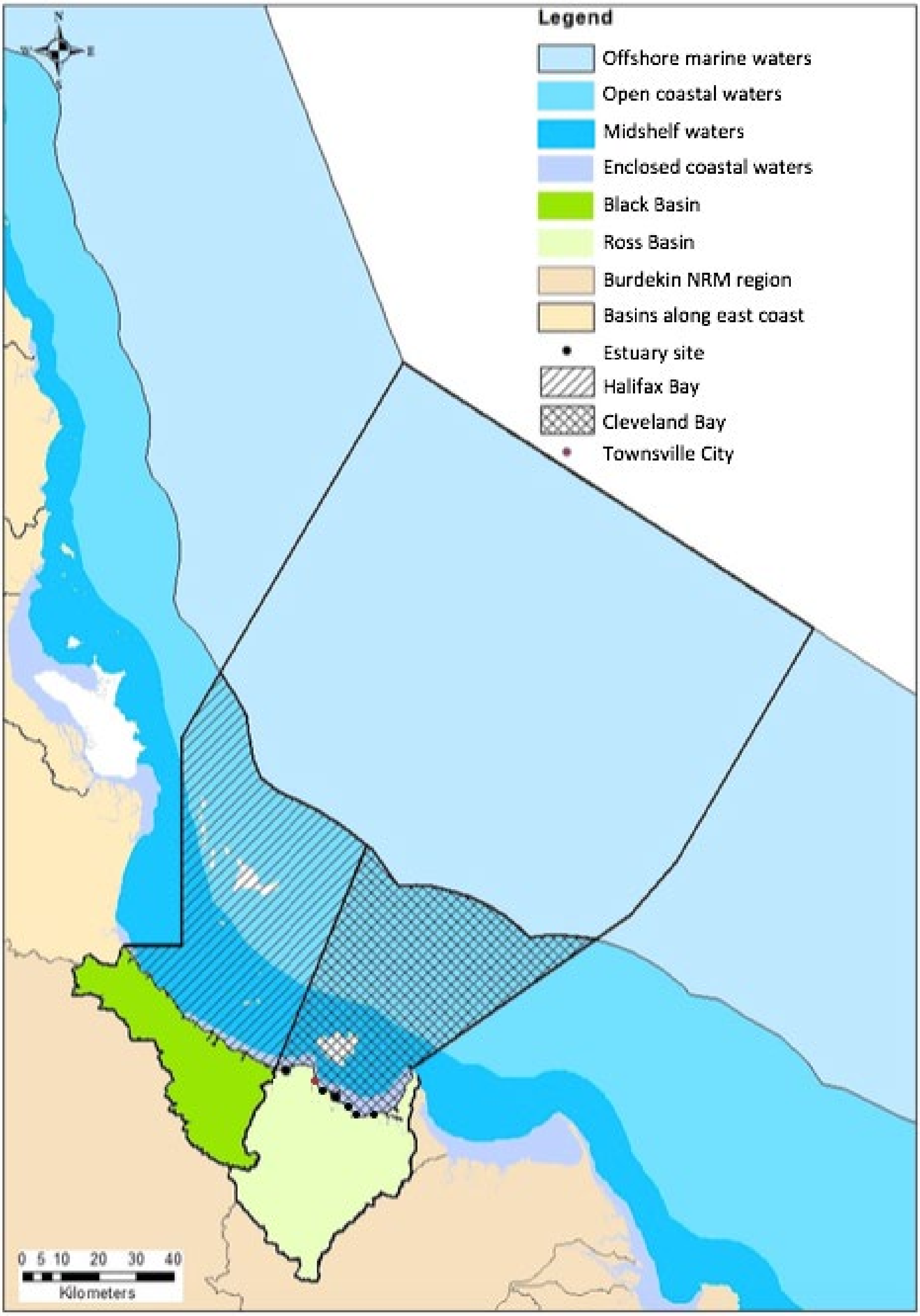

Figure 8. Geographic boundary reported upon by the Dry Tropics Partnership, comprising the Ross and Black basins, estuarine/coastal zones, Cleveland Bay and Halifax Bay inshore marine zones and the offshore marine zone. The inshore marine zones comprise open coastal, midshelf and enclosed coastal waters. The right angle in the offshore marine zone is the boundary of the Hinchinbrook Planning area.

3.3.1 Freshwater and estuarine/coastal reporting zone

The freshwater and estuarine areas are divided into two reporting zones; the Ross Basin and the Black Basin. These reporting areas are based on the boundaries outlined in the Townsville WQIP (Gunn & Manning, 2010). The estuarine/coastal zones include the intertidal waters (mixing zone between freshwater and saltwater) and coastal beaches. This zone also includes the semi-enclosed area between the Port of Townsville and the breakwater.

3.3.1.1 Inshore marine zone

The inshore marine zone is divided into two zones, Cleveland Bay and Halifax Bay, as shown in Figure 9. This division was chosen as it aligns with the terrestrial boundary that delineates the Ross and Black estuarine/coastal zones. This makes it easier to communicate how discharge from each catchment influences each marine zone. The division was also based on the distribution of the sediment plumes from the three major rivers; the Black River (within the Black Basin), Bohle River and Ross River (both within the Ross Basin). Sediment plumes observed on Google Earth© satellite images (from 2008 onwards) show the Black River discharges into Halifax Bay inshore marine zone, whilst the Ross River and Bohle River mostly discharge into the Cleveland Bay inshore marine zone. However it is noted that the discharge from the Bohle and Black rivers are relatively close (around 5 km apart) and historically, tributaries from the Bohle River fed into the Black River. It is possible that discharge from the Bohle River may impact upon the Halifax Bay inshore marine zone.

Modelling commissioned for the Townsville WQIP (Gunn & Manning, 2010) determined that water discharged from the Black and Ross basins travelled approximately 27 km offshore, as shown by the maroon shading in Figure 9. Waters outside of the modelled area are likely to be almost exclusively impacted by discharge from the Burdekin Catchment (Lewis and Sweatman, 2018, pers. comm.). This means that in Figure 9 the inshore marine area that is shaded in thatching or diagonal lines, and not shaded in maroon, is influence by discharge from the Burdekin Catchment.

Wolfe et al., (2018) modelled the level of river influence (tracer) and DIN concentration discharged into the marine zones from major river systems along the Queensland coast, as shown in Figure 10. Modelling included rivers within the Burdekin Catchment but excluded rivers within the Black and Ross basins (Wolff, et al., 2018). Tracer is used as an indication of the extent of a river plume (Wolff, et al., 2018). Both the inshore and offshore marine areas offshore of the Black and Ross basins were heavily impacted by discharge from other rivers (Wolff, et al., 2018). Rivers within the Burdekin Catchment were modelled to have the greatest impact on the Townsville Dry Tropics area (Wolff, et al., 2018).

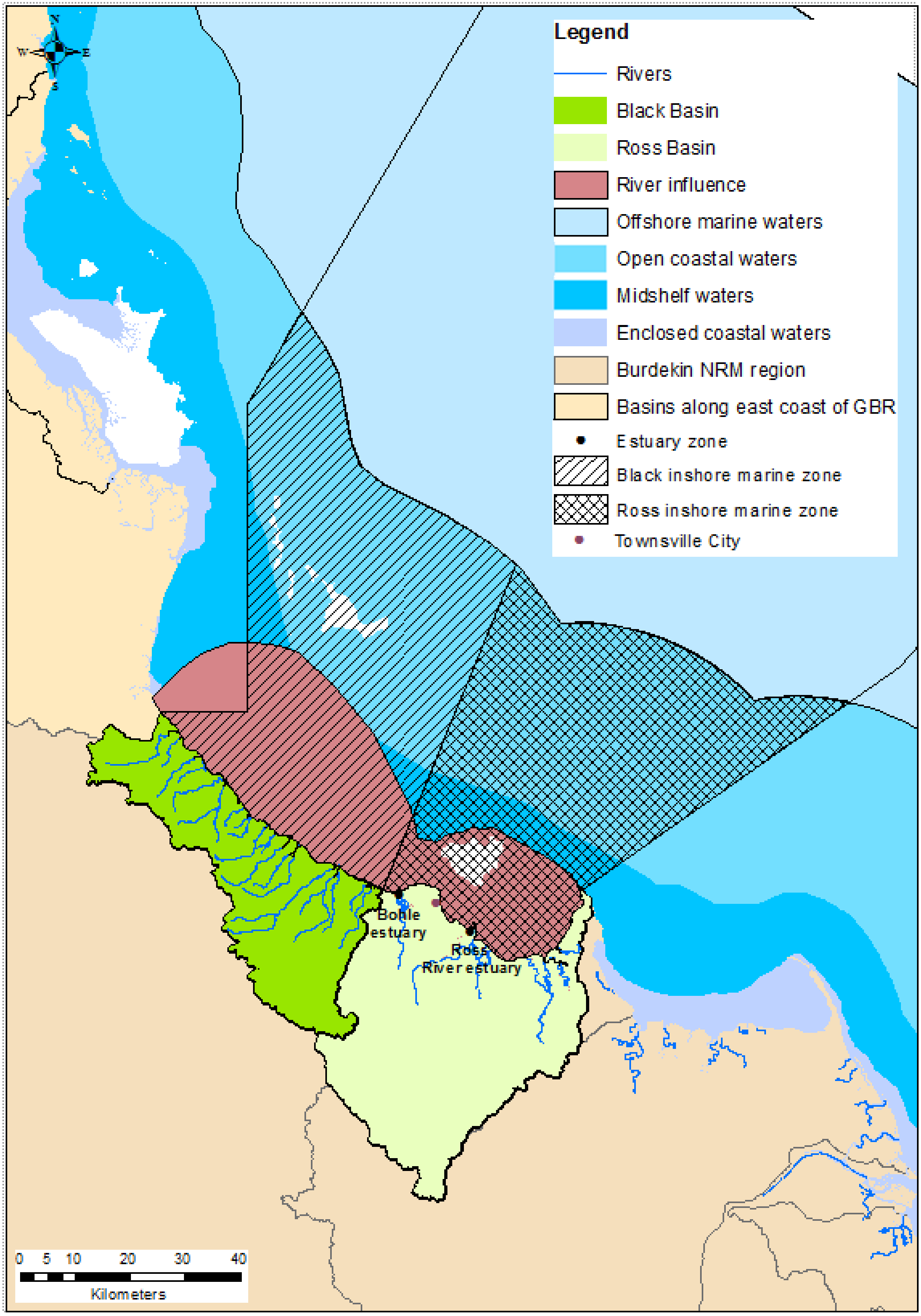

Figure 9. The modelled zone of influence (shown in maroon shading) from the Black and Ross basins. The broader inshore marine zones (shaded in thatching or diagonal lines, and not shaded in maroon) is influence by discharge from the Burdekin Catchment.

a) River influence

b) DIN exposure

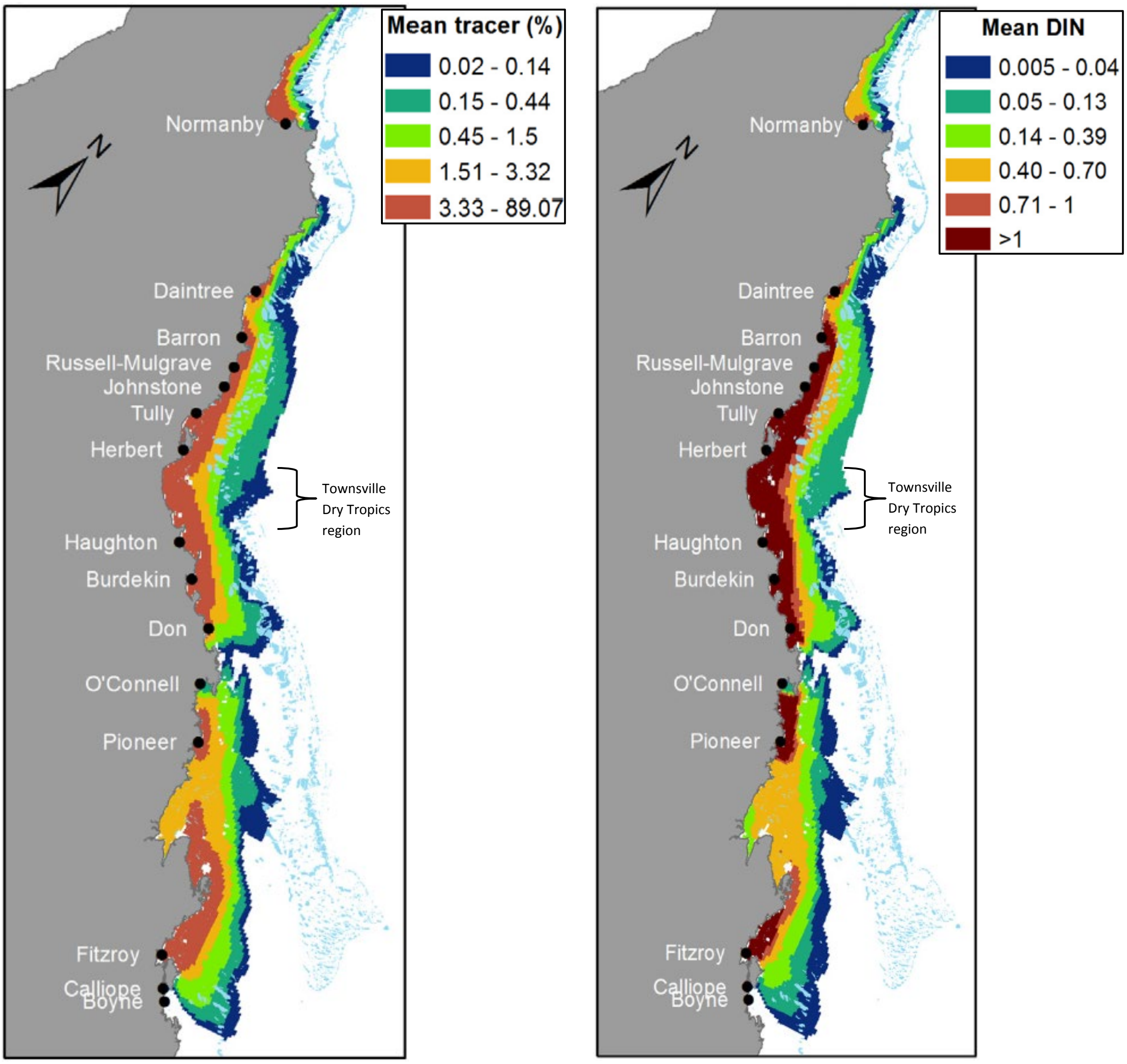

Figure 10. Modelled estimates of (a) mean river influence (tracer) and (b) mean concentrations of DIN (in micromolar), discharging from the main rivers along the east coast of Queensland during the 2010-2011 wet season. Data bins are based on quantile distribution. The colour categories are divided into data bins of 20%. For (b) the top (highest) 20% data bin is split into two colours (reds) to show the region with >1 micromolar (dark red) (Wolff, et al., 2018).

3.3.1.2 Boundary between the inshore and offshore marine zones

The outer boundary for the inshore marine zone was based on the water body delineations of open coastal, midshelf and offshore marine waters guidelines from the Department of Environment and Science (2018). The inshore marine zones comprise enclosed coastal, open coastal and midshelf waters (Department of Environment and Science, 2018).

3.3.1.3 *Offshore marine zones*

For the report card, there is one offshore marine zone, extending from the inshore zone boundary to the edge of the outer boundary of the GBR Marine Park.

4 Method for developing report card scores

Methods for assigning scores for the Pilot Report Card were developed with the assistance of experts. Specific considerations were given to the following:

- Incorporation of existing targets for the region
- The meaning and representativeness of the final score
- The ability to provide a score that enables long term trends to be assessed
- Ensuring the Report Card is comparable with other Report Cards and programs

The development and final scoring methods are the same as the methods used by the 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 report detailing the methods for the Townsville Dry Tropics will be finalised later in 2019. Where new methods have been developed for the Townsville Dry Tropics report, the method is currently outlined in the results for the Pilot Report Card document (Whitehead, 2019) and will be included in the Townsville Dry Tropics methods document (currently under development).

4.1 Guidelines and targets

Guidelines and targets have been developed for a wide range of metrics and include national and state water quality guidelines, environment protection policies, water quality improvement plans, NRM plans, and the Reef 2050 Plan. For the report card, the most regionally relevant guidelines and targets for the Townsville Dry Tropics were used, with the appropriate guidelines and targets created into report card scoring categories. Where possible, the same methods used by the other regional report cards were used. In the future, the report card will look towards establishing and reporting on progress towards targets.

4.2 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 (Biodiversity, Water, Community and Economy).

Indicators are grouped into indicator categories, which are in turn aggregated into an index (or indices) and then into an overall score for each reporting component (Biodiversity, Water, Community and Economy). The scores for Biodiversity, Water, Community and Economy will not be aggregated into a single grade within a zone.

The score for indicators, indicator categories, indices and the overall score for Biodiversity, Water, Community and Economy will be presented in the coaster, as shown in Figure 11. This ensures the results are succinctly presented and all environmental services/benefits are given equal representation in the report card. There will be seven coasters in the report card (one coaster per zone, for the Ross and Black freshwater, Ross and Black estuarine/coastal, Cleveland Bay and Halifax Bay inshore marine and offshore marine zones). Presentation of the coasters in the report card can be with or without the two outer rings (indicators and indicator categories).

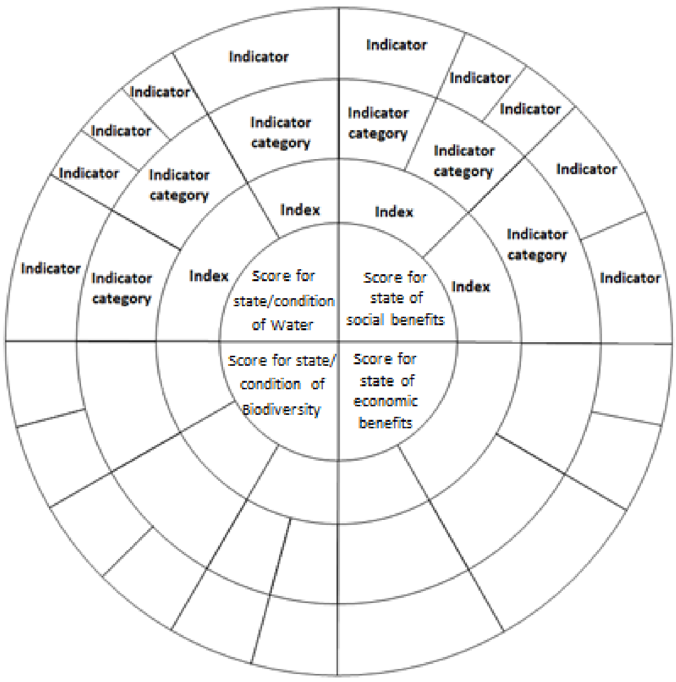

Figure 11. Terminology for defining the levels of aggregation for indicators and how they are displayed in the report card.

4.3 Scoring categories

Ordinal values provide a clear and easy to understand method to score the results of the report card. The Townsville Dry Tropics report card uses five grades: 'A' (Very Good), 'B' (Good), 'C' (Moderate), 'D' (Poor) and 'E' (Very Poor) (as shown in Table 6). These grades are evenly distributed within a 0 to 100 scoring range as shown in Table 6, which reflects the GBR report card approach to scoring. This method is used by both the Wet Tropics and Mackay-Whitsunday report cards. As shown in Table 6, the grades are presented using a colour coding system, which makes the grades easy to interpret and align with the other report cards. Dark green indicates a "Very Good" score, light green indicates "Good", yellow indicates "Moderate", orange indicates "Poor" and red indicates "Very Poor".

Table 6. Grades and scoring range for the Townsville Dry Tropics report card.

Grade	Scoring range
A: Very Good	81-100
B: Good	61-<81
C: Moderate	41-<61
D: Poor	21-<41
E: Very Poor	<21

A description of each grade for the environmental indicators has been developed. The meaning of each grade for indicators that measure the condition of biodiversity and water are shown in Table 7. The descriptions are applicable across all environments (basins, estuaries, inshore marine and offshore marine). The meaning of each grade for indicators that measure change in habitat extent (compared to pre-European levels) for basins and estuaries are provided in Table 8. The grades and definition may change over time if this is necessary so that they are more regionally appropriate. To provide consistency across the report cards, descriptions are the same as used by both the Wet Tropics and Mackay-Whitsunday.

Table 7. Descriptions of the grades used to score indicators of water quality and habitat condition for freshwater, estuaries/coastal, inshore and offshore marine zones.

Grade	Definition
A: Very Good	Conditions frequently meet guidelines or reference values and the majority of critical habitats are intact.
B: Good	Conditions generally meet guidelines or reference values and most critical habitats are intact.
C: Moderate	Some conditions do not meet guidelines or reference values and critical habitats are usually impacted.
D: Poor	Conditions often do not meet guidelines or reference values and most critical habitats are impacted.
E: Very Poor	Most conditions do not meet guidelines or reference values and most critical habitats are severely impacted.

Table 8. Descriptions of the grades used to score indicators of habitat extent for freshwater and estuaries/coastal zones.

Grade	Definition
A: Very Good	Habitat extent is at or very close to pre-European levels (minimum or no change in habitat extent compared to pre-European levels).
B: Good	Habitat extent is close to pre-European levels (minimum change).
C: Moderate	Habitat extent is moderately departed from pre-European levels (moderate change).
D: Poor	Habitat extent is strongly departed from pre-European levels (strong change).
E: Very Poor	Habitat extent is severely departed from pre-European levels (severe change).

4.4 Overview of the method for scoring water quality

Report card scores for water quality are derived by comparing the medians of each water quality measure against guideline values (GV) found in the scheduled environmental protection policy water quality objectives. The appropriate GV is found by matching the geographical location of the monitoring site to the appropriate water type, desired ecosystem protection level, and flow regime (if applicable). The GV can change or be updated over time. When this occurs, the TWG and Partnership will need to decide when to change the GV used in the report card scoring process (as scores and grades derived using different GV may no longer be comparable over time, which impacts trends).

The Townsville Dry Tropics Repot Card uses the GV as the boundary between "Good" (B) and "Moderate" (C) water quality condition. For a water quality metric to be graded as "Good", the median (of the metric) should be compliant with its associated GV. This is consistent with the Mackay Whitsunday and Wet Tropics report cards. It is noted that other report cards use different scoring frameworks. For example, the Gladstone Healthy Harbour Partnership (GHHP) report card uses the GV as the boundary between Satisfactory (C) and Poor (D) bandwidths. This results in the water quality metrics for the GHHP report card being lower relative to the Mackay Whitsunday and Wet Tropics report cards. (GHHP also uses a different five band grading scheme with unequal bandwidths).

4.4.1 Explanation for the method of each scoring grade

The Pilot Report Card will employ the scoring methods below for calculating grades. The suitability of guideline values for the region and scoring methodologies are subject to review for future iterations of the Townsville Dry Tropics report cards.

The logic for the scoring process is as follows:

1. Determine if the median of the metric being scored is compliant with its guideline value (GV), and
2. If it is, then its score will either be within the "Good" or "Very Good" bandwidths. If it is not compliant, then the median will be scored within the "Moderate", "Poor" or "Very Poor" bandwidths.

4.4.1.1 Basis for scoring "Very Good"

If the median is equal or better than (≥) the GV and equal or more than 80% of the data are also ≥GV, then a condition assessment score of 90 is assigned (90 is the mid-point of the "Very Good" scoring band (81-100)).

In the past, the TWG considered other options, including a value at the bottom (81) or top (100) of scoring band. However this would decrease and increase aggregated scores and grades respectively. The TWG have been unable to develop a practical method to derive scores between 81 and 100 (instead of assigning a mid-point score of 90 for "Very Good"). Functioning ecosystems have to include some level of nutrients and sediment, so a method based simply upon reductions of these metrics to near zero concentrations is inappropriate (otherwise, distilled water could be considered as having ideal water quality). It is noted that a more nuanced scoring system for "Very Good" would likely be supported by the Independent Science Panel (ISP).

4.4.1.2 Basis for scoring "Good"

If the median is ≥GV, but less than (<) 80% of data values are ≥GV, the condition is considered "Good", and a score is calculated between 61 and <81. The condition score for "Good" (61 to <81) is determined by calculating the position (through linear interpolation) of the GV relative to the 50^{th} and 80^{th} percentiles of the data for that metric. Linear interpolation is used because the scoring bandwidths cover a linear range between 0 and 100 and the TWG has no basis for choosing an alternative method (although there is no *a priori* reason why the interpolation has to be linear).

4.4.1.3 Basis for scoring "Moderate, Poor and Very Poor"

Where the median is worse (non-compliant) with the GV, a score is calculated between 0 and <61. The score is based on a linear interpolation of the median relative to the GV and the Scaling Factor (SF). This method was used because the bandwidths for the scores cover a linear range between 0 and 100. Where the median is worse than the SF, a score of 0 is assigned.

4.4.1.4 Basis for designating the Scaling Factor (SF)

The SF for a metric is nominally defined as the 90^{th} (or 10^{th}) percentile. Ideally, it should be calculated from long-term monitoring data from the waterway being assessed. Alternatively, where long-term data sets are unavailable, the SF is derived from available data and then adjusted through expert opinion to produce a reasonable scoring range (from the GV to the SF). The same or similar SF should be used for waterways with the same or similar GVs. This enables grades to be compared between waterways. The SF should not be adjusted annually as more data is collected as then trends over time cannot be established. Instead, SFs should be reviewed periodically after multiple years of data collection. Some report cards use the term Worst Case Scenario rather than SF. However, SF is more appropriate description in this situation as the SF provides the lower boundary for the scores of “Moderate”, “Poor” and “Very Poor”. The upper boundary for these grades is the GV.

4.5 Confidence measures

The report card includes a qualitative confidence measure for each score. This is important so that readers know how accurate the score is likely to be. The confidence measure is provided by experts, which is the same method used by the Wet Tropics and Mackay-Whitsunday report card. The confidence measure is provided for each indicator in each reporting zone. There are currently five criteria used to provide an overall confidence score which are weighted according to their importance. A purpose of each criterion and their weighting are shown in Table 9. The confidence scores for each indicator category and index are scored from low (1) to very high (5) and displayed on the report card as shown in Table 10. The detailed methods for generating confidence scores are outlined on 53 and 54 in the Wet Tropics Methods document (Wet Tropics Healthy Waterways Partnership, 2018) and will be listed in the Dry Tropics method document (to be published).

Table 9. Confidence criterion, weighting and an explanation of the purpose of the criterion.

Criterion	Weighting	Purpose of criterion
Maturity of method	Weighted 0.36 so it does not outweigh the importance of the other criteria	To show the confidence that the method/s being used are tested and accepted broadly by the scientific community. Methods must be repeatable and well documented. Maturity of methodology is not a representation of the age of the method but the stage of development. It is expected that all methods used would be robust, repeatable and defendable.
Validation	Weighted 0.71 so it does not outweigh the importance of the representa-tiveness criteria.	To show the proximity of the indicator being measured to the indicators reported. The use of proxies is scored lower than direct measures. The reason for this criterion is to minimise compounded error.
Representa-tiveness	This criterion is considered most important so is weighted 2.	To show the confidence in the representativeness of monitoring/data to adequately report against relevant targets. This criterion takes in to consideration the spatial and temporal resolution of the data as well as the sample size.
Directness	Weighted 0.71 so it does not outweigh the importance of the representa-tiveness criteria.	This criterion is similar to “validation” but instead of looking at the proximity of the indicator, the criterion looks at the confidence in the relationship between the monitoring and the indicators being reported against.
Measured error	Weighted 0.71 so it does not outweigh the importance of the representa-tiveness criteria.	To incorporate uncertainty (as defined above) into the metric and use any quantitative data where it exists.

Table 10. Presentation of confidence scores in the report card.

Confidence scores	Display on report card
Very High (5)	●●●●●
High (4)	●●●●○
Moderate (3)	●●●○○
Low (2)	●●○○○
Very low (1)	●○○○○
No data	○○○○○

5 Dry Tropics Indicators

Indicators serve as proxies for ecosystem attributes of interest (Levin, et al., 2009). In a few instances, indicators simply track the abundance of a single species that is of ecological, social or economic importance (Levin, et al., 2009).

5.1 Approach to selecting indicators

5.1.1 Community and expert workshop

It is important that the report card is relevant to the community and stakeholders. To ensure this, at the September 2018 workshop (mentioned in section 2.5.1) all 34 attendees (experts and community members) listed potential indicators of each reporting component (Biodiversity, Water, Community and Economy) that were relevant to them. From the workshop, 81 potential indicators were proposed, with these indicators presented in Table 11. These were refined using the criteria outlined in section 5.1.3 to select indicators for the report card.

Table 11. List of potential indicators identified by workshop participants for each reporting component (Biodiversity, Water, Community and Water) and for gross pollutants (threat to biodiversity).

ES/EB	Potential indicator list from workshop
Biodiversity	Riparian extent
	Wetland plants (indicates change in hydrology)
	Mangrove cover/extent, species diversity
	Light penetration (Photic depth)
	Seagrass seeds, biomass abundance, meadow area, and species composition
	Coral reefs: disease, cover, larval connectivity, Crown of thorns starfish (CoTS), diversity of hard cover species
	Fish diversity and density, fishing pressure, fish kills
	Macroinvertebrates
	Birds (habitat indicator)
	Land cover (indicator of habitat and erosion)
	Weeds and pests (indicator of habitat condition)
	Aquatic plant biomass (indicator of eutrophication)
	Percent catchment developed
	Freshwater connectivity (no. barriers and height)
	Connectivity of green areas
	Environmental authorities with discharge license
	Actions for threatened species protection
	Marine megafauna: Turtle, dolphin, dugong

Gross pollutants (pressure to biodiversity)	Microplastic loads (indicator of reduced water quality, sewage/stormwater filtering and management)
	Policy change % plastic bags/containers
	Behaviour change % single use items
	Plastics containers and bags
	Landfill audits and recycling effort
	Cost of effort to remove litter and dump
	Impact to amenity value – land prices etc.
	Number of reported litter incidents
	Identify litter types that impact key values e.g. % plastics, % single use, % from land
	Perception of impact
	Number of organised clean ups and engagement
Water	Turbidity/Total suspended sediments (TSS)
	Dissolved inorganic nitrogen (DIN), Nitrogen (N), Ammonia/Ammonium ($NH_{3/4}$)
	Phosphorus (P)
	PFAS
	Groundwater use/volume
	Dissolved Metals and contaminants
	% imperviousness/disconnection
	Flow
	Temperature
	Electrical conductivity
	Endochrine disruptors
	Rainfall
	pH
	Water production / use per capita
	% Recycled water used
	Hydrocarbons in groundwater
	Source of fine sediment discharge in Cleveland Bay
	Water colour
	Sediment deposition in drains/waterways, volumes removed in clean outs
	Presence/absence of invasive species in waterways
	Volume of herbicides/contaminants sold in the region
	Flood frequency (indicates change in waterway)
Economy	Economic contribution of waterway dependent industries (tourism, fishing , recreation and ports)
	Value and jobs employed in tourism and fishing
	Value of resources associated with industries such as ports and fishing
	Economic values $ and non $
	Quality of life (e.g. income)
	Financial buffers of insurance
	Number of tourism businesses using environmental assets
Community	Use of areas/resources e.g. urban parkland/gardens on waterways, public spaces, outings to the Strand
	Recreational opportunities
	Environmental access
	Visitor satisfaction
	Social attitude to place
	Existence value of GBR
	Perceived quality of life
	Identity with Townsville
	Cultural connection
	Sense of place (PLAY SCORE)
	Likelihood of residents to recommend visiting here
	Non-dollar values
	Level of protection for local landscapes
	Safety of people (indicator of low lying areas)
	Traditional owner (TO) driven indicators need special consideration through TO Conversations
	Stewardship intentions and aspirations for stewardship

5.1.2 Literature search

A literature search was undertaken to identify indicators that are commonly used in other report cards, government reports or scientific research papers (both in Australia and overseas). The search was conducted to ensure that all indicators relevant to the Townsville Dry Tropics were considered (as some indicators may have been overlooked at the workshop).

Where possible it is beneficial that the Townsville Dry Tropics Report Card contains indicators that are the same or similar to indicators used by other programs and report cards. This allows for consistency between report cards and means a scoring method for the indicator may already be developed.

A total of 210 potential indicators of Biodiversity, Water, Community and Economy were identified from the literature. The 210 indicators were refined using the criteria outlined in section 5.1.3. The indicators that were identified from both the workshop and the literature were prioritised to be included in the Pilot Report Card or if not included, developed and included in subsequent report cards.

5.1.3 Selection criteria

The following criteria were used to guide the selection of indicators for the Dry Tropics:

- Must be scientifically proven links that the indicator reflects the health of a specific environmental or social and economic process
- Sensitive to change
- Follows the SMART criteria (specific, measurable, attainable (cost-effective), relevant to our catchment and time-bound (sensitive to short term changes))
- Signals can be measured in a simple, repeated and cost efficient way, and analysed in a way so that the results are scientifically robust, clearly understood, unambiguous and easily repeatable
- Links with management objectives and actions (i.e. indicator can be influenced by management practices)
- Aligns with the WQIP
- Aligns with the Reef 2050 Plan
- Representative of the community values in the region
- Easily communicated and understood by stakeholders, management and the community (audience of the report card)
- Clearly linked to an objective of the report card
- Can be used to provide a report card score

The selection of indicators was also based on the availability of data (or whether it would be available within the next few years) and whether guideline values existed (or could be developed) for relevant indicators.

5.1.4 Link between the modified framework and indicators

It is important that the chosen indicators align with the modified framework. The alignment of indicators with the modified framework is shown in Figure 12. Multiple indicators are used to report on the state, drivers and pressures for each of the four reporting components (Biodiversity, Water, Community and Economy). Where indicators align with the modified framework as presented in Figure 12.

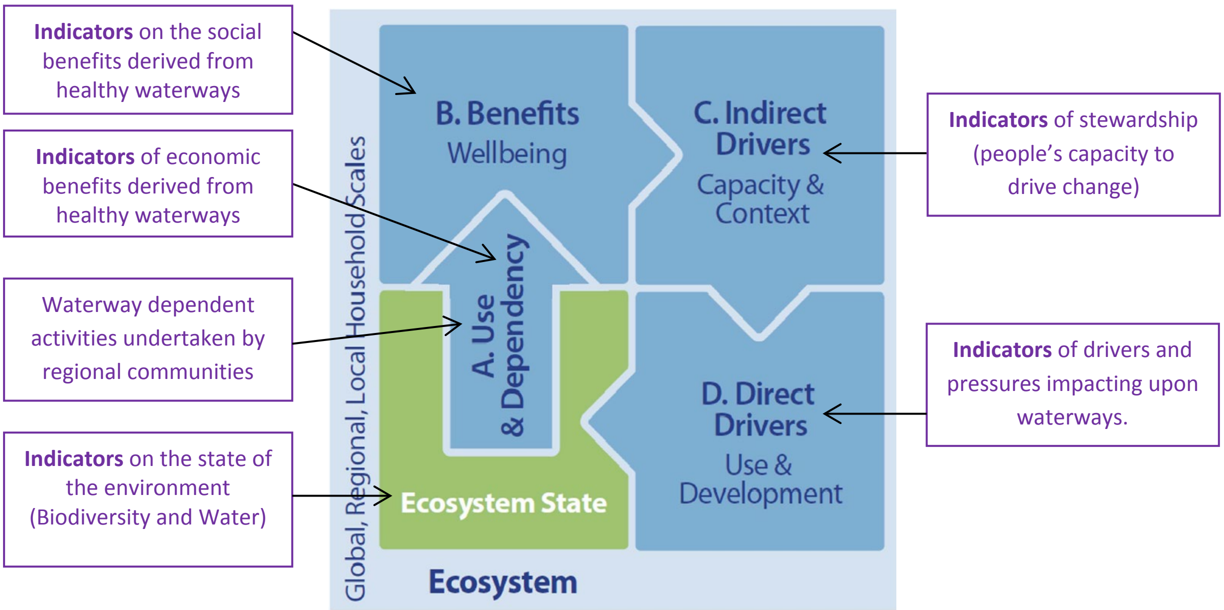

Figure 12. Representation of where indicators align within the modified framework.

Note: The activities undertaken by communities are presented as contextual information, as resource use cannot be scored. Source: Adapted from Marshall, et al., 2016.

5.2 Indicators for the report card

The environmental indicators with available data were compared to the list of appropriate indicators for the Townsville Dry Tropics Report Card. If an indicator had available data and appropriate for the Townsville Dry Tropics, a benchmark and a scoring metric was established using the methods outlined in section 4.

Some indicators were identified as a priority, but a score cannot yet be computed due to either a lack of data or the indicator scoring method has not been developed. The aim is to progress data collection and indicator development to provide scores for the indicators identified in Table 12, Table 14, Table 17 and Table 19 (in sections 5.4, 5.5, 5.6 and 5.7).

5.3 Rules for inclusion

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 (as shown in section 4.2) to visually show which components contribute to the overall grade. There is currently no rule for how many indices are required before generating into an overall grade. This will be revised and a method devised if necessary.

5.4 Indicators of Biodiversity

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

- Flora and fauna, artificial barriers and gross pollutants for the two freshwater and estuarine/coastal zones
- Flora and fauna and gross pollutants for the two inshore marine zones and one marine offshore zone.

The indices of artificial barriers and gross pollutants comprise pressure indicators, whilst Habitat comprises state and pressure indicators, and Fauna comprises state indicators. The indices, indicator categories and indicators for the pilot report, future reports and 'aspirational' indicators are shown in Table 12. Indicators to be developed for future reports are defined as indicators where there is data or a scoring method available (but not both). Aspirational indicators are those that have been identified as important to the region but no data is available and it is unlikely data will become available within the next three years. For most of aspiration indicators there is also no method to score the indicator. In order to report on aspirational indicators, monitoring programs would need to be expanded or developed for the Dry Tropics region and in most instances methods would need to be developed to score the indicators. The explanations for selecting each indicator category are provided in Table 13.

It is noted that some indicators, including riparian, wetland, saltmarsh and mangrove extent, are not assessed annually due to monitoring timeframes. These indicators are still included in each report card, with the indicator having a constant score over multiple years. The limitations of the accuracy of non-annual data sets will be acknowledged in the report card (e.g. riparian habitat can change annually but is only monitored once every four years).

Table 12. Indicators used to determine the score for Biodiversity for the freshwater, estuarine/coastal and inshore and offshore marine zones. The frequency of sampling and reporting is also shown. Aspirational indicators are those that have been identified as important to the region but no data is available and it is unlikely data will become available within the next three years. For most of aspiration indicators there is also no method to score the indicator.

Zone	Index	Indicator category	Indicator	Sampling frequency	Frequency of reporting	Included in pilot report?
Freshwater	Flora & fauna	Riparian vegetation	Change in riparian extent from pre-European levels	4 yearly	4 yearly	Yes
			Riparian condition	TBC	TBC	No (aspirational)
		Wetlands	Change in wetland extent from pre-European levels	4 yearly	4 yearly	Yes
			Wetland condition	TBC	TBC	No (aspirational)
		Fauna	Birds	Annually	Annually	No (aspirational)
			Macroinvertebrates	TBC	TBC	No (aspirational)
			Fish	TBC	TBC	No (aspirational)
	Artificial barriers	Fish barriers	Barrier transparency, barrier density and barrier location	4 yearly	4 yearly	No (future reports)
		Impoundment length	Impoundment length	4 yearly	4 yearly	No (future reports)
	Gross pollutants	Plastic fragments^	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
		Plastic bottles	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
		Straws and plastic cutlery	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
		Plastic bags	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
		Cigarette butts	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
		Total rubbish (excluding previous categories)	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
Estuarine/coastal	Flora & fauna	Saltmarsh	Change in saltmarsh extent from pre-European levels	4 yearly	4 yearly	Yes
			Saltmarsh condition	TBC	TBC	No (aspirational)
		Mangroves	Change in mangrove extent from pre-European levels	4 yearly	4 yearly	Yes
			Mangrove condition	TBC	TBC	No (aspirational)
		Fauna	Birds (non-migratory species)	Weekly to monthly	Annually	No (future reports)
			Fish	TBC	TBC	No (aspirational)
	Artificial barriers	Fish barriers	Barrier transparency, barrier density and barrier location	4 yearly	4 yearly	No (future reports)
	Gross pollutants	Plastic fragments	No. of items/weight per unit effort	Annually	Annually	No (future reports)
		Plastic bottles	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
		Straws and plastic cutlery	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
		Plastic	No. of items/weight per unit effort	Annually	Annually	No (future reports)
		Cigarette butts	No. of items/weight per unit effort	Annually	Annually	No (future reports)
		Total rubbish (excluding previous categories)	No. of items/weight per unit effort	Annually	Annually	No (future reports)

Inshore marine	Flora & fauna	Coral	Composition	Biannually*	Annually*	Yes
			Change in cover	Biannually*	Annually*	Yes
			Juvenile density	Biannually*	Annually*	Yes
			Macroalgae cover	Biannually*	Annually*	Yes
			Cover	Biannually*	Annually*	Yes
		Seagrass	Area/Abundance (% cover/biomass)	Annually	Annually	Yes (area reported upon)
			Reproduction	Annually	Annually	No (future reports)
			Tissue nutrient status	Annually	Annually	No (future reports)
			Meadow area	Annually	Annually	Yes
			Species composition	Annually	Annually	Yes
		Fauna	Dolphins	TBC	TBC	No (aspirational)
			Dugongs	TBC	TBC	No (aspirational)
			Turtles	TBC	TBC	No (aspirational)
			Fish	TBC	TBC	No (aspirational)
	Gross pollutants	Plastic fragments	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
		Plastic bottles	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
		Straws and plastic cutlery	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
		Plastic bags	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
		Cigarette butts	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
		Total rubbish (excluding previous categories)	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
Offshore marine	Flora & fauna	Coral	Change in cover	Biannually*	Annually*	Yes
			Juvenile density	Biannually*	Annually*	Yes
			Cover	Biannually*	Annually*	Yes
		Fish	Species diversity	TBC	TBC	No (aspirational)
	Gross pollutants	Plastic fragments	No. of items/weight per unit effort	TBC	TBC	No (aspirational)
		Plastic bottles	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
		Straws and plastic cutlery	No. of items/weight per unit effort	Annually	Annually	No (aspirational)
		Plastic bags	No. of items/weight per unit effort	TBC	TBC	No (aspirational)
		Cigarette butts	No. of items/weight per unit effort	TBC	TBC	No (aspirational)
		Total rubbish (excluding previous categories)	No. of items/weight per unit effort	TBC	TBC	No (aspirational)

^Note indicator categories are indicative only and will be confirmed once there is a confirmed method for scoring the indicators.

*Each AIMS coral survey site is monitored every two years, with monitoring of sites alternating between the years. Coral condition is reported as a two-year rolling mean based on the most recent data for all sites.

Table 13. Explanation of the links between indicator categories for Biodiversity and the health of waterways.

Zone	Indicator category	Link between indicator and waterway ecosystem health
Freshwater	Riparian vegetation, Wetlands	Riparian vegetation and wetlands help maintain water quality by filtering or retaining/ transforming nutrients, sediments and pollutants, slowing the rate of water flow and stabilising river banks (Lukacs, 1996). They also facilitate groundwater recharge and provide important habitats for many species (Lukacs, 1996; Oeding, et al., 2018).
	Weeds	Weeds can reduce channel capacity, increase flooding and erosion in adjacent areas, decrease water quality and compete with native species (Department of Primary Industries, n.d.).
	Macroinvertebrates	Previous studies (e.g. (Sharley, et al., 2008; Townsend, et al., 2009; Holt & Miller, 2010) have determined that macroinvertebrate communities can be good indicators of water quality. They are commonly used ecological indicators in Australia (Sharley, et al., 2008; Townsend, et al., 2009) and overseas (Holt & Miller, 2010). Macroinvertebrates respond to different stressors and disturbances, including the presence of fine sediment, metals, nutrients, and hydrologic alterations (Sharley, et al., 2008; Townsend, et al., 2009; Holt & Miller, 2010).
	Fish barriers, Impoundment length	Man-made barriers, including dams, weirs, flow gauging stations and culverts, can restrict the movement of aquatic species (Department of Water and Environmental Regulation, 2017). This may result in increased competition between individuals for food and habitat, increased predation pressure and the interruption of natural breeding/spawning cycles (Fairfull & Witheridge, 2003). Barriers can also restrict the movement of organic material, reduce water flow and water depth and decrease the water available to downstream habitats (Department of Water and Environmental Regulation, 2017).
Estuary/ coastal	Artificial barriers	
	Saltmarsh	Saltmarshes assist in maintaining water quality by filtering and settling pollutants (including nutrients and sediment) and reducing erosion and flood risk (Daly, 2013). Additionally they provide habitat and food for species and act as a carbon sink (Daly, 2013).
	Mangroves	Mangroves filter land runoff, which helps to improve the quality of water discharging into the ocean (Goudkamp & Chin, 2006). They also buffer the coastline from storms and cyclones (Goudkamp & Chin, 2006) and provide crucial habitat for many fish species (Department of Fisheries, 2012).
Inshore marine	Seagrass	Seagrass provides food and habitat for marine species, including fish, dugongs and turtles (Australian Institute of Marine Science (AIMS), n.d.). Additionally, seagrass meadows reduce wave energy and trap sediments (AIMS, n.d.). This reduces the amount of sediment settling on corals, helps to stabilise the ocean floor and improves water quality (AIMS, n.d.).
Inshore & offshore marine	Coral	Coral reefs provide habitats for many marine organisms and are the spawning grounds for many fish species (Queensland Museum, n.d.). Corals also help with nutrient cycling, assist in carbon and nitrogen fixing and protect coastlines from the damaging effects of wave action and tropical storms (Queensland Museum, n.d.).
All zones	Megafauna: Birds, dolphins, dugongs, turtles	Previous research has found that birds can indicate the condition of riparian ecosystems (Bryce, et al., 2002), terrestrial wetlands (Paillisson, et al., 2002; Deluca, et al., 2004), marine ecosystems (Sydeman, et al., 2007) and urban areas (Reynaud & Thioulouse, 2000; Bellocq, et al., 2016). Birds also respond to disturbances, including urban expansion (Lee *et al.* 2005), changes in hydrological regimes (Paillisson, et al., 2002; Desgranges, et al., 2006) and eutrophication (Fernandez *et al.* 2005). They can also indicate the presence of containments such as pesticides (Furness, 1993), heavy metals (Zhang & zhang Ma, 2011; Ishii, et al., 2017), oil and plastic particles (Tasker & Furness, 2003). Marine megafauna, including dolphins, dugongs and turtles, are important to monitor as they are easily recognised species that may help to gain public attention and community support toward broader conservation objectives (Ford, et al., 2017). Some studies indicate that megafauna, such as dolphins, have the potential to provide an indication of the status of other aquatic biota (Turvey, et al., 2012). However, often conservation strategies directed at protecting megafauna may be inadequate for protecting other species and thus it is important to ensure that other species, not only megafauna, are protected (Ford, et al., 2017).
	Gross pollutants	Animals, including birds, mammals, fish, can become entangled in debris (Page, et al., 2004; Boren, et al., 2006; Gregory, 2009) or ingest debris (Verlis, et al., 2013; Gregory, 2009). This can cause death by starvation or result in debilitation, leading to a reduced quality of life and lowered reproductive performance (Gregory, 2009). Containers, plastic bags and cigarette butts were chosen because these rubbish items are linked with management actions (implementation of container deposit scheme, plastic bag ban and smoking bans). Since some rubbish may be coming from overseas, if possible, the origin of the rubbish collected will be identified. Tracking changes in the quantity of rubbish within each of these categories will give an indication of whether management actions have helped to reduce rubbish within regional waterways. Plastic fragments were chosen due to the risk they pose to animals (through ingestion).
	Fish	A study evaluating fish assemblages as indicators within estuaries along the east coast of Australia found that fish may be a viable indicator if changes in fish assemblage are measured at a site year on year (Sheaves, et al., 2012).

5.5 Indicators of Water

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

- Hydrology, nutrients, Physical and chemical (Phys-chem.) properties and contaminants for the two freshwater and two estuarine/coastal zones
- Hydrology, nutrients and contaminants for the two inshore marine zones
- Phys-chem. properties for the one offshore marine zone.

For Water, groundwater is also included as a separate zone, with the indices Hydrology and Contaminants being measured.

The indices, indicator categories and indicators for the pilot and future reports and aspirational indicators are shown in Table 14. The explanations for selecting each indicator category are provided in Table 15.

Table 14. Indicators used to determine the score of Water for the freshwater, estuarine/coastal and inshore and offshore marine zones. The frequency of sampling and reporting is also shown. Aspirational indicators are those that have been identified as important to the region but no data is available and it is unlikely data will become available within the next three years. For most of aspiration indicators there is also no method to score the indicator.

Zone	Index	Indicator category	Indicator	Sampling frequency	Frequency of reporting	Included in Pilot Report Card
Freshwater	Hydrology	% catchment impervious/developed	% catchment impervious/developed	TBC	TBC	No (future reports)
		% native land cover	% native land cover	TBC	TBC	No (future reports)
		Flow	Flow rate	TBC	TBC	No (future reports)
	Nutrients	Phosphorus (P)	Total phosphorus (P) or dissolved inorganic phosphorus/ filterable reactive phosphorus (FRP)	Monthly	Annually	Yes
		Dissolved inorganic nitrogen (DIN)	Oxidised nitrogen (NOx) and Ammonia as N	Monthly	Annually	Yes
	Phys-chem.	Dissolved Oxygen (DO)	Dissolved Oxygen (DO)	Monthly	Annually	Yes
		Turbidity	Turbidity	Monthly	Annually	Yes
		pH	pH	Monthly	Annually	No (future reports)
	Contam-inants	Pesticides	Concentration of 22 pesticides	TBC	TBC	No (aspirational)
		Metals	Concentration of metals	TBC	TBC	No (aspirational)
		PFAS (Per- and poly-fluoroalkyl substances)	Concentration of PFAS (Per- and poly-fluoroalkyl substances)	TBC	TBC	No (aspirational)
Estuary/coast	Hydrology	% catchment impervious/ developed	% catchment impervious/developed	TBC	TBC	No (future reports)
		% native land cover	% native land cover	TBC	TBC	No (future reports)
		Flow	Flow	TBC	TBC	No (future reports)
	Nutrients	Phosphorus (P)	Total phosphorus (P) or dissolved inorganic phosphorus/FRP	Monthly	Annually	Yes
		Dissolved inorganic nitrogen (DIN)	Oxidised nitrogen (NOx) and Ammonia as N	Monthly	Annually	Yes
		Particulate nitrogen (PN)	Particulate nitrogen (PN)	Monthly	Annually	Yes
	Phys-chem.	Dissolved Oxygen (DO)	Dissolved Oxygen (DO)	Monthly	Annually	Yes
		Turbidity	Turbidity	Monthly	Annually	Yes
		pH	pH	Monthly	Annually	No (future reports)
	Contam-inants	Pesticides	Concentration of 22 pesticides	TBC	TBC	No (aspirational)
		Metals	Concentration of metals	TBC	TBC	No (aspirational)
Inshore marine	Nutrients	Phosphorus	Total Phosphorus (P) or particulate Phosphorus (PP)	Monthly	Annually	Yes
		Oxidised nitrogen (NOx)	Oxidised nitrogen (NOx)	9 times over 6-7 months	Annually	Yes
		Particulate Nitrogen (PN)	Particulate Nitrogen (PN)	9 times over 6-7 months	Annually	Yes
	Phys-chem.	Total suspended solids (TSS)	TSS	9 times over 6-7 months	Annually	Yes
		Turbidity	Turbidity	Continuous, hourly reads	Annually	Yes
		Secchi depth	Secchi depth	9 times over 6-7 months	Annually	Yes
		Temperature	Temperature	TBC	Annually	No (future reports)
		pH	pH	TBC	Annually	No (future reports)

	Chlorophyll *a*	Chlorophyll *a*	Chlorophyll *a*	Continuous, hourly reads	Annually	Yes
	Contaminants	Metals	Concentration of metals	TBC	TBC	No (future reports)
Offshore marine	Phys-chem.	Turbidity/TSS	Turbidity/TSS	TBC	TBC	No (aspirational)
		Temperature	Temperature	TBC	Annually	No (future reports)
	Chlorophyll *a*	Chlorophyll *a*	Chlorophyll *a*	TBC	TBC	No (aspirational)
Ground water	Hydrology	Quantity/recharge rates	Quantity/recharge rates	TBC	TBC	No (aspirational)
	Contaminants	Salinity/electrical conductivity (EC)	Salinity/Conductivity	TBC	TBC	No (aspirational)
			Common ion analysis when significant change (±) in EC	TBC	TBC	No (aspirational)

Table 15. Explanation of the links between the indicator categories for Water and the health of waterways.

Zone	Indicator	Link between indicator and waterway ecosystem health
Freshwater & groundwater	PFAS (Per- and poly-fluoroalkyl substances)	At sufficient concentrations, PFAS are harmful to humans (Post, et al., 2017) and the aquatic ecosystem (Ahrens & Bundschuh, 2014). They are water soluble and do not break down in the environment, with concentrations accumulating over time (Post, et al., 2017). The indicator category is included as a pollutant of water quality.
Freshwater & estuary/coast	% catchment impervious/developed	Catchment imperviousness impacts upon receiving waters (Walsh, 2000) and is a measure of urban density (Walsh, et al., 2002).Catchment impervious reduces water infiltration, with most water becoming surface water flows (Miller, et al., 2014). This increases the amount of water flowing in rivers and increase the risk of flooding, the peak flows within rivers, flood duration and response time (flooding continues after the rainfall has subsided) (Miller, et al., 2014). Storm water conveyance systems in particular can significantly increase the severity and duration of flooding (Miller, et al., 2014).
	% native land cover	"Land cover and land use changes, including the modification of the type or amount of surface vegetation, the permeability of soil and other surfaces, can substantially alter hydrologic environmental services and the availability and quality of water (Kepner, et al., 2012; Wagner, et al., 2013).
	Flow	Measuring water flow is important due to its impact on water quality and on the living organisms and habitats in the stream (United States Environmental Protection Agency (US EPA), 2012). Large, swiftly flowing rivers can receive pollution discharges and be little affected if pollution sources are sufficiently low concentrations, whereas small streams have less capacity to dilute and degrade wastes (US EPA, 2012). Flow rates also determines the kinds of organisms that can live in the stream, with some species requiring fast-flowing areas, whilst other require slow flowing streams (US EPA, 2012). Additionally, it also affects the amount of silt and sediment carried by the stream, with sediment introduced to slow-flowing streams able to settle, whilst in faster flowing streams sediment will be suspended for longer in the water column (US EPA, 2012). Flow also impacts the level of dissolved oxygen (DO) and fast-moving streams generally have higher levels of DO than slow flowing streams (US EPA, 2012).
	Concentration of pesticides	Pesticides released into the environment may pose both ecological and human health risks and therefore are an important parameter to measure (Knauer, 2016). Pesticides include herbicides (weeds), insecticides (insects), fungicides (fungi), nematocides (nematodes), and rodenticides (vertebrate poisons) (Ongley, 1996). Pesticides can be toxic to organisms, causing death or long-term health impacts, including reproductive failure, birth defects, growth inhibition, cancers or tumours (Ongley, 1996).
	Dissolved Oxygen (DO)	Dissolved oxygen is crucial for most aquatic organisms, with a lack of oxygen potentially resulting in death of individuals, reduction in growth, impacts on recruitment and changes in behaviours and/or habitat use (Franklin, 2014). Pesticides can have impact on levels of biological organisation, including primary producers, microorganisms, invertebrates and vertebrates (Schäfer, et al., 2011).
Freshwater, estuary/coast & inshore	Phosphorus (P)	Phosphorous is an important indicator of water quality to monitor, as excessive quantities of phosphorus can lead to water quality problems such as eutrophication and harmful algal growth and blooms (United States Environmental Protection Agency (US EPA), 2017). Phosphorus generally occurs in small quantities in the natural environment and even small increases can negatively affect water quality and biological condition (US EPS, 2017).

marine	Dissolved inorganic nitrogen (DIN)	Dissolved inorganic nitrogen can be carried further offshore than particulate nutrients and thus can be a substantial pollutant for offshore marine life, including corals (Reef & Rainforest Research Centre, n.d.). High concentrations of nutrients promote algal growth (De'ath & Fabricius, 2010). Excessive amounts of algae are detrimental to reefs as algae can combine with sediment and create a plume that can smother corals and seagrass meadows (Brodie, et al., 2012). High nitrogen concentrations can increase the susceptibility of when corals are exposed to high temperatures (Wooldridge, 2009).
	Metals	At high concentrations, metals, especially heavy metals, can be severely toxic to aquatic organisms (Govind & Madhuri, 2014). Metals can also accumulate in organisms, which can result in animals higher up the food chain accumulating metals (Govind & Madhuri, 2014).
Freshwater, estuary/coast & inshore & offshore marine	pH	"The pH of a waterbody reflects its water inputs and the chemical characteristics of the surrounding land. The pH of runoff from the land, or of groundwater inputs to surface water, is affected by the type of minerals and soils the water contacts as it moves through the land. Water pH affects both biological and chemical processes (Alberta Environment and Parks, n.d.). The pH levels of most natural waters are between 6.0 and 8.5, with most aquatic organisms requiring pH to be within a particular range. "If water is too alkaline or too acidic the physiological processes of an organism may be disrupted" (Environment Protection Authority (EPA) Victoria, 2017), including reproduction. Values below 4.5 and above 9.5 usually lethal to aquatic organisms (Alberta Environment and Parks, n.d.). "The pH also affects the solubility of organic compounds, metals, and salts. For example, in highly acidic waters, certain minerals can dissolve and release metals and other chemical substances into the water" (Alberta Environment and Parks, n.d.). This results in these metal toxicants being more available for plants and animals to take up and accumulate, which can lead to severe ecosystem impacts" (EPA Victoria, 2017). The pH of an ocean is also important, as ocean acidification can result in a reduction in the amount of calcium carbonate minerals within the ocean (National Oceanic and Atmospheric Administration, 2018). This can affect the ability of some calcifying organisms to produce and maintain their shells (National Oceanic and Atmospheric Administration, 2018).
	Temperature	Water temperature is one of the most important characteristics of an aquatic system, as it affects many processes including dissolved oxygen, chemical and biological processes and species composition of aquatic ecosystems (Regional Aquatics Monitoring Program, 2018). Human activities affecting water temperature can include the discharge of cooling water or heated industrial effluents, agriculture and forest harvesting (due to effects on shading), urban development that alters the characteristics and path of stormwater runoff, and climate change (Regional Aquatics Monitoring Program, 2018).
	Turbidity and total suspended solids (TSS)	Suspended sediment/turbidity is a highly important cause of water quality decline and can result in substantial degradation to aquatic ecosystems, aesthetic issues, higher costs of water treatment and impact upon fisheries (Brazier & Bilotta, 2008). Suspended particles diffuse sunlight and absorb heat, which can increase the water temperature and reduce the amount of light that is available for photosynthesis (The Clean Water Team: California Water Boards, 2010). Aquatic organisms are impacted by both the concentration of suspended sediments and the duration of exposure (Newcombe & Macdonald, 1991). For example, sedimentation on coral reefs may smother coral polyps, inhibiting photosynthetic production and increasing respiration (Erftemeijer, et al., 2012). Increasing respiration levels is energetically expensive and can result in growth inhibition and a reduction in other metabolic processes (Erftemeijer, et al., 2012). At sufficient concentrations, sedimentation may also reduce recruitment rates, the abundance and diversity of corals and other reef fauna, including fish, decrease live coral cover and cause changes in the relative abundance of species (Erftemeijer, et al., 2012).
Inshore & offshore marine	Chlorophyll *a*	The concentration of chlorophyll is a proxy for the amount of photosynthetic plankton, or phytoplankton, present in the ocean (US Global Change Research Program, n.d.), with excessive chlorophyll a leading to harmful algal blooms and eutrophication, especially in enclosed coastal waters (United States Environmental Protection Agency (US EPA), 2016).
Groundwater	Salinity/ electrical conductivity (EC)	Saltwater intrusion into freshwater environments, including in groundwater, can result in substantial ecological and morphological changes in freshwater habitats (Department of the Environment and Energy (DEE), 2004). Saltwater intrusion leads to the loss of freshwater vegetation and may result in the spread of saline mudflats (in wet areas) or barren landscapes (in dry areas). This reduces the diversity of fauna and flora within the area (DEE, 2004). A change in freshwater groundwater systems can be due to changes in recharge (Şen, 2015). For example, a change in precipitation or evapotranspiration during the major recharge season (wet season) can influence recharge rates (Şen, 2015), with high recharge resulting in lower EC. A shallow water table can result in salts accumulating near the soil surface (Rengasamy, 2006). In Australia, provided the water table was 4 m below the surface, saline groundwater generally does not affect native vegetation and some species could cope with shallower water tables (Rengasamy, 2006).
	Quantity/ recharge rates	Groundwater is a highly important source of water, especially in semi-arid and arid zones (National Water Commission, 2012). Recharge rates are impacted by human activities, with built up and paved areas promoting runoff and inhibiting groundwater recharge (Alley, 2009). An over-extraction of groundwater can result in aquifers becoming depleted, which an impact upon ecosystems (and industries) dependent upon them (National Water Commission, 2012). For example, a lack of groundwater can result in ecosystems that depend upon groundwater inputs, such as wetlands, drying out (National Water Commission, 2012). River flows can also be reduced if the river depends on flows from shallow groundwater (National Water Commission, 2012).

5.6 Indicators of Community

The score for Community is based on indicators that are grouped into five indicator categories, which are:

- Value of waterways
- Wellbeing from waterways
- Perception of waterway management
- Perception of environmental condition
- Community Stewardship

These five indicator categories are grouped into three indices, which are:

- Value and wellbeing from waterways
- Perception of waterways
- Community stewardship

All indicator categories are scored for each zone. The explanations for selecting each index are provided in Table 16. The indices, indicator categories and indicators (survey questions) for the pilot report, future reports and 'Aspirational' indicators (developed last) are presented in Table 17. It is aimed that Indigenous cultural values and perceptions will be included in the reporting. However, due to financial and time constraints this is an aspirational aim.

Table 16. Explanation of how each index indicates a benefit to the Community of the Townsville Dry Tropics region.

Index	Link between indicator and waterway ecosystem health
Value and wellbeing from waterways	"Understanding the human dimension of [waterways], including how people, industries and communities interact in it, value it, perceive it, and respond to environmental and societal changes, is essential for long-term planning, and for evaluating the outcomes of management decisions" (Marshall, et al., 2014). "Human and community wellbeing are becoming increasingly important in the management of natural resources" (Marshall, et al., 2014). The perceived health of and threats to the environment (e.g. Reef) impacts upon a person's wellbeing and is thus an important social measure (Marshall, et al., 2014).
Perception of waterways	Community perception of waterways is important for informing waterway management (Department of Environment and Primary Industries, 2013). The perception of environmental condition has an important influence on a person's feelings of security and wellbeing (Marshall, et al., 2014).
Community Stewardship	Stewardship can benefit the environment and also support management decisions (Bennett, et al., 2018). Stewardship that has environmental objectives is often directly linked to or associated with social, cultural or economic benefits (Bennett, et al., 2018).

Table 17. Indicators used to determine the score of Community for the freshwater, estuarine/coastal and inshore and offshore marine zones. 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 that are not included in the Pilot Report Card are aspirational and indicative only and are subject to change. Questions will be tailored so scores can be produced for each zone. The frequency of sampling has not been determined and therefore is not included within this table.

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 waterways	Values of waterways	I value our beaches and estuaries because they support 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
		Wellbeing from 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
			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
			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 inshore marine zone(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
	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

5.7 Indicators of Economy

For each reporting zone the score for Economy is based on indicators that are grouped into the two indices:

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

The two indices are scores for each zone. The explanations for selecting each index are provided in Table 18. The indices, indicator categories, indicators and sub-indicators (survey questions) for the pilot and future reports and aspirational indicators, are shown in Table 19. The survey questions relating to industry stewardship currently only consider two industries, commercial fishing and tourism.

At present, economic data is based solely on responses to survey questions. It is aimed that in future reports, indicators will be developed to directly measure economic values (e.g. waterfront house prices. compared to non-waterfront house prices within close proximity to each other). However, at present, data, monetary and time limitations mean that surveys will continue to be used, as a method has already been established and data is available.

Table 18. Explanation of how each index represents a benefit to the economy.

Index	Link between indicator and waterway ecosystem health
Non-monetary economic values	The community can derive many economic opportunities from healthy functioning ecosystems and how they value these opportunities may change over time. An understanding of how the community values these opportunities can assist decision makers in monitoring public support of the management of natural resources (Marshall, et al., 2016).
Industry sustainability (Ecological and Economic)	The economic sustainability of some industries depends on waterway health (Cesar, 2003). Monitoring the direct and indirect pressures these industries exert on the environment provides an insight into their ecological sustainability. Assessing the relative benefits these industries provide in terms of revenue and employment opportunities indicates the ongoing viability and sustainability of the industry (Millenium Ecosystem Assessment, 2005)

Table 19. Indicator categories and indicators used to determine the score of Economy for the freshwater, estuarine/coastal and inshore and offshore marine zones. The postcodes of survey respondents that were used to generate the score for each zone are also shown. The frequency of sampling has not been determined and therefore is not included within this table.

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

	Industry Sustainability	Ecological sustainability	I always consider the environmental impact of the production process for goods and services that my business uses	TBD	No (future reports)
			I usually make any extra effort to reduce the waste my business generates	TBD	No (future reports)
			My business re-uses or recycles most goods and waste	TBD	No (future reports)
		Economic sustainability	How long have you been involved in the GBR tourism industry?	TBD	No (future reports)
			How long has your current business been operating?	TBD	No (future reports)
			What proportion of your household income came from tourism in the last financial year?	TBD	No (future reports)
			How many employees (FTE) did your operation employ over the previous 12 months	TBD	No (future reports)
			Do you have insurance for your business assets?	TBD	No (future reports)
			Could you please indicate (approximately) your business turnover (entire revenue) for the past 12 months, in broad categories?	TBD	No (future reports)
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 (future reports)
			Does your operation use Carbon offsets to counter emissions	4 years	No (future reports)
			Does your operation have green energy, such as solar panels, for your vessel	4 years	No (future reports)
			Does your operation participate in industry best practices via a code of practice, or memorandum of understanding (MOU)	4 years	No (future reports)
			Does your operation use alternative fuels such as biodiesel and ethanol	4 years	No (future reports)
			Does your operation employ formally trained guides providing interpretation about the Reef	4 years	No (future reports)
			I am optimistic about the future of my business in the GBR	4 years	No (future reports)
			My business has performed this year as well as last year	4 years	No (future reports)
		Economic sustainability	Does your operation use an emissions calculator to plan your business operations	4 years	No (future reports)
			How many employees (FTE) did your operation employ over the previous 12 months	4 years	No (future reports)
			Do you have insurance for your business assets?	4 years	No (future reports)
			Could you please indicate (approximately) your business turnover (entire revenue) for the past 12 months, in broad categories?	4 years	No (future reports)
			I am optimistic about the future of my business in the GBR	4 years	No (future reports)
			My business has performed this year as well as last year	4 years	No (future reports)

5.8 Alignment of indicators with report card objectives

It is important to ensure that the indicator categories align with the objectives of the report card. The objectives that each indicator category aligns with are presented in Table 20.

Table 20. Alignment of indicators selected for the Pilot Report Card with the objectives of the report card. BO, WO, CO and EO stands for biodiversity, water, community and economic objectives respectively. The number corresponding to each objective is the order they are listed in the report card objectives section.

Objectives (keywords)	Indicators categories	Objective that each indicator category aligns with
Biodiversity objectives: • change in habitat over time (BO 1) • change in fauna over time (BO 2) • state of habitat and fauna against progress targets (BO 3) • pressures to biodiversity, including the quantity of gross pollutants (BO 4)	Riparian vegetation	BO 1 & 3
	Wetland vegetation	BO 1 & 3
	Weeds	BO 1, 3 & 4
	Birds	BO 2 & 3
	Macroinvertebrates	BO 2 & 3
	Fish	BO 2 & 3
	Fish barriers	BO 4
	Impoundment length	BO 4
	Plastic fragments	BO 4
	Containers (from container deposit scheme)	BO 4
	Plastic bags	BO 4
	Cigarette butts	BO 4
	Total rubbish (excluding previous categories)	BO 4
	Saltmarsh	BO 1 & 3
	Mangroves	BO 1 & 3
	Coral	BO 1 & 3
	Seagrass	BO 1 & 3
	Megafauna	BO 2 & 3
Water objectives: • quality of water against agreed benchmarks to track changes over time (WO 1) • quality of water against progress targets (WO 2) • pollutants (WO 3) • water quantity (WO 4) • pressures upon water quality and quantity (WO 5)	% catchment impervious/developed	WO 4 & 5
	% catchment native cover	WO 4 & 5
	Phosphorus (P)	WO 1, 2, 3 & 5
	Dissolved inorganic nitrogen (DIN)	WO 1, 2, 3 & 5
	Turbidity	WO 1, 2, 3 & 5
	pH	WO 1, 2, 3 & 5
	Concentration of pesticides	WO 1, 2, 3 & 5
	Metals	WO 1, 2, 3 & 5
	PFAS (Per- and poly-fluoroalkyl substances)	WO 1, 2, 3 & 5
	Chlorophyll *a*	WO 1, 2, 3 & 5
	Salinity (for groundwater)	WO 1, 2, 3 & 5
	Quantity/recharge rates	WO 4 & 5
Community objectives: • trends in the value of waterways (CO 1) • trends in the wellbeing of waterways (CO 2) • trends in the perception of management and environmental condition (CO3) • cultural importance (CO4) • stewardship and capacity of the community (CO 5)	Values of waterways	CO 1 & 3
	Wellbeing from waterways	CO 1, 2 & 3
	Perception of management of waterways	CO 2
	Perception of environmental condition	CO 1 & 2
	Community Stewardship	CO 1, 4 & 5
Economic objectives: • report on the direct economic benefits of industries (EO1) • assess how the community values the economic opportunities provided by waterways (EO 2)	Tourism attraction value	EO 2
	Science and education value	EO 2
	Fresh local seafood	EO 2
	Perception of economic value	EO 2
	Ecological sustainability	EO 1, 2 & 3

• assess the ecological and economic sustainability of industries dependent on healthy waterways (EO3)	Economic sustainability	EO 1, 2 & 3

6 Stewardship framework

To understand how well non-agricultural sectors in GBR catchments manage water quality, the Office of the Great Barrier Reef is leading the development of the Urban Water Management Practice and Stewardship framework (Urban Stewardship Framework). This is being developed collaboratively between key stakeholders for use in regional report cards. The Urban Stewardship Framework will cover management practices relating to greenfield site development, stormwater runoff in brown field (mature) urban areas, sewage treatment plant discharges and sewerage network operation and maintenance. In line with the Agricultural Management Practice Framework, individual management practices will be assessed based on an A to D (best to worst) basis according to clearly-defined criteria that have been developed based on inputs from industry experts. The rating results for the various management practices will then be pooled to rate urban water stewardship at the region scale. That information will then be available to present in the regional report card, so the standard of urban water management in the region can be clearly articulated to the general public. This framework is still under development and will be incorporated into future report cards.

7 Program management

The Dry Tropics Partnership is managed by the Partnership in accordance with the Governance Charter. The Governance Charter outlines the purpose and objectives of the Partnership and contains guidelines for operational structures, responsibilities and roles, and for the Memorandum of Understanding.

7.1 Data management and sharing

7.1.1 Data management

It is crucial for the development of the report card that data is available and accessible. Data is currently stored and management by the Technical Officer. A community data management system is sought that can be managed by the Wet Tropics, Dry Tropics, and Mackay Whitsundays partnerships. It is aimed that the data system will include elements of both storage and automation.

7.1.2 Data sharing

To ensure transparency of the data, the data and results presented in the report card will be available in its raw format, as well as in a summarised format. In instances where data is provided to the Partnership but it is not intended for public release, the data owner can enter a data sharing agreement with the Partnership to maintain data confidentiality. The data that has been analysed (i.e. raw data that has been converted into report card scores) is the intellectual property of the Partnership.

8 Future program

The Pilot Report Card (release date of April 2019) predominantly includes data from June 2017 to July 2018. In future report cards, the Partnership will aim to address the indicators not included in the Pilot Report Card. The Partnership will also aim to address the indicators that were not fully reported upon.

The aim is also to develop the 'aspirational' indicators. It is expected that over time, new opportunities will arise and new limitations will be identified. This may result in changes to the prioritisation of indicators. In subsequent years, the Partnership intends to set regional targets associated with indicators, so that the report card includes progress toward long-term targets. Table 21 outlines the opportunities for addressing the knowledge gaps to include the aspirational indicators in the report card.

Table 21. Potential opportunities and their limitations for addressing knowledge gaps to include the aspirational indicators within the report card.

Reporting component	Opportunity	Current limitation	Potential way to overcome limitation
Biodiversity	Develop score for mangrove condition	Funding (insufficient sampling) and method development	
	Develop score for wetland condition	Funding (insufficient sampling) and method development	
	Develop score for saltmarsh condition	Funding (insufficient sampling) and method development	
	Develop score for riparian condition	Funding (insufficient sampling) and method development	
	Develop score for native vegetation cover and condition	Funding (insufficient sampling) and method development	
	Fish diversity and density	Funding (no program within Townsville) and method development	Potential for DES to expand their monitoring into the Townsville Dry Tropics with field support
	Macroinvertebrates	Method development and improving monitoring data	Engage with Creek Watch to improve sampling methods
Water	Develop monitoring for the concentration of pesticides	Funding (no dedicated program within Townsville) and method development	
	Develop PFAS indicator	Data accessibility (Defence data) and method development	Engage with data holders to access data

	Groundwater use/volume	Monitoring (few long-term bores in the Dry Tropics) and method development	
Community	Develop biannual or annual surveys for social indicators	Funding	
Economy	Develop economic monitoring and indicators	Data accessibility (private companies) and method development	Engage with data holders to access data

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