HEALTHY WATERS PARTNERSHIP dry tropics

Townsville Dry Tropics
Waterways Report Card 2024

TECHNICAL REPORT

Complete Report

Reporting on data collected 2022 - 2023

JULY 2024 | Healthy Waters Partnership for the Dry Tropics (HWP)

1 General

1.1 Authorship Statement

This technical report presents the results of the Townsville Dry Tropics 2022–2023 Report Card (released in July 2024) and was prepared by the Partnership's Technical Officer (TO), Adam Shand, with support and review from the Partnership's Senior Technical Officer (STO), Dinny Taylor. Significant support and review were received from the Regional Report Cards Technical Working Group (TWG) members, and the Wet Tropics Waterways Partnership and the Healthy Rivers to Reef Partnership. This report is endorsed by the Healthy Waters Partnership for the Dry Tropics (HWP).

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1.2 Current Townsville Dry Tropics TWG Members and their Respective Organisations

Table 1. Current HWP TWG members and respective organizations.

Member	Organisation
Diane Tarte	TWG: Chair (Independent)
Dinny Taylor	HWP: STO
Adam Shand	HWP: TO
Richard Hunt	Wet Tropics Waterways (WTW)
Martine Newman	WTW
Brie Sherow	Healthy Rivers to Reef Partnership (HRRP)
Cinzia Cattaneo	HRRP
Andrew Moss	Department of Environment, Science, and Innovation (DESI)
Glynis Orr	DESI
Reiner Mann	DESI
Angus Thompson	AIMS
Michael Rasheed	James Cook University (JCU)
Alex Carter	JCU
Travis Sydes	Far North Qld Regional Organisation of Councils (FNQROC)
Nicole Flint	Central Queensland University (CQU)
Paula Cartwright	JCU
Jamie Corfield	DESI
David Moffatt	DESI
Stephen Lewis	JCU
Tyson Schmid	Townsville City Council (TCC)

1.3 Acknowledgements

We thank partners who kindly contributed their data, members of the Healthy Waters Partnership for the Dry Tropics (HWP) Management Committee, and members of the Technical Working Group (TWG) who provided feedback on the document. Partners include Townsville City Council (Townsville Water & Waste), Port of Townsville, Australian Institute of Marine Science, Department of Environment, Science, and Innovation, Queensland Herbarium (through the Department of Environment, Science, and Innovation), James Cook University (TropWater), Ornatas, and Reef Check

Australia. Creative Commons (Receiving Environment Monitoring Program, Sewage Treatment Plant data) by Townsville City Council is licensed under CC BY 4.0/Adapted Material. The Partnership acknowledges the Australian Marine Debris Initiative, Tangaroa Blue Foundation, the community organisations, and individuals involved in the collection and the provision of the litter data used in this report.

Members of the Reef Independent Science Panel are acknowledged for their advice and review of the document. The Partnership would like to acknowledge the assistance provided by Dr Bill Venables in the development of the litter model.

2 Executive Summary

This executive summary includes three summary sections covering:

- The Healthy Waters Partnership for the Dry Tropics,
- Climate and land use in the Townsville Dry Tropics region,
- The state and condition of the environment, including scores and grades for each index for each environment, and site-specific scores and grades for litter.

2.1 The Healthy Waters Partnership for the Dry Tropics

The Healthy Waters Partnership for the Dry Tropics (referred to as "the Partnership" or "HWP") was launched in January 2019, with a focus on producing an annual Report Card. The pilot annual Report Card was released in May 2019 and reports on data mainly from the 2017–2018 year. Following this pilot, each year an annual report card has been produced, with the current Report Card using data from the 2022–2023 year. Where a seasonal monitoring program extends outside of the year period, such as inshore coral, data from the whole monitoring period are included. For monitoring programs that collect data less frequently than annually (for example, wetland and riparian extent) then the most recent data set is included. In June 2021, the Partnership also began releasing annual Stewardship Reports, highlighting the management actions of partners (Table 2).

Table 2. Timeline of key HWP publications.

Released:	**2024**	**2023**	**2022**	**2021**	**2020**	**2019**
Reporting period:	**22-23**	**21–22**	**20–21**	**19–20**	**18–19**	**17–18**
Report Card	✓ (current)	✓	✓	✓	✓	✓ (pilot)
Stewardship Report	✓ (current)	✓	✓	✓		

The key deliverable for the Report Card is an assessment of the state of the environment. The Report Card focuses on three indices that are directly dependent on waterway health: Water Quality, Habitat and Hydrology, and Fish. Indices are scored and graded for the freshwater, estuarine, inshore marine, and offshore marine environments within the Townsville Dry Tropics region. However, not all indices are scored and graded for each environment (for example, fish is only scored within the freshwater environment.

The results presented in the 2022–2023 Report Card cover all areas of the Townsville Dry Tropics reporting region. On land, the Partnership region extends from the Crystal Creek catchment in the north, to the Ross River (lower) and Alligator Creek catchments in the south. In the marine environment the Partnership extends from the coastline to the outer edge of the Great Barrier Reef (GBR) Marine Park. The reporting region for the partnership incorporates all islands within this area, including Magnetic Island and the Palm Island group.

The Townsville Dry Tropics reporting region is divided into seven unique areas based on the environment type (freshwater, estuarine, inshore marine, and offshore marine), and riverine basin (Basin) (Black and Ross) or Bay (Zone) (Cleveland Bay and Halifax Bay) (Figure 1, Table 3). If required, Basins/Zones are divided into sub-basins/sub-zones based geographical definition and constructed boundaries (ports, weirs) provided by the Queensland water quality objectives (Department of Environment and Science 2018).

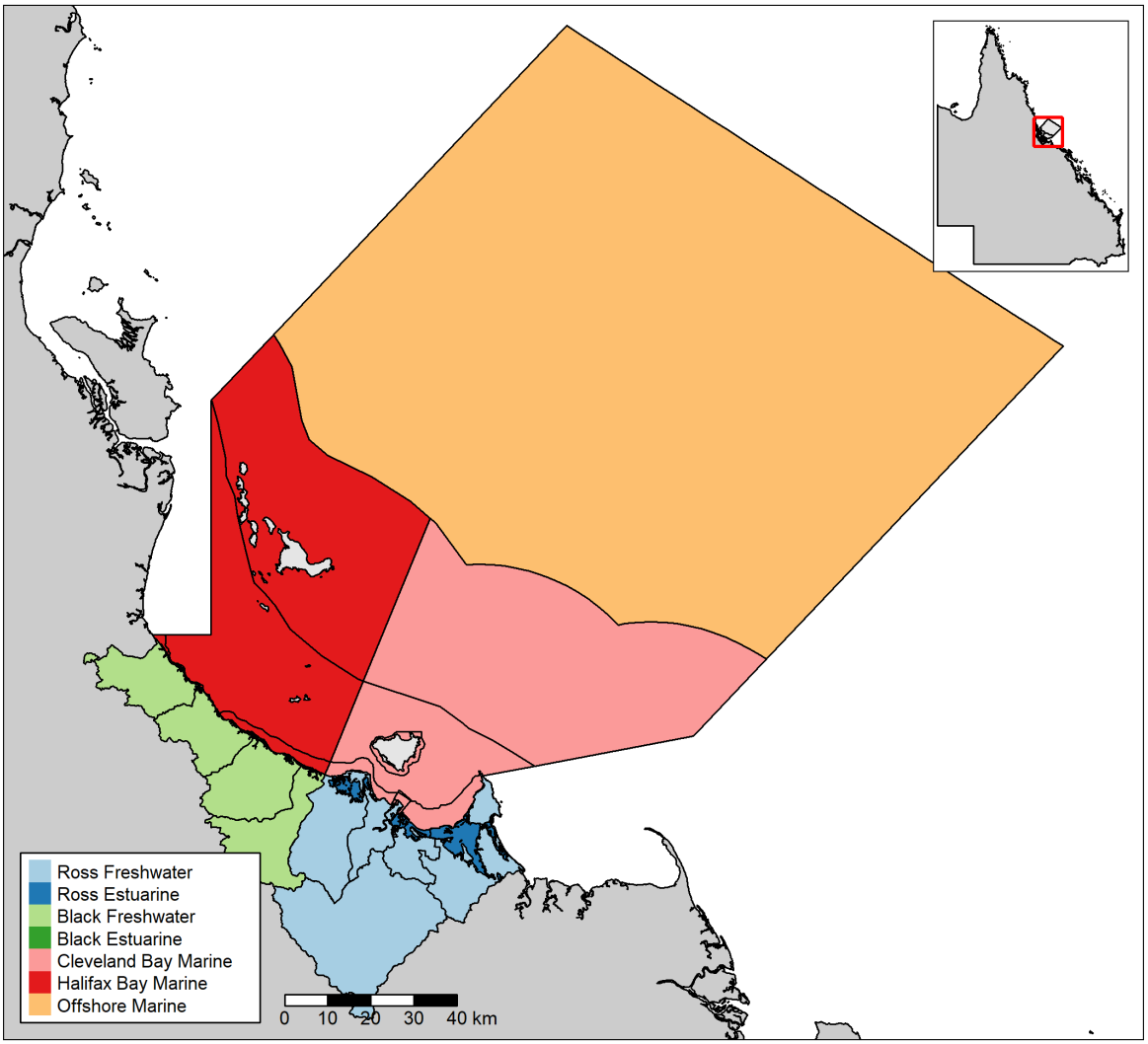

Figure 1. Geographic boundary of the HWP reporting region, divided into seven areas (The Townsville Dry Tropics reporting region is divided into seven unique areas based on the environment type

Table 3. The seven reporting areas in the Townsville Dry Tropics region.

Basin/Zone	Waterway
Ross Freshwater	Freshwater
Black Freshwater	Freshwater
Ross Estuarine	Estuarine
Black Estuarine	Estuarine
Cleveland Bay	Inshore Marine
Halifax Bay	Inshore Marine
Offshore Marine	Offshore Marine

This document is a detailed technical report that provides context and insight into the annual Report Card. It is intended to be read in conjunction with the "Townsville Dry Tropics Program Design" (Healthy Waters Partnership for the Dry Tropics 2024) and "Methods for Townsville Dry Tropics 2022–2023 Report Card (released in 2024)" (Healthy Waters Partnership for the Dry Tropics 2024). A table of every indicator measured is presented in 8.1 Terminology and Data Aggregation. An example of the coasters used for reporting results in the final Report Card is presented in 8.3 Presentation.

2.2 Climate and Land Use in the Townsville Dry Tropics Region

During 2022–2023, the Townsville Dry Tropics region recorded no major flooding events, tropical cyclones, or changes to the prevailing La Niña conditions (Bureau of Meteorology 2023). Key influences for the 2022–2023 reporting period are summarised below.

- Total rainfall was 1239mm in the Ross Basin, and 1425mm in the Black Basin. Annual rainfall in both basins was classified as “average”, although exceeded the long-term mean (calculated from the most recent 30-year block of data: 1991 to 2020) of 1061mm and 1420mm respectively.
- Monthly rainfall ranged from “very much below average” to “very much above average” for the respective monthly means throughout the year.
    - Months above their monthly average occurred in late 2022, whilst those below their monthly average occurred in 2023.
- The annual average air temperature was 24.8°C in the Ross Basin, and 24.2°C in the Black Basin and was classified as “very much above average” in both basins.
    - Annual mean temperatures exceeded the long-term mean (calculated from the oldest 30-year block of data available in the dataset (from 1911 to 1940) by 1.1°C in both basins.
- Monthly air temperatures were measured as the “highest 1%” on record for five months of the year.
    - These excessive temperatures were recorded before and after summer (but not during), leading to an extended summer with no reprieve, but also no record breaking absolute maximum temperatures.
- The annual average sea surface temperature was 27.1°C, nearly 1°C above the long-term average of 26.2°C.
    - Despite this, monthly sea surface temperatures remain average or very slightly above the average for some months of the year (Figure 14).
- The risk of coral bleaching ranged from “low risk” to “possible”, with most of the marine zone experiencing between 0 to 4 Degree Heating Weeks.
- Grazing and conservation remain the two most significant land use types. (Ross: 30.6% Conservation, 45.3% Grazing. Black: 43.0% Conservation, 39.9% Grazing).

2.3 State and Condition of the Environment

The results presented in this document describe the state and condition of the waterways and environment in the seven reporting areas of the Townsville Dry Tropics region (Figure 1, Table 3). Within each area standardised scores and grades are produced for environmental indicators, indicator categories, and indices. Results from multiple indicators are aggregated into results for indicator categories, which are aggregated into results for indices (see Page 4). Indicators, and thus the indices reported for each area vary (Table 4). Confidence levels based on how the data were collected and analysed are also reported.

Table 4. Indices measured in each area of the Townsville Dry Tropics region.

Basin/Zone	Water Quality (WQ)	Latest update	Habitat and Hydrology (HH)	Latest update	Fish (F)	Latest update
Black Freshwater	✓	22–23	✓	22–23	✓	22-23
Black Estuarine	✓	22–23	✓ (Only Habitat)	22–23		
Halifax Bay	✓	22–23	✓ (Only Habitat)	22–23		
Ross Freshwater	✓	22–23	✓	22–23	✓	22-23
Ross Estuarine	✓	22–23	✓ (Only Habitat)	22–23		
Cleveland Bay	✓	22–23	✓ (Only Habitat)	22–23		
Offshore Marine	✓	19–20	✓ (Only Habitat)	22–23		

The index and standardised scores of each area for the 2022–2023 reporting period are presented below for quick reference. Selected key messages for results of particular interest are provided and refer to indicators which are presented in detail within the results sections.

2.3.1 Freshwater Environment

Table 5. Comparison of 2022–2023 weighted scores for Water Quality (WQ), Habitat and Hydrology (HH), Fish (F), and Pesticides (P) indices in the Ross Freshwater Basin and the Black Freshwater Basin against previous years.

Basin	2022-2023				2021–2022			2020–2021			2019–2020			2018–2019		
	WQ	HH	F	P[1]	WQ	HH	F	WQ	HH	F	WQ	HH	F	WQ	HH	F
Ross	67	61	49	81	70	X	X	73	X	X	70	X	57	66	51	ND
Black	66	79	55	82	68	X	X	68	X	X	67	X	78	62	71	ND

■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

2.3.1.1 *Key Messages*

2.3.1.1.1 Water Quality

- The Ross Freshwater Basin grade remained "good" although the score declined slightly from 70 to 67.
    - Most influential was the decline in the score for Dissolved Inorganic Nitrogen (DIN) in the Bohle River which decreased in score from 70 to 67 within the same grade of "good".
    - Nutrients in the Ross Freshwater Basin decreased from "good" to "moderate", whilst physical-chemical properties did not change grade.
- The Black Freshwater Basin score decreased from 68 to 66 within the same grade of "good".
    - Neither nutrients nor physical-chemical properties changed notably.
- The Bohle River Total Phosphorus (TP) grade remained "very poor" for the fifth year in a row, and the DIN grade decreased from "poor" to "very poor" compared with 2021-2022.

[1] Pesticide results are not representative of the Ross and Black Basins, but rather of the specific pesticide sampling sites within the Ross and Black Basins.

- Althaus Creek shows ongoing low scores and grades for the TP and Turbidity indicators, and further investigation would be required to isolate specific drivers.
- DIN values in the Upper Ross and Paluma Lake sub basins remain "NA" due to the Water Quality Objective values (WQOs) being equal to or less than the Limit of Reporting values (LOR).

2.3.1.1.2 Habitat and Hydrology

- Standardised scores for the habitat and hydrology index increased in both freshwater basins.
    - The riparian extent indicator category improved in both basins, with the Black Freshwater Basin recording its first increase in freshwater riparian vegetation score since the beginning of the HWP Technical Report.
- Sub basin scores have been calculated and presented for the first time. This allowed for several new observations such as:
    - Identifying the Stuart Creek sub basin as the location with the greatest loss of riparian vegetation extent between 2019 and 2021.
    - Identifying the Bluewater and Rollingstone Creek sub basins as the locations with the greatest loss of wetland extent between 2019 and 2021.
    - Identifying several sub basins with the Black Freshwater Basins that have gained riparian vegetation extent between 2019 and 2021.

2.3.1.1.3 Fish

- This is the second time the fish index has been measured and scores for the fish index declined in both basins.
    - The primary driver was the PONIS indicator category in the Ross Basin (decreased from 60 to 41), and the POISE indicator category in the Black basin (decreased from 66 to 25).
- Within the Ross Basin, 4011 fish from 29 species were caught during sampling.
    - 86% (3447) were indigenous and were released after identification.
    - 14% (564) were non-indigenous and were euthanised.
        - 529 fish were alien, 35 were translocated.
    - Scores indicate that most waterways were graded as "moderate".
- Within the Black Basin, 2217 fish from 25 species were caught during sampling.
    - 83% (1830) were indigenous and were released after identification.
    - 17% (387) were non-indigenous and were euthanised.
        - All non-indigenous species were alien.
    - Scores indicate that some waterways were graded "very good' whilst others were "very poor".
    - The significant decrease in the POISE indicator category score is most likely connected to heavy rainfall before sampling dispersing the fish populations.

2.3.1.1.4 Pesticides

- This is the first year in which pesticides data have been reported in the Townsville Dry Tropics Technical Report.
- Pesticide results and scores are not representative of the entire basin, as pesticides were only monitored at two sites (one in Ross River and one in Black River).

- The pesticides index is a risk matrix, even if scores are “very good”, this does not necessarily indicate the absence of pesticides completely.
- Both pesticide sites received grades of “very good” with at least 99% of species protected.

2.3.2 Estuarine Environment

Table 6. Comparison of 2022–2023 weighted scores for Water Quality and Habitat indices in the Ross Estuarine Basin and Black Estuarine Basin against previous years.

Basin	2022-2023		2021–2022		2020–2021		2019–2020		2018–2019	
	WQ	H	WQ	H	WQ	H	WQ	H	WQ	H
Ross	79 (B)	74 (B)	83 (A)	X	88 (A)	X	88 (A)	X	39 (D)	73 (B)
Black	68 (B)	50 (C)	64 (B)	X	66 (B)	X	47 (C)	X	52 (C)	71 (B)

■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

2.3.2.1 *Key Messages*

2.3.2.1.1 Water Quality

- The Ross Estuarine Basin grade declined from “very good” (83) to “good” (79).
  - Most influential was the decline in the score for Total Phosphorus in the Louisa Creek sub basins, which saw a decrease in grade from “poor” (22) to “very poor” (0).
- The Black Estuarine Basin score increased from 64 to 68 within the same grade of “good”.
  - Improvements in the turbidity grade in the Crystal Creek sub basin from “very poor” (7) to “moderate” (43), and the High DO score in the Althaus Creek sub basin from “poor” (28) to “very good” (90) were the primary drivers.
- Across the entire Dry Tropics Region, 11 of 13 watercourses received a grade of “good” or “very good” for nutrients, and 10 of 13 received a grade of "good” or “very good” for physical-chemical properties.
- Althaus Creek shows ongoing low scores and grades for the turbidity indicator, and further investigation would be required to isolate specific drivers.
- Louisa Creek shows ongoing low scores and grades for the Low DO and TP indicators and further investigation would be required to isolate specific drivers.

2.3.2.1.2 Habitat

- Sub Basins scores have been calculated and presented for the first time. This allowed for several new observations such as:
  - Identifying the Bohle River and Crystal Creek sub basins as the main areas of mangrove and saltmarsh loss and several sub basins as the main areas of gain of mangrove and saltmarsh vegetation.
  - Identifying the Black River, Bluewater Creek and Rollingstone Creek sub basins as key drivers of riparian vegetation loss and several sub basins as the main areas of gain of riparian vegetation.
- The Black Estuarine Basin recorded its first increase (11.7ha) in mangrove and saltmarsh vegetation since the beginning of the Dry Tropics Technical Report.

- The Black Estuarine Basin also recorded its first ever loss in riparian vegetation (-9.8ha) since the beginning of the Dry Tropics Technical Report.
    - This may be connected to the ongoing urban development throughout the basin.
- In the Ross Estuarine Basin mangrove and saltmarshes decreased (-8.5ha) and riparian vegetation increased (0.2ha).

2.3.3 Inshore Marine Environment

Table 7. Comparison of 2022–2023 weighted scores for Water Quality and Habitat in Cleveland Bay and Halifax Bay against previous years.

Zone	2022-2023		2021–2022		2020–2021		2019–2020		2018–2019	
	WQ	H	WQ	H	WQ	H	WQ	H	WQ	H
Cleveland Bay	73 (B)	53 (C)	81 (A)	57 (C)	81 (A)	54 (C)	81 (A)	48 (C)	36 (D)	56 (C)
Halifax Bay	73 (B)	47 (C)	69 (B)	45 (C)	70 (B)	49 (C)	60 (C)	52 (C)	45 (C)	52 (C)

■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

2.3.3.1 *Key Messages*

2.3.3.1.1 Water Quality

- The Cleveland Bay inshore marine zone grade remained “good” although the score declined slightly from 81 to 73.
    - Most influential was a combination of the Turbidity and Secchi indicators in the Enclosed Coastal and Open Coastal sub zones.
- The Halifax Bay inshore marine zone grade remained “good” although the score increased slightly from 69 to 73.
    - Most influential was a combination of the Nitrogen Oxides (NOx) indicator category in the Enclosed Coastal sub zone, and the Turbidity and Total Suspended Solids (TSS) indicators in all sub zones.
- Following a review of EPP water quality objectives, the model methodology used to calculate inshore marine water quality scores has been updated (See: Updated Methodology, section 12.1.3).

2.3.3.1.2 Habitat

- The Cleveland Bay inshore marine zone grade remained “moderate” although the score declined slightly from 57 to 53.
    - The seagrass grade within Cleveland Bay remained “good”. The score declined slightly from 73 to 68, however can be explained by local environmental conditions.
        - Declines were region wide and not confined to areas closest to dredging activity, pointing to wider/regional drivers of change.
        - Unfavourable growing conditions for seagrass included a heatwave, above average out of season rainfall, sustained periods of high wind and multiple periods of low light conditions across many areas of the Bay.
        - As individual one-off events, these unfavourable conditions were not likely to impact seagrass but the cumulative impact of them throughout the year

was likely to have been behind the relatively small declines recorded in October 2022.
    - The total area of seagrass remained above the long-term average.
    - The coral grade with Cleveland Bay declined from "moderate" (41) to "poor" (39), however has fluctuated within this range for the past four years.
- The Halifax Bay inshore marine zone grade remained "moderate" although the score increased slightly from 45 to 47.
    - The coral grade with Halifax Bay was 47 (moderate), neither its highest nor lowest in the past five years.
    - There remains a significant amount of macroalgae recorded at five of seven sites.

2.3.4 Offshore Marine Environment

Table 8. Comparison of 2022–2023 weighted scores for Habitat in the Offshore Marine Environment against previous years.

Zone	2022-2023		2021–2022		2020–2021		2019–2020		2018–2019	
	WQ	H	WQ	H	WQ	H	WQ	H	WQ	H
Offshore	ND	63 (B)	ND	64 (B)	ND	62 (B)	100 (A)	56 (C)	97 (A)	59 (C)

■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

2.3.4.1 *Key Messages*

2.3.4.1.1 Water Quality

- No data were available for the 2022–2023 Townsville Dry Tropics Technical Report and water quality was not assessed.

2.3.4.1.2 Habitat

- The Offshore Marine Zone coral grade remained "good" although the score decreased slightly from 64 to 63.
    - Juvenile density was graded as "very good" at 7 of 9 reefs surveyed.
    - All coral reefs had an overall grade of "moderate" or "good".

2.3.5 Litter

Litter is a recently developed metric and was first included in the 2019–2020 report card. The methodology has been updated from the initial year of data collection, and data collected from new sites. Data from the previous years has been updated using the new method. Zone scores are not comparable as the sites' litter collected from each year in each Zone varies, thus only site-specific scores and grades are presented (Table 9).

Table 9. Comparison of 2022–2023 standardised scores and grades for Litter in the Townsville Dry Tropics region against previous years.

Zone	Site	Scores and Grades			
		2019-2020	2020-2021	2021-2022	2022-2023
Halifax Bay	North West Beach, Pelorus Island	95 (VLP)	NA	NA	NA
	West Beach, Pelorus Island	80 (VLP)	NA	NA	NA
	North Beach, Orpheus Island	4 (VHP)	NA	NA	NA
	Little Pioneer Bay, Orpheus Island UW	NA	NA	NA	91 (VLP)
	Fig Tree Bay, Orpheus Island	NA	NA	NA	28 (HP)
	Big Rock Bay, Orpheus Island	21 (HP)	7 (VHP)	7 (VHP)	7 (VHP)
	Fig Tree Beach, Orpheus Island	NA	16 (VHP)	19 (VHP)	NA
	Pioneer Bay, Orpheus Island	NA	NA	NA	84 (VLP)
	Picnic Bay, Orpheus Island	0 (VHP)	11 (VHP)	2 (VHP)	5 (VHP)
	Boulder Beach North, Orpheus Island	NA	NA	14 (VHP)	NA
	Yanks Jetty, Orpheus Island	74 (LP)	76 (LP)	NA	NA
	Boulder Beach, Orpheus Island	NA	NA	1 (VHP)	NA
	South Beach, Orpheus Island	42 (MP)	NA	10 (VHP)	NA
	Fantome Island, Northern End	NA	12 (VHP)	36 (HP)	57 (MP)
	North West Beach, Fantome Island	NA	NA	NA	61 (LP)
	Ollera Beach	39 (HP)	NA	NA	NA
	Rollingstone Beach	50 (MP)	NA	NA	NA
	Toomulla Beach	53 (MP)	NA	83 (VLP)	NA
	Saunders Beach	71 (LP)	NA	NA	NA
	Bushland Beach, Townsville	NA	62 (LP)	NA	55 (MP)
Cleveland Bay	Myrmidon Reef	NA	98 (VLP)	NA	NA
	Radical Bay, Magnetic Island	NA	NA	NA	96 (VLP)
	Horseshoe Bay, Magnetic Island	NA	NA	34 (HP)	83 (VLP)
	Florence Bay, Magnetic Island	NA	NA	NA	51 (MP)
	Arthur Bay, Magnetic Island	NA	43 (MP)	NA	NA
	Alma Bay, Magnetic Island	45 (MP)	63 (LP)	71 (LP)	60 (LP)
	Alma Bay, Magnetic Island UW	97 (VLP)	98 (VLP)	NA	100 (VLP)
	Geoffrey Bay, Magnetic Island	NA	80 (VLP)	NA	NA
	Geoffrey Bay Reef, Magnetic Island UW	93 (VLP)	NA	NA	NA
	Nelly Bay Beach, Magnetic Island	53 (MP)	77 (LP)	73 (LP)	77 (LP)
	Nelly Bay, Magnetic Island UW	100 (VLP)	99 (VLP)	99 (VLP)	99 (VLP)
	Shelly Beach, Pallarenda	63 (LP)	29 (HP)	NA	44 (MP)
	Shelly Cove, Cape Pallarenda Conserv. Park	67 (LP)	70 (LP)	91 (VLP)	92 (VLP)
	Pallarenda Beach	NA	NA	72 (LP)	84 (VLP)
	Rowes Bay	75 (LP)	75 (LP)	87 (VLP)	89 (VLP)
	Kissing Point	NA	79 (LP)	NA	NA
	Strand Park	62 (LP)	74 (LP)	NA	NA
	Strand Waterpark Beach	NA	86 (VLP)	NA	NA
	Secret Beach, Ross River	NA	NA	NA	81 (VLP)
Ross	Three Mile Creek, Pallarenda	NA	37 (HP)	NA	NA
	Strand Rock Pool	NA	47 (MP)	NA	74 (LP)
	Jezzine Barracks, TSV Heritage Precinct	NA	NA	NA	63 (LP)
	West End	NA	NA	NA	66 (LP)
	Ross Creek	NA	NA	46 (MP)	59 (MP)
	Queensland Country Bank Stadium	NA	23 (HP)	21 (HP)	NA
	South Townsville Recreational Boat Park	NA	33 (HP)	NA	NA
	Anderson Park	NA	NA	91 (VLP)	NA

Zone	Site	Scores and Grades			
		2019-2020	2020-2021	2021-2022	2022-2023
	Sherriff Park	NA	NA	73 (LP)	NA
	Aplins Weir Rotary Park	41 (MP)	35 (HP)	69 (LP)	74 (LP)
	Lake Idalia Wetland Foreshore	NA	NA	NA	45 (MP)
	Apex Park, Condon	NA	NA	62 (LP)	NA

■ Very High Pressure (VHP) = 0 to <20 | ■ High Pressure (HP) = 20 to <40 | ■ Moderate Pressure (MP) = 40 to <60 | ■ Low Pressure (LP) = 60 to <80 | ■ Slight Pressure (SP) = 80 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

Key Messages

- The east coast of Orpheus Island continues to have the highest litter pressure in the region.
- The litter pressure at Fantome Island appears to be decreasing which may be associated with regular collection as well as local factors.
- Florence Bay had the highest litter pressure on Magnetic Island and Shelley Beach had the highest litter pressure on the mainland for Cleveland Bay.
- There were no sites with very low pressure within the Ross Basin, with the Lake Idalia Wetland Foreshore having the highest litter pressure.

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4 Glossary of Terms

Table 10. Glossary of terms used in the Townsville Dry Tropics Report Card Results 2024 Technical Report.

AIMS	Australian Institute of Marine Science.
Alien species	Species that are not native to any part of Australia.
Artificial barriers	Any barrier that prevents or delays connectivity between key habitats. Potentially impacting migratory fish populations, reducing diversity of aquatic species and the condition of aquatic ecosystems (Moore 2016).
Basin	Area of land where surface water runs to smaller creeks or rivers discharging into a common point, may include many sub-basins or sub-catchments.
BOM	Bureau of Meteorology.
Catchment area	Area of land from which rainfall flows into a river, lake or reservoir and discharges into a common point.
Chlorophyll-*a*	An indicator of phytoplankton biomass, widely considered a useful proxy of nutrient availability and system productivity.
Climate	Refers to both natural climate variability and climate change.
CVA	Conservation Volunteers Australia.
DES	Department of Environment and Science of the Queensland Government.
DHW	An accumulated measurement of sea surface temperature (SST) that assesses the instantaneous bleaching heat stress during the prior 12-week period. (Significant coral bleaching usually occurs when the DHW value reaches 4 °C-weeks. By the time the DHW value reaches 8 °C-weeks, severe, widespread bleaching and significant mortality are likely).
DIN	Dissolved Inorganic Nitrogen. Comprised of nitrate, nitrite, and ammonium.
DO	Dissolved Oxygen.
HWP	Healthy Waters Partnership for the Dry Tropics.
Ecosystem	A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.
Ecosystem Health	An ecological system is healthy and free from 'distress syndrome' if it is stable and sustainable. That is, if it is active and maintains its organization and autonomy over time and is resilient to stress. Ecosystem health is thus closely linked to the idea of sustainability, which is seen to be a comprehensive, multiscale, dynamic measure of system resilience, organization, and vigour.

Enclosed Coastal (EC)	A partially smooth, semi protected water body including shallow, enclosed waters near an estuary mouth and generally considered the interface between coastal and inland waters. Its boundaries depend on the local or regional authorities.
Environmental values (EV)	Characteristics or qualities of a natural system that supports viable natural communities and human uses.
eReefs	Integrated modelling system to visualise, communicate and report reef information for the GBR.
Floor rounding	Rounding decimal places down to the nearest integer. (for example, 60.9 = 60).
Flow (as an indicator)	The degree that the natural river currents or stream flows have been modified, influencing waterways and ecosystem health.
FRP	Filterable Reactive Phosphorus.
GBR	Great Barrier Reef.
GBR Report Card	GBR Report Card under the Reef Water Quality Protection Plan (2013).
GBRMPA	Great Barrier Reef Marine Park Authority.
GBRMP	Great Barrier Reef Marine Park.
High DO	High Dissolved Oxygen. Can be a sign of algae growth and poor water quality.
Impoundment length	An indicator used in the 'in-stream habitat modification' indicator for freshwater basins in the region. The proportion (%) of the linear length of the main river channel when at the full capacity of artificial in-stream structures, such as dams and weirs.
Index	The aggregation of indicator categories. For example, the water quality index is an aggregation of nutrient, phys-chem, and Chlorophyll *a* indicator categories.
Indicator	A measure of one component of an environment. For example, the total amount of phosphorous (TP) present in the water.
Indicator category	The aggregation of indicators. For example, the nutrient indicator category is an aggregation of TP and DIN indicators.
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, Great Barrier Reef Marine Park Authority 2009).
Inshore Marine Zone	Inshore Marine Zone is a reporting zone in the Townsville Dry Tropics Report Card that includes Inshore Marine environments.

ISP	Independent Science Panel.
Invasive species	Invasive species include both alien and translocated species.
JCU	James Cook University.
Litter	Any type of waste material that is less than 200 litres in volume and that has been deposited unlawfully.
Low DO	Low Dissolved Oxygen. Can result in anoxic waterways (depletion of oxygen) and poor water quality.
LTMP	Long Term Monitoring Program of GBR Midshelf and offshore reef communities.
Macroalgae (cover)	Indicator used to assess coral health. Macroalgae includes seaweed and other visible benthic (attached to the bottom) marine algae.
Marine Debris	Also called marine litter. Defined as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment.
MD	Moderate disturbed waters.
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) (Great Barrier Reef Marine Park Authority 2009).
MMP	Marine Monitoring Program of the inshore reef communities along Wet Tropics, Burdekin, Mackay, Whitsunday, and Fitzroy regions of the GBR.
Modified Wetland	Modified wetlands are existing wetlands which were also former natural wetlands, where activities that modify wetland hydrology and/or structures associated with these activities have been observed from aerial or satellite imagery or from field survey data (Queensland Wetlands Program 2023).
MSL	Mean Sea Level
Non-indigenous species	See Invasive species.
NOx	Generic term for nitrogen oxides such as mixtures of nitrites and nitrates.
NRM	Natural resource management.
NTU	Nephelometric Turbidity Unit. The units that turbidity is measured in.
OGBRWH	Office of the Great Barrier Reef and World Heritage, Queensland Government.

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) (Great Barrier Reef Marine Park Authority 2009).
Offshore Marine	Offshore is a reporting zone in the Townsville Dry Tropics Report Card that includes offshore waters.
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) (Great Barrier Reef Marine Park Authority 2009).
Palustrine wetlands	Vegetated, non-riverine or non-channel systems that include billabongs, swamps, bogs, springs, soaks etc and have more than 30% emergent vegetation.
Physical-chemical properties	(Phys-chem properties). Indicator category that includes dissolved oxygen and turbidity.
PN	Particulate Nitrogen.
POTL	Port of Townsville Limited.
PP	Particulate Phosphorus.
QA/QC	Quality Assurance / Quality Control.
QPSMP	Queensland Ports Seagrass Monitoring Program.
RE	Regional Ecosystem.
Reef 2050 Plan	The overarching framework of the Australian and Queensland governments for protecting and managing the reef until 2050.
REMP	Receiving Environment Monitoring Program. A REMP provides a basis for evaluating whether the discharge limits or other conditions imposed upon an activity have been successful in maintaining or protecting receiving environment values over time.
Resilience (seagrass)	A multivariate metric developed by the MMP to measure the capacity of seagrass to cope with disturbances (Collier et al., 2021). The resilience metric better accommodates differences in recovery strategies between species in comparison to previous indicators.
Riparian extent	Vegetation with a 50m buffer from a waterway.
RIMReP	Reef 2050 Integrated Monitoring and Reporting Program.
Secchi	Secchi depth. A measure used to gauge the transparency (clarity) of water.

TCC	Townsville City Council.
Translocated species	Species that are native to Australia but not native to the specific waterway.
TP	Total Phosphorus.
TSS	Total Suspended Solids.
Turbidity	A measure of how cloudy/opaque water is, recorded in NTU.
Waterway	A land-based body of water, e.g. a creek, river, or stream.
WQO	Water Quality Objectives. Defined for specific regions, these values act as a management target. They do not necessarily reflect 'natural' condition but rather a state that is considered acceptable considering environmental, social, and economic factors.
WQGV	Water Quality Guideline Values. Defined for broad scale regions, these values act as an 'earliest baseline' and ideally reflect the natural state of the environment pre-European/pre-developed settlement (or pre-land clearing). They allow managers to assess how water quality has changed from 'natural' condition.

5 Table of Tables

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7 Introduction

7.1 Overview

The Healthy Waters Partnership for the Dry Tropics (referred to as "the Partnership" or "HWP") was launched in January 2019, with a focus on producing an annual Report Card. The current Report Card is for the 2022–2023 year.

Where a seasonal monitoring program extends outside of the year period, such as inshore coral, data from the whole monitoring period are included. For monitoring programs that collect data less frequently than annually (for example, wetland and riparian extent) then the most recent data set is included. In June 2021, the Partnership also began releasing annual Stewardship Reports, highlighting the actions of partners to improve waterway health (Table 11).

Table 11. Timeline of key HWP publications.

Released:	**2024**	**2023**	**2022**	**2021**	**2020**	**2019**
Reporting period:	**22-23**	**21–22**	**20–21**	**19–20**	**18–19**	**17–18**
Report Card	✓ (current)	✓	✓	✓	✓	✓ (pilot)
Stewardship Report	✓ (current)	✓	✓	✓		

The key deliverable for the Report Card is an assessment of the state of the waterway health. The Report Card focuses on three indices for waterway health: Water Quality, Habitat and Hydrology, and Fish. Indices are scored and graded for the freshwater, estuarine, inshore marine, and offshore marine environments within the Townsville Dry Tropics region. However, not all indices are scored and graded for each environment (for example, fish is only scored within the freshwater environment). To assess trends over time, summary results from previous reports are presented alongside this year's results.

7.2 Report Card Zones

The results presented in the 2022–2023 Report Card cover all areas of the Townsville Dry Tropics reporting region. On land, the Partnership region extends from the Crystal Creek catchment in the north, west to the Ross River (upper) catchment and to the Alligator Creek catchment in the south. In the marine environment the Partnership extends from the coastline to the outer edge of the Great Barrier Reef (GBR) Marine Park. The reporting region for the partnership incorporates all islands within this area, including Magnetic Island and the Palm Island group.

The Townsville Dry Tropics reporting region is divided into seven unique areas based on the environment type (freshwater, estuarine, inshore marine, and offshore marine) and riverine basin (Basin) (Black and Ross) or Bay (Zone) (Cleveland Bay and Halifax Bay) (Table 12, Figure 2). If required, Basins/Zones are divided into sub-basins/sub-zones based geographical definition and constructed boundaries (ports, weirs) provided by the Queensland water quality objectives (Department of Environment and Science 2018). The freshwater and estuarine zones for Magnetic Island and the Palm Island group are not currently included as there is no data available.

Table 12. The seven reporting areas in the Townsville Dry Tropics region.

Basin/Zone	Waterway
Ross Freshwater	Freshwater
Black Freshwater	Freshwater
Ross Estuarine	Estuarine
Black Estuarine	Estuarine
Cleveland Bay	Inshore Marine
Halifax Bay	Inshore Marine
Offshore Marine	Offshore Marine

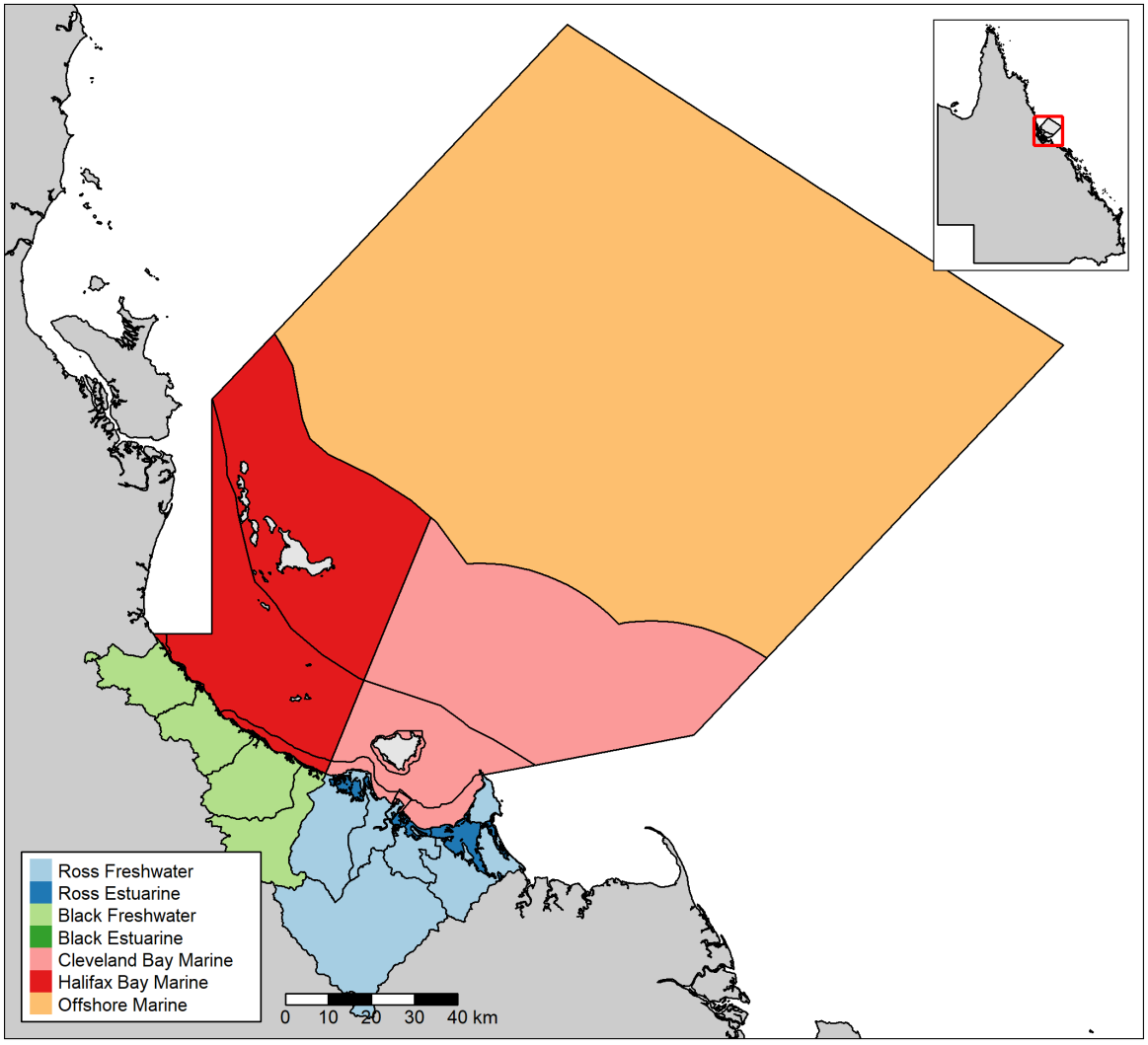

Figure 2. Geographic boundary of the HWP reporting region, divided into seven areas (Table 12).

The topography of the Townsville Dry Tropics also plays a critical role in the division and understanding of the dynamics of the local environment. A digital elevation model (DEM) is presented below that exemplifies the key mountain ranges and coastal planes that will be discussed throughout this technical report (Figure 3).

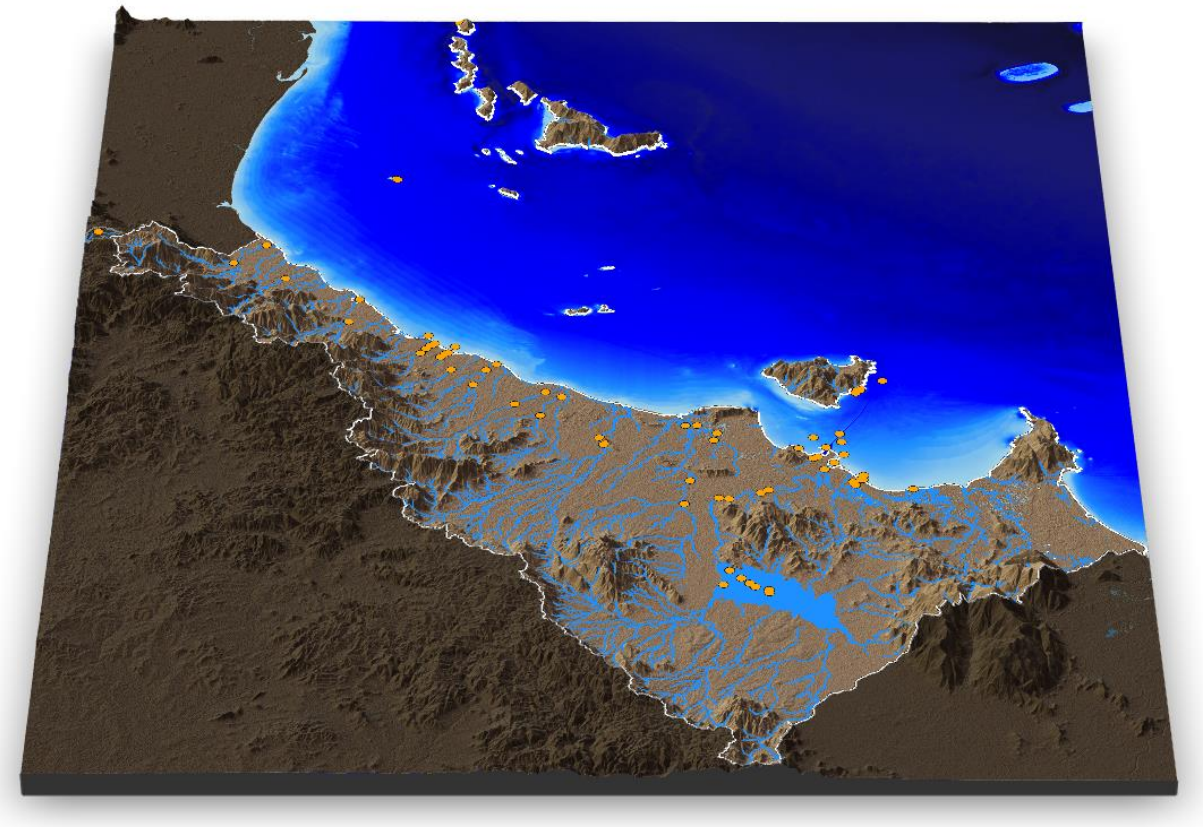

Figure 3. Digital Elevation Model (DEM) of the Townsville Dry Tropics region. Orange points symbolise water quality sampling locations. Note the high mountain ranges and low coastal planes.

7.3 Purpose of This Document

This report (hereby referred to as the Technical Report) provides insight into the results found in the 2022–2023 Report Card. Within are weighted and unweighted scores for indicators, indicator categories, and indices for all sites in the seven areas (Table 12). Key messages and confidence scores for each index are also provided. For further details on the design of the Report Card program, refer to the "Townsville Dry Tropics Program Design" and "Methods for Townsville Dry Tropics 2022–2023 Report Card (released in 2024)" (Healthy Waters Partnership for the Dry Tropics 2024).

7.4 Report Card History

A history of the Partnerships' Report Cards can be found in "Methods for Townsville Dry Tropics 2022–2023 Report Card (released in 2024)" (Healthy Waters Partnership for the Dry Tropics 2024).

8 Methods

Detailed methods can be found in "Methods for Townsville Dry Tropics 2022–2023 Report Card (released in 2024)". Key components to understand the Technical Report are presented below.

8.1 Terminology and Data Aggregation

Data is reported and aggregated at multiple levels: indicator, indicator category, and index. Results from indicators are aggregated into indicator categories, which are aggregated into indices. Results can only be aggregated if they meet the follow rules:

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

There are three indices in the report card: Water Quality, Habitat and Hydrology, and Fish. Some indices are only measured in certain areas. A complete list can be found in Table 13.

Table 13. All indicators, indicator categories, and indices used in the 2022-2023 Technical Report and Report Card.

Environment	Index	Indicator Category	Indicator
Freshwater	Water Quality	Nutrients	Dissolved Inorganic Nitrogen
			Total Phosphorus
		Phys-Chem	Turbidity
			High/Low DO
	Habitat and Hydrology	Riparian vegetation	Change in riparian extent
		Wetlands	Change in wetland extent
		Artificial barriers	Fish barriers
			Impoundment length
	Fish	Proportion of Indigenous Species Expected	Indigenous Species
		Proportion of Non-Indigenous Species Expected	Translocated Species
			Alien Species
	Pesticides	Pesticides	Pesticides
Estuarine	Water Quality	Nutrients	Dissolved Inorganic Nitrogen
			Total Phosphorus
		Phys-Chem	Turbidity
			High/Low DO
	Habitat	Mangrove and Saltmarsh Extent	Change in mangrove and saltmarsh extent
		Riparian Vegetation	Change in riparian extent
Inshore	Water Quality	Nutrients	Total Phosphorus
			Nitrogen Oxides
			Total Nitrogen
			Filterable Reactive Nitrogen
			Particulate Nitrogen
			Particulate Phosphorous
		Phys-Chem	Total Suspended Solids

			Turbidity
			Secchi Depth
		Chlorophyll a	Chlorophyll a
	Habitat	Coral	Hard Coral Composition
			Coral Cover
			Change in coral cover
			Juvenile Density
			Macroalgae cover
		Seagrass	Biomass
			Meadow area
			Species composition
Offshore	Habitat	Coral	Change in coral cover
			Coral Cover
			Juvenile Density
All	Litter	Litter	Litter

8.2 Scoring

Data are graded using five ordinal values commonly used in Report Cards: “Very Good” (A) to “Very Poor” (E). Each indicator is scored on a scale appropriate for the variable being measured and thus some indicators have different scoring ranges. To ensure results for all indicators are comparable, all scores are converted (if required) into a standardised score between 0 and 100 (Table 14).

Table 14. Standardised scoring range and corresponding grades used in the Technical Report.

Scoring Range[2]	**Grade and Colour Code**
81 to 100	Very Good, (A), or Very Low Pressure
61 to <81	Good, (B), or Low Pressure
41 to <61	Moderate, (C), or Moderate Pressure
21 to <41	Poor, (D), or High Pressure
0 to <21	Very Poor, (E), or Very High Pressure

8.3 Presentation

The information in this technical report is summarised in an annual Report Card. The Report Card uses a stylized coaster to present the final grades for each index with their associated colours (Figure 4. B). This coaster is a slimmed down version of the aggregation used within the technical report (Figure 4. A). Coasters are created for each of the seven areas in the Townsville Dry Tropics region (Figure 2).

[2] Some indicators may have slightly different scoring ranges than demonstrated in this table.

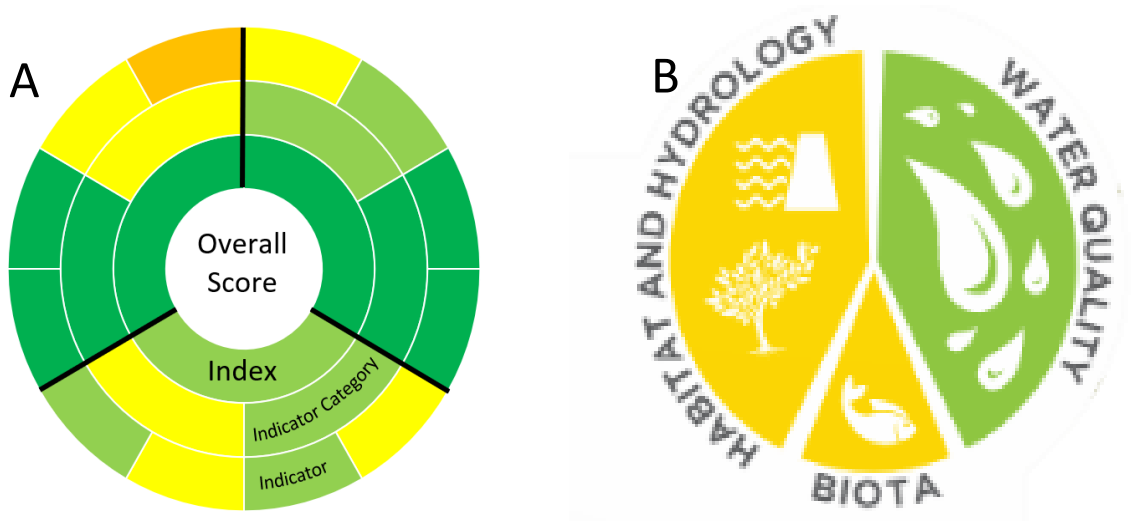

Figure 4. Coasters used within the Technical Report (A) and Report Card (B).

8.4 Confidence Measure

Results are given a qualitative confidence score based on the accuracy and appropriateness of the data used in the analysis. Scores are calculated using five criteria which are weighted to reflect their importance (Table 15). Final confidence scores range from 4.5 (very low) to 13.5 (very high).

Table 15. The criteria, score and weighting used to generate indices confidence scores.

Criteria	Score	Weighting
Maturity of Methodology	New = 1; Developed = 2; Established = 3	0.36
Validation	Limited = 1; Not comprehensive = 2; Comprehensive = 3	0.71
Representativeness	Low = 1; Moderate = 2; High = 3	2
Directness	Conceptual = 1; Indirect = 2; Direct = 3	0.71
Measured error	>25% = 1; 10% – 25% = 2; <10% = 3	0.71

Environmental Stressors

2022–2023

Written by Adam Shand

As part of the results for the Townsville Dry Tropics Report Card 2024 (Reporting on data from July 2022– June 2023)

Healthy Waters Partnership for the Dry Tropics (HWP)

July 2024

9 Environmental Stressors in The Townsville Dry Tropics Region

Environmental stressors such as extreme climate and intensive land use are an influential factor for almost every indicator measured in the Technical Report. For the 2022–2023 report period, the Townsville Dry Tropics region experienced a variety of climatic conditions. Overall, the region could be described as having been rainier, and hotter than usual. The land use category data showed a large amount of urban/intensive and conservation land uses. Key points are summarised below:

- Total rainfall was 1239mm in the Ross Basin, and 1425mm in the Black Basin. Annual rainfall in both basins was classified as “average”, although exceeded the long-term mean (calculated from the most recent 30-year block of data: 1991 to 2020) of 1061mm and 1420mm respectively.
- Monthly rainfall ranged from “very much below average” to “very much above average” for the respective monthly means throughout the year.
    - Months above their monthly average occurred in late 2022, whilst those below their monthly average occurred in 2023.
- The annual average air temperature was 24.8°C in the Ross Basin, and 24.2°C in the Black Basin and was classified as “very much above average” in both basins.
    - Annual mean temperatures exceeded the long-term mean (calculated from the oldest 30-year block of data available in the dataset (from 1911 to 1940) by 1.1°C in both basins.
- Monthly air temperatures were measured as the “highest 1%” on record for five months of the year.
    - These excessive temperatures were recorded before and after summer (but not during), leading to an extended summer with no reprieve, but also no record breaking absolute maximum temperatures.
- The annual average sea surface temperature was 27.1°C, nearly 1 °C above the long-term average of 26.2°C.
    - Despite this, monthly sea surface temperatures remain average or very slightly above the average for some months of the year (Figure 14).
- The risk of coral bleaching ranged from “low risk” to “possible”, with most of the marine zone experiencing between 0 to 4 Degree Heating Weeks.
- Grazing and conservation remain the two largest land use types by area. (Ross: 30.6% Conservation, 45.3% Grazing. Black: 43.0% Conservation, 39.9% Grazing).

9.1 Land Use

Land use data describes what the dominant use for the land is, with nationally consistent descriptions set by the Australian Land Use and Management (ALUM) Classification system (Department of Agriculture, Fisheries and Forestry 2023). Land use in the Townsville Dry Tropics region in 2021 is summarised in Table 16, and Figure 5.

Table 16. Total area and percentage of land use classes in the Townsville Dry Tropics region in 2021.

Land Use (2021)	Ross Basin		Black Basin	
	%	km²	%	km²
Conservation	30.6	538.1	43.0	492.6
Dryland Agriculture	0.0	0.6	0.1	1.1
Forestry	2.6	45.0	6.8	78.0
Grazing	45.3	795.1	39.9	456.9
Irrigated Agriculture	0.6	10.8	1.8	20.3
Mining	0.3	5.5	0.5	5.3
Urban/Intensive	12.7	223.6	5.4	62.1
Water	7.8	137.6	2.6	29.4
Total Area	-	1756.2	-	1145.9

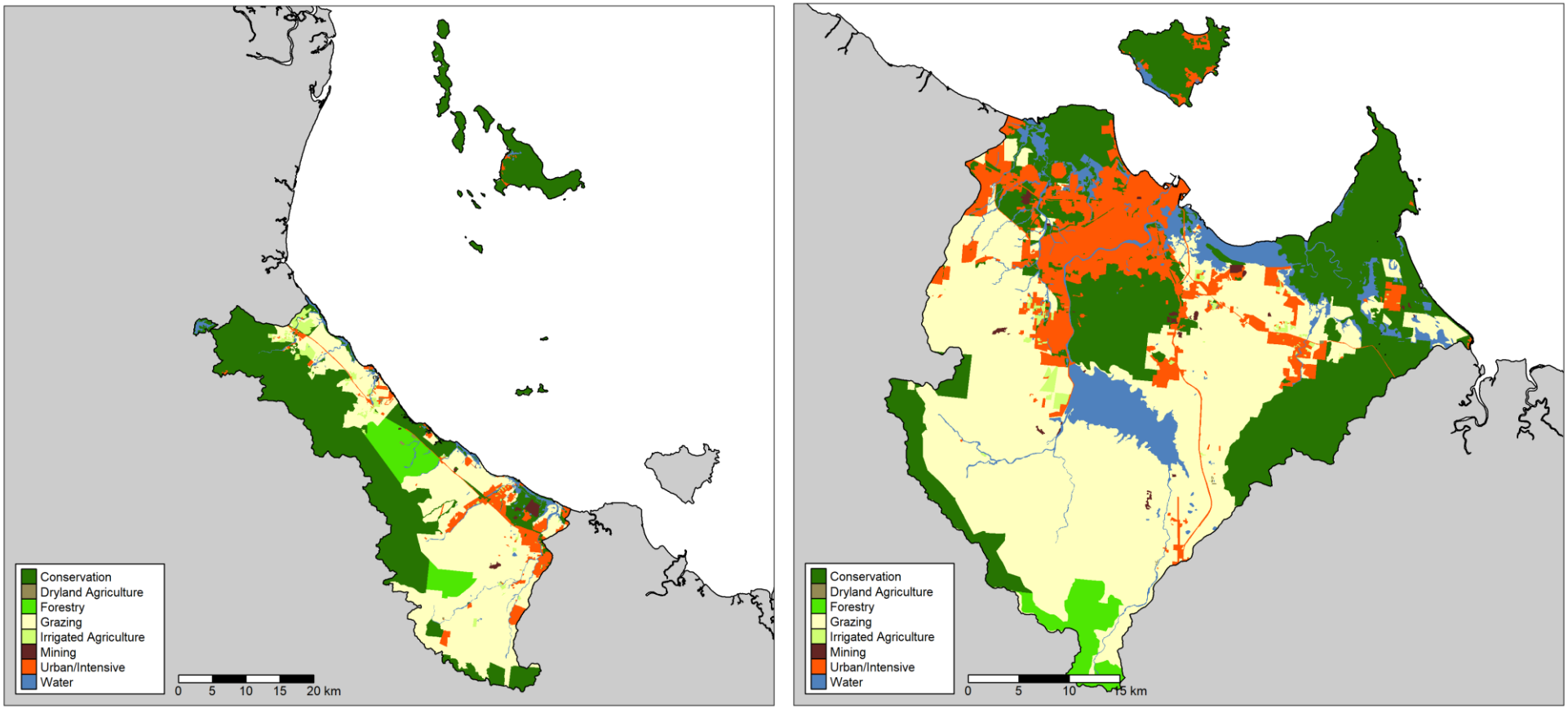

Figure 5. Land use categories in the Ross Basins and Black Basins of the Dry Tropics region in 2021.

9.2 Climate

A changing climate and extreme weather can have a major impact on the health of the environment both globally and within the Townsville Dry Tropics region. These forces directly and indirectly put pressure on local waterways and can influence the results presented in this report (IPCC 2022, United Nations 2023). Between 1st July 2022 and 30th June 2023, the Townsville Dry Tropics region recorded no major flooding events, cyclones, or changes to the prevailing La Niña conditions (Bureau of Meteorology 2023). Key influences for the 2022–2023 reporting period are summarised below.

9.2.1 Rainfall

Monthly rainfall across the Townsville Dry Tropics region was unevenly distributed, with monthly percentile rainfall in the Ross and Black basins ranging from "very much above average" (90th - 99th percentile) to "very much below average" (1st – 10th percentiles). The monthly averages are calculated from the most recent 30-year block of data: 1991 to 2020 (Table 17).

Table 17. Monthly rainfall percentiles in the Ross Basin and Black Basin grouped into seven categories.

Basin	2022							2023					Annual
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
Ross													
Black													

■ = Lowest 1% | ■ = Very much below average | ■ = Below Average | ■ = Average | ■ = Above Average | ■ = Very much above average | ■ = Highest 1%

In both basins this translated to periods of high intensity rainfall followed by episodes of low to no rainfall. However, in the Ross Basin these peaks and troughs are mostly (excluding late Oct) still aligned with the expected seasonal variation (as shown in (Figure 6)). However, in the Black Basin, this translated to the peaks and troughs of rainfall consistently occurring earlier than would be expected (Figure 7).

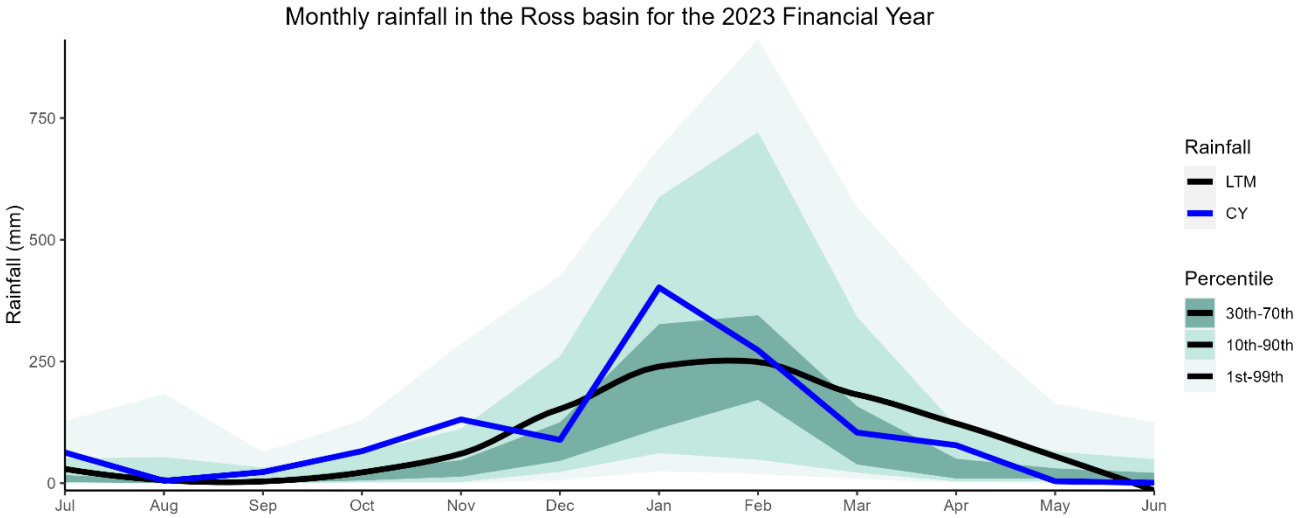

Figure 6. Monthly rainfall in the Ross Basin in comparison to the long-term mean (calculated from 1991 to 2020). The Blue line indicates rainfall for the current financial year. The black line indicates the long-term rainfall. The dark green shading represents the 30th to 70th percentiles of the long-term mean, the medium green shading represents the 10th to 90th percentiles of the long-term mean, and the light green shading represents the 1st to 99th percentiles of the long-term mean.

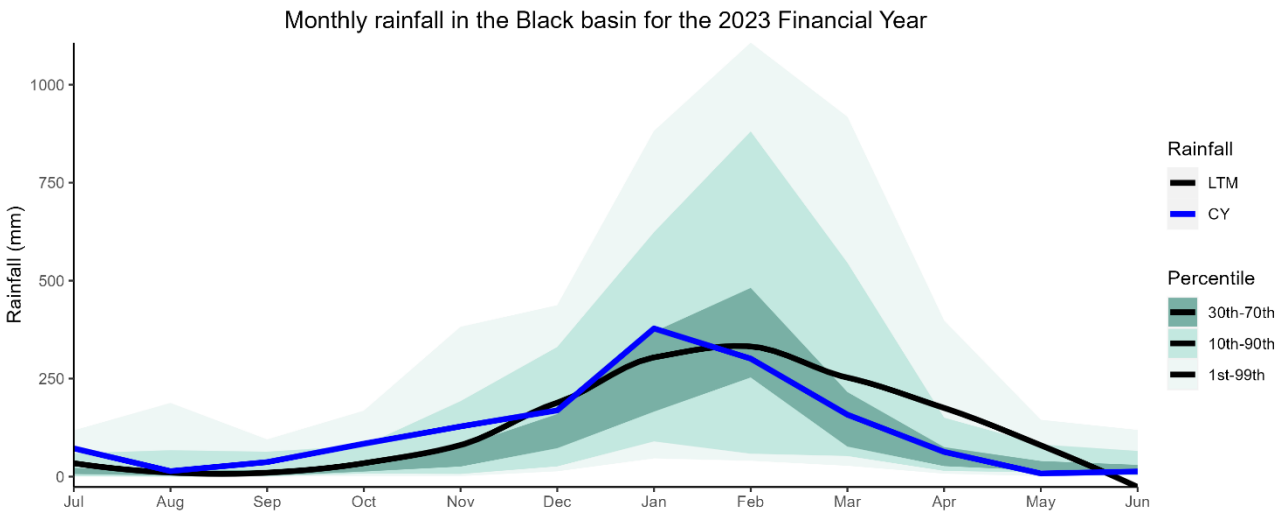

Figure 7. Monthly rainfall in the Black Basin in comparison to the long-term mean (calculated from 1991 to 2020). The Blue line indicates rainfall for the current financial year. The black line indicates the long-term rainfall. The dark green shading represents the 30th to 70th percentiles of the long-term mean, the medium green shading represents the 10th to 90th percentiles of the long-term mean, and the light green shading represents the 1st to 99th percentiles of the long-term mean.

Total annual rainfall was 1239mm in the Ross Basin, and 1425mm in the Black Basin. This was greater than the long-term mean (calculated from the most recent 30-year block of data: 1991 to 2020) by 178mm and 5mm respectively (Table 18).

Table 18. Annual rainfall summary statistics for the Ross Basin and Black Basin.

Basin	Annual Rainfall	Long-term mean 1991-2020 (ltm)	Anomaly (+/- ltm)	Percentage of the ltm
Ross	1239mm	1061mm	+178mm	116.8%
Black	1425mm	1420mm	+5mm	100.4%

Annual rainfall was the greatest in the north of the Black Basin with just over 2000mm, while the least amount of rainfall was recorded on the western ridge of the Ross and Black Basins with only 800 to 1000mm. Interestingly, the western ridge of both basins received significantly less rain than usual and were the only areas to record below average annual rainfall (Figure 8, Figure 9). Historic annual rainfall trends for each basin are presented in Appendix A and Appendix B. Season specific annual rainfall trends for each basin are presented in Appendix C.

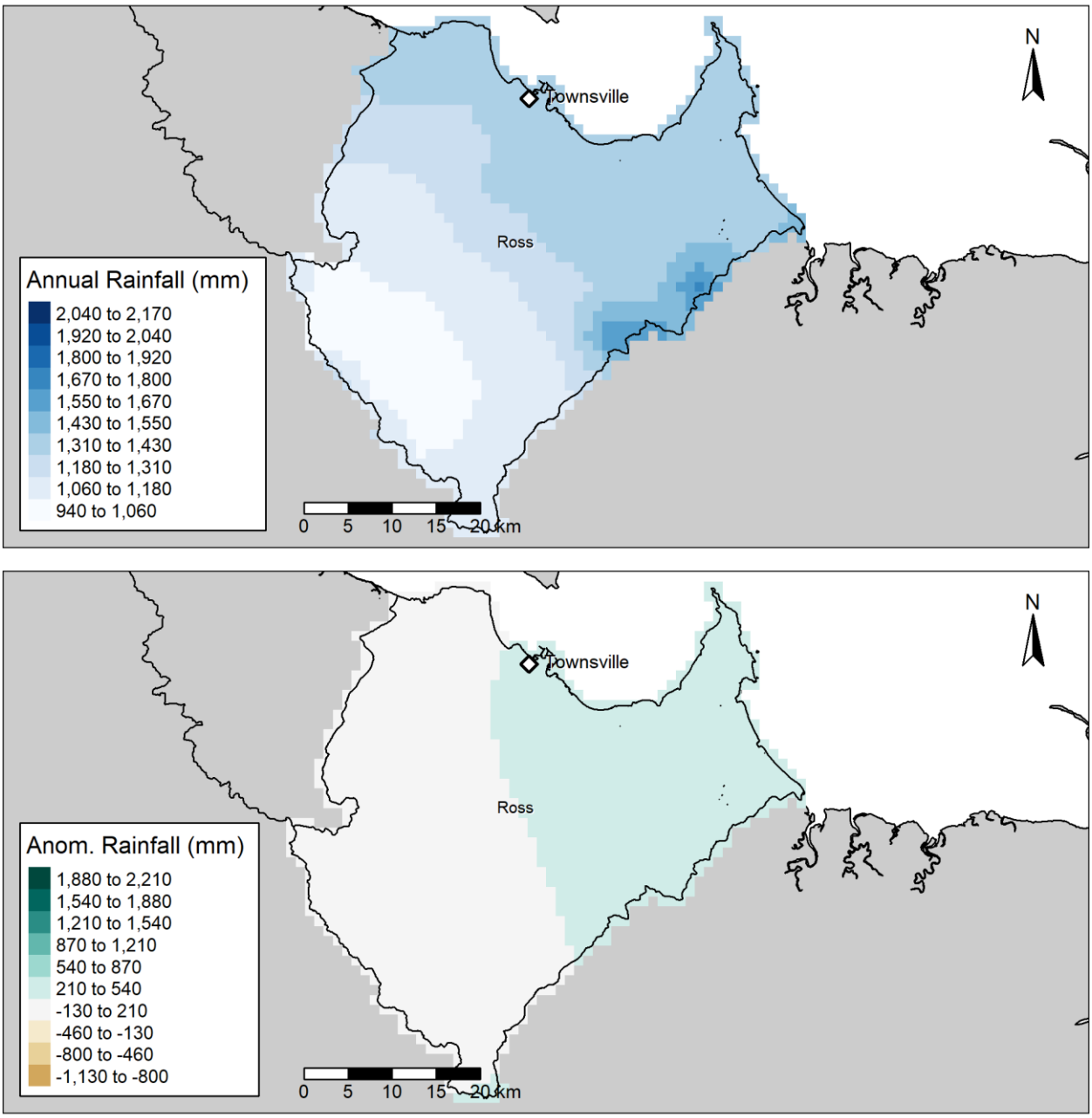

Figure 8. Total annual rainfall for the Ross Basin, of the Dry Tropics region for 2022-2023, and the anomaly of the 2022-2023 rainfall from the long-term mean (i.e., how much more or less (mm) was the 2022-2023 rainfall in comparison to the long-term historic average. Rainfall values were derived by summing monthly averages calculated across spatial grid sub-sets of each basin. The long-term mean was calculated from the most recent 30-year block (climate normal), which is 1991-2020. The scale for the annual rainfall map is based on the actual rainfall recorded for the financial year across the entire Dry Tropics Region (inclusive of the Black Basin). The scale for the anomaly rainfall map is based on the absolute min and max anomaly values recorded within the 30-year reference period inclusive of the current financial year.

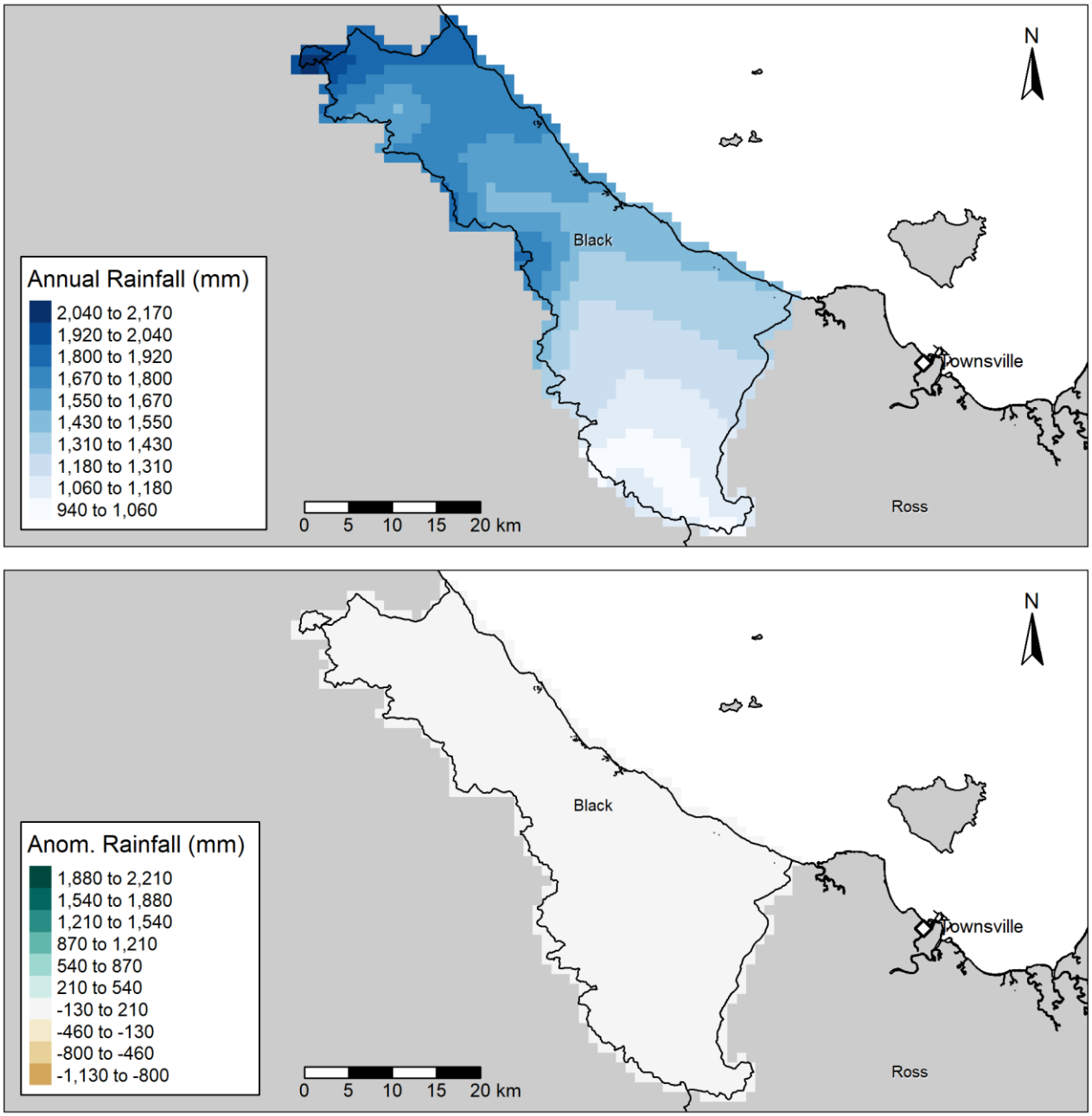

Figure 9. Total annual rainfall for the Black Basin, of the Dry Tropics region for 2022-2023, and the anomaly of the 2022-2023 rainfall from the long-term mean (i.e., how much more or less (mm) was the 2022-2023 rainfall in comparison to the long-term historic average. Rainfall values were derived by summing monthly averages calculated across spatial grid sub-sets of each basin. The long-term mean was calculated from the most recent 30-year block (climate normal), which is 1991-2020. The scale for the annual rainfall map is based on the actual rainfall recorded for the financial year across the entire Dry Tropics Region (inclusive of the Ross Basin). The scale for the anomaly rainfall map is based on the absolute min and max anomaly values recorded within the 30-year reference period inclusive of the current financial year.

9.2.2 Air Temperature

Mean monthly air temperature fluctuated above and below the respective monthly means in both basins throughout the reporting period, however, was predominantly greater than average. For only one month of the year in each basin were temperatures "below average", whilst for five months of the year temperatures in each basin were in the "highest 1%" on record (Table 19). The monthly averages which are compared to the current year of data are calculated from the oldest 30-year block of data available in the dataset (from 1911 to 1940). The selection of this data was in effort to establish a "pre-industrial" baseline for comparison.

Table 19. Monthly air temperature percentiles in the Ross Basin and Black Basin grouped into seven categories.

Basin	2022					2023							Annual
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
Ross													
Black													

■ = Lowest 1% | ■ = Very much below average | ■ = Below Average | ■ = Average | ■ = Above Average | ■ = Very much above average | ■ = Highest 1%

Although for five months of the year temperatures recorded were in the "highest 1%", maximum temperatures during the summer months did not exceed their respective monthly averages (Dec, Jan, Feb). Instead, above average temperatures were recorded in the months leading up to, and preceding, summer. This created an extended, "tabletop", summer with no reprieve, but also no record breaking absolute maximum temperatures. I.e., summer started earlier and finished later. This is clearly visible in Figure 10 and Figure 11.

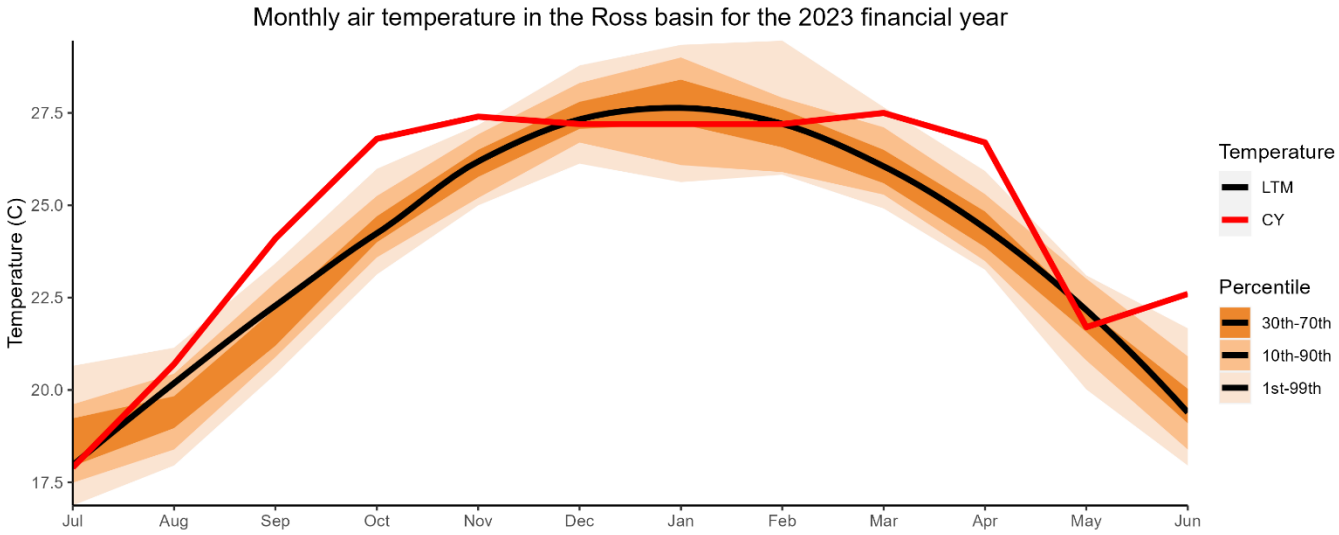

Figure 10. Monthly air temperature in the Ross Basin in comparison to the long-term mean (calculated from 1911 to 1940). The red line indicates air temperature for the current financial year. The black line indicates the long-term air temperature. The dark orange shading represents the 30th to 70th percentiles of the long-term mean, the medium orange shading represents the 10th to 90th percentiles of the long-term mean, and the light orange shading represents the 1st to 99th percentiles of the long-term mean.

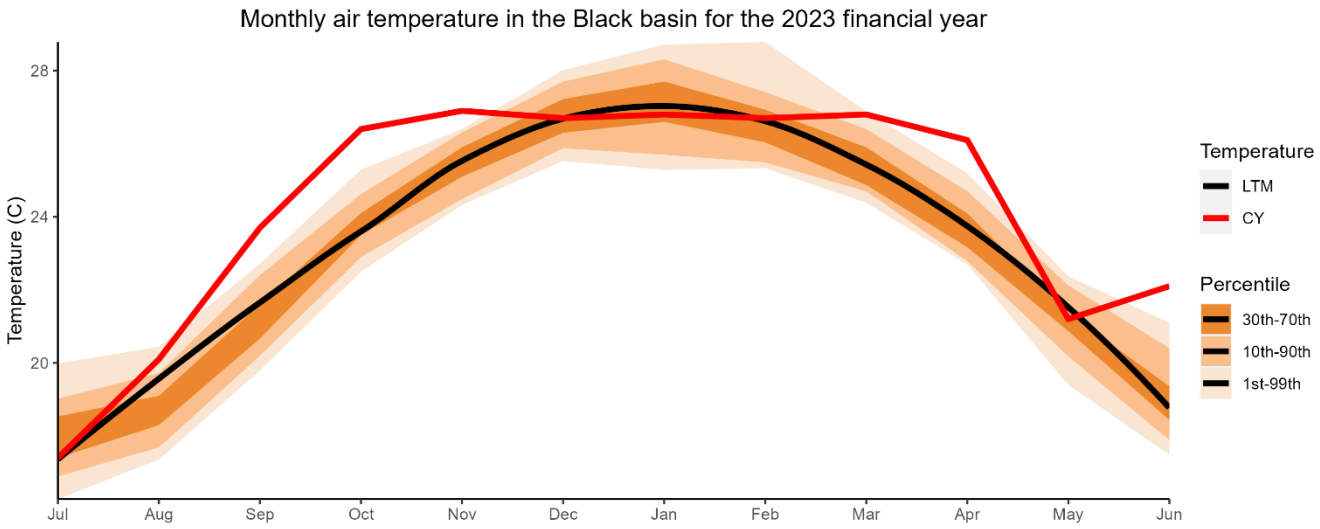

Figure 11. Monthly air temperature in the Black Basin in comparison to the long-term mean (calculated from 1911 to 1940). The red line indicates air temperature for the current financial year. The black line indicates the long-term air temperature. The dark orange shading represents the 30th to 70th percentiles of the long-term mean, the medium orange shading represents the 10th to 90th percentiles of the long-term mean, and the light orange shading represents the 1st to 99th percentiles of the long-term mean.

The mean annual air temperature was 24.8°C in the Ross Basin, and 24.2°C in the Black Basin. This was greater than the long-term mean (calculated from the oldest 30-year block of data available in the dataset (from 1911 to 1940) by 1.1°C in both basins (Table 20).

Table 20. Annual air temperature summary statistics for the Ross Basin and Black Basin.

Basin	Annual Air Temperature	Long-term mean 1911-1940 (ltm)	Anomaly (+/- ltm)	Percentage of the ltm
Ross	24.8°C	23.7°C	+1.1°C	104.6%
Black	24.2°C	23.1°C	+1.1°C	104.8%

Mean annual temperatures ranged from 20.6°C along the hinterlands of the Black Basin and mountains of the Ross Basin, to 25.5°C along the coastal regions of each basin. All areas within the Townsville Dry Tropics region recorded a mean annual temperature greater than that of the long-term mean (calculated from 1991-1940), with a greater difference apparent along the coastline (Figure 12 and Figure 13). Historic annual temperature trends for each basin are presented in Appendix C and Appendix E.

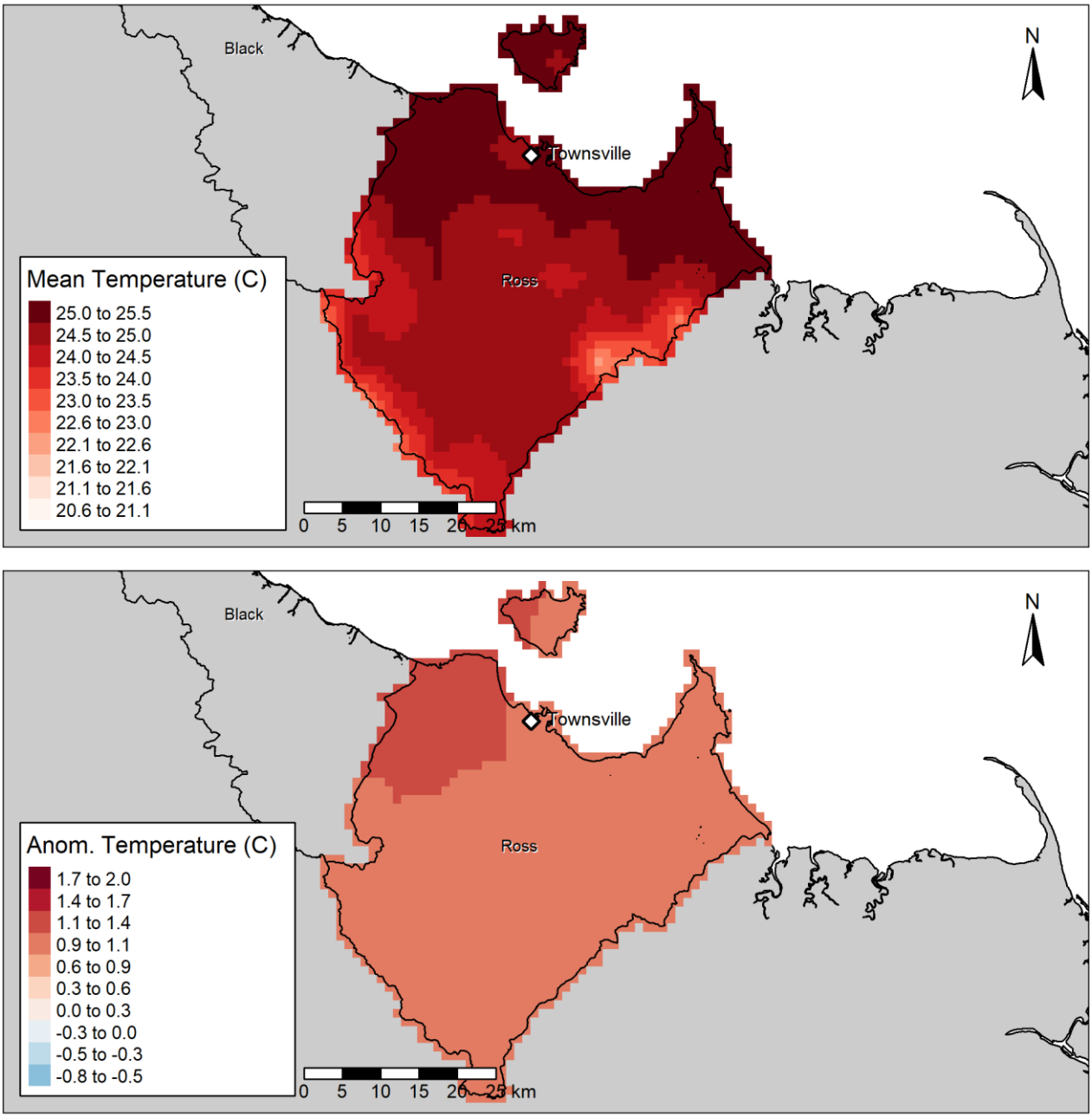

Figure 12. Mean annual air temperature for the Ross Basin, of the Dry Tropics region for 2022-2023, and the anomaly of the 2022-2023 air temperature from the long-term mean (i.e., how much more or less (C) was the 2022-2023 air temperature in comparison to the long-term historic average. Air temperature values were derived by taking the mean of monthly averages calculated across spatial grid sub-sets of each basin. The long-term mean was calculated from the oldest 30-year block (climate normal), which is 1911-1940. The scale for the annual air temperature map is based on the actual air temperature recorded for the financial year across the entire Dry Tropics Region (inclusive of the Black Basin). The scale for the anomaly air temperature map is based on the absolute min and max anomaly values recorded within the 30-year reference period, or, within the past 5-years (as the greatest anomalies mostly occurred during recent reporting years).

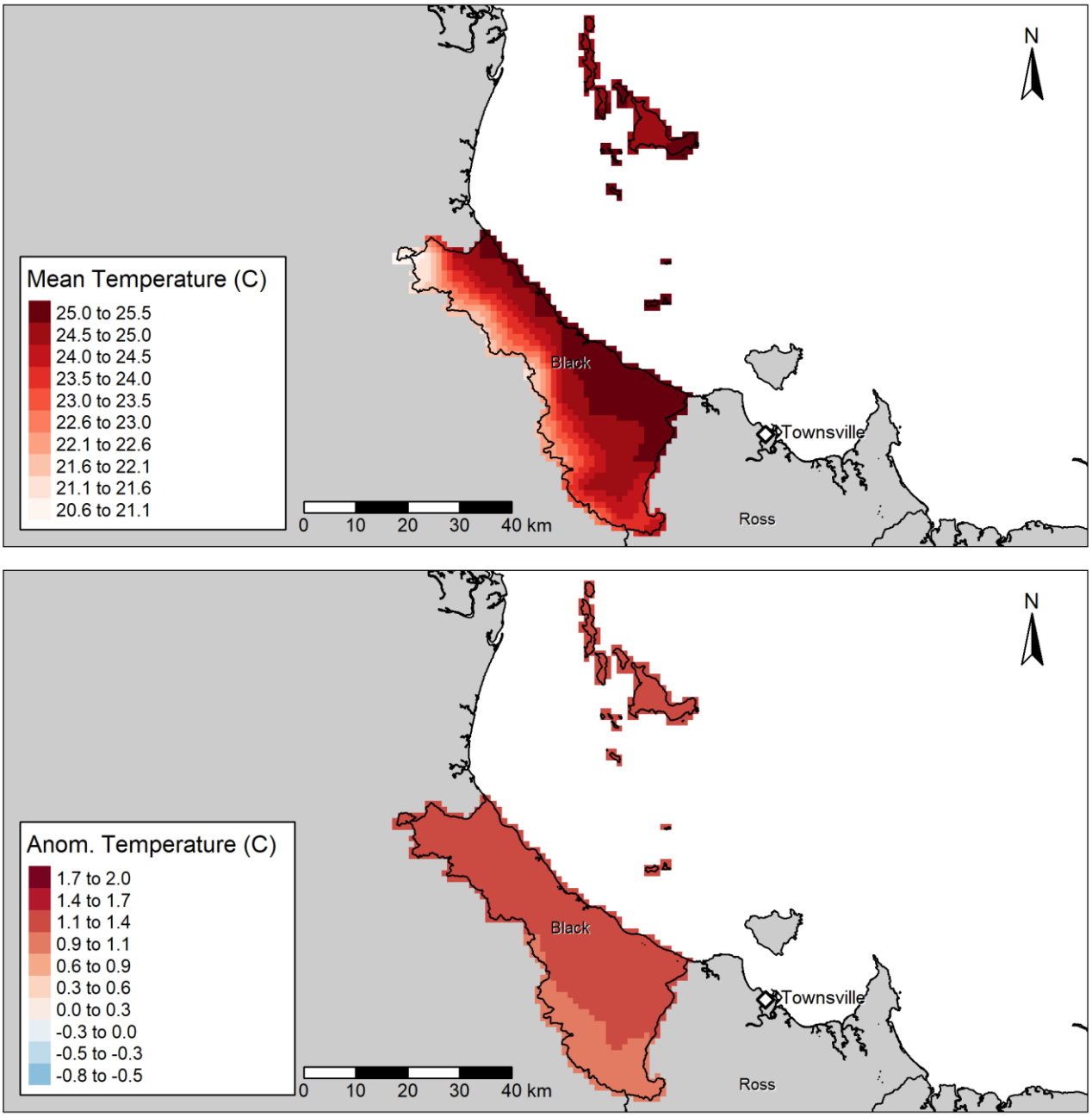

Figure 13. Mean annual air temperature for the Black Basin, of the Dry Tropics region for 2022-2023, and the anomaly of the 2022-2023 air temperature from the long-term mean (i.e., how much more or less (C) was the 2022-2023 air temperature in comparison to the long-term historic average. Air temperature values were derived by taking the mean of monthly averages calculated across spatial grid sub-sets of each basin. The long-term mean was calculated from the oldest 30-year block (climate normal), which is 1911-1940. The scale for the annual air temperature map is based on the actual air temperature recorded for the financial year across the entire Dry Tropics Region (inclusive of the Ross Basin). The scale for the anomaly air temperature map is based on the absolute min and max anomaly values recorded within the 30-year reference period, or, within the past 5-years (as the greatest anomalies mostly occurred during recent reporting years).

9.2.3 Sea Surface Temperature

Monthly sea surface temperature in the Townsville Dry Tropics marine region was average or "above average" for every month of the reporting period. In July, August, and February, sea surface temperatures for the month were average, and for every other month of the year, the month was above its own monthly average. The monthly averages are calculated from the most recent 30-year block of data: 1991 to 2020 (Table 21).

Table 21. Monthly sea surface temperature percentiles in the Ross Basin and Black Basin grouped into seven categories.

Region	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual
TSV													

■ = Lowest 1% | ■ = Very much below average | ■ = Below Average | ■ = Average | ■ = Above Average | ■ = Very much above average | ■ = Highest 1%

Although all monthly temperatures meet or exceeded their long-term monthly temperature averages for every month of the year, the 2022-2023 financial year did not experience any significant coral bleaching (Section 9.2.4). This may be because although the summer temperatures occurred earlier, and extended later than normal, peak summer temperatures were not as extreme (Figure 14). This created a "tabletop", summer with no reprieve, but also lower absolute maximum temperatures.

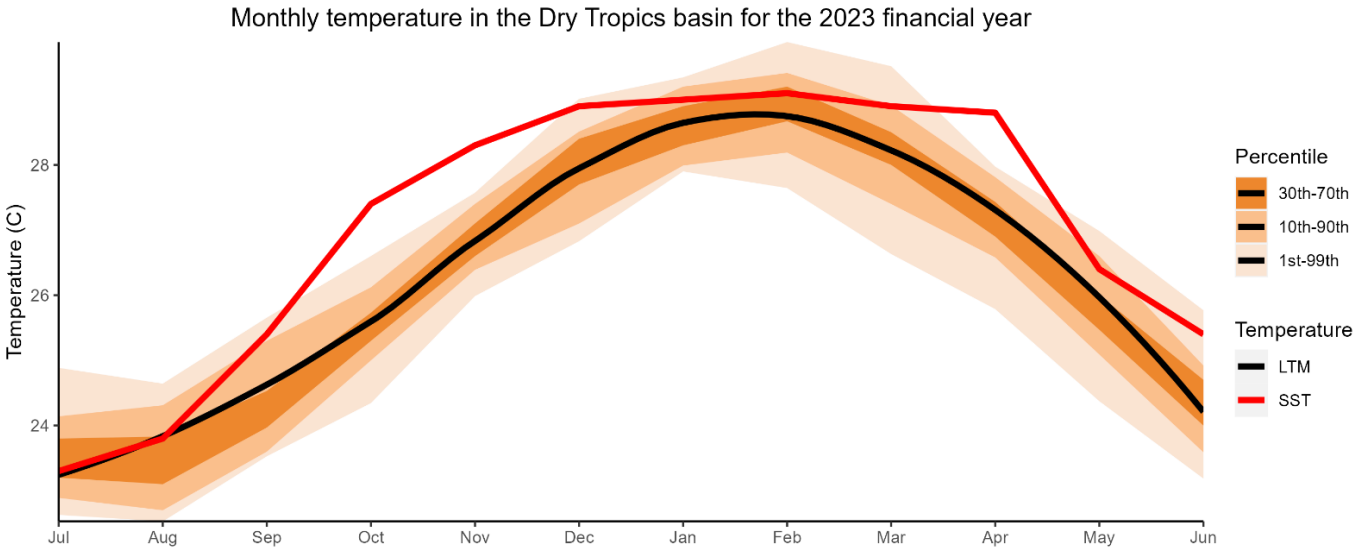

Figure 14. Monthly sea surface temperature in the Dry Tropics marine environment in comparison to the long-term mean (calculated from 1991 to 2020). The red line indicates the temperature for the current financial year. The black line indicates the long-term temperature. The dark orange shading represents the 30th to 70th percentiles of the long-term mean, the medium orange shading represents the 10th to 90th percentiles of the long-term mean, and the light orange shading represents the 1st to 99th percentiles of the long-term mean.

The mean annual sea surface temperature in the Townsville Dry Tropics marine region was 27.1°C, the same temperature as the previous reporting period. However, this was greater than the long-term mean (calculated from the most recent 30-year block of data: 1991 to 2020) by 0.9°C (Table 22).

Table 22. Annual sea surface temperature summary statistics for the Townsville Dry Tropics marine region.

Region	Annual Sea Surface Temperature	Long-term mean 1991-2020 (ltm)	Anomaly (+/- ltm)	Percentage of the ltm
Townsville Dry Tropics	27.1°C	26.2°C	+0.9°C	103.4%

The highest temperatures were recorded in the northern most reaches of the marine region and gradually decreased southward. Annual sea surface temperature anomalies highlighted that despite low monthly temperatures, annual temperatures remain average or very slightly above average (Figure 15). Historic annual sea surface temperature trends are presented in Appendix F.

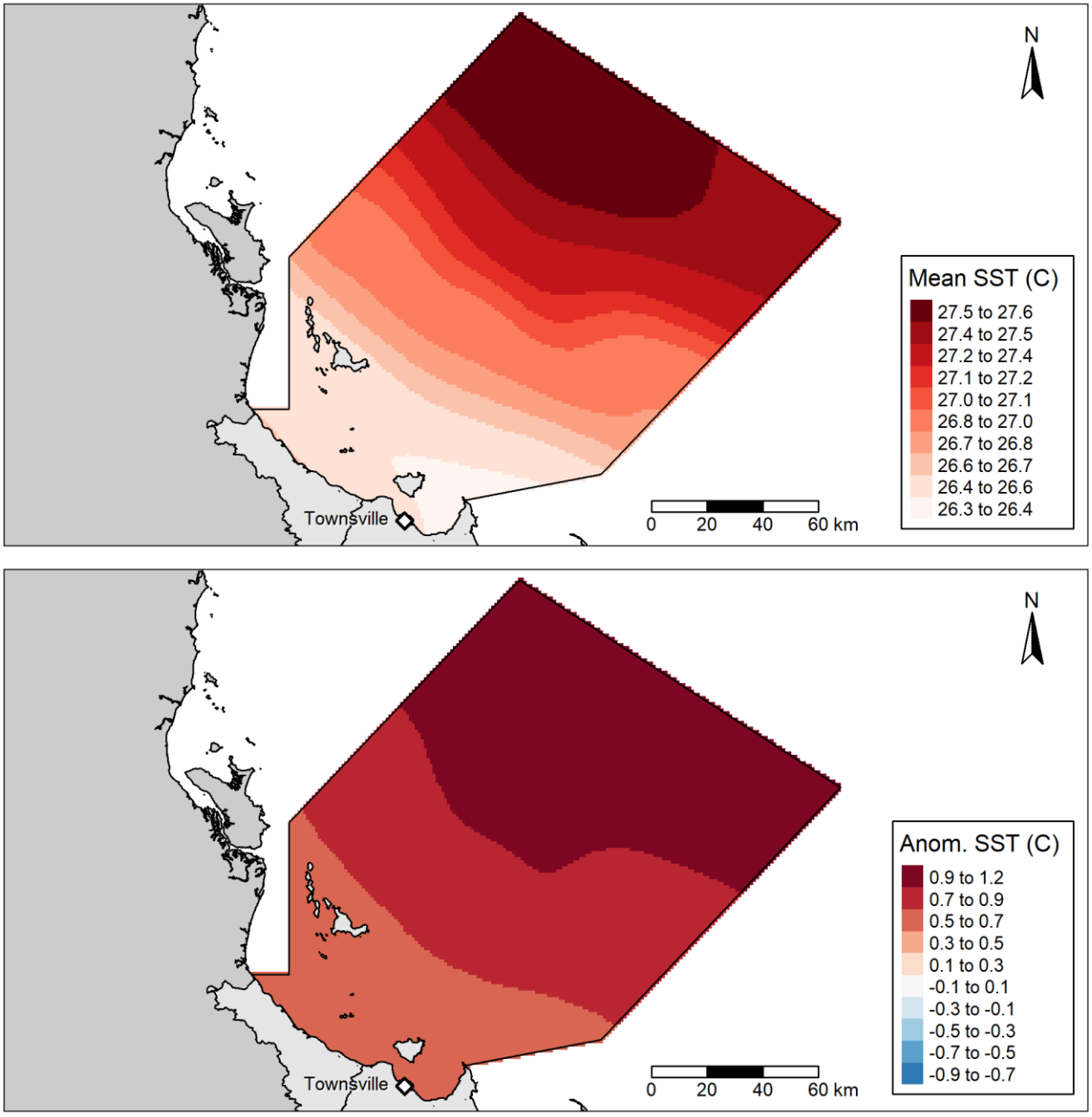

Figure 15. Total annual sea surface temperature for the Dry Tropics Region for 2022-2023, and the anomaly of the 2022-2023 sea surface temperature from the long-term mean (i.e., how much more or less (C) was the 2022-2023 sea surface temperature in comparison to the long-term historic average. Sea surface temperature values were derived by taking the mean of monthly averages calculated across spatial grid sub-sets of each basin. The long-term mean was calculated from the most recent 30-year block (climate normal), which is 1991-2020. The scale for the annual sea surface temperature map is based on the actual sea surface temperature recorded for the financial year across the entire Dry Tropics Region. The scale for the anomaly sea surface temperature map is based on the absolute min and max anomaly values recorded within the 30-year reference period inclusive of the current financial year.

9.2.4 Degree Heating Weeks (Coral Bleaching)

Mass coral bleaching has been linked to prolonged periods of heat stress (Glynn and D'Croz 1990). NOAA's Coral Reef Watch degree heating week (DHW) dataset provides a measure of this heat stress and acts as a proxy to coral bleaching (NOAA 2023). In 2022–2023, coral bleaching risk in the Townsville Dry Tropics marine region ranged from "low risk" to "possible", with only a very small area showing a bleaching risk of possible (not inclusive of the entire GBR region). Coral bleaching likelihood ranged from "low likelihood of bleaching (0-2 DHWs)" to "bleaching possible (4-6 DHWs)", with only a very small fraction of the region recording DHWs of 4 or greater (Figure 16). Although above-average water temperatures occurred from October to December 2022 (Figure 14), increased rainfall in early 2023 (Figure 6, Figure 7) was found to have stopped further heat accumulation of waters of the GBR (AIMS 2023). Historic degree heating week are presented in Appendix G.

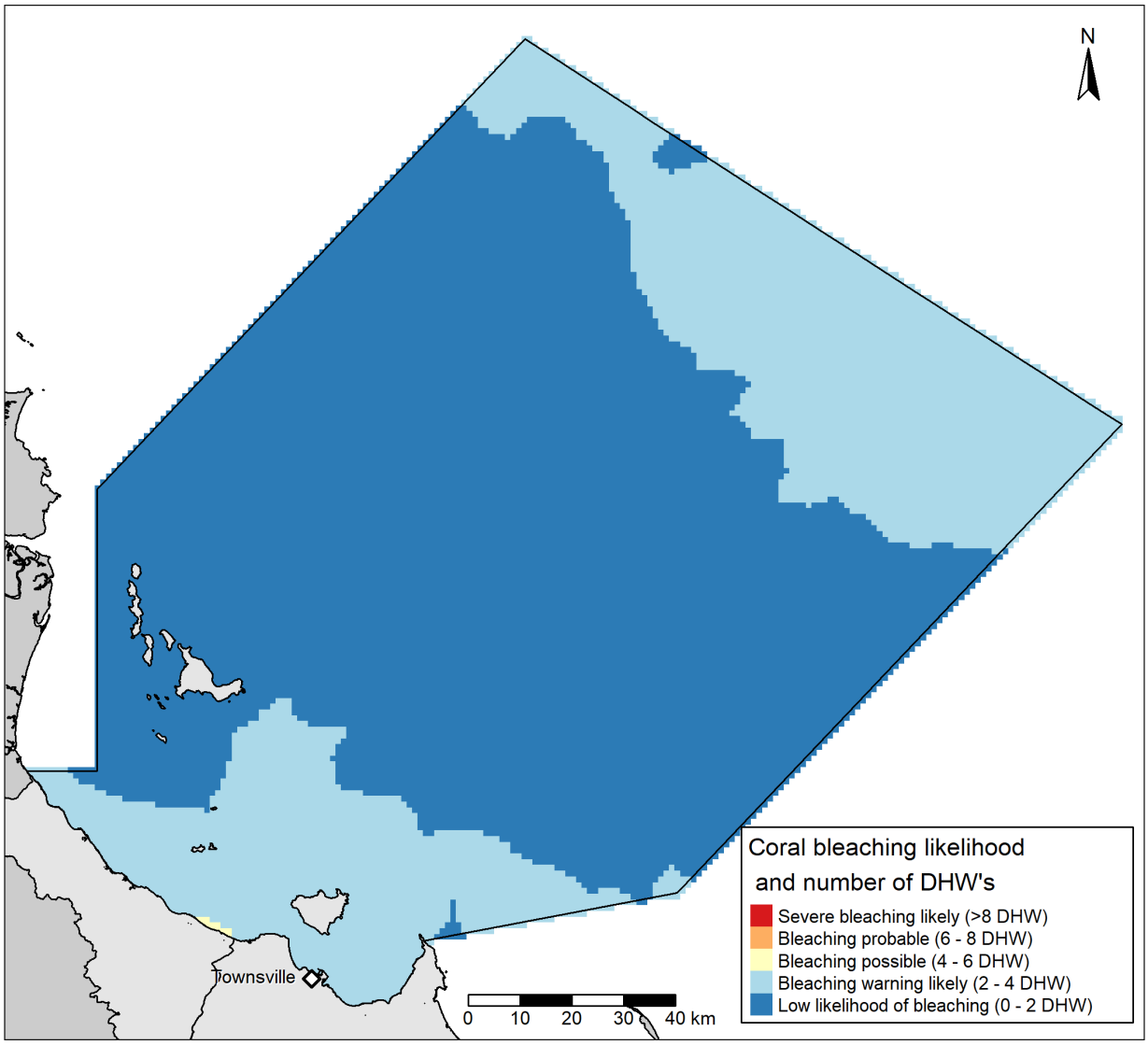

Figure 16. Total annual degree heating weeks (bleaching events) in the Dry Tropic marine region for the 2022-2023 financial year.

Freshwater 2022–2023

Written by Adam Shand

As part of the results for the Townsville Dry Tropics Report Card 2024 (Reporting on data from July 2022– June 2023)

Healthy Waters Partnership for the Dry Tropics (HWP)

July 2024

10 Freshwater Environment

Within the freshwater environment, water quality, pesticides, habitat and hydrology, and fish are the four indices scored. Each of these indices are made up of indicator categories and indicators which are updated on varying time scales from annually to every three to four years. All indicator categories use data provided by multiple partners of the Partnership. In the Townsville Dry Tropics region, the water quality and pesticides indices are updated annually, with the most recent data from the 2022–2023 financial year.

For the first time since the Partnership began reporting, the Pesticides index has been included in the technical report. However, as of the 2022-2023, report the pesticides index is not combined with the water quality index and is not representative of the entire Ross and Black Basins, but rather the specific sampling sites within the Ross and Black Basins. This is because it uses a different method of calculation in comparison to the other water quality measures and data is only sourced from two locations.

Index scores are calculated for the Ross Freshwater Basin and the Black Freshwater Basin. The extent of each basin is shown in Figure 17 (below), and the results are presented below.

10.1 Water Quality

The water quality index for the freshwater environment of the Townsville Dry Tropics regions consists of two indicator categories: Nutrients, and Physical-Chemical Properties. These are divided into five indicators and for each indicator the parameters used to calculate the scores were the:

- Water Quality Objectives (WQOs);
- Scaling factors (SF);
- Annual medians, calculated from the monthly medians; and
- 80th percentile (and 20th percentile for DO), calculated from the monthly medians, and,
- The weighted basin scores include the proportion of the sub basin area for each basin area.

The Townsville Dry Tropics Methods Document (2024) provides definition of the WQO and SF for each watercourse, and the conversion of the raw data to a standardised score using the annual medians and percentiles, and sub basin weights. Values can also be found in Appendix H and Appendix J.

The nutrients indicator category is comprised of two indicators, Dissolved Inorganic Nitrogen (DIN), and Total Phosphorus (TP) and the scores for nutrients are averaged from the scores of the two indicators. The physical-chemical properties indicator category is comprised of three indicators, Turbidity, High DO, and Low DO. The score is calculated as the average of Turbidity and the minimum score from High DO and Low DO.

10.1.1 Monitoring Sites

Data for the two freshwater indicator categories are collected from the same sites. There are 24 sites (codes) spread across the two basins, divided into eight (8) sub basins in line with the Water Quality Improvement Plan (WQIP) WQIP (Townsville City Council, Queensland Government, Australian Government 2010) (Table 23 and Figure 17).

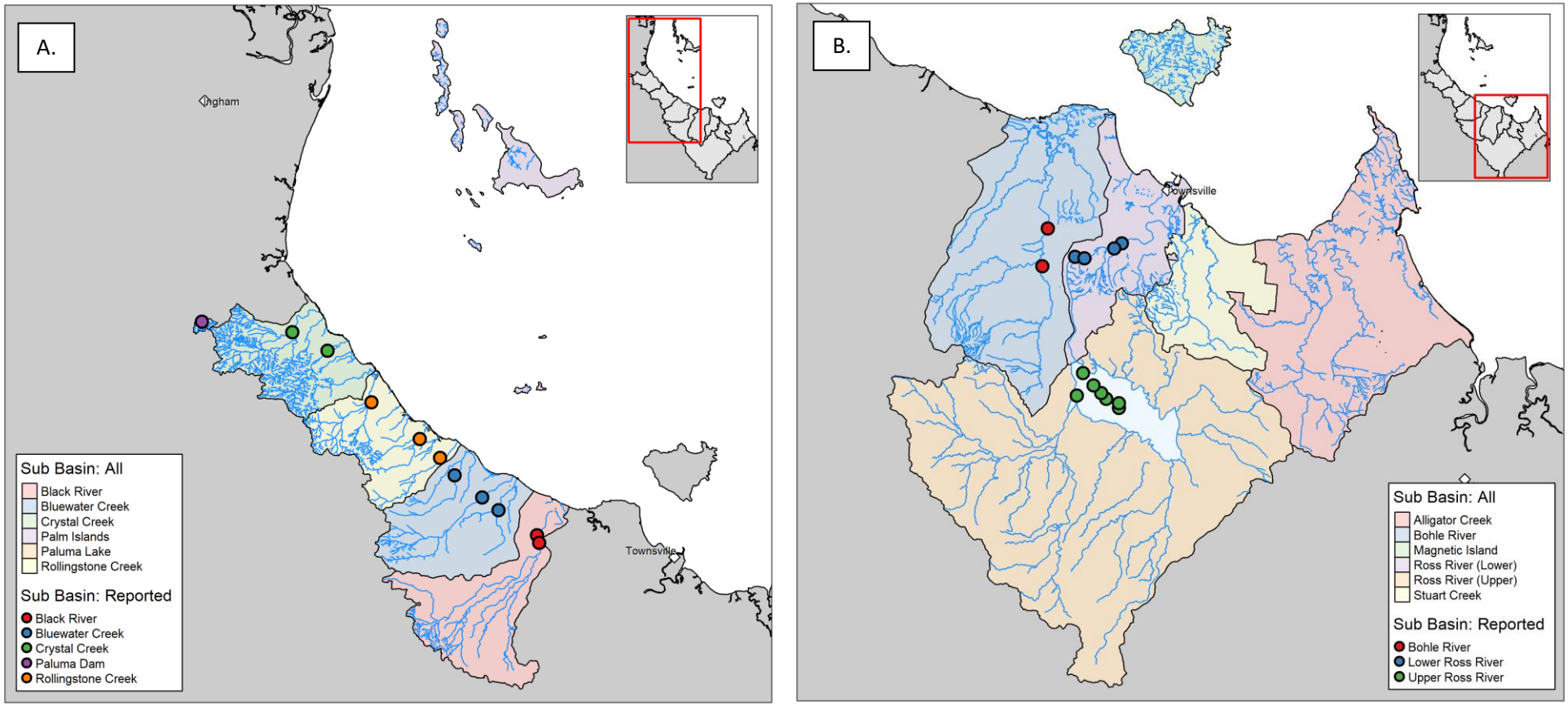

Figure 17. Freshwater basins (A. = Black, B. = Ross), and sub basins (see legend).

Table 23. Townsville Dry Tropics freshwater water quality site summary.

Basin	Sub Basin	Watercourse	Number of Sites
Ross	Upper Ross	Ross Lake	7
	Lower Ross	Ross River	4
	Bohle	Bohle River	2
Black	Black River	Black River	2
	Bluewater Creek	Althaus Creek	1
		Bluewater Creek	1
		Sleeper Log Creek	1
	Rollingstone Creek	Leichhardt Creek	1
		Saltwater Creek	1
		Rollingstone Creek	1
	Crystal Creek	Ollera Creek	1
		Crystal Creek	1
	Paluma	Paluma Lake	1

10.1.2 Overall Summary: Freshwater Water Quality

The overall water quality grade remained "good" in both the Black and Ross Freshwater Basins, however scores decreased noticeably in the Ross Basin (Table 24). This decrease in the Ross was largely driven by a change in grade and score for nutrients ("good"(69) to "moderate" (60)).

Table 24. Freshwater Water Quality Index Scores and Grades with comparison to previous years.

Basin	Nutrients	Phys-Chem Properties	Water Quality				
			22-23	21–22	20–21	19–20	18–19
Ross	60	74	67	70	73	70	66
Black	70	63	66	68	68	67	62

Standardised scoring range: Very Poor (E) = 0 to <21 | Poor (D) = 21 to <41 | Moderate (C) = 41 to <61 | Good (B) = 61 to <81 | Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

10.1.2.1 *Key Messages*

- The Ross Freshwater Basin grade remained "good" although the score declined slightly from 70 to 67.
    - Most influential was the decline in the score for Dissolved Inorganic Nitrogen (DIN) in the Bohle River which saw a decrease in score from 70 to 67 within the same grade of "good".
    - Nutrients in the Ross Freshwater Basin decreased from "good" to "moderate", whilst physical-chemical properties did not change grade.
- The Black Freshwater Basin score decreased from 68 to 66 within the same grade of "good".
    - Neither nutrients nor physical-chemical properties changed notably.
- The Bohle River Total Phosphorus (TP) grade remained "very poor" for the fifth year in a row, and the DIN grade decreased from "poor" to "very poor" compared with 2021-2022.

- Althaus Creek shows ongoing low scores and grades for the TP and Turbidity indicators, and further investigation would be required to isolate specific drivers.
- DIN values in the Upper Ross and Paluma Lake sub basins remain "NA" due to the Water Quality Objective values (WQOs) being equal to or less than the Limit of Reporting values (LOR).

10.1.3 Nutrients

For the 2022–2023 technical report the nutrients indicator category is comprised of two indicators, Dissolved Inorganic Nitrogen (DIN), and Total Phosphorus (TP). The scores and grades for the Ross and Black freshwater basins, and their associated sub basins are presented in Table 25. Annual medians, samples collected, months sampled, WQOs, and SFs are presented in Appendix H. Historical scores are presented in Appendix I.

As there have been continuous gaps in the data for TP, investigation is continuing into the potential to include Filterable Reactive Phosphorus (FRP) in the analysis. Discussions for this are ongoing.

10.1.3.1 *Results: Freshwater Nutrients*

The nutrient indicator category for the Ross Freshwater Basin was graded as "moderate" with a weighted score of 60, a decrease from the previous report of 69 (good). The Upper Ross sub basin maintained its "good" grade, however, did not receive DIN scores as the assigned water quality objective (WQO) is equal to or less than the limit of reporting (LOR). The Lower Ross sub basin maintained a "good" grade, whilst the Bohle River sub basins decreased from "poor" to "very poor". The decrease in grades in the Bohle River sub basin was caused by a decrease in score and grade for the DIN indicator. The source of nutrient inputs continues to require investigation, so that management can be implemented to improve the water quality.

The nutrients indicator category for the Black Freshwater Basin was graded as "good" with a weighted score of 70, an increase from the previous report's score of 68 (good). Sub basins grades for nutrients ranged from "moderate" to "very good", with a "very poor" grade for the TP indicator at Althaus Creek. Despite an overall increase in basin score, TP scores continue to decline at Althaus Creek (Appendix I) and require additional investigation to determine the cause. Paluma Lake did not receive DIN scores due to issues with LOR and WQO values.

Table 25. Unweighted and weighted standardised scores and grades for the nutrient indicators and indicator category in the Townsville Dry Tropics Freshwater Basins.

Basin	Sub Basin	Watercourse	Unweighted Score and Grade					Weighted Score and Grade	
			DIN	TP	Nutrients[3]	Weighting (proportion)	Area (km2)	Sub Basin	Basin
Ross	Upper Ross	Ross Lake	NA[3]	73	73	0.32	458	23.4	60
	Lower Ross	Aplins Weir	62	ND	62	-	-	-	
		Gleesons Weir	59	ND	59	-	-	-	
		Blacks Weir	63	90	76	-	-	-	
			61	90	66	0.56	786	37.1	
	Bohle River	Bohle Mid-Field	0	0	0	-	-	-	
		Bohle Far-Field	0	0	0	-	-	-	
			0	0	0	0.12	169	0	
			37	40	45	1	1413		
Black	Black River	Black River	63	39	51	0.37	250	19.1	70
	Bluewater Creek	Althaus Ck	90	18	54	-	-	-	
		Bluewater Ck	73	90	81	-	-	-	
		Sleeper Log Ck	90	77	83	-	-	-	
			84	61	73	0.24	162	17.6	
	Rollingstone Creek	Leichhardt Ck	90	90	90	-	-	-	
		Saltwater Ck	90	90	90	-	-	-	
		Rollingstone Ck	61	90	75	-	-	-	
			80	90	85	0.21	145	18.3	
	Crystal Creek	Ollera Ck	90	90	90	-	-	-	
		Crystal Ck	90	90	90	-	-	-	
			90	90	90	0.17	116	15.5	
	Paluma Lake	Paluma Lake	NA[4]	90	90	0	2	0.3	
			82	76	79	1	675		

Standardised scoring range: ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 90. (Scores are capped at 90) **|** ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

[3] Sites indicators are average within each indicator to calculate watercourse indicators which are averaged to calculate sub basin indicators. Watercourse indicators are averaged between each indicator to calculate watercourse indicator categories, which are averaged to calculate sub basin indicator categories.

[4] Data removed as the LOR was >= the WQO, and more than half (Ross Lake: 214 of 234, Paluma Lake: 17 of 24) of the concentration values were <= the WQO.

10.1.4 Physical-Chemical Properties

For the 2022–2023 technical report the physical-chemical properties indicator category is comprised of three indicators, Turbidity (NTU), High DO, and Low DO. The scores and grades for the Ross and Black freshwater basins, and their associated sub basins are presented in Table 26. Annual medians, samples collected, months sampled, WQOs, and SFs are presented in Appendix J. Historical scores are presented in Appendix K.

10.1.4.1 *Results: Freshwater Physical-Chemical Properties*

The physical-chemical indicator category for the Ross Freshwater Basin was graded as “good” with a weighted score of 74, an increase from the previous report of 68 (good). The Upper Ross sub basin was graded as “very good”, the Lower Ross sub basin was graded as “good”, and the Bohle River sub basin was graded as “moderate”. Both the Upper Ross and Bohle sub basins did not record a change in grade, however the Lower Ross basin increased (from “moderate” to “good”). This increase was driven by improvements in the low DO indicator at the Gleeson and Blacks Weir sites (increased from “very poor” to “good” and “moderate” respectively).

The physical-chemical indicator category for the Black Freshwater Basin was graded as “good” with a weighted score of 63, a slight decrease from the previous report of 64 (good). Sub basins grades ranged from “moderate” to “good”. However, turbidity was “very poor” at Althaus Creek and Sleeper Log Creek, and low DO was “very poor” at Ollera Creek. Despite little change in the overall basin score, turbidity scores continue to remain “very poor” at Althaus Creek and Sleeper Log Creek and require additional investigation to determine the cause.

Table 26. Unweighted and weighted standardised scores and grades for the physical-chemical properties indicators and indicator category in the Townsville Dry Tropics Freshwater Basins.

Basin	Sub Basin	Watercourse	Unweighted Score and Grade						Weighted Score and Grade	
			Turbidity	High DO	Low DO	PhysChem	Weighting (proportion)	Area (km2)	Sub Basin	Basin
Ross	Upper Ross	Ross Lake	90	90	90	90	0.32	458	28.8	74
	Lower Ross	Aplin's Weir	90	90	46	68	-	-	-	
		Gleesons Weir	90	90	67	78	-	-	-	
		Blacks Weir	90	90	44	67	-	-	-	
			90	90	53	71	0.56	786	40.0	
	Bohle River	Bohle Mid-Field	62	90	50	56	-	-	-	
		Bohle Far-Field	63	90	0	31	-	-	-	
			63	90	25	44	0.12	169	5.3	
			81	90	49	65	1	1413		
Black	Black River	Black River	72	64	90	68	0.37	250	25.4	63
	Bluewater Creek	Althaus Ck	0	51	90	25	-	-	-	
		Bluewater Ck	70	90	62	66	-	-	-	
		Sleeper Log Ck	13	90	72	43	-	-	-	
			28	77	75	45	0.24	162	10.8	
	Rollingstone Creek	Leichhardt Ck	68	90	62	65	-	-	-	
		Saltwater Ck	57	90	90	73	-	-	-	
		Rollingstone Ck	90	90	51	70	-	-	-	
			72	90	67	69	0.2148	145	15	
	Crystal Creek	Ollera Ck	90	90	0	45	-	-	-	
		Crystal Ck	90	90	90	90	-	-	-	
			90	90	45	67	0.1719	116	11.6	
	Paluma Lake	Paluma Lake	90	90	52	71	0.003	2	0.2	
			64	83	66	62	1	675	64	

Standardised scoring range: ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 90. (Scores are capped at 90) | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

10.1.5 Confidence Scores

There was low confidence in the water quality scores for the Ross Freshwater Basin due to limited spatial sampling in the basin, with only two rivers and Ross Lake sampled. There was moderate confidence in the water quality scores for the Black Freshwater Basin, with most major watercourses sampled. The score for each criterion is shown in Table 27.

Table 27. Confidence scores for the freshwater water quality indicator categories.

Basin	Indicator category	Maturity (*0.36)	Validation (*0.71)	Representativeness (*2)	Directness (*0.71)	Measured error (*0.71)	Final Score	Rank
Ross	Nutrients	2	3	1	3	1	7.6	Low (2)
	Phys-chem	2	3	1	3	1	7.6	Low (2)
	Water quality index						7.6	Low (2)
Black	Nutrients	2	3	1.5	3	1	8.6	Mod (3)
	Phys-chem	2	3	1.5	3	1	8.6	Mod (3)
	Water quality index						8.6	Mod (3)

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

Confidence criteria were scored 1–3 and weighted by the value identified in parenthesis. Weighted scores were summed to produce a final score (4.5 – 13.5). Final scores were ranked from 1 to 5 (very low to very high).

10.2 Pesticides

The pesticides index (Pesticides Risk Metric – PRM) for the freshwater environment of the Townsville Dry Tropics region represent the average pesticide risk over the wet season for 182 days. 22 pesticides, including nine PSII herbicides (Photosystem II inhibitors), 10 non PSII herbicides and three insecticides were measured. The wet season is determined as commencing when a rise in river water level occurs, which coincides with an increase in aqueous pesticides concentrations (M.St.J. Warne 2023).

10.2.1 Monitoring Sites

Data for the pesticides index are collected from two sample sites, one in the Ross Freshwater Basin, along Ross River, and one in the Black Freshwater Basin, along Black River (Table 28, and Appendix O).

Table 28. Townsville Dry Tropics freshwater pesticides site summary.

Basin	Sub Basin	Watercourse
Ross	Lower Ross	Ross River
Black	Black	Black River

10.2.2 Overall Summary: Pesticides

As noted above, the pesticide index and pesticide results are not representative of the entire Ross and Black Basins, but rather the individual monitoring sites within each Basin. Further, the pesticides index is a risk matrix, even if scores are “very good”, this does not necessarily indicate the absence of pesticides completely.

The overall pesticides grade was “very good” at both sampling sites within the Black and Ross Freshwater Basins (81 and 82 respectively). (Table 24). This is the first year that pesticides data have been reported in the HWP Technical Report. Historical data shown has been back calculated.

Table 29. Freshwater Pesticides Index Scores and Grades with comparison to previous years.

Monitoring Site	Pesticides				
	22-23	21–22	20–21	19–20	18–19
Ross River	81 (A)	89 (A)	94 (A)	89 (A)	98 (A)
Black River	82 (A)	91 (A)	92 (A)	89 (A)	100 (A)

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

10.2.2.1 *Key Messages*

- This is the first year in which pesticides data have been reported in the Townsville Dry Tropics Technical Report.
- Pesticide results and scores are not representative of the entire basin, as pesticides were only monitored at two sites (one in Ross River and one in Black River).
- The pesticides index is a risk metric, even if scores are “very good”, this does not necessarily indicate the absence of pesticides completely.
- Both pesticide sites received grades of “very good” with at least 99% of species protected.

10.2.3 Results: Pesticides

The scores and grades for the Ross and Black freshwater monitoring locations, are presented in Table 30. The relevant contribution of each of the pesticide classes are presented in Figure 46 and Figure 47 in Appendix P.

Table 30. The percentage of species protect and standardised scores for the pesticide risk metric in the Ross and Black freshwater basins.

Monitoring Site	Proportion: Insecticides	Proportion: Other Herbicides	Proportion: PSII Herbicides	% Protect	Standardised Scores
Ross River	0.45	0.44	0.11	99.0	81.0
Black River	0.39	0.61	<0.01	99.1	82.9

Pesticide risk metric scoring range: ■ Very Poor = <80% (very high risk)| ■ Poor = <90 to 80% (high risk)| ■ Moderate = <95 to 90% (moderate risk)| ■ Good = <99 to 95% (low risk)| ■ Very Good = ≥99% (very low risk). **Standardised scoring range:** ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

Analysis of the samples found that 5 unique pesticides were detected at the Ross River site (Fipronil, Fluroxypyr, MCPA, Tebuthiuron, Triclopyr), and 10 were detected at the Black River site (2,4-D, Atrazine, Diuron, Fipronil, Haloxyfop (acid), Hexazinone, Imazapic, MCPA, Tebuthiuron, Triclopyr). This is an increase in the number of unique pesticides detected at both locations during the 2021-2022 reporting period (Ross River: 3, Black River: 4).

10.2.4 Confidence Scores

There was low confidence in the pesticide scores for both the Ross and Black Freshwater Basins due to limited spatial and temporal sampling in the basin (only two rivers sampled and only for part of the year) (Table 31).

Table 31. Confidence scores for the freshwater pesticide index.

Index	Maturity (*0.36)	Validation (*0.71)	Representativeness (*2)	Directness (*0.71)	Measured error. (*0.71)	Final Score	Rank
Pesticides	3	2	1	2	2	7.3	Low (2)

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

Confidence criteria were scored 1–3 and weighted by the value identified in parenthesis. Weighted scores were summed to produce a final score (4.5 – 13.5). Final scores were ranked from 1 to 5 (very low to very high).

10.3 Habitat and Hydrology

The habitat and hydrology index in the freshwater environment consists of the habitat indicator categories (Freshwater Riparian Extent and Freshwater Wetland Extent), and the hydrology indicator category (Artificial Barriers). Results are provided by a combination of partners of the Partnership and from the Reef 2050 Report Card. Data is updated approximately every four years.

10.3.1 Overall Summary: Freshwater Habitat and Hydrology

For the 2022-2023 reporting period the standardised scores for the habitat and hydrology index improved in both freshwater basins This was driven by an improved score in the riparian extent indicator category. The Ross Freshwater Basin received a score of 61 (good), and the Black Freshwater Basin received a score of 79 (good) (Table 32). For the first time since the beginning of this technical report, sub basin results have also been calculated and presented.

Table 32. Standardised scores for the habitat and hydrology indicator categories and index in the Ross Freshwater Basin and Black Freshwater Basin.

Basin	Riparian Extent	Wetland Extent	Artificial Barriers	Habitat and Hydrology Index			
				22-23	21–22	20–21	19–20
Ross	54	80	49	61	X	X	51
Black	81	64	100	79	X	X	71

Standardised scoring range: Very Poor (E) = 0 to <21 | Poor (D) = 21 to <41 | Moderate (C) = 41 to <61 | Good (B) = 61 to <81 | Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

10.3.1.1 *Key Messages*

- Standardised scores for the habitat and hydrology index increased in both freshwater basins.
    - The riparian extent indicator category improved in both basins, with the Black Freshwater Basin recording its first increased in freshwater riparian vegetation since the beginning of this Dry Tropics Technical Report.
- Sub basin scores have been calculated and presented for the first time. This allowed for several new observations such as:
    - Identifying the Stuart Creek sub basin as the location with the greatest loss of riparian vegetation extent between 2019 and 2021.
    - Identifying the Bluewater and Rollingstone Creek sub basins as the locations with the greatest loss of wetland extent between 2019 and 2021.
    - Identifying several sub basins with the Black Freshwater Basins that have gained riparian vegetation extent between 2019 and 2021.

10.3.2 Freshwater Riparian Extent

The Partnership uses methods sourced from the Reef Water Quality Report Card, although presents results at a sub basin level. Data is scored based on the amount of vegetation coverage in comparison to the most recent previous dataset. For this report 2021 vegetation data (published in late 2023) is compared against 2019 data. The objective of this index is to record zero loss in vegetation between datasets.

10.3.2.1 *Monitoring Sites*

The area for the riparian extent indicator category is provided in Appendix Q and Appendix R.

10.3.2.2 *Results: Freshwater Riparian Extent*

For the 2022–2023 reporting period no sub basins in the Ross Basin gained vegetation, and no sub basins in the Black Basin lost vegetation (Table 33). The Stuart Creek sub basin had greatest percent-loss change, possibly due to the "state development area" within its boundaries (Queensland Government State Development and Infrastructure 2003).

Table 33. Riparian extent area, loss and standardised score in the freshwater basins and sub basins of the Townsville Dry Tropics.

Basin/Sub Basin	Freshwater Riparian Extent						
	Area (ha)				Extent Change (19-21)		Standardised Score
	Pre-Clear	…	2019	2021	ha	%	
Alligator Creek	5,303.2	…	4,551	4,542.7	-8.3	-0.18	57
Bohle River	6,544.4	…	4,874.3	4,868.5	-5.9	-0.12	60
Magnetic Island	2,013.0	…	1,916.1	1,916.1	0	0	80
Ross River (Lower)	2,097.5	…	1,527.5	1,527.5	0	0	80
Ross River (Upper)	19,426.9	…	16,328.2	16,282.2	-46.0	-0.28	52
Stuart Creek	2,889.8	…	2,307.7	2,292.8	-14.9	-0.64	35
Ross freshwater	38,274.8	…	31,504.9	31,429.8	-75.1	-0.24	54
Black River	9,918.1	…	8,904.9	8,909.2	+4.3	+0.05	81
Bluewater Creek	7,614.3	…	6,896.2	6,908.2	+12.0	+0.17	81
Crystal Creek	7,071.3	…	6,337.7	6,345.7	+8.0	+0.13	81
Palm Islands	901.2	…	775.1	775.1	0	0	80
Paluma Lake	121.7	…	28	28	0	0	80
Rollingstone Creek	5,806.1	…	5,396.7	5,406.5	+9.8	+0.18	81
Black freshwater	31,432.7	…	28,338.5	28,372.6	+34.1	+0.12	81

Riparian extent scoring range: ■ = Very Poor: >1% loss | ■ = Poor: 0.51 to 1% loss | ■ = Moderate: 0.11 to 0.5% loss | ■ = Good: 0 to 0.1% loss| ■ = Very Good: increase in vegetation.

Standardised scoring range: ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

The final standardised scores were 54 (moderate) in the Ross Basin, and 81 (very good) in the Black Basin. Notably, the Black Basin recorded an increase in freshwater riparian vegetation, however it is not clear if this is the result of growth of native vegetation or weed species (Table 34). Further, it should be noted that because vegetation is compared to most recent previous assessment, a score of "good" simply means that there was no vegetation loss since the previous assessment, not since "pre-European times". Historic vegetation trends for each basin are presented in Appendix S and Appendix U.

Table 34. Historic standardised score for the Freshwater Riparian indicator category.

Basin	Freshwater Riparian Extent Standardised Scores				
	22-23	21-22	20-21	19-20	18-19
Ross Freshwater	54	X	X	X	44
Black Freshwater	81	X	X	X	56

Riparian extent scoring range: ■ = Very Poor: >1% loss | ■ = Poor: 0.51 to 1% loss | ■ = Moderate: 0.11 to 0.5% loss | ■ = Good: 0 to 0.1% loss| ■ = Very Good: increase in vegetation.

Standardised scoring range: ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

10.3.3 Freshwater Wetland Extent

The Partnership uses methods sourced from the Reef Water Quality Report Card, however, presents results at a sub basin level with minor changes to the assessed area: including Magnetic Island and the Palm Island group in the analysis of wetland extent. Data is scored based on the amount of wetland coverage in comparison to the most recent previous dataset. For this report 2019 wetland data (published in late 2023) is compared against 2017 data. The objective of this index is to record zero loss in vegetation between datasets.

10.3.3.1 *Monitoring Sites*

The area for the wetland extent indicator category is provided in Appendix V and Appendix W.

10.3.3.2 *Results: Freshwater Wetland Extent*

For the 2022–2023 reporting period only the Bluewater Creek and Rollingstone Creek sub basins recorded a loss in vegetation, no sub basins recorded a gain in vegetation (Table 35).

Table 35. Freshwater wetland area, loss and standardised score in the freshwater basins and sub basins of the Townsville Dry Tropics.

Basin/Sub Basin	Freshwater Wetland Extent						
	Area (ha)				Extent Change (17-19)		Standardised Score
	2001	...	2017	2019	ha	%	
Alligator Creek	528.1	...	526.5	526.5	0.0	0.0	80
Bohle River	227.4	...	206.1	206.1	0.0	0.0	80
Magnetic Island	28.3	...	28.3	28.3	0.0	0.0	80
Ross River (Lower)	62.5	...	61.0	61.0	0.0	0.0	80
Ross River (Upper)	46	...	46.0	46.0	0.0	0.0	80
Stuart Creek	11.1	...	11.1	11.1	0.0	0.0	80
Ross freshwater	903.4	...	879.0	879.0	0.0	0.0	80
Black River	33.5	...	33.5	33.5	0.0	0.0	80
Bluewater Creek	52.1	...	45.1	44.9	-0.2	-0.46	43
Crystal Creek	222	...	219.1	219.1	0.0	0.0	80
Palm Islands	61.9	...	61.9	61.9	0.0	0.0	80
Paluma Lake	ND	...	ND	ND	ND	ND	ND
Rollingstone Creek	77.7	...	76.9	76.8	-0.2	-0.2	56
Black freshwater	447.3	...	436.6	436.2	-0.4	-0.08	64

Wetland extent scoring range: ■ = Very Poor: >3% loss | ■ = Poor: 0.51 to 3% loss | ■ = Moderate: 0.11 to 0.5% loss | ■ = Good: 0 to 0.1% loss| ■ = Very Good: increase in vegetation.

Standardised scoring range: ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

The final standardised scores were 54 (moderate) in the Ross Basin, and 81 (very good) in the Black Basin. It should be noted that although no increases in wetland vegetation were detected, due to selective nature of the assessment (only measuring pristine palustrine) this does not mean that there wasn't a gain/loss of other types of wetlands within the area. Further, because vegetation is compared to most recent previous assessment, a score of "good" simply means that there was no vegetation loss since the previous assessment, not since the "pre-European times". Historic vegetation trends for each basin are presented in Appendix X and Appendix Y.

Table 36. Historic standardised score for the Freshwater wetland indicator category.

Basin	Freshwater Wetland Extent Standardised Scores				
	22-23	21-22	20-21	19-20	18-19
Ross Freshwater	80	X	X	40	45
Black Freshwater	64	X	X	58	40

Wetland extent scoring range: ■ = Very Poor: >3% loss | ■ = Poor: 0.51 to 3% loss | ■ = Moderate: 0.11 to 0.5% loss | ■ = Good: 0 to 0.1% loss| ■ = Very Good: increase in vegetation.

Standardised scoring range: ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

10.3.3.3 *Updated Wetlands Dataset*

The data and method used to map wetland extent was updated in 2023 (Version 6.0). Although results can no longer be compared to previous technical reports the latest data includes a remapping of all previous years of data. This remapping has been used to back calculate all historic scores presented in Table 36. A comparison between new and old scores is shown in Appendix Z.

10.3.4 Freshwater Artificial Barriers

The artificial barriers indicator category is comprised of two indicators: impoundment length and fish barriers. Both indicators are updated approximately every four years, with impoundment length updated in 2022 and fish barriers scheduled to be updated in 2024.

10.3.4.1 *Monitoring Sites*

The area for the artificial barriers indicator category is provided in Appendix AA and Appendix BB.

10.3.4.2 *Results: Freshwater Artificial Barriers*

There is no change to the results for the artificial barriers indicator category or the impoundment length and fish barrier indicators in this technical report. The Black Freshwater Basin received a standardised score of 100 (very good) due to the lack of artificial barriers, and the Ross Freshwater Basin received a standardised score of 49 (moderate) due to the high frequency of barriers, and their proximity to the downstream limit of the water way, particularly in the Ross River (Table 37).

Table 37. Standardised scores for the artificial barrier's indicator category in the Ross Freshwater Basin and Black Freshwater Basin.

Basin	Impoundment Length	Fish Barriers	Artificial Barriers
Ross freshwater	34	65	49
Black freshwater	100	100	100

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

10.3.4.3 *Results: Freshwater Impoundment length*

Impoundment length in the Townsville Dry Tropics region has remained consistent between reporting periods. The Black Basin received a score of 100 (very good), with no impoundments. In the Ross Basin, of the 895km of assessed waterways, 72km were impounded. The Ross basin received a score of 34 (poor) due to the Ross River Dam, and three weirs (Black, Gleeson and Aplin's) on the Ross River.

Table 38. Natural and Impounded stream length and standardised score in the freshwater basin of the Townsville Dry Tropics.

Basin	Waterway				Standardised Score (Grade)
	Natural	Impounded	Total	% Impounded	
Ross freshwater	824km	72km	895km	8.0%	34
Black freshwater	659km	0km	659km	0.0%	100

Standardised scoring range: ■ = Very Poor: ≥10% impoundment ■ = Poor: 7 to <10% ■ = Moderate: 4 to <7% ■ = Good: 1 to <4% ■ = Very Good: <1% impoundment | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

10.3.4.4 *Results: Freshwater Fish Barriers*

In the Ross Basin, there were 12 barriers across five measured waterways, four were classified as impassable, and all were located on the Ross River. In the Black Freshwater Basin 92km of the Black River was assessed, and no fish barriers, passable or impassable, were identified (Table 39). Barrier density in the Ross Basin ranged from 3.5km of waterway per barrier, to 65.9km per barrier, and the percentage of stream to first barrier ranged from 0.4% to 100%. In the Black Basin, percentage of stream to first barrier was 100% (Table 40). The fish barrier indicator received a standardised score of 65 (good) in the Ross Basin, and 100 (very good) in the Black Basin (Table 40).

Table 39. Waterway characteristics and fish barriers in the Ross Freshwater Basin and Black Freshwater Basin.

Basin	Waterway Name	Waterway length	Number of Barriers: Passable	Number of Barriers: Impassable	Length to first barrier: Passable	Length to first barrier: Impassable
Ross freshwater	Ross River	263.6km	0	4	1.0km	1.0km
	Bohle River	51.1km	2	0	7.2km	51.1km
	Stuart Creek	17.5km	5	0	11.9km	17.5km
	Alligator Creek	13.7km	1	0	0.7km	13.7km
	Whites Creek	11.1km	0	0	11.1km	11.1km
Ross Average		71.4km	1.6	0.8	6.4km	18.9km
Black freshwater	Black River	92.0km	0	0	0.0km	92.0km

Table 40. Standardised scores for the components of the fish barrier's indicator.

Waterway	Barrier density (km/barrier)	Percentage of stream to first … barrier: Passable	Percentage of stream to first … barrier: Impassable	Standardised Score (Grade)
Ross River	65.9km	0.4%	0.4%	40
Bohle River	25.5km	14.1%	100%	61
Stuart Ck	3.5km	68.2%	100%	60
Alligator Ck	13.7km	5.2%	100%	60
Whites Ck	NA	100%	100%	100
Ross Average	27.2km	37.6%	80.1%	65
Black River	NA	100%	100%	100

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

10.3.5 Confidence Scores

Confidence in the riparian extent, wetland extent, and artificial barriers indicator categories was low or very low with a rank of 1, 1, and 2 out of 5 respectively.

Table 41. Confidence scores for the mangrove and saltmarsh extent and riparian extent indicator categories.

Indicator Category	Maturity (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Score (Rank)
R. Extent	2	2	1	2	1	6.3 (1)
W. Extent	2	2	1	2	1	6.3 (1)
A. Barriers	2	1	2	2	1	7.6 (2)

Rank based on score: 1 (very low) = 4.5 to 6.3; | 2 (low) = >6.3 to 8.1; | 3 (moderate) = >8.1 to 9.9; | 4 (high) = >9.9 to 11.7; | 5 (very high) = >11.7 to 13.5.

10.4 Fish

The Fish index for the freshwater basin of the Townsville Dry Tropics regions consists of two indicator categories, the Proportion of Indigenous Species Expected (POISE), and the Proportion of Non-Indigenous Species (PONIS). Results for this index are provided by partners of the Partnership and are updated every three years. The latest update occurred in the 2022–2023. technical report using data collected in 2021-2022. This is the second time since the beginning of the report card that the fish index has been measured.

10.4.1 Monitoring Sites

The monitoring sites used for the fish index are provided in Appendix CC.

10.4.2 Overall Summary: Freshwater Fish

For the 2022-2023 reporting period the standardised scores for the fish index declined in both freshwater basins. The Ross Basin received a score of 49 (moderate), and the Black Basin received a score of 55 (moderate) (Table 42).

Table 42. Standardised scores for the POISE and PONIS indicator categories and fish index in the Ross and Black Basins.

Basin	POISE	PONIS	Fish Index			
			22-23	21-22	20-21	19-20
Ross	58	41	49	X	X	57
Black	25	84	55	X	X	78

Standardised scoring range: Very Poor (E) = 0 to <21 | Poor (D) = 21 to <41 | Moderate (C) = 41 to <61 | Good (B) = 61 to <81 | Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

10.4.2.1 *Key Messages*

- This is the second time the fish index has been measured and scores for the fish index declined in both basins.
    - The primary driver was the PONIS indicator category in the Ross Basin (decreased from 60 to 41), and the POISE indicator category in the Black basin (decreased from 66 to 25).
- Within the Ross Basin, 4011 fish from 29 species were caught during sampling.
    - 86% (3447) were indigenous and were released after identification.
    - 14% (564) were non-indigenous and were euthanised.
        - 529 fish were alien, 35 were translocated.
    - Scores indicate that most waterways were “moderate”.
- Within the Black Basin, 2217 fish from 25 species were caught during sampling.
    - 83% (1830) were indigenous and were released after identification.
    - 17% (387) were non-indigenous and were euthanised.
        - All non-indigenous species were alien.
    - Scores indicate that some waterways were “very good’ whilst others were “very poor”.
    - The significant decrease in the POISE indicator category score is most likely connected to heavy rainfall before sampling dispersing the fish populations.

10.4.3 Proportion of Indigenous Species Expected (POISE)

The proportion of indigenous species expected (POISE) indicator category is a measure of observed versus expected species and compares the richness of indigenous[5] species. Presence/Absence and site scores are provided in Appendix DD to Appendix FF.

10.4.3.1 *Results: POISE*

The POISE indicator category was measured to be 0.645 in the Ross Basin and 0.429 in the Black Basin, showing that despite the large number of indigenous species, presence is still lower than the pre-disturbance model for both basins. Standardised scores were 58 (moderate) and 25 (poor) in the Ross and Black Basins respectively (Table 43). The grade did not change within the Ross Basin (moderate) however did decrease from "good" to "poor" in the Black Basin. This grade change was most likely driven by heavy rainfall preceding sampling that dispersed the fish populations. Several site locations had to be altered as they were no longer suitable due to significantly increased water depth.

Table 43. The Proportion of Indigenous Species Expected (POISE) indicator category raw and standardised scores for each basin in the Townsville Dry Tropics Region.

Basin	POISE	Standardised Score			
		22-23	21-22	20-21	19-20
Ross	0.645	58	X	X	54
Black	0.429	25	X	X	66

Scoring range (POISE): ■ = Very Poor: 0 to <0.40 | ■ = Poor: 0.40 to <0.53 | ■ = Moderate: 0.53 to <0.67 | ■ = Good: 0.67 to <0.80 | ■ = 0.80 to 1.

Standardised scoring range: ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

In the Ross Basin 4011 fish of 29 species were caught, 86% (3447) of which were indigenous. In the Black Basin 2217 fish of 25 species were caught, 83% (1830) of which were indigenous. All indigenous species were released after identification. Despite the similar percentages, the standardised score for the Black Freshwater Basin was notably lower (58 compared to 25). This is because the standardised scores are calculated from the median POISE value. In turn this indicates that the Black Freshwater Basin had a great number of waterways with a very poor number of indigenous species found compared to what was expected, and a few waterways with an exceptional (very good) number of indigenous species. Comparatively, most waterways in the Ross Freshwater Basin were moderate.

10.4.4 Proportion of Non-Indigenous Species (PONIS)

The proportion of non-indigenous species (PONIS) indicator category is a measure of observed translocated and alien species compared to the total number of observed species. Presence/Absence and site score are provided in Appendix DD to Appendix FF.

[5] Species classification definitions can be found in "Methods for Townsville Dry Tropics 2022–2023 Report Card (released in 2024)".

10.4.4.1 *Results: PONIS*

Within the PONIS indicator category, the median proportion of translocated species was measured to be 0.0 in both the Ross Freshwater Basin and Black Freshwater Basin, due to the very low presence of translocated species (note that although some translocated species were reported, the median measurement was 0.0). While the median proportion of alien species was 0.102 in the Ross Freshwater Basin, and 0.029 in the Black Freshwater Basin. Thus, the PONIS indicator category was also measured to be 0.102 and 0.029 in the Ross and Black Basins respectively. Standardised scores were 41 (moderate) in the Ross Basin and 96 (very good) in the Black Basin (Table 44).

Table 44. The Proportion of Non-Indigenous Species (PONIS) indicator category raw and standardised scores for each basin in the Townsville Dry Tropics Region.

Basin	Proportion of:		PONIS	Standardised Score			
	Translocated	Alien		22-23	21-22	20-21	19-20
Ross	0.0	0.102	0.102	41	X	X	60
Black	0.0	0.029	0.029	96	X	X	91

Scoring range (PONIS): ■ = Very Poor: >0.2 to 1 | ■ = Poor: >0.1 to 0.2 | ■ = Moderate: >0.05 to 0.1 | ■ = Good: >0.03 to 0.05 | ■ = 0 to 0.03.

Standardised scoring range: ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

In the Ross Basin, of the 4011 fish caught, 14% (564) were non-indigenous (529 alien, 35 translocated). In the Black Basin, of the 2217 fish caught, 17% (387) were non-indigenous (all of which were alien). All non-indigenous species were euthanised. Once again, despite similar percentages, the standardised scores for each basin are notably different (41 compared to 96). This is because the standardised scores are calculated from the median PONIS value. In turn this indicates that the Black Freshwater Basin had a great number of waterways with a very good (low) numbers of non-indigenous species, and a few waterways with a very poor (high) numbers of non-indigenous species. Comparatively, most waterways in the Ross Freshwater Basin were moderate.

10.4.5 Confidence Scores

Confidence in the fish index was moderate with a rank of 3 out of 5. The fish index received a maturity score of 2, as the methodology has been peer-reviewed, but not yet published. A validation score of 2 as frequent in-field observations were conducted, however a level of modelling was required to calculate pre-disturbance populations. A representativeness of 2 due to a limited sample size and number sampling locations relative to the population. A directness of 3 as the fish species were measured directly, and a measured error of 1 as the final scores are reliant on modelled populations (Table 45).

Table 45. Confidence scores for the fish index in the freshwater basin of the Townsville Dry Tropics.

Index	Maturity (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Score (Rank)
Fish	2	2	2	3	1	9.7 (3)

Rank based on score: 1 (very low) = 4.5 to 6.3; | 2 (low) = >6.3 to 8.1; | 3 (moderate) = >8.1 to 9.9; | 4 (high) = >9.9 to 11.7; | 5 (very high) = >11.7 to 13.5.

Estuarine 2022–2023

Written by Adam Shand

As part of the results for the Townsville Dry Tropics Report Card 2024 (Reporting on data from July 2022– June 2023)

Healthy Waters Partnership for the Dry Tropics (HWP)

July 2024

11 Estuarine Environment

Within the estuarine environment, water quality, and habitat are the two indices scored. Each of these indices are made up of indicator categories and indicators which are updated on varying time scales from annually to every three to four years. All indicator categories use data provided by multiple partners of the Partnership. In the Townsville Dry Tropics region, the water quality index is updated annually, with the most recent data from the 2022-2023 financial year. The habitat index is updated approximately every four years with the most recent update (2021 data) occurring for the 2022-2023 technical report.

Index scores are calculated for the Ross Estuarine Basin and the Black Estuarine Basin. The extent of each basin is shown in Figure 20 (below), and the results are presented below.

11.1 Water Quality

The water quality index for the estuarine environment of the Townsville Dry Tropics regions consists of two indicators categories: Nutrients, and Physical-Chemical Properties. These are divided into five indicators and for each indicator the parameters used to calculate the scores were the:

- Water Quality Objectives (WQOs),
- Scaling Factors,
- Annual medians, calculated from the monthly medians,
- 80th percentile (and 20th percentile for DO), calculated from the monthly median, and,
- The weighted basin scores include the proportion of each individual estuary area of the total basin estuary area.

The Townsville Dry Tropics Methods Document (2024) provides definition of the WQOs, and SFs used for each watercourse, and the conversion of raw data to standardised scores using the annual medians, percentiles, and sub basin weights. Values can also be found in Appendix GG and Appendix II.

The nutrients indicator category is comprised of two indicators, Dissolved Inorganic Nitrogen (DIN), and Total Phosphorus (TP) and the scores for nutrients are averaged from the scores of the two indicators. The physical-chemical properties indicator category is comprised of three indicators, Turbidity, High DO, and Low DO. The score is calculated as the average of Turbidity and the minimum score from High DO and Low DO.

11.1.1 Monitoring Sites

Data for the two estuarine indicator categories are collected from the same sites. There are 22 sites (codes) spread across 12 estuaries within the two basins. These are divided into seven (7) sub basins in line with the WQIP (Townsville City Council, Queensland Government, Australian Government 2010) (Table 46, and Figure 20).

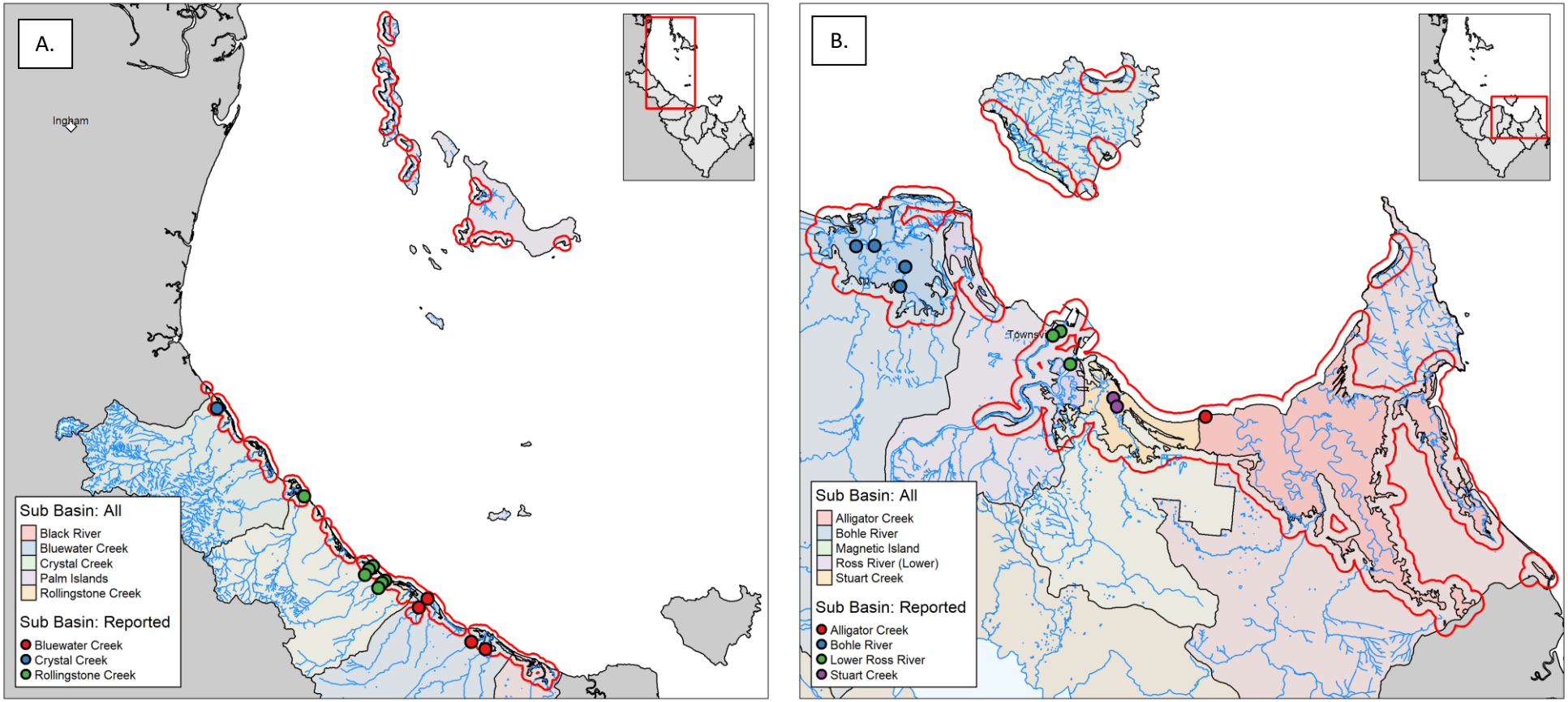

Figure 18. Estuarine Basins (A.= Black, B. = Ross) and Sub Basins (see legend). Red lines are added to highlight hard to see areas.

Table 46. Townsville Dry Tropics estuarine water quality site summary.

Basin	Sub Basin	Watercourse	Number of Sites
Ross Estuarine	Bohle	Bohle River	1
		Louisa Creek	3
	Lower Ross	Ross Creek	2
		Ross River	1
	Stuart	Sandfly Creek	2
	Alligator	Pearce's Creek	1
Black Estuarine	Bluewater	Althaus Creek	1
		Bluewater Creek	1
		Sleeper Log Creek	2
	Rollingstone	Camp Oven Creek	3
		Saltwater Creek	3
		Rollingstone Creek	1
	Crystal	Crystal Creek	1

11.1.2 Overall Summary: Estuarine Water Quality

The water quality index was graded as "good" in both the Ross and Black Estuarine Basins, and this marks a decrease in score and grade in the Ross Estuarine Basin (from "very good" (83) to "good" (79)), and an increase in score in the Black Estuarine Basin (64 to 68) (Table 47). The decrease in the Ross Estuarine Basin was driven by a reduced nutrients score, whilst the increase in the Black Estuarine Basin was due to an increased physical-chemical score and grade.

Table 47. Current and previous water quality scores and grades for the Townsville Dry Tropics Estuarine Basins.

Basin	Nutrients	Phys-Chem Properties	Water Quality				
			22-23	21–22	20–21	19–20	18–19
Ross Estuarine	82	77	79	83	88	88	39
Black Estuarine	71	64	68	64	66	47	52

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

11.1.2.1 *Key Messages*

- The Ross Estuarine Basin grade declined from "very good" (83) to "good" (79).
    - Most influential was the decline in the score for Total Phosphorus in the Louisa Creek sub basins, which saw a decrease in grade from "poor" (22) to "very poor" (0).
- The Black Estuarine Basin score increased from 64 to 68 within the same grade of "good".
    - Improvements in the turbidity grade in the Crystal Creek sub basin from "very poor" (7) to "moderate" (43), and the High DO score in the Althaus Creek sub basin from "poor" (28) to "very good" (90) were the primary drivers.

- Across the entire Dry Tropics Region, 11 of 13 watercourses received a grade of “good” or “very good” for nutrients, and 10 of 13 received a grade of "good” or “very good” for physical-chemical properties.
- Althaus Creek shows ongoing low scores and grades for the turbidity indicator, and further investigation would be required to isolate specific drivers.
- Louisa Creek shows ongoing low scores and grades for the Low DO and TP indicators and further investigation would be required to isolate specific drivers.

11.1.3 Nutrients

For the 2022–2023 technical report the nutrients indicator category is comprised of two indicators, Dissolved Inorganic Nitrogen (DIN), and Total Phosphorus (TP). The scores and grades for the Ross and Black Estuarine Basins, and their associated sub basin estuaries are presented in Table 48. Annual medians, samples collected, months sampled, WQOs, and SFs are presented in Appendix GG. Historical scores are presented in Appendix HH.

11.1.3.1 *Results: Estuarine Nutrients*

The Ross Estuarine Basin received a nutrient indicator category score of 82 (very good). Within the basin, five of six watercourses received nutrient indicator category grades of “very good”, with scores of 90. The Louisa Creek watercourse was the only location to receive a grade of “poor” (score of 33), which was driven by the TP indicator. Other than the TP indicator in the Louisa Creek watercourse, all watercourses in the Ross Estuarine Basin received grades of “very good” or “good” for both the TP and DIN indicators (Table 48).

The low scores for the TP indicator at Louisa Creek have consistently occurred across multiple years of reporting. Low scores have been identified to be driven by concentration rather than differences in water quality objective, sampling methodology, or scaling factors (Appendix GG). The distribution of sites with the Louisa Creek watercourse, and their associated scores, also suggests a diluting effect, with scores generally increasing further downstream (Table 48). These consistent spatial and temporal trends suggest an ongoing source of increased TP upstream of the sampling location that is unique to the Louisa Creek watercourse, such as its proximity to the outflow of the Mount St Johns Wastewater Treatment Plant, industrial areas, and residential developments, particularly those with septic systems.

The Black Estuarine Basin received a nutrient indicator category score of 71 (good). Within the basin, six of seven watercourses received a nutrient indicator category grade of “good” or “very good”, with scores of 62 or greater. The Althaus Creek watercourse was the only location to receive a grade of “moderate” (score of 52), which was driven by both the DIN and TP indicators. Although these scores are not yet consistently low across multiple reporting periods possible drivers include groundwater, soil type, landuse, and timing relative to tides and rainfall (Appendix HH). Also, of note, is the DIN indicator in the Rollingstone Creek watercourse, which received a “poor” grade (34). This has been noted in some previous reports and may require further investigation of aspects such as runoff and the surrounding land use (Table 48).

Table 48. Weighted and unweighted standardised scores and grades for the nutrient indicator category and indicators in the Townsville Dry Tropics Estuarine Environment.

Basin	Sub Basin Estuary	Watercourse	Unweighted Score and Grade			Weighting (proportion)	Area (km2)	Weighted Score and Grade	
			DIN	TP	Nutrients			Sub Basin	Basin
Ross Estuarine	Bohle	Bohle River	90	90	90	-	-	-	82
		Louisa Creek	67	0	33	-	-	-	
			78	45	61	0.28	348	17.3	
	Lower Ross	Ross Creek	90	90	90	-	-	-	
		Ross River	90	90	90	-	-	-	
			90	90	90	0.69	864	62.5	
	Stuart	Sandfly Creek	90	90	90	0.02	28	2.0	
	Alligator	Pearce's Creek	90	90	90	0	5	0.4	
			86	75	80	1	1245		
Black Estuarine	Bluewater Creek	Althaus Ck	49	56	52	-	-	-	71
		Bluewater Ck	65	90	77	-	-	-	
		Sleeper Log Ck	61	90	75	-	-	-	
			58	78	68	0.52	277	45.9	
	Rollingstone Creek	Camp Oven Creek	80	90	85	-	-	-	
		Saltwater Ck	78	90	84	-	-	-	
		Rollingstone Ck	34	90	62	-	-	-	
			64	90	77	0.25	135	19.6	
	Crystal Creek	Crystal Ck	56	90	73	0.22	118	16.3	
			60	85	72	1	531		

Standardised scoring range: ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 90. (Scores are capped at 90) | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

11.1.4 Physical-Chemical Properties

For the 2022–2023 technical report the physical-chemical properties indicator category is comprised of three indicators, Turbidity (NTU), High DO, and Low DO. The scores and grades for the Ross and Black Estuarine Basins, and their associated sub basins are presented in Table 49. Annual medians, samples collected, months sampled, WQOs, and SFs are presented in Appendix II. Historical scores are presented in Appendix JJ.

11.1.4.1 *Results: Estuarine Physical-Chemical Properties*

The Ross Estuarine Basin received a physical-chemical properties score of 77 (good). Five of six watercourses received nutrient indicator category grades of “very good” or “good”, with scores of 62 or greater. The Louisa Creek watercourse was the only location to receive a grade of “moderate” (score of 32), which was driven by the Low DO indicator (Table 49). The watercourse also received a “very poor” grade for TP (Results: Estuarine Nutrients). The relationship between DO and nutrients is well established, and the “very poor” low DO score is likely due to increased TP upstream of the sampling location. Sources of increased TP may include the outflow of the Mount St Johns Wastewater Treatment Plant, industrial areas, and residential developments.

The Black Estuarine Basin received a physical-chemical properties indicator category score of 64 (good). Five of seven watercourses received a physical-chemical properties indicator category grade of “good” or “very good”, with scores of 66 or greater. The Camp Oven Creek watercourse received a grade of “moderate” (49), which was driven by a combination of “moderate” grades for both the Turbidity and Low DO indicators. The Althaus Creek watercourse receive a grade of “poor” (40), which was driven solely by a “very poor” grade for the Turbidity Indicator. Althaus Creek has received “very poor” grades for the Turbidity indicator for several years and should be investigated for probable causes (Appendix JJ).

High turbidity can be caused by silt, mud, algae, plant pieces, ash, or chemicals. Given the sandy clay nature of the stratigraphy of the Althaus Creek alluvium, it is possible that the turbidity is naturally occurring, with high readings occurring either during or following rainfall events. Investigation of the turbidity data with rainfall suggests that the baseline (no rainfall for an extended period) turbidity in the creek is very close to the WQO. Analysis of the suspended solids within water samples for mineral and organic content would assist in determining the cause of the turbidity.

It should also be noted that the same watercourse (Althaus Creek) also received low scores and grades for the nutrients indicator category (Results: Estuarine Nutrients).

Table 49. Weighted and unweighted standardised scores and grades for the physical-chemical indicator category and indicators in the Townsville Dry Tropics Estuarine Environment.

Basin	Sub Basin Estuary	Watercourse	Unweighted Score and Grade						Weighted Score and Grade	
			Turbidity	High DO	Low DO	Phys-Chem	Weighting (proportion)	Area (km2)	Sub Basin	Basin
Ross Estuarine	Bohle	Bohle River	67	90	90	78				77
		Louisa Creek	65	90	0	32				
			66	90	45	55	0.28	348	15.6	
	Lower Ross	Ross Creek	90	90	90	90				
		Ross River	75	90	90	82				
			82	90	90	86	0.69	864	60.0	
	Stuart	Sandfly Creek	34	90	90	62	0.02	28	1.4	
	Alligator	Pearce's Creek	48	90	90	69	0	5	0.3	
			63	90	75	69	1	1245		
Black Estuarine	Bluewater Creek	Althaus Ck	0	80	90	40				64
		Bluewater Ck	63	90	73	68				
		Sleeper Log Ck	59	90	90	74				
			40	86	84	61	0.52	277	31.9	
	Rollingstone Creek	Camp Oven Creek	55	90	42	49				
		Saltwater Ck	69	90	90	79				
		Rollingstone Ck	80	90	77	78				
			68	90	70	69	0.25	135	17.6	
	Crystal Creek	Crystal Ck	43	90	90	66	0.22	118	14.9	
			53	88	79	65	1	531		

Standardised scoring range: ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 90. (Scores are capped at 90) | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

11.1.5 Confidence Scores

Overall, there was moderate confidence in the results due to limited ability to define the measured error, however, all other criterion received a score of 2 or greater (Table 50).

Table 50. Confidence scores for the nutrients, and physical-chemical properties indicator categories.

Indicator Category	Maturity (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Score (Rank)
Nutrients	2	3	2	3	1	9.6 (3)
Phys-Chem	2	3	2	3	1	9.6 (3)

Rank based on score: 1 (very low) = 4.5 to 6.3; | 2 (low) = >6.3 to 8.1; | 3 (moderate) = >8.1 to 9.9; | 4 (high) = >9.9 to 11.7; | 5 (very high) = >11.7 to 13.5.

11.2 Habitat

In the estuarine environment the habitat index is comprised of two indicator categories: Mangrove and Saltmarsh Extent, and Estuarine Riparian Extent. Data for these indicator categories is updated approximately every four years with the most recent update occurring in 2023.

11.2.1 Overall Summary: Estuarine Habitat

The scores and grades for the estuary habitat indicator categories and habitat index for 2022–2023, and the indices for previous reporting years are presented in Table 51. Scores in the Ross Basin Estuarine Basin have increased over reporting years, however scores in the Black Estuarine Basin have decreased. In the Ross Estuarine Basin, the habitat index received a score of 74 (good) and in the Black Estuarine Basin, the habitat index received a score of 50 (moderate) (Table 51).

Table 51. Standardised score for the estuarine habitat index.

Basin	Mangrove and Saltmarsh Extent	Riparian Extent	Habitat Index			
			22-23	21-22	20-21	19-20
Ross Estuarine	68	81	74	X	X	73
Black Estuarine	81	20	50	X	X	71

Standardised scoring range: Very Poor (E) = 0 to <21 | Poor (D) = 21 to <41 | Moderate (C) = 41 to <61 | Good (B) = 61 to <81 | Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

11.2.1.1 *Key Messages*

- Sub Basins scores have been calculated and presented for the first time. This allowed for several new observations such as:
    - Identifying the Bohle River and Crystal Creek sub basins as the main areas of mangrove and saltmarsh loss and several sub basins as the main areas of gain of mangrove and saltmarsh vegetation.
    - Identifying the Black River, Bluewater Creek and Rollingstone Creek sub basins as key drivers of riparian vegetation loss and several sub basins as the main areas of gain of riparian vegetation.
- The Black Estuarine Basin recorded its first increase (11.7ha) in mangrove and saltmarsh vegetation since the beginning of the Dry Tropics Technical Report.
- The Black Estuarine Basin also recorded its first ever loss in riparian vegetation (-9.8ha) since the beginning of the Dry Tropics Technical Report.
    - This may be connected to the ongoing urban development throughout the basin.
- In the Ross Estuarine Basin mangrove and saltmarshes decreased (-8.5ha) and riparian vegetation increased (0.2ha).

11.2.2 Mangrove and Saltmarsh Extent

The mangrove and saltmarsh extent indicator category provides a measure of the total area of mangrove and saltmarsh and the amount of change (loss or gain) of this vegetation relative to the last time it was measured. Detailed methods can be found in 2024 Methods document (Healthy Waters Partnership for the Dry Tropics 2024). Data is scored based on the amount of mangrove and saltmarsh coverage in comparison to the most recent previous dataset. For this report 2021

mangrove and saltmarsh data (published in late 2023) is compared against 2019 data. The objective of this index is to record zero loss in vegetation between datasets.

11.2.2.1 *Monitoring Sites*

The area assessed for this indicator category is provided in Appendix NN and Appendix OO.

11.2.2.2 *Results: Estuarine Mangrove and Saltmarsh*

The standardised score and grade for the mangrove and saltmarsh extent indicator category is calculated as a percentage lost/gained from 2019 to 2021. For the 2022–2023 reporting period the total area of mangrove and saltmarsh extent was 13,633.4ha in the Ross Estuarine Basin, and 1,197.9ha in the Black Estuarine Basin. This represents a loss of 8.5ha (0.06%) in the Ross Estuarine Basin, and a gain of 11.7ha (0.99%) in the Black Estuarine Basin (Table 53). The loss was primarily driven by the loss of saltmarsh in the Ross River (Lower) and the Bohle River, and the loss of mangroves in the Crystal Creek and Bluewater Creek estuaries. The Ross Estuarine Basin received a final standardised score of 68 (B) and the Black Estuarine Basin received a standardised score of 81 (A) (Table 53). Several factors may have contributed to these changes in vegetation extent, including saltwater intrusion, coastal squeeze, and sea level rise. Historic analysis of mangrove and saltmarsh extent is provided in Appendix PP and Appendix QQ.

Table 52. Historic standardised score for the Estuarine mangrove and saltmarsh extent indicator category.

Basin	Estuarine Mangrove and Saltmarsh Extent Standardised Scores				
	22-23	21-22	20-21	19-20	18-19
Ross Estuarine	68	X	X	X	67
Black Estuarine	81	X	X	X	63

Mangrove and Saltmarsh scoring range: ■ = Very Poor: >3% loss | ■ = Poor: 0.51 – 3% loss | ■ = Moderate: 0.11 – 0.5% loss | ■ = Good: 0 – 0.1% loss | ■ = Very Good: increase in mangrove of saltmarsh area.

Standardised scoring range: ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

Table 53. Mangrove and saltmarsh area, loss, and standardised score in the Townsville Dry Tropics estuarine basins and sub basins.

Basin/Sub Basin	Mangroves						Saltmarsh						Total (Mangrove + Saltmarsh)						Standardised Score
	Area (ha)				Change (19-21)		Area (ha)				Change (19-21)		Area (ha)				Change (19-21)		
	Pre-Clear	...	2019	2021	ha	%	Pre-Clear	...	2019	2021	ha	%	Pre-Clear	...	2019	2021	ha	%	
Alligator Creek	2,406.0	...	2,442.0	2,441.4	-0.6	-0.03	6,085.6	...	5,998.2	6,008.7	+10.5	+0.18	8,491.5	...	8,440.2	8,450.1	+9.9	+0.12	81
Bohle River	525.6	...	588.8	591.9	+3.1	+0.53	1,819.5	...	1,692.5	1,677.9	-14.6	-0.86	2,345.1	...	2,281.3	2,269.9	-11.4	-0.5	40
Magnetic Island	181.2	...	179.6	179.6	0.0	0.0	79.2	...	78	78	0.0	0.0	260.4	...	257.6	257.6	0.0	0.0	80
Ross River (Lower)	487.9	...	400.4	401.8	+1.4	+0.35	658.9	...	572.6	560.5	-12.1	-2.12	1,146.7	...	973	962.3	-10.7	-1.1	36
Ross River (Upper)	ND	...	ND	ND	ND	ND	ND	...	ND	ND	ND	ND	ND	...	ND	ND	ND	ND	ND
Stuart Creek	454.1	...	473.1	476.3	+3.3	+0.69	1,343.3	...	1,216.7	1,217.3	+0.5	+0.04	1,797.5	...	1,689.8	1,693.6	+3.8	+0.22	81
Ross freshwater	4,0548.8	...	4,083.8	4,091	+7.2	+0.18	9,986.4	...	9,558	9,542.4	-15.6	-0.16	14,041.2	...	13,641.9	13,633.4	-8.5	-0.06	68
Black River	81.7	...	81.0	84.4	+3.3	+4.12	63.9	...	62.2	64.7	+2.4	+3.91	145.7	...	143.3	149.1	+5.8	+4.03	81
Bluewater Creek	282.1	...	280.0	273.4	-6.6	-2.36	138.1	...	131.4	138.1	+6.7	+5.13	420.2	...	411.4	411.5	+0.1	+0.03	81
Crystal Creek	234.3	...	224.0	219.3	-4.7	-2.11	19.4	...	16.7	16.9	+0.2	+1.34	253.7	...	240.7	236.2	-4.5	-1.87	29
Palm Islands	136.7	...	135.6	135.6	0.0	0.0	2.2	...	0.7	0.7	0.0	0.0	138.9	...	136.3	136.3	0.0	0.0	80
Paluma Lake	ND	...	ND	ND	ND	ND	ND	...	ND	ND	ND	ND	ND	...	ND	ND	ND	ND	ND
Rollingstone Creek	170.3	...	170.3	187.8	+17.4	+10.24	91.5	...	84.2	77.1	-7.1	-8.43	261.8	...	254.5	264.9	+10.3	+4.07	81
Black freshwater	905.2	...	890.9	900.4	+9.4	+1.06	315.1	...	295.3	297.6	+2.3	+0.78	1,220.3	...	1,186.2	1,197.9	+11.7	+0.99	81

Mangrove and Saltmarsh scoring range: ■ = Very Poor: >3% loss | ■ = Poor: 0.51 – 3% loss | ■ = Moderate: 0.11 – 0.5% loss | ■ = Good: 0 – 0.1% loss | ■ = Very Good: increase in mangrove of saltmarsh area.

Standardised scoring range: ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

■ = increase in vegetation, ■ = no change in vegetation, ■ = decrease in vegetation.

11.2.3 Estuarine Riparian Extent

The Partnership uses methods sourced from the Reef Water Quality Report Card, however, presents results at an estuarine level. The most recent results from the Reef Water Quality Report Card are from 2017, however results presented in this report are from 2021.

11.2.3.1 *Monitoring Sites*

The area assessed for this indicator category is provided in Appendix RR and Appendix SS.

11.2.3.2 *Results: Estuarine Riparian Extent*

The standardised score and grade for the estuarine riparian extent indicator category is calculated as a percentage lost/gained from 2019 to 2021. For the 2022–2023 reporting period the total area of estuarine remnant riparian vegetation was 4,627.7ha in the Ross Estuarine Basin, and 848.5ha in the Black Estuarine Basin. From 2019 to 2021, the Ross Estuarine Basin gained 0.2ha (0.0% due to rounding) of vegetation, and the Black Estuarine Basin lost 9.8ha (1.14%) of vegetation. No estuaries in the Ross Estuarine Basin lost vegetation. Estuaries in the Black Estuarine Basin varied from "very poor" (Black River, Bluewater Creek, Rollingstone Creek), to "very good" (Crystal Creek), which recorded a gain in vegetation (Table 55). Notably, the Ross Basin recorded an increase in estuarine riparian vegetation, however it is not clear if this is the result of growth of native vegetation or weed species. Further, it should be noted that because vegetation is compared to most recent previous assessment, a score of "good" simply means that there was no vegetation loss since the previous assessment, not since "pre-European times". The standardised score in the Ross Estuarine Basin was 81 (very good), and the standardised score in the Black Estuarine Basin was 20 (very poor) (Table 54). Historic vegetation trends for each basin are presented in Appendix TT and Appendix UU.

Table 54. Historic standardised score for the Estuarine riparian extent indicator category.

Basin	Estuarine Riparian Extent Standardised Scores		
	22-23	21-22	20-21
Ross Estuarine	81	80	ND
Black Estuarine	20	80	ND

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

Table 55. Riparian Extent area, loss and standardised score in the estuarine basins and sub basins of the Townsville Dry Tropics.

Basin/Sub Basin	Estuarine Riparian Extent						
	Area (ha)				Extent Change (19-21)		Standardised Score
	Pre-Clear	...	2019	2021	ha	%	
Alligator Creek	2,324.8	...	2,320.2	2,320.3	+0.2	+0.01	81
Bohle River	884.9	...	867	867	0.0	0.0	80
Magnetic Island	90.5	...	88.3	88.3	0.0	0.0	80
Ross River (Lower)	564.7	...	530.4	530.4	0.0	0.0	80
Ross River (Upper)	ND	...	ND	ND	ND	ND	ND
Stuart Creek	824.4	...	821.7	821.7	0.0	0.0	80
Ross estuarine	4,689.3	...	4,627.5	4,627.7	+0.2	+0.0	81
Black River	151.2	...	151.1	149.3	-1.9	-1.24	20
Bluewater Creek	315.1	...	316.3	312.3	-4.0	-1.26	20
Crystal Creek	160.5	...	159.4	159.6	+0.2	+0.11	81
Palm Islands	50.4	...	50.1	50.1	0.0	0.0	80
Paluma Lake	ND	...	ND	ND	ND	ND	ND
Rollingstone Creek	178.3	...	181.4	177.3	-4.1	-2.25	20
Black estuarine	855.6	...	858.2	848.5	-9.8	-1.14	20

Riparian extent scoring range: ■ = Very Poor: >1% loss | ■ = Poor: 0.51 to 1% loss | ■ = Moderate: 0.11 to 0.5% loss | ■ = Good: 0 to 0.1% loss| ■ = Very Good: increase in vegetation.

Standardised scoring range: ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

11.2.4 Confidence Scores

Overall, there was moderate confidence in the results due to a lack of ability to directly measure the environment, however, all other criterion received a score of 2 or greater (Table 56).

Table 56. Confidence scores for the mangrove and saltmarsh extent and riparian extent indicator categories.

Indicator Category	Maturity (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Score (Rank)
M. & S. Extent	2	2	2	1	2	8.2 (3)
R. Extent	2	2	2	1	2	8.2 (3)

Rank based on score: 1 (very low) = 4.5 to 6.3; | 2 (low) = >6.3 to 8.1; | 3 (moderate) = >8.1 to 9.9; | 4 (high) = >9.9 to 11.7; | 5 (very high) = >11.7 to 13.5.

Inshore Marine 2022–2023

Written by Adam Shand

As part of the results for the Townsville Dry Tropics Report Card 2024 (Reporting on data from July 2022– June 2023)

Healthy Waters Partnership for the Dry Tropics (HWP)

July 2024

12 Inshore Marine Environment

Within the inshore environment, water quality and habitat are the two indices scored. Each of these indices are made up of indicator categories and indicators which are updated annually. All indicator categories use data provided by multiple partners of the Partnership team.

Index scores are calculated for the Cleveland Bay Inshore Marine Zone, and the Halifax Bay Inshore Marine Zone.

12.1 Water Quality

The water quality index for the Inshore Marine Environment of the Townsville Dry Tropics regions consists of three indicator categories: Nutrients, Physical-Chemical Properties, and Chlorophyll *a*. These are divided into eight indicators and for each indicator the parameters used to calculate scores are the:

- Water Quality Objectives (WQOs), and
- Annual means or medians (depending on the indicator), calculated from the monthly medians or means.

The Townsville Dry Tropics Methods Document (2024) provides definitions of the WQOs and guidelines for using mean or median values. Values can also be found in Appendix VV and Appendix XX.

The nutrients indicator category is comprised of four indicators, Nitrogen Oxides (NOx), Particulate Nitrogen (PN), Particulate Phosphorus (PP), and Total Phosphorus (TP). The scores for nutrients are averaged from the scores of the four indicators. The physical-chemical properties indicator category is comprised of three indicators, Turbidity, Total Suspended Solids (TSS), and Secchi Depth, and the score is calculated as the average from the scores of the three indicators. Finally, the Chlorophyll *a* indicator category is comprised of only one indicator, the Chlorophyll *a* indicator.

12.1.1 Monitoring Sites

In the 2022–2023 technical report, water quality data was collected from 20 sites (codes). Sites were grouped into eight geographic areas, six sub zones, and two zones as detailed in Table 57, with locations presented in Figure 21.

Table 57. Townsville Dry Tropics Inshore Marine water quality site summary.

Zone	Sub Zone	Geographic Area	Number of Sites
Cleveland Bay	Enclosed Coastal	Enclosed Coastal: Inside Port Zone	3
		Enclosed Coastal: Outside Port Zone	4
	Open Coastal	Open Coastal: Inside Port Zone	1
		Open Coastal: Outside Port Zone	3
	Magnetic Island	Magnetic Island	3
Halifax Bay	Enclosed Coastal	Enclosed Coastal	2
	Open Coastal	Open Coastal	2
	Midshelf	Midshelf	2

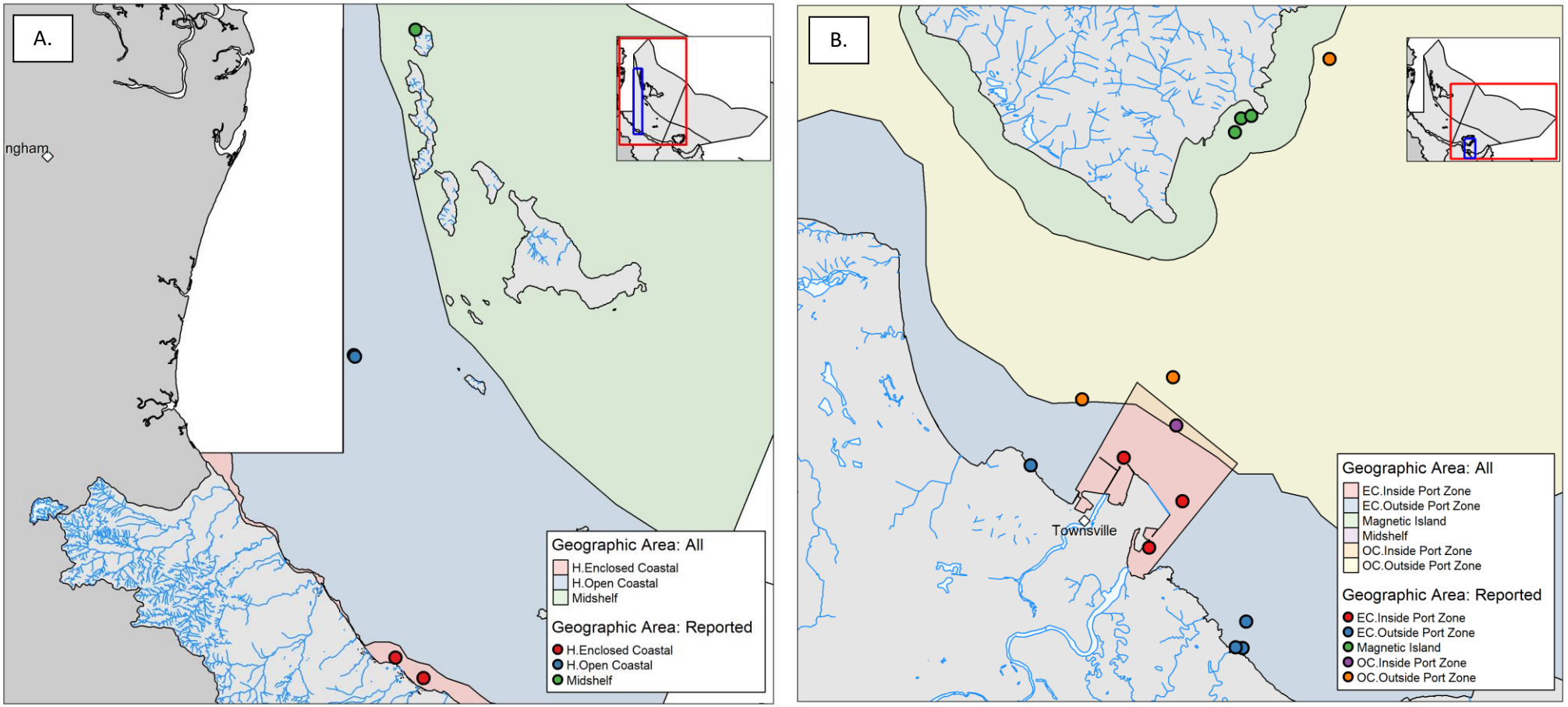

Figure 19. Inshore Marine Zones (A. = Halifax Bay, B. = Cleveland Bay), and Geographic Areas (see legend).

12.1.2 Overall Summary: Inshore Water Quality

The water quality index was graded as "good" in both Cleveland and Halifax Bay. This marks a decrease in score in Cleveland Bay (78 to 73), and an increase in score in Halifax Bay (69 to 73) (Table 58). The change in both bays was driven predominantly by a change in the physical-chemical properties indicator category.

Table 58. Current and previous water quality scores and grades for the Townsville Dry Tropics Inshore Marine Environment.

Zone	Nutrients	Phys-Chem Properties	Chlorophyll *a*	Water Quality				
				22-23	21–22	20–21	19–20	18–19
CB	84	48	87	73	78	73	79	36
HB	77	76	68	73	69	73	54	45

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

12.1.2.1 *Key Messages*

- The Cleveland Bay inshore marine zone grade remained "good" although the score declined slightly from 78 to 73.
    - Most influential was a combination of the Turbidity and Secchi indicators in the Enclosed Coastal and Open Coastal sub zones.
- The Halifax Bay inshore marine zone grade remained "good" although the score increased slightly from 69 to 73.
    - Most influential was a combination of the Nitrogen Oxides (NOx) indicator category in the Enclosed Coastal sub zone, and the Turbidity and Total Suspended Solids (TSS) indicators in all sub zones.

12.1.3 Updated Methodology

Following a review of EPP water quality objectives (WQOs) the methodology used to calculate the inshore marine water quality scores and grades has been updated. In previous methods, the mean value of the NOx indicator was compared against the WQO values, this has been changed so that the median value of the NOx indicator is now compared. All prior results have been back calculated and are presented in Table 58.

12.1.4 Nutrients

For the 2022–2023 technical report the nutrients indicator category is comprised of four indicators, Nitrogen Oxides (NOx), Particulate Nitrogen (PN), Particulate Phosphorus (PP), and Total Phosphorus (TP), however not all indicators are measured at each site (determined by data provider). The scores and grades for Cleveland and Halifax Bay, and their associated sub zones are presented in Table 59. Annual mean or median values (depending on the indicator), samples collected, months sampled, and WQOs are presented in Appendix VV. Historical scores are presented in Appendix WW.

12.1.4.1 *Results: Inshore Nutrients*

Cleveland Bay received a nutrient indicator category score of 84 (very good). Within the zone, the enclosed coastal and open coastal sub zones received nutrient indicator category grades of "very good" (100), however the Open Coastal Outside Port Zone did not receive NOx scores due to the LOR

for the laboratory being unable to detect concentrations lower than the WQO[6] (despite data being available). The Magnetic Island Sub Zone received a grade of "poor" (22). All three indicators in this sub zone (NOx, PN, and PP) were graded as "poor" or "very poor" with scores of 19, 8, and 40 respectively (Table 59).

A low nutrients indicator category score in the Magnetic Island Sub Zone relative to other sub zones could be attributed to several factors. Considerations includes the use of different indicators and water quality objectives (WQOs), different sampling times and frequency, or differences in sampling programs and analysis methods (for example, LORs) (Appendix VV). It is also important to note that Magnetic Island Sub Zone is considered a world heritage area and such the WQOs must meet these strict standards. Equally, nutrient sources such as septic systems, large infrastructure projects in close proximity, and a greater exposure to large southern influences such as the Burdekin River may contribute to a low grade and score. A comparison of median values indicate that NOx concentrations were roughly equal to, or in some cases less than, the median values in other geographic areas (Appendix VV). Thus, it is possible to attribute differences in WQOs as the main driver of a low NOx score in the Magnetic Island Sub Zone for the 2022-2023 report. However, it is important to note that over several reports, the Magnetic Island Sub Zone has consistently received low scores and grades, and not always due to more stringent WQOs. It is likely that the multitude of unique geographic and regulatory characteristics of the Magnetic Island Sub Zone, in combination, continue to result in a low NOx score.

The poor grade for NOx in the Enclosed Coastal Outside Port Zone is likely influenced by similar factors as discussed above. However, the majority of the sampling sites in this geographic area are located in close proximity to the mouth of Sandfly Creek where the bay is very shallow and muddy, and can be affected by the tide and wind in addition to discharge from the Cleveland Bay Wastewater Treatment plant (Figure 21).

Halifax Bay Inshore received a nutrient indicator category score of 77 (good). Within the zone, the open coastal and midshelf sub zones received a nutrient indicator category grade of "good", and the enclosed coastal sub zone received a grade of "very good" (Table 59). Across all indicators in all geographic areas, only the PN indicator did not receive a grade of "good" or "very good". Instead, the PN indicator received a grade of "poor" in both the Open Coastal and Midshelf locations, which remain consistent with previous reporting years. Interestingly the NOx indicator shows signs of improvement from previous reporting years and should be carefully monitored to determine drivers.

[6] Data removed as the LOR was >= the WQO, and more than half of the concentration values were <= the WQO.

Table 59. Standardised scores and grades for the nutrient indicator category and indicators comprising the nutrient indicator category in the Townsville Dry Tropics Inshore Marine Environment.

Zone	Sub Zone	Area	NOx	PN	PP	TP	Nutrients	Zone Nutrients
Cleveland Bay	Enclosed Coastal	Inside Port Zone	100	ND	ND	100	100	84
		Outside Port Zone	100	ND	ND	100	100	
			100	ND	ND	100	100	
	Open Coastal	Inside Port Zone	100	ND	ND	100	100	
		Outside Port Zone	NA[7]	ND	ND	100	100	
			100	ND	ND	100	100	
	Magnetic Island	Magnetic Island	19	8	40	ND	22	
			79	8	40	100	84	
Halifax Bay	Enclosed Coastal	Enclosed Coastal	100	ND	ND	100	100	77
	Open Coastal	Open Coastal	100	32	63	ND	65	
	Midshelf	Midshelf	100	25	71	ND	65	
			100	29	67	100	77	

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

[7] Data removed as the LOR was >= the WQO, and more than half (8 of 8) of the concentration values were <= the WQO.

12.1.5 Physical-Chemical Properties

For the 2022–2023 technical report the physical-chemical properties indicator category is comprised of three indicators, Turbidity (NTU), Total Suspended Solids (TSS), and (Secchi) Depth. The scores and grades for Cleveland and Halifax Bay, and their associated sub zones are presented in Table 60. Annual mean or median values (depending on the indicator and WQO), samples collected, months sampled, and WQOs are presented in Appendix XX. Historical scores are presented in Table 95.

12.1.5.1 *Results: Inshore Physical-Chemical Properties*

Cleveland Bay received a physical-chemical properties indicator category score of 48 (moderate). Within the zone, the enclosed coastal and open coastal sub zones received a grade of "poor" (36, 39) and the magnetic island sub zone received a grade of "very good" (91). Grades for indicators ranged from 0 to 89 for Turbidity, 0 to 100 for TSS, and 0 to 85 for Secchi (Table 60).

The wide range of scores and grades received for all indicators could be attributed to several factors, including the use of different water quality objectives (WQOs), different sampling times and frequency, or differences in sampling programs and analysis methods (Appendix XX). Equally, spatial variations such as proximity to large river outflows, distance offshore, and proximity to the Cleveland Bay shipping channel may contribute to a low grade and score. Some variation in indicators scores between geographic areas can be explained by differences in WQOs. For example, mean values for Secchi were similar in the Open Coastal Inside Port Zone and Open Coastal Outside Port Zone areas (1.2 and 1.1), but differences in WQOs resulted in significantly different standardised scores (72 and 0) (Table 60, Appendix XX). However, in the 2022-2023 the majority of scores and grades were driven predominantly by the concentrations measured for each indicator, rather than differences in WQOs. In the Enclosed Coastal Outside Port Sub Zone, the Secchi indicator did not record the same very low scores and grades as the Turbidity and TSS indicators as there is only one location where Secchi depth is monitored. The additional Turbidity and TSS sample sites are in close proximity to the mouth of Sandfly Creek where the bay is very shallow and muddy and can be affected by the tide and wind in addition to discharge from the Cleveland Bay Wastewater Treatment plant (Figure 21).

In the Enclosed Coastal Inside Port Sub Zone the Turbidity indicator score dropped from 100 in 2021-2022 to 28 in the current year. Investigation of the data found that the highest 50 percent of the readings were associated with higher turbidity readings further up the Ross River estuary than in the enclosed coastal zone with decreasing readings with distance from the river mouth. At the time of sampling strong ESE winds had prevailed for the preceding weeks, and the occasion of the highest results coincided with release of water from Ross Dam resulting in visible weeds in the water column. It is well known that plant material in the water column will contribute to high turbidity readings. Further factors occurring during this time included the Port of Townsville Channel Upgrade project, as well as standard port operations.

Halifax Bay received a physical-chemical properties indicator category score of 76 (good). Within the zone, both the Enclosed Coastal and Midshelf sub zone received a physical-chemical indicator category grade of "very good", with the Open Coastal sub zone receiving a grade of "good", and one received a grade of "moderate". Across all indicators the "poor" grade for Secchi, driven largely by a "very poor" grade in the Open Coastal sub zone, contrasted the "very good" grade for TSS and Turbidity (Table 60). In the previous report it was noted that a spatial trend of improved water quality further offshore was apparent. Although this is not clearly evident in the grades and scores, a comparison of concentrations at each site once again supports this observation (Appendix XX).

Table 60. Standardised scores and grades for the physical-chemical properties indicator category and indicators comprising the physical-chemical properties indicator category in the Townsville Dry Tropics Inshore Marine Environment.

Zone	Sub Zone	Area	Turbidity	TSS	Secchi	Phys Chem	Zone Phys Chem
Cleveland Bay	Enclosed Coastal	Inside Port Zone	28	85	60	58	48
		Outside Port Zone	0	0	63	21	
			14	43	61	39	
	Open Coastal	Inside Port Zone	66	44	72	61	
		Outside Port Zone	30	3	0	11	
			48	24	36	36	
	Magnetic Island	Magnetic Island	89	100	85	91	
			42	46	56	48	
Halifax Bay	Enclosed Coastal	Enclosed Coastal	88	88	ND	88	76
	Open Coastal	Open Coastal	82	86	11	60	
	Midshelf	Midshelf	100	100	41	80	
			90	91	26	76	

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

12.1.6 Chlorophyll *a*

For the 2022–2023 technical report the Chlorophyll *a* indicator category is comprised of only one indicator, Chlorophyll *a*. The scores and grades for Cleveland and Halifax Bays, and their associated sub zones are presented in Table 61. Annual mean values, samples collected, months sampled, and WQOs are presented in Appendix XX. Historical scores are presented in Table 95.

12.1.6.1 *Results: Inshore Chlorophyll a*

Cleveland Bay received a Chlorophyll *a* indicator category score of 87 (very good). The Magnetic Island and Enclosed Coastal sub zones received grades of "very good" (84 and 90) and the Open Coastal Sub Zone was not graded (Table 61). Mean values were below objectives in all locations (Appendix XX).

Halifax Bay received chlorophyll *a* score of 68 (good). The Enclosed Coastal Water Sub Zone received a score of 100 (very good), the Open Coastal Waters Sub Zone received a score of 61 (good), and the Midshelf Sub Zone received a score of 43 (moderate). At each sub zone the grade decreases, from very good in the Enclosed Coastal Sub Zone to moderate in the Midshelf Sub Zone (Table 61). However, this result needs to be considered along with the differing WQO's with the WQO in the Enclosed Coastal more than four times higher than in the other sub zones (Appendix XX, Table 95).

Table 61. Standardised scores and grades for the Chlorophyll a indicator in the Townsville Dry Tropics Inshore Marine Environment.

Zone	Sub Zone	Area	Chl *a*	Zone Chl *a*
Cleveland Bay	Enclosed Coastal	Inside Port Zone	ND	87
		Outside Port Zone	90	
			90	
	Open Coastal	Inside Port Zone	ND	
		Outside Port Zone	ND	
			ND	
	Magnetic Island	Magnetic Island	84	
			87	
Halifax Bay	Enclosed Coastal	Enclosed Coastal	100	68
	Open Coastal	Open Coastal	61	
	Midshelf	Midshelf	43	
			68	

Standardised scoring range: Very Poor (E) = 0 to <21 | Poor (D) = 21 to <41 | Moderate (C) = 41 to <61 | Good (B) = 61 to <81 | Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

12.1.7 Overlap with the Wet Tropics Technical Report

The Townsville Dry Tropics reporting region shares four sites (BUR1, BUR2, Pandora, Pelorus) with the Wet Tropics reporting region (Appendix CCC). Underlying data is identical, however differences in aggregation and reporting style may result in minor discrepancies in the presentation of results.

12.1.8 Confidence Scores

Overall, there was low confidence in the results due to limited spatial and temporal sampling for some indicators in both bays (Table 62). For example, within Cleveland Bay almost all sites are within an 11km section of water near the coastline, despite the Enclosed Coastal Waters stretching more than 58km. It is noted that there is less development in these other areas and thus current monitoring may capture most of the areas impacted by human activities. More sampling, both along the coast and further offshore, would enable a more accurate understanding of the water quality within the inshore area.

Table 62. Confidence scores for the nutrients, physical-chemical properties, and Chlorophyll a indicator categories.

Indicator Category	Maturity (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Score (Rank)
Nutrients	2	3	1	3	1	7.6 (2)
Phys-Chem	2	3	1	3	1	7.6 (2)
Chlorophyll *a*	2	3	1	3	1	7.6 (2)

Rank based on score: 1 (very low) = 4.5 to 6.3; | 2 (low) = >6.3 to 8.1; | 3 (moderate) = >8.1 to 9.9; | 4 (high) = >9.9 to 11.7; | 5 (very high) = >11.7 to 13.5.

12.2 Habitat

The habitat index is comprised of two indicator categories: coral and seagrass, and both indicator categories source their results and discussion from reports published by partner organisations (Mckenna 2023, Thompson 2024).

12.2.1 Overall Summary: Inshore Habitat

Habitat scores where "moderate" in both Cleveland Bay (53) and Halifax Bay (47). Grades did not change in either bay, however scores decreased slightly in Cleveland Bay, and increased slightly in Halifax Bay. Neither bay received their highest or lowest scores since this technical report began, and once again these results provide insight into the mixed habitat health of the Inshore Marine Environment. This highlights that several intertwined factors play a role in the grades and scores of this indicator (Table 63).

Table 63. Standardised score for the Inshore Marine Environment habitat index.

Zone	Coral	Seagrass	Habitat Index				
			22-23	21-22	20-21	19-20	18-19
Cleveland Bay	39	68	53	57	54	48	56
Halifax Bay	47	ND	47	45	49	52	52

Coral Standardised scoring range: ■ = Very Poor: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 100.

Seagrass Standardised scoring range: ■ = Very Poor: 0 to <25 | ■ = Poor: 25 to <50 | ■ = Moderate: 50 to <65 | ■ = Good: 65 to <85 | ■ = Very Good: 85 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

12.2.1.1 *Key Messages*

- The Cleveland Bay inshore marine zone grade remained "moderate" although the score declined slightly from 57 to 53.
    - The seagrass grade within Cleveland Bay remained "good". The score declined slightly from 73 to 68, however can be explained by local environmental conditions.
        - Declines were region wide and not confined to areas closest to dredging activity, pointing to wider/regional drivers of change.
        - Unfavourable growing conditions for seagrass included a heatwave, above average out of season rainfall, sustained periods of high wind and multiple periods of low light conditions across many areas of the Bay.
        - As individual one-off events these unfavourable conditions were not likely to impact seagrass but the cumulative impact of them throughout the year were likely to have been behind the relatively small declines recorded in October 2022.
    - The total area of seagrass remained above the long-term average.
    - The coral grade with Cleveland Bay declined from "moderate" (41) to "poor" (39), however has fluctuated within this range for the past four years.
- The Halifax Bay inshore marine zone grade remained "moderate" although the score increased slightly from 45 to 47, neither its highest nor lowest in the past five years.
    - There remains a significant amount of macroalgae recorded at five of seven sites.

12.2.2 Coral

Coral data was primarily collected by the Great Barrier Reef Marine Monitoring Program (MMP)[8], and the Australian Institute of Marine Science's Long-term Monitoring Program (LTMP)[8]. Data was also collected by the citizen science group, Reef Check Australia (RCA)[8].

12.2.2.1 *Monitoring Sites*

Within Cleveland Bay six sites were sampled, with one site sampled twice by different monitoring programs (Geoffrey Bay). In Halifax Bay six sites were sampled, (Table 64). Reef locations are shown in Figure 22 and Figure 23, noting that the Palms West Reef consists of two sites.

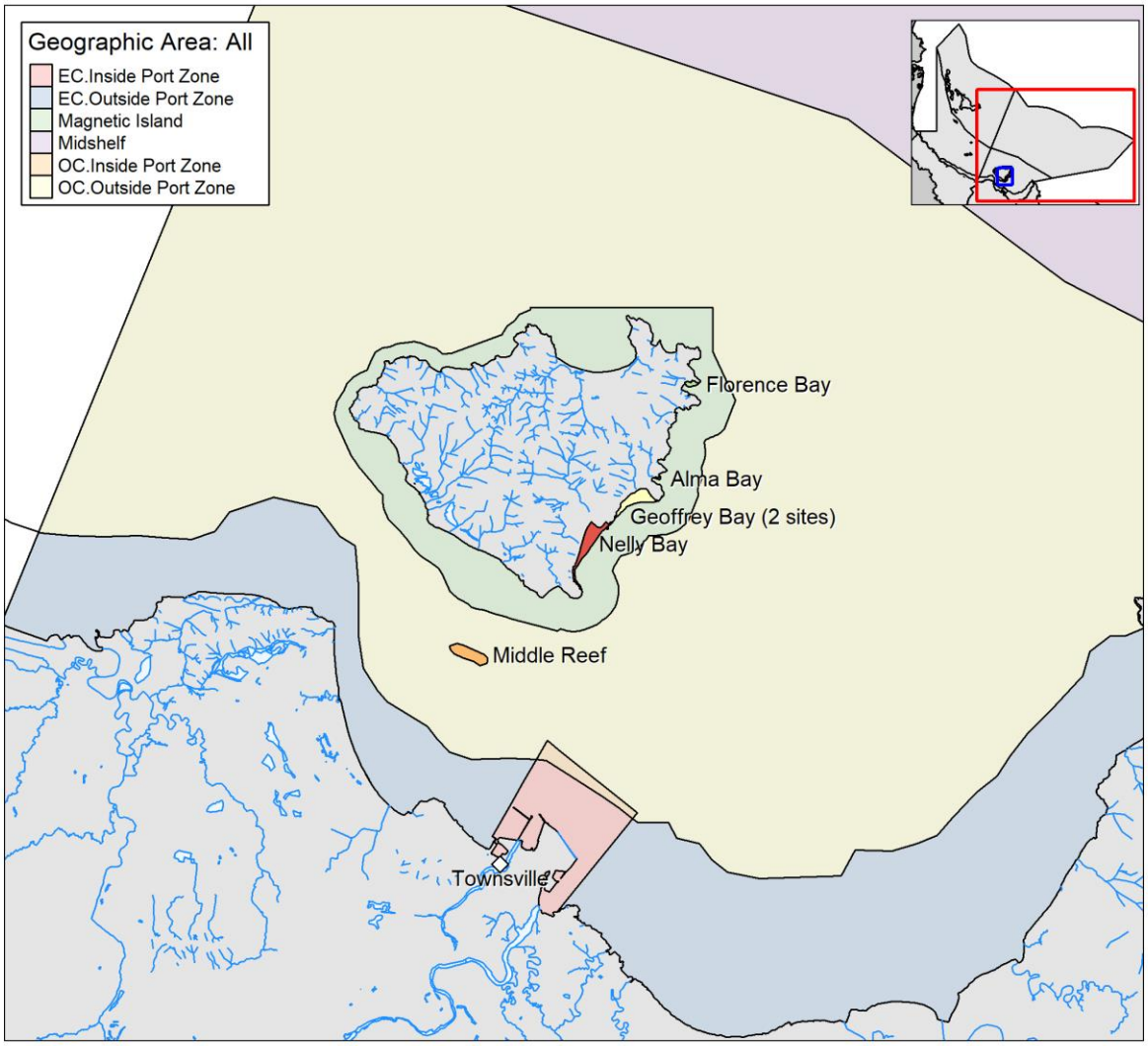

Figure 20. Coral reef sampling locations in the Cleveland Bay Inshore marine zone.

[8] MMP, LTMP, RCA

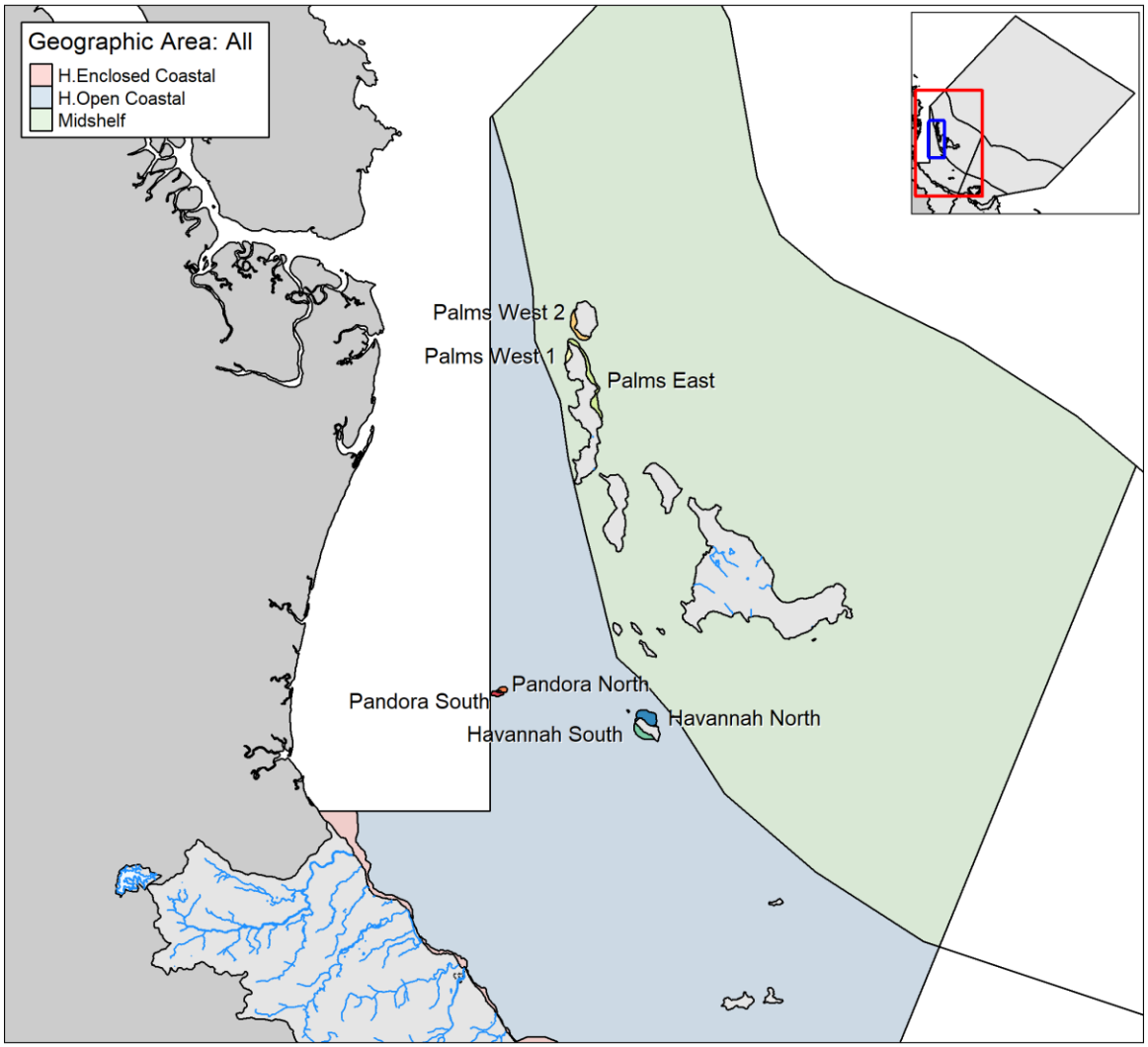

Figure 21. Coral reef sampling locations in the Halifax Bay Inshore marine zone.

Table 64. Inshore Marine coral sampling locations and sampling programs.

Zone	Sampling Program	Sampling Site	ID
Cleveland Bay	MMP & RCA	Geoffrey Bay	1
	RCA	Alma Bay	2
		Florence Bay	3
		Middle Reef	4
		Nelly Bay	5
Halifax Bay	MMP	Palms East	6
		Palms West	7
		Pandora South	8
		Havannah South	9
	LTMP	Pandora North	10
		Havannah North	11

12.2.2.2 *Results: Inshore Coral*

In Cleveland Bay, the grade for the coral indicator category was "poor", with a score of 39. In Halifax Bay, the grade for the coral indicator category improved from the previous reporting period with a score of 47 (moderate). These results show a mixed trend of overall coral health and recovery as reefs have been exposed to pressures, such as increased water temperatures that contributed to coral bleaching in 2020 (Table 65).

Table 65. Inshore Marine Environment coral indicator category scores for current and previous technical reports.

Zone	Coral Standardised Score				
	22-23	21–22	20–21	19–20	18–19
Cleveland Bay	39	41	36	44	38
Halifax Bay	47	45	48	50	52

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

Discussion has been paraphrased from the Marine Monitoring Program Annual Report for inshore coral reef monitoring 2022-23 report and applies to the Cleveland Bay and Halifax Bay sites collectively. Reference: (Thompson 2024).

"Coral Composition received a score of 'good' and has remained stable on the boundary of 'good' and 'moderate' since 2021. The Coral cover indicator score remained categorised as 'moderate' having continued to increase since 2013. In 2023 hard coral cover had increased at Geoffrey Bay, Palms East, Havannah South, Pandora North, and Havannah North. Increases were attributed to recovery of *Acropora, Montipora, Goniopora* and *Alveopora*, and Merulinidae. The regional rate of increase in hard coral cover over the last four years remained within modelled expectations as reflected by the 'moderate' score for the Cover change indicator score, however, the rate of hard coral recovery was 'poor' at Pandora South and Havannah North.

The Macroalgae indicator score has continued to decline and remains 'very poor'. Very poor scores were recorded at Geoffrey Bay, Pandora South, Havannah South, Pandora North, and Havannah North. Where the cover of macroalgae was high, the macroalgal communities were dominated by large brown species of the genus *Lobophora* and/or Family Sargassaceae.

The Juvenile coral indicator remained categorised as 'poor', although has increased at Geoffrey Bay, Palms East, Palms West, Pandora South, and Havannah South. Decreases were recorded at Pandora North and were greatest at Havannah North. Influential in the regional decline in juvenile densities in recent years have been declines in genus *Turbinaria* as strong cohorts that settled on some reefs following cyclone Yasi have died or grown beyond the juvenile size classes" (Thompson 2024).

Table 66. Inshore Marine coral indicator and indicator category scores for all sites and zones.

Zone	ID	Hard Coral Composition	% Coral Cover	% Change Hard Coral	Juvenile Density	Macroalgae	Indicator Category
Cleveland Bay	1	50	51	65	29	0	39
	2	ND	63	ND	ND	ND	ND
	3	ND	65	ND	ND	ND	ND
	4	ND	70	ND	ND	ND	ND
	5	ND	25	ND	ND	ND	ND
Cleveland Bay		50	53	65	29	0	39
Halifax Bay	6	100	67	29	27	100	65
	7	0	51	49	52	100	50
	8	75	25	34	31	20	37
	9	100	53	44	30	0	45
	10	0	85	44	40	11	36
	11	100	29	50	62	0	48
Halifax Bay		62	52	42	40	38	47

Standardised scoring range: Very Poor (E) = 0 to <21 | Poor (D) = 21 to <41 | Moderate (C) = 41 to <61 | Good (B) = 61 to <81 | Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

12.2.3 Seagrass

Data for the seagrass indicator category was sourced from the Port of Townsville Long-Term Seagrass Monitoring Program (LTSMP), with monitoring conducted by James Cook University (JCU) (Mckenna 2023). The 2022–2023 technical report uses data collected during September to October in 2022.

12.2.3.1 *Monitoring Sites*

Seagrass was only monitored in Cleveland Bay in 2022-2023. Across Cleveland Bay ten seagrass meadows are monitored in the LTSMP and divided into three spatially distinct groups: Magnetic Island, Cape Pallarenda/Strand, and Cleveland Bay (Table 67). Meadow locations are provided in Figure 24.

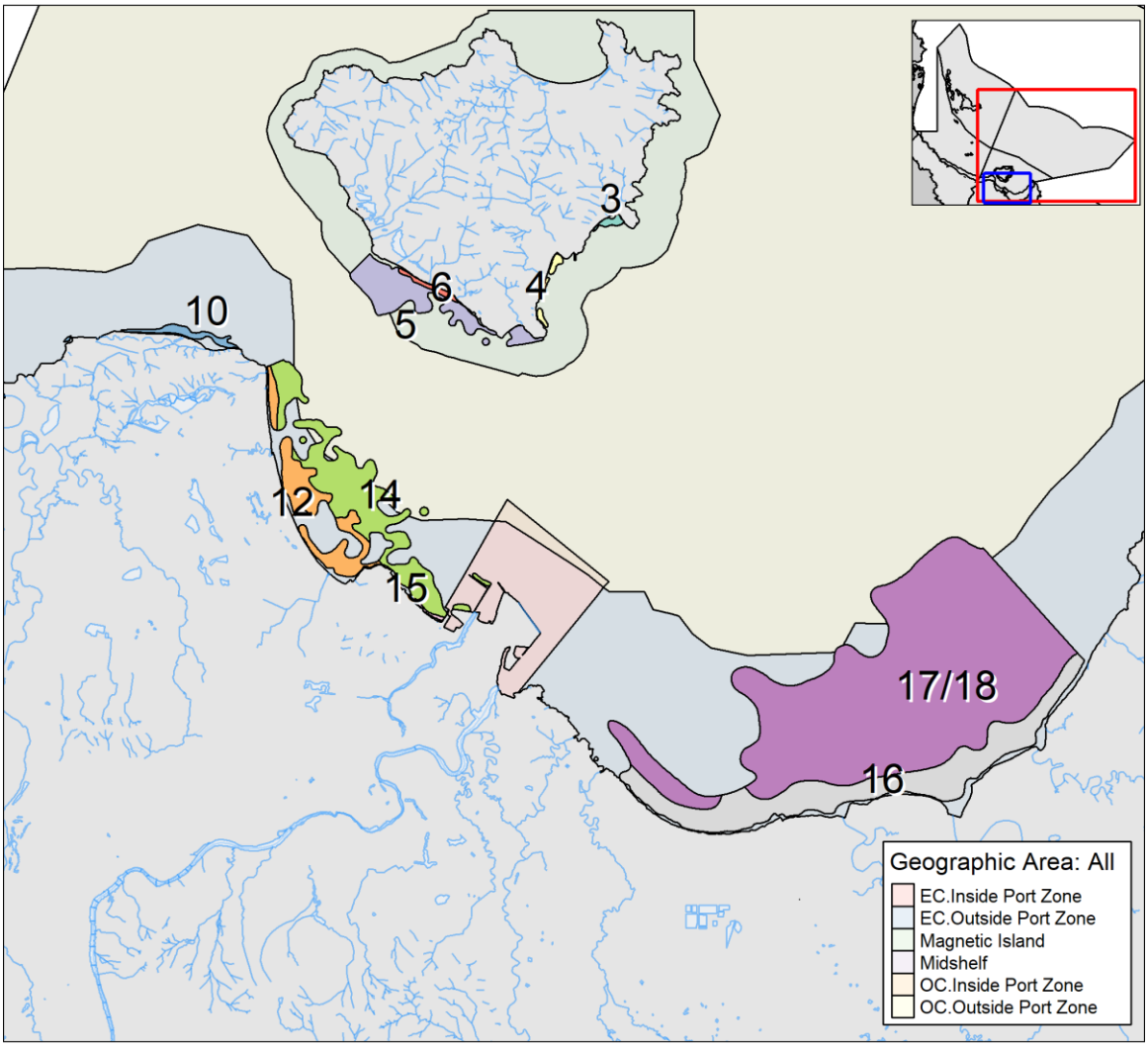

Figure 22. Seagrass meadow monitored for the LTSMP 2022 assessment.

Table 67. Overview of the Long-term Seagrass Monitoring Program (LTSMP) meadows. Adapted from (Mckenna 2023).

Region	Meadow	ID	History
Magnetic Island	Geoffrey Bay	3	Detailed Annual >10 years
	Nelly Bay	4	Detailed Annual >10 years
	Cockle/Picnic Bay	5	Detailed Annual >10 years
	Cockle Bay	6	Detailed Annual >10 years
Cape Pallarenda – Strand	Shelly Beach	10	Detailed Annual >10 years
	Rowes Bay	12	Detailed Annual >10 years
	Pallarenda inc. Virago Shoal	14	Detailed Annual >10 years
	Strand	15	Detailed Annual >10 years
Cleveland Bay	Cleveland Bay	16	Detailed Annual >10 years
	Cleveland Bay	17/18	Detailed Annual >10 years

12.2.3.2 *Results: Inshore Seagrass*

In Cleveland Bay, the grade for seagrass monitoring meadows was good, with a score of 68. This is a slight decrease on the score from the previous two reporting periods. These results show a recovery for overall seagrass health in comparison to the 19-20 report period (Table 68) where the seagrass had been impacted by the February 2019 flood.

Table 68. Standardised score for the seagrass indicator category.

Zone	Seagrass Standardised Score				
	22-23	21-22	20-21	19-20	18-19
Cleveland Bay Inshore Marine Zone	68	73	71	52	74

Standardised scoring range: ■ = Very Poor: 0 to <25 | ■ = Poor: 25 to <50 | ■ = Moderate: 50 to <65 | ■ = Good: 65 to <85 | ■ = Very Good: 85 to 100| ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

Discussion has been paraphrased from the Port of Townsville Seagrass Monitoring Program 2022 report. Reference: (Mckenna 2023).

"The seagrass condition category is comprised of three indicators: biomass, area, and species composition. Meadow scores are calculated as the lowest individual score of the three indicators, except when species composition is the lowest. When species composition is the lowest score the final meadow score is calculated as the average of the two lowest indicator scores (McKenna S 2022) (Carter 2023).

There are four monitoring meadows around Magnetic Island (3, 4, 5, 6). Three of the four meadows were of satisfactory or better condition in 2022, however, Meadow 6 was in poor condition due to a decrease in area from 50 ha in October 2021 to 22 ha in October 2022. This meadow, however, is highly variable in extent from year to year. Meadow 4 had expanded deeper and connected multiple patches along the shore, and its area was the largest it has been in the history of program (16 years, 21 ha). The species composition of all Magnetic Island meadows was above baseline conditions, with a species mix that reflected a good or very good condition in all meadows (Table 69).

There are four monitoring meadows that make up the Cape Pallarenda - Strand region (Meadows 10, 12, 14, 15). Three of the four meadows were in good or very good condition in October 2022; however, Meadow 10 was in a poor condition due to a decrease in area. The spatial footprint of Meadow 10 has been on a downward trajectory since 2014 with seagrass loss occurring on all sides of the meadow, although biomass and species composition remain in good condition. Interestingly, Meadow 12, that bounds and is on the seaward side of Meadow 10, has continued to expand shoreward as Meadow 10 retracts. For the meadows closest to the Channel Upgrade (CU) Project works (12, 14 and 15), area, biomass and species composition all remain in good or very good condition in 2022. Meadows 12 and 14 were slightly patchier in 2022 compared to 2021 but similar to previous years. Seagrass was present to 5.2m below MSL in October 2022 similar to previous surveys.

There are two monitoring meadows in Cleveland Bay, Meadow 16, and Meadow 17/18. These meadows are the largest coastal meadows in Townsville and were both in a satisfactory or better condition in 2022. In Meadow 16 species composition and biomass were both in good condition with density 'hotspots' increasing from 60 gDW m^{-2} in 2021 to 100 gDW m^{-2} in 2022. However, this is the first time since 2011 the area of the meadow has been below good condition. Coincidingly the

seaward Meadow 17/18 that bounds Meadow 16 has expanded shallower and meadow biomass rebounded from a low in 2019 to be in good condition for the last three years" (Mckenna 2023).

Table 69. Seagrass indicator scores for all meadows in the Cleveland Bay Inshore Marine Environment.

Region	ID	Biomass	Area	Species Comp.	Meadow Score
Magnetic Island	3	59	93	84	59
	4	87	100	99	87
	5	61	69	97	61
	6	80	47	89	47
Cape Pallarenda – Strand	10	73	49	75	49
	12	90	100	81	86
	14	70	67	99	67
	15	90	89	81	85
Cleveland Bay	16	83	63	97	63
	17/18	76	90	98	76
Overall					68

Standardised scoring range: ■ = Very Poor: 0 to <25 | ■ = Poor: 25 to <50 | ■ = Moderate: 50 to <65 | ■ = Good: 65 to <85 | ■ = Very Good: 85 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

12.2.4 Confidence Scores

There is very high confidence in the seagrass and coral indicator categories due to the efficacy and maturity of the habitat monitoring programs. Seagrass received a rank of 5 out of 5, and coral received a rank of 3, and 4 (Cleveland Bay was not as well represented as Halifax Bay) (Table 70).

Table 70. Confidence scores for the coral and seagrass indicator categories.

Indicator Category	Maturity (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Score (Rank)
Coral (CB)	3	3	1.5	3	2	9.8 (3)
Coral (HB)	3	3	2	3	2	10.8 (4)
Seagrass	3	3	3	3	3	13.5 (5)

Rank based on score: 1 (very low) = 4.5 to 6.3; | 2 (low) = >6.3 to 8.1; | 3 (moderate) = >8.1 to 9.9; | 4 (high) = >9.9 to 11.7; | 5 (very high) = >11.7 to 13.5.

Offshore Marine 2022–2023

Written by Adam Shand

As part of the results for the Townsville Dry Tropics Report Card 2024 (Reporting on data from July 2022– June 2023)

Healthy Waters Partnership for the Dry Tropics (HWP)

July 2024

13 Offshore Marine Environment

The Offshore Marine Environment in the Townsville Dry Tropics region consists of only one zone (the Offshore Marine Zone). The water quality and habit indies are measured in this zone, however currently only the habitat index is reported (see section 13.1.1 Data source). The extent of the zone is shown in Figure 25, and results are presented below.

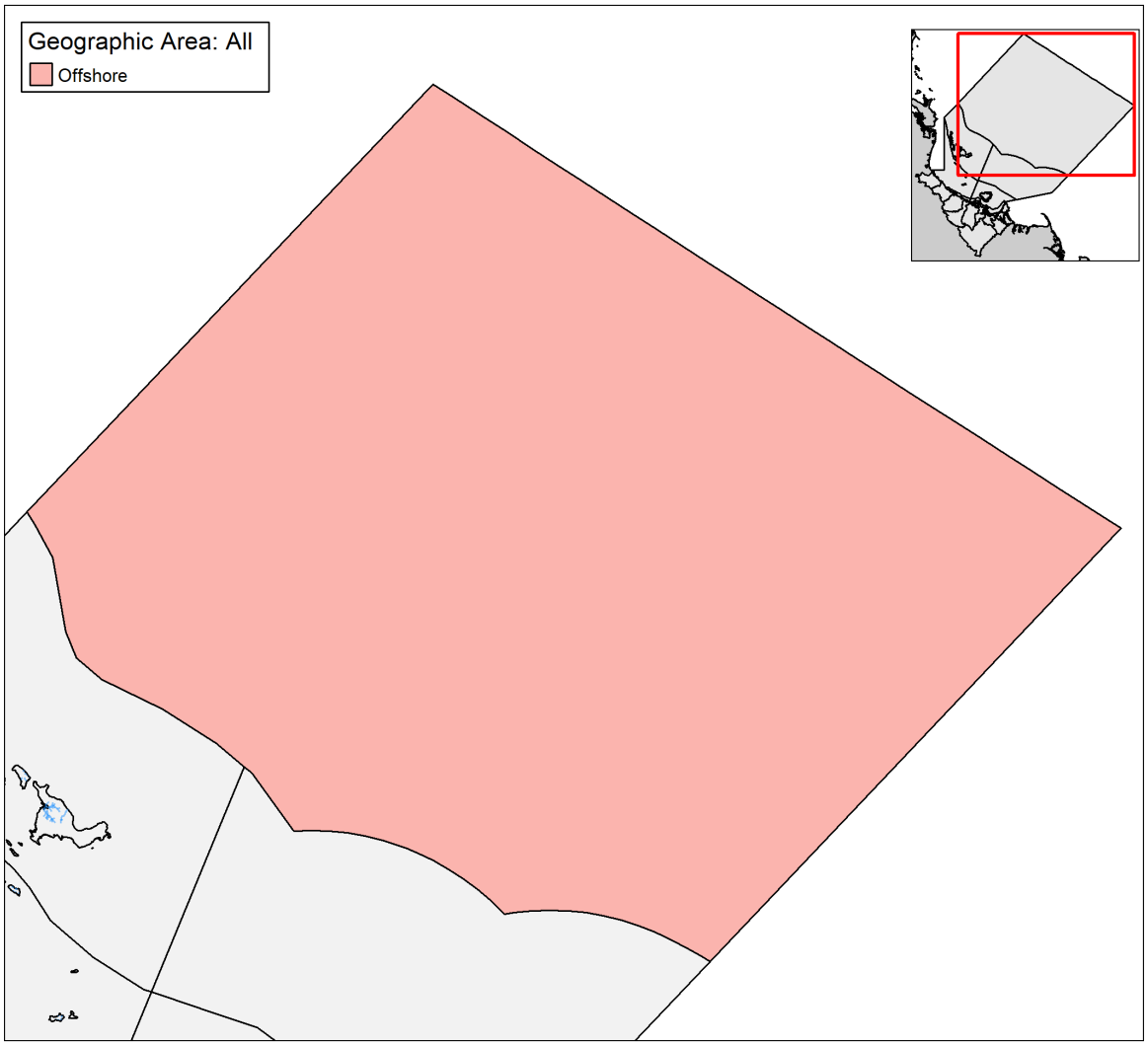

Figure 23. Dry Tropics offshore marine zone.

13.1 Water Quality

The 2022–2023 reporting period was the third year in which the water quality index has not been reported (see section 13.1.1 Data source). For years previous to 2020–2021 offshore water quality results were obtained from the BoM Marine Water Quality (MWQ) dashboard and were based upon relative area (%) of the water body where the annual mean value met the water quality guideline value (Table 71). The scores were similar for all reporting years.

Table 71. Current and previous water quality scores and grades for the Townsville Dry Tropics Offshore Marine Zone.

Zone	Water Quality				
	2022-2023	2021–2022	2020–2021	2019–2020	2018–2019
Offshore Marine	ND	ND	ND	100	97

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

13.1.1 Data source

During 2019–2020 there were limitations in the technical support for maintaining the BoM Marine Water Quality (MWQ) dashboard processing scripts and satellite data streams. Consequently, the more recent data for the 2019–2020 time series may be of lower quality than earlier time series data and the confidence criteria for validation was lowered from 2 to 1. In early 2021 the Bureau of Meteorology advised that the MWQ dashboard had been decommissioned and that the underlying data preparation workflow was being discontinued. Alternative data sources are to be identified for the 2023–2024 reporting year.

13.2 Habitat

The habitat index for the Offshore Marine Zone consists only of the coral indicator category. The coral indicator category sources its results from AIMS' Long-Term Monitoring Program (LTMP) (AIMS 2023). In the Townsville Dry Tropics region this data is updated every year with the most recent update occurring in 2023.

13.2.1 Overall Summary: Offshore Habitat

The score for the habitat index in the Offshore Marine Zone was similar to the previous reporting period, receiving a score of 63 within the same grade (good). These results show the continued stability of coral health in the Offshore Marine Zone after several years of disturbances (Table 72).

Table 72. Standardised score for the Offshore Marine Zone habitat index.

Zone	Coral	Habitat Index				
		2022-2023	2021–2022	2020–2021	2019–2020	2018–2019
Offshore Marine Zone	63	63	64	62	54	59

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

13.2.1.1 *Key Messages*

- The Offshore Marine Zone coral grade remained.
  - Juvenile density was graded as "very good" at 7 of 9 reefs surveyed.
  - All coral reefs had an overall grade of "moderate" or "good".

13.2.2 Coral

Coral data was collected by the Australian Institute of Marine Science's LTMP (AIMS 2023). In previous reporting years additional coral monitoring has been conducted by Reef Check Australia

(RCA), however no additional sampling occurred during 2022–2023 due to a limited budget. Coral was monitored between Mar 2023 and May 2023.

13.2.2.1 *Monitoring Sites*

The coral indicator category was monitored at nine locations in the Offshore Marine Zone. All sites were monitored as part of the LTMP and have been sampled in previous years (Figure 26).

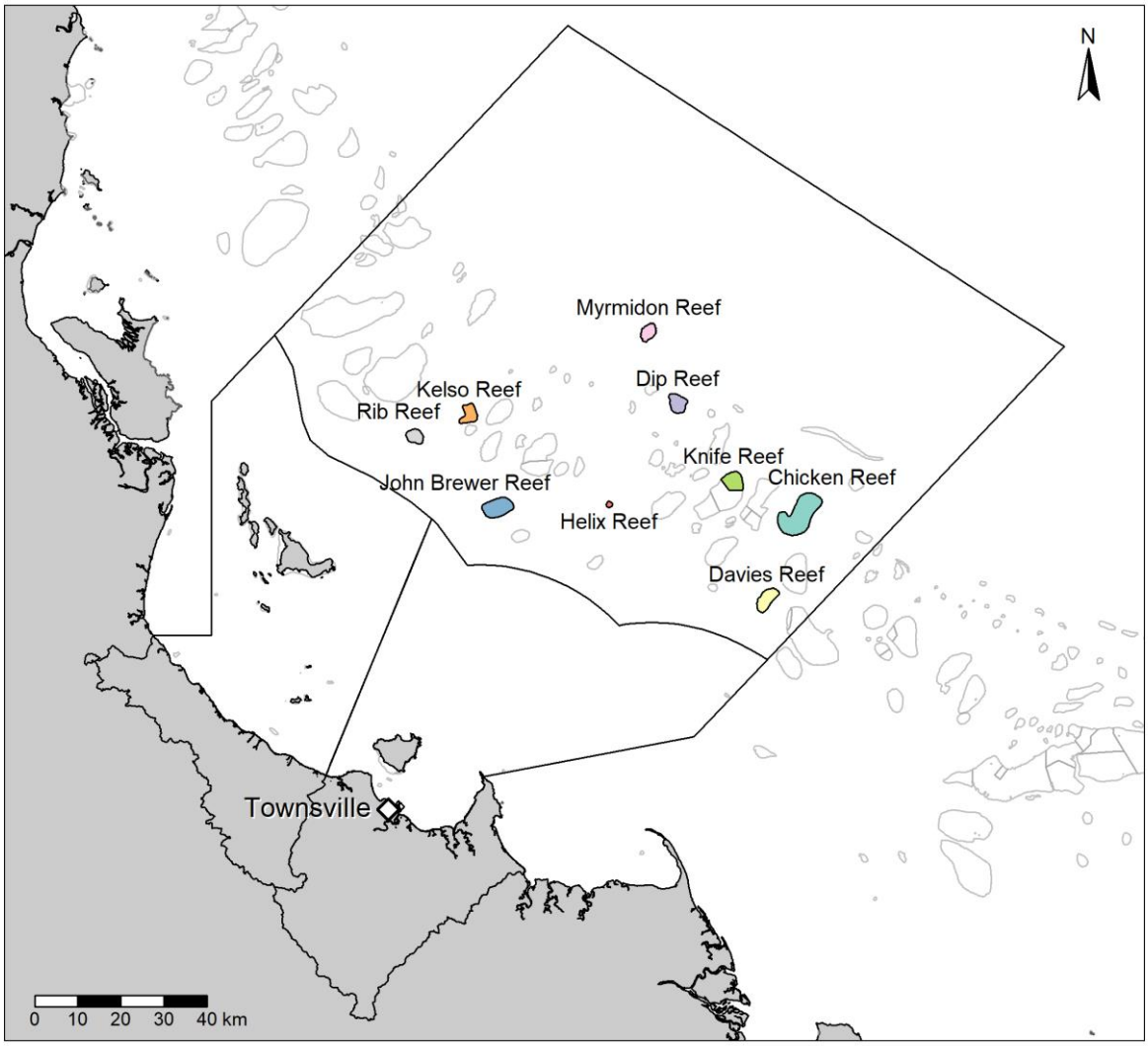

Figure 24. Offshore marine coral sampling locations in the Dry Tropics region.

13.2.2.2 *Result: Offshore Coral*

In the Offshore Marine Zone, the coral indicator category is comprised of three indicators: change in coral cover, percentage of coral cover, and juvenile density. Base on the combined scores of these indicators overall offshore coral index score remained good with individual reefs all grades as being in either moderate or good condition (Table 73). Contributing strongly to the good coral index score were high numbers of juvenile corals with scores for the Juvenile density indicator remaining good or very good at all reefs. In contrast, scores for the Coral cover indicator were variable ranging from very poor at John Brewer Reef, where corals are yet to recover from a recent crown-of-thorns starfish

outbreak[9], through to good at the more offshore reefs of Chicken, Knife, and Myrmidon. Fluctuation in coral cover is expected as reefs are exposed to severe disturbances, of concern is the slower recovery suggested by poor scores from the Cover change indicator at Davies and Helix. However, the moderate to good cover change scores at other reefs demonstrate ongoing recovery potential (Table 73).

Table 73. Coral indicator and indicator category scores for the Offshore Marine Zone.

Reef	Change in Coral Cover	% Coral Cover	Juvenile Density	Standardised Score (Grade)
Chicken Reef	53	73	100	75
Davies Reef	25	50	100	58
Dip Reef	60	42	76	60
Helix Reef	26	44	100	57
John Brewer Reef	45	18	63	42
Kelso Reef	47	38	100	62
Knife Reef	48	70	100	73
Myrmidon Reef	51	63	100	71
Rib Reef	74	31	100	68
Offshore Marine Zone	48	48	93	63

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

13.2.3 Confidence Scores

The overall confidence of the coral indicator category was high with a rank of 4 out of 5. Only Representativeness and Measured Error were not given 3/3 as some components of the indicator do not have their error quantified, and there are several reefs that are not part of the LTMP surveys.

Table 74. Confidence scores for the coral and seagrass indicator categories.

Indicator Category	Maturity (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Score (Rank)
Coral	3	3	2	3	2	10.8 (4)

Rank based on score: 1 (very low) = 4.5 to 6.3; | 2 (low) = >6.3 to 8.1; | 3 (moderate) = >8.1 to 9.9; | 4 (high) = >9.9 to 11.7; | 5 (very high) = >11.7 to 13.5.

[9] Reef Monitoring | John Brewer Reef | Benthic community cover (aims.gov.au)

Litter 2022–2023

Written by Dinny Taylor

As part of the results for the Townsville Dry Tropics Report Card 2024 (Reporting on data from July 2022– June 2023)

Healthy Waters Partnership for the Dry Tropics (HWP)

July 2024

14 Litter

The litter index is comprised of a single indicator to assess the “pressure” that the amount of litter and/or marine debris (from here referred to as litter) present in a location may be having on that environment. The data used to derive the scores and grades for the litter index is from Tangaroa Blue Foundation's (TBF) Australian Marine Debris Initiative Database (AMDI). The data is collected by volunteers, and partners through the Reef Clean program which is funded through the Australian Government's Reef Trust.

A model has been developed for the combined regions of the Wet Tropics Waterways Partnership, Healthy Waters Partnership for the Dry Tropics, Healthy Rivers to Reef Partnership, and the Gladstone Healthy Harbours Partnership from ‘baseline’ data from the period ~2009 to June 2019 available from the AMDI following the method developed by Venables and Whitehead (2019). The litter collected at sites each year is compared with this baseline to determine their score and grade.

The model developed by Venables and Whitehead (2019) was based on a smaller dataset of 2016–2019 data that had been pre-cleaned by TBF. As more data has now become available, the model has been re-fitted using a negative binomial distribution (rather than Gaussian) to take the additional data into account. Further, as the model was also fitted to data for the Wet Tropics Waterways Partnership, the Healthy Rivers to Reef Partnership, and the Gladstone Healthy Harbours Partnership, the zones included in the model were redefined based on a combination of the location and the landuse category included within the AMDI data (refer Methods). During the current reporting period, the score function used during the development for the previous year became unstable. A thorough investigation into a more stable score function has been conducted (refer Methods Appendix I). The recalculated results for the model, and the 2019–2020, 2020–2021, 2021-2022 years are provided in the Methods Appendix J and in Section 14.2 below respectively.

14.1 Monitoring Sites

There were 26 litter collection sites for the 2022–2023 period, and these are shown in (Figure 27 and Figure 28) where the colours indicate the grade. There were twelve sites in Cleveland Bay, eight sites in the Halifax Bay, and twelve sites in the Ross Basin. There were no sites defined as the Black Basin. Beach sites are defined by the AMDI landuse category where the volunteers collecting the litter have indicated whether the litter is largely sourced from direct deposit onto the land or washed up from the sea. It was considered that this was the best proxy available to define the boundary between a freshwater basin and the adjacent estuarine or inshore zone.

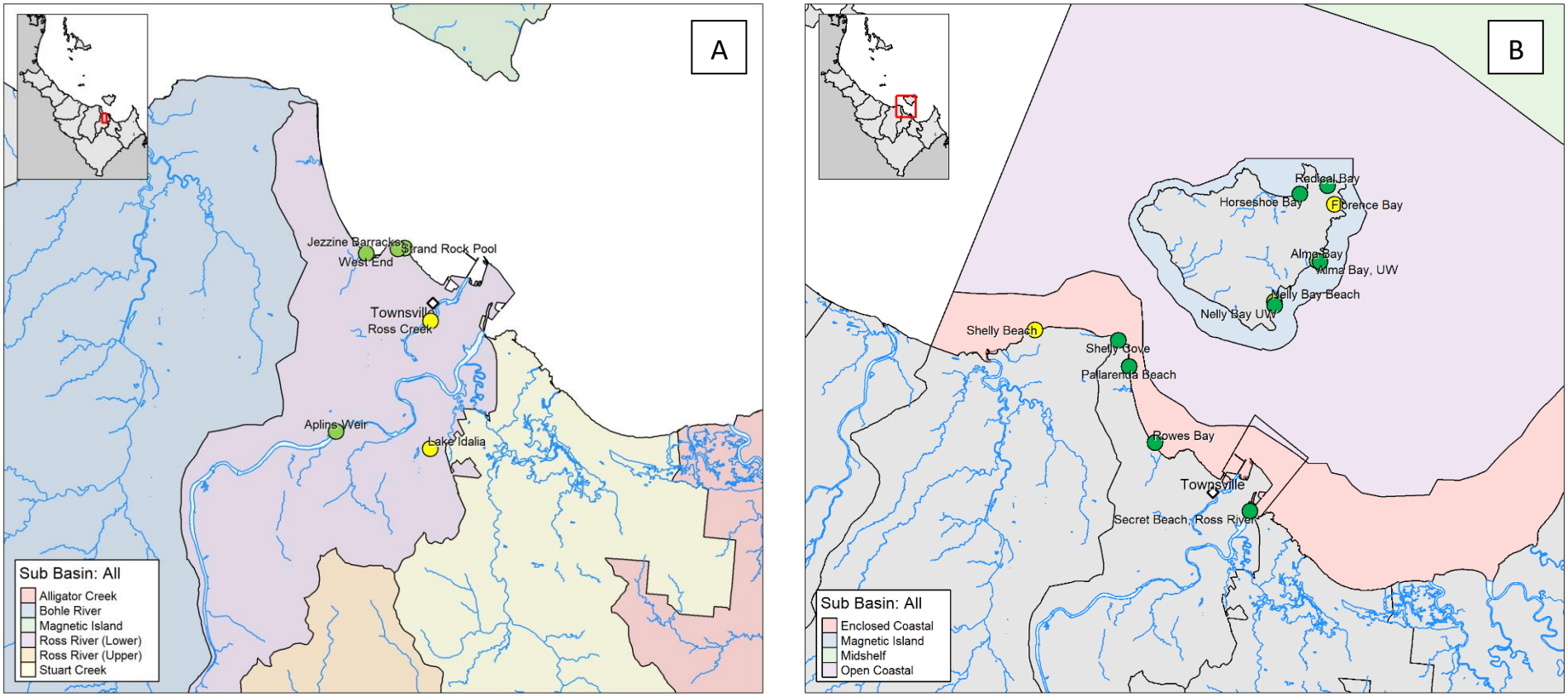

Figure 25. (A) Ross Basin and (B) Cleveland Bay Litter collection locations for the 2022-23 reporting period.

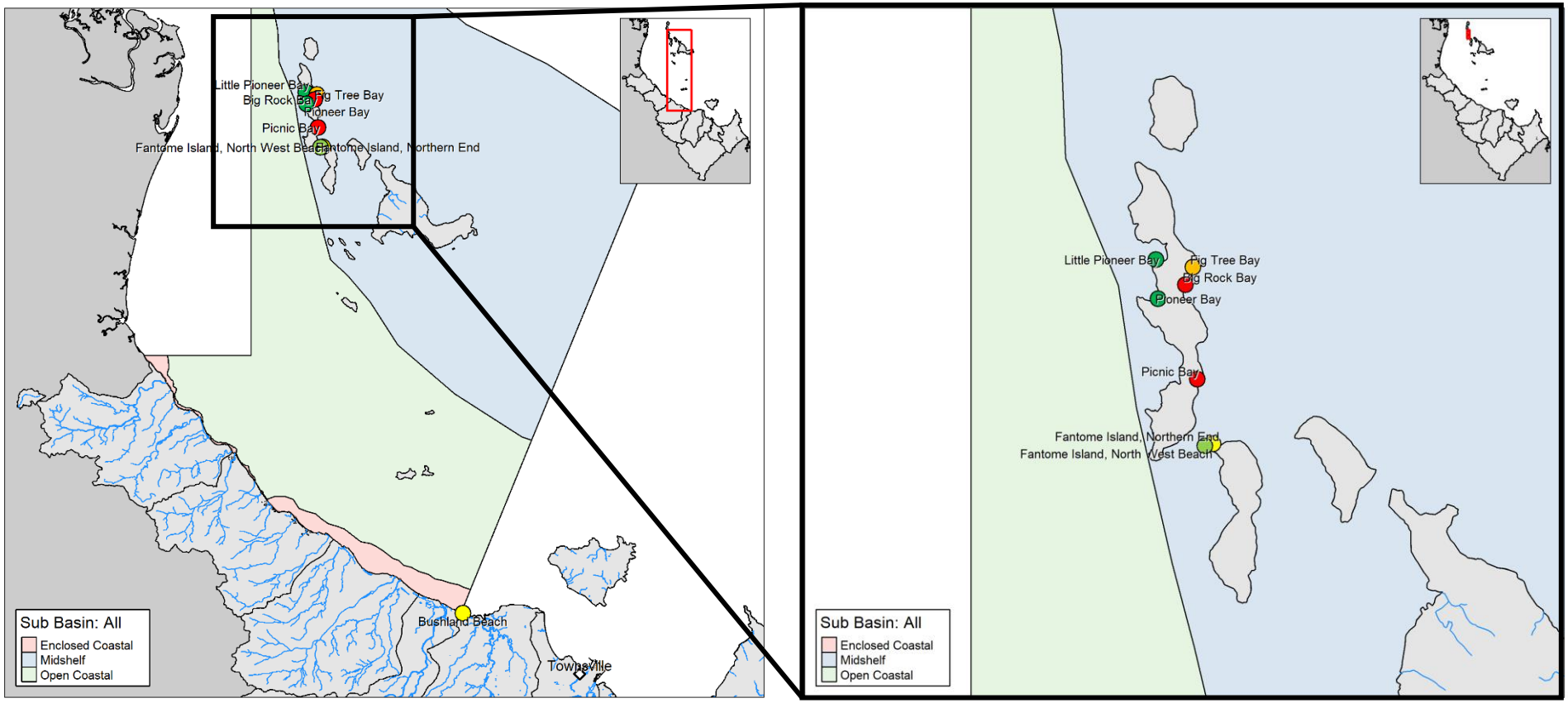

Figure 26. Halifax Bay litter collection locations for the 2022-23 reporting period.

14.2 Comparison with previous years

Table 75 presents a comparison of the 2022–2023 year for the litter index with previous years.

Table 75: Comparison of Litter Index for 2022–2023 with previous years

Zone	Site	Scores and Grades			
		2019-2020	2020-2021	2021-2022	2022-2023
Halifax Bay	North West Beach, Pelorus Island	95 (VLP)	NA	NA	NA
	West Beach, Pelorus Island	80 (VLP)	NA	NA	NA
	North Beach, Orpheus Island	4 (VHP)	NA	NA	NA
	Little Pioneer Bay, Orpheus Island UW	NA	NA	NA	91 (VLP)
	Fig Tree Bay, Orpheus Island	NA	NA	NA	28 (HP)
	Big Rock Bay, Orpheus Island	21 (HP)	7 (VHP)	7 (VHP)	7 (VHP)
	Fig Tree Beach, Orpheus Island	NA	16 (VHP)	19 (VHP)	NA
	Pioneer Bay, Orpheus Island	NA	NA	NA	84 (VLP)
	Picnic Bay, Orpheus Island	0 (VHP)	11 (VHP)	2 (VHP)	5 (VHP)
	Boulder Beach North, Orpheus Island	NA	NA	14 (VHP)	NA
	Yanks Jetty, Orpheus Island	74 (LP)	76 (LP)	NA	NA
	Boulder Beach, Orpheus Island	NA	NA	1 (VHP)	NA
	South Beach, Orpheus Island	42 (MP)	NA	10 (VHP)	NA
	Fantome Island, Northern End	NA	12 (VHP)	36 (HP)	57 (MP)
	North West Beach, Fantome Island	NA	NA	NA	61 (LP)
	Ollera Beach	39 (HP)	NA	NA	NA
	Rollingstone Beach	50 (MP)	NA	NA	NA
	Toomulla Beach	53 (MP)	NA	83 (VLP)	NA
	Saunders Beach	71 (LP)	NA	NA	NA
	Bushland Beach, Townsville	NA	62 (LP)	NA	55 (MP)
Cleveland Bay	Myrmidon Reef	NA	98 (VLP)	NA	NA
	Radical Bay, Magnetic Island	NA	NA	NA	96 (VLP)
	Horseshoe Bay, Magnetic Island	NA	NA	34 (HP)	83 (VLP)
	Florence Bay, Magnetic Island	NA	NA	NA	51 (MP)
	Arthur Bay, Magnetic Island	NA	43 (MP)	NA	NA
	Alma Bay, Magnetic Island	45 (MP)	63 (LP)	71 (LP)	60 (LP)
	Alma Bay, Magnetic Island UW	97 (VLP)	98 (VLP)	NA	100 (VLP)
	Geoffrey Bay, Magnetic Island	NA	80 (VLP)	NA	NA
	Geoffrey Bay Reef, Magnetic Island UW	93 (VLP)	NA	NA	NA
	Nelly Bay Beach, Magnetic Island	53 (MP)	77 (LP)	73 (LP)	77 (LP)
	Nelly Bay, Magnetic Island UW	100 (VLP)	99 (VLP)	99 (VLP)	99 (VLP)
	Shelly Beach, Pallarenda	63 (LP)	29 (HP)	NA	44 (MP)
	Shelly Cove, Cape Pallarenda Conserv. Park	67 (LP)	70 (LP)	91 (VLP)	92 (VLP)
	Pallarenda Beach	NA	NA	72 (LP)	84 (VLP)
	Rowes Bay	75 (LP)	75 (LP)	87 (VLP)	89 (VLP)
	Kissing Point	NA	79 (LP)	NA	NA
	Strand Park	62 (LP)	74 (LP)	NA	NA
	Strand Waterpark Beach	NA	86 (VLP)	NA	NA
	Secret Beach, Ross River	NA	NA	NA	81 (VLP)
Ross	Three Mile Creek, Pallarenda	NA	37 (HP)	NA	NA
	Strand Rock Pool	NA	47 (MP)	NA	74 (LP)
	Jezzine Barracks, TSV Heritage Precinct	NA	NA	NA	63 (LP)
	West End	NA	NA	NA	66 (LP)
	Ross Creek	NA	NA	46 (MP)	59 (MP)

Zone	Site	Scores and Grades			
		2019-2020	2020-2021	2021-2022	2022-2023
	Queensland Country Bank Stadium	NA	23 (HP)	21 (HP)	NA
	South Townsville Recreational Boat Park	NA	33 (HP)	NA	NA
	Anderson Park	NA	NA	91 (VLP)	NA
	Sherriff Park	NA	NA	73 (LP)	NA
	Aplins Weir Rotary Park	41 (MP)	35 (HP)	69 (LP)	74 (LP)
	Lake Idalia Wetland Foreshore	NA	NA	NA	45 (MP)
	Apex Park, Condon	NA	NA	62 (LP)	NA

Standardised scoring range: ■ = Very High Pressure: 0 to <20 | ■ = High Pressure: 20 to <40 | ■ = Moderate Pressure: 40 to <60 | ■ = Low Pressure: 60 to <80 | ■ = Very Low Pressure: 80 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

As there are a small number of sites where litter collections occur each year, it is difficult to obtain a picture of whether improvement is occurring or not. There are a number of factors that are not included in the metric that could have a bearing on the amount of litter collected at sites, particularly land based sites, such as, the frequency of TCC emptying bins, the location of bins (ease of use to main trafficked areas), the number of people using the area on a daily, weekly, or monthly basis, proximity of the collection to a public holiday, or regional event. The variance associated with Zone, Site and Year accounted for a proportion of the total variance, however, the residual variance of the model indicates that there are potentially several variables that have not been identified.

14.3 Key Messages

- The east coast of Orpheus Island continues to have the highest litter pressure in the region.
- The litter pressure at Fantome Island appears to be decreasing which may be associated with regular collection as well as local factors.
- Florence Bay had the highest litter pressure on Magnetic Island and Shelley Beach had the highest litter pressure on the mainland for Cleveland Bay.
- There were no sites with very low pressure within the Ross Basin, with the Lake Idalia Wetland Foreshore having the highest litter pressure.

14.4 Results

Litter pressure results are presented in Table 76. In the Ross Freshwater Basin, there were no sites with very low litter pressure with Ross Creek and the Lake Idalia Wetland Foreshore having moderate pressure, which was the highest measured within the basin.

For the Magnetic Island sites within Cleveland Bay, Florence Bay had the highest pressure (MP) and Radical Bay had the lowest pressure of the land based sites (VLP), with the underwater sites at Alma Bay and Nelly Bay being the lowest pressure of all sites. Horseshoe Bay showed a vast improvement going from high pressure in 2021-2022 to very low pressure in 2022-2023. For the Townsville sites within Cleveland Bay, Shelly Beach had moderate pressure whilst all other sites had very low pressure. Whilst Shelly Cove and Rowes Bay maintained their very low pressure, while Pallarenda Beach improved from low pressure to very low pressure.

Pioneer Bay and Little Pioneer Bay underwater had the lowest pressure of the sites within the Palm Island group of Halifax Bay. The remainder Orpheus Island sites (Table 76) continued to have very high pressure except Fig Tree Beach which had high pressure. Discussion with K-M Coulter-Atkins (TBF, 2022) found that the litter at Orpheus Island is largely sourced from the sea and was found to

be washing onto the beach whilst the litter collection was occurring. The Fantome Island northern end site has shown a year on year improvement from initially very high pressure to most recently moderate pressure. The only main land site in Halifax Bay for the Townsville Dry Tropics region was Bushland Beach, which had moderate pressure.

Table 76: Litter Index Results for 2022–2023

Zone	Site	Score (Grade)
Halifax Bay	Little Pioneer Bay, Orpheus Island UW	91 (VLP)
	Fig Tree Bay, Orpheus Island	28 (HP)
	Big Rock Bay, Orpheus Island	7 (VHP)
	Pioneer Bay, Orpheus Island	84 (VLP)
	Picnic Bay, Orpheus Island	5 (VHP)
	Fantome Island, Northern End	57 (MP)
	North West Beach, Fantome Island	61 (LP)
	Bushland Beach, Townsville	55 (MP)
Cleveland Bay	Radical Bay, Magnetic Island	96 (VLP)
	Horseshoe Bay, Magnetic Island	83 (VLP)
	Florence Bay, Magnetic Island	51 (MP)
	Alma Bay, Magnetic Island	60 (LP)
	Alma Bay, Magnetic Island UW	100 (VLP)
	Nelly Bay Beach, Magnetic Island	77 (LP)
	Nelly Bay, Magnetic Island UW	99 (VLP)
	Shelly Beach, Pallarenda	44 (MP)
	Shelly Cove, Cape Pallarenda Conservation Park	92 (VLP)
	Pallarenda Beach	84 (VLP)
	Rowes Bay	89 (VLP)
	Secret Beach, Ross River	81 (VLP)
Ross	Strand Rock Pool, Townsville	74 (LP)
	Jezzine Barracks, Townsville Heritage Precinct	63 (LP)
	West End, Townsville	66 (LP)
	Ross Creek, Townsville	59 (MP)
	Aplins Weir Rotary Park	74 (LP)
	Lake Idalia Wetland Foreshore	45 (MP)

Standardised scoring range: ■ = Very High Pressure: 0 to <20 | ■ = High Pressure: 20 to <40 | ■ = Moderate Pressure: 40 to <60 | ■ = Low Pressure: 60 to <80 | ■ = Very Low Pressure: 80 to 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

14.5 Confidence Scores

The overall confidence score for the litter index was low with a score of 2 out of 5, this is an improvement on the previous score of 1 following the further development of the litter index method. The maturity is scored at 2, as a generalised linear negative binomial mixed model for data across a much larger region than solely the Townsville Dry Tropics has been developed. This has improved the robustness of the metric applying a distribution appropriate to the data and using a much larger dataset from which to derive the model. Validation is scored as 1 as modelling is used to derive an estimate of the amount of litter one might expect to collect in a one-hour period at each

location at any time that location might be visited. This expected value considers the variability of the data available. Representativeness is scored at 1 as there is variation in the frequency of the data collection at each site, and variation in the way the data is reported. For example, some sites are cleaned up four times per year, whilst others may be cleaned once every few years. Whilst the model can consider the frequency of the collection by volunteers contributing to the AMDI in an individual year, it does not consider the last time litter was collected at each location (by anyone). It is not possible to do so as this information is not available. Some collectors may include the time they spend sorting the litter, whilst others may not. This brings variation into the data that is difficult to account for within the model. The measured error has been scored at 2 as the model provides estimates based on the variability of the data, however, there is also error associated with the transformation of the data to score and grade.

Table 77: Confidence scores for the Litter Index

Indicator Category	Maturity (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Score (Rank)
Litter	2	1	1	3	2	2 (low)

Rank based on score: 1 (very low) = 4.5 to 6.3; | 2 (low) = >6.3 to 8.1; | 3 (moderate) = >8.1 to 9.9; | 4 (high) = >9.9 to 11.7; | 5 (very high) = >11.7 to 13.5.

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Appendices 2022-2023

Written by Adam Shand and Dinny Taylor

As part of the results for the Townsville Dry Tropics Report Card 2024 (Reporting on data from July 2022– June 2023)

Healthy Waters Partnership for the Dry Tropics (HWP)

July 2024

15 Appendices

Appendix A. Ross Basin Long-Term Annual Rainfall Trends

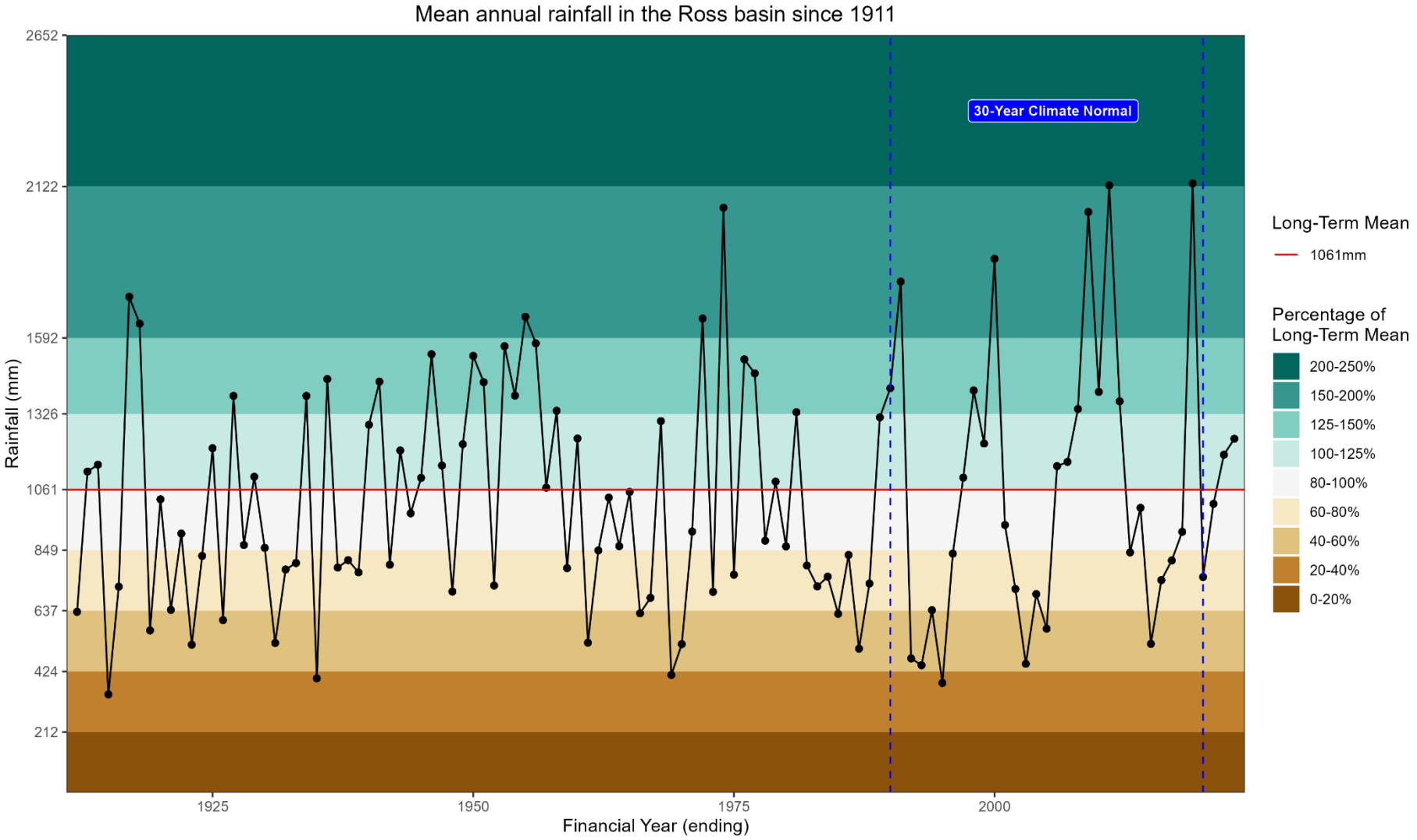

Figure 27. Ross Basin long-term annual rainfall trends.

Appendix B. Black Basin Long-Term Annual Rainfall Trends

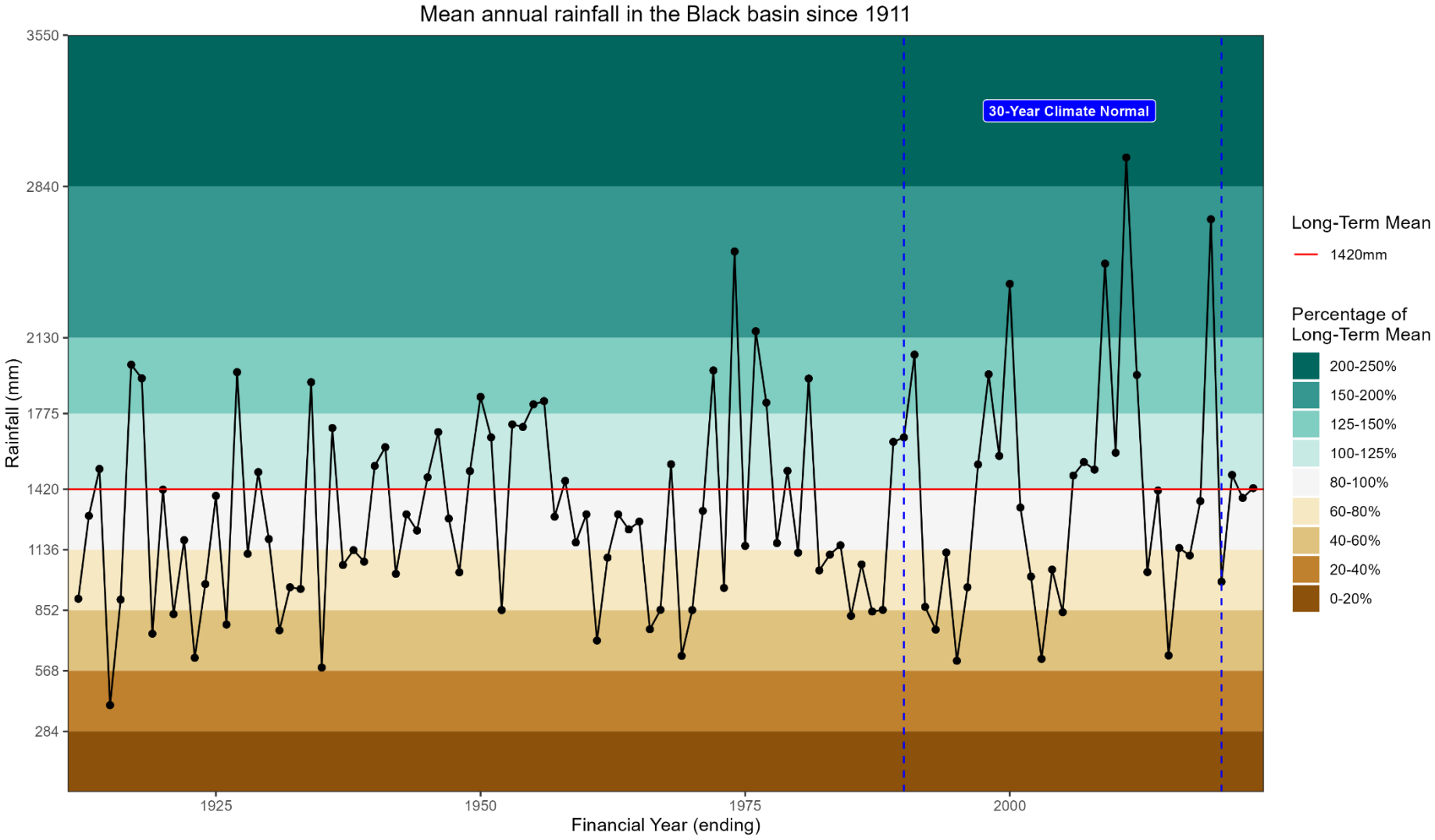

Figure 28. Black Basin long-term annual rainfall trends.

Appendix C. Season-specific Annual Rainfall Trends for the Ross and Black Basins

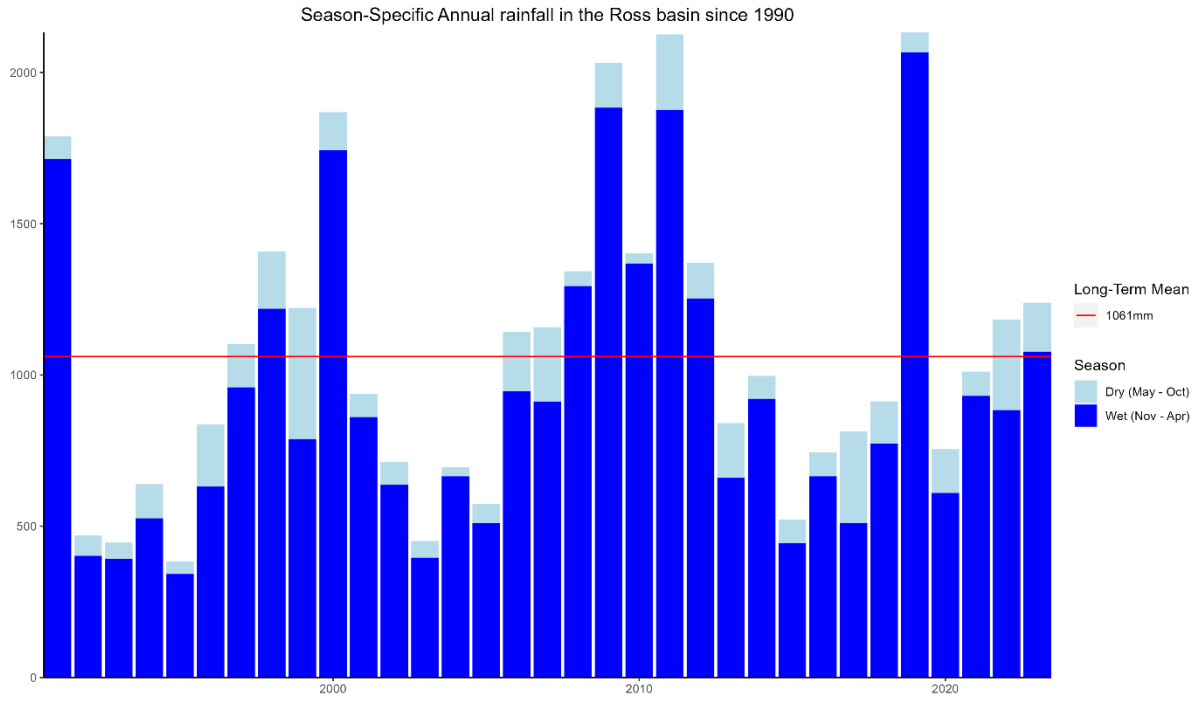

Figure 30. Season-specific annual rainfall in the Ross Basin since 1990.

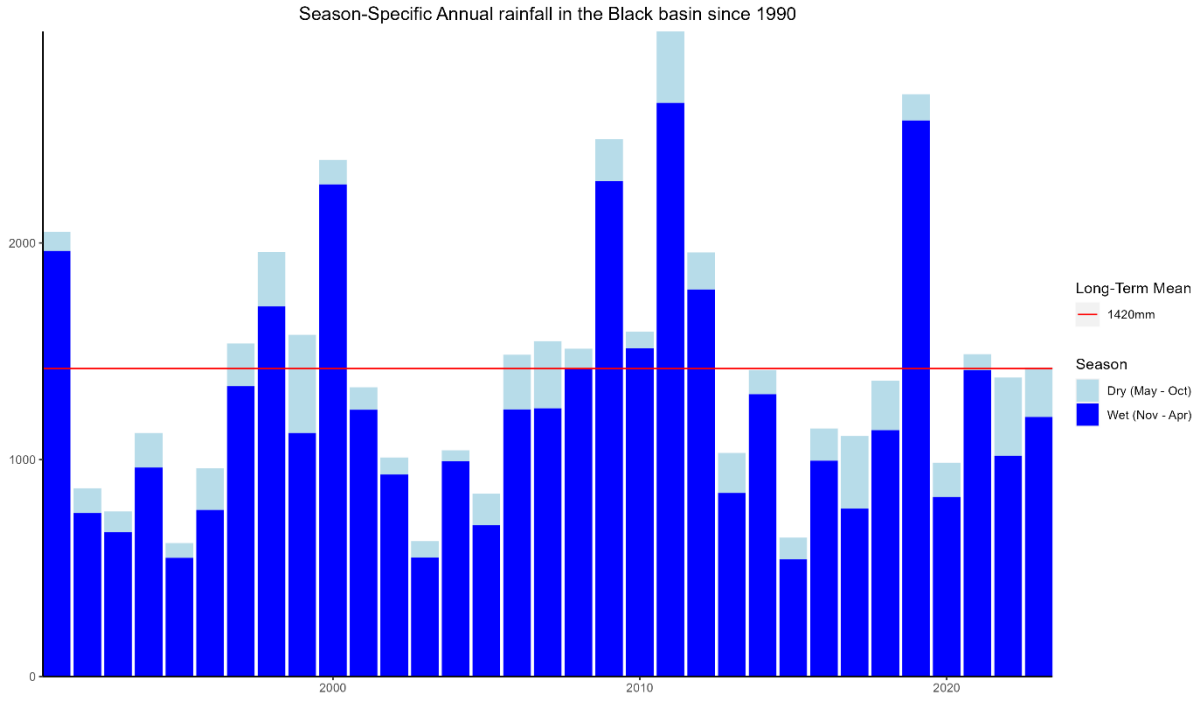

Figure 29. Season-specific annual rainfall in the Black Basin since 1990.

Appendix D. Ross Basin Long-Term Annual Air Temperature

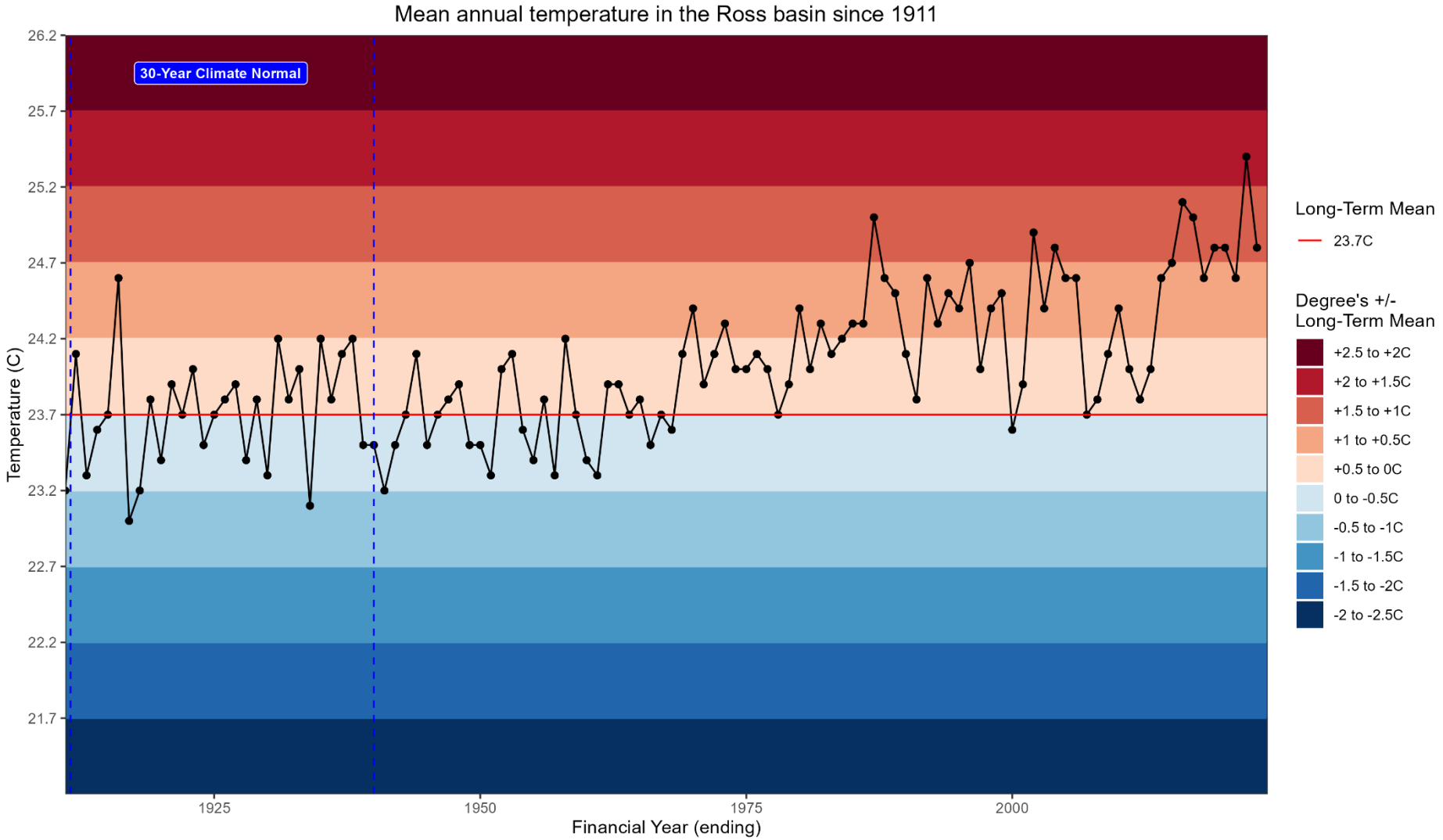

Figure 31. Ross Basin long-term annual air temperature trends.

Appendix E. Black Basin Long-Term Annual Air Temperature

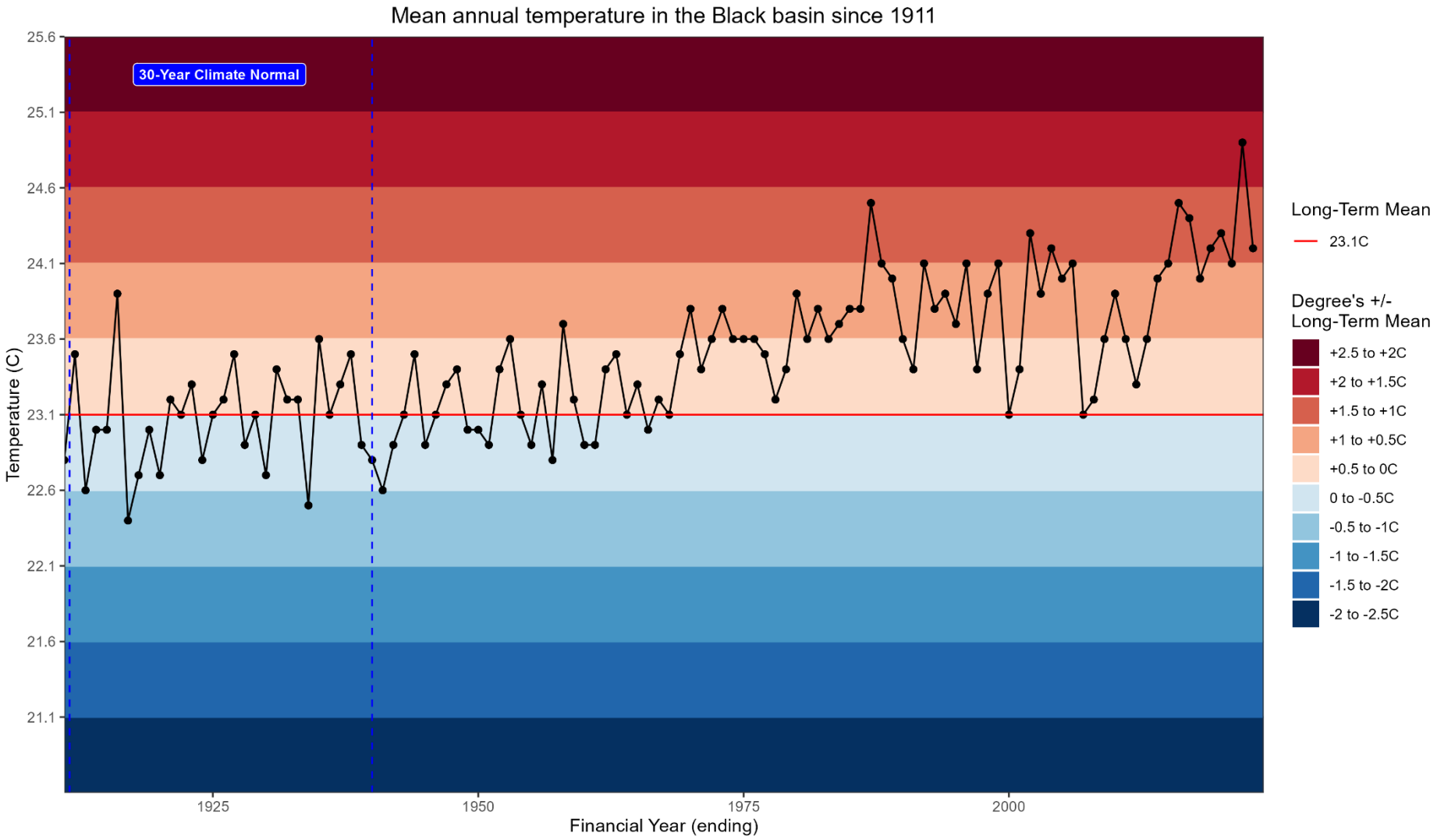

Figure 32. Black Basin long-term annual air temperature trends.

Appendix F. Townsville Dry Tropics Marine Waters Long-Term Annual Sea Surface Temperature

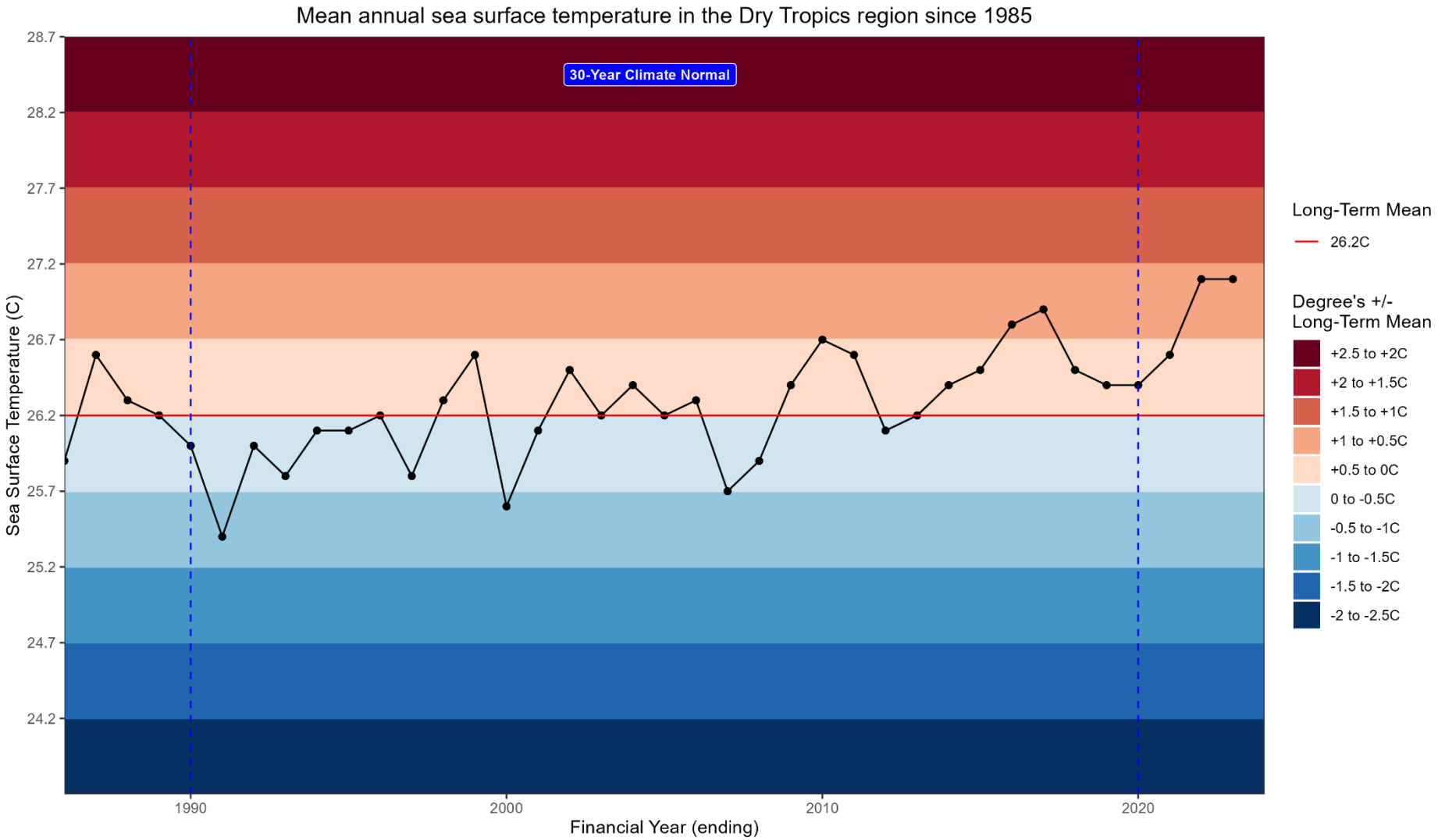

Figure 33. Black Basin long-term annual sea surface temperature trends.

Appendix G. Townsville Dry Tropics Marine Waters 5-year Historic Degree Heating Week Maps

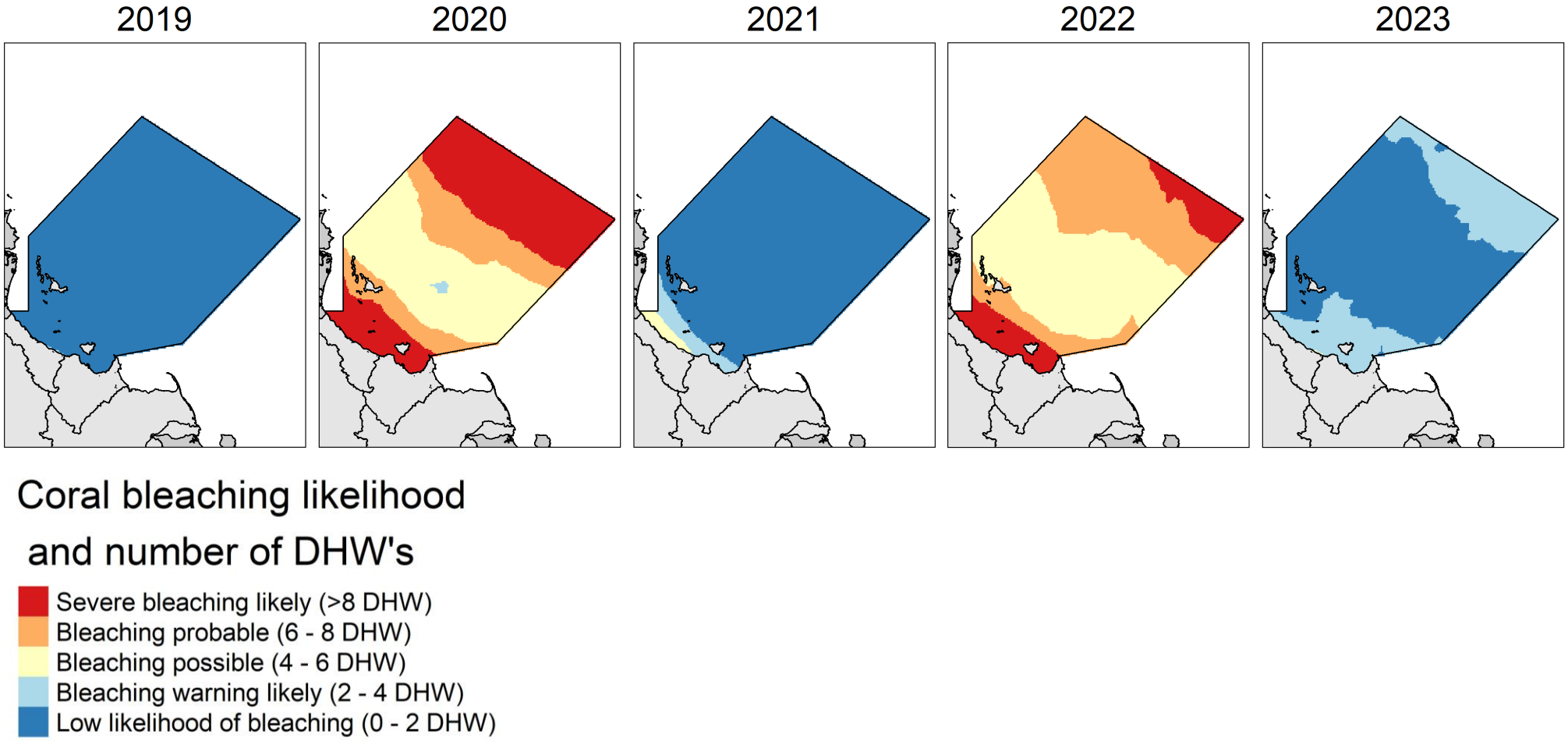

Figure 34. Dry Tropics Marine Region 5-year Historic Degree Heating Week Map.

Appendix H. Freshwater Water Quality Nutrients: Sampling Frequencies, Medians, Water Quality Objectives, and Scaling Factors

Table 78. Number of samples, number of months sampled, median, water quality objective values, and scaling factors for DIN and TP in the Townsville Dry Tropics Freshwater Environments.

Watercourse	DIN (mg/L)					TP (mg/L)				
	N.Samples	N.Months	Median	WQO	SF	N.Samples	N.Months	Median	WQO	SF
Ross Lake	NA	NA	NA	0.02	0.38	162	12	0.015	0.03	0.46
Aplin's Weir	63	12	0.017	0.02	0.38	ND	ND	ND	0.03	0.46
Gleesons Weir	10	10	0.028	0.02	0.38	ND	ND	ND	0.05	0.46
Blacks Weir	11	11	0.015	0.02	0.38	11	11	0.010	0.03	0.46
Bohle Mid-Field	12	11	2.663	0.08	0.38	12	11	3.800	0.05	0.46
Bohle Far-Field	12	11	0.583	0.08	0.38	12	11	1.100	0.05	0.46
Black River	63	12	0.016	0.02	0.05	12	12	0.024	0.02	0.03
Althaus Ck	11	11	0.004	0.02	0.05	11	11	0.027	0.02	0.03
Bluewater Ck	12	12	0.013	0.02	0.05	12	12	0.010	0.02	0.03
Sleeper Log Ck	12	12	0.003	0.02	0.05	12	12	0.016	0.02	0.03
Leichhardt Ck	12	12	0.005	0.02	0.05	12	12	0.013	0.02	0.03
Saltwater Ck	12	12	0.003	0.02	0.05	12	12	0.012	0.02	0.03
Rollingstone Ck	12	12	0.020	0.02	0.05	12	12	0.009	0.02	0.03
Ollera Ck	8	8	0.007	0.02	0.05	8	8	0.009	0.02	0.03
Crystal Ck	12	12	0.009	0.02	0.05	12	12	0.007	0.02	0.03
Paluma Lake	NA	NA	NA	0.02	0.05	12	12	0.010	0.03	0.06

Key: ■ = Mean/Median is lower than the guideline value | ■ = Mean/Median is higher than the guideline value | ND = No Data | NA = Not Applicable (data available but not usable).

Appendix I. Freshwater Water Quality Nutrients Scores Historic Comparison

Table 79. Townsville Dry Tropics freshwater water quality historic nutrient indicator scores.

Basin	Sub Basin	Watercourse	DIN				TP			
			22-23	21–22	20–21	19–20	22-23	21–22	20–21	19–20
Ross	Upper Ross	Ross Lake	NA	90	90	68	73	61	90	61
	Lower Ross	Aplin's Weir	62	61	59	66	ND	ND	ND	ND
		Gleesons Weir	59	90	62	74	ND	ND	ND	ND
		Blacks Weir	63	59	61	59	90	90	90	70
			61	70	60	66	90	90	90	70
	Bohle River	Bohle Mid-Field	0	36	43	0	0	0	0	0
		Bohle Far-Field	0	60	66	29	0	0	0	0
			0	48	54	15	0	0	0	0
			37	66	68	49	40	37	60	33
Black	Black River	Black River	63	63	61	78	39	61	54	9
	Bluewater Ck	Althaus Ck	90	90	67	74	18	48	90	90
		Bluewater Ck	73	66	63	90	90	90	73	66
		Sleeper Log Ck	90	71	74	62	77	90	90	90
			84	75	68	75	61	76	84	82
	Rollingstone Ck	Leichhardt Ck	90	90	74	90	90	90	76	55
		Saltwater Ck	90	90	70	90	90	90	90	90
		Rollingstone Ck	61	62	0	64	90	90	90	90
			80	80	48	81	90	90	85	78
	Crystal Ck	Ollera Ck	90	71	66	63	90	90	90	90
		Crystal Ck	90	69	90	90	90	90	90	90
			90	70	78	76	90	90	90	90
	Paluma Lake	Paluma Lake	NA	NA	63	90	90	90	90	90
			82	74	63	79	76	82	83	76

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

Appendix J. Freshwater Water Quality Physical-Chemical Properties: Sampling Frequencies, Medians, Water Quality Objectives and Scaling Factors

Table 80. Number of samples, number of months sampled, median, water quality objective values, and scaling factors for Turbidity, High DO, Low DO, in the Townsville Dry Tropics Freshwater Environments.

Watercourse	Turbidity (NTU)					Dissolved Oxygen (%Sat)						
	N.Samples	N.Months	Median	WQO	SF	N.Samples	N.Months	Median	High DO WQO	High DO SF	Low DO WQO	Low DO SF
Ross Lake	139	12	5.600	10	35	162	12	100.760	110	120	90	70
Aplin's Weir	11	11	4.200	10	35	11	11	85.391	110	120	90	70
Gleesons Weir	10	10	3.600	10	35	10	10	93.900	110	120	90	70
Blacks Weir	11	11	2.800	10	35	11	11	84.773	110	120	90	70
Bohle Mid-Field	12	11	19.500	22	35	12	11	82.340	110	120	85	70
Bohle Far-Field	12	11	17.600	22	35	12	11	66.660	110	120	85	70
Black River	12	12	2.525	5	10	12	12	102.650	105	120	90	70
Althaus Ck	11	11	27.830	5	10	11	11	107.300	105	120	90	70
Bluewater Ck	12	12	2.865	5	10	12	12	90.350	105	120	90	70
Sleeper Log Ck	12	12	8.875	5	10	12	12	91.500	105	120	90	70
Leichhardt Ck	12	12	4.045	5	10	12	12	90.550	105	120	90	70
Saltwater Ck	12	12	5.255	5	10	12	12	96.450	105	120	90	70
Rollingstone Ck	12	12	0.790	5	10	12	12	86.800	105	120	90	70
Ollera Ck	8	8	1.485	5	10	8	8	54.700	105	120	90	70
Crystal Ck	12	12	0.505	5	10	12	12	98.350	105	120	90	70
Paluma Lake	12	12	1.650	10	20	12	12	87.383	110	120	90	70

Key: ■ = for Turbidity Mean/Median is lower than the guideline value, for DO, Median is within the range between the High and Low DO guideline values | ■ = for Turbidity Mean/Median is higher than the guideline value, for DO, the Median is higher than the High DO or Lower than the Low DO guideline value | ND = No Data | NA = Not Applicable (data available but not usable).

Appendix K. Freshwater Water Quality Physical-Chemical Properties Scores Historic Comparison

Table 81. Townsville Dry Tropics freshwater water quality historic physical-chemical indicator scores.

Basin	Sub Basin	Watercourse	Turbidity				High DO				Low DO			
			22-23	21–22	20–21	19–20	22-23	21–22	20–21	19–20	22-23	21–22	20–21	19–20
Ross	Upper Ross	Ross Lake	90	90	90	90	90	90	90	90	90	90	90	90
	Lower Ross	Aplin's Weir	90	90	90	90	90	80	90	90	46	55	74	90
		Gleesons Weir	90	90	90	90	90	90	90	90	67	11	50	73
		Blacks Weir	90	90	90	90	90	90	90	90	44	19	26	56
			90	90	90	90	90	90	90	90	53	28	50	73
	Bohle River	Bohle Mid-Field	62	67	90	90	90	90	90	90	50	26	0	0
		Bohle Far-Field	63	66	90	90	90	90	90	90	0	40	37	0
			63	66	90	90	90	90	90	90	25	33	18	0
			81	82	90	90	90	88	90	90	49	40	52	51
Black	Black River	Black River	72	90	69	90	64	47	53	62	90	90	90	90
	Bluewater Ck	Althaus Ck	0	0	12	90	51	90	69	4	90	90	90	81
		Bluewater Ck	70	90	90	90	90	79	90	90	62	66	77	11
		Sleeper Log Ck	13	0	90	70	90	90	90	90	72	20	76	32
			28	30	64	83	77	86	90	90	75	59	81	41
	Rollingstone Ck	Leichhardt Ck	68	90	90	90	90	90	90	90	62	61	61	27
		Saltwater Ck	57	75	90	90	90	90	90	90	90	90	66	90
		Rollingstone Ck	90	90	90	90	90	90	90	90	51	40	74	51
			72	90	90	90	90	90	90	90	67	63	67	56
	Crystal Ck	Ollera Ck	90	90	90	90	90	90	90	90	0	0	59	0
		Crystal Ck	90	90	90	90	90	90	90	90	90	90	73	75
			90	90	90	90	90	90	90	90	45	45)	66	37
	Paluma Lake	Paluma Lake	90	90	90	90	90	90	90	90	52	55	90	69
			64	70	80	88	83	85	85	79	66	60	75	53

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

Appendix L. Freshwater Water Quality Sub Basin Historic Scores

Table 82. A comparison of nutrient and physical chemical properties indicator category scores, and the water quality index scores, for freshwater sub basins between years.

Sub Basin	Nutrients				Phys-Chem				Water Quality			
	22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20
Upper Ross	81	75			90	90			85	82		
Lower Ross	66	75			71	57			68	66		
Bohle River	0	24			44	58			22	41		
Black River	51	62			68	68			60	65		
Bluewater Ck	73	76			45	44			59	60		
Rollingstone Ck	85	85			69	74			77	79		
Crystal Ck	90	79			67	67			78	73		
Paluma Lake	62	65			71	72			67	69		

Appendix M. Freshwater Water Quality 2022–2023 Boxplots

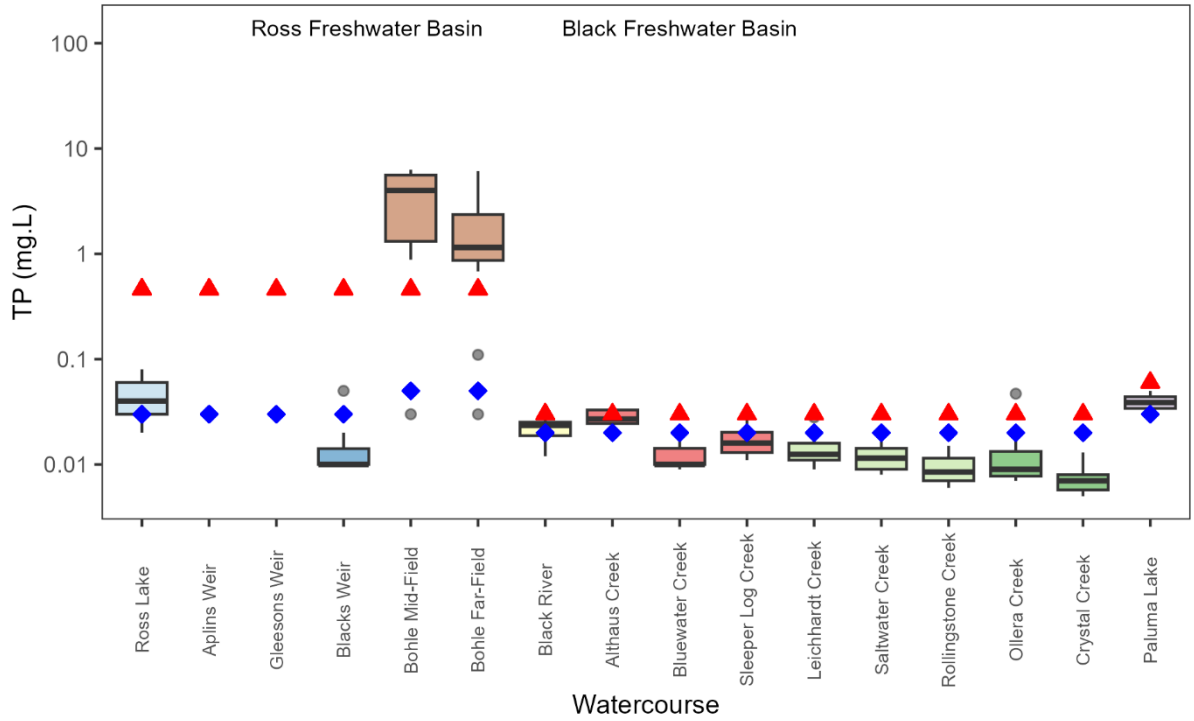

Figure 35. Total Phosphorus (TP) (mg/l) boxplot: red triangles indicate the scaling factor, blue diamonds indicate the water quality objective.

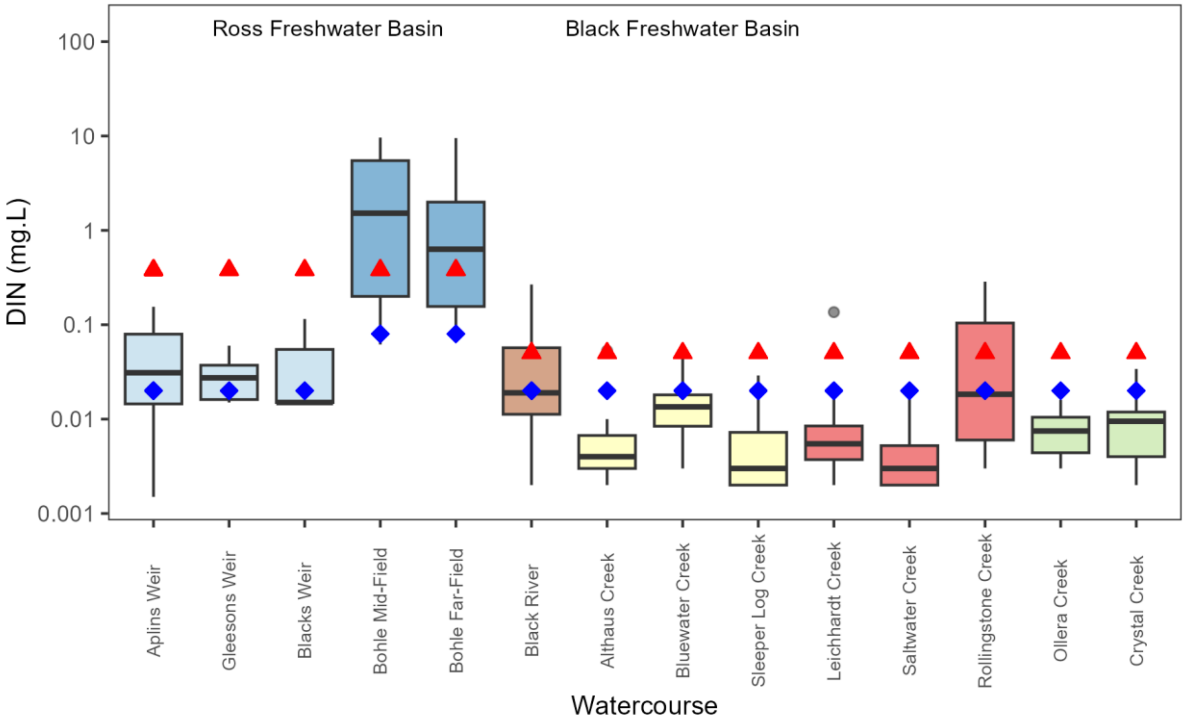

Figure 36. Dissolved Inorganic Nitrogen (DIN) (mg/L) Boxplot: red triangles indicate the scaling factor, blue diamonds indicate the water quality objective.

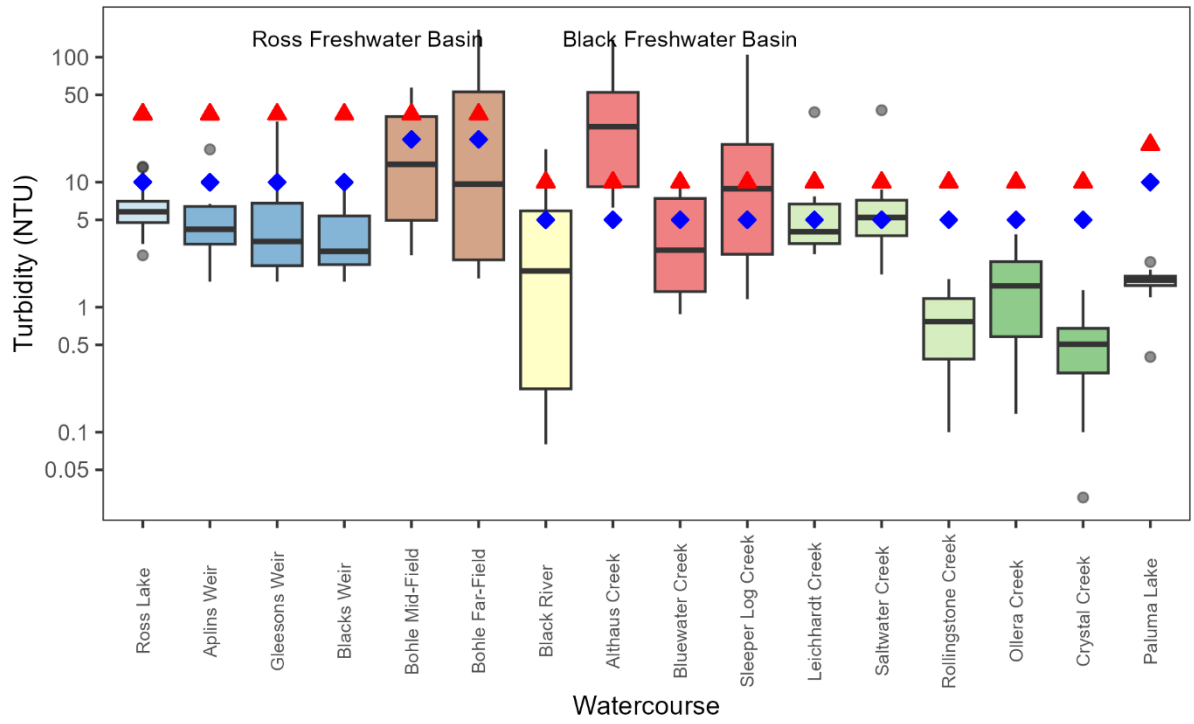

Figure 38. Turbidity (NTU) boxplot: red triangles indicate the scaling factor, blue diamonds indicate the water quality objective.

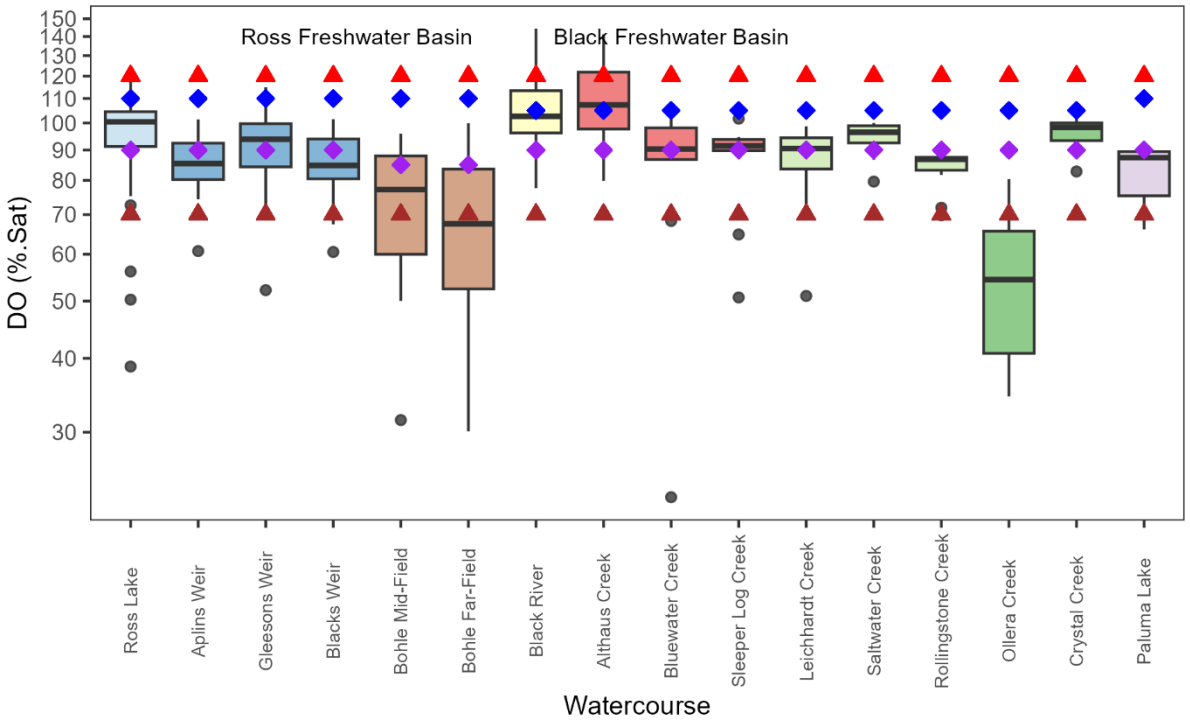

Figure 37. Dissolved Oxygen (DO) (% Saturation) boxplot: red triangles indicate the high DO scaling factor, blue diamonds indicate the high DO water quality objective, purple diamonds indicate the low DO water quality objective, and brown triangles indicate the low DO scaling factor.

Appendix N. Freshwater Water Quality Line Plots

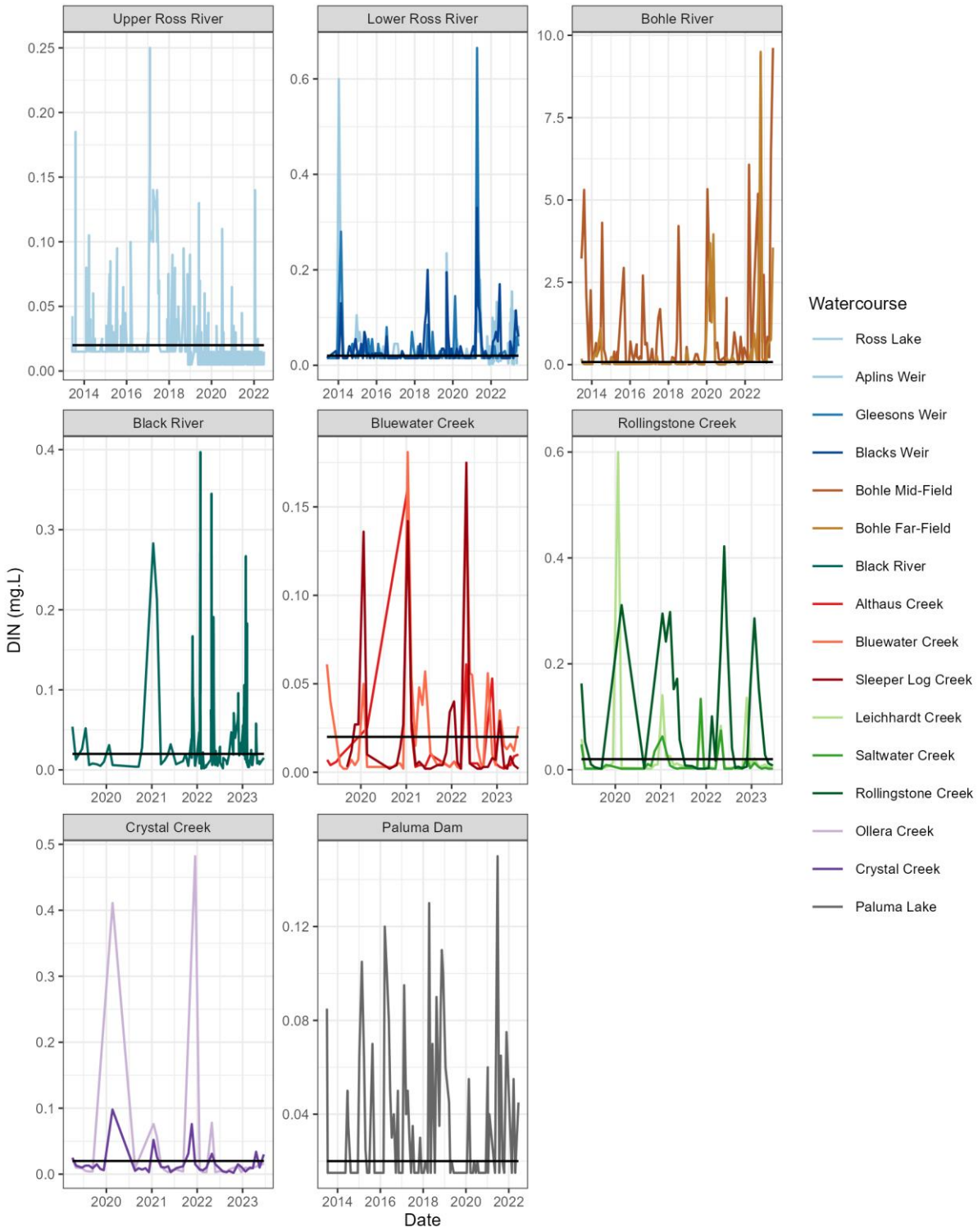

Figure 39. Historical concentrations of dissolved inorganic nitrogen (DIN) in the freshwater sub basins. Black line indicates the water quality objective.

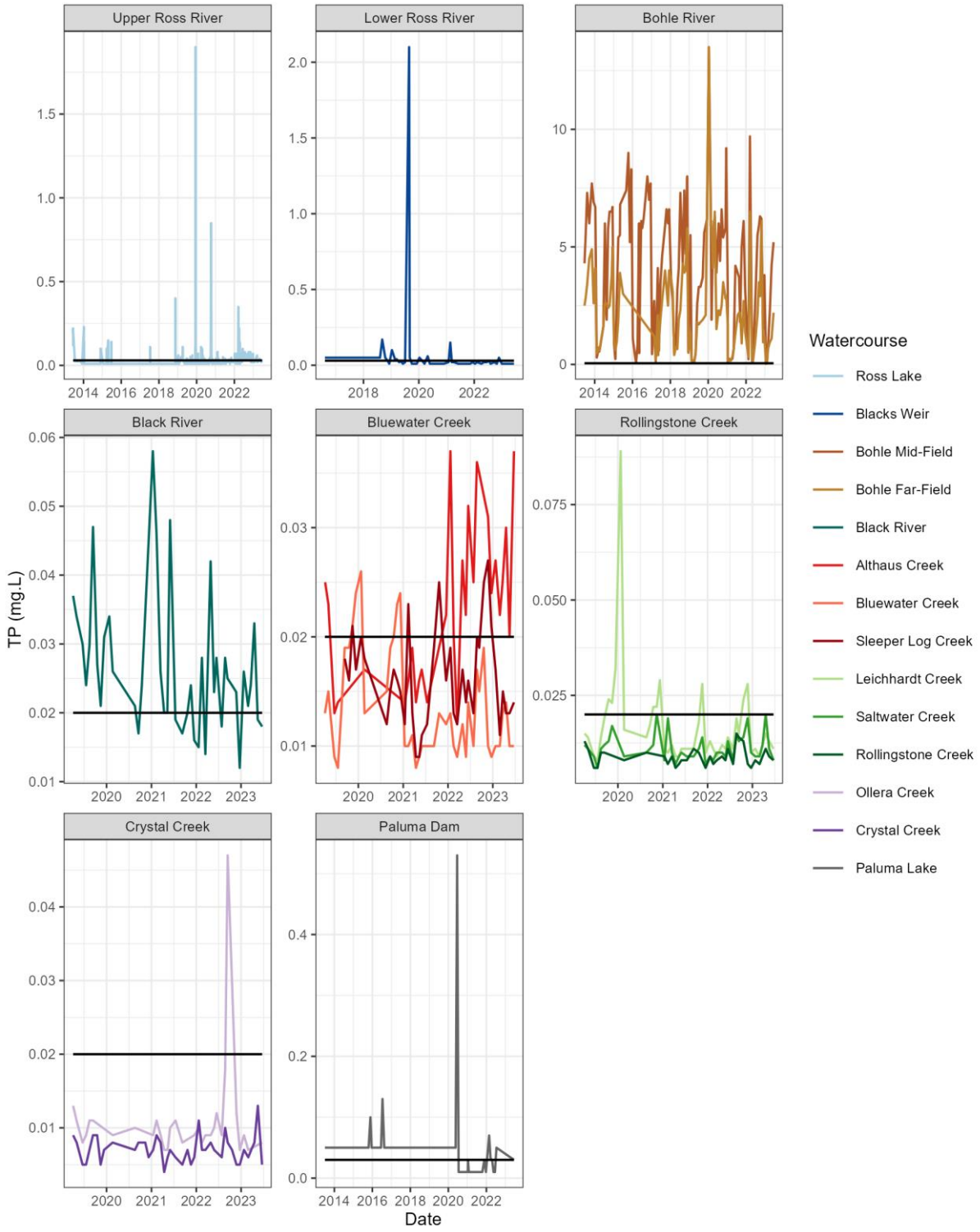

Figure 40. Historical data for total phosphorus in the freshwater sub basins. Black line indicates the water quality objective.

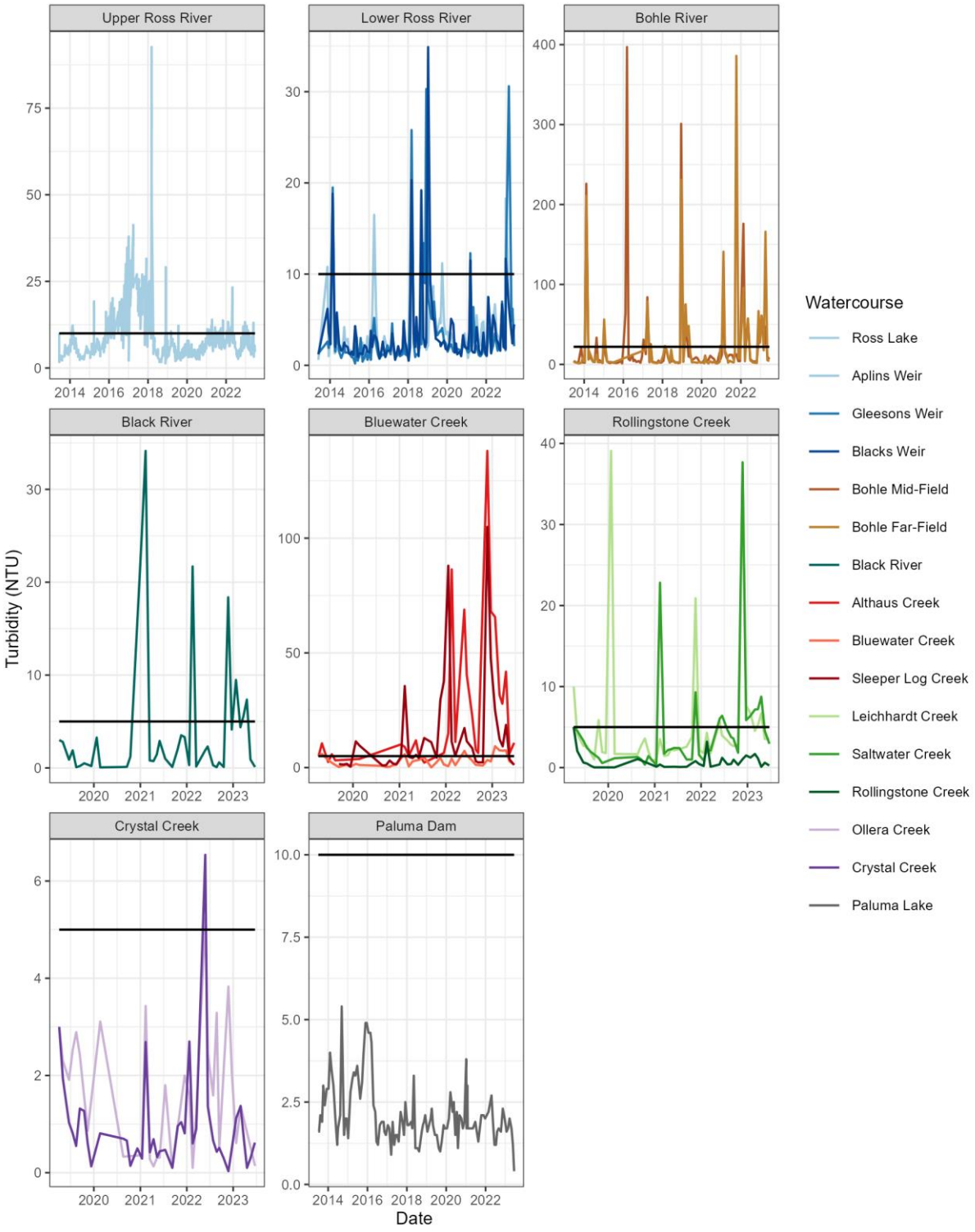

Figure 41. Historical turbidity in the freshwater sub basins. Black lines indicates the water quality objectives.

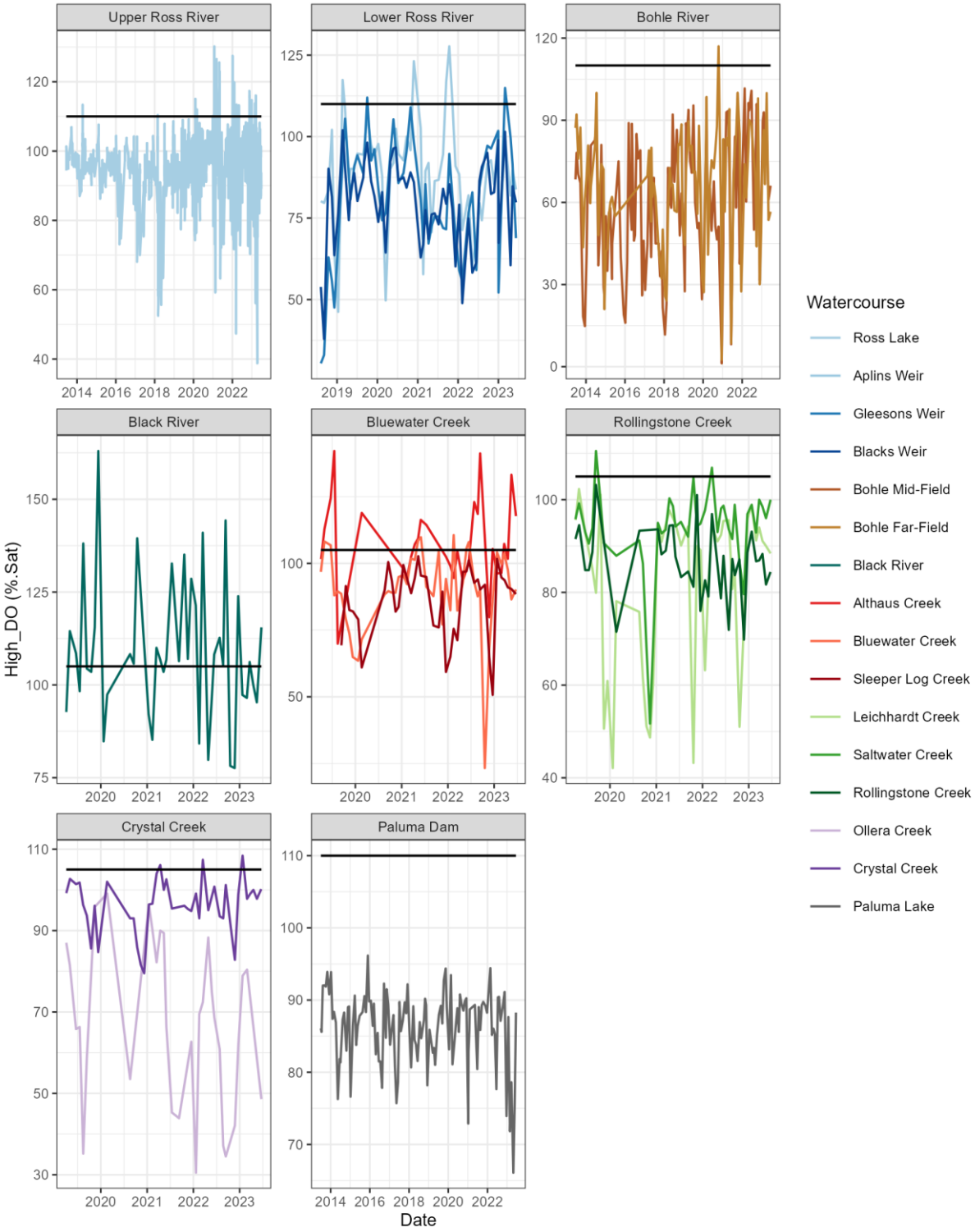

Figure 42. Historical dissolved oxygen in the freshwater sub basins. Black lines indicate the water quality objective (High DO).

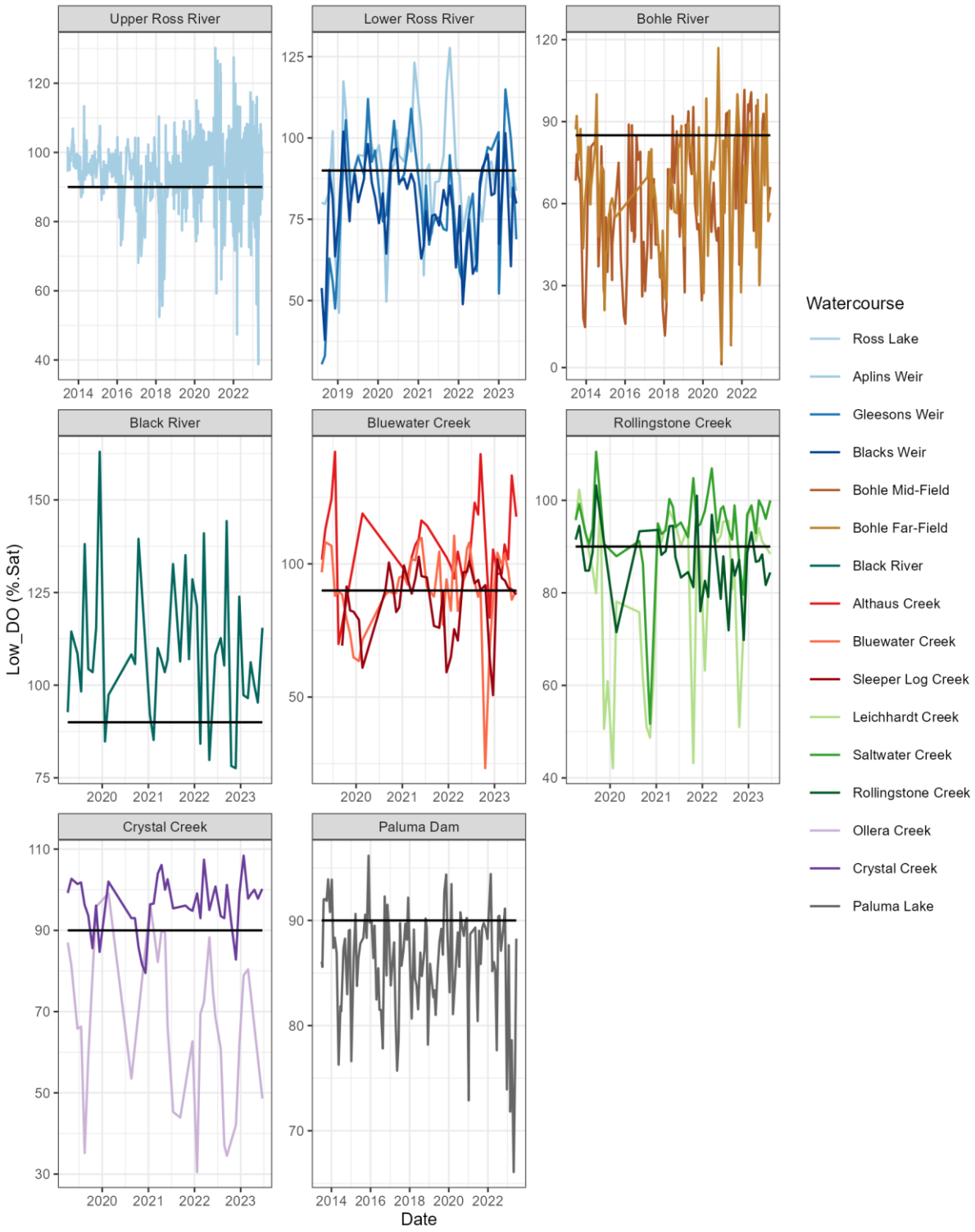

Figure 43. Historical dissolved oxygen in the freshwater sub basins. Black lines indicate the water quality objective (Low DO).

Appendix O. Freshwater Pesticides Sampling Locations

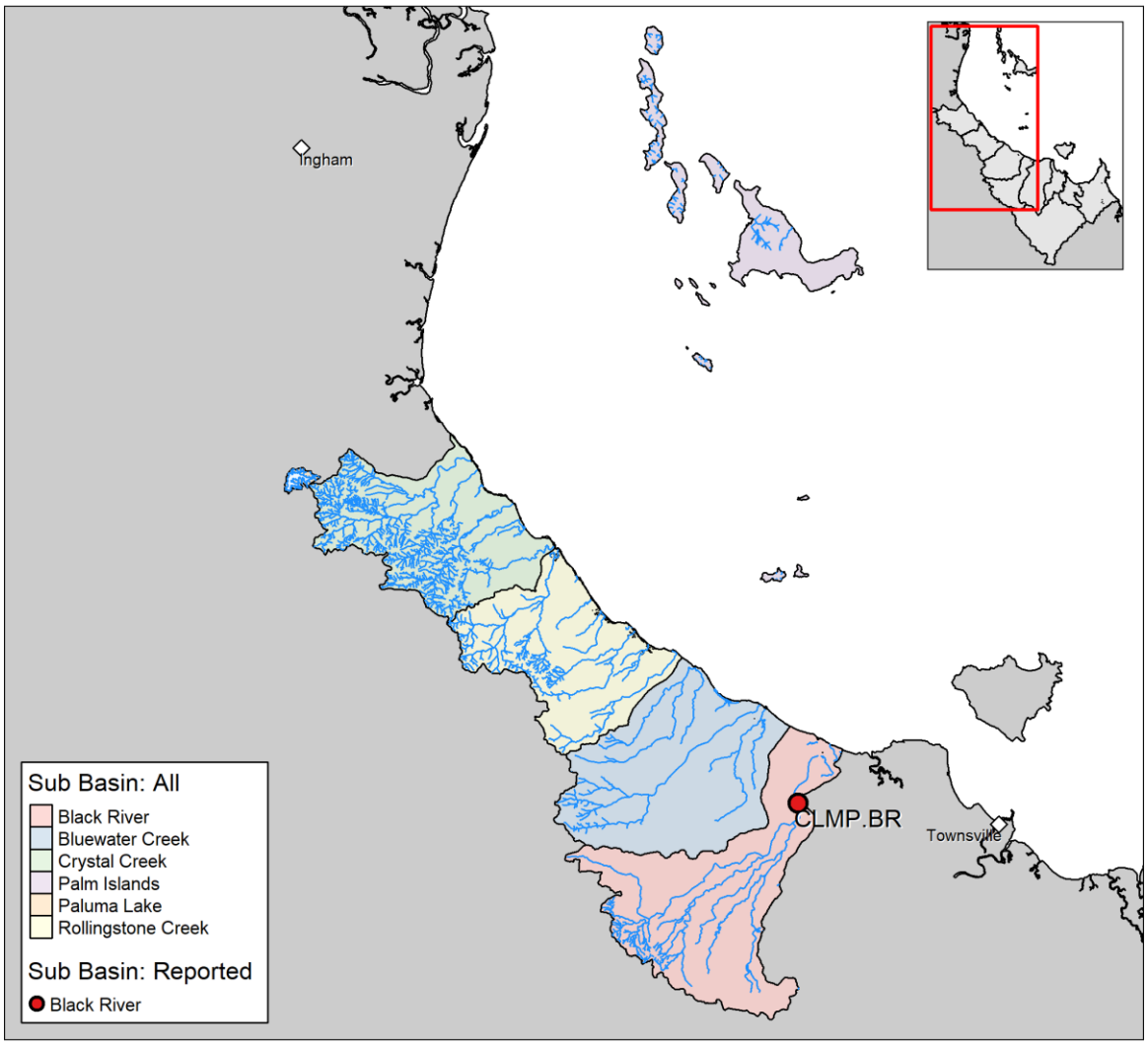

Figure 44. Black Freshwater Basin pesticide site locations.

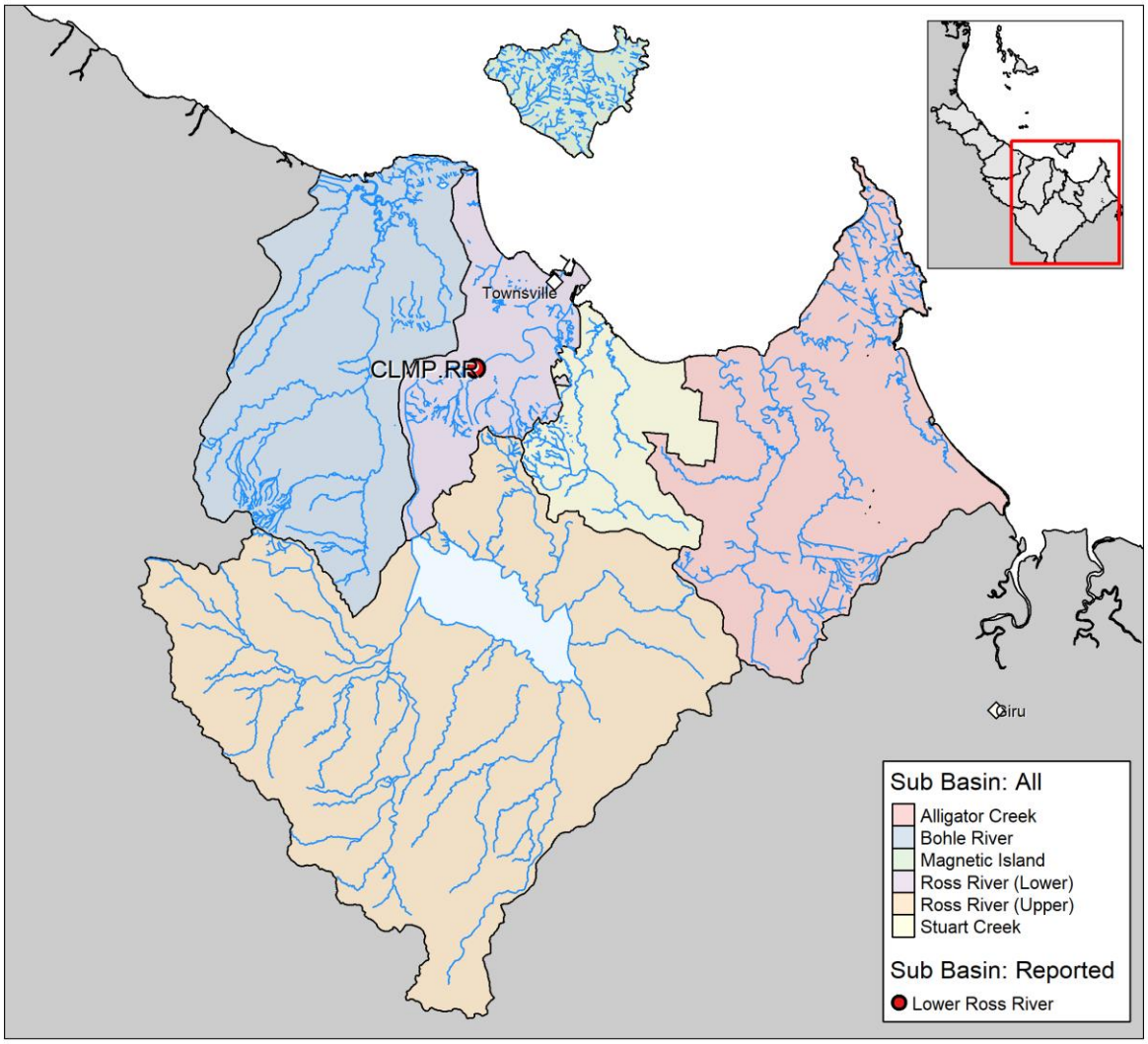

Figure 45. Ross Freshwater Basin pesticide site locations.

Appendix P. Freshwater Pesticides Historical Species Affected

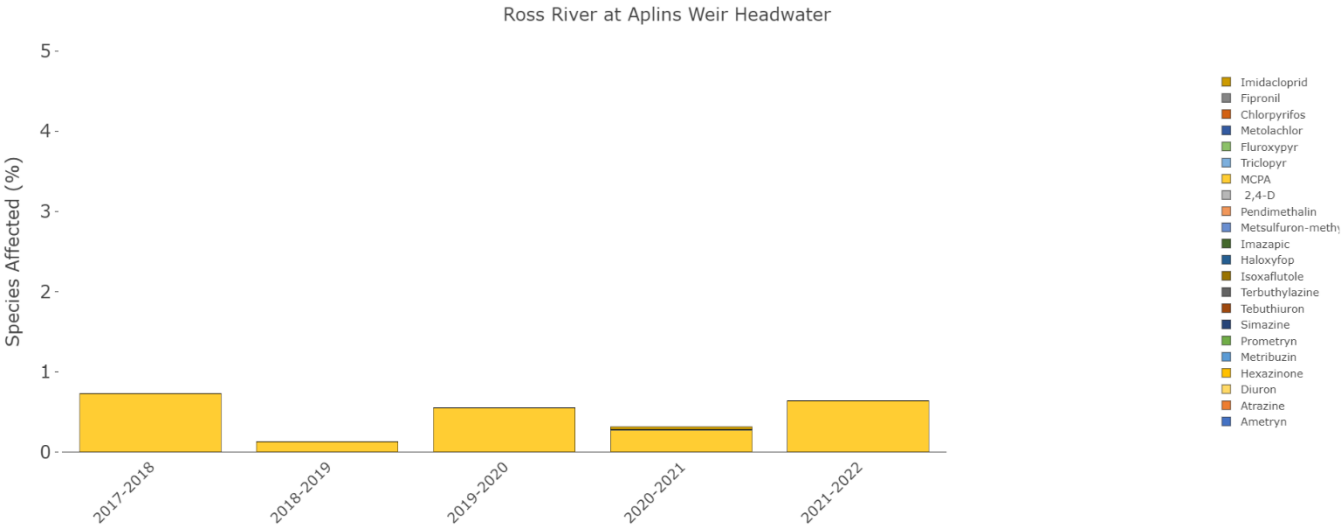

Figure 47. Historic pesticide proportions at the Ross River at Aplins Weir Headwater CLMP monitoring site.

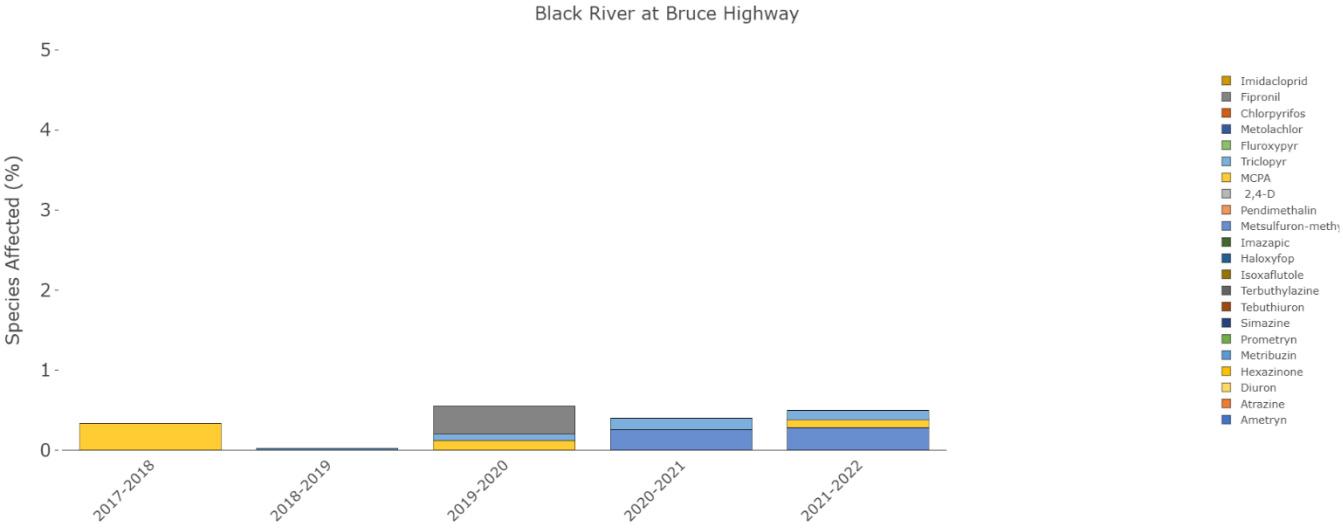

Figure 46. Historic pesticide proportions at the Black River CLMP monitoring site.

Appendix Q.Freshwater Riparian Extent: Assessed Area in the Ross Basin of the Townsville Dry Tropics Region

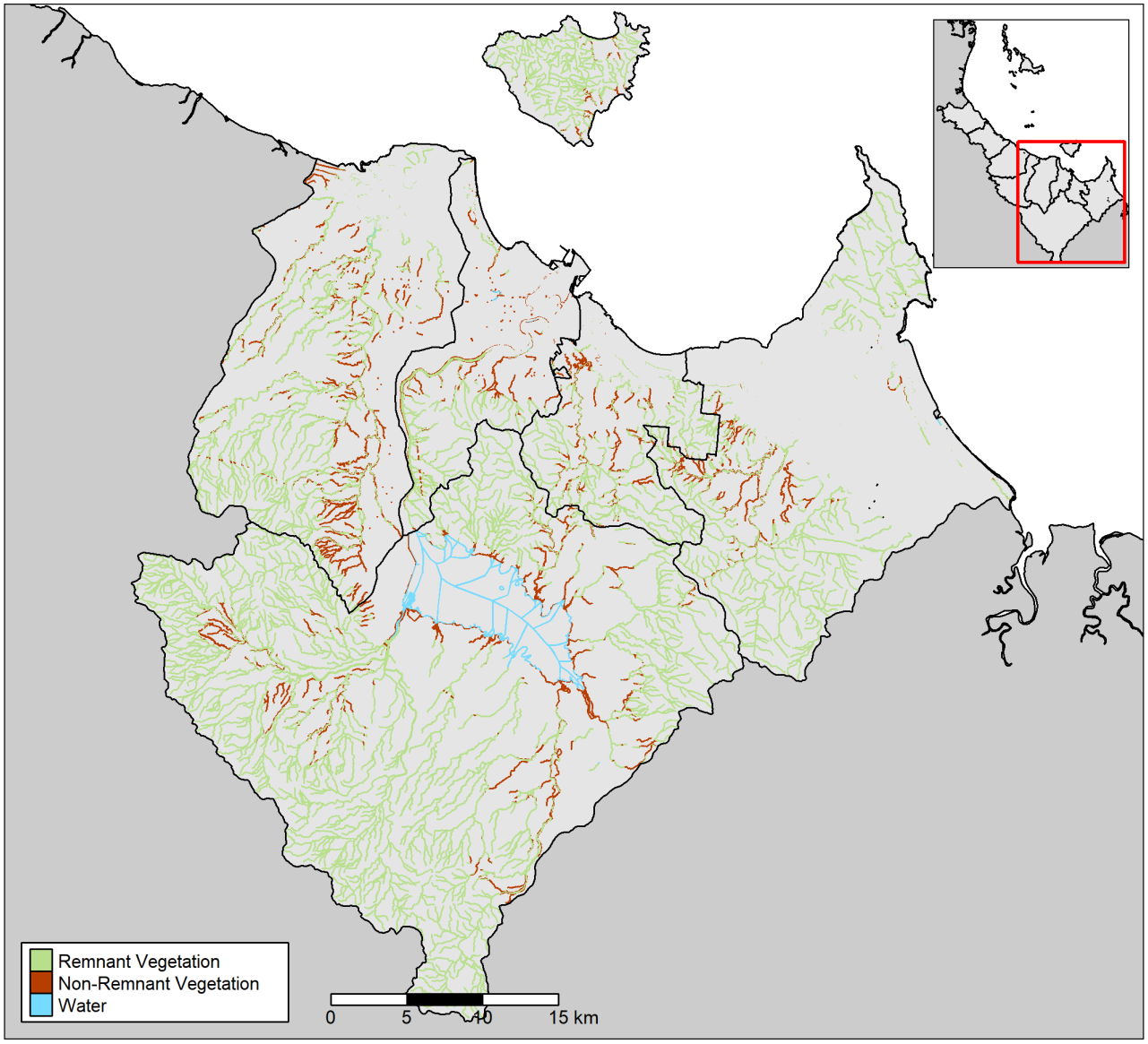

Figure 48. Freshwater riparian extent assessed for vegetation in the Ross Basin of the Dry Tropics region.

Appendix R. Freshwater Riparian Extent: Assessed Area in the Black Basin of the Townsville Dry Tropics Region

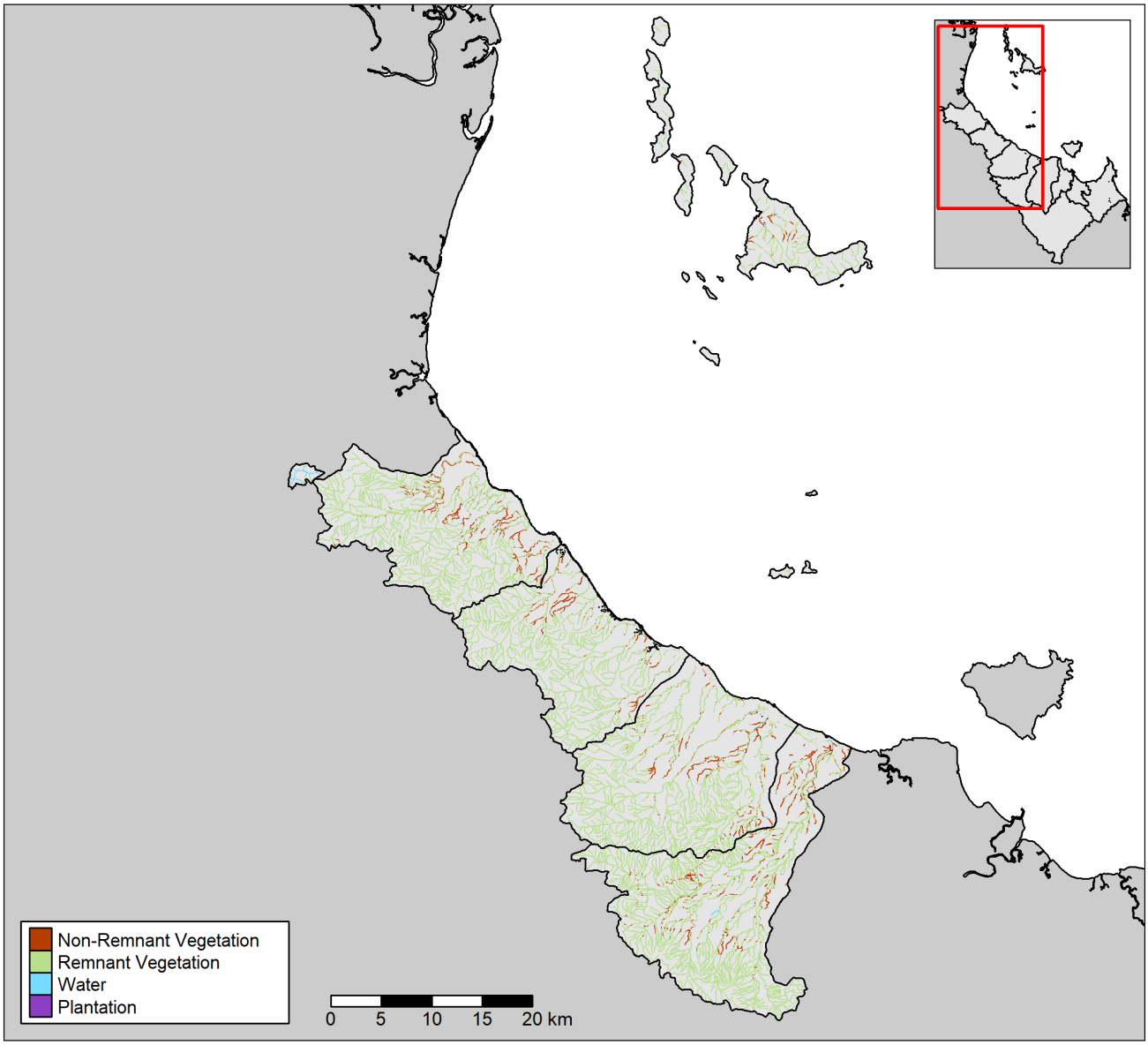

Figure 49. Freshwater riparian extent assessed for vegetation in the Black Basin of the Dry Tropics region.

Appendix S. Freshwater Riparian Extent Historical Scores

Basin/Sub Basin	Extent Change: 19-21 Report Card Year: 22-23	Extent Change: 19-21 Report Card Year: 21-22	Extent Change: 19-21 Report Card Year: 20-21	Extent Change: 19-21 Report Card Year: 19-20
Alligator Creek	57	X	X	
Bohle River	60	X	X	
Magnetic Island	80	X	X	
Ross River (Lower)	80	X	X	
Ross River (Upper)	52	X	X	
Stuart Creek	35	X	X	
Ross freshwater	54	X	X	
Black River	81	X	X	
Bluewater Creek	81	X	X	
Crystal Creek	81	X	X	
Palm Islands	80	X	X	
Paluma Lake	80	X	X	
Rollingstone Creek	81	X	X	
Black freshwater	81	X	X	

Appendix T. Ross Freshwater Riparian Vegetation Change Over Time

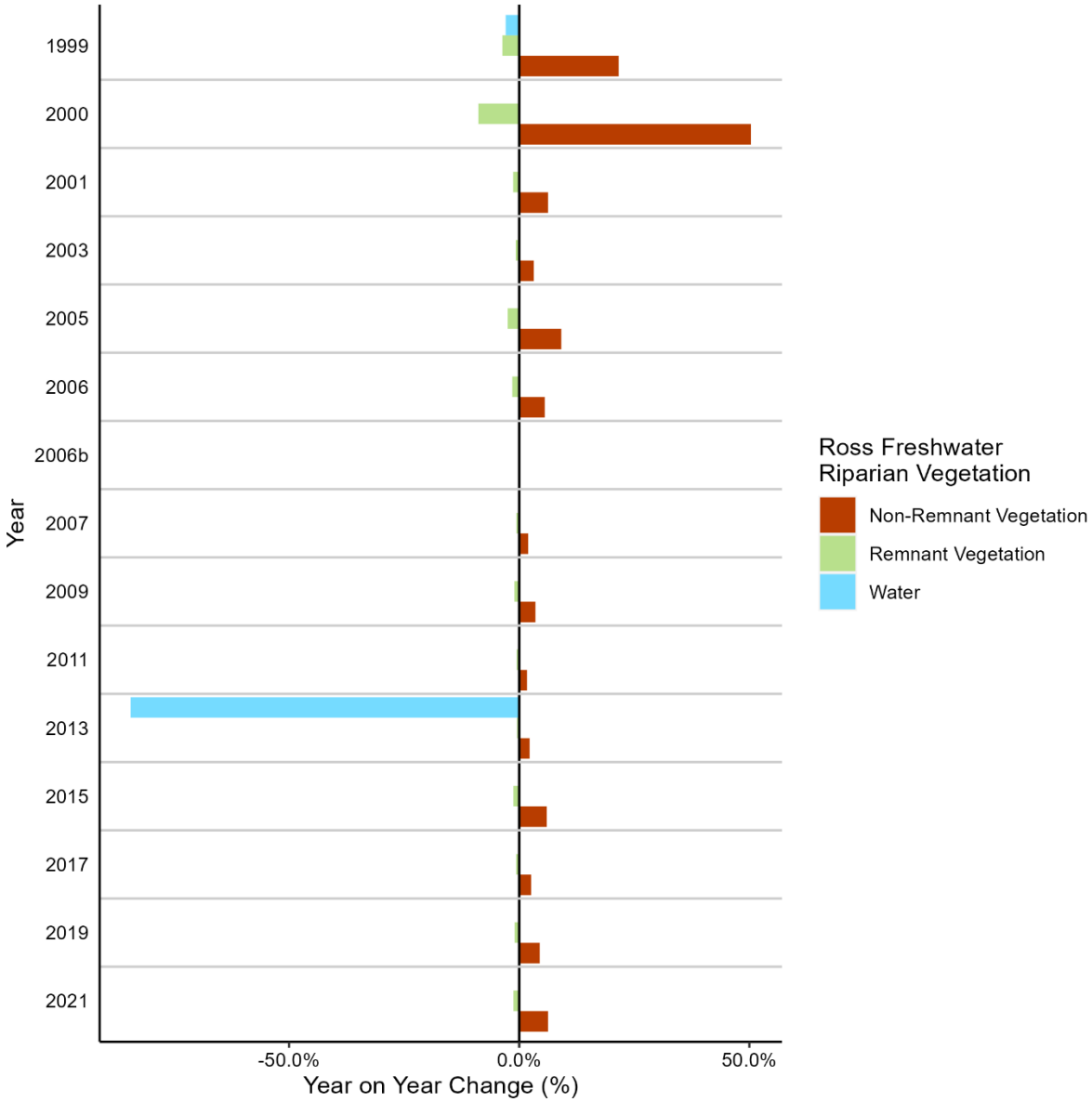

Figure 50. Ross Freshwater riparian vegetation change over time.

Appendix U. Black Freshwater Riparian Vegetation Change Over Time

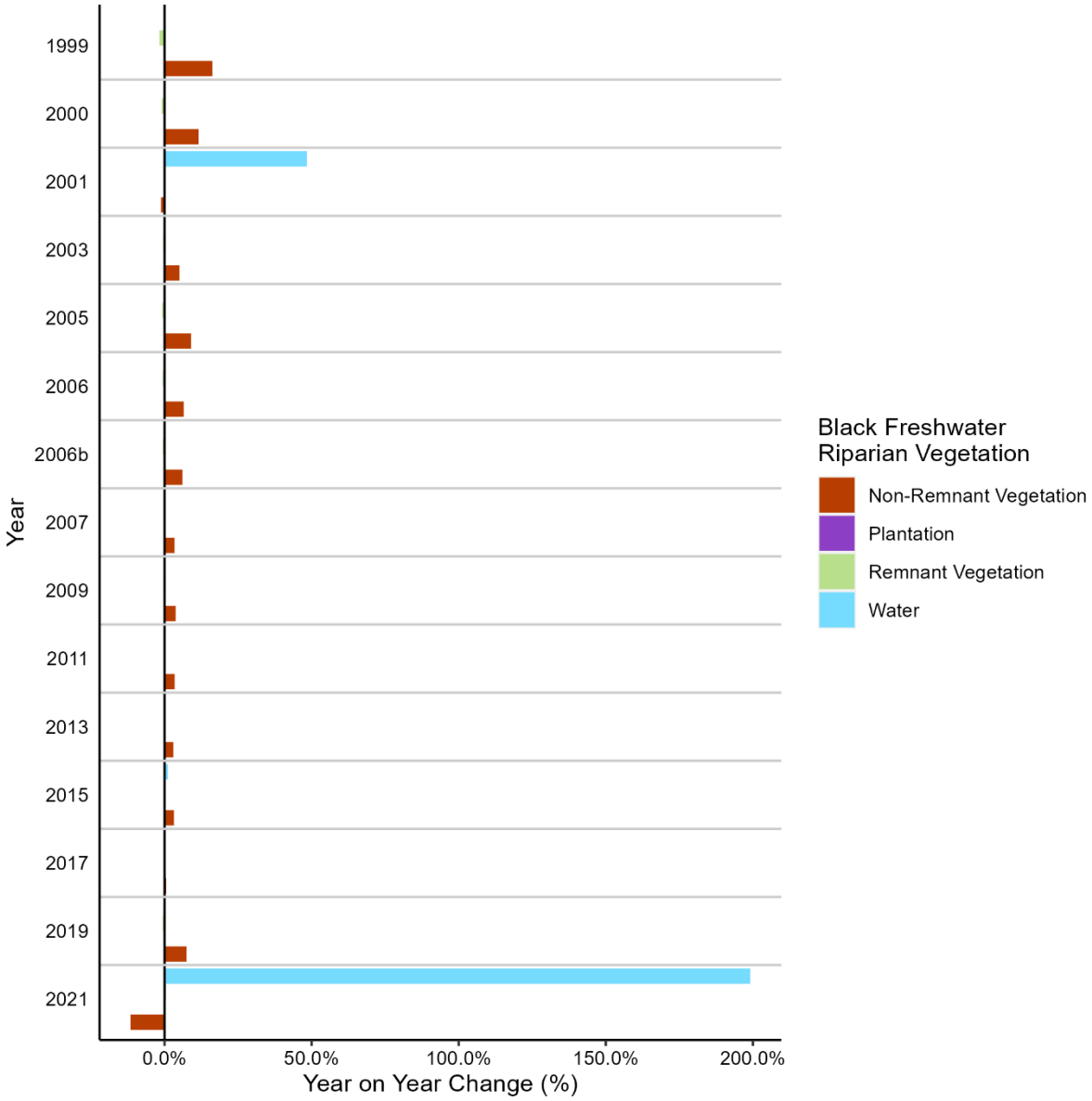

Figure 51. Black Freshwater riparian vegetation change over time.

Appendix V. Freshwater Wetland Extent: Assessed Area in the Ross Basin of the Townsville Dry Tropics Region

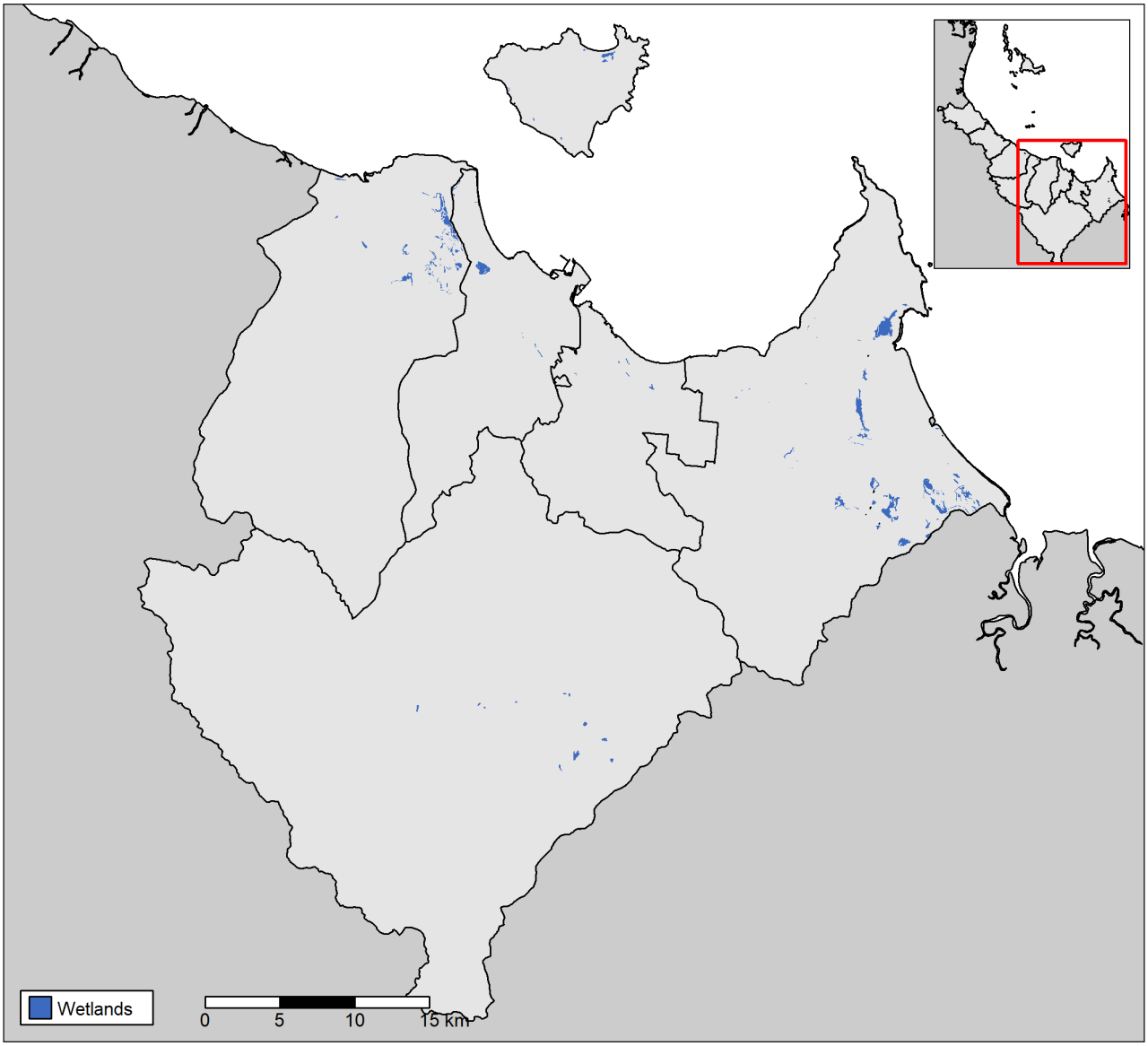

Figure 52. Freshwater wetlands assessed in the Ross freshwater environment of the Dry Tropics region.

Appendix W. Freshwater Wetland Extent: Assessed Area in the Black Basin of the Townsville Dry Tropics Region

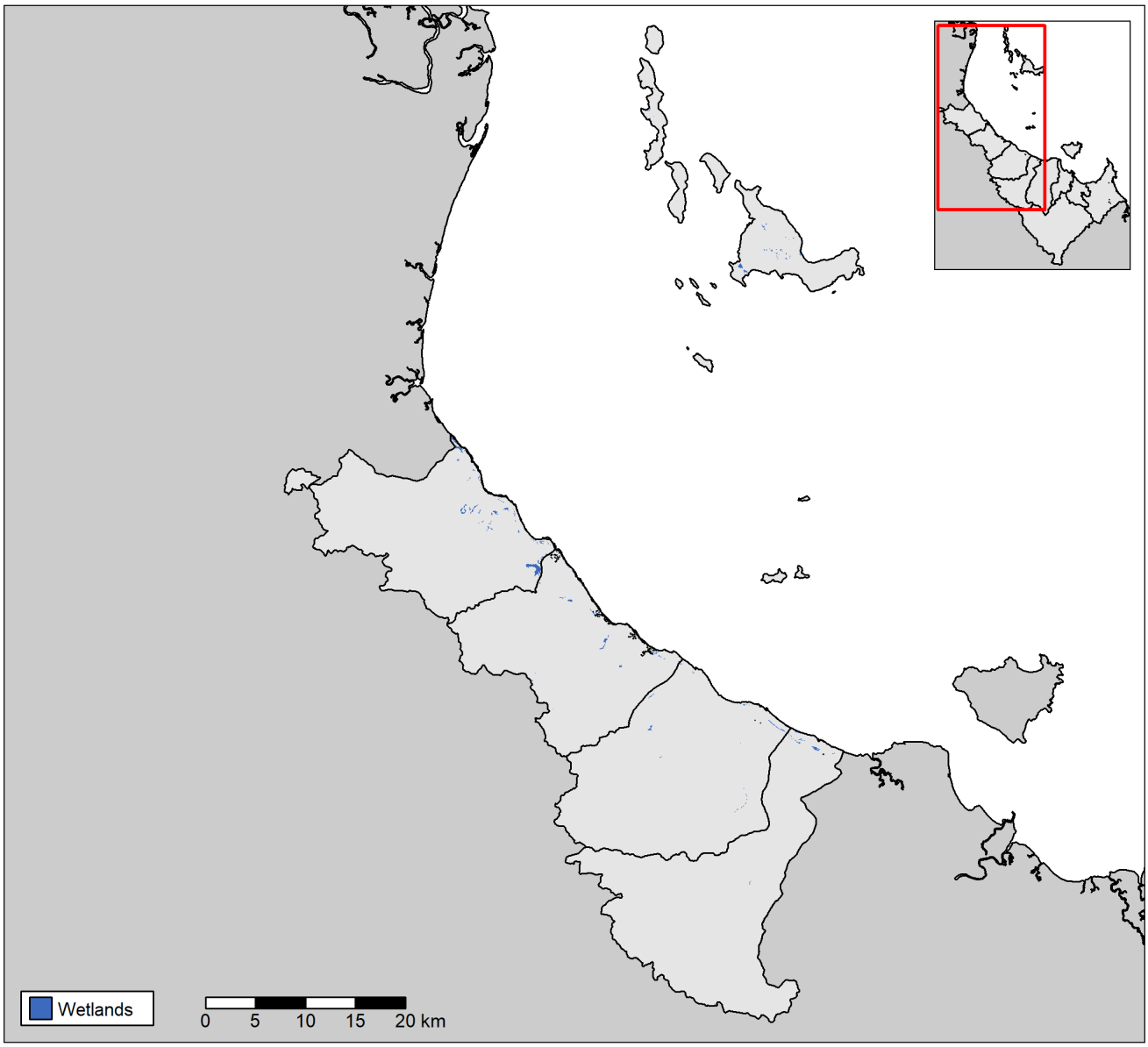

Figure 53. Freshwater wetlands assessed in the Black freshwater environment of the Dry Tropics region.

Appendix X. Ross Freshwater Wetland Vegetation Change Over Time

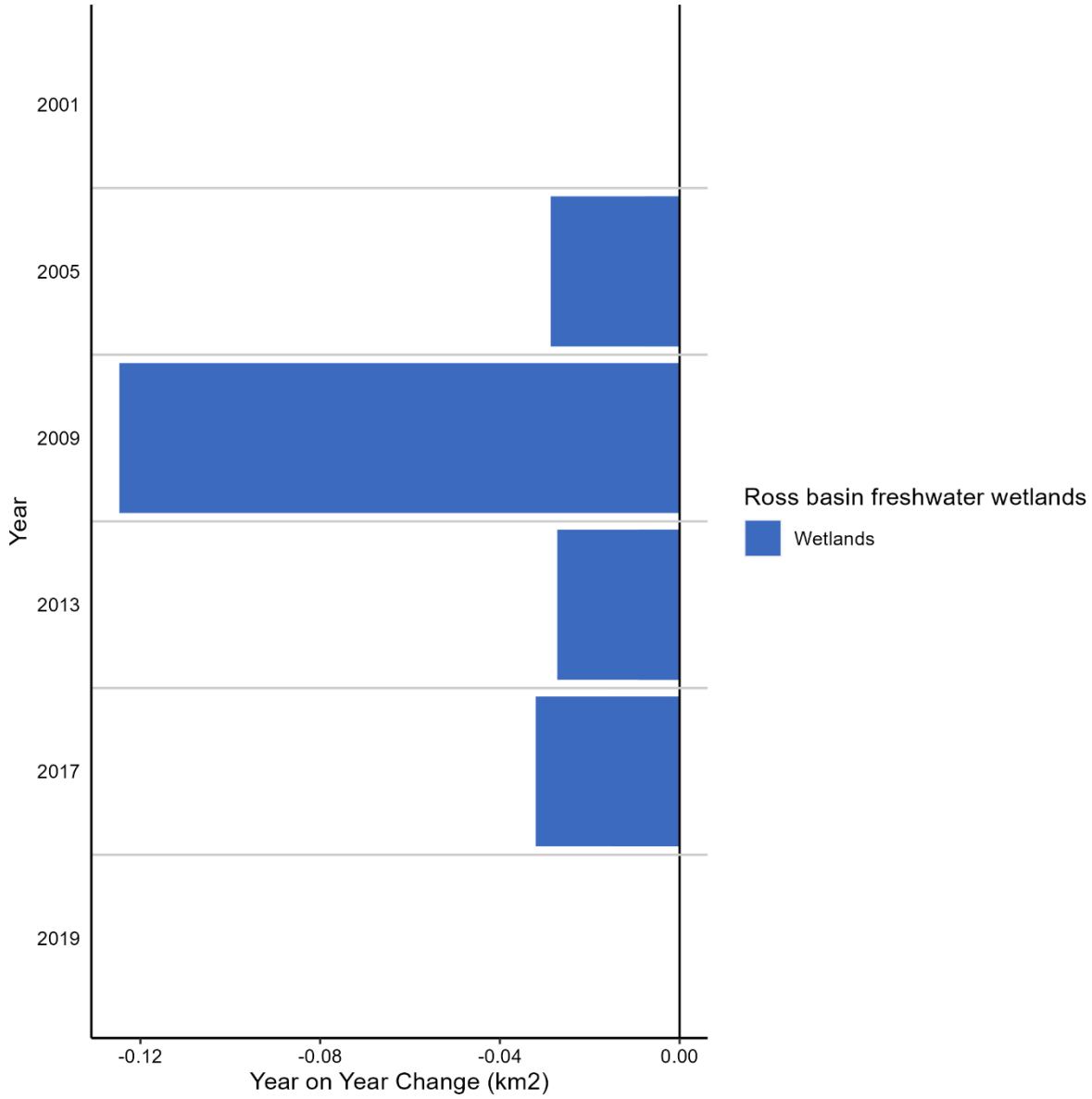

Figure 54. Ross freshwater wetland vegetation change over time.

Appendix Y. Black Freshwater Wetland Vegetation Change Over Time

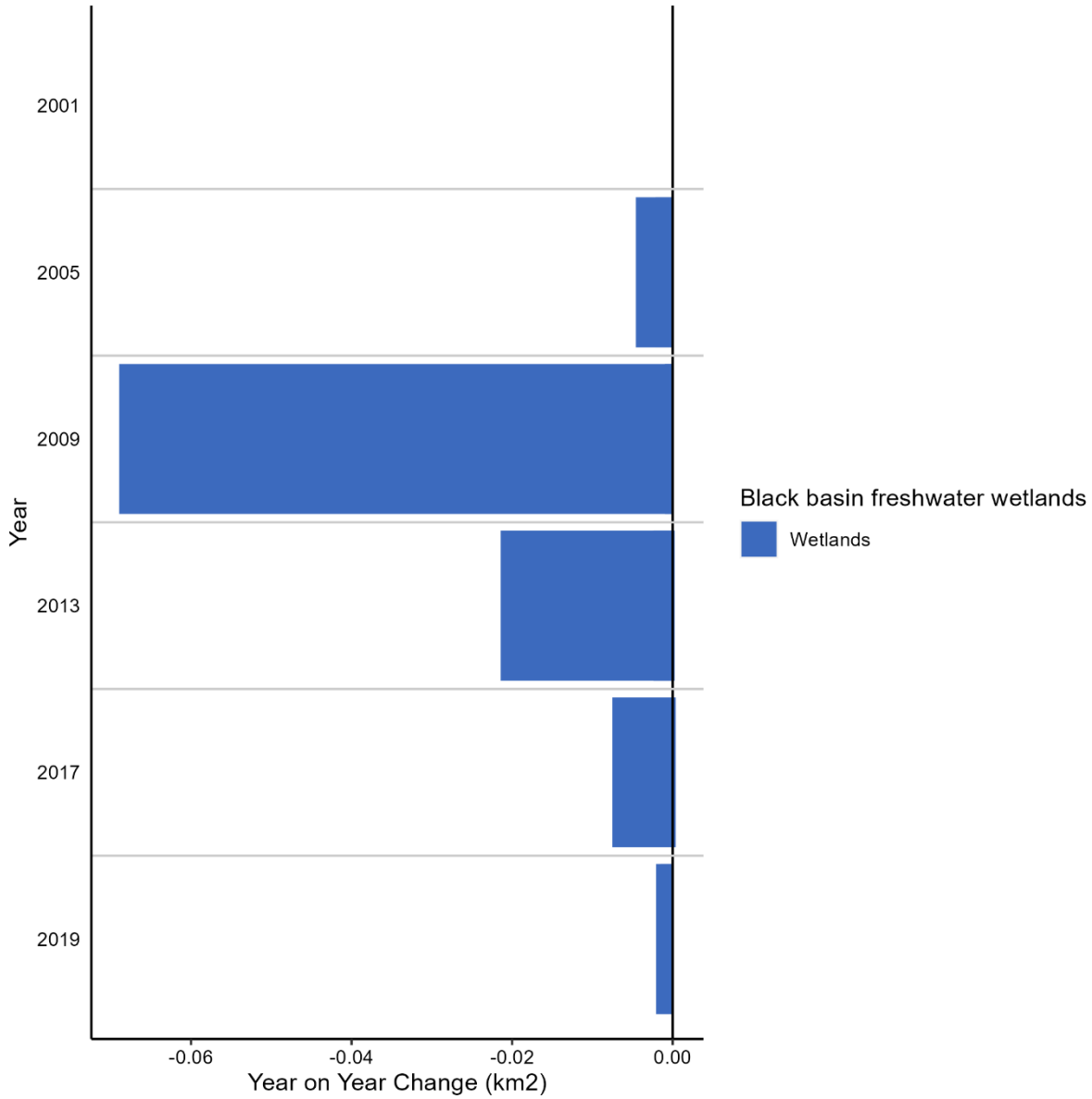

Figure 55. Black freshwater wetland vegetation change over time.

Appendix Z. Effect of the New Wetland Vegetation Dataset

Table 83. Old (version 5.0 data) and new (version 6.0 data) freshwater wetland extent in 2017.

Basin/Sub Basin	Freshwater Wetland Extent		Difference (ha)
	Area (NEW) 2017 (ha)	Area (OLD) 2017 (ha)	
Alligator Creek	526.5	364	162.5
Bohle River	206.1	192.6	13.5
Magnetic Island	28.3	11.8	16.5
Ross River (Lower)	61.0	43.3	17.7
Ross River (Upper)	46.0	46	0
Stuart Creek	11.1	10.1	1
Ross freshwater	**879.0**	**667.7**	**211.3**
Black River	33.5	13.6	19.9
Bluewater Creek	45.1	43.6	1.5
Crystal Creek	219.1	213.8	5.3
Palm Islands	61.9	47.4	14.5
Paluma Lake	NA	NA	NA
Rollingstone Creek	76.9	77.3	-0.4
Black freshwater	**436.6**	**395.6**	**41**

Appendix AA.Freshwater Impoundment Length Assessed Area in the Townsville Dry Tropics Region

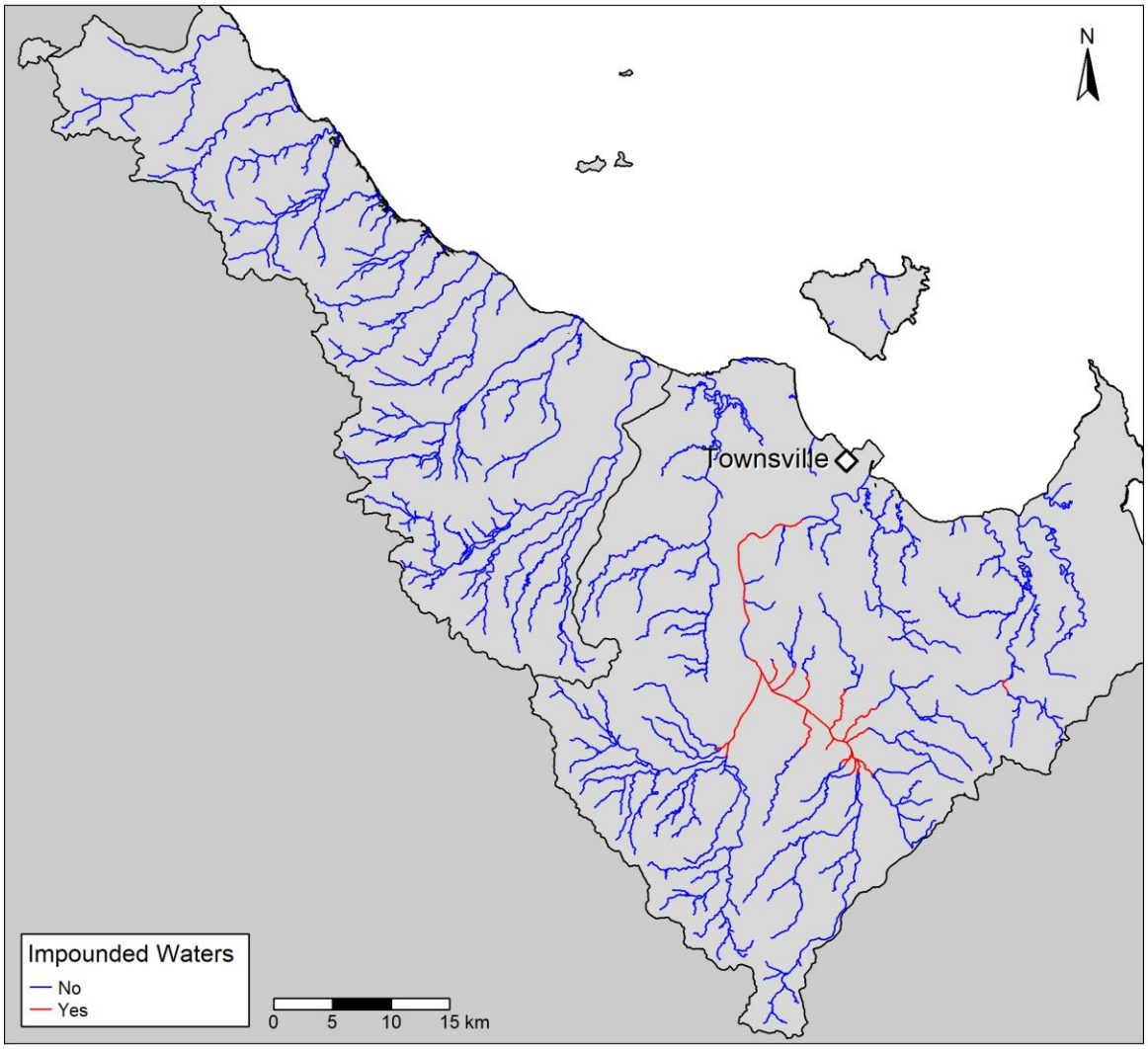

Figure 56. Impounded and non-impounded waters in the Dry Tropics region.

Appendix BB.Freshwater Fish Barrier Locations in the Townsville Dry Tropics Region

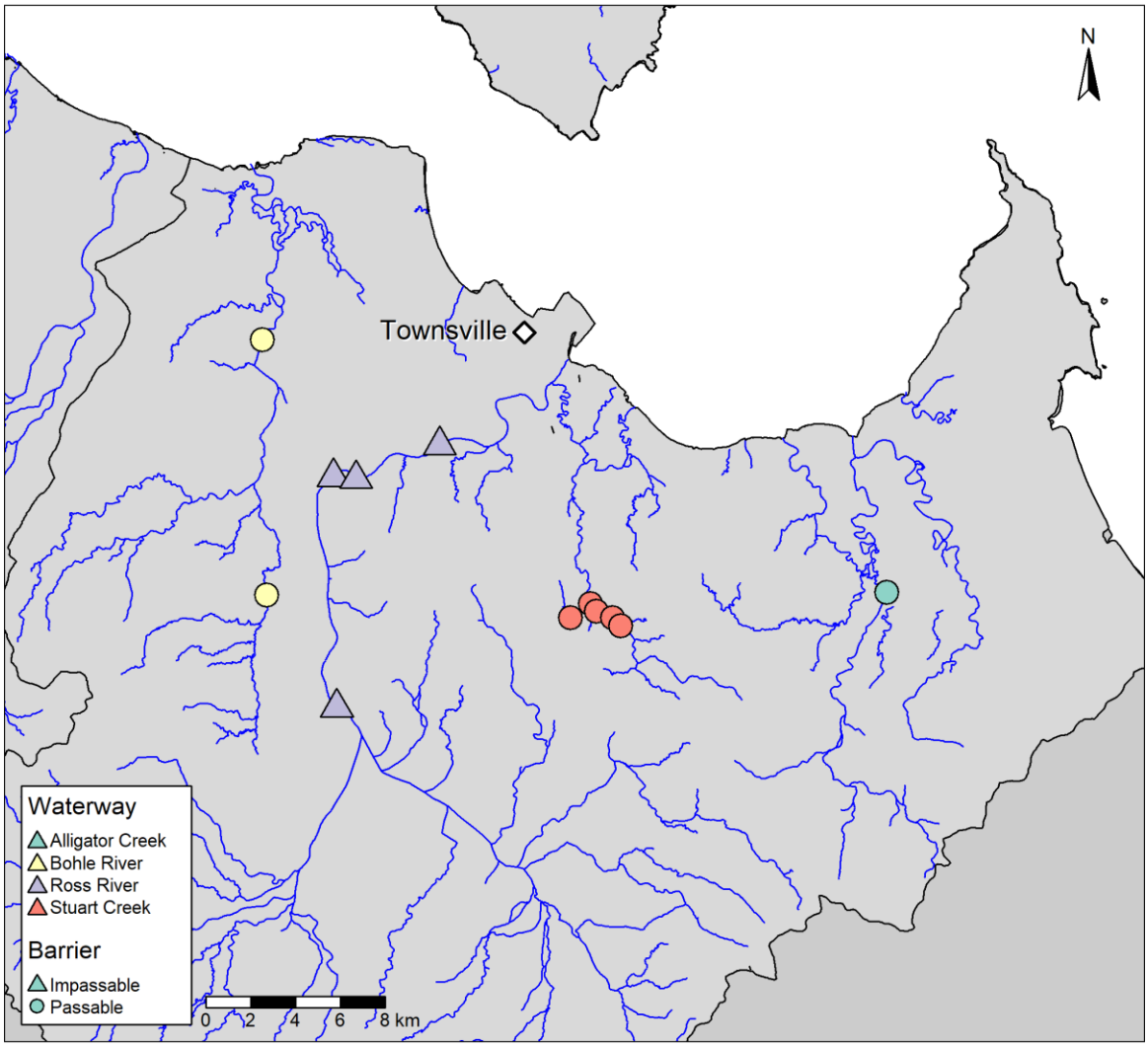

Figure 57. Fish barriers located on major and high importance waterways in the Dry Tropics region.

Appendix CC. Freshwater Fish Sampling Locations in the Dry Tropic Reporting Region

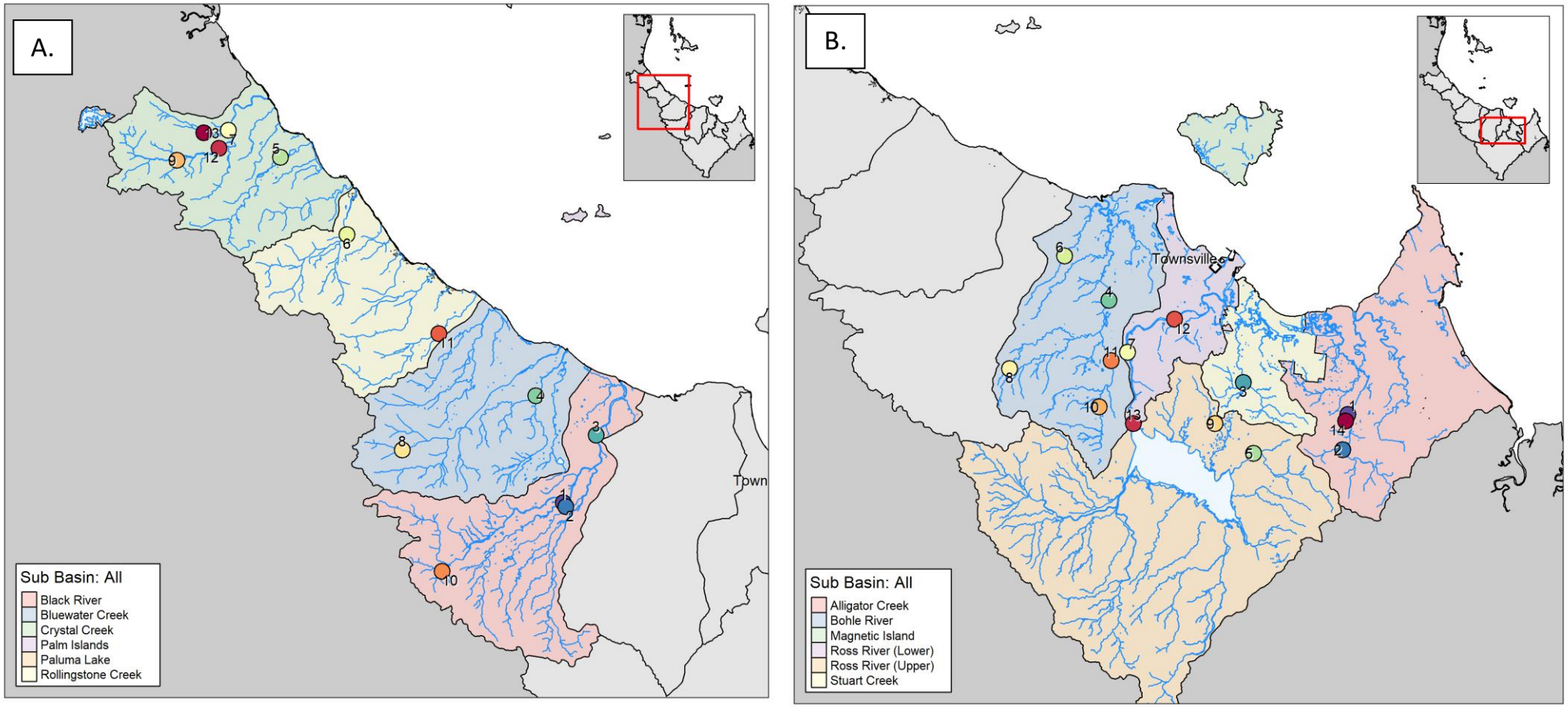

Figure 58. 2022-2023 freshwater fish sampling locations in the Townsville Dry Tropics Region. (A. = Black Basin, B. = Ross Basin). For Site ID's refer to Table 84 below.

Table 84. List of Site Names and Site Numbers for the 2022-2023 fish monitoring locations.

Basin	Site	Site Number
Ross	Alligator Creek Road, Alligator Creek	1
	Alligator Creek Road, Bowling Green Bay National Park, Mount Elliot	2
	Bougainville Street, Roseneath	3
	Dalrymple Road, Mount Louisa	4
	Flinders Highway, Ross River	5
	Geaney Lane, Deeragun	6
	Gollogly Drive, Rasmussen	7
	Granitevale Road, Alice River	8
	Kavenagh Court, Oak Valley	9
	Off Laudberg Road, Kelso	10
	Off S Beck Drive, Rasmussen	11
	Riverview Park, Annandale	12
	Riverway Drive, Kelso	13
	Strachan Road, Alligator Creek	14
Black	Adrenaline Paintball, Black River	1
	Black River Road, Black River	2
	Bruce Highway, Black River	3
	Bruce Highway, Bluewater	4
	Bruce Highway, Mutarnee	5
	Bruce Highway, Rollingstone	6
	Daly Road, Mutarnee	7
	Forestry Road, Paluma Range National Park, Lynam	8
	Intake Road, Paluma Range National Park, Crystal Creek	9
	Page Road, Hervey Range	10
	Setter Road, Bluewater	11
	Spiegelhauer Road, Mutarnee	12
	Volk Road, Mutarnee	13

Appendix DD. Key of Freshwater Fish Species Found in the Townsville Dry Tropics Region

Table 85. Key of freshwater fish species found in the Townsville Dry Tropics region.

Basin	Species	Type	Key
Ross	Barred grunter	Indigenous	1
Ross	Blue gourami	Alien	2
Ross	Bony bream	Indigenous	3
Ross	Freshwater longtom	Indigenous	4
Ross	Midas cichlid	Alien	5
Ross	Mouth almighty	Indigenous	6
Ross	Northern carp gudgeon (undescribed)	Indigenous	7
Ross	Rendahl's tandan	Indigenous	8
Ross	Seven-spot archerfish	Indigenous	9
Ross	Sleepy cod	Translocated	10
Ross	Speckled goby	Indigenous	11
Black/Ross	Barramundi	Indigenous	12
Black/Ross	Butter jew	Indigenous	13
Black/Ross	Eastern rainbowfish	Indigenous	14
Black/Ross	Empire gudgeon	Indigenous	15
Black/Ross	False Celebes goby	Indigenous	16
Black/Ross	Fly-specked hardyhead	Indigenous	17
Black/Ross	Gambusia	Alien	18
Black/Ross	Guppy	Alien	19
Black/Ross	Hyrtl's tandan	Indigenous	20
Black/Ross	Jungle perch	Indigenous	21
Black/Ross	Long-finned eel	Indigenous	22
Black/Ross	Mangrove jack	Indigenous	23
Black/Ross	Mozambique tilapia	Alien	24
Black/Ross	Northern perchlet (undescribed)	Indigenous	25
Black/Ross	Platy	Alien	26
Black/Ross	Southern purple-spotted gudgeon	Indigenous	27
Black/Ross	Spangled perch	Indigenous	28
Black/Ross	Swamp eel	Indigenous	29
Black	Black spine-cheek gudgeon	Indigenous	30
Black	Brown spine-cheek gudgeon	Indigenous	31
Black	Giant mottled eel	Indigenous	32
Black	Roman-nose goby	Indigenous	33
Black	Scaleless goby	Indigenous	34
Black	Sea mullet	Indigenous	35
Black	Snake-head gudgeon	Indigenous	36

Appendix EE. Presence/Absence of Fish Species in Waterways Across the Ross Freshwater Basin and Black Freshwater Basin

Table 86. Fish species present within waterways across the Ross Freshwater Basin.

Site #.	Species #																																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0
3	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	1	1	0	0	0	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0
5	0	0	1	0	0	1	1	0	0	1	0	0	0	1	0	0	1	1	0	1	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0
7	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0
11	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0
12	1	0	1	1	1	1	1	0	1	1	1	1	0	1	0	0	1	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0
13	1	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	1	1	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0
14	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0

Legend: ■ = Species Present | ■ = Species Absent. Note: where multiple sites occur in a river or creek, they are combined to create the site score.

Table 87. Fish species present within waterways across the Black Freshwater Basin.

Site #	Species #																																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	1	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	1	0	1	1	0	1	0	1	0	1	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	1	0	1	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	1	0	0	1
12	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0

Legend: ■ = Species Present | ■ = Species Absent. Note: where multiple sites occur in a river or creek, they are combined to create the site score.

Appendix FF. Distribution of Fish Data Across All Monitoring Sites in The Ross Freshwater Basin and Black Freshwater Basin

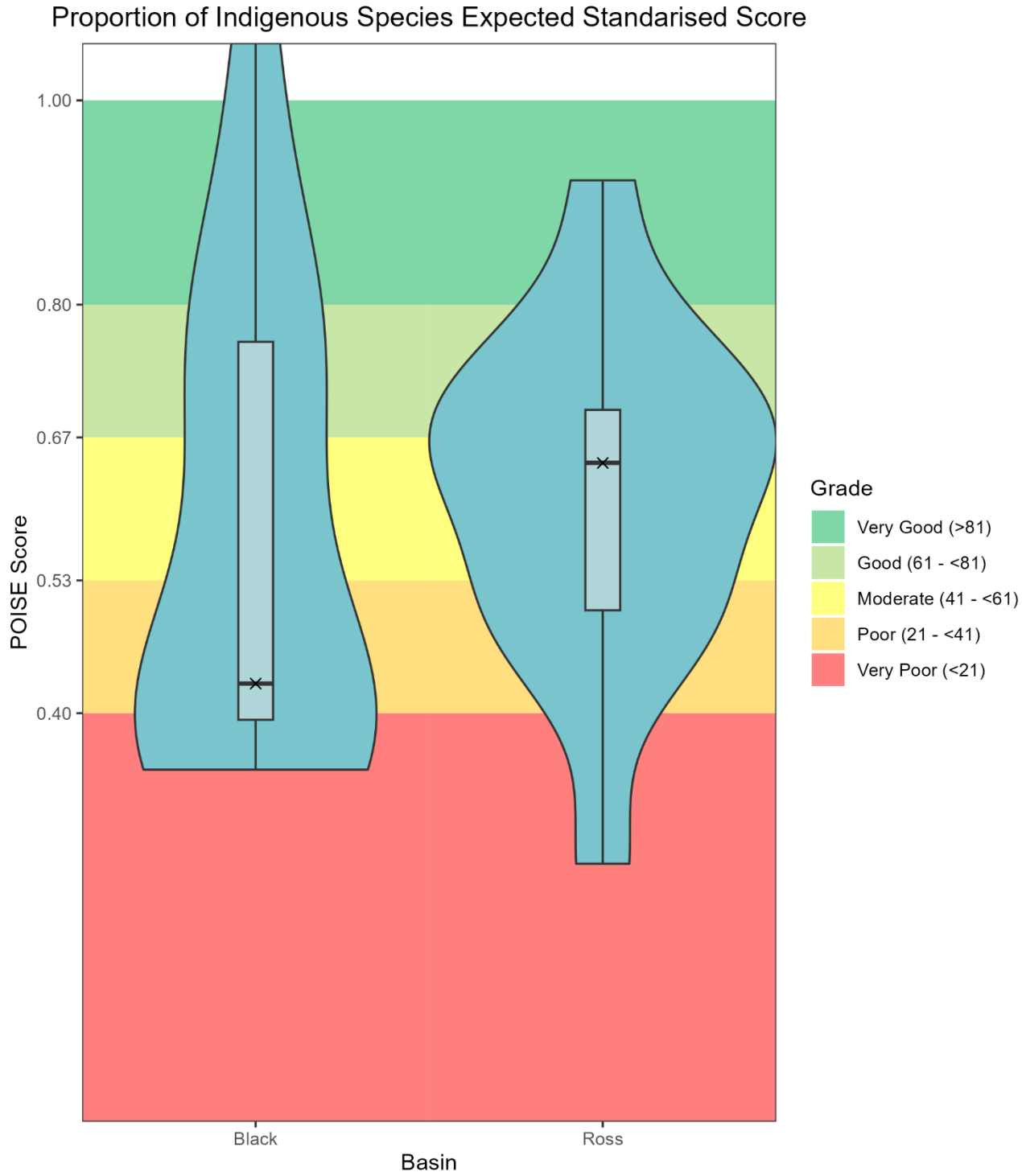

Figure 59. POISE scores for sites in each basin of the Townsville Dry Tropics region.

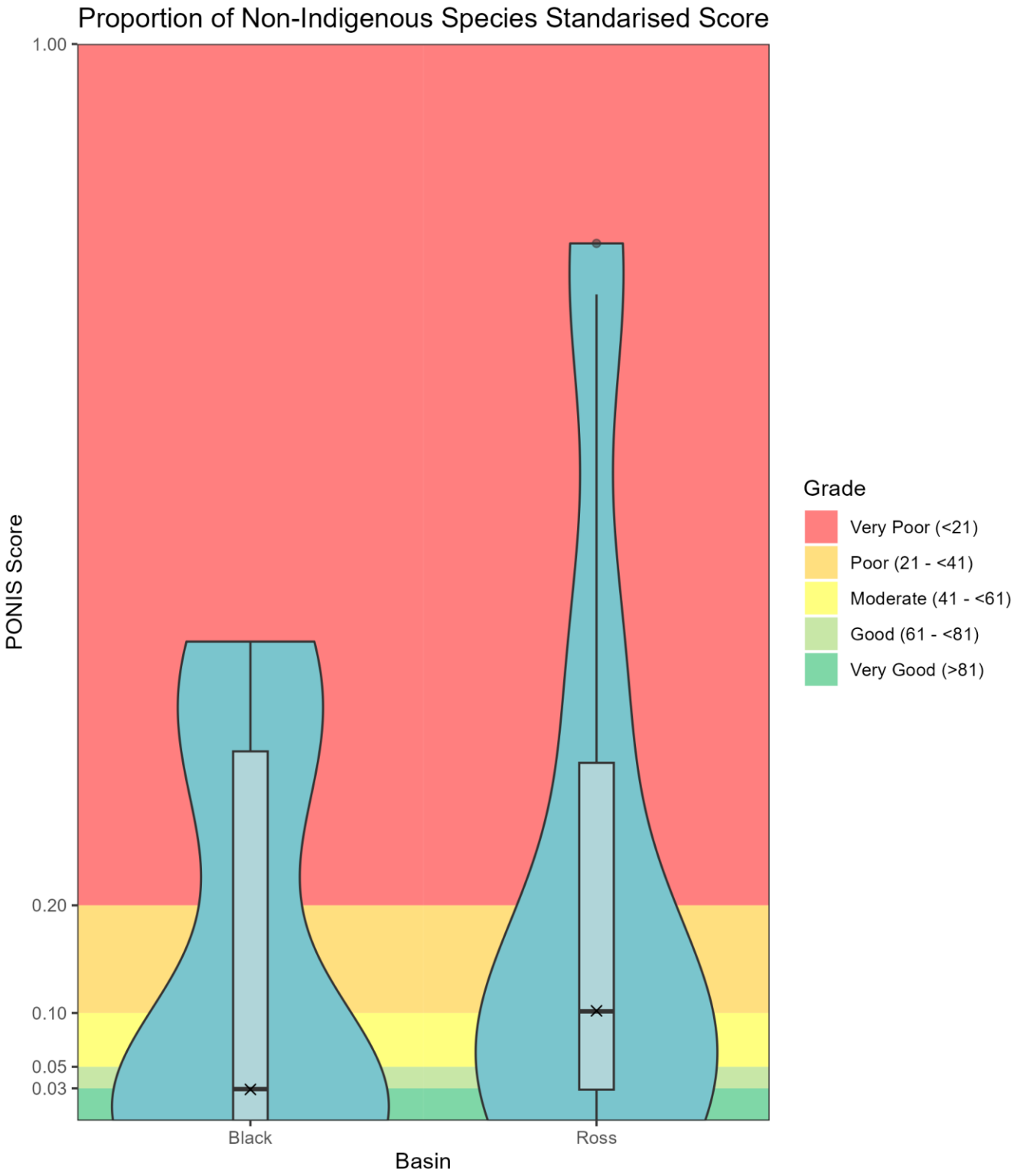

Figure 60. PONIS scores for sites in each basin of the Townsville Dry Tropics region.

Appendix GG. Estuarine Water Quality Nutrients: Sample Frequencies, Medians, Water Quality Objectives, and Scaling Factors

Table 88. Number of samples, number of months sampled, median, water quality objective values, and scaling factors for DIN and TP in the Townsville Dry Tropics Estuarine Environments.

Watercourse	DIN (mg/L)					TP (mg/L)				
	N.Samples	N.Months	Median	WQO	SF	N.Samples	N.Months	Median	WQO	SF
Bohle River	17	10	0.011	0.07	0.09	17	10	0.007	0.05	0.09
Louisa Creek	42	10	0.039	0.07	0.09	46	10	0.110	0.05	0.09
Ross Creek	8	4	0.010	0.07	0.09	8	4	0.002	0.05	0.09
Ross River	4	4	0.004	0.07	0.09	4	4	0.006	0.05	0.09
Sandfly Creek	31	10	0.033	0.07	0.09	31	10	0.028	0.05	0.09
Alligator Creek	16	11	0.006	0.07	0.09	16	11	0.005	0.05	0.09
Althaus Creek	12	12	0.034	0.02	0.09	12	12	0.026	0.025	0.04
Bluewater Creek	12	12	0.019	0.02	0.09	12	12	0.014	0.025	0.04
Sleeper Log Creek	17	11	0.020	0.02	0.09	17	11	0.016	0.025	0.04
Camp Oven Creek	34	12	0.009	0.02	0.09	34	12	0.002	0.025	0.04
Saltwater Creek	45	12	0.014	0.02	0.09	45	12	0.002	0.025	0.04
Rollingstone Creek	12	12	0.050	0.02	0.09	12	12	0.013	0.025	0.04
Crystal Creek	12	12	0.025	0.02	0.09	12	12	0.018	0.025	0.04

Key: = Mean/Median is lower than the guideline value | = Mean/Median is higher than the guideline value | ND = No Data | NA = Not Applicable (data available but not usable).

Appendix HH. Estuarine Water Quality Nutrients Scores Historic Comparison

Table 89. Townsville Dry Tropics estuarine water quality historic nutrient indicator scores.

Basin	Sub Basin	Watercourse	DIN				TP			
			22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20
Ross Estuarine	Bohle	Bohle River	90	90	90	90	90	90	90	90
		Louisa Creek	67	79	75	74	0	22	30	30
			78	85	83	82	45	56	60	60
	Lower Ross	Ross Creek	90	90	90	90	90	90	90	90
		Ross River	90	90	90	90	90	90	90	90
			90	90	90	90	90	90	90	90
	Stuart	Sandfly Creek	90	76	90	90	90	90	90	90
	Alligator	Alligator	90	90	90	90	90	90	90	90
			86	85	88	88	75	82	83	83
Black Estuarine	Bluewater Creek	Althaus Ck	49	90	69	90	56	90	90	72
		Bluewater Ck	65	63	53	70	90	90	90	90
		Sleeper Log Ck	61	90	90	ND	90	90	90	ND
			58	81	71	80	78	90	90	81
	Rollingstone Creek	Camp Oven Creek	80	80	90	ND	90	90	83	ND
		Saltwater Ck	78	70	90	66	90	90	90	90
		Rollingstone Ck	34	61	36	49	90	90	90	90
			64	71	72	58	90	90	88	90
	Crystal Creek	Crystal Ck	56	65	27	58	90	90	90	90
			60	72	57	65	85	90	89	87

Standardised scoring range: Very Poor (E) = 0 to <21 | Poor (D) = 21 to <41 | Moderate (C) = 41 to <61 | Good (B) = 61 to <81 | Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

Appendix II. Estuarine Water Quality Physical-Chemical Properties: Sampling Frequencies, Medians, Water Quality Objectives and Scaling Factors

Table 90. Number of samples, number of months sampled, median, water quality objective values, and scaling factors for Turbidity and DO in the Townsville Dry Tropics Estuarine Environments.

Watercourse	Turbidity (NTU)					Dissolved Oxygen (%Sat)						
	N.Samples	N.Months	Median	WQO	SF	N.Samples	N.Months	Median	High DO WQO	High DO SF	Low DO WQO	Low DO SF
Bohle River	17	10	15.350	20	45	17	10	94.175	105	120	85	70
Louisa Creek	40	10	16.800	20	45	40	10	67.640	105	120	85	70
Ross Creek	8	4	3.485	20	45	6	3	91.750	105	120	85	70
Ross River	4	4	13.575	20	45	3	3	93.410	105	120	85	70
Sandfly Creek	30	10	30.725	20	45	26	9	89.920	105	120	85	70
Alligator Creek	15	11	24.900	20	45	13	10	90.750	105	120	85	70
Althaus Creek	12	12	20.390	8	15	12	12	101.050	105	120	85	70
Bluewater Creek	12	12	7.400	8	15	12	12	93.350	105	120	85	70
Sleeper Log Creek	17	11	8.160	8	15	17	11	89.300	105	120	85	70
Camp Oven Creek	31	11	8.658	8	15	28	11	80.555	105	120	85	70
Saltwater Creek	38	12	5.661	8	15	37	12	92.489	105	120	85	70
Rollingstone Creek	12	12	4.920	8	15	12	12	91.800	105	120	85	70
Crystal Creek	12	12	10.015	8	15	12	12	92.200	105	120	85	70

Key: ■ = for Turbidity Mean/Median is lower than the guideline value, for DO, Median is within the range between the High and Low DO guideline values | ■ = for Turbidity Mean/Median is higher than the guideline value, for DO, the Median is higher than the High DO or Lower than the Low DO guideline value | ND = No Data | NA = Not Applicable (data available but not usable).

Appendix JJ. Estuarine Water Quality Physical-Chemical Properties Scores Historic Comparison

Table 91. Townsville Dry Tropics estuarine water quality historic physical-chemical indicator scores.

Basin	Sub Basin	Watercourse	Turbidity				High DO				Low DO			
			22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20
Ross Estuarine	Bohle	Bohle River	67	66	90	90	90	90	90	90	90	90	90	90
		Louisa Creek	65	66	68	90	90	90	25	90	0	24	21	90
			66	66	79	90	90	90	57	90	45	41	56	90
	Lower Ross	Ross Creek	90	90	90	90	90	90	90	90	90	90	90	ND
		Ross River	75	90	90	90	90	90	70	90	90	90	90	ND
			82	90	90	90	90	90	80	90	90	90	90	ND
	Stuart	Sandfly Creek	34	76	33	52	90	90	90	90	90	90	90	90
	Alligator	Alligator	48	90	69	90	90	90	90	90	90	90	90	90
			63	81	68	81	90	90	79	90	75	90	81	90
Black Estuarine	Bluewater Creek	Althaus Ck	0	0	0	3	80	33	90	68	90	28	90	90
		Bluewater Ck	63	90	90	7	90	76	90	73	73	0	90	90
		Sleeper Log Ck	59	63	84	ND	90	90	90	90	90	90	90	ND
			40	51	58	5	86	66	90	77	84	39	90	90
	Rollingstone Creek	Camp Oven Creek	55	42	63	ND	90	90	53	90	42	54	65	ND
		Saltwater Ck	69	83	86	90	90	77	90	90	90	75	90	90
		Rollingstone Ck	80	69	65	73	90	90	90	90	77	64	90	90
			68	65	71	82	90	86	78	90	70	64	81	90
	Crystal Creek	Crystal Ck	43	7	68	90	90	90	90	90	90	69	90	34
			53	41	66	59	88	81	86	86	79	57	87	71

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

Appendix KK. Estuarine Water Quality Sub Basin Historic Scores

Table 92. A comparison of nutrient and physical chemical properties indicator category scores, and the water quality index scores, for estuarine sub basins between years.

Sub Basin	Nutrients				Phys-Chem				Water Quality			
	22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20
Bohle River	61	63			55	55			58	59		
Lower Ross	90	90			86	85			88	87		
Stuart Ck	90	81			62	77			76	79		
Alligator Ck	90	90			69	90			79	90		
Bluewater Ck	68	85			61	58			64	71		
Rollingstone Ck	77	82			69	73			73	77		
Crystal Ck	73	77			66	48			69	63		

Appendix LL. Estuarine Water Quality 2022–2023 Boxplots

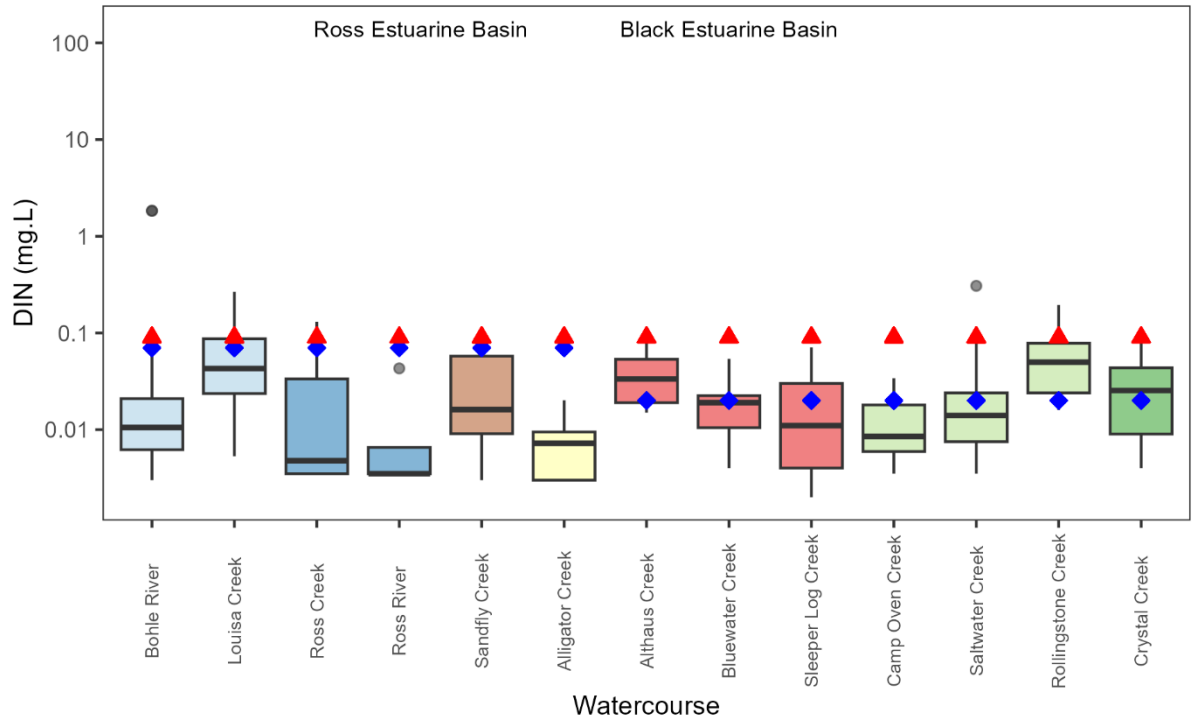

Figure 62. Dissolved Inorganic Nitrogen (DIN) (mg/L) Boxplot: red triangles indicate the scaling factor, blue diamonds indicate the water quality objective.

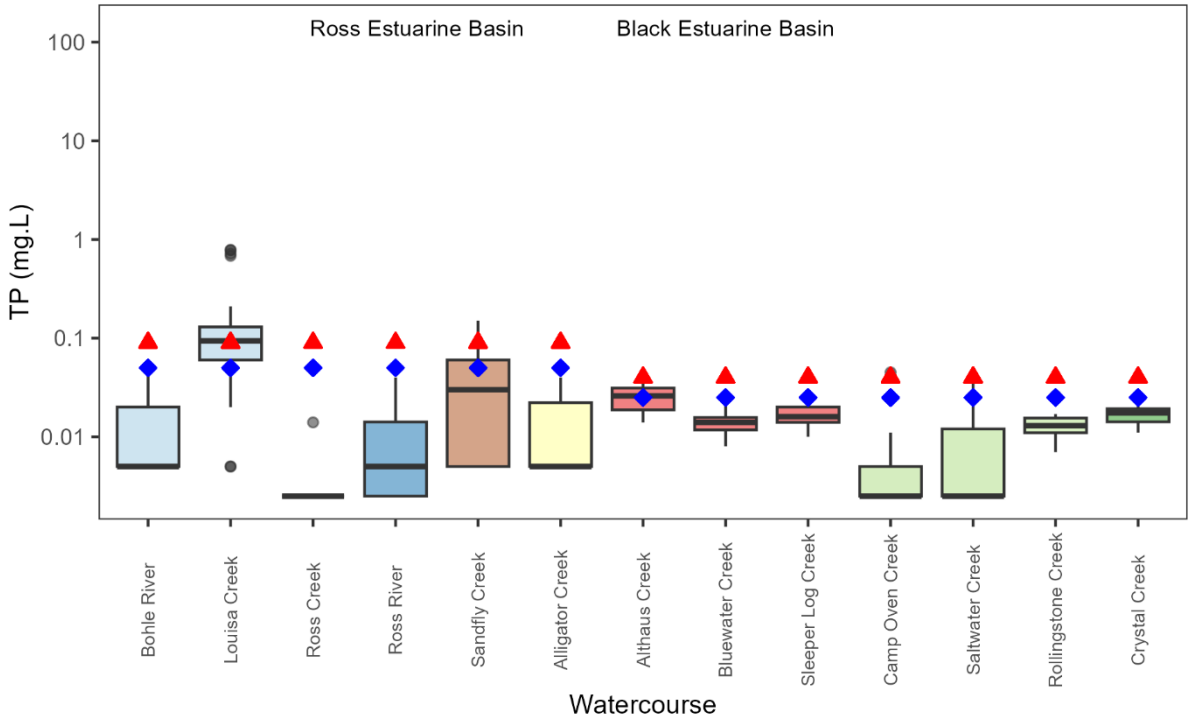

Figure 61. Total Phosphorus (TP) (mg/L) Boxplot: red triangles indicate the scaling factor, blue diamonds indicate the water quality objective.

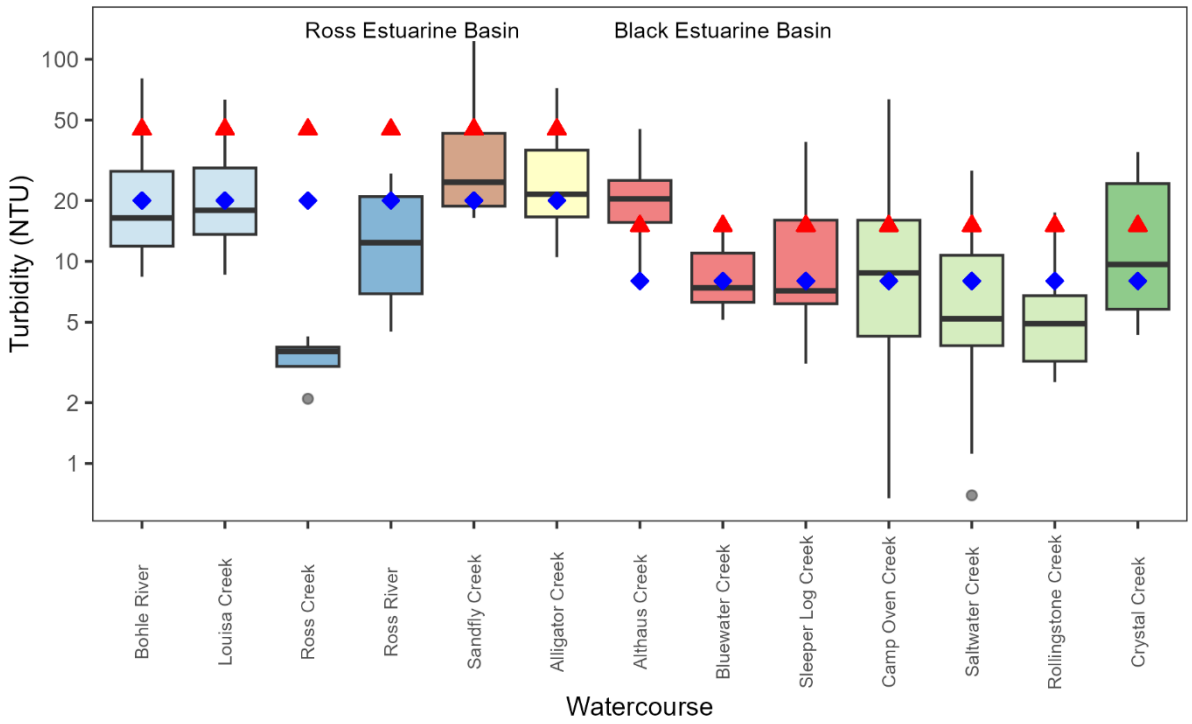

Figure 64. Turbidity (NTU) Boxplot: red triangles indicate the scaling factor, blue diamonds indicate the water quality objective.

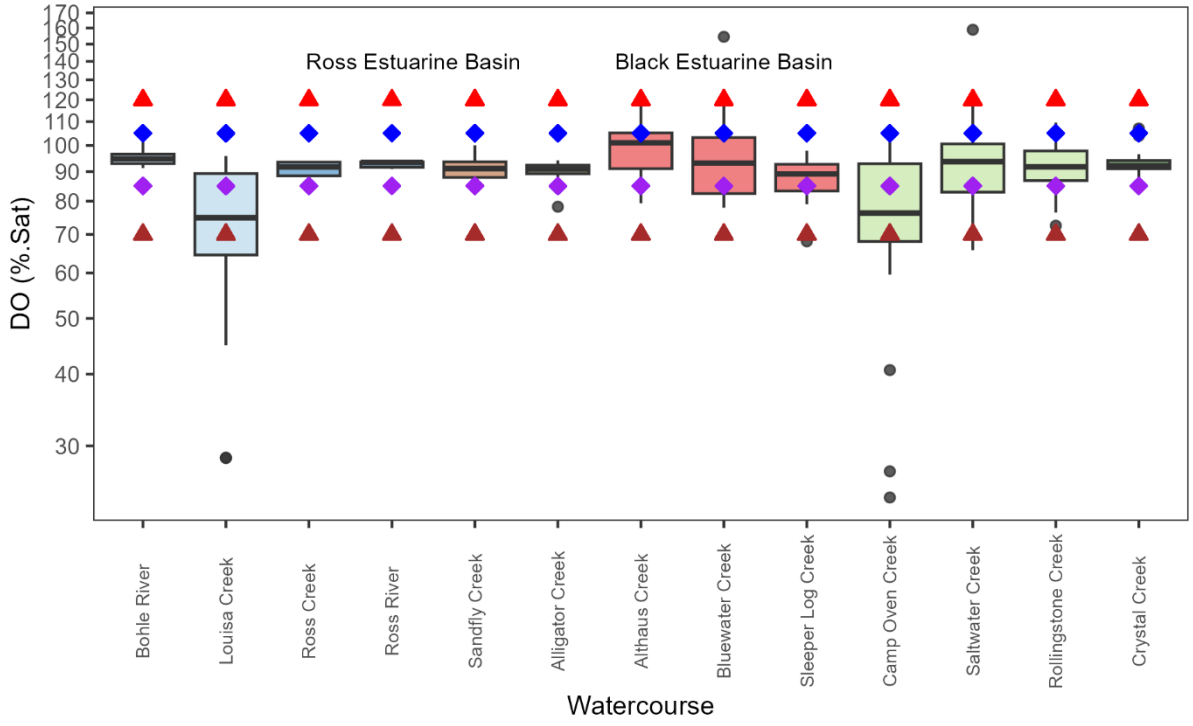

Figure 63. Dissolved Oxygen (DO) (% Saturation) boxplot: red triangles indicate the high DO scaling factor, blue diamonds indicate the high DO water quality objective, purple diamonds indicate the low DO water quality objective, and brown triangles indicate the low DO scaling factor.

Appendix MM. Estuarine Water Quality Line Plots

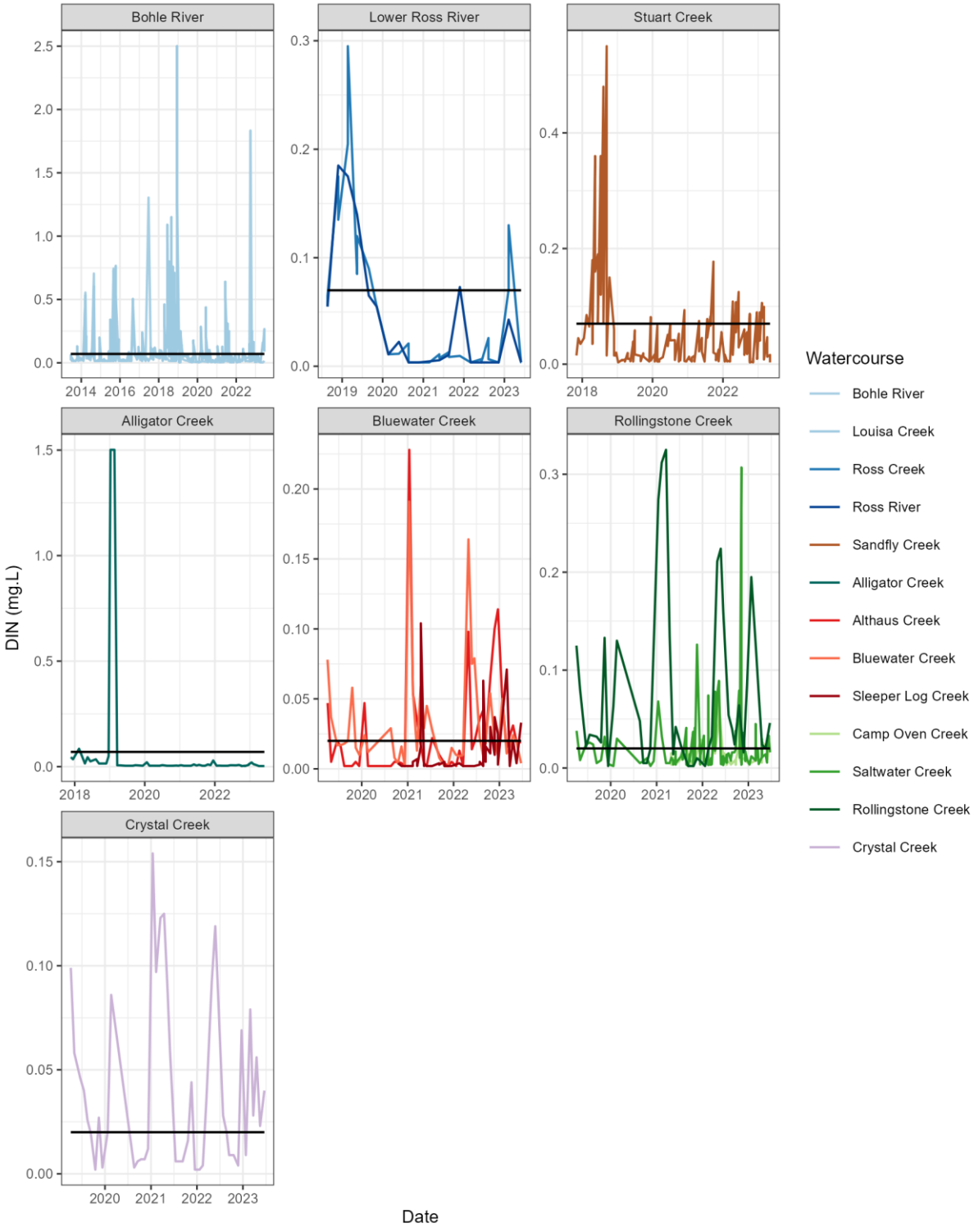

Figure 65. Historical concentrations of dissolved inorganic nitrogen (DIN) in the freshwater sub basins. Black line indicates the water quality objective.

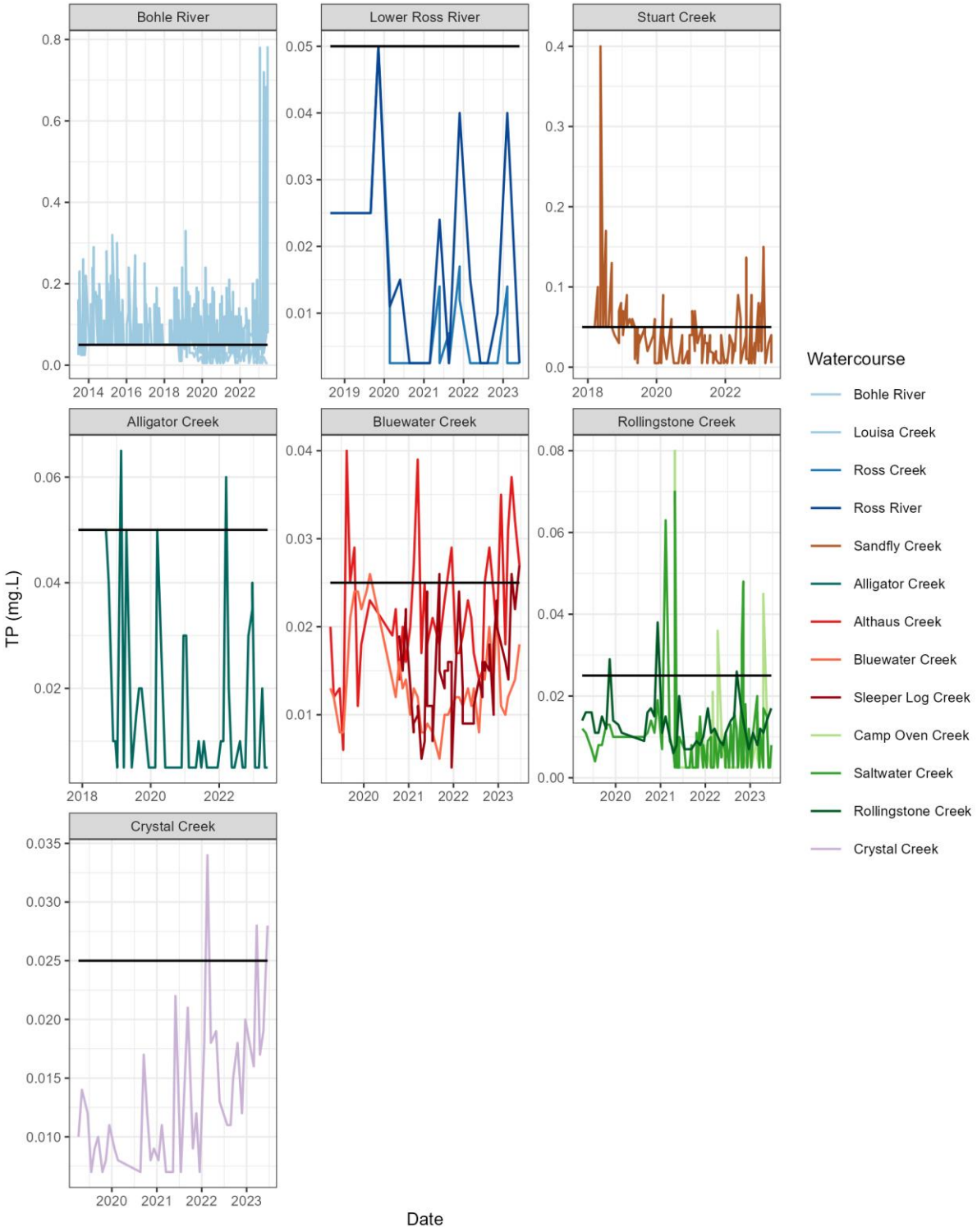

Figure 66. Historical concentrations of Total Phosphorus (TP) in the freshwater sub basins. Black line indicates the water quality objective.

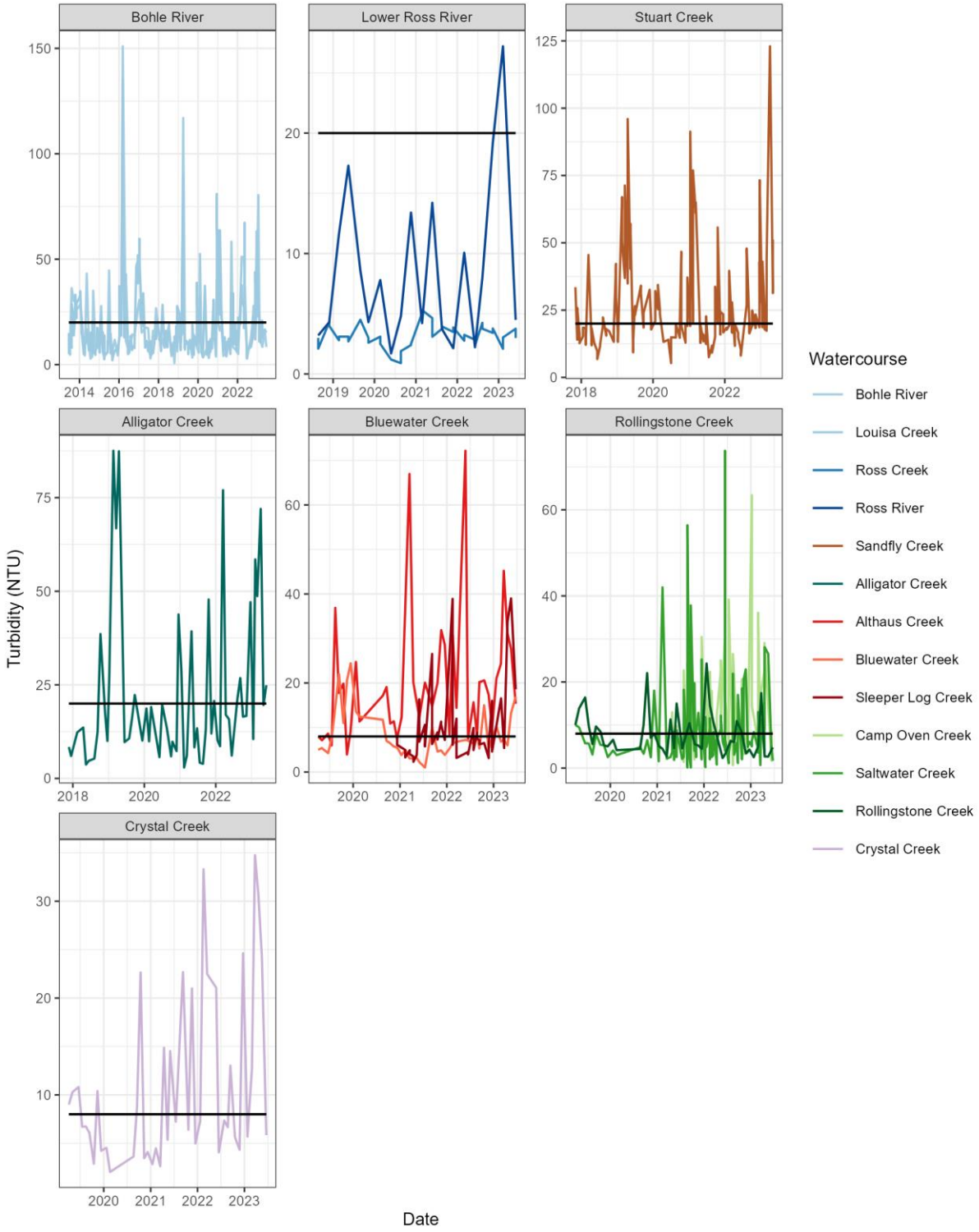

Figure 67. Historical concentrations of turbidity (NTU) in the freshwater sub basins. Black line indicates the water quality objective.

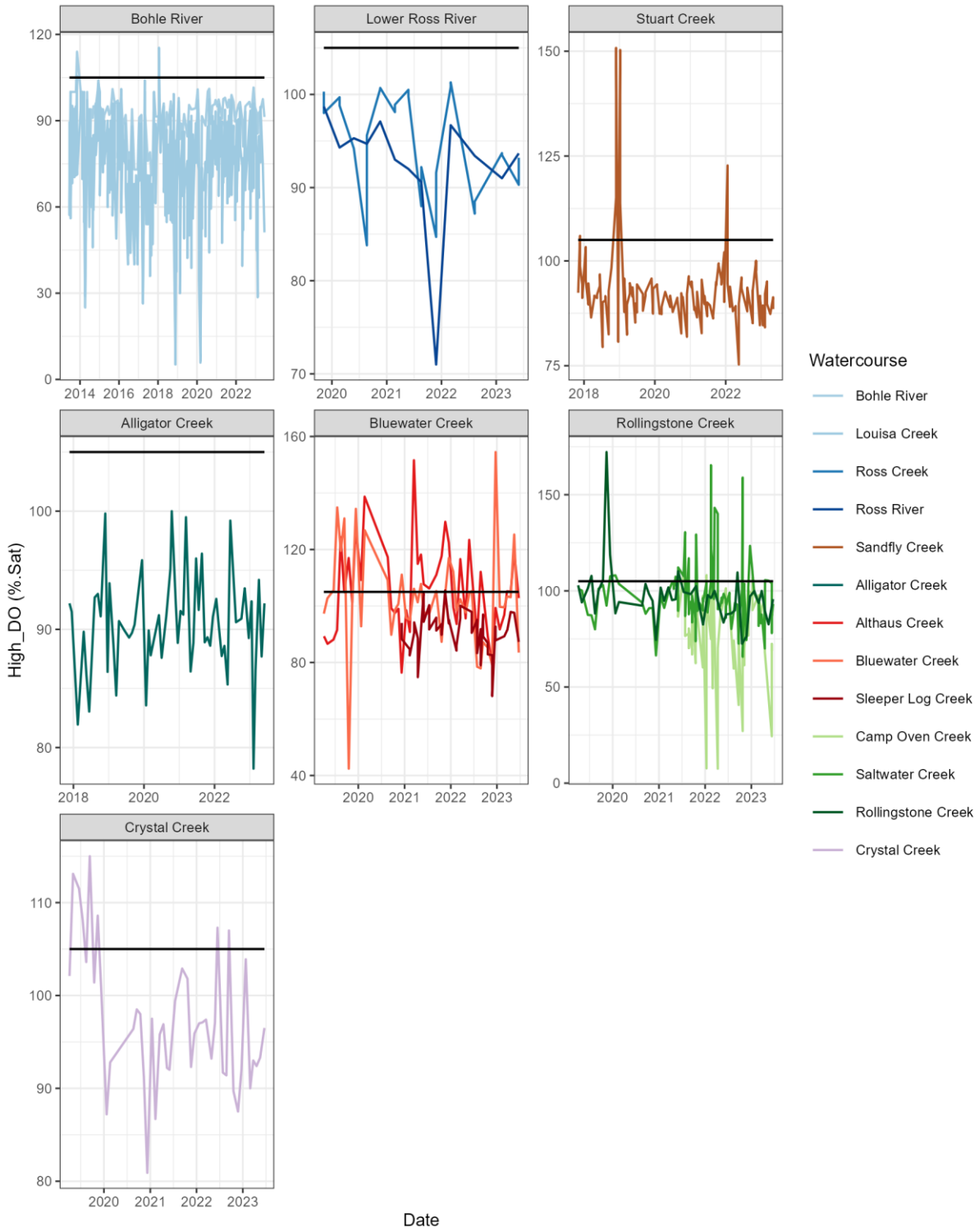

Figure 68. Historical dissolved oxygen in the freshwater sub basins. Black lines indicate the water quality objective (High DO).

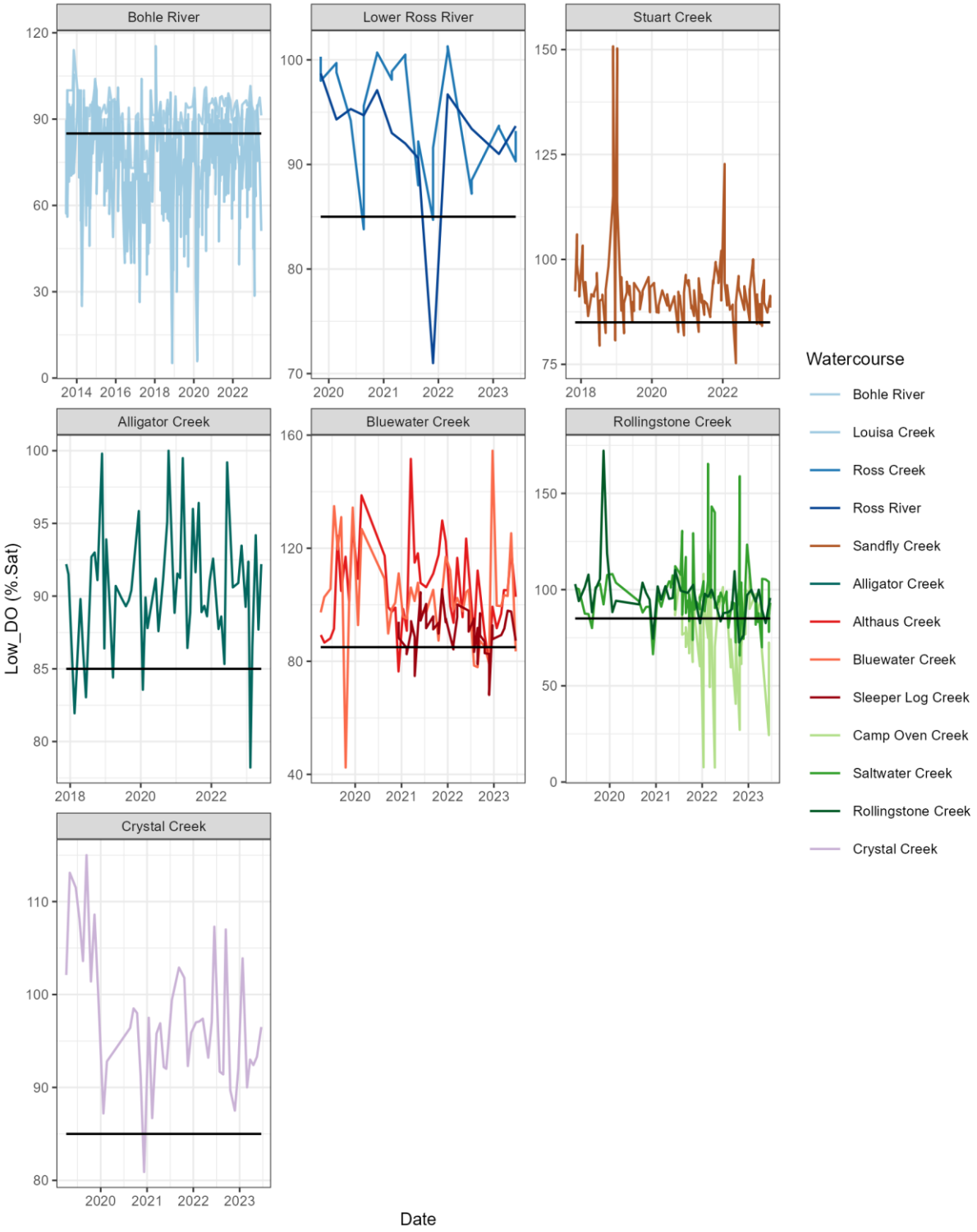

Figure 69. Historical dissolved oxygen in the freshwater sub basins. Black lines indicate the water quality objective (Low DO).

Appendix NN. Estuarine Mangrove and Saltmarsh Extent: Assessed Area in the Ross Basin of the Townsville Dry Tropics Region

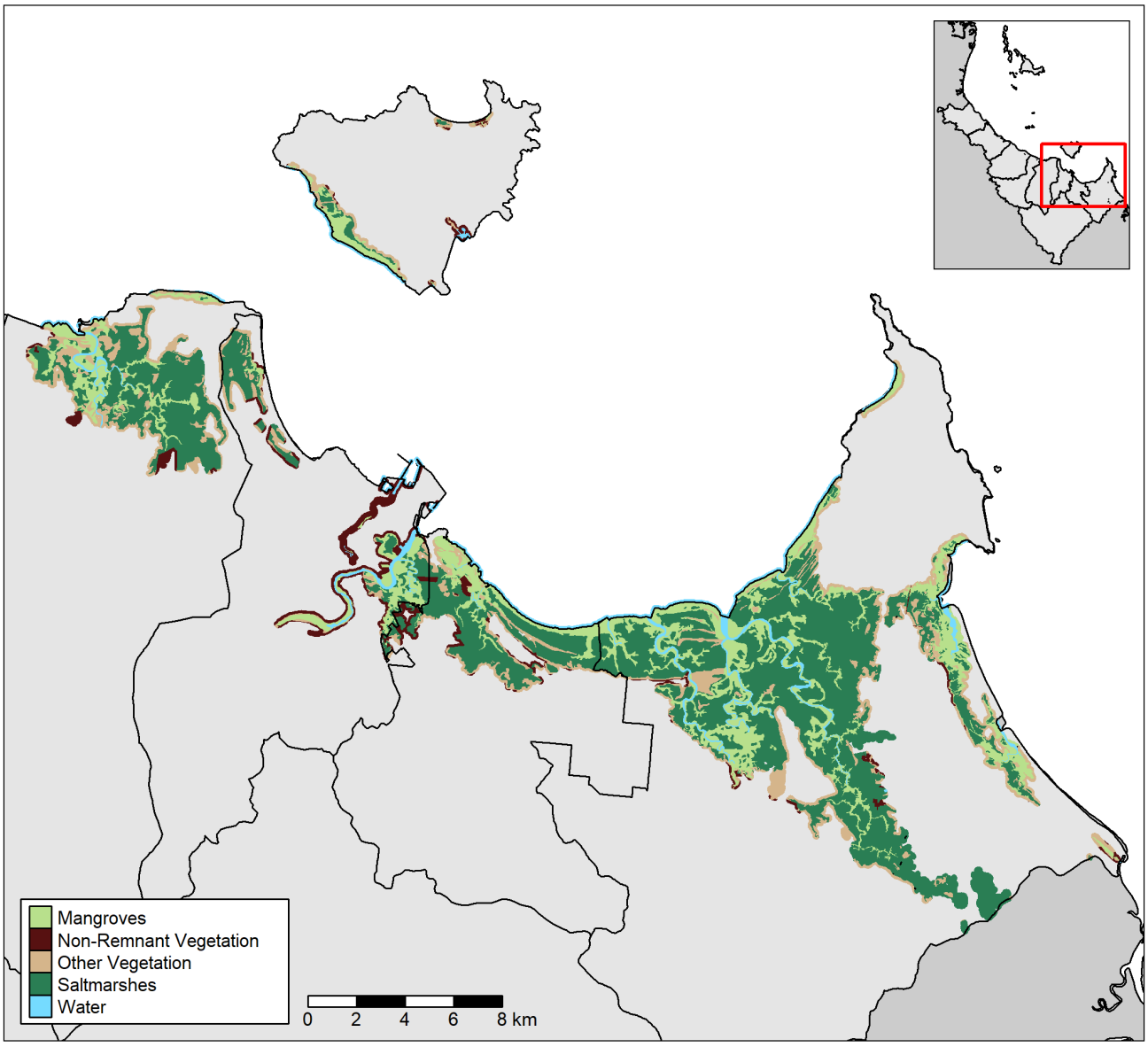

Figure 70. Total area in the Ross Basin of the Dry Tropics region that was assessed for changes in Mangrove and Saltmarsh extent.

Appendix OO. Estuarine Mangrove and Saltmarsh Extent: Assessed Area in the Black Basin of the Townsville Dry Tropics Region

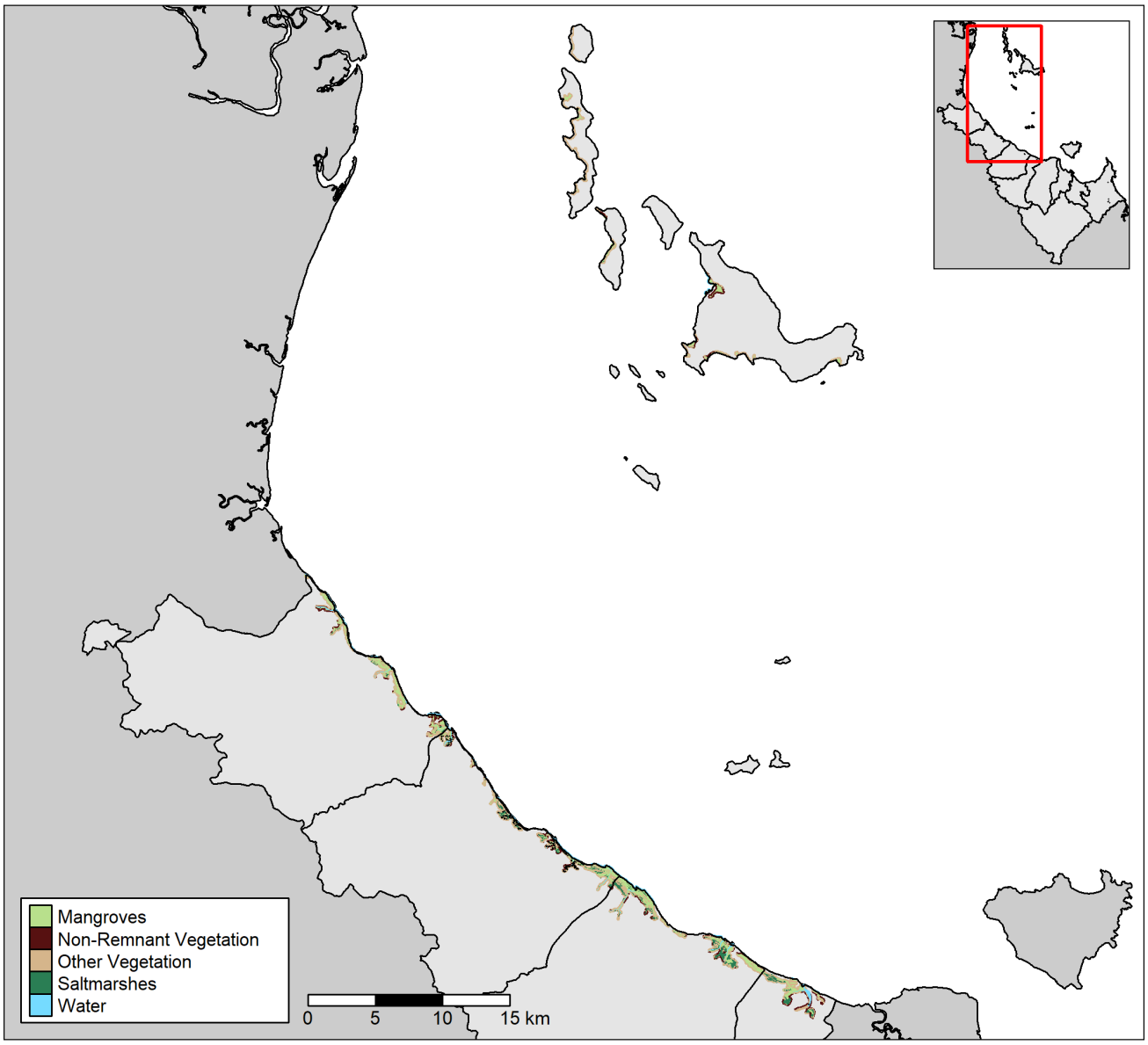

Figure 71. Total area in the Black Basin of the Dry Tropics region that was assessed for changes in Mangrove and Saltmarsh extent.

Appendix PP. Ross Estuarine Area Mangrove and Saltmarsh Vegetation Change Over Time

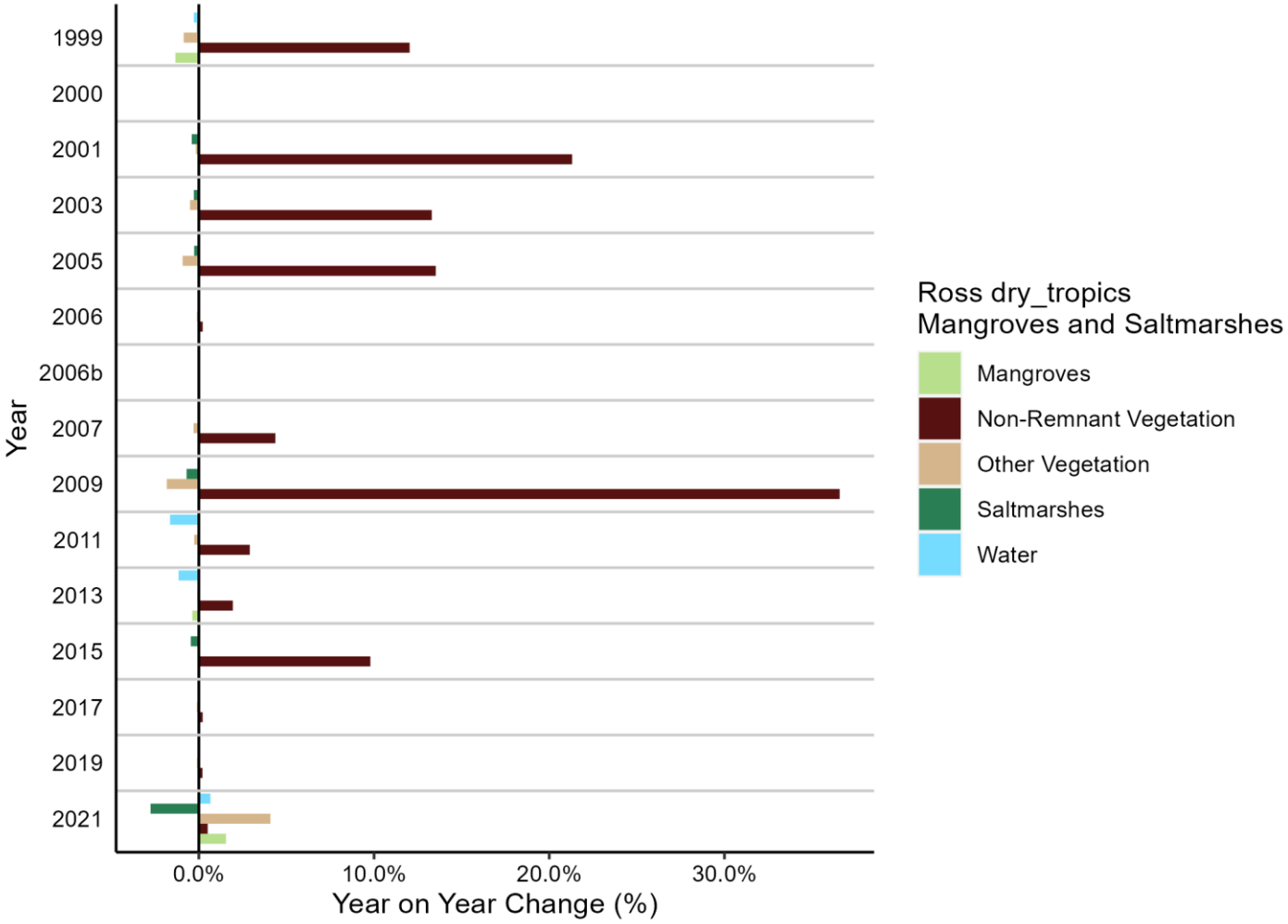

Figure 72. Ross Estuarine Area Mangrove and Saltmarsh Vegetation Change.

Appendix QQ. Black Estuarine Area Mangrove and Saltmarsh Vegetation Change Over Time

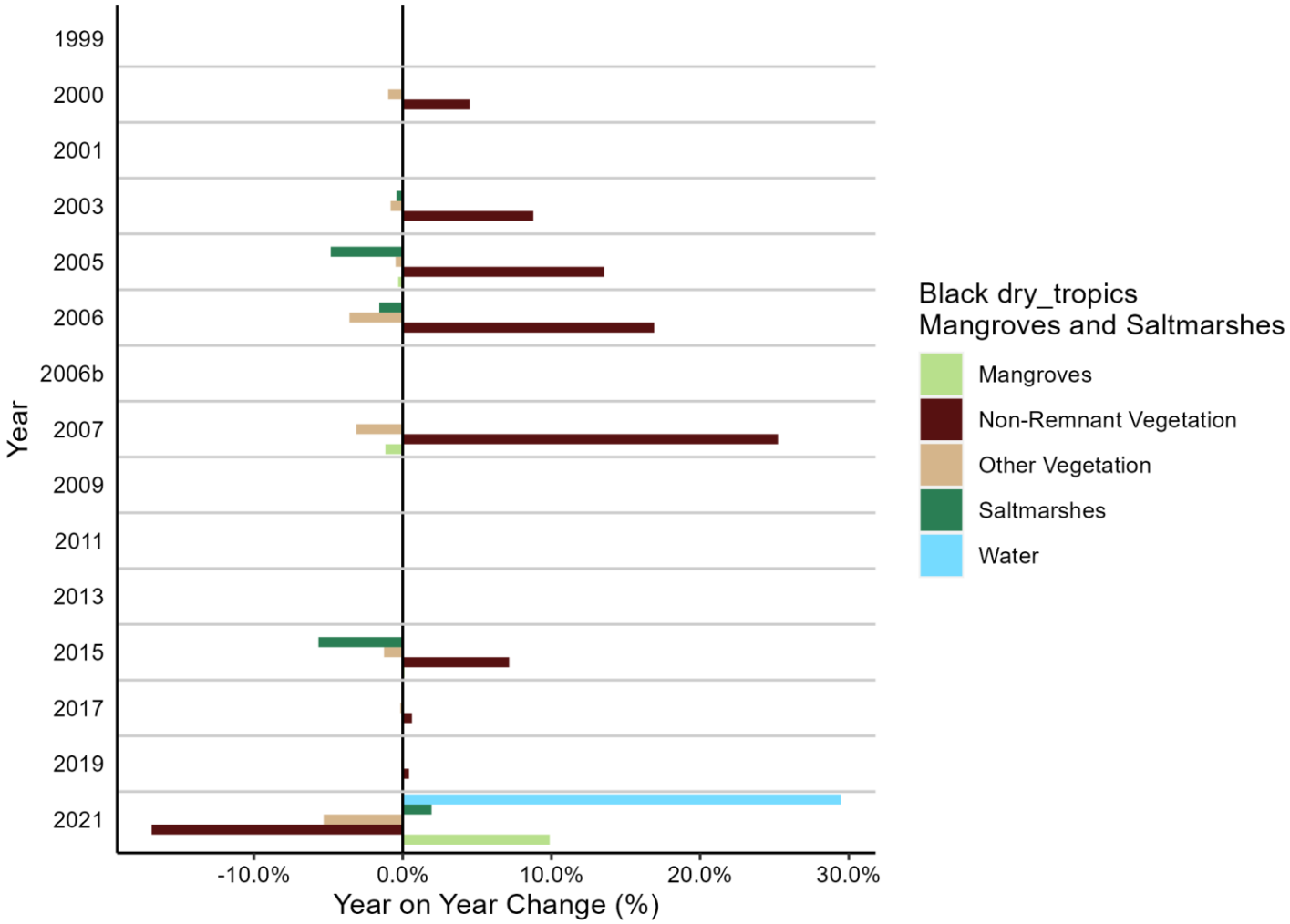

Figure 73. Black Estuarine Area Mangrove and Saltmarsh Vegetation Change.

Appendix RR. Estuarine Riparian Extent: Assessed Area in the Ross Basin of the Townsville Dry Tropics Region

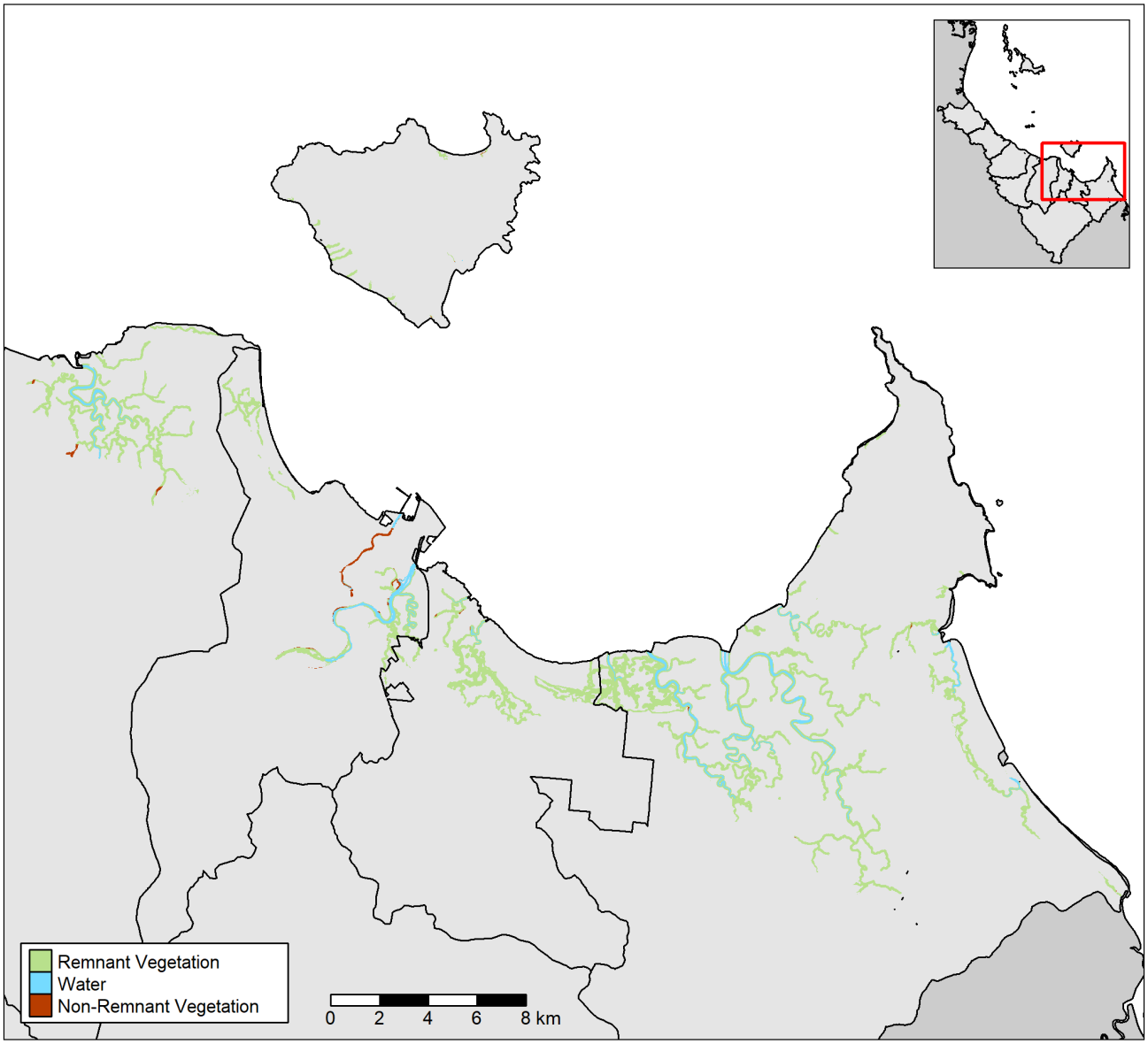

Figure 74. Ross Estuarine Riparian Vegetation Change.

Appendix SS. Estuarine Riparian Extent: Assessed Area in the Black Basin of the Townsville Dry Tropics Region

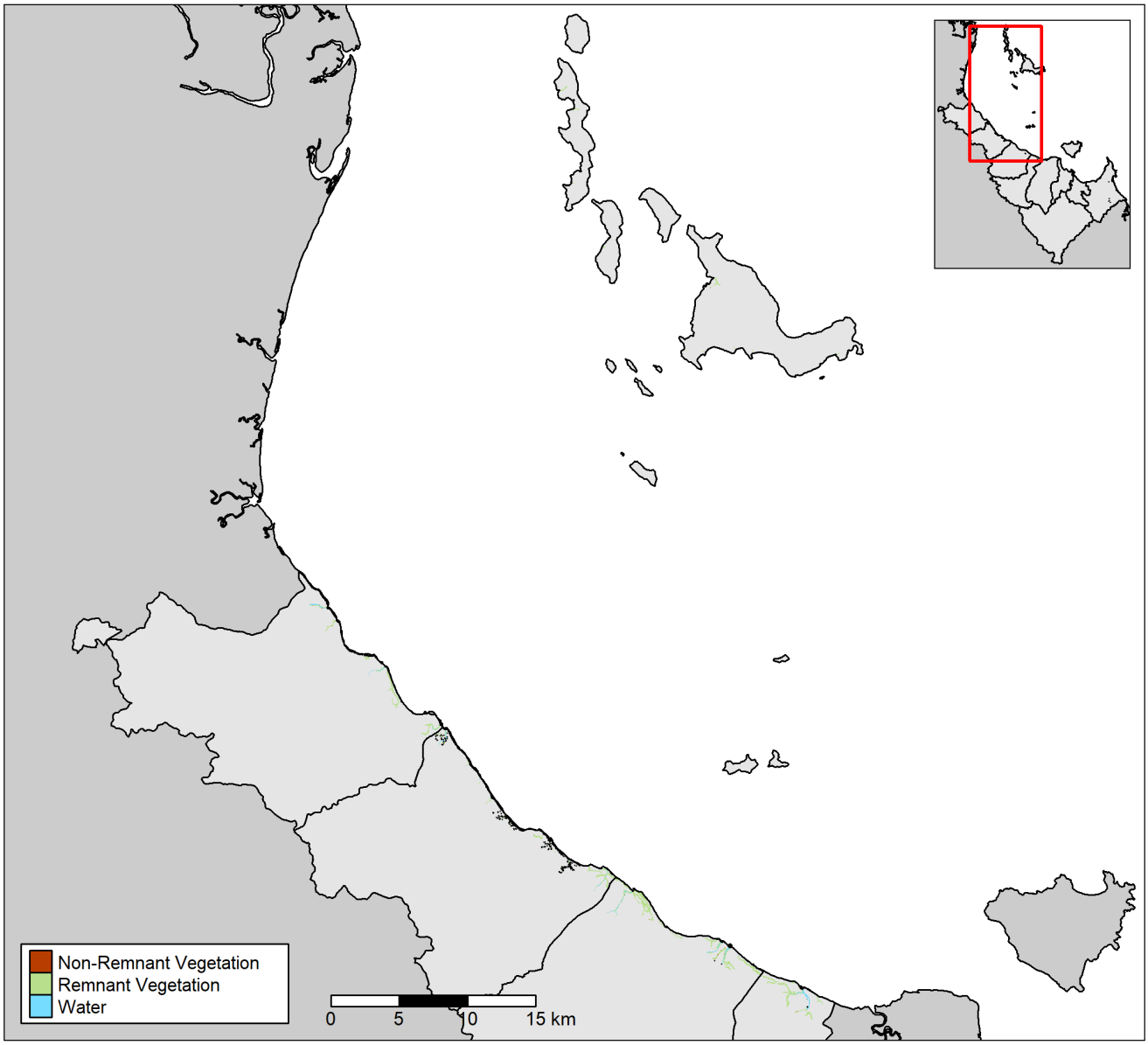

Figure 75. Black Estuarine Riparian Vegetation Change.

Appendix TT. Ross Estuarine Riparian Vegetation Change Over Time

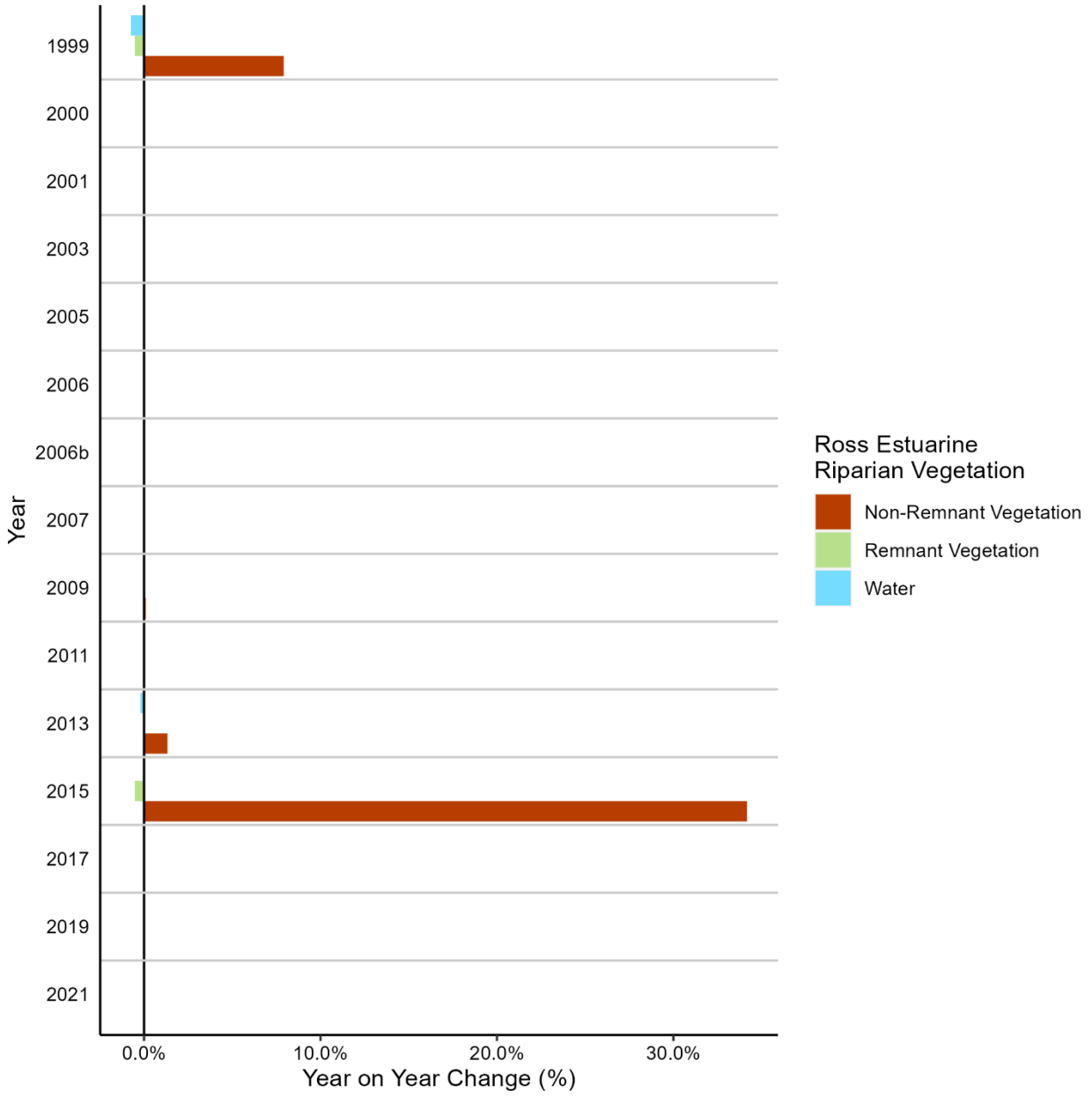

Figure 76. Ross Estuarine riparian vegetation change over time.

Appendix UU. Black Estuarine Riparian Vegetation Change Over Time

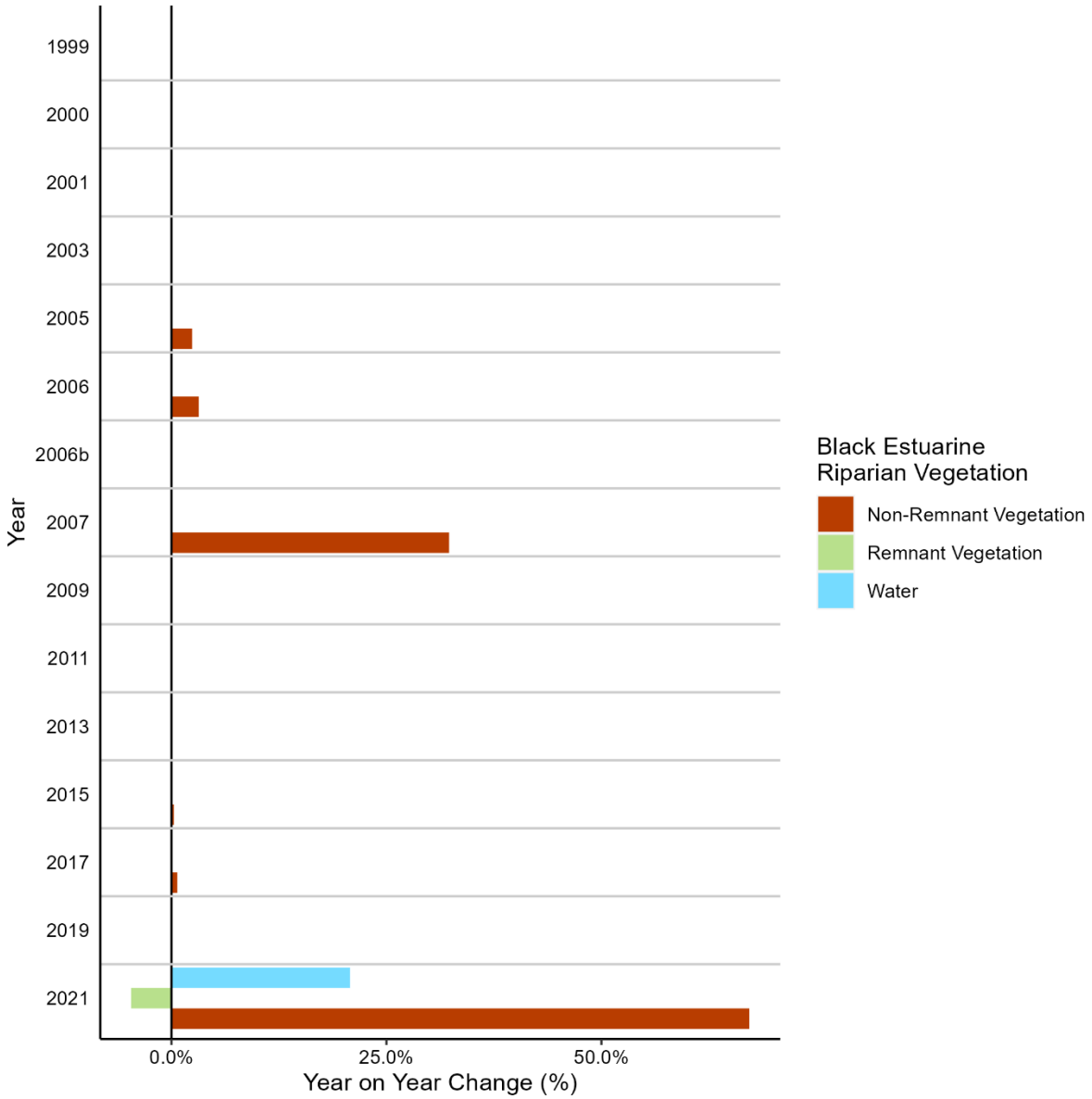

Figure 77. Black Estuarine riparian vegetation change over time.

Appendix VV. Inshore Marine Water Quality Nutrients: Sample Frequencies, Means, Medians, and WQOs

Table 93. Number of samples, days sampled, mean, median and water quality objective values for nutrient indicators in the Townsville Dry Tropics Inshore Marine Environment.

Area	NOx (mg/L)				PN (ug/L)				PP (mg/L)				TP (mg/L)			
	N. Samples	N. Months	Median	WQO	N. Samples	N. Months	Mean	WQO	N. Samples	N. Months	Mean	WQO	N. Samples	N. Months	Median	WQO
E.C.IPZ	12	4	0.0010	0.009	ND	ND	ND	ND	ND	ND	ND	ND	12	4	0.0025	0.03
E.C.OPZ	34	11	0.0015	0.009	ND	ND	ND	ND	ND	ND	ND	ND	26	11	0.0050	0.03
O.C.IPZ	4	4	0.0010	0.009	ND	ND	ND	ND	ND	ND	ND	ND	4	4	0.0025	0.03
O.C.OPZ	NA	NA	NA	0.002	ND	ND	ND	ND	ND	ND	ND	ND	8	4	0.0025	0.02
Mag. Is.	9	7	0.0016	0.001	9	7	0.0381	0.021	9	7	0.0035	0.0028	ND	ND	ND	ND
E.C.W	24	12	0.0001	0.003	ND	ND	ND	ND	ND	ND	ND	ND	24	12	0.0025	0.02
O.C.W	9	7	0.0007	0.002	9	7	0.0277	0.02	9	7	0.0027	0.0028	ND	ND	ND	ND
Mid	9	7	0.0009	0.002	9	7	0.0301	0.02	9	7	0.0023	0.0028	ND	ND	ND	ND

Key: = Mean/Median is lower than the guideline value | = Mean/Median is higher than the guideline value | ND = No Data | NA = Not Applicable (data available but not usable).

Appendix WW. Inshore Marine Water Quality Nutrient: Scores Historic Comparison

Table 94. Townsville Dry Tropics inshore marine environment historic nutrient indicator scores.

Zone	Sub Zone	Area	NOX				PN				PP				TP			
			22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20
Cleveland Bay	Enclosed Coastal	E.C.IPZ	100	100	100	100	ND	ND	ND	ND	ND	ND	ND	ND	100	100	100	100
		E.C.OPZ	100	100	94	94	ND	ND	ND	ND	ND	ND	ND	ND	100	100	16	16
			100	100	97	97	ND	ND	ND	ND	ND	ND	ND	ND	100	100	58	58
	Open Coastal	O.C.IPZ	100	100	100	100	ND	ND	ND	ND	ND	ND	ND	ND	100	100	100	100
		O.C.OPZ	NA	100	100	NA	ND	ND	ND	ND	ND	ND	ND	ND	100	100	100	100
			100	100	100	100	ND	ND	ND	ND	ND	ND	ND	ND	100	100	100	100
	Magnetic Island	Mag. Is.	19	23	0	4	8	3	23	13	40	36	55	29	ND	ND	ND	ND
			79	80	73	74	8	3	23	13	40	36	55	29	100	100	79	79
Halifax Bay	Enclosed Coastal	E.C.W	100	100	100	ND	ND	ND	ND	ND	ND	ND	ND	ND	100	100	100	ND
	Open Coastal	O.C.W	100	97	75	36	32	18	33	0	63	76	38	66	ND	ND	ND	ND
	Midshelf	Midshelf	100	55	94	19	25	32	27	0	71	82	73	64	ND	ND	ND	ND
			100	84	90	28	29	25	30	0	67	79	55	65	100	100	100	ND

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

Appendix XX. Inshore Marine Water Quality Phys-Chem and Chlorophyll *a*: Sample Frequencies, Means, Medians, and WQOs

Table 95. Number of samples, mean, median, and water quality objective values for physical-chemical properties and Chlorophyll a indicators in the Townsville Dry Tropics Inshore Marine Environment.

Area	Turbidity (NTU)				TSS (mg/L)				Secchi (m)[10]				Chlorophyll *a*			
	N. Samples	N. Months	Median	WQO	N. Samples	N. Months	Mean	WQO	N. Samples	N. Months	Mean	WQO	N. Samples	N. Months	Mean	WQO
E.C.IPZ	12	4	7.100	4.9	12	4	14.167	22	12	4	0.989	1	ND	ND	ND	ND
E.C.OPZ	24	11	13.950	4.9	25	11	29.840	15	3	3	1.053	1	21	11	1.531	2.6
O.C.IPZ	4	4	4.450	4.9	4	4	26.500	22	4	4	1.219	1	ND	ND	ND	ND
O.C.OPZ	312	12	4.257	3	8	4	19.187	10	7	4	1.109	3	ND	ND	ND	ND
Mag. Is.	387	10	1.640	2.7	9	7	1.471	3.7	9	7	4.600	3	295	11	0.559	0.84
E.C.W	20	10	3.702	6	24	12	9.146	15	ND	ND	ND	ND	24	12	0.646	2
O.C.W	352	12	1.019	1.5	9	7	1.271	2	9	7	5.722	10	361	12	0.450	0.45
Mid	305	12	0.567	1.5	9	7	0.777	2	9	7	7.956	10	314	12	0.551	0.45

Key: ■ = Mean/Median is lower than the guideline value | ■ = Mean/Median is higher than the guideline value | ND = No Data | NA = Not Applicable (data available but not usable).

[10] The secchi depth indicator operates inversely to all other indicators. I.e., a "good" value is one that is above the guideline value, as this shows greater water clarity.

Appendix YY. Inshore Marine Water Quality Physical-Chemical Properties and Chlorophyll *a* Historic Comparison

Table 96. Townsville Dry Tropics inshore marine environment historic physical-chemical and Chlorophyll a indicator scores.

Zone	Sub Zone	Area	Turbidity				TSS				Secchi				Chlorophyll *a*			
			22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20
Cleveland Bay	Enclosed Coastal	E.C.IPZ	28	100	89	74	85	100	85	100	60	92	93	78	ND	ND	ND	ND
		E.C.OPZ	0	0	0	0	0	3	20	14	63	83	100	78	90	81	63	100
			14	50	44	37	43	51	52	57	62	87	96	78	90	81	63	100
	Open Coastal	O.C.IPZ	66	100	100	100	44	100	98	100	72	100	100	100	ND	ND	ND	ND
		O.C.OPZ	30	38	15	63	3	54	76	81	0	39	56	47	ND	ND	ND	ND
			48	69	57	81	24	77	87	90	36	69	78	73	ND	ND	ND	ND
	Magnetic Island	Mag. Is.	89	77	73	78	100	85	85	100	85	80	83	77	84	83	83	80
			42	65	58	63	46	71	73	79	56	78	86	76	87	82	73	90
Halifax Bay	Enclosed Coastal	E.C.W	88	58	100	ND	88	74	84	ND	ND	ND	ND	ND	100	100	100	ND
	Open Coastal	O.C.W	82	77	73	89	86	72	63	92	11	6	29	6	61	74	69	66
	Midshelf	Midshelf	100	100	93	100	100	77	92	100	41	30	21	1	43	53	60	69
			90	78	88	94	91	74	80	96	26	18	25	3	68	76	76	68

Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 – 100 | ND = No Data | NA = Not Applicable (data available but not usable) | X = Data was not updated this year.

Appendix ZZ. Inshore Marine Water Quality Sub Basin Historic Scores

Table 97. A comparison of nutrient and physical chemical properties indicator category scores, and the water quality index scores, for inshore sub zones between years.

Sub Zone	Nutrients				Phys-Chem				Chla				Water Quality			
	22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20	22-23	21-22	20-21	19-20
CB.Enclosed Coastal	100	100	77	77	39	63	64	57	90	81	64	100	76	81	68	78
CB.Open Coastal	100	100	100	100	36	72	74	82	ND	ND	ND	ND	68	86	87	91
Magnetic Island	22	20	26	16	91	79	80	85	84	83	83	80	66	61	63	60
HB.Enclosed Coastal	100	100	100	34	88	65	92	62	100	100	100	67	96	88	97	54
HB.Open Coastal	65	64	49	28	60	49	55	67	61	75	69	69	62	62	58	54
Midshelf	65	56	65	77	80	61	68	57	43	53	61	100	63	57	64	78

Appendix AAA. Inshore Marine Water Quality 2021–2022 Boxplots

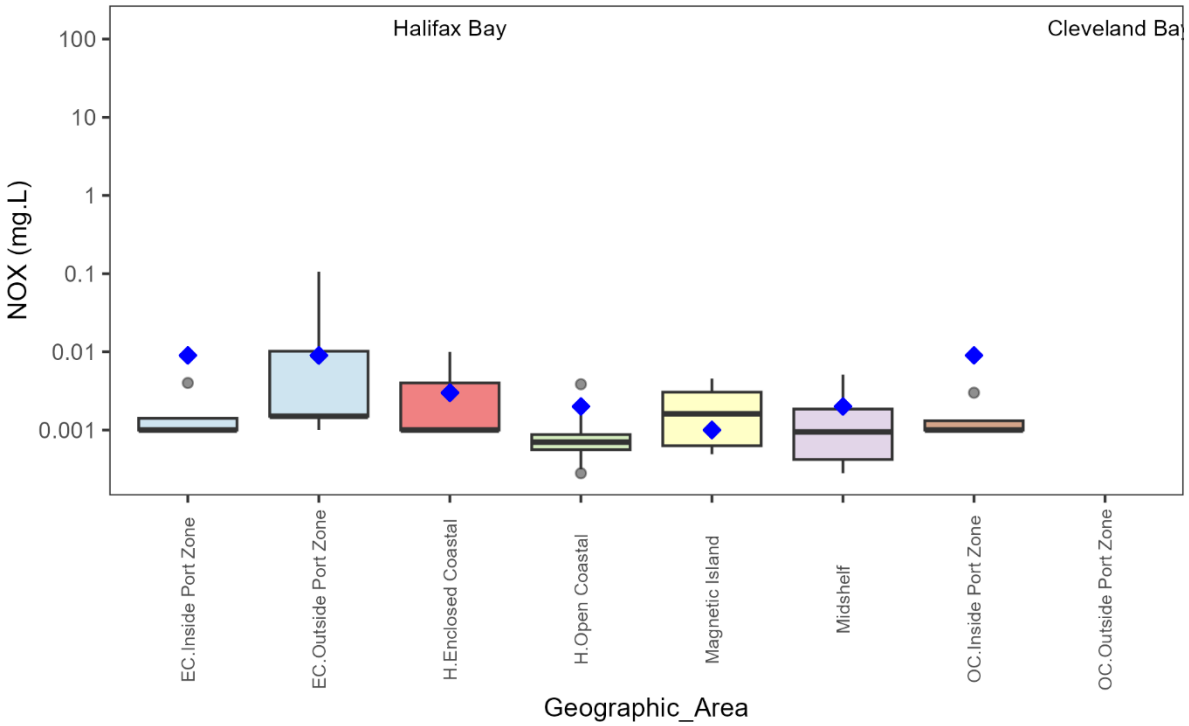

Figure 79. Nitrogen Oxides (NOX) (mg/L) Boxplot: blue diamonds indicate the water quality objective.

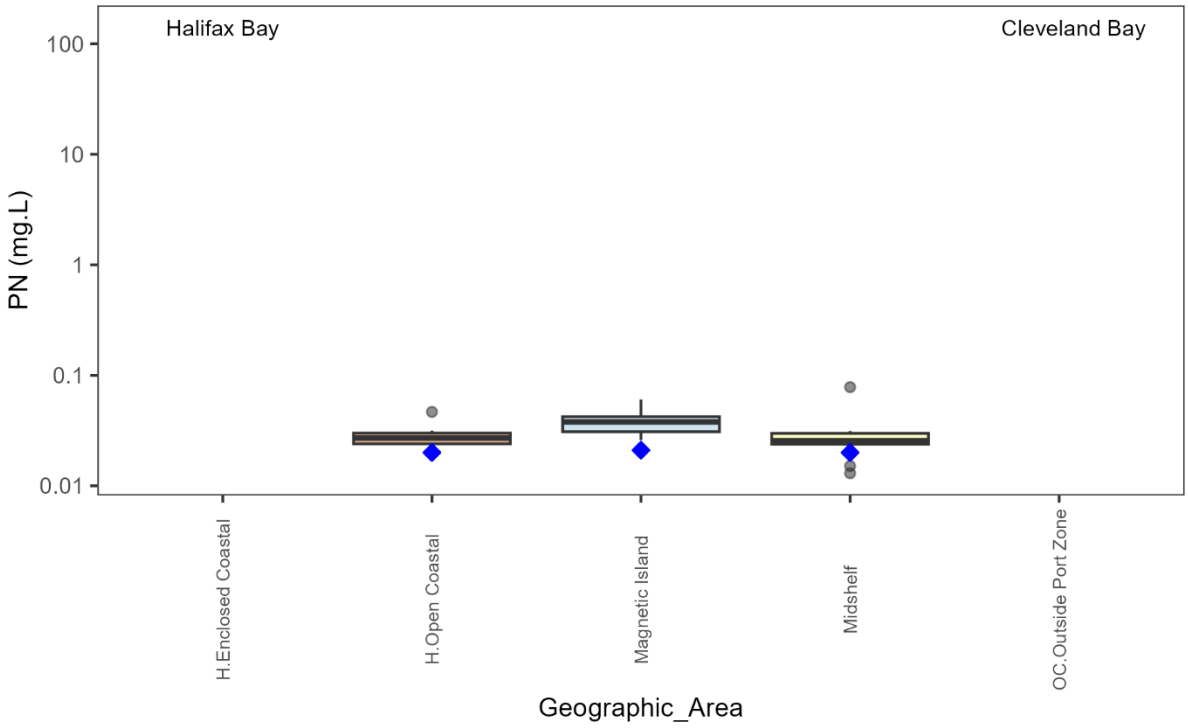

Figure 78. Particulate Nitrogen (PN) (mg/L) Boxplot: blue diamonds indicate the water quality objective.

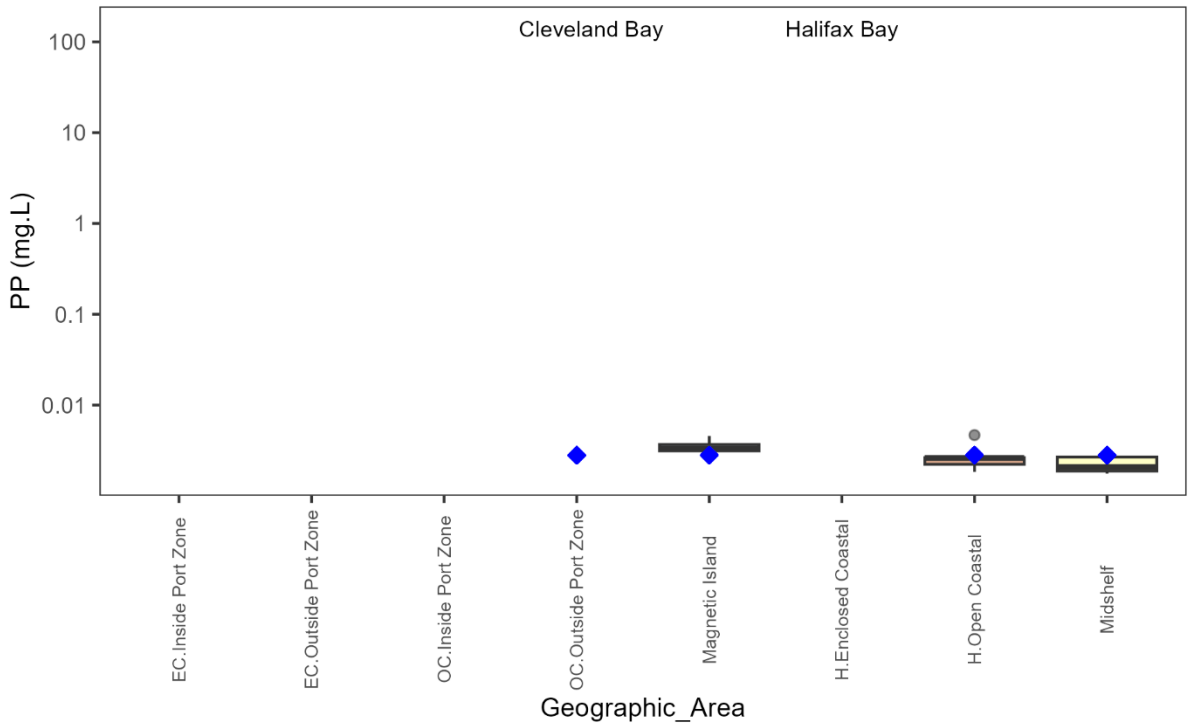

Figure 80. Particulate Phosphorus (PP) (mg/L) Boxplot: blue diamonds indicate the water quality objective.

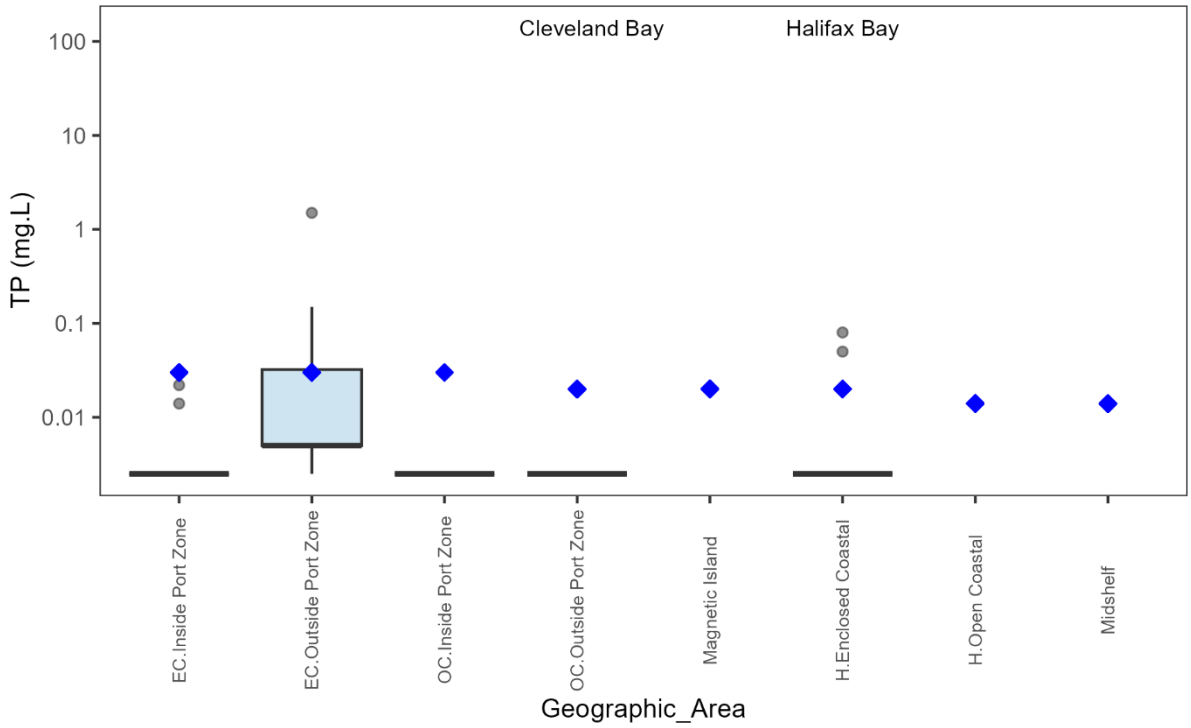

Figure 81. Total Phosphorus (TP) (mg/L) Boxplot: blue diamonds indicate the water quality objective.

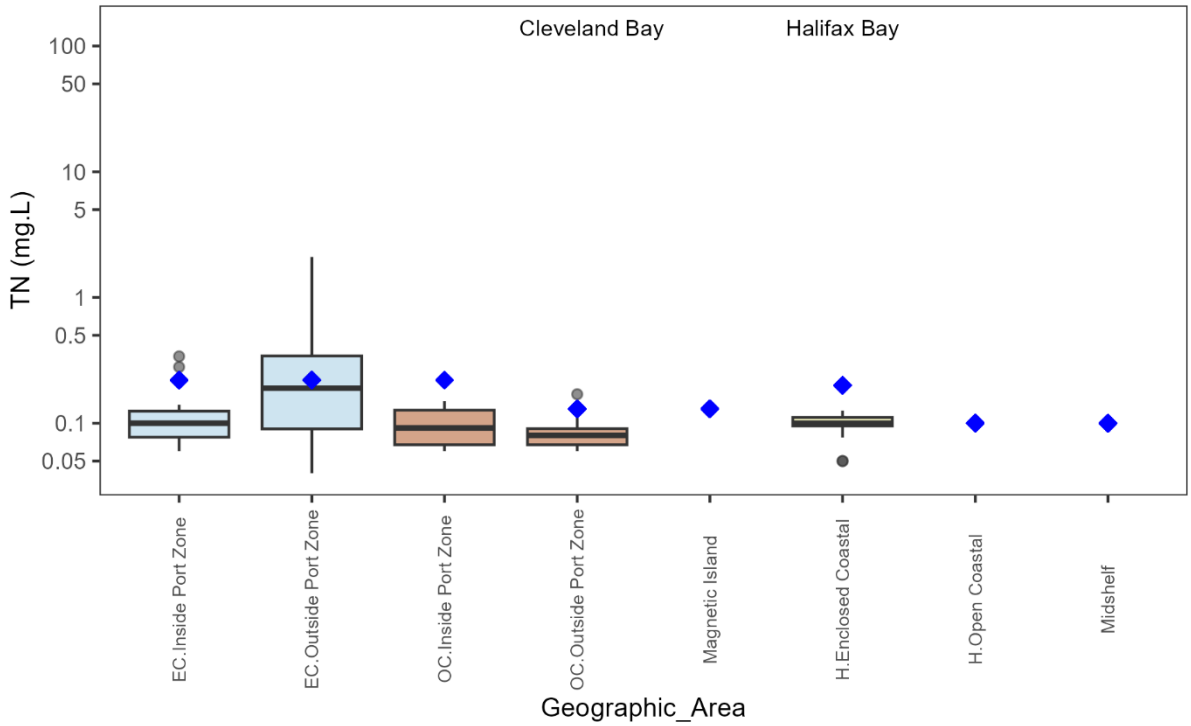

Figure 83. Total Nitrogen (TN) (mg/L) Boxplot: blue diamonds indicate the water quality objective.

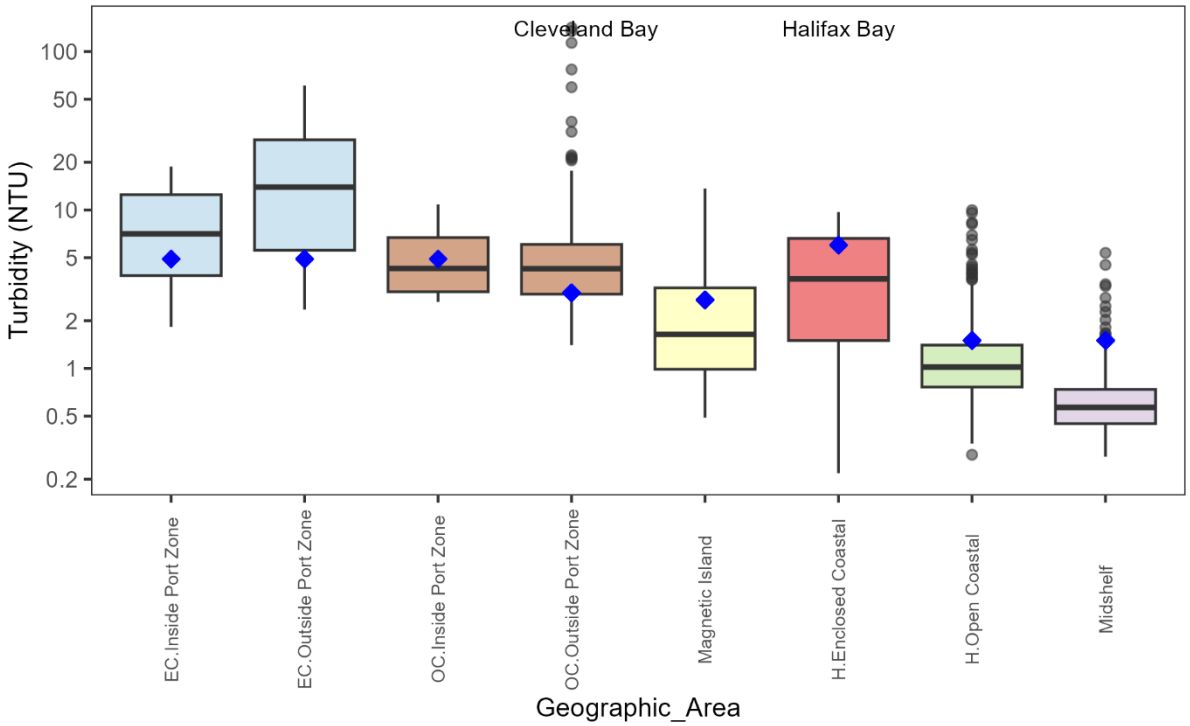

Figure 82. Turbidity (NTU) Boxplot: blue diamonds indicate the water quality objective.

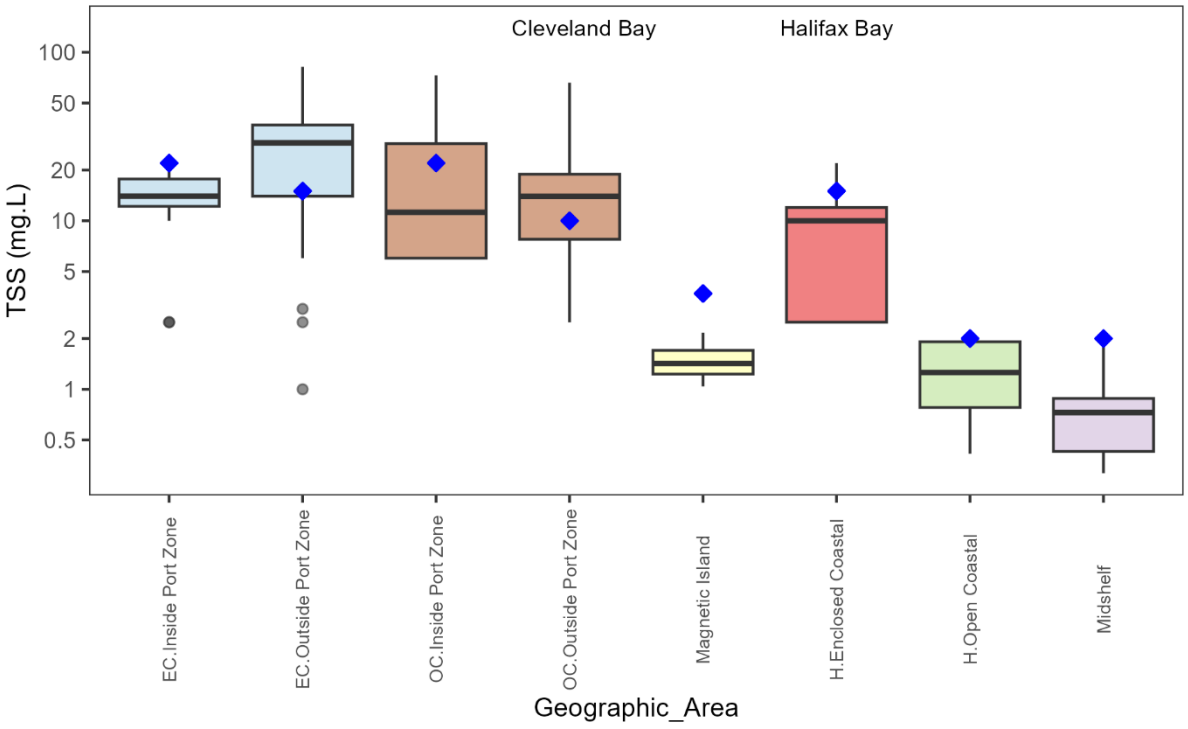

Figure 85. Total Suspended Solids (TSS) (mg/L) Boxplot: blue diamonds indicate the water quality objective.

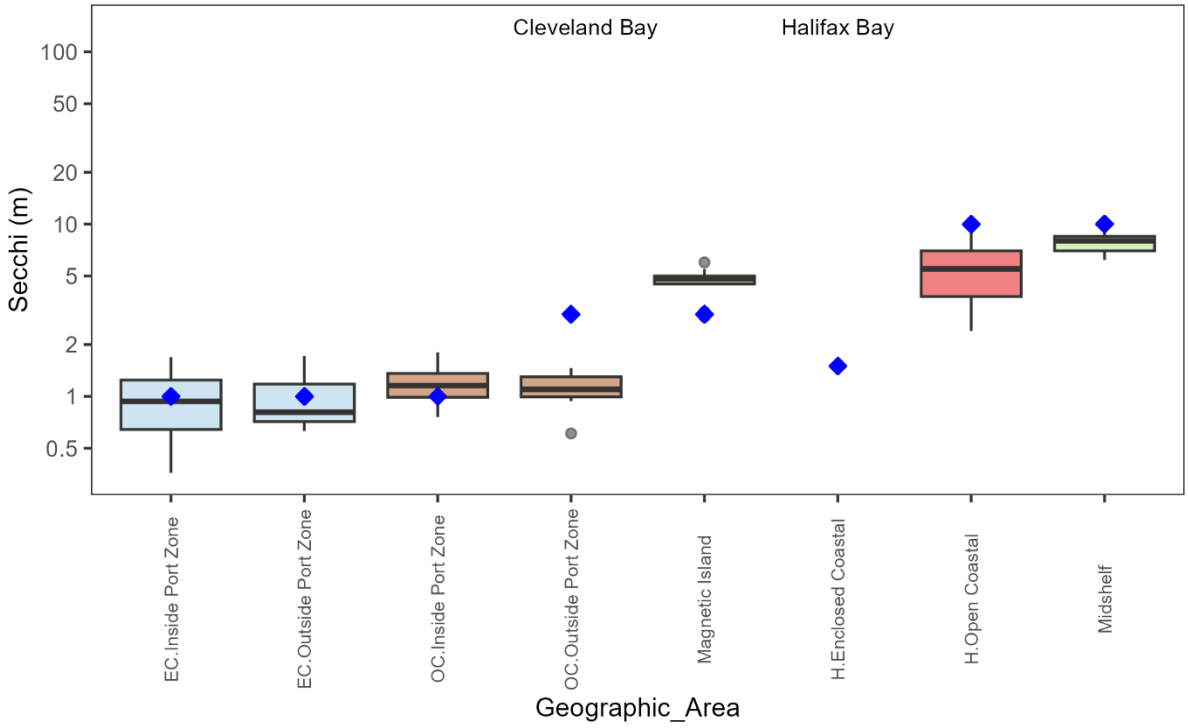

Figure 84. Secchi Depth (m) Boxplot: blue diamonds indicate the water quality objective.

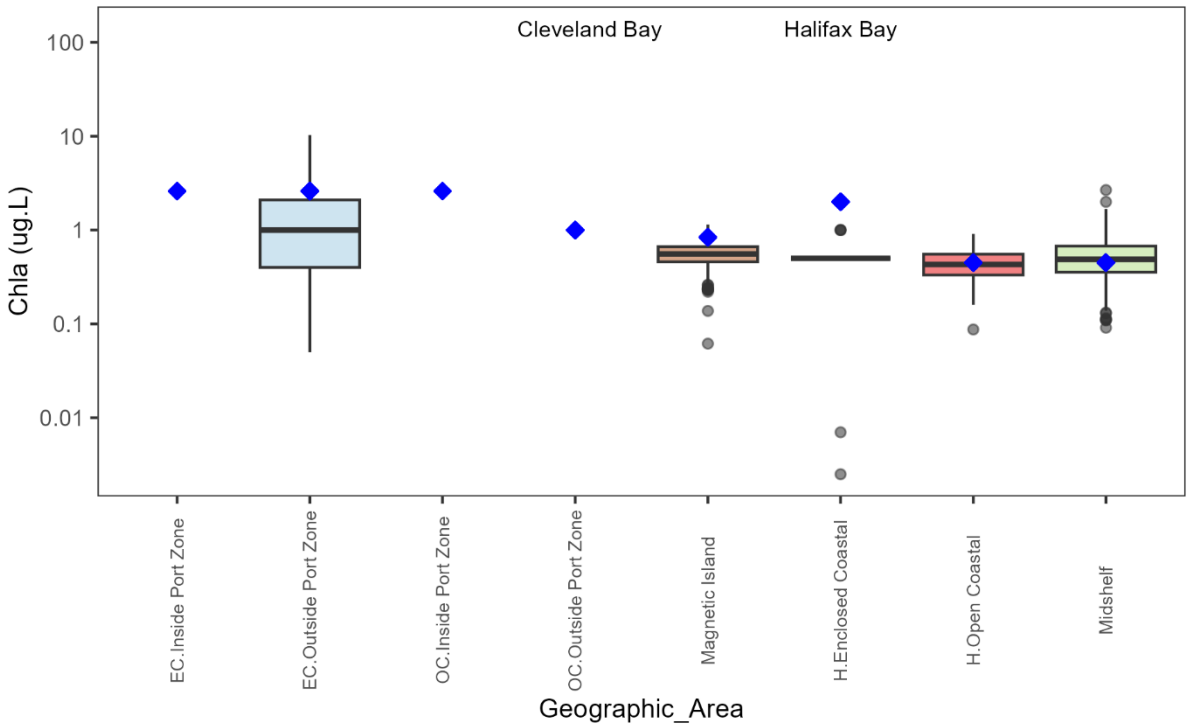

Figure 86. Chlorophyll a) Boxplot: blue diamonds indicate the water quality objective.

Appendix BBB. Inshore Marine Water Quality Line Plots

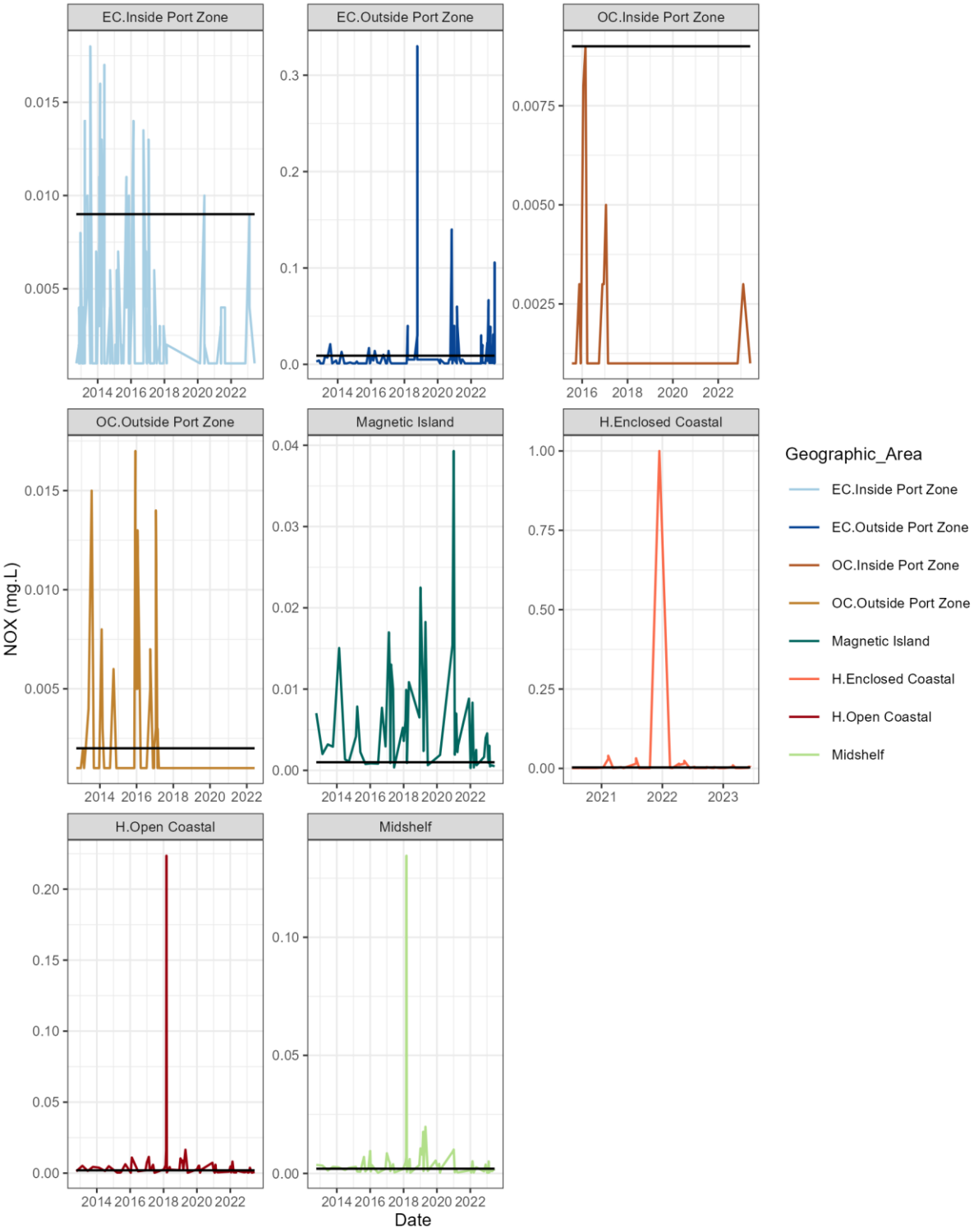

Figure 87. Dry Tropics inshore marine water quality line plots: NOx. The black line indicates water quality guidelines.

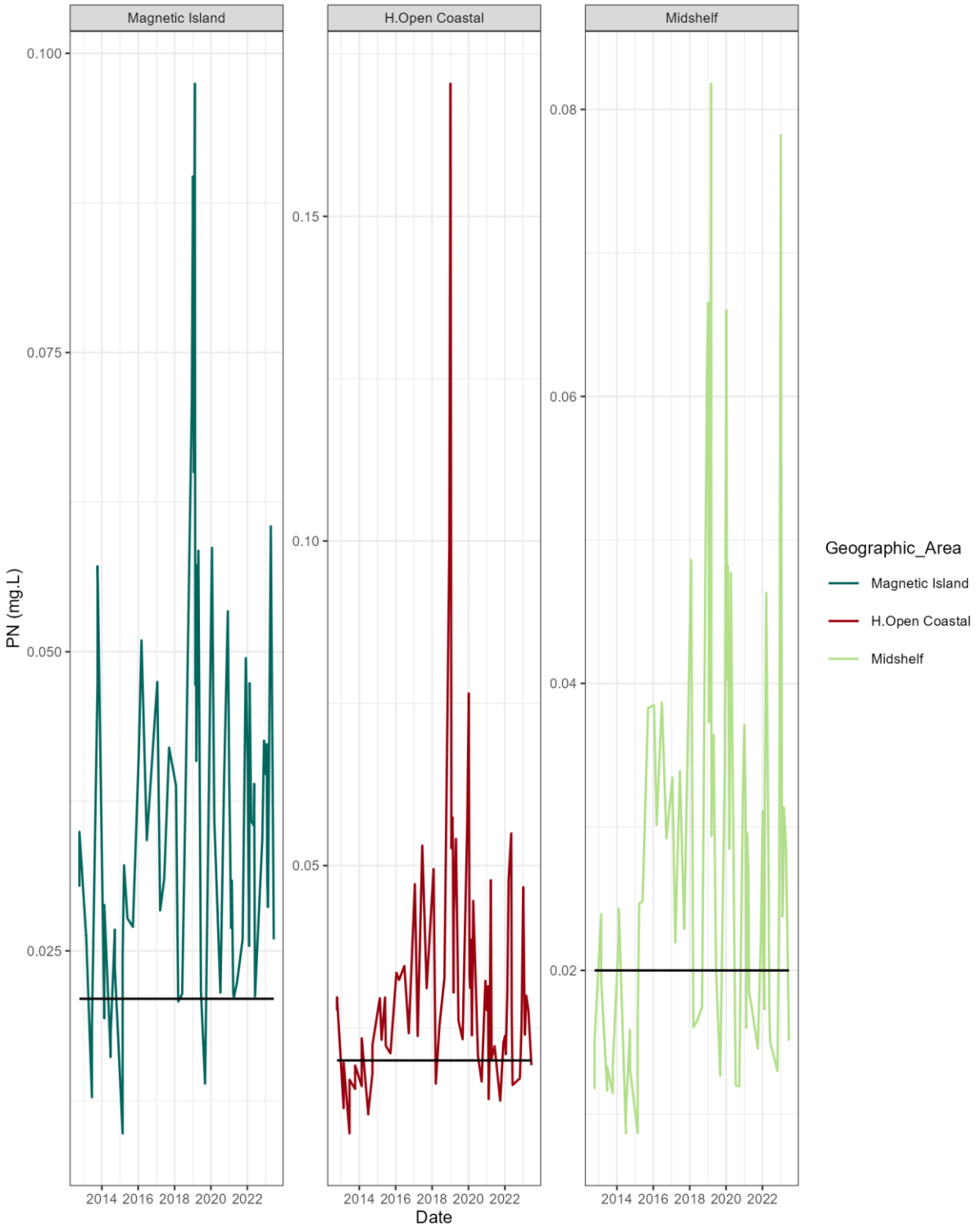

Figure 88. Dry Tropics inshore marine water quality line plots: PN. The black line indicates water quality guidelines.

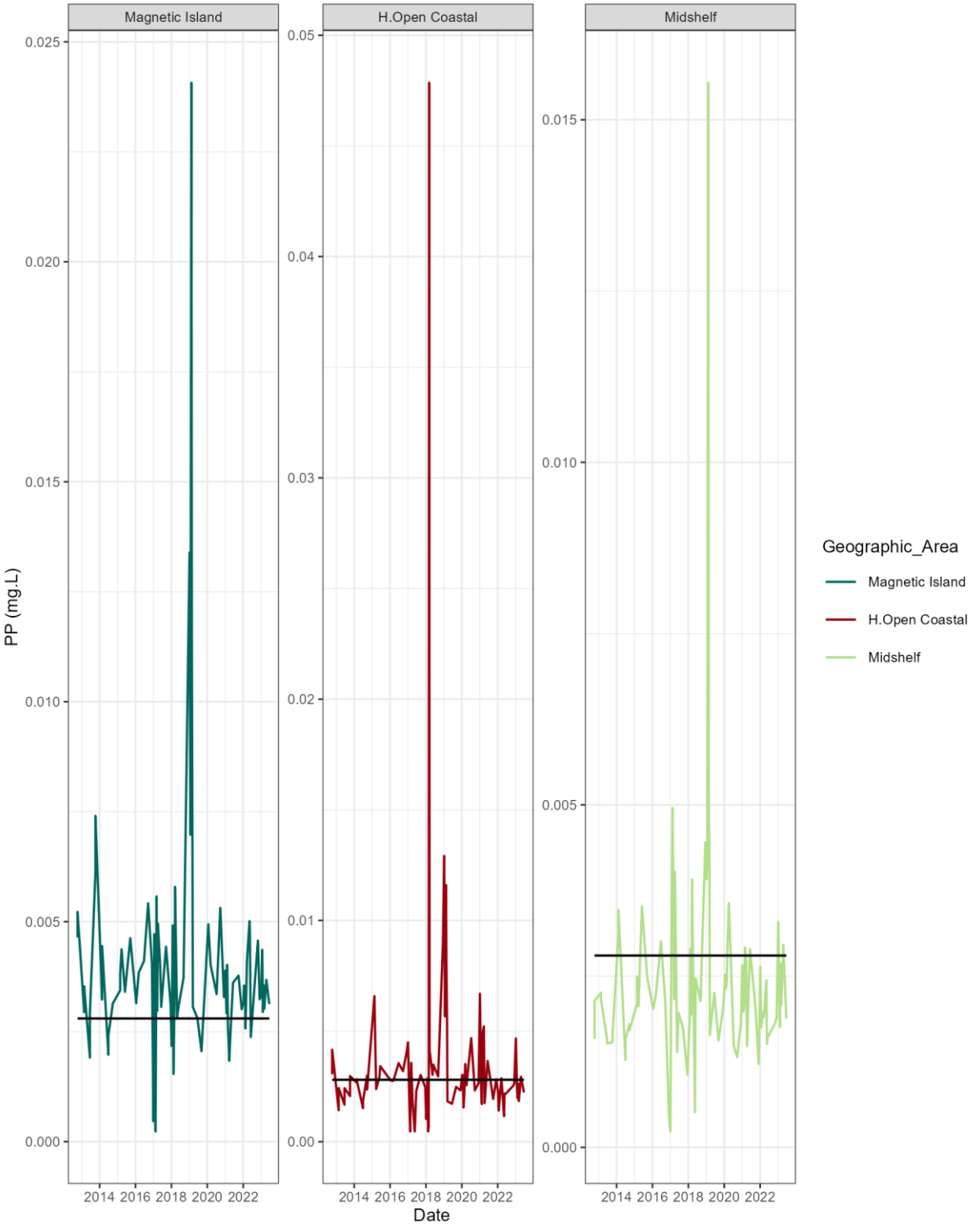

Figure 89. Dry Tropics inshore marine water quality line plots: PP. The black line indicates water quality guidelines.

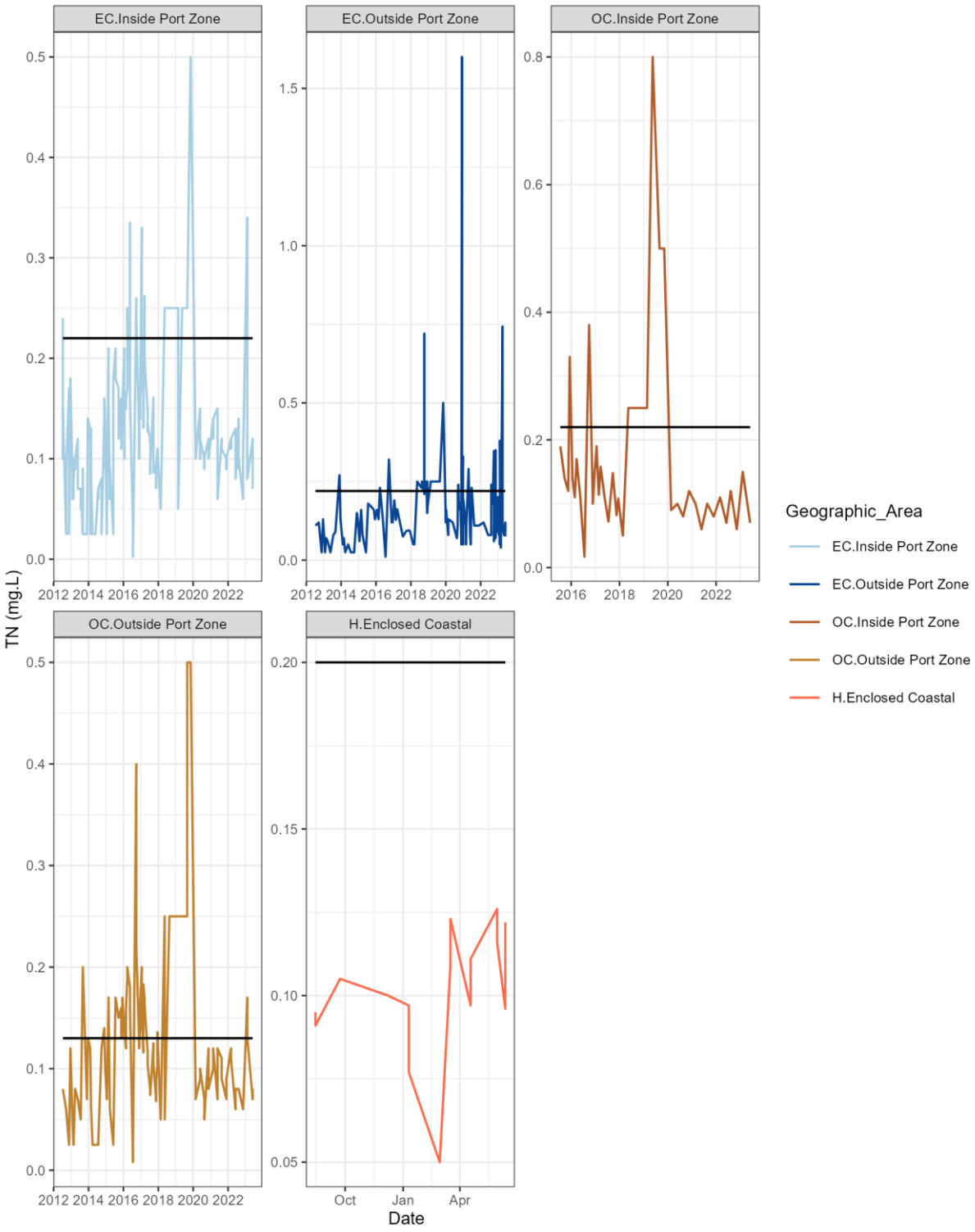

Figure 90. Dry Tropics inshore marine water quality line plots: TN. The black line indicates water quality guidelines.

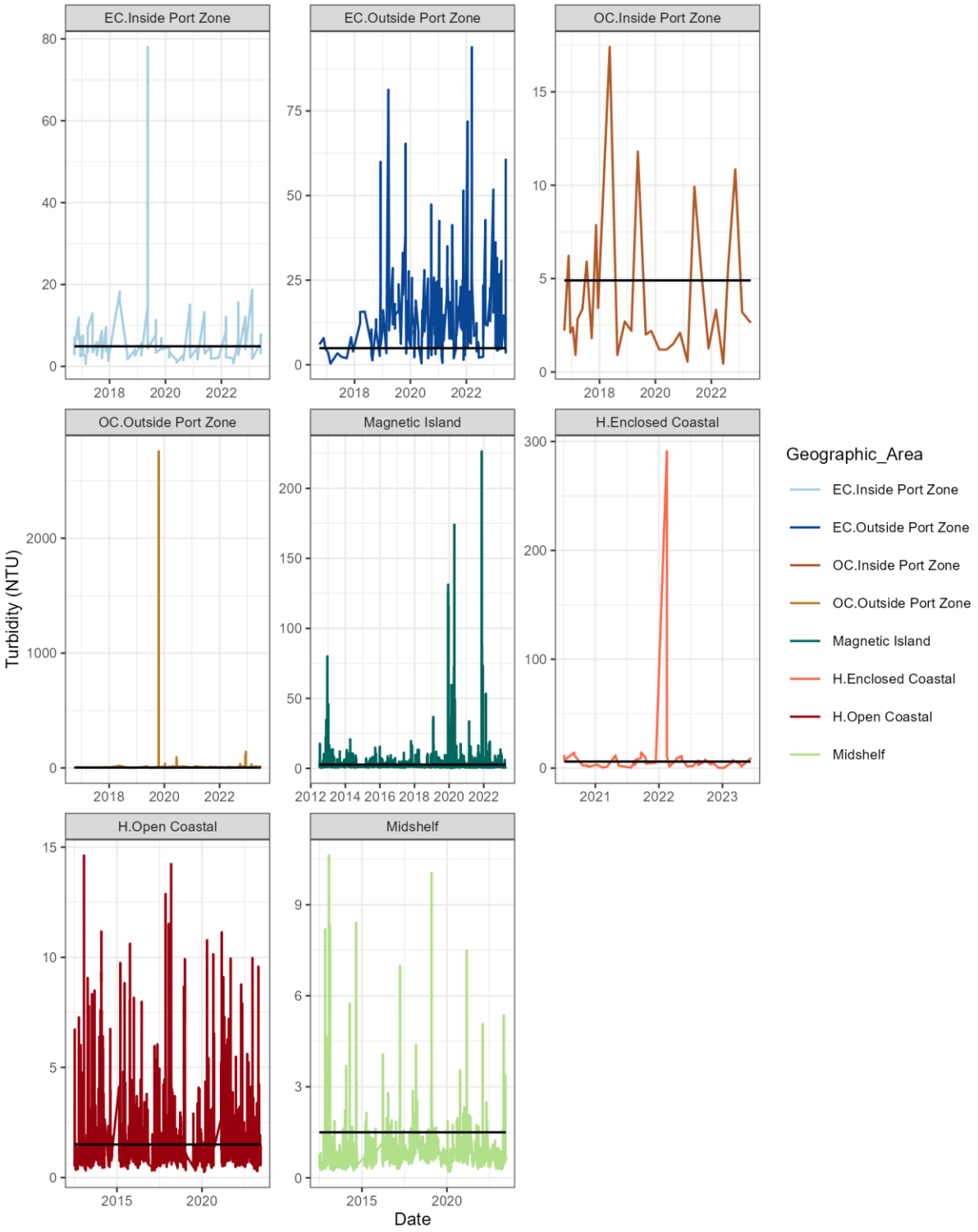

Figure 91. Dry Tropics inshore marine water quality line plots: NTU. The black line indicates water quality guidelines.

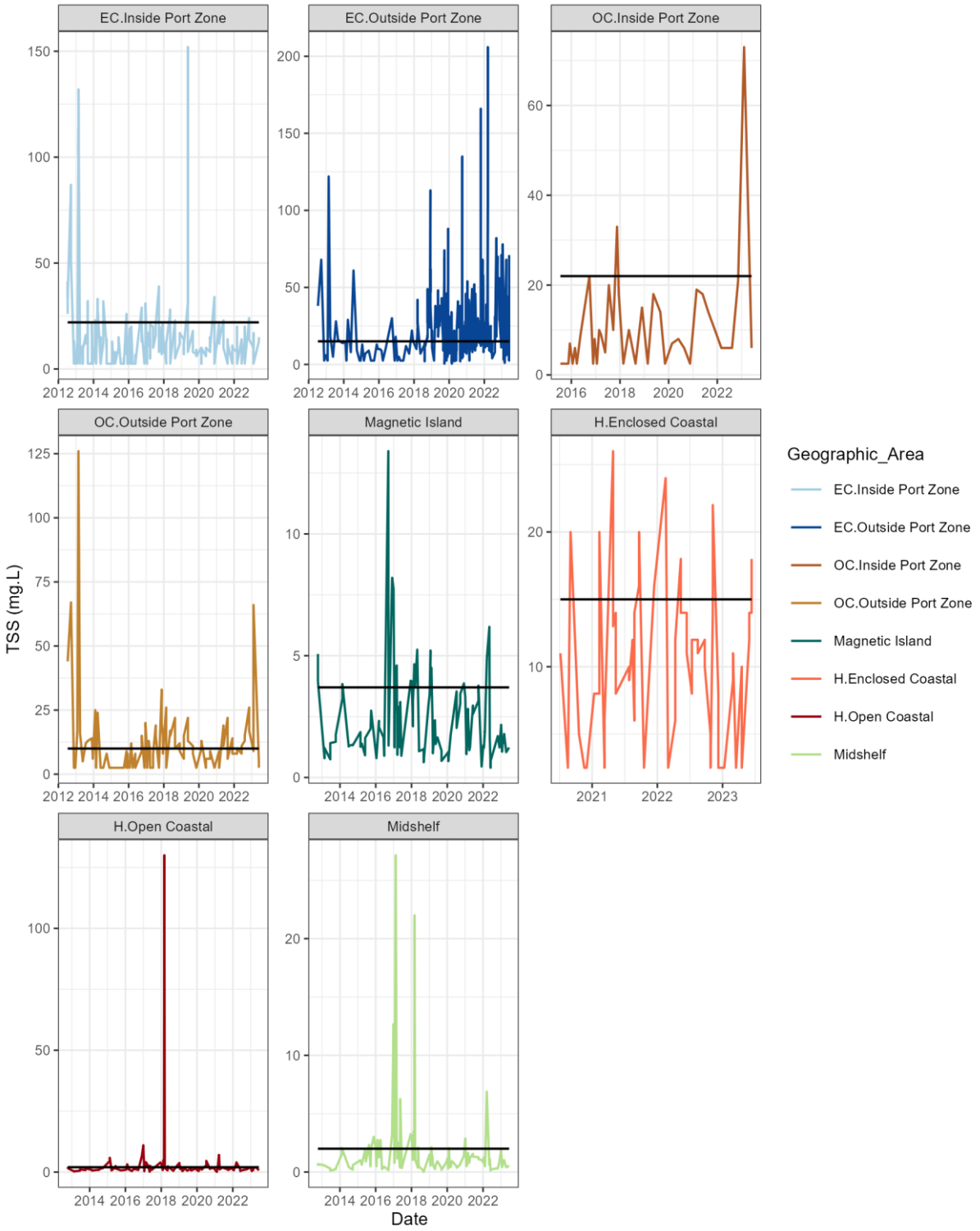

Figure 92. Dry Tropics inshore marine water quality line plots: TSS. The black line indicates water quality guidelines.

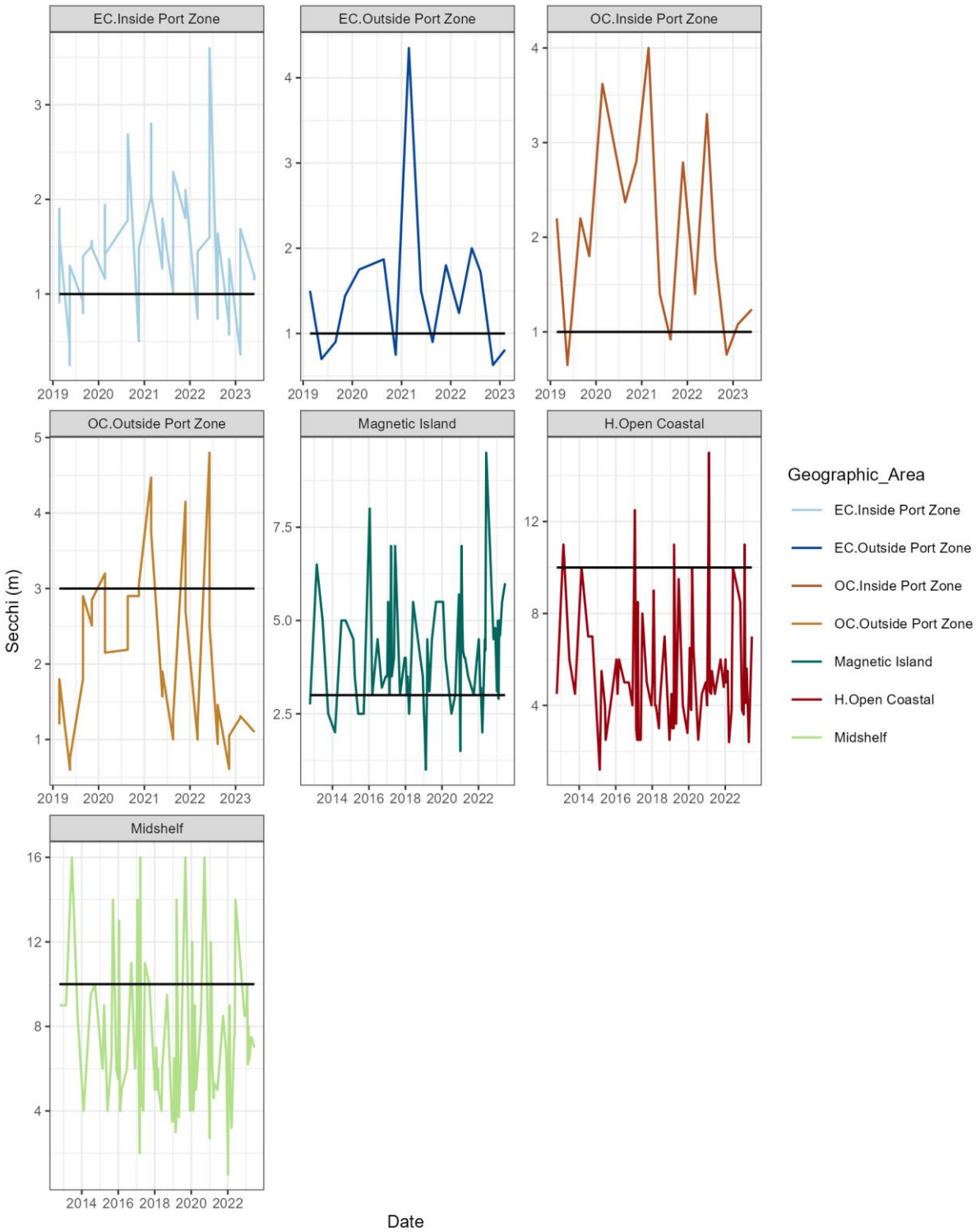

Figure 93. Dry Tropics inshore marine water quality line plots: Secchi. The black line indicates water quality guidelines.

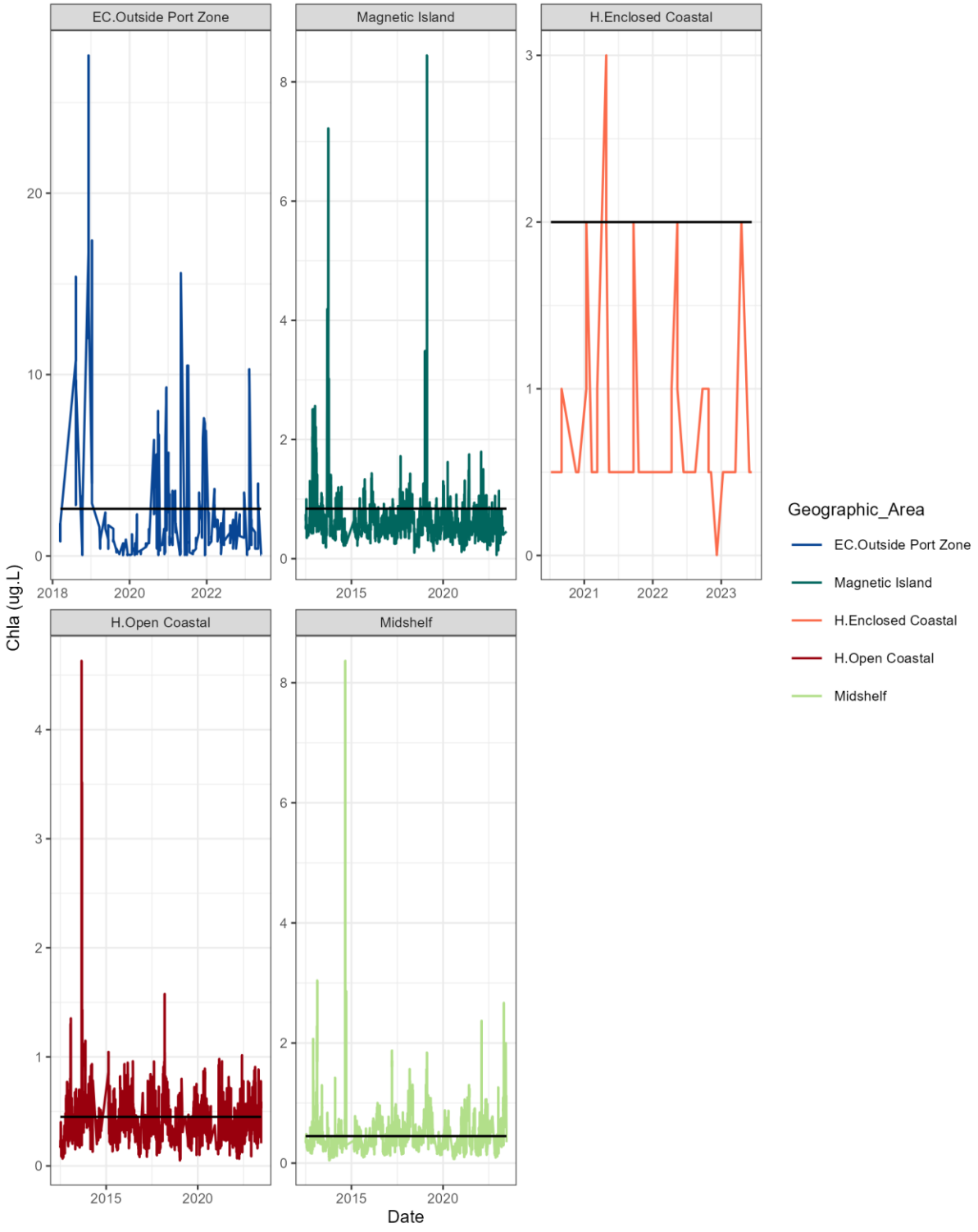

Figure 94. Dry Tropics inshore marine water quality line plots: Chl a. The black line indicates water quality guidelines.

Appendix CCC. Overlap of Dry Tropics and Wet Tropics Sampling Sites

Table 98. Comparison between the Dry Tropics and Wet Tropics inshore marine water quality (nutrient indicator category) scores .

Region	Zone	Sub Zone	Area	NOx	PN	PP	TP	Nutrients	Zone Nutrients
Dry Tropics	Halifax Bay	Enclosed Coastal	Enclosed Coastal	100	ND	ND	100	100	77
		Open Coastal	Open Coastal	100	32	63	ND	65	
		Midshelf	Midshelf	100	25	71	ND	65	
				100	29	67	100	77	
Wet Tropics	Palm Island	NA	NA	84	29	67	ND	63	63

Table 99 Comparison between the Dry Tropics and Wet Tropics inshore marine water quality (physical-chemical properties indicator category) scores.

Region	Zone	Sub Zone	Area	Turbidity	TSS	Secchi	Phys Chem	Zone Phys Chem
Dry Tropics	Halifax Bay	Enclosed Coastal	Enclosed Coastal	88	88	ND	88	76
		Open Coastal	Open Coastal	82	86	11	60	
		Midshelf	Midshelf	100	100	41	80	
				90	91	26	76	
Wet Tropics	Palm Island	NA	NA	83	93	ND	87	87

Appendix DDD. Report Change Log

The table below lists section number, page and paragraph number, and summary of updates for the 2022–2023 technical report to assist reviewers.

The theme of this years change log is **refinement** and **efficiency.**

Section	Page Number	Details
Header	NA	Logo changed from old Dry Tropics Partnership for Healthy Waters (DTPHW) logo to new Healthy Waters Partnership for the Dry Tropics (HWP) logo.
Footer	NA	Dates. Name changed from "Dry Tropics Partnership for Healthy Waters" to "Healthy Waters Partnership for the Dry Tropics"
Throughout Doc	NA	Change log key table added (temporary – removed for final publication). "Dry Tropics" changed to "Townsville Dry Tropics" to clarify the region in which the report is focused.
Front Cover	i	Dates. Reporting capitalised. Logo changed to new (HWP) logo.
1. General	ii	NA
1.1 Authorship Statement	ii	Dates. Partnership name changed.
1.2 Current DTPHW Members	ii	Update member details: Cinzia Cattaneo (MWI), Martine Newman (WT) , Reiner Mann (DESI), Travis Sydes (FNQROC), Nicole Flint (CQU), Tyson Schmid (TCC) added. Carl Mitchell (DESI), Michael Newham (DESI), Elaine Glen (POTL), Adam King (TCC) removed. All DES acronyms changed to DESI.
1.3 Acknowledgements	iii.	NA
2. Executive Summary	iv	Mention of dates removed (generalise sentence). "Climate" changed to "climate and land use". Specification of environments removed (rather than listing all environments one by one, just state "each environment").
2.1 The Dry Tropics Partnership	iv-v	Dates. Change "Management Response" to "Stewardship". Table updated to include new year.
2.2 Climate and Land use in the Dry Tropics Region	vi	The sentence that summarised the key dot points that followed was removed. Dates. Values (e.g., mm of rainfall, degrees). LTM calculation (more detail in climate section).

Section	Page Number	Details
2.3 State and Condition of the Environment	vi-vii	Table updated with latest year of data.
2.3.1 Freshwater Environment	vii-xi	Tables updated with 2022-2023 results. Key Messages added for all indices. Pesticides added for the first time.
2.3.2 Estuarine Environment	ix-x	Tables updated with 2022-2023 results. Key Messages added for all indices.
2.3.3 Inshore Marine Environment	x-xi	Tables updated with 2022-2023 results. Key Messages added for all indices.
2.3.4 Offshore Marine Environment	xi	Tables updated with 2022-2023 results. Key Messages added for all indices.
2.3.5 Litter	xi-xiii	Tables updated with 2022-2023 results. Key Messages added for the index.
Table of Contents	xiv-xv	NA
4. Glossary of Terms	xvi-xx	NA
5. Table of Tables	xxi-xxiv	NA
6. Table of Figures	xxv-xxx	NA
7. Introduction	1	NA
7.1 Overview	1	Dates. Change “Management Response” to “Stewardship”. Table updated to include new year.
7.2 Report Card Zones	1-3	Dates. New Digital Elevation Model added (figure 3).
7.3 Purpose of This Document	3	Dates.
7.4 Report Card History	3	Removed. Sentence directing the reader to the Methods document to find the removed material.
8. Methods	3	Dates.
8.1 Terminology and Aggregation	3-5	Paragraph simplified. Table expanded to include all indicators.
8.2 Scoring	5	NA
8.3 Presentation	5-6	NA
8.4 Confidence Measure	6	Paragraph simplified.
8.5 Objectives/Measures/Baselines for Scoring Data	NA	Section removed. Reasoning: it is not necessary to understand the technical report. Further, the type of objective is clarified within each section.
Environmental Stressors Page divider	7	Dates. Names.

Section	Page Number	Details
9. Environmental Stressors in the Townsville Dry Tropics Region	8	Dates. Values/descriptions of stressors.
9.1 Land Use	9-10	Table 16 simplified to only show current year. Additional land use types provided (e.g., mining separated from urban use) for Table 16 and Figure 5. Link to data source removed (this detail is in the methods).
9.2 Climate	11	Dates. The sentence that summarised the key dot points that followed was removed.
9.2.1 Rainfall	11-14	Link to data source removed (this is in the methods). Values (e.g., mm of rainfall). Figures divided into separate basins (previous was the Dry Tropics overall). LTM now based on 1991-2020 data. Monthly line plots added.
9.2.2 Air Temperature	15-18	Link to data source removed (this is in the methods). Values (e.g., degrees). Figures divided into separate basins (previous was the Dry Tropics overall). LTM now based on 1911-1940 data. Monthly line plots added.
9.2.3 Sea Surface Temperature	19-20	Link to data source removed (this is in the methods). Values (e.g., degrees). LTM now based on 1991-2020 data. Monthly line plots added.
9.2.4 Degree Heating Weeks (Coral Bleaching)	21	Link to data source removed (this is in the methods). Values (e.g., DHWs). Section name changed from “Coral Bleaching (Degree Heating Weeks)” to “Degree Heating Weeks (Coral Bleaching)”
9.3 Climate Summary	NA	Section removed from here and added to section “9 Climate and Land Use in the Townsville Dry Tropics Region”.
Freshwater Page divider	22	Dates. Names.
10 Freshwater Environment	23	Text updated to include pesticides.

Section	Page Number	Details
10.1 Water Quality	23	Update year on methods doc reference
10.1.1 Monitoring Sites	23-25	Update number of sites (although no new sites were added, the wrong number of sites were written in the text last year). Updated table formatting and included missing sites (codes).
10.1.2 Overall Summary: Freshwater Quality	25-26	Text updated. Table updated with new results. Key messages updated.
10.1.3 Nutrients	26-27	Comparison of FRP removed, and instead simply note that the comparison of FRP is ongoing. Results text updated. Table updated with new results.
10.1.4 Physical-Chemical Properties	28-29	Results text updated. Table updated with new results.
10.1.5 Confidence Scores	30	NA
10.2 Pesticides	31	Entirely new section, all subsequent components new.
10.2.1 Monitoring Sites	31	New
10.2.2 Overall Summary: Pesticides	31	New
10.2.3 Results: Pesticides	32	New
10.2.4 Confidence Scores	33	New
10.3 Habitat and Hydrology	34	Link to data source removed (this is in the methods). Description simplified.
10.3.1 Overall Summary: Freshwater Habitat and Hydrology	34	Dates. Values (scores, grades). Key messages.
10.3.2 Freshwater Riparian Extent	34	Acknowledge latest update of data. Acknowledge subbasin calculations.
10.3.2.1 Monitoring Sites	35	New maps created. Link to data source, and description of data removed (this is in the methods).
10.3.2.2 Results: Freshwater Riparian Extent	35-36	Mention of method of score calculation removed (is in methods). Dates. Text that simply repeats information in table significantly cut down.
10.3.3 Freshwater Wetland Extent	36	Acknowledge subbasin calculations.

Section	Page Number	Details
10.3.3.1 Monitoring Sites.	36	New maps created. Link to data source, and description of data removed (this is in the methods).
10.3.3.2 Results: Freshwater Wetland Extent	36-37	Mention of method of score calculation removed (is in methods). Dates. Text that simply repeats information in table significantly cut down.
10.3.3.3 Updated Wetlands Dataset	38	Entirely new section. Appendix items are new as well.
10.3.4 Artificial Barriers	38	Shorten. Question regarding next update for fish barriers.
10.3.4.1 Monitoring Sites.	38	New maps created. Link to data source, and description of data removed (this is in the methods).
10.3.4.1 Results: Artificial Barriers	38	Moved to the start of the section rather than the end. Descriptive text shortened.
10.3.4.2 Results: Freshwater Impoundment Length	38	Text that simply repeats information in table significantly cut down.
10.3.4.3 Results: Freshwater Fish Barriers	39	Definition of barriers removed (already in methods). Description of methodology removed. Scoring ranges for sub indicators removed (already present in methods, and sub indicator scores are not shown in the tech report).
10.3.5 Confidence Scores	40	Text shortened.
10.4 Fish	41	Dates.
10.4.1 Monitoring Sites	41	New Maps created. Description of site selection removed (is in methods).
10.4.2 Overall Summary: Freshwater Fish	41	New Summary Table added (now that we have two sets of data). Text shortened. Dates. Values (e.g., number of fish). Key Messages Updated. Remove species classification definitions as this can be found in the methods.
10.4.3 Proportion of Indigenous Species Expected	42	New section, separating the previous results into individual indicator categories.
10.4.3.1 Results: POISE	42	New section, allows for more clarity on indicator category results and meaning.

Section	Page Number	Details
10.4.4 Proportion of Non-Indigenous Species Expected	42	New section, separating the previous results into individual indicator categories.
10.4.4.1 Results: PONISE	43	New section, allows for more clarity on indicator category results and meaning.
10.4.5 Confidence Scores	43	NA
Estuarine Page divider	44	Dates. Names.
11 Estuarine Environment	45	Add new maps detailed sub basins like in WQ maps.
11.1 Water Quality	45	Dates.
11.1.1 Monitoring Sites	45—47	Dates.
11.1.2 Overall Summary: Estuarine Water Quality	47-48	Text and table updated with newest results.
11.1.3 Nutrients	48-49	Table updated with newest results. Results text updated with newest results.
11.1.4 Physical Chemical Properties	50-51	Table updated with newest results. Results text updated with newest results.
11.1.5 Confidence Scores	52	NA
11.2 Habitat	53	Dates. Link to data source, and description of data removed (this is in the methods).
11.2.1 Overall Summary: Estuarine Habitat	53	Dates. Values (scores, grades). Key Messages.
11.2.2 Mangrove and Saltmarsh Extent	53-54	Description of vegetation types removed (in methods).
11.2.2.1 Monitoring Sites	54	Text shortened. New maps (in appendix).
11.2.2.2 Results: Estuarine Mangroves and Saltmarsh	54-56	Text shortened. Dates. Values (e.g., ha of vegetation). New Table with sub basins included. New appendix tables with historic data.
11.2.3 Estuarine Riparian Extent	56	Clarification on methods source.
11.2.3.1 Monitoring Sites	56	Text shortened. New maps (in appendix).
11.2.3.2 Results: Estuarine Riparian Extent	56-57	Text shortened. Values (scores, grades). Tables re-ordered to save a page.
11.2.5 Confidence Scores	57	NA

Section	Page Number	Details
Inshore Page divider	58	Dates. Names.
12 Inshore Environment	59	NA
12.1 Water Quality	59	Dates.
12.1.1 Monitoring Sites	59-60	New Maps (figure 22).
12.1.2 Overall Summary: Estuarine Water Quality	61	Text and score updates. Table updated with latest year of data. Scores back calculated (see ”Updated Methodology”).
12.1.3 Updated Methodology	61	Entirely new section
12.1.4 Nutrients	61-63	Scores and text updated. Tables updated with latest year of data. Historic data (in appendix updated).
12.1.5 Physical Chemical Properties	64-65	Scores and text updated. Tables updated with latest year of data. Historic data (in appendix updated).
12.1.6 Chlorophyll a	66	Scores and text updated. Tables updated with latest year of data. Historic data (in appendix updated).
12.1.7 Overlap with the Wet Tropics Technical Report	66	NA (appendix updated).
11.1.8 Confidence Scores	67	NA
12.2 Habitat	68	NA
12.2.1 Overall Summary: Inshore Habitat	68	Text and scores updated. Tables updated with latest results. Key Messages updated with greater detail.
12.2.2 Coral	69	Text shortened. Outline of methods removed (this is in methods doc and in the original source material).
12.2.2.1 Monitoring Sites	69-71	Text shortened. Maps updated with new outline for “Palms West 1” reef – moved closer to actual location.
12.2.2.2 Results: Inshore Coral	71-72	Link to data removed (in methods).
12.2.3 Seagrass	72	Outline of sampling time removed (this is in methods doc and in the original source material).
12.2.3.1 Monitoring Sites	72-73	Description shortened. Maps updated with newest seagrass boundaries
12.2.3.2 Results	73-75	All text cut down to essentials (this text is already in the main seagrass report).
12.2.4 Confidence Scores	75	Text shortened.

Section	Page Number	Details
Offshore Page divider	76	Dates. Names.
13 Offshore Marine Environment	77	Add new maps detailing area.
13.1 Water Quality	77-78	Dates. Table updated.
13.1.1 Data Source	78	Entirely new section. Provided detailed explanation of the source/problems with data.
13.2 Habitat	78	Dates.
13.2.1 Overall Summary: Offshore Habitat	78	Text shortened. Values (Score), table updated. Key messages updated.
13.2.2 Coral	79	Dates of sampling updated.
13.2.2.1 Monitoring Sites	79	Text shortened.
13.2.2.2 Results: Offshore Coral	79-80	Text clarified, cleaned up, and references added. Values (scores and grades).
13.2.3 Confidence Scores	80	Text shortened.
Litter Page divider	81	Dates. Names.
14 Litter	82	text updated
14.1 Monitoring Sites	83	Text updated.
14.2 Comparison with previous years	83-85	Table and text updated
14.3 Key Messages	85	Text updated
14.4 Results	85-86	Table and text updated
14.5 Confidence Scores	86-87	No change
15. References	88	Removed references that are no longer used.
Appendices page divider	90	Dates. Names.
16. Appendices	91-167	NA
Appendix A. to G.		New climate graphs/maps
Appendix H.		Table updated with summary stats for latest year.
Appendix I.		2022-2023 DIN and TP scores added.
Appendix J.		Table updated with summary stats for latest year.
Appendix K.		2022-2023 Turbidity and High/Low DO scores added.
Appendix L. and M.		New freshwater box and line plots for latest results added.
Appendix N.		New pesticides sampling locations maps.

Section	Page Number	Details
Appendix O. to R.		New freshwater riparian maps/graphs
Appendix S. to V.		New freshwater wetlands maps/graphs
Appendix W.		New table showing effect of updated wetland data.
Appendix X. and Y.		NA
Appendix Z.		New fish sampling locations
Appendix AA. to CC.		New fish sampling data and plots
Appendix DD.		Summary stats tables updated with latest data
Appendix EE.		Historical results table updated with latest data
Appendix FF.		Summary stats tables updated with latest data
Appendix GG.		Historical results table updated with latest data
Appendix HH. and II.		New estuarine box and line plots with latest data.
Appendix JJ. to MM.		New estuarine mangrove and saltmarsh maps/graphs
Appendix NN. to QQ.		New estuarine riparian maps and graphs
Appendix RR.		Summary stats tables updated with latest data
Appendix SS.		Historical results table updated with latest data
Appendix TT.		Summary stats tables updated with latest data
Appendix UU.		Historical results table updated with latest data
Appendix VV. and WW.		New inshore box and line plots with latest data.
Appendix XX.		Values for DT and WT updated.
Appendix YY.		New table.