Dry Tropics Partnership for Healthy Waters
Waterways Report Card 2023

# TECHNICAL REPORT

## Complete Report

Reporting on data collected 2021 - 2022

# 1 General

## 1.1 Authorship Statement

This technical report presents the results of the Townsville Dry Tropics 2021–2022 Report Card (released in 2023) and was prepared by the Partnership's Senior Technical Officer (STO), Dinny Taylor, and the Partnership's Technical Officer (TO), Adam Shand. Significant support and review were received from the Regional Report Cards Technical Working Group (TWG) members, and the Wet Tropics and Mackay-Whitsunday-Isaac regional Report Cards. This report is endorsed by the Dry Tropics Partnership for Healthy Waters.

Suggested citation: Shand, A., Taylor, D., (2023). *Technical Report for the Townsville Dry Tropics annual report cards. Updated 2023.* Dry Tropics Partnership for Healthy Waters, Townsville.

## 1.2 Current Townsville Dry Tropics TWG Members and their Respective Organisations

*Table 1. Current DTPHW TWG members and respective organizations.*

| Member | Organisation |
|---|---|
| Diane Tarte | TWG: Chair (Independent) |
| Dinny Taylor | DTPHW: STO |
| Adam Shand | DTPHW: TO |
| Richard Hunt | Wet Tropics Partnership |
| Brie Sherow | Mack-Whitsunday-Isaac Partnership |
| Lyndon Llewellyn | Australian Institute of Marine Science (AIMS) |
| Angus Thompson | AIMS |
| Glynis Orr | Department of Environment and Science (DES) |
| Carl Mitchell | DES |
| Jamie Corfield | DES |
| David Moffatt | DES |
| Andrew Moss | DES |
| Michael Newham | DES |
| Michael Rasheed | James Cook University (JCU) |
| Stephen Lewis | JCU |
| Paula Cartwright | JCU |
| Elaine Glen | Port of Townsville (POTL) |
| Adam King | Townsville City Council (TCC) |

## 1.3 Acknowledgements

We thank partners who kindly contributed their data, members of the Townsville Dry Tropics Management Committee, and members of the Technical Working Group (TWG) who provided feedback on the document. Members include Townsville City Council (Townsville Water & Waste), Port of Townsville, Australian Institute of Marine Science, Department of Environment and Science, Queensland Herbarium (through the Department of Environment and Science), James Cook

University (TropWater), and Ornatas. Creative Commons (Receiving Environment Monitoring Program, Sewage Treatment Plant data) by Townsville City Council is licensed under CC BY 4.0/Adapted Material. Members of the Reef Independent Science Panel are also acknowledged for their advice and review of the document.

# 2 Executive Summary

This executive summary includes three summary sections covering:

- The Dry Tropics Partnership,
- Environmental Stressors in the Dry Tropics region during 2021–2022,
- The state and condition of the environment, including scores and grades for each index for each environment (Freshwater, Estuarine, Inshore Marine, and Offshore Marine), and site-specific scores and grades for litter.

## 2.1 The Dry Tropics Partnership

The Dry Tropics partnership for Healthy Waters (referred to as the Partnership) was formed in November 2018 and launched in January 2019. The current geographic scope of the Partnership covers the waterways and environment in the Dry Tropics region. On land, the Partnership region extends from the Crystal Creek catchment in the north, to the Ross River (upper) and Alligator Creek catchments in the south. In the water, the region 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 Dry Tropics reporting region is divided into seven unique zones based on the waterway type (freshwater, estuarine, inshore marine, and offshore marine), and riverine basin (Black and Ross) (Table 2, Figure 1). If required, zones are divided into sub-zones (or catchments) based on the prevailing sub-water type, and catchment. For further information on the methodology of constructing the Dry Tropics reporting region refer to "Methods for Townsville Dry Tropics 2021–2022 Report Card (released in 2023)".

*Table 2. The seven reporting zones in the Dry Tropics region.*

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

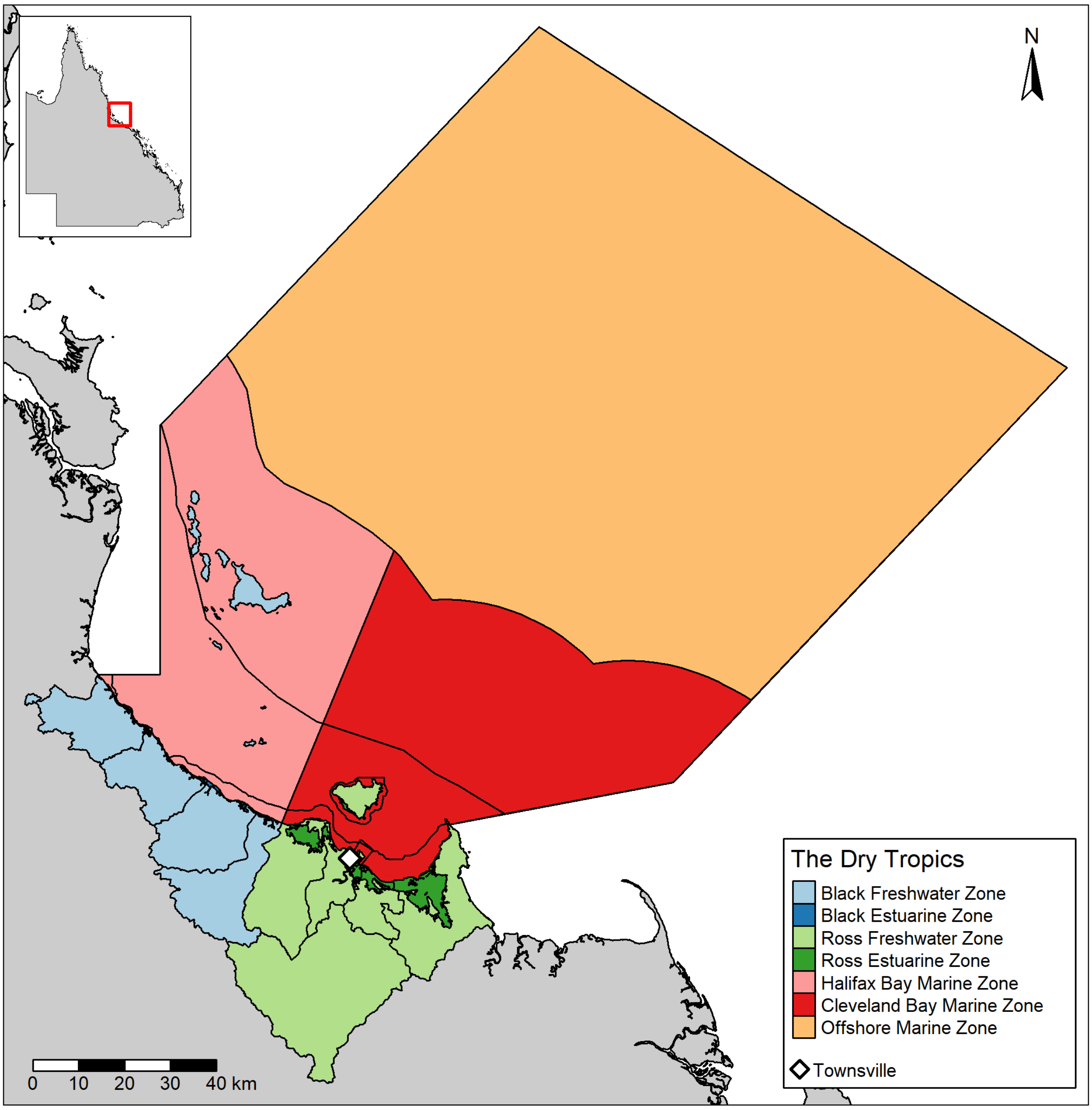


*Figure 1. Geographic boundary of the DTPHW reporting region, divided into seven zones (**Table 2**).*

In May 2019 the Partnership released its pilot annual Report Card, reporting and summarising data from the 2017–2018 financial year. In June 2020, the Partnership began releasing annual Report Cards for the proceeding financial year, and in June 2021, the Partnership also began releasing annual Management Response Reports, highlighting the management actions of partners (Table 3).

*Table 3. Timeline of key DTPHW publications.*

| **Released:** | **2023** | **2022** | **2021** | **2020** | **2019** |
|---|---|---|---|---|---|
| **Reporting period:** | **2021–2022** | **2020–2021** | **2019–2020** | **2018–2019** | **2017–2018** |
| Report Card | ✓ (current) | ✓ | ✓ | ✓ | ✓ (pilot) |
| Stewardship Report | ✓ (current) | ✓ | ✓ | | |

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" and "Methods for Townsville Dry Tropics 2021–2022 Report Card (released in 2023)".

## 2.2 Climate and Land Use in the Dry Tropics Region

During 2021–2022, the Dry Tropics region recorded a wide range of weather events. There were no major flooding events, tropical cyclones, or changes to the prevailing La Niña conditions (Bureau of Meteorology 2022, Climate Council 2021). However, multiple heatwaves were experienced, both extremely high and low monthly rainfall figures were recorded, annual average seawater temperature was above average, and the risk of coral bleaching was above average (Bureau of Meterology 2023, NOAA 2023). Key influences are summarised below.

- Total rainfall was 1166mm in the Ross Basin, and 1383mm in the Black Basin. Annual rainfall in both basins was classified as "average", although slightly exceeding the long-term mean. Monthly rainfall ranged from "very much below average" to the "highest 1%" on record.
- Annual air temperature averaged 25.4°C in the Ross Basin, and 24.9°C in the Black Basin and exceeded the long-term annual mean in both basins. The monthly average air temperature across both basins was equal to or greater than average for every month of the year.
- The annual average sea surface temperature was 27.1°C and exceeded the long-term mean. Monthly average sea surface temperature was "very much above average" or the "highest 1%" on record for ten months of the year.
- The risk of coral bleaching ranged from "possible" to "highly likely".
- From 2016–2021 intensive land use increased by 6.19km$^2$, conservation and natural environment land use increased by 4.85km$^2$, and production from natural environments land use decreased by 22.6km$^2$.

## 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 zones of the Dry Tropics region (Figure 1, Table 2). Within each zone 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 3). Indicators, and thus the indices reported for each zone vary (Table 4). Confidence levels based on how the data were collected and analysed are also reported.

*Table 4. Indices measured in each zone of the Dry Tropics region.*

| Zone | Water Quality (WQ) | Latest update | Habitat and Hydrology (HH) | Latest update | Fish (F) | Latest update |
|---|---|---|---|---|---|---|
| Black Freshwater | ✓ | 21–22 | ✓ | 19–20 | ✓ | 19–20 |
| Black Estuarine | ✓ | 21–22 | ✓ (Only Habitat) | 21–22 | | |
| Halifax Bay | ✓ | 21–22 | ✓ (Only Habitat) | 21–22 | | |
| Ross Freshwater | ✓ | 21–22 | ✓ | 19–20 | ✓ | 19–20 |
| Ross Estuarine | ✓ | 21–22 | ✓ (Only Habitat) | 21–22 | | |
| Cleveland Bay | ✓ | 21–22 | ✓ (Only Habitat) | 21–22 | | |
| Offshore Marine | ✓ | 19–20 | ✓ (Only Habitat) | 21–22 | | |

The index and standardised scores of each zone for the 2021–2022 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 2021–2022 weighted scores for Water Quality (WQ), Habitat and Hydrology (HH), and Fish (F) indices in the Ross Freshwater Basin and the Black Freshwater Basin against previous years.*

| Zone | 2021–2022 | | | 2020–2021 | | | 2019–2020 | | | 2018–2019 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | WQ | HH[1] | F[2] | WQ | HH | F | WQ | HH | F | WQ | HH | F |
| Ross | 70 (B) | 51 (C) | 57 (C) | 73 (B) | 51 (C) | 57 (C) | 70 (B) | 51 (C) | 57 (C) | 66 (B) | 51 (C) | ND |
| Black | 68 (B) | 71 (B) | 78 (B) | 68 (B) | 71 (B) | 78 (B) | 67 (B) | 71 (B) | 78 (B) | 62 (B) | 71 (B) | 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 indicates no data available.

#### 2.3.1.1 *Key Messages*

##### 2.3.1.1.1 Water Quality

- The Ross Freshwater Basin saw a decrease in score from 73 to 70 within the same grade of 'good' with the decline associated with a decrease in the score for TP in Ross Lake and a decrease in the score for DIN in the Bohle River.
- The Black Freshwater Basin score and grade have remained stable across the reporting years.
- The Bohle River TP scores remain 'very poor' and the DIN scores have decreased with the grade decreased from 'moderate' to 'poor' compared with 2020–2021.
- There was an increase in the number of watercourses with 'very poor' or 'poor' scores associated with low dissolved oxygen % saturation in both the Ross and Black basins in the 2021–2022 year.

##### 2.3.1.1.2 Habitat and Hydrology

- There have been no changes to the habitat and hydrology index scores for the 2021–2022 technical report.
    - The method of aggregation was updated for the 2021–2022 report. Historic scores have been back calculated (Appendix U).
    - The area assessed for the wetland extent indicator was updated for the 2021–2022 report. Historic scores have been back calculated (Appendix T).

##### 2.3.1.1.3 Fish

- As no new data has been recorded there has been no change to the fish index scores for the 2021–2022 technical report.

[1] Habitat and Hydrology data is collected every four years. Latest update: 2022. Next update: 2026.

[2] Fish data is collected every three years. Latest update: 2020. Next update: 2023.

- Scores and grades are based on 2019–2020 data and may not be representative of 2021–2022 condition.

### 2.3.2 Estuarine Environment

*Table 6. Comparison of 2021–2022 weighted scores for Water Quality and Habitat indices in the Ross Estuarine Basin and Black Estuarine Basin against previous years.*

| Basin | 2021–2022 | | 2020–2021 | | 2019–2020 | | 2018–2019 | |
|---|---|---|---|---|---|---|---|---|
| | WQ | H[3] | WQ | H | WQ | H | WQ | H |
| Ross | 83 (A) | 73 (B) | 88 (A) | 73 (B) | 88 (A) | 73 (B) | 39 (D) | 73 (B) |
| Black | 64 (B) | 71 (B) | 66 (B) | 71 (B) | 47 (C) | 71 (B) | 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 indicates no data available.

#### 2.3.2.1 *Key Messages*

##### 2.3.2.1.1 Water Quality

- There was no change to the water quality index grade (although the Ross Estuarine Basin score decreased from 88 to 83 and Black Estuarine Basin score decreased from 66 to 64).
    - 9 of 13 watercourses received a grade of "good" or "very good" for both nutrients and physical-chemical properties indicator categories.
    - The Camp Oven Creek and Crystal Creek watercourses exhibited unusually low Turbidity scores and should be closely monitored moving forward.
    - Althaus Creek shows ongoing issues with turbidity, and further investigation is required to isolate specific drivers.
    - Louisa Creek shows ongoing issues with Low DO and TP and further investigation is required to isolate specific drivers.

##### 2.3.2.1.2 Habitat

- The grade and score for the habitat index did not change in either the Ross Estuarine Basin or Black Estuarine Basin.
    - Across both habitat indicator categories vegetation loss was minimal, with a maximum loss of 0.09%. This amount of loss is within the margin of error of the method.

[3] Only Habitat data is collected. Data collected every four years. Latest update: 2022. Next update: 2026.

### 2.3.3 Inshore Marine Environment

*Table 7. Comparison of 2021–2022 weighted scores for Water Quality and Habitat in Cleveland Bay and Halifax Bay against previous years.*

| Zone | 2021–2022 | | 2020–2021 | | 2019–2020 | | 2018–2019 | |
|---|---|---|---|---|---|---|---|---|
| | WQ | H | WQ | H | WQ | H | WQ | H |
| Cleveland Bay | 81 (A) | 57 (C) | 81 (A) | 54 (C) | 81 (A) | 48 (C) | 36 (D) | 56 (C) |
| Halifax Bay | 67 (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 indicates no data available.

#### 2.3.3.1 *Key Messages*

##### 2.3.3.1.1 Water Quality

- There has been no change in water quality grade since the previous report card (although the score for Halifax Bay decreased from 70 to 67).
    - All indicator categories have a grade of "good" or "very good".
    - The inclusion of additional indicators (TP and FRP) would create a net gain in scores across both zones.
- Other than during the 2018–2019 reporting period that included a major flood event, the WQ scores for Cleveland Bay has consistently been 81 and Halifax Bay has improved to 67–70.

##### 2.3.3.1.2 Habitat

- Habitat scores are improving from post flood (2019) conditions.
- Habitat in Cleveland Bay received its highest score in the past four years of 57 due to the recovery of seagrass.
- Habitat (coral) in Halifax Bay has received its lowest score in the past four years of 45.
    - Seagrass in Cleveland Bay has almost recovered to pre–2019 conditions.
    - Coral in Cleveland Bay has fluctuated between moderate and poor for the past four years.
    - There remains a significant amount of macroalgae recorded at four of six sites.

### 2.3.4 Offshore Marine Environment

*Table 8. Comparison of 2021–2022 weighted scores for Habitat in the Offshore Marine Environment against previous years.*

| Zone | 2021–2022 | | 2020–2021 | | 2019–2020 | | 2018–2019 | |
|---|---|---|---|---|---|---|---|---|
| | WQ | Habitat | WQ | Habitat | WQ | Habitat | WQ | Habitat |
| Offshore marine | NA | 64 (B) | NA | 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. NA indicates no data available.

#### 2.3.4.1 *Key Messages*

##### 2.3.4.1.1 Water Quality

- No data was available for the 2021–2022 Dry Tropics Technical Report and water quality was not assessed.

##### 2.3.4.1.2 Habitat

- The habitat index received its highest score in the past four years of 64.
    - Coral continues to recover from poor conditions in the previous reporting periods.
    - Juvenile density was graded as very good at 8 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 is collected from each year in each Zone varies, thus only site-specific scores and grades are presented (Table 9).

*Table 9. Comparison of 2021–2022 standardised scores and grades for Litter in the Dry Tropics region against previous years.*

| Zone | Site | Scores and Grades 2019–2020 | 2020–2021 | 2021–2022 |
|---|---|---|---|---|
| Halifax Bay | North West Beach, Pelorus Island | 88 ( VLP ) | NA | NA |
| | West Beach, Pelorus Island | 75 ( LP ) | NA | NA |
| | North Beach, Orpheus Island | 5 ( VHP ) | NA | NA |
| | Big Rock Bay, Orpheus Island | 24 ( HP ) | 9 ( VHP ) | 11 ( VHP ) |
| | Fig Tree Beach, Orpheus Island | NA | 19 ( VHP ) | 21 ( HP ) |
| | Picnic Bay, Orpheus Island | 1 ( VHP ) | 14 ( VHP ) | 3 ( VHP ) |
| | Boulder Beach North, Orpheus Island | NA | NA | 16 ( VHP ) |
| | Yanks Jetty, Orpheus Island | 69 ( LP ) | 80 ( VLP ) | NA |
| | Boulder Beach, Orpheus Island | NA | NA | 2 ( VHP ) |
| | South Beach, Orpheus Island | 42 ( MP ) | NA | 11 ( VHP ) |
| | Fantome Island, Northern End | NA | 14 ( VHP ) | 36 ( HP ) |
| | Ollera Beach | 40 ( MP ) | NA | NA |
| | Rollingstone Beach | 50 ( MP ) | NA | NA |
| | Toomulla Beach | 52 ( MP ) | NA | NA |
| | Toomulla main beach | NA | NA | 78 ( LP ) |
| | Saunders Beach | 66 ( LP ) | NA | NA |
| | Bushland Beach, Townsville | NA | 65 ( LP ) | NA |
| Cleveland Bay | Myrmidon Reef | NA | 95 ( VLP ) | NA |
| | Horseshoe Bay, Magnetic Island | NA | NA | 34 ( HP ) |
| | Arthur Bay, Magnetic Island | NA | 43 ( MP ) | NA |
| | Alma Bay, Magnetic Island | 46 ( MP ) | 61 ( LP ) | 68 ( LP ) |
| | Alma Bay, Magnetic Island UW | 93 ( VLP ) | 96 ( VLP ) | NA |
| | Geoffrey Bay, Magnetic Island | NA | 77 ( LP ) | NA |
| | Geoffrey Bay Reef, Magnetic Island UW | 88 ( VLP ) | NA | NA |
| | Nelly Bay Beach, Magnetic Island | 52 ( MP ) | 73 ( LP ) | 69 ( LP ) |
| | Nelly Bay, Magnetic Island UW | 99 ( VLP ) | 98 ( VLP ) | 97 ( VLP ) |
| | Shelly Beach, Pallarenda | 61 ( LP ) | 31 ( HP ) | NA |
| | Shelly Cove, Cape Pallarenda Conservation Park | 65 ( LP ) | 68 ( LP ) | 87 ( VLP ) |
| | Pallarenda Beach | NA | NA | 69 ( LP ) |
| | Kissing Point, Townsville | NA | 75 ( LP ) | NA |
| | Rowes Bay | 71 ( LP ) | 72 ( LP ) | 83 ( VLP ) |
| | Strand Park, Townsville | 60 ( LP ) | 71 ( LP ) | NA |
| | Strand Waterpark Beach | NA | 81 ( VLP ) | NA |
| Ross | Three Mile Creek, Pallarenda | NA | 36 ( HP ) | NA |
| | Strand Rock Pool, Townsville | NA | 46 ( MP ) | NA |
| | Queensland Country Bank Stadium | NA | 25 ( HP ) | 22 ( HP ) |
| | Ross Creek, Townsville | NA | NA | 45 ( MP ) |
| | South Townsville Recreational Boat Park | NA | 33 ( HP ) | NA |
| | Anderson Park, Townsville | NA | NA | 87 ( VLP ) |
| | Sherriff Park Townsville | NA | NA | 69 ( LP ) |
| | Aplins Weir Rotary Park | 41 ( MP ) | 35 ( HP ) | 66 ( LP ) |
| | Apex Park, Condon | NA | NA | 60 ( LP ) |

■ 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 indicates no data available.

#### 2.3.5.1 *Key Messages*

- The east coast of Orpheus Island continues to have the highest litter pressure in the region.
- The northern beaches of Townsville have had low litter pressure on the occasion's collections have occurred there.
- Queensland Country Bank Stadium (high pressure) during events continues to have the highest litter pressure in the Ross litter zone, whilst Ross Creek has moderate pressure.
- Horseshoe Bay has the highest litter pressure on Magnetic Island.

# 3 Table of Contents

# 4 Glossary of Terms

*Table 10. Glossary of terms used in the DTPHW 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. |
| **DTPHW** | Dry Tropics Partnership for Healthy Waters. |
| **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. (E.g., 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. E.g., the water quality index is an aggregation of nutrient, phys-chem, and chl a indicator categories. |
| **Indicator** | A measure of one component of an environment. E.g., the total amount of phosphorous (TP) present in the water. |
| **Indicator category** | The aggregation of indicators. E.g., 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. |
| **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. |
| **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. |
| **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. |
| **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

# 6 Table of Figures

# 7 Introduction

## 7.1 Overview

The Dry Tropics Partnership for Healthy Waters (referred to as the Partnership) 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. Each year an annual report card is produced, with the current Report Card reporting on data mainly from the 2021–2022 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 (e.g., wetland and riparian extent) then the most recent data set is included.

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).

To assess trends over time, summary results from previous reports are presented alongside this year's results. For some indicators, the methodology used has changed between years and therefore only data after the methodology change is compared to current results.

## 7.2 Report Card Zones

The results presented in the 2021–2022 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 (upper) and Alligator Creek catchments in the south. In the water 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 Dry Tropics reporting region is divided into seven unique zones based on the waterway type (freshwater, estuarine, inshore marine, and offshore marine), and riverine basin (Black and Ross) (Table 11, Figure 2). If required, zones are divided into sub-zones (or catchments) based on the prevailing sub-water type, and catchment. For further information on the methodology of constructing the Dry Tropics reporting region refer to "Methods for Townsville Dry Tropics 2021–2022 Report Card (released in 2023)".

*Table 11. The seven reporting zones in the Dry Tropics region.*

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

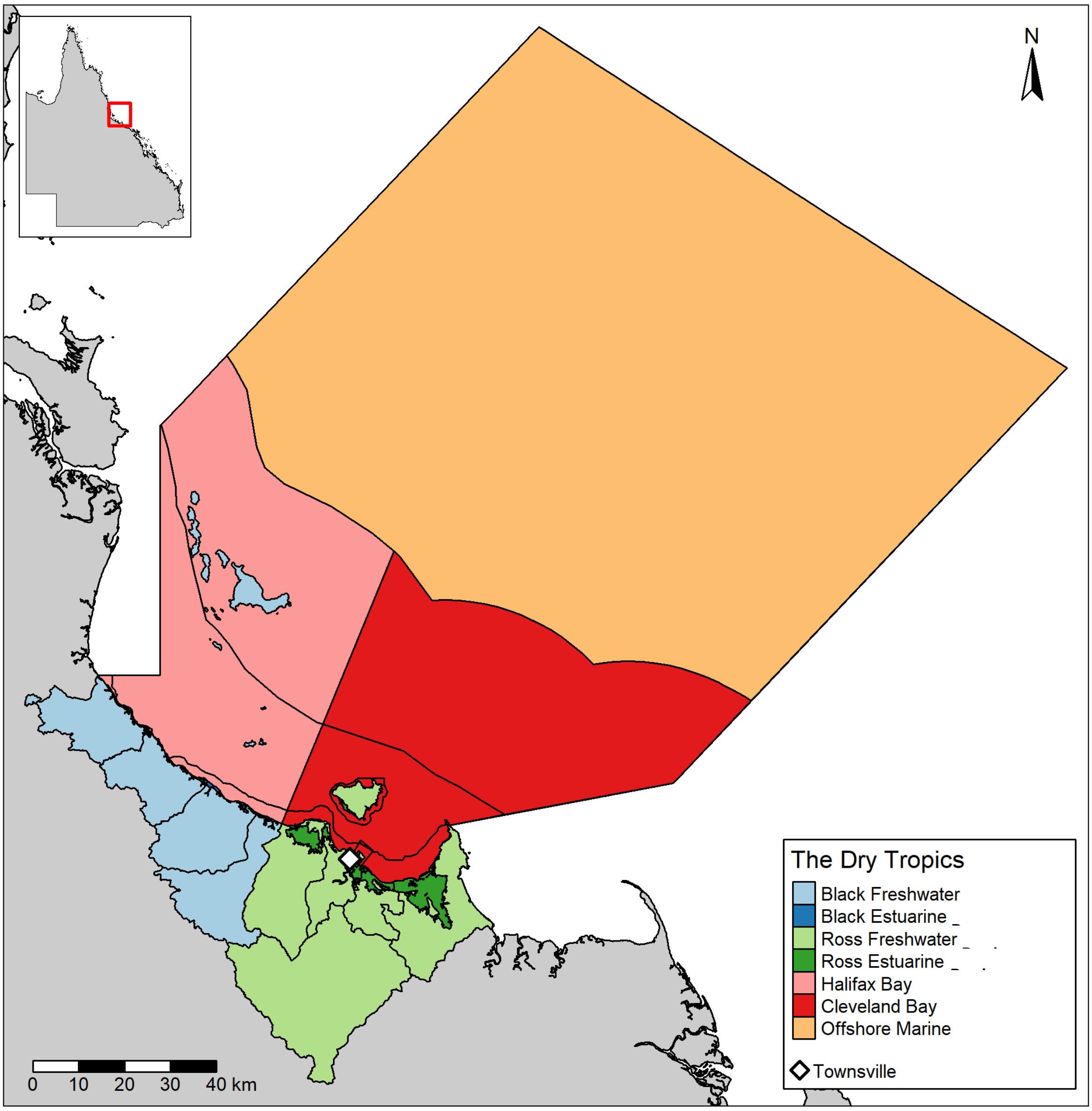


*Figure 2. Geographic boundary of the DTPHW reporting region, divided into seven zones (Table 11).*

# 8 Methods

Detailed methods can be found in "Methods for Townsville Dry Tropics 2021–2022 Report Card (released in 2023)". Key components required to understand the Technical Report are presented below.

## 8.1 Terminology and Data Aggregation

Data is reported and aggregated at multiple levels within this document. These levels are indicator, indicator category, and index. Results from multiple indicators are aggregated into results for indicator categories, which are aggregated into results for indices (Table 12).

*Table 12. Levels of data aggregation used within the Technical Report and Report Card.*

| Indicator | Indicator Category | Index/Indices |
|---|---|---|
| Dissolved Inorganic Nitrogen | Nutrients | Water Quality |
| Total Phosphorus | | |
| Turbidity | Physical-Chemical Properties | |
| Total Suspended Solids | | |

There are three indices in the report card: Water Quality, Habitat and Hydrology, and Fish. Some indices are only measured in certain zones, for example, the Habitat and Hydrology index is referred to as the Habitat index for the inshore and Offshore Marine Zones as hydrology indicators such as water flow are not included. A complete list of indicators can be found in Appendix A.

Scores for indicators and indicator categories can only be aggregated to the next level if they meet the "minimum information rules for aggregating data". These rules are:

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

## 8.2 Scoring

All indicators and their aggregations 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 13).

*Table 13. Standardised scoring range and corresponding grades used in the Technical Report.*

| Scoring Range | Grade and Colour Code |
|---|---|
| 81 to 100 | Very Good (A) |
| 61 to <81 | Good (B) |
| 41 to <61 | Moderate (C) |
| 21 to <41 | Poor (D) |
| 0 to <21 | Very Poor (E) |

## 8.3 Presentation

The information in this technical report is summarised and presented 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 3. B). This coaster is a slimmed down version of the aggregation used within the technical report (Figure 3. A). A coaster is created for each of the seven zones in the Dry Tropics region (Figure 2).

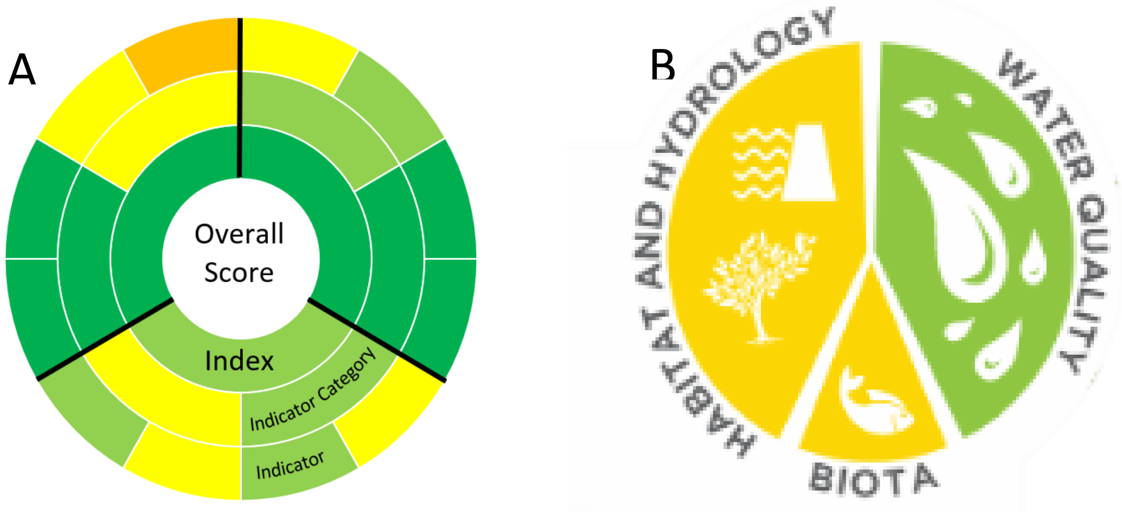


*Figure 3. Coasters used within the Technical Report (A) and Report Card (B).*

## 8.4 Confidence Measure

Results for each index 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 14). Final confidence scores range from 4.5 (very low, with a rating of 1) to 13.5 (very high, with a rating of 5).

*Table 14. 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 |

## 8.5 Objectives/Measures/Baselines For Scoring Data

Indicators are compared against either water quality objectives, ecosystem condition measures, or the earliest available data/baseline. Water quality objectives and ecosystem condition measures are used to assess whether actions positively or negatively influence the environment with respect to the objective or measure. The objective or measure may not reflect the ‘natural’ (pre-development) state of environment, but rather a state that is considered acceptable considering environmental, social, and economic factors. Earliest baselines ideally reflect the natural state of the environment pre-European/pre-developed settlement (or pre-land clearing). Comparing indicators against the earliest baseline is important to show how the environment has changed from a 'natural' environment.

Although earliest baselines are ideal, for some indicator in this report card there is no known data available that accurately describes the state of the environment pre-development. The use of water quality objectives, ecosystem condition measures, or the earliest available data/baseline for each indicator are shown in Table 15. Note that all indicators within an indicator category use the same baseline, and indicator categories are presented instead.

*Table 15. Summary of baselines used for each indicator category.*

| Index | Indicator Category | Objective/Measure/Baseline |
|---|---|---|
| Water Quality | Nutrients | Water Quality Objective |
| | Phys-Chem properties | |
| | Chlorophyll-a | |
| Habitat and Hydrology | Artificial Barriers | Earliest Baseline |
| | Coral condition (composition and cover change) | |
| | Seagrass Condition | |
| | Mangrove and Saltmarsh Extent | Ecosystem condition measure |
| | Riparian Extent | |
| | Wetland Extent | |
| | Coral Condition (Juvenile density and cover) | |
| | Coral Condition (macroalgae) | |
| Fish | Indigenous species expected within waterways | Earliest Baseline |
| | The proportion of Indigenous (native) fish | |

Dry Tropics Partnership for Healthy Waters
Waterways Report Card 2023

# TECHNICAL REPORT

## PART 2: Climate and Land Use

Reporting on data collected 2021 - 2022

JULY 2023 | Dry Tropics Partnership for Healthy Waters (DTPHW)

Written by Adam Shand and Dinny Taylor

# 9 Climate and Land Use in The Townsville Dry Tropics Region

Environmental stressors such as extreme climate and intensive land use are an influential factor for every indicator measured in the Technical Report. This section presents a summary of the relevant stressors over the 2021–2022 reporting period. For a detailed assessment and explorations of trends for each stressor over an extended period see Appendix B.

## 9.1 Urban Environment (Land Use)

Land use data[4] 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 Dry Tropics is summarised in Table 16 and visualised in Figure 4.

*Table 16. Total area and percentage of region for land use classes in the Dry Tropics region in 1999 and 2021 at the primary level.*

| **Land Use** | **2021** | | **2016** | | **1999** | |
|---|---|---|---|---|---|---|
| | **%** | **km²** | **%** | **km²** | **%** | **km²** |
| Conservation and Natural Environments | 35.5 | 1030.98 | 35.1 | 1026.13 | 28.6 | 835.63 |
| Intensive Uses | 10.2 | 296.54 | 9.90 | 290.35 | 8.3 | 243.40 |
| P. f. Dryland Agriculture and Plantations | 0.1 | 1.74 | 0.1 | 3.17 | 0.1 | 2.63 |
| P. f. Irrigated Agriculture and Plantations | 1.2 | 33.44 | 1.2 | 35.75 | 1.1 | 31.75 |
| P. f. Relatively Natural Environments | 47.3 | 1375.00 | 47.8 | 1397.60 | 56.0 | 1636.67 |
| Water | 5.8 | 169.12 | 5.8 | 169.67 | 5.9 | 172.76 |

[4] All land use data was downloaded from QSpatial's [Catalogue] (Queensland Government 2023).

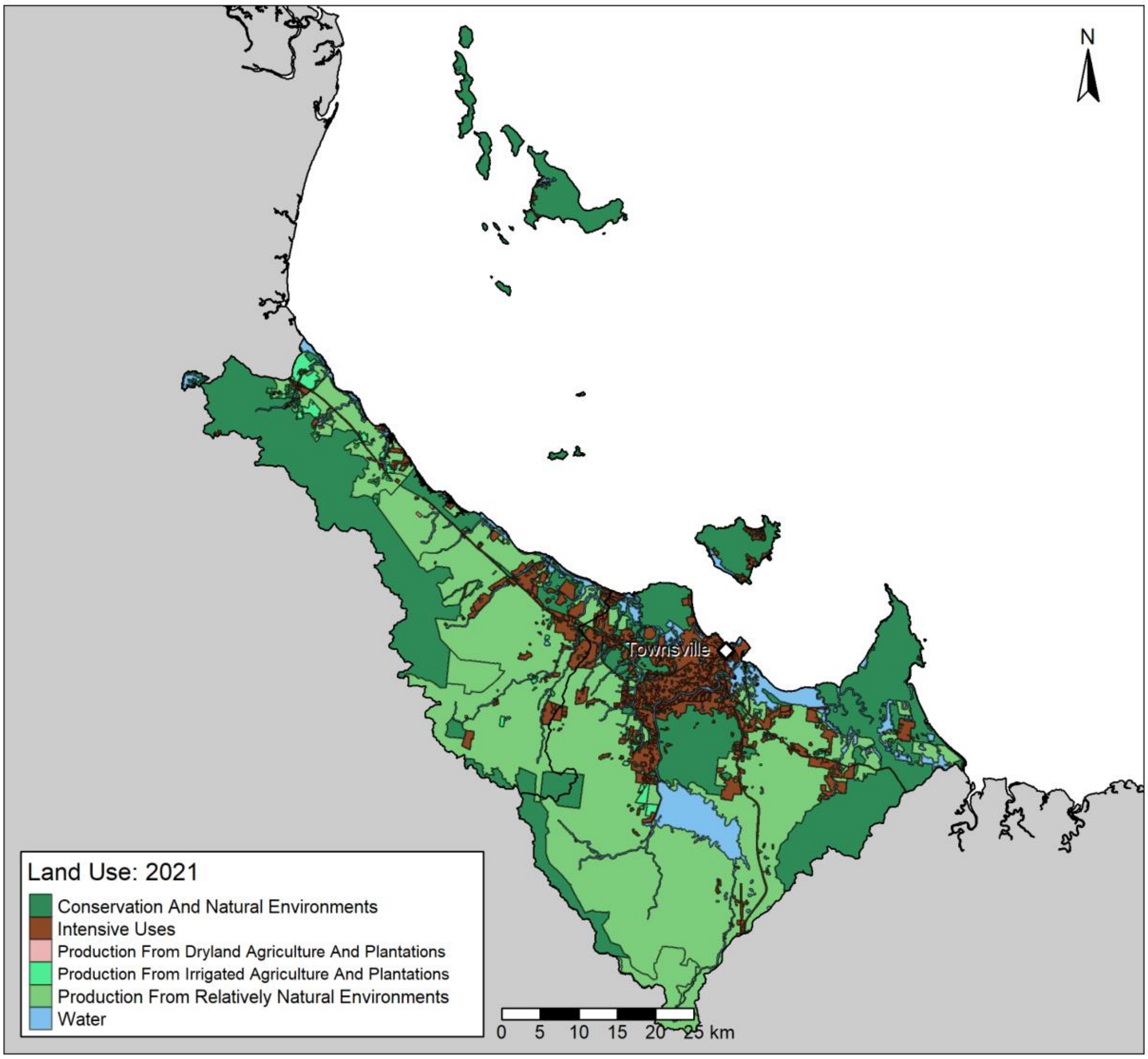


*Figure 4. Land use categories in the Dry Tropics region in 2021 shown at the primary level.*

## 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 2021 and 30th June 2022, the Dry Tropics region recorded a wide range of weather events. There were no major flooding events, cyclones, or changes to the prevailing La Niña conditions (Bureau of Meterology 2023, Climate Council 2021). However, multiple heatwaves were experienced, periods of both extremely high and low monthly rainfall figures were recorded, average sea-surface water temperature was above average, and the chance of coral bleaching was above average (Bureau of Meterology 2023, NOAA 2023). The key influences are explored below.

### 9.2.1 Rainfall

Monthly rainfall[5] across the Dry Tropics region was unevenly distributed, with monthly percentile rainfall in the Ross and Black basins ranging from "very much below average" (1st – 10th percentiles) to the "highest 1%" (99th percentile) on record (Table 17).

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

| Basin | 2021 | | | | | | 2022 | | | | | | 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%

Total annual rainfall was 1166mm in the Ross Basin, and 1383mm in the Black Basin (Table 18).

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

| Basin | Annual Rainfall | Long-term mean (ltm) | Anomaly (+/- ltm) | Percentage of the ltm |
|---|---|---|---|---|
| Ross | 1166mm | 1029mm | +137mm | 113% |
| Black | 1383mm | 1326mm | +57mm | 104% |

Annual rainfall was the greatest in the hinterlands of the Black Basin with up to 2000mm, while the least amount of rainfall was recorded on the southern plateau of the Ross Basin with only 800 to 1000mm. A large area of the Black Basin received less rain that usual, while the southern end of the Black Basin and centre of the Dry Tropics region received more rain than usual (Figure 5).

[5] All rainfall data was downloaded from the BOM's [Australian Water Outlook] portal (Bureau of Meteorology 2022).

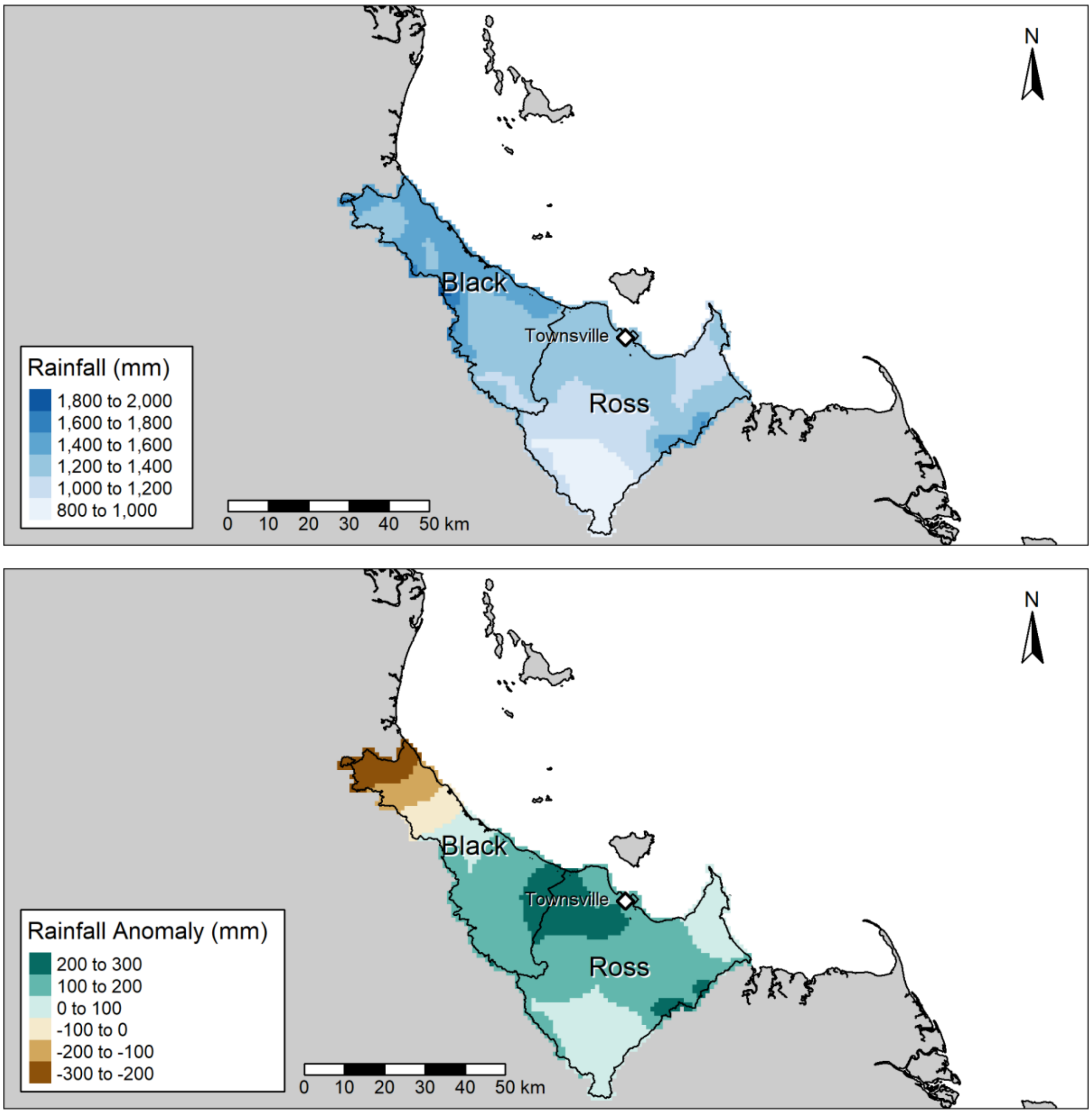


*Figure 5. Total annual rainfall and rainfall anomaly in the Ross and Black Basin.*

### 9.2.2 Air Temperature

Mean monthly air temperature[6] was consistently equal to or greater than average every month of the reporting period across both the Ross and Black basins. For five months of the year each basin recorded their "highest 1%" air temperature on record ( Table 19).

[6] All air temperature data was downloaded from BOM's [Gridded Climatology Data] portal (Bureau of Meteorology 2022)

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

| Basin | 2021 | | | | | | 2022 | | | | | | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | |
| Ross | Highest 1% | Highest 1% | Average | Highest 1% | Very much above average | Above Average | Very much above average | Above Average | Highest 1% | Highest 1% | Very much above average | Average | Highest 1% |
| Black | Highest 1% | Highest 1% | Average | Highest 1% | Very much above average | Above Average | Very much above average | Above Average | Highest 1% | Highest 1% | Very much above average | Average | Highest 1% |

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

The mean annual air temperature was 25.4°C in the Ross Basin, and 24.9°C in the Black Basin (Table 18).

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

| Basin | Annual Air Temperature | Long-term mean (ltm) | Anomaly (+/- ltm) | Percentage of the ltm |
|---|---|---|---|---|
| Ross | 25.4°C | 24.0°C | +1.4°C | 106% |
| Black | 24.9°C | 23.5°C | +1.4°C | 106% |

Maximum mean annual temperatures of more than 26°C were recorded in both basins and a minimum mean temperature of ~22°C in the Ross Basin and ~21°C in the Black Basin was recorded. (Figure 6). All areas within the Dry Tropics regions recorded mean temperatures above the long-term mean, with a difference of ~1.30°C to ~1.50°C throughout, particularly in the most northern reaches of the Black Basin (Figure 6).

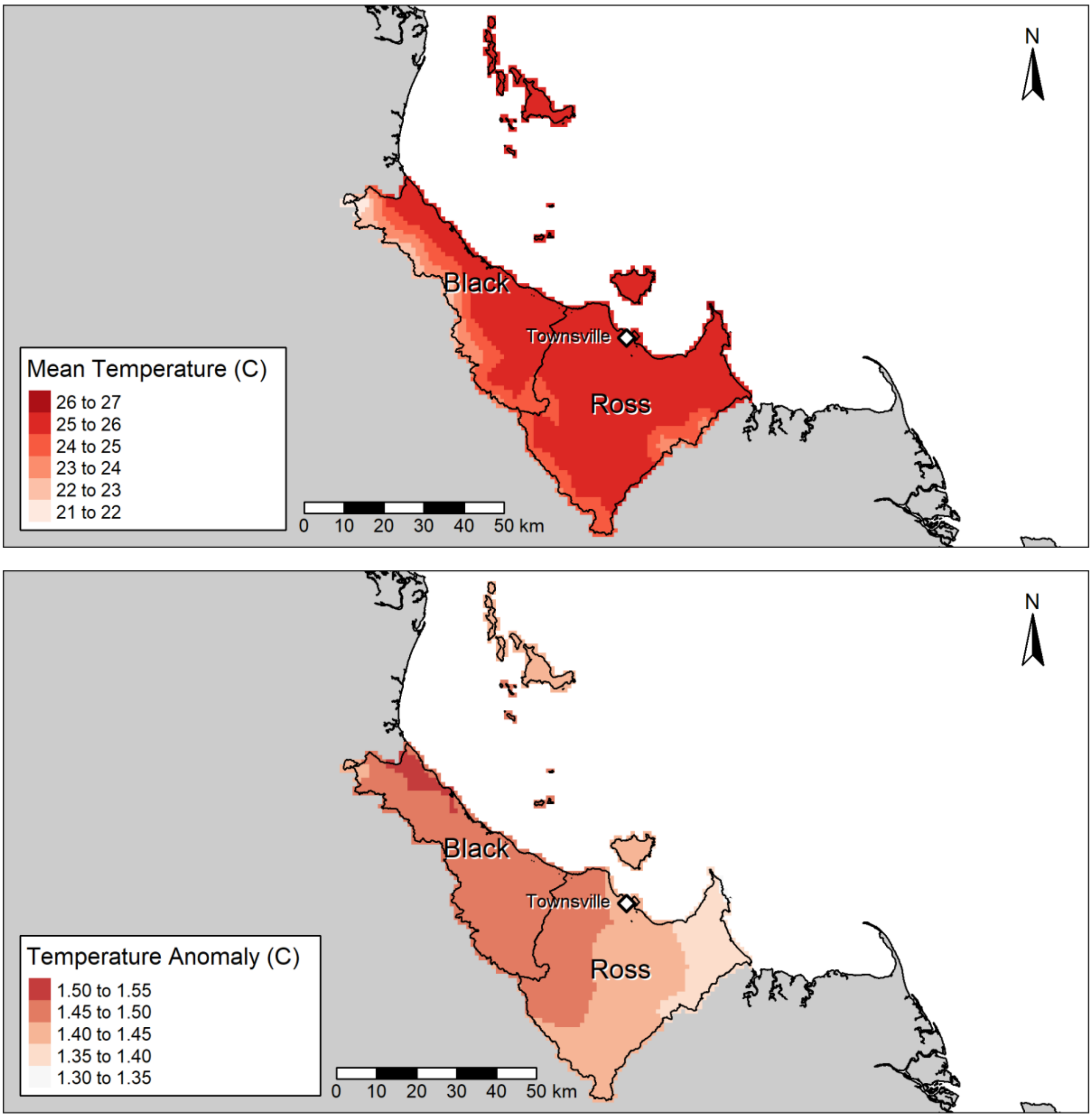


*Figure 6. Total annual air temperature and air temperature anomaly in the Ross and Black Basin.*

### 9.2.3 Sea Surface Temperature

Monthly sea surface temperature[7] in the Dry Tropics marine region was "very much above average" or the "highest 1%" on record for ten months of the year. February and September were the only two months of the year where monthly sea surface temperature remained "average" or "above average" respectively (Table 21).

[7] All sea surface temperature data was downloaded from NOAA's [Coral Reef Watch] portal (NOAA 2023)

*Table 21. Monthly air 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dry Tropics | | | | | | | | | | | | | |

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

The mean annual sea surface temperature in the Dry Tropics marine region was 27.1°C and represents an increase from last year in the Dry Tropics marine region (Appendix G, Table 22).

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

| **Region** | **Annual Sea Surface Temperature** | **Long-term mean (ltm)** | **Anomaly (+/- ltm)** | **Percentage of the ltm** |
|---|---|---|---|---|
| Dry Tropics | 27.1°C | 26.3°C | +0.8°C | 103% |

The highest temperatures were recorded in the northern most reaches of the marine region and gradually decreased southward. Annual sea surface temperature anomalies further highlighted that lower temperatures recorded approximately 30km offshore were not a frequent occurrence (Figure 7).

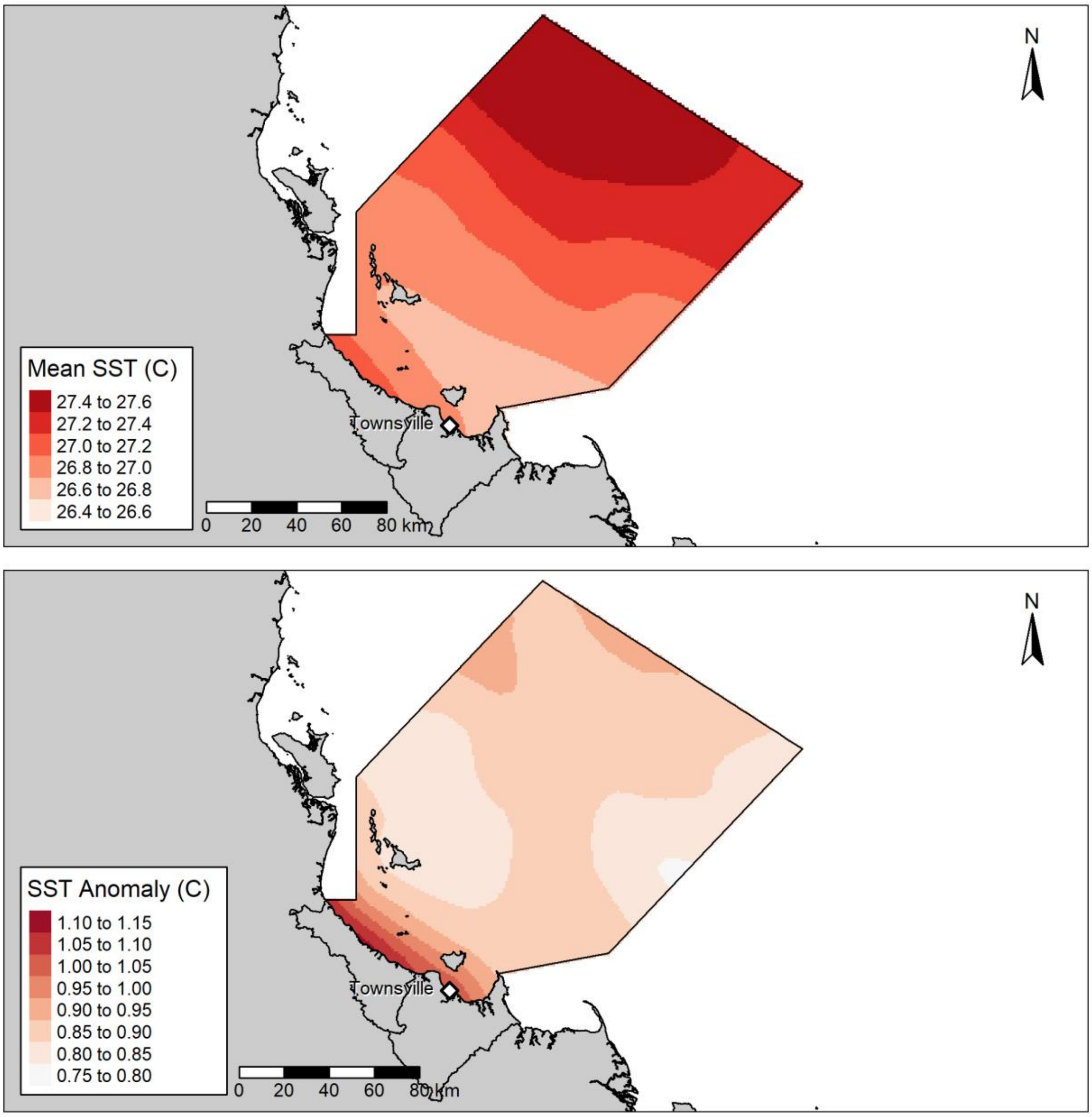


*Figure 7. Total annual sea surface temperature and sea surface temperature anomaly in the Dry Tropic marine region.*

### 9.2.4 Coral Bleaching (Degree Heating Weeks)

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[8] (NOAA 2023). In 2021–2022, coral bleaching risk in the Dry Tropics marine region ranged from "possible" to "highly likely", with no region showing low risk. DHWs ranged from 4 to 6, up to >8 and highly likely bleaching risk (>8 DHWs) was predominantly recorded in the coastal waters, and at the eastern edge of the region (Figure 8). The greater number of DHWs inshore aligns with the records of increased annual sea surface temperature and increased annual sea surface temperature anomalies in the same location (Sea Surface Temperature, Figure 7).

[8] All degree heating week data was downloaded from NOAA's [Coral Reef Watch] portal (NOAA 2023)

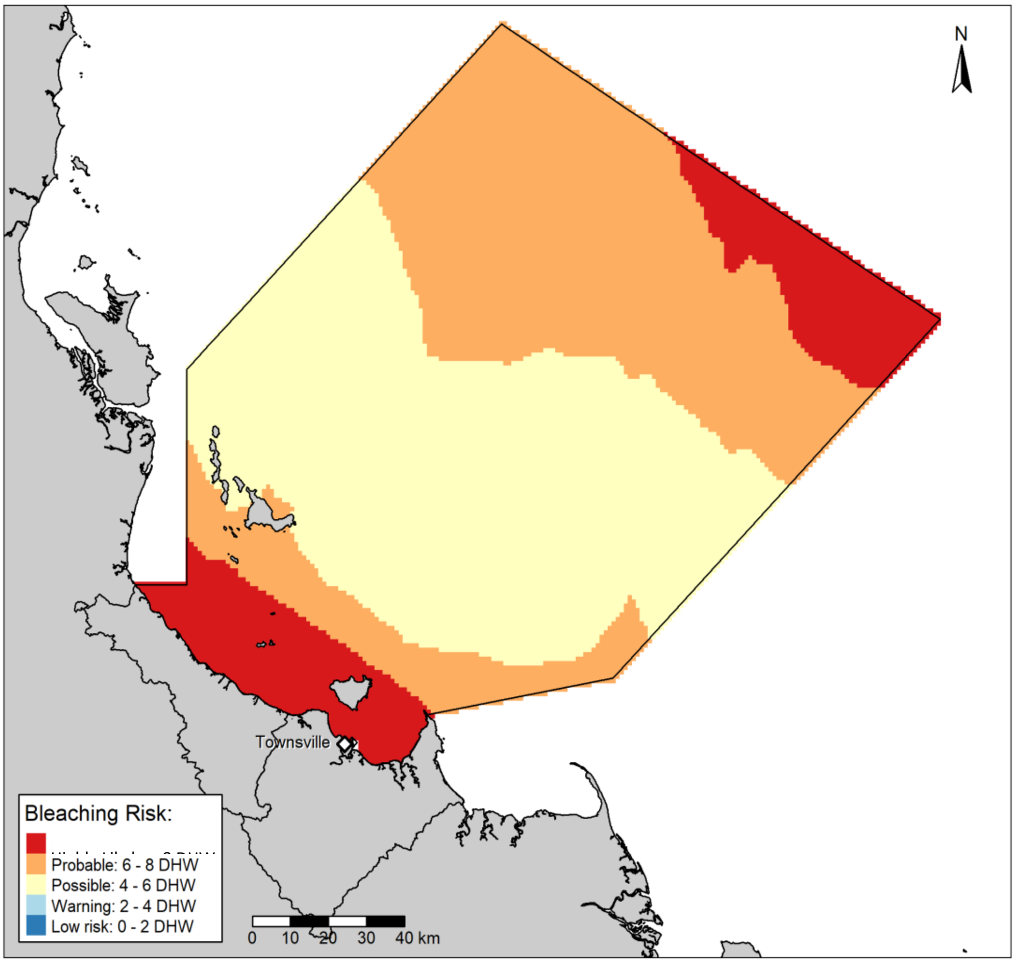


*Figure 8. Total annual degree heating weeks (bleaching events) in the Dry Tropic marine region.*

## 9.3 Climate and Land Use Summary

For the 2021–2022 report period, the Dry Tropics region experienced a variety of climatic conditions. Overall, the region could be described as rainier than usual, and hotter than usual. The updated land use category data showed an increase in both intensive and conservation land uses. Key points are summarised below:

- The major change in land use was a decrease in production from relatively natural environments, followed by an increase in conservation and natural environments, and an increase in intensive uses.
- Total annual rainfall in both basins was average, although slightly exceeded the long-term mean. However, monthly rainfall showed significant fluctuation ranging from “very much below average” to the “highest 1%” on record.
- Monthly air temperature across both basins was consistently equal to or greater than average and exceeded the long-term mean. For five months of the year each basin recorded their “highest 1%” air temperature on record for the month.
- The annual sea surface temperature was 27.1°C and exceed the long-term mean. Monthly average sea surface temperature was “very much above average” or the “highest 1%” on record for ten months of the year.

- The heat stress risk of coral bleaching ranged from "possible" to "highly likely" throughout the marine environment.

Dry Tropics Partnership for Healthy Waters
Waterways Report Card 2023

# TECHNICAL REPORT

## PART 3: Freshwater Results

Reporting on data collected 2021 - 2022

JULY 2023 | Dry Tropics Partnership for Healthy Waters (DTPHW)

Written by Adam Shand and Dinny Taylor

# 10 Freshwater Environment

Within the freshwater environment, water quality, habitat and hydrology, and fish are the three 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 DTPHW team. In the Dry Tropics region, the water quality index is updated annually, with the most recent data from the 2021–2022 financial year.

Index scores are calculated for the Ross Freshwater Basin and the Black Freshwater Basin. The extent of each basin is shown in Figure 9, and the results are presented below.

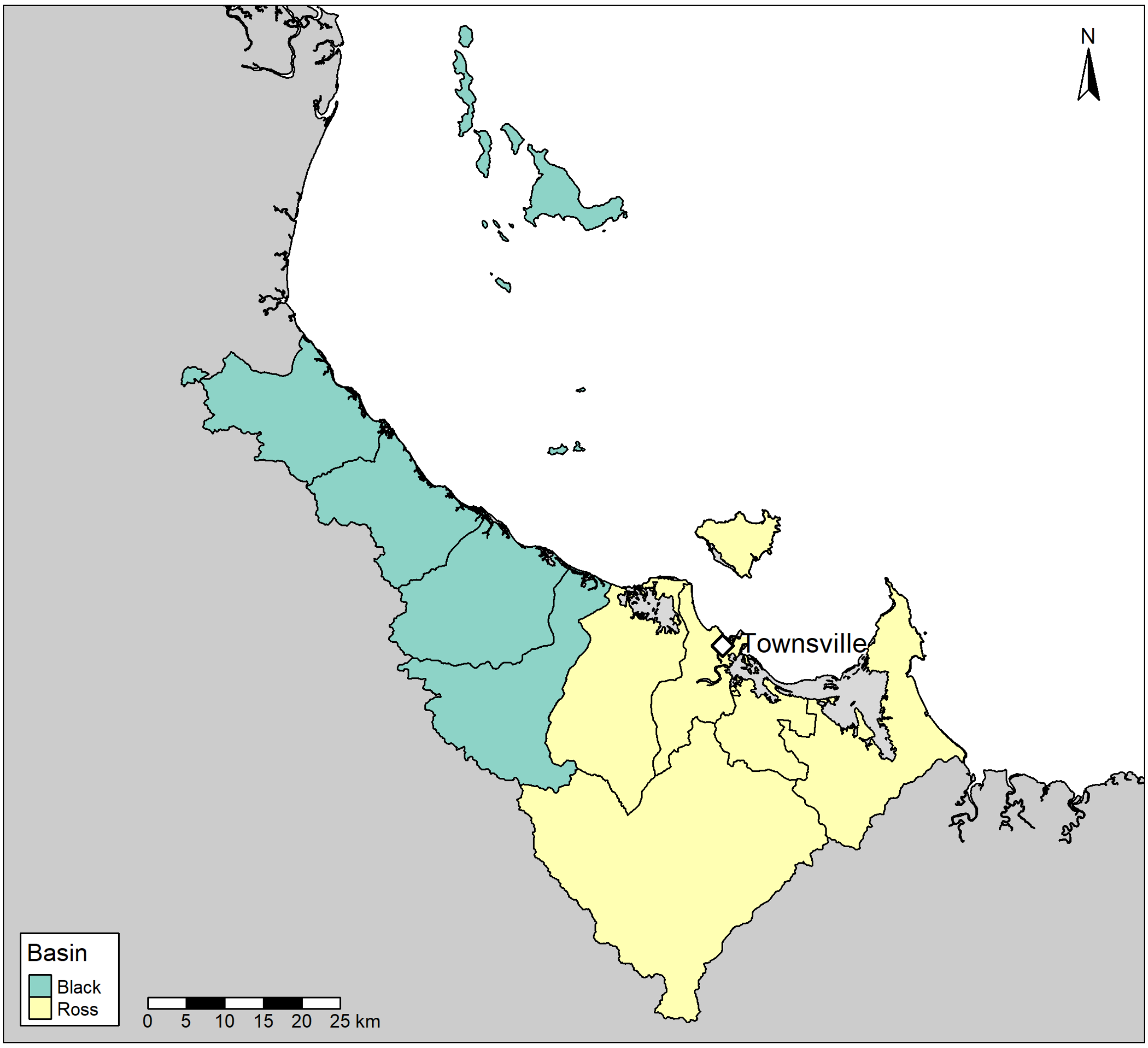


*Figure 9. Freshwater Basins and delineation of Sub Basins*

## 10.1 Water Quality

The water quality index for the freshwater environment of the 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 dissolved oxygen), calculated from the monthly medians.

The Methods Document (2023) 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 percentile fractions. The annual medians and percentile fractions are calculated from the monthly medians to remove the skewing associated with a greater number of samples collected during the wet season. Some sites become dry during the dry season and are unable to be sampled.

Weighted scores are calculated using the proportion of the total basin area for each sub basin. The weighted score for the basin is the sum of the average of the products of the sub basin proportion and their respective indicator scores[9].

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 22 sites spread across the two basins, divided into eight (8) sub basins in line with the WQIP (Townsville City Council, Queensland Government, Australian Government 2010) (Table 23 and Appendix I).

[9] $Weighted\ Basin\ Score = \sum_i^n \left(\frac{1}{m}\sum_j^m \left(Indicator_j * weight_i\right)\right)$

Where *i* is the Sub basin, *j* is the indicator, *n* is the number of sub basins, and *m* is the number of indicators

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

| Basin | Sub Basin | Water Course | Site |
|---|---|---|---|
| Ross | Bohle River | Bohle River | BOH22.3 |
| | | | BOH18.1 |
| | Lower Ross | Lower Ross River | Aplin's Weir |
| | | | Blacks Weir |
| | | | Gleesons Weir |
| | Upper Ross | Ross Lake | RLS1 |
| | | | RLS2 |
| | | | RLS3 |
| | | | RLS4 |
| | | | RLS5 |
| | | | RLS6 |
| | | | RLS7 |
| Black | Black River | Black River | BR6.8 |
| | Bluewater Creek | Althaus Creek | AltC7.0 |
| | | Bluewater Creek | BWC6.1 |
| | | Sleeper Log Creek | SLC5.2 |
| | Rollingstone Creek | Leichhardt Creek | LC4.5 |
| | | Saltwater Creek | SC2.7 |
| | | Rollingstone Creek | RC5.5 |
| | Crystal Creek | Ollera Creek | OC3.7 |
| | | Crystal Creek | CryC7.1 |
| | | Paluma Lake | Paluma Lake Site 1 |

### 10.1.2 Overall Summary: Freshwater Water Quality

The overall water quality has remained a grade of 'good' for both the Ross Freshwater Basin and Black Freshwater Basin, with a slight decrease in score for the Ross Freshwater Basin Table 24. This decrease is associated with a decrease in nutrient scores in the Ross Lake and Bohle Rivers as well as low, low dissolved oxygen scores across the basin.

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

| Basin | Nutrients | Phys-Chem Properties | Water Quality | | | |
|---|---|---|---|---|---|---|
| | | | 2021–2022 | 2020–2021 | 2019–2020 | 2018–2019 |
| Ross | 71 | 68 | 70 | 73 | 70 | 66 |
| Black | 73 | 64 | 68 | 68 | 67 | 62 |

**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.

#### 10.1.2.1 *Key Messages*

- The Ross Freshwater Basin saw a decrease in score from 73 to 70 within the same grade of 'good' with the decline associated with a decrease in the score for TP in Ross Lake and a decrease in the score for DIN in the Bohle River.
- The Black Freshwater Basin score and grade have remained stable across the reporting years 2019–2022.
- The Bohle River TP grade remains 'very poor' and the DIN scores have decreased with the grade decreased from 'moderate' to 'poor' compared with 2020–2021.
- There was an increase in the number of watercourses with 'very poor' or 'poor' scores associated with low dissolved oxygen % saturation in both the Ross and Black freshwater basins in the 2021–2022 year.

### 10.1.3 Nutrients

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. Data source investigations have provided the comparison presented in Appendix J.

#### 10.1.3.1 *Results: Freshwater Nutrients*

The scores and grades for the Ross and Black freshwater basins, and their associated sub basins are presented in Table 25 and the annual medians, total number of samples collected, the number of months in which sampling occurred, WQO and SF are presented in Appendix J.

The nutrient indicator category for the Ross Freshwater Basin was graded as 'good' with a weighted score of 71. The Upper Ross and Lower Ross sub basins were graded as 'good', whilst the Bohle River was graded as 'poor' for nutrients. However, it is noted that this does not include a score for TP for two of the three sites within the Lower Ross as data is not available. Comparison of the available FRP data for these sites (Appendix J) with the available WQO suggests that these sites would receive a score of 90 for FRP. In this scenario, the nutrient grade for the Lower Ross would increase (~79) as the sub basin score is the average of the nutrient scores for the watercourses. Whilst the DIN scores for Aplin's Weir and Blacks Weir are lower than for Gleesons Weir, they are relatively stable when considering historical data (Appendix K).

The Bohle River TP grade remains 'very poor' and the DIN scores have decreased from 54 to 48 with the grade remaining 'moderate' compared with 2020–2021. The source of nutrient inputs to the Bohle River continue to require investigation, so that management can be implemented to improve the water quality.

The nutrient indicator category for the Black Freshwater Basin was graded as 'good' with a weighted score of 73. Each of the sub basins achieved this grade, except Rollingstone Creek, which achieved a grade of 'very good'. Althaus Creek had a decrease in grade for TP from 2020–2021 to 'moderate'. Whilst data was available for DIN for Paluma Lake, it was not included in the report as the ammonium component had a higher limit of reporting than its water quality objective.

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

| Basin | Sub Basin | Watercourse | Unweighted Score and Grade | | | | | Weighted Score and Grade | |
|---|---|---|---|---|---|---|---|---|---|
| | | | DIN | TP | Nutrients[10] | Weighting (%) | Area (km2) | Sub Basin | Basin |
| Ross | Upper Ross | Ross Lake | 90 | 61 | 75 | 0.32 | 458 | 24.2 | 71 |
| | Lower Ross | Aplins Weir | 61 | NA | 61 | - | - | - | |
| | | Gleesons Weir | 90 | NA | 90 | - | - | - | |
| | | Blacks Weir | 59 | 90 | 74 | - | - | - | |
| | | | 70 | 90 | 75 | 0.56 | 786 | 44.8 | |
| | Bohle River | Bohle Mid-Field | 36 | 0 | 18 | - | - | - | |
| | | Bohle Far-Field | 60 | 0 | 30 | - | - | - | |
| | | | 48 | 0 | 24 | 0.12 | 169 | 2.9 | |
| | | | 66 | 37 | 58 | 1 | 1413 | | |
| Black | Black River | Black River | 63 | 61 | 62 | 0.37 | 250 | 23.1 | 73 |
| | Bluewater Creek | Althaus Ck | 90 | 48 | 69 | - | - | - | |
| | | Bluewater Ck | 66 | 90 | 78 | - | - | - | |
| | | SleeperLog Ck | 71 | 90 | 80 | - | - | - | |
| | | | 75 | 76 | 76 | 0.24 | 162 | 18.3 | |
| | Rollingstone Creek | Leichhardt Ck | 90 | 90 | 90 | - | - | - | |
| | | Saltwater Ck | 90 | 90 | 90 | - | - | - | |
| | | Rollingstone Ck | 62 | 90 | 76 | - | - | - | |
| | | | 80 | 90 | 85 | 0.21 | 145 | 18.3 | |
| | Crystal Creek | Ollera Ck | 71 | 90 | 80 | - | - | - | |
| | | Crystal Ck | 69 | 90 | 79 | - | - | - | |
| | | | 70 | 90 | 80 | 0.17 | 116 | 13.8 | |
| | Paluma Lake | Paluma Lake | NA | 90 | 90 | 0 | 2 | 0.3 | |
| | | | 74 | 82 | 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).

[10] 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.

### 10.1.4 Physical-Chemical Properties

#### 10.1.4.1 *Results: Freshwater Physical-Chemical Properties*

The scores and grades for the Ross and Black freshwater basins, and their associated sub basins are presented in Table 26 and the annual medians, total number of samples collected, the number of months in which sampling occurred, WQO and SF are presented in Appendix L.

The physical-chemical indicator category for the Ross Freshwater Basin was graded as 'good' with a weighted score of 68. The Lower Ross and Bohle River sub basins both received a grade of 'moderate' for the physical-chemical indicator category due to low scores for low dissolved oxygen. Unusually low dissolved oxygen % saturation was observed at Blacks Weir from December 2021 to June 2022, at Gleesons Weir from January to June 2022, and at Aplin's Weir from February to May 2022. The Bohle also had some sporadically low dissolved oxygen % saturation (~ 30% saturation) at varying times throughout the reporting year. Further, higher turbidity readings were observed in the Bohle during the wet season and may be associated with rainfall events.

The Black Freshwater Basin received a grade of 'good' with a weighted score of 64 for the physical-chemical indicator category. Of the sub basins, Paluma Lake, Crystal Creek, Rollingstone Creek, and Black River received a grade of 'good'. Low dissolved oxygen contributed to a lower score at Sleeper Log Creek (very poor), Rollingstone Creek (poor), Ollera Creek (very poor), and Paluma Lake (moderate). The consistency of the lower low dissolved oxygen scores across both the Ross and Black freshwater basins during the year suggests that there may have been some environmental influence contributing to this. Althaus Creek continued to have 'very poor' turbidity and Sleeper Log Creek turbidity score decreased to a grade of 'very poor'.

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

| Basin | Sub Basin | Watercourse | Unweighted Score and Grade | | | | | | Weighted Score and Grade | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Turbidity | High DO | Low DO | PhysChem | Weighting (%) | Area (km2) | Sub Basin | Basin |
| Ross | Upper Ross | Ross Lake | 90 | 90 | 90 | 90 | 0.32 | 458 | 28.8 | 68 |
| | Lower Ross | Aplin's Weir | 90 | 80 | 55 | 72 | - | - | - | |
| | | Gleesons Weir | 90 | 90 | 11 | 50 | - | - | - | |
| | | Blacks Weir | 90 | 90 | 19 | 54 | - | - | - | |
| | | | 90 | 86 | 28 | 59 | 0.56 | 786 | 33.3 | |
| | Bohle River | Bohle Mid-Field | 67 | 90 | 26 | 46 | - | - | - | |
| | | Bohle Far-Field | 66 | 90 | 40 | 53 | - | - | - | |
| | | | 66 | 90 | 33 | 50 | 0.12 | 169 | 6 | |
| | | | 82 | 88 | 40 | 61 | 1 | 1413 | | |
| Black | Black River | Black River | 90 | 47 | 90 | 68 | 0.37 | 250 | 25.5 | 64 |
| | Bluewater Creek | Althaus Ck | 0 | 90 | 90 | 45 | - | - | - | |
| | | Bluewater Ck | 90 | 79 | 66 | 78 | - | - | - | |
| | | Sleeper Log Ck | 0 | 90 | 20 | 10 | - | - | - | |
| | | | 30 | 86 | 59 | 44 | 0.24 | 162 | 10.7 | |
| | Rollingstone Creek | Leichhardt Ck | 90 | 90 | 61 | 75 | - | - | - | |
| | | Saltwater Ck | 75 | 90 | 90 | 82 | - | - | - | |
| | | Rollingstone Ck | 90 | 90 | 40 | 65 | - | - | - | |
| | | | 85 | 90 | 63 | 74 | 0.2148 | 145 | 16 | |
| | 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 | 55 | 72 | 0.003 | 2 | 0.2 | |
| | | | 70 | 84 | 60 | 63 | 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).

### 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 of method (*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 Habitat and Hydrology

The habitat and hydrology index for the freshwater basins of the Dry Tropic region consists of two habitat specific indicator categories and one hydrology specific indicator category. The habitat indicator categories are Freshwater Riparian Extent and Freshwater Wetland Extent. Both indicator categories source methodology from the Reef Water Quality Report Card[11]. The data used in the Reef Water Quality Report Card is updated approximately every four years with the next expected updated in 2023. The hydrology specific indicator category is Artificial Barriers and consists of two indicators: Impoundment Length and Fish Barriers. Results for these indicators are provided by a combination of partners of the DTPHW team. This data is updated approximately every four years.

### 10.2.1 Overall Summary: Freshwater Habitat and Hydrology

For the 2021-2022 reporting period the standardised scores for the habitat and hydrology index remained the same in both freshwater basins. The Ross Freshwater Basin received a score of 51 (moderate), and the Black Freshwater Basin received a score of 71 (good). Changes to the assessed area for the Wetland Extent indicator, and changes to the method of aggregation of the indicator categories did change scores. However, these updates have been incorporated and back calculated into the historic results presented below (Table 28).

[11] All results are downloaded from the Reef 2050 Water Quality Improvement Plan's [Reef Water Quality Report Card] (Australian Government 2023).

*Table 28. 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 2021–2022 | Habitat and Hydrology Index 2020–2021 | Habitat and Hydrology Index 2019–2020 |
|---|---|---|---|---|---|---|
| Ross freshwater | 44 | 60 | 49 | 51 | 51 | 5 |
| Black freshwater | 56 | 57 | 100 | 71 | 71 | 71 |

**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

#### 10.2.1.1 *Key Messages*

- The method of aggregation was updated for the 2021–2022 technical report. Historic scores have been back calculated to include this update (Appendix U).
- The area assessed for the wetland extent indicator category was updated for the 2021–2022 report. Historic scores have been back calculated to include this update (Appendix T).
- There was no change to the habitat and hydrology index scores for the 2021–2022 report.

### 10.2.2 Freshwater Riparian Extent

Currently the Dry Tropics Partnership uses the results published by the Reef Plan Great Barrier Reef Report Card with no changes, edits, or updates. The most recently published results are from 2017 and are included in this report.

#### 10.2.2.1 *Monitoring Sites*

The area assessed for the freshwater riparian extent indicator category includes all mapped waterway lines in the Ross Freshwater Basin and Black Freshwater Basin as per the Regulated Vegetation Management Category R data[12], and the Watercourse Lines datasets[13]. However, this currently does not include Ross Lake or waterways on any islands within the Dry Tropics reporting region (e.g., Magnetic Island), a map of the area is provided in Appendix M.

#### 10.2.2.2 *Results: Freshwater Riparian Extent*

The standardised score and grade for the freshwater riparian extent indicator category is calculated as a percentage lost/gained in 2017 compared to the amount of vegetation present during the 2013 assessment. Preclear estimates[14] of vegetation extent are presented to provide a broader overview of general vegetation trends.

For the 2021–2022 reporting period the total area of freshwater riparian extent[14] was approximately 25,365ha in the Ross Freshwater Basin, and 23,448ha in the Black Freshwater Basin (based on 2017 vegetation) which represents loss in both basins since 2013. From 2013 to 2017, Ross Freshwater Basin has lost 135ha (0.45%) of its freshwater riparian vegetation, and from preclearing estimates

---

[12] The Regulated Vegetation Management Category R data is available for download from QSpatial's [Catalogue] (Queensland Government 2023).

[13] The Watercourse Lines dataset is available for download from QSpatial's [Catalogue] (Queensland Government 2023).

[14] Total areas are estimates only as the exact pre-clear estimates used by the Reef 2050 plan is not provided.

has lost approximately 4,635ha (15.45%) in total, assuming the pre-cleared extent was 100% vegetated. In the Black Freshwater Basin, 0.52ha (0.20%) of riparian vegetation has been lost from 2013 to 2017, and approximately 2,552ha (9.81%) in total has been lost from preclearing estimates (Table 30).

*Table 29. Riparian Extent in the freshwater basin of the Dry Tropics.*

| Basin | Freshwater Riparian Extent | | |
|---|---|---|---|
| | 2017 (ha)[14] | 2013 (ha)[14] | Pre-clear (ha)[14] |
| Ross freshwater | ~25,365 | ~25,500 | ~30,000 |
| Black freshwater | ~23,448 | ~23,500 | ~26,000 |

In the Ross Freshwater Basin, the final standardised score was 44 (moderate) with an area loss of 135ha and percent loss of 0.45%, and in the Black Freshwater Basin the final standardised score was 56 (moderate) with an area loss of 0.52ha and percent loss of 0.20% (Table 30).

*Table 30. Riparian Extent loss and standardised score in the freshwater basin of the Dry Tropics.*

| Basin | Freshwater Riparian Extent | | |
|---|---|---|---|
| | Extent loss 2013–2017 | | Standardised Score |
| | $km^2$ | % | |
| Ross freshwater | -135[15] | -0.45 | 44 |
| Black freshwater | -52 | -0.20 | 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

### 10.2.3 Freshwater Wetland Extent

The Dry Tropics Partnership uses the same methods, data, and analysis as published by the Reef Plan Great Barrier Reef Report Card, with minor changes to the assessed area: including Magnetic Island and the Palm Island group in the analysis of wetland extent. This update has been back calculated and incorporated into all historic freshwater habitat and hydrology results presented in this report. Results prior to back calculation are provided in Appendix T.

#### 10.2.3.1 *Monitoring Sites*

The area assessed for the freshwater wetland extent indicator category covers the entire Ross and Black freshwater basins, as well as all islands within the Dry Tropics region. Maps of the wetlands within this area that area assessed are provided in Appendix Q.

#### 10.2.3.2 *Results: Freshwater Wetland Extent*

The standardised score and grade for the wetland extent indicator category is calculated as a percentage lost/gained in 2017 compared to the amount of vegetation present during the 2013

[15] Exact area changes are provided by the Reef 2050 Report and are known to this precision.

assessment. Vegetation extents from earlier years are presented to provide a broader overview of general vegetation trends.

For the 2021–2022 reporting period the total area of wetland riparian extent was 667.69ha in the Ross Freshwater Basin, and 440.47ha in the Black Freshwater Basin (based on 2017 vegetation) which represents loss in both basins since 2013. From 2013 to 2017, Ross Freshwater Basin has lost 0.78ha (0.11%) of its freshwater wetland vegetation, and from 2009 estimates has lost 3.62ha (0.54%). In the Black Freshwater Basin, 0.80ha (0.18%) of wetland vegetation has been lost from 2013 to 2017, and 2.57ha (0.58%) has been lost from 2009 (Table 31).

*Table 31. Wetland Extent in the freshwater basin of the Dry Tropics.*

| Basin | Freshwater Wetland Extent | | |
|---|---|---|---|
| | 2017 (ha) | 2013 (ha) | 2009 (ha) |
| Ross freshwater | 667.69 | 668.47 | 671.31 |
| Black freshwater | 440.47 | 441.27 | 443.04 |

In the Ross Freshwater Basin, the final standardised score was 60 (moderate) with an area loss of 0.72ha and percent loss of 0.11%, and in the Black Freshwater Basin the final standardised score was 57 (moderate) with an area loss of 0.80ha and percent loss of 0.18% (Table 32).

*Table 32. Wetland Extent loss and standardised score in the freshwater basin of the Dry Tropics.*

| Basin | Freshwater Wetland Extent | | |
|---|---|---|---|
| | Extent loss 2013–2017 | | Standardised Score (Grade) |
| | ha | % | |
| Ross freshwater | -0.72 | -0.11 | 60 |
| Black freshwater | -0.80 | -0.18 | 57 |

**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

#### 10.2.3.3 *Change to Assessed Area*

The update to the assessed area increased the score in the Ross Freshwater Basin from 59 to 60 and increased the score in the Black Freshwater Basin from 55 to 57 (Appendix T).

### 10.2.4 Artificial Barriers

Artificial in-stream barriers, such as weirs and dams are often built for flood mitigation purposes, water storage, drinking water supply, hydropower, or even to stop saltwater ingress (WaterNSW 2022, City of Townsville 2022). Although useful, these barriers often have a profound impact upon stream ecology, connectivity (e.g., fish migration), and natural water flow (Faulks 2011). 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 (results presented in this report) and fish barriers scheduled to be updated in 2023.

#### 10.2.4.1 *Monitoring Sites*

Both indicators define assessable waterways using the Waterways for Waterway Barrier Works data[16]. All waterways that were classified as "major" or "high" importance for fish movement and fish communities based on the Strahler stream order system were selected.

The assessed area for the impoundment length indicator has been updated to include all islands within the Dry Tropics region (e.g., Magnetic Island), although this had no impact on the standardised score for the indicator. Streams used, and their classification as either impounded or not impounded, are presented in Appendix R. There has been no change to the assessed area for the fish barriers indicator, the streams used, and the location of passable and impassable barriers is presented in Appendix S.

#### 10.2.4.2 *Results: Freshwater Impoundment length*

Total impoundment length in the Dry Tropics region has remained relatively consistent between reporting periods. In the Black Freshwater Basin, of the 659km of assessed waterways no impoundments were recorded. The Black Freshwater Basin received a very good score of 100, with no impounded waterways. In the Ross Freshwater Basin, the total amount of assessed waterways increased by 7km from 888km during the 2020–2021 reporting period, to 895km during this reporting period. This was due to the inclusion of Magnetic Island waterways; however, this had no impact on the final standardised score of 34. Throughout the Ross Freshwater Basin, no new impoundments were recorded, and the basin received a poor score, with 8.0% impoundment. This was due to the presence of the Ross River Dam, and three weirs (Black, Gleeson and Aplin's) on the Ross River.

*Table 33. Natural and Impounded stream length and standardised score in the freshwater basin of the 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.

#### 10.2.4.3 *Results: Freshwater Fish Barriers*

The fish barriers indicator category measures the frequency, location, and total number of barriers such in the waterway. All barriers were classified as either passable (a physical barrier that does not prevent fish movement) or impassable (a physical barrier that does prevent fish movement). There is no change to the results for the fish barriers indicator in the 2021–2022 technical report.

In the Ross Freshwater Basin, there were 12 barriers identified across five measured waterways. Of these four were classified as impassable, and all were located on the Ross River. Five of the remaining passable barriers were located on Stuart Creek, two on Bohle River, and one on Alligator Creek. Of the 357km of waterways assessed in the Ross Freshwater Basin, the average waterway length was 71.4km, and had an average of 1.6 passable and 0.8 impassable barriers. In the Black

[16] Data is available from the QSpatial [Catalogue]. Note that the currently available dataset is an updated (changed) version of the dataset used in this report.

Freshwater Basin 92km of the Black River was assessed, and no fish barriers, passable or impassable, were identified (Table 34).

*Table 34. Waterway characteristics and fish barriers in the Ross Freshwater Basin and Black Freshwater Basin.*

| Basin | Waterway Name | 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 |

For each waterway assessed in the Dry Tropics reporting region calculations of barrier density, percentage of stream to first passable barrier, and percentage of stream to first impassable barrier were conducted. In the Ross Freshwater Basin, barrier density ranged from 3.5km of waterway per barrier, to 65.9km per barrier, and percentage of passable and impassable waterway length ranged from 0.4% to 100%. In the Black Freshwater Basin, no barriers were recorded, thus barrier density was not applicable and percentage of stream to first barrier was 100% (Table 35). The fish barrier indicator received a standardised score of 65 (good) in the Ross Freshwater Basin, and 100 (very good) in the Black Freshwater Basin (Table 35).

*Table 35. 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 Total | 27.2km | 37.6% | 80.1% | 65 |
| Black River | NA | 100% | 100% | 100 |

**Barrier density scoring range:** ■ = Very Poor: 0 to 2km | ■ = Poor: >2 to 4km | ■ = Moderate: >4 to 8km | ■ = Good: >8 to 16km | ■ = >16km.

**Percentage of stream to first passable barrier scoring range:** ■ = Very Poor: 0 to <40% | ■ = Poor: 40 to <60% | ■ = Moderate: 60 to <80% | ■ = Good: 80 to <100% | ■ = 100%.

**Percentage of stream to first impassable barrier scoring range:** ■ = Very Poor: 0 to 60% | ■ = Poor: >60 to 80% | ■ = Moderate: >80 to 90% | ■ = Good: >80 to 100% | ■ = 100%.

**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.

#### 10.2.4.4 *Results: Freshwater Artificial Barriers*

Despite updates to the assessed area for impoundment length, the freshwater artificial barriers indicator category did not change during the 2021–2022 reporting period. Further, the fish barriers indicator has not been updated and thus all results for the artificial barriers indicator category remain unchanged. 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 36).

*Table 36. 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: 0 to <21 | ■ = Poor: 21 to <41 | ■ = Moderate: 41 to <61 | ■ = Good: 61 to <81 | ■ = Very Good: 81 to 100

#### 10.2.4.5 *Change to Aggregation and Wetland Extent Indicator*

The method of aggregation of the riparian, wetland extent, and artificial barriers indicator categories has been updated to provide equal weighting to each indicator category, this change moves the Dry Tropics 2021–2022 technical report to be in line with the reporting structure of the Reef 2050 report card. The area assessed for the wetland extent indicator category has been updated to include all islands in the Dry Tropics region. Results with these updates are presented in Table 28. Results before these updates are presented in Appendix U. In combination these changes changed the index score from 77 to 71 in the Black Freshwater Basin and from 50 to 51 in the Ross Freshwater Basin.

### 10.2.5 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. All indicator categories received; a maturity score of 2, as the methodology has been peer-reviewed, but not yet published; a directness scored of 2 as the data has a quantifiable relationship with estuarine habitat condition; and a measured error score of 1 as many components of the underlying dataset do not have their error quantified. The riparian extent and wetland extent indicator categories received a validation score of 2 as regular ground truthing does occur, however the artificial barriers indicator category only received a validation score of 1 as large amounts of data are based on remote sensing or regional expert opinion only. Finally, the representativeness of the two extent indicator categories received a score of 1 due to their sample size, while artificial barriers received a 2 due to its large sample size (relative to the population).

*Table 37. 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.

## 10.3 Fish

The Fish index for the freshwater basin of the Dry Tropics regions consists of two indicator categories, the Proportion of Indigenous Species Expected, and the Proportion of Non-Indigenous Species Expected. The Fish index is designed to provide a basic description of how similar regional fish communities are to the best available estimate of their natural state. Condition ratings are based on the median result across multiple sites within each basin, with each site generally being assessed on a single occasion. Non-indigenous fish affect aquatic plants and animals by competing for food and space, preying on native species, introducing exotic diseases and parasites, and driving habitat changes and therefore it is important to assess them within the environment (Department of Climate Change, Energy, the Environmental and Water 2023). Results for this index are provided by partners of the DTPHW team and are updated every three years.  The existing data is for the 2018-2019 period with the next update scheduled for the 2022–2023 technical report.

### 10.3.1 Proportion of Indigenous Species Expected and Proportion of Non-Indigenous Species Expected

Both the Proportion of Indigenous Species Expected (POISE) and Proportion of Non-Indigenous Species Expected (PONISE) indicator categories are the measure of observed verse expected species, they compare the richness of species captured during the sampling year against the predicted number of species calculated by a pre-disturbance model. The POISE indicator category compares the species richness of indigenous species, while the PONISE indicator category compares the species richness of translocated and alien species. PONISE is further broken into two indicators, the Proportion of Translocated Fish, and the Proportion of Alien Fish. The classification of fish as indigenous, translocated or alien is shown below (Table 38).

*Table 38. The distinction between indigenous, translocated, and alien fish species.*

| Native to Australia? | Native to Waterway? | Classification |
|---|---|---|
| Yes | Yes | Indigenous |
| Yes | No | Translocated |
| No | No | Alien |

#### 10.3.1.1 *Monitoring Sites*

24 sites had been sampled across the Dry Tropics region for the 2021–2022 report (2019 data). Sites were selected using an objective randomised design however five site locations had to adjusted. Four sites in the upper Ross River catchment (upstream of the Ross River Dam) could not be sampled due

to access constraints, and one site within the Black Weir pool could not be sampled due to resource constraints. These sites were moved elsewhere in accordance with the site selection method. A lack of sampling within the upper catchment and weir pool may have influenced results, however the current result is still considered reasonable in relation to other basins. In the Ross Freshwater Basin 11 sites were sampled across 9 unique waterways, with Alligator Creek assessed three times. In the Black Freshwater Basin 13 sites were sampled across 11 unique waterways, with Alice River and Crystal Creek both assessed twice (Appendix V).

#### 10.3.1.2 *Results*

A total of 7,741 fish were caught during sampling across the Dry Tropics region of which 110 were retained for laboratory confirmation of identification, 968 were introduced species that were euthanised, and the remainder were released unharmed. 33 unique species were caught during sampling with 26 species recorded in the Ross Freshwater Basin, and 23 species recorded in the Black Freshwater Basin (Appendix V). The basins shared 16 species and recorded the presence of both indigenous and alien species. Translocated species were only found in the Ross Freshwater Basin. Of the 26 species recorded in the Ross 22 were indigenous, three were alien, and one was translocated. Three indigenous species were recorded for the first time (Giant Mottled Eel, Bunaka and Scaleless Goby) (Appendix X). Of the 23 species recorded in the Black Freshwater Basin, 20 were indigenous and three were alien, all three alien species were found in both basins (Gambusia, Guppy and Mozambique tilapia) (Appendix Y).

The POISE indicator category was measured to be 0.62 in the Ross Freshwater Basin and 0.70 in the Black Freshwater Basin, showing that despite the large number of indigenous species, presence is still lower than the pre-disturbance model. Within the PONISE the translocated species indicator 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. Similarly, although some alien species were recorded, presence was low and the alien species indicator was measured to be 0.037 in the Ross Freshwater Basin, and 0.012 in the Black Freshwater Basin (Table 39).

*Table 39. Raw scores for the Proportion of Indigenous Species Expected, and Proportion of Non-Indigenous Species Expected indicator categories in the Dry Tropics region.*

| Basin | Proportion of Indigenous species Expected | Proportion of: | | |
|---|---|---|---|---|
| | | Translocated Species | Alien Species | Non-Indigenous Species Expected |
| Ross freshwater | 0.62 | 0.0 | 0.037 | 0.051 |
| Black freshwater | 0.70 | 0.0 | 0.012 | 0.012 |

**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.

**Scoring range (PONISE):** ■ = 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 0.3.

#### 10.3.1.3 *Final Result: Freshwater Fish*

In the Ross Freshwater Basin, the POISE indicator category received a standardised score of 54, and the PONISE indicator category received a standardised score of 60 for a fish index score of 57. In the Black Freshwater Basin, the POISE indicator category received a standardised score of 66, and the PONISE indicator category received a standardised score of 91 for a fish index score of 78. Overall, the fish index, and thus fish communities, were in a moderate condition within the Ross Freshwater

Basin and good condition within the Black Freshwater Basin (Table 40). Raw results and boxplots for the POISE and PONISE indicator categories are provided in Appendix X, Appendix Y, and Appendix Z.

*Table 40. Standardised score and grade for the Proportion of Indigenous Species Expected, and Proportion of Non-Indigenous Species Expected indicator categories, and Fish Index in the Dry Tropics region.*

| Basin | Proportion of: Indigenous Species Expected | Proportion of: Non-Indigenous Species Expected | Fish |
|---|---|---|---|
| Ross freshwater | 54 | 60 | 57 |
| Black freshwater | 66 | 91 | 78 |

**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

#### 10.3.1.4 *Key Messages*

- 7,741 fish of 33 unique species were caught during sampling across the Dry Tropics region, 6,773 fish from 29 unique species were indigenous, and 968 fish from four unique species were non-indigenous.
- Of the 26 species recorded in the Ross Freshwater Basin, 22 were indigenous, 3 were alien, and 1 was translocated. Of the 23 species recorded in the Black Freshwater Basin, 20 were indigenous and 3 were alien.
- 3 indigenous species were recorded for the first time in the Ross Freshwater Basin (Giant Mottled Eel, Bunaka and Scaleless Goby).

### 10.3.2 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 41).

*Table 41. Confidence scores for the fish index in the freshwater basin of the 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 (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.

Dry Tropics Partnership for Healthy Waters
Waterways Report Card 2023

# TECHNICAL REPORT

## PART 4: Estuarine Results

Reporting on data collected 2021 - 2022

JULY 2023 | Dry Tropics Partnership for Healthy Waters (DTPHW)

Written by Adam Shand and Dinny Taylor

# 11 Estuarine Environment

The Estuarine Environment in the Dry Tropics region is comprised of two basins: the Ross Estuarine Basin and the Black Estuarine Basin. In each basin the water quality, and habitat and hydrology indices are reported. The extent of each basin is shown in Figure 10, and results are presented below.

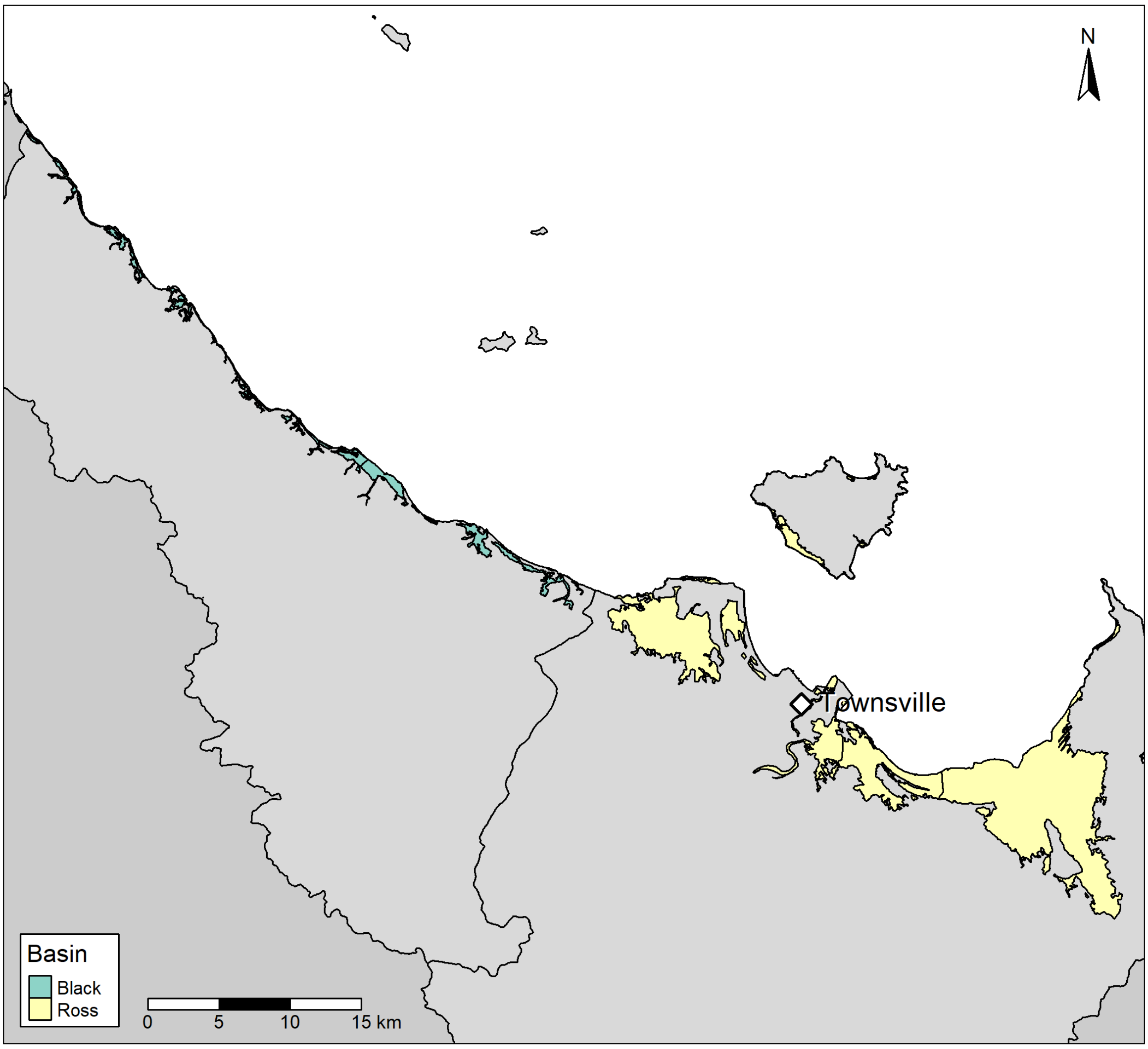


*Figure 10. Dry Tropics Estuarine Basins.*

## 11.1 Water Quality

The water quality index for the Estuarine Environment of the Dry Tropics region consists of two indicator categories: Nutrients, and Physical-Chemical Properties. Both indicator categories use data provided by multiple partners of the DTPHW team. The water quality index is updated annually, with the most recent updated including data from the 2021–2022 financial year.

### 11.1.1 Monitoring Sites

In the 2021–2022 technical report, all water quality data was collected from 22 sites. Sites were grouped into 13 watercourses, seven sub basins and two basins as detailed in Table 42, with locations presented in Appendix AA.

*Table 42. Dry Tropics estuarine water quality site summary.*

| Basin | Sub Basin | Watercourse | Site |
|---|---|---|---|
| Ross Estuarine | Bohle | Bohle River | BOH3.9 |
| | | Louisa Creek | LOU0.9, LOU6.0, TC4A |
| | Lower Ross | Ross Creek | RC04, RC07 |
| | | Ross River | RR05 |
| | Stuart | Sandfly Creek | CB3, CB9 |
| | Alligator | Alligator Creek | CB8 |
| Black Estuarine | Bluewater | Althaus Creek | AltC1.7 |
| | | Bluewater Creek | BWC2.4 |
| | | Sleeper Log Creek | SLC0.0, SLC2.0 |
| | Rollingstone | Camp Oven Creek | CO1, CO2, CO3 |
| | | Saltwater Creek | SWC0.6, SC1, SC2 |
| | | Rollingstone Creek | RolC0.8 |
| | Crystal | Crystal Creek | CryC1.0 |

### 11.1.2 Overall Summary: Estuarine Water Quality

The water quality index has improved since the 2018–2019 Dry Tropics Report for both estuarine basins. In the Ross Estuarine Basin, the index improved from a score of 39 (poor) in 2018–2019, to a score of 88 (very good) in 2019–2020 with the low scores in 2018–2019 attributed to the 2019 flood. The scores for the water quality index have remained relatively consistent over the last three reporting periods and the index decreased from 88 to 83, although has kept a "very good" grade.

In the Black Estuarine Basin, the index improved from 52 (moderate) in 2018–2019 to 64 (good) in 2021–2022. The index score also improved between the 2019–2020 and 2020–2021 reports from 47 to 66 but decreased from 66 to 64 between the 2020–2021 and 2021–2022 reporting periods (Table 43).

*Table 43. Current and previous water quality scores and grades for the Dry Tropics Estuarine Basins.*

| Basin | Nutrients | Phys-Chem Properties | Water Quality | | | |
|---|---|---|---|---|---|---|
| | | | 2021–2022 | 2020–2021 | 2019–2020 | 2018–2019 |
| Ross Estuarine | 88 | 78 | 83 | 88 | 88 | 39 |
| Black Estuarine | 74 | 55 | 64 | 66 | 47 | 52 |

**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.

### 11.1.3 Key Messages

- There was no change to the water quality index grade (although the Ross Estuarine score decreased from 88 to 83 and Black Estuarine score decreased from 66 to 64).
- 9 of 13 watercourses received a grade of "good" or "very good" for both the nutrients and physical-chemical properties indicator categories.
- The Camp Oven Creek and Crystal Creek watercourses exhibited unusually low Turbidity scores and should be closely monitored moving forward.

- Althaus Creek shows ongoing issues with the Turbidity indicator, and further investigation is required to isolate specific drivers.

Louisa Creek shows ongoing issues with the Low DO and TP indicators and further investigation is required to isolate specific drivers.

### 11.1.4 Nutrients

For the 2021–2022 technical report the nutrients indicator category is comprised of two indicators, Dissolved Inorganic Nitrogen (DIN), and Total Phosphorus (TP). Full results can be found in Appendix CC.

#### 11.1.4.1 *Results: Estuarine Nutrients*

Median values for each indicator are compared against the relevant water quality objectives. Values are standardised before the comparison and aggregation of indicators. Median values, sample frequency, water quality objectives, and scaling factors are presented in Appendix BB, standardised scores are shown in Table 44.

##### 11.1.4.1.1 Ross Estuarine Basin

The Ross Estuarine Basin received a nutrient indicator category score of 88 (very good). Within the basin, five of six watercourses received nutrient indicator category grades of “very good”, with scores of 83 or greater. The Louisa Creek watercourse was the only location to receive a grade of “moderate” (score of 50), which was driven by the TP indicator at two of three sites. Other than the TP indicator in the Louisa Creek watercourse, all watercourses received grades of “very good” or “good” for both the TP and DIN indicators (Table 44).

The low scores for the TP indicator at two of three sites in the Louisa Creek watercourse may be the results of a variety of factors including water quality objectives, number of samples, sample timing, and sample location. However, the WQOs for Louisa Creek are identical to other watercourses in the Ross Estuarine Basin, and the median value is notably higher than the other locations. These both indicate the scores are driven by concentration rather than differences in objectives (Appendix BB).

Although the number of samples taken in the Louisa Creek watercourse is more than 3x that of any other watercourse in the Ross Estuarine Basin (Appendix BB), it appears unlikely that these additional samples picked up broad trends/events missed by samples in other watercourses. Samples were collected on the same days as the other locations and were consistently higher throughout the reporting period (Appendix FF, Figure 46, Appendix HH). Furthermore, historical analysis of the watercourses and sites show a consistent trend of high TP concentrations (Appendix GG, Figure 52) and low scores (Appendix AA). Finally, the distribution of the sites within the Louisa watercourse suggests an upstream point source and diluting effect, with scores generally increasing further downstream (Figure 44). These 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.

*Table 44. Unweighted standardised scores and grades for the nutrient indicator category and indicators in the Dry Tropics Estuarine Environment.*

| Basin | Sub Basin | Watercourse | Unweighted Score and Grade DIN | Unweighted Score and Grade TP | Unweighted Score and Grade Nutrients | Weighting (%) | Area (km2) | Weighted Score and Grade Sub Basin | Weighted Score and Grade Basin |
|---|---|---|---|---|---|---|---|---|---|
| Ross Estuarine | Bohle | Bohle River | 90 | 90 | 90 | | | | 88 |
| | | Louisa Creek | 79 | 22 | 50 | | | | |
| | | | 82 | 39 | 60 | 0.28 | 348 | 16.97 | |
| | Lower Ross | Ross Creek | 90 | 90 | 90 | | | | |
| | | Ross River | 90 | 90 | 90 | | | | |
| | | | 90 | 90 | 90 | 0.69 | 864 | 62.47 | |
| | Stuart | Sandfly Creek | 76 | 90 | 83 | 0.002 | 28 | 1.86 | |
| | Alligator | Alligator | 90 | 90 | 90 | 0 | 5 | 0.35 | |
| Black Estuarine | Bluewater Creek | Althaus Ck | 90 | 90 | 90 | | | | 74 |
| | | Bluewater Ck | 63 | 90 | 76 | | | | |
| | | SleeperLog Ck | 90 | 90 | 90 | | | | |
| | | | 83 | 90 | 86 | 0.48 | 278 | 41.39 | |
| | Rollingstone Creek | Camp Oven Creek | 80 | 90 | 85 | | | | |
| | | Saltwater Ck | 70 | 90 | 80 | | | | |
| | | Rollingstone Ck | 61 | 90 | 75 | | | | |
| | | | 73 | 90 | 81 | 0.23 | 135 | 19.02 | |
| | Crystal Creek | Crystal Ck | 65 | 90 | 77 | 0.2 | 119 | 15.85 | |

**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).

#### 11.1.4.1.2 Black Estuarine Basin

The Black Estuarine Basin received a nutrient indicator category score of 74 (good). Within the basin, all seven watercourses received a nutrient indicator category grade of “good” or “very good”, with scores of 75 or greater. The DIN indicator at site SC1 in the Saltwater Creek watercourse was the only indicator to not receive a grade of “good” or “very good”, instead received a grade of moderate (56). However this lower score does not appear to be consistent across multiple reporting periods (Appendix AA, Appendix GG, Figure 51).

### 11.1.4.2 *Physical Chemical Properties*

For the 2021–2022 technical report the physical-chemical properties indicator category is comprised of three indicators, Turbidity (NTU), High DO, and Low DO.

### 11.1.4.3 *Results: Estuarine Physical-Chemical Properties*

Median values for each indicator are compared against the relevant water quality objectives. Values are standardised before the comparison and aggregation of indicators (Lonborg 2016). Median values, sample frequency, water quality objectives, and scaling factors are presented in Appendix DD, standardised scores are shown in Table 45.

#### 11.1.4.3.1 Ross Estuarine Basin

The Ross Estuarine Basin received a physical-chemical properties score of 78 (good). Five of six watercourses received nutrient indicator category grades of “very good” or “good”, with scores of 78 or greater. The Louisa Creek watercourse was the only location to receive a grade of “moderate” (score of 45), which was driven by the Low DO indicator at two of three sites (Table 45).

In Louisa Creek, two of three sites have consistently scored “very poor” for the low DO indicator. These results are likely due to ongoing influences specific to the watercourse (Appendix DD, Appendix GG, Figure 55). These sites also received the “very poor” grade for TP. 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 (Figure 44).

#### 11.1.4.3.2 Black Estuarine Basin

The Black Estuarine Basin received a nutrient indicator category score of 55 (moderate). Four of seven watercourses received a nutrient indicator category grade of “good” or “very good”, with scores of 76 or greater. The Camp Oven Creek and Crystal Creek watercourses received grades of “moderate” and the Althaus Creek watercourse was the only location to receive a grade of “very poor” (16), which was driven by the Turbidity and High DO indicators. Despite the “good” or “very good” grade for most watercourses, scores for all indicators ranged from “poor” or “very poor” to “very good”.

*Table 45. Unweighted standardised scores and grades for the physical chemical indicator category and indicators in the Dry Tropics Estuarine Environment.*

| Basin | Sub Basin | Watercourse | Unweighted Score and Grade | | | | | | Weighted Score and Grade | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Turbidity | High DO | Low DO | Phys-Chem | Weighting (%) | Area (km2) | Sub Basin | Basin |
| Ross Estuarine | Bohle | Bohle River | 66 | 90 | 90 | 78 | | | | 78 |
| | | Louisa Creek | 66 | 90 | 24 | 45 | | | | |
| | | | 66 | 90 | 41 | 53 | 0.28 | 348 | 16.97 | |
| | Lower Ross | Ross Creek | 90 | 90 | 90 | 90 | | | | |
| | | Ross River | 90 | 90 | 70 | 80 | | | | |
| | | | 90 | 90 | 83 | 86 | 0.69 | 864 | 62.47 | |
| | Stuart | Sandfly Creek | 76 | 90 | 90 | 83 | 0.002 | 28 | 1.86 | |
| | Alligator | Alligator | 90 | 90 | 90 | 90 | 0 | 5 | 0.35 | |
| Black Estuarine | Bluewater Creek | Althaus Ck | 0 | 33 | 90 | 16 | | | | 55 |
| | | Bluewater Ck | 90 | 76 | 90 | 83 | | | | |
| | | SleeperLog Ck | 62 | 90 | 90 | 76 | | | | |
| | | | 53 | 72 | 90 | 63 | 0.48 | 278 | 41.39 | |
| | Rollingstone Creek | Camp Oven Creek | 42 | 90 | 54 | 48 | | | | |
| | | Saltwater Ck | 82 | 77 | 90 | 80 | | | | |
| | | Rollingstone Ck | 69 | 90 | 90 | 79 | | | | |
| | | | 63 | 84 | 74 | 69 | 0.23 | 135 | 19.02 | |
| | Crystal Creek | Crystal Ck | 7 | 90 | 90 | 48 | 0.2 | 119 | 15.85 | |

**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).

In two of the three watercourses (Camp Oven Creek, Crystal Creek), "very poor" grades for the Turbidity indicator are unexpected and are not consistent across multiple reporting periods (Appendix EE). Further, other indicators in these watercourses received grades of "good" or "very good" both for this reporting period, and previous periods which may indicate the lack of ongoing issues (Table 45, Appendix DD). However, for the Althaus Creek watercourse, consistently "very poor" Turbidity suggests an ongoing source of increased turbidity, possibly due to its proximity to the more urbanized Townsville region compared to other locations in the Black Estuarine Basin and further investigation is required (Appendix DD, Appendix GG, Figure 53).

### 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 46).

*Table 46. 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

The habitat and hydrology index for the estuarine environment of the Dry Tropics region consists only of habitat specific indicator categories and is referred to throughout as the habitat index. The habitat index is comprised of two indicator categories: Mangrove and Saltmarsh Extent, and Estuarine Riparian Extent. Both indicator categories use data from the regional ecosystem vegetation spatial layers[17]. In the Dry Tropics region this data is updated approximately every four years with the most recent update occurring in 2022 (publication of 2019 regional ecosystem vegetation).

### 11.2.1 Overall Summary: Estuarine Habitat

The scores and grades for the estuary habitat indicator categories and habitat index for 2021–2022, and the indices for previous reporting years are presented in Table 47. Scores have remained consistent over reporting years with no changes in grades or scores. In the Ross Estuarine Basin, the habitat index received a score of 73 (good) and in the Black Estuarine Basin, the habitat index received a score of 71 (good) (Table 47).

[17] All regional ecosystem data was downloaded from QSpatial's [Catalogue] (Queensland Government 2023).

*Table 47. Standardised score for the estuarine habitat index.*

| Basin | Mangrove and Saltmarsh | Riparian Extent | Habitat Index | | |
|---|---|---|---|---|---|
| | | | 2021–2022 | 2020–2021 | 2019–2020 |
| Ross Estuarine | 67 | 80 | 73 | 73 | 73 |
| Black Estuarine | 63 | 80 | 71 | 71 | 71 |

**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.

#### 11.2.1.1 *Key Messages*

- Across both habitat extent indicator categories vegetation loss was minimal, with a maximum loss of 0.09%. It should be noted that this amount of loss is within the margin of error of the method.
- The grade and score for the habitat index did not change in either the Ross or Black estuarine basins.

### 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. The specific regional ecosystem (RE) vegetation types that are selected to be included in this analysis are:

- RE 11.1.1 *Sporobolus virginius* grassland on marine clay plains
- RE 11.1.2 *Samphire forbland* on marine clay plains
- RE 11.1.3 Sedgelands on marine clay plains
- RE 11.1.4 Mangrove low open forest and/or woodland on marine clay plains

#### 11.2.2.1 *Monitoring Sites*

The entire estuarine environment in both the Ross and Black estuarine basins was assessed for mangrove and saltmarsh extent. The vegetation was separated into “no vegetation”, “other vegetation” (vegetation but not the target RE type), and mangrove and saltmarsh (target RE type). A map of the assessed area and the composition of these vegetation groups is provided in Appendix II.

#### 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 compared to the amount of vegetation present during the 2013 assessment. Other years of data are presented to provide a broader overview of general mangrove and saltmarsh trends.

For the 2021–2022 reporting period the total area of mangrove and saltmarsh extent was 11,620.9ha in the Ross Estuarine Basin, and 981.6ha in the Black Estuarine Basin (based on 2019 vegetation) which represents no loss in both basins since 2017. From 2013 to 2019, Ross Estuarine Basin has lost 7.9ha (0.07%) of mangrove and saltmarsh, and from preclearing estimates has lost 133.2ha (1.15%). In the Black Estuarine Basin, 0.9ha (0.09%) of mangrove and saltmarsh was lost from 2013 to 2019, and 9.3ha (0.95%) was lost from preclearing estimates (Table 48).

*Table 48. Mangrove and saltmarsh extent in the estuarine environment of the Dry Tropics.*

| **Basin** | **Mangrove and Saltmarsh Extent** | | | |
|---|---|---|---|---|
| | **2019 (ha)** | **2017 (ha)** | **2013 (ha)** | **Pre-clear (ha)** |
| Ross Estuarine | 11,620.9 | 11,620.9 | 11,628.8 | 11,754.1 |
| Black Estuarine | 981.6 | 981.6 | 982.5 | 990.9 |

Further, between 1997 and 2019, Ross Estuarine Basin lost 24ha (0.21%), which is less than one fifth of the loss from pre-clear to 2019. This suggests that most the vegetation loss in the Ross Estuarine Basin occurred before extensive record keeping began. In the Black Estuarine Basin, from 1997 to 2019 5ha (0.57%) of mangrove and saltmarsh was lost. This is roughly half of the total vegetation loss from pre-clearing to 2019, and suggests that only a moderate amount of land clearing occurred in the Black Estuarine Basin before record keeping began (Appendix KK, Appendix LL).

In the Ross Estuarine Basin, the final standardised score was 67 (B) with a total percent loss of only 0.07%, and in the Black Estuarine Basin the final standardised score was 63 (B) with a total percent loss of only 0.09% (Table 49).

*Table 49. Mangrove and saltmarsh loss and standardised score in the estuarine environment of the Dry Tropics.*

| **Basin** | **Mangrove and Saltmarsh Extent** | | |
|---|---|---|---|
| | **Extent loss 2013–2019** | | **Standardised Score (Grade)** |
| | **ha** | **%** | |
| Ross Estuarine | -0.79 | -0.07 | 67 |
| Black Estuarine | -0.09 | -0.09 | 63 |

**Standardised 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.

### 11.2.3 Estuarine Riparian Extent

The estuarine riparian extent indicator category provides a similar measure of estuarine vegetation, however, targets the riparian buffer zone of estuarine waters. The riparian buffer zone is defined as areas within a 50-metre buffer of each waterway, and the indicator category includes any vegetation that is present within the zone (Scarth, et al. 2006). Although not targeting specific vegetation groups, this measure provides insight into any vegetation loss in the critical buffer zone which plays an important role in water quality and water flow (Hoffmann 2009).

#### *11.2.3.1 Monitoring Sites*

The estuarine riparian buffer zone in both the Ross and Black estuarine basins was assessed for total vegetation extent. The vegetation was separated into no vegetation, and vegetation. A map of the assessed area and the composition of these vegetation groups is provided in Appendix JJ.

#### *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 compared to the amount of vegetation present during the 2013 assessment. Other years of data are presented to provide a broader overview of general riparian trends.

For the 2021–2022 reporting period the total area of mangrove and saltmarsh extent was 1,777.5ha in the Ross Estuarine Basin, and 125.5ha in the Black Estuarine Basin (based on 2019 vegetation) which represents no loss in both basins since 2017. From 2013 to 2019, both basins also had no loss of their riparian vegetation. In comparison to preclearing estimates Ross Estuarine Basin has lost 10.6ha (0.60%) of its estuarine riparian vegetation, and Black Estuarine Basin has lost 1.4ha (1.13%) (Table 50).

*Table 50. Estuarine riparian extent in the estuarine environment of the Dry Tropics.*

| Basin | Estuarine Riparian Extent | | | |
|---|---|---|---|---|
| | **2019 (ha)** | **2017 (ha)** | **2013 (ha)** | **Pre-clear (ha)** |
| Ross Estuarine | 1,777.5 | 1,777.5 | 1,777.5 | 1,788.1 |
| Black Estuarine | 125.5 | 125.5 | 125.5 | 127.0 |

In the Ross Estuarine Basin, from 1997 to 2019 1.3ha (0.07%) of estuarine riparian vegetation was lost. Although only a small amount, this indicates clearing of riparian vegetation is ongoing. However, from 1997 to 2019, Black Estuarine Basin there was no loss, which suggests all riparian vegetation loss occurred before extensive record keeping began, and that riparian land clearing has not occurred since (Appendix MM, Appendix NN).

In the Ross Estuarine Basin, the final standardised score was 80 (B) with no loss of riparian vegetation, and in the Black Estuarine Basin the final standardised score was 80 (B) with no loss of riparian vegetation (Table 51).

*Table 51. Estuarine riparian extent loss and standardised scores in the estuarine environment of the Dry Tropics.*

| Basin | Estuarine Riparian Extent | | |
|---|---|---|---|
| | **Extent loss 2013–2019** | | **Standardised Score (Grade)** |
| | **ha** | **%** | |
| Ross Estuarine | 0.0 | 0.0 | 80 |
| Black Estuarine | 0.0 | 0.0 | 80 |

**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.

### 11.2.3.3 *Back Calculated Scores*

As the spatial area assessed for the mangrove and saltmarsh indicator category was updated, results in previous technical reports have been superseded. Further, the additional of the riparian extent indicator category, has also impacted results. Previous results have been back calculated and updated in Table 47. Results before back calculation can be found Appendix OO.

The update increased the habit index score in the Ross Estuarine Basin from 71 to 73 and reduced the habitat index score in the Black Estuarine Basin from 77 to 71. The Mangrove and saltmarsh indicator category decreased from 71 to 67 in the Ross Estuarine Basin, and from 77 to 63 in the Black Estuarine Basin.

### 11.2.4 Confidence Scores

Confidence in the mangrove and saltmarsh extent and riparian extent indicator categories was moderate with a rank of 3 out of 5. For both indicator categories method maturity received a score of 2, as the methodology has been peer-reviewed, but not yet published. Validation received a 2 as the measures are based on remote sensing data with regular (but not comprehensive) ground truthing. Representativeness received a 2 as the remoting sensing data is at a scale of greater than 1:10,000 but less than 1:1,000,000. Directness scored a 1 as the loss of vegetation was not measured directly and was simply inferred by changes in cover in satellite imagery. And the measured error scored a 2 as some components of the underlying dataset do not have their error quantified.

*Table 52. 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.

dry tropics partnership for healthy waters

Dry Tropics Partnership for Healthy Waters
Waterways Report Card 2023

# TECHNICAL REPORT

## PART 5: Inshore Marine Results

Reporting on data collected 2021 - 2022

JULY 2023 | Dry Tropics Partnership for Healthy Waters (DTPHW)

Written by Adam Shand and Dinny Taylor

# 12 Inshore Marine Environment

The Inshore Marine Environment in the Dry Tropics region is comprised of two zones: Cleveland Bay and Halifax Bay. In each zone the water quality, and habitat and hydrology indices are reported. Zones are divided into sub zones based on their water types and water quality objectives. The extent of each zone and sub zone is shown in Figure 11, and results are presented below.

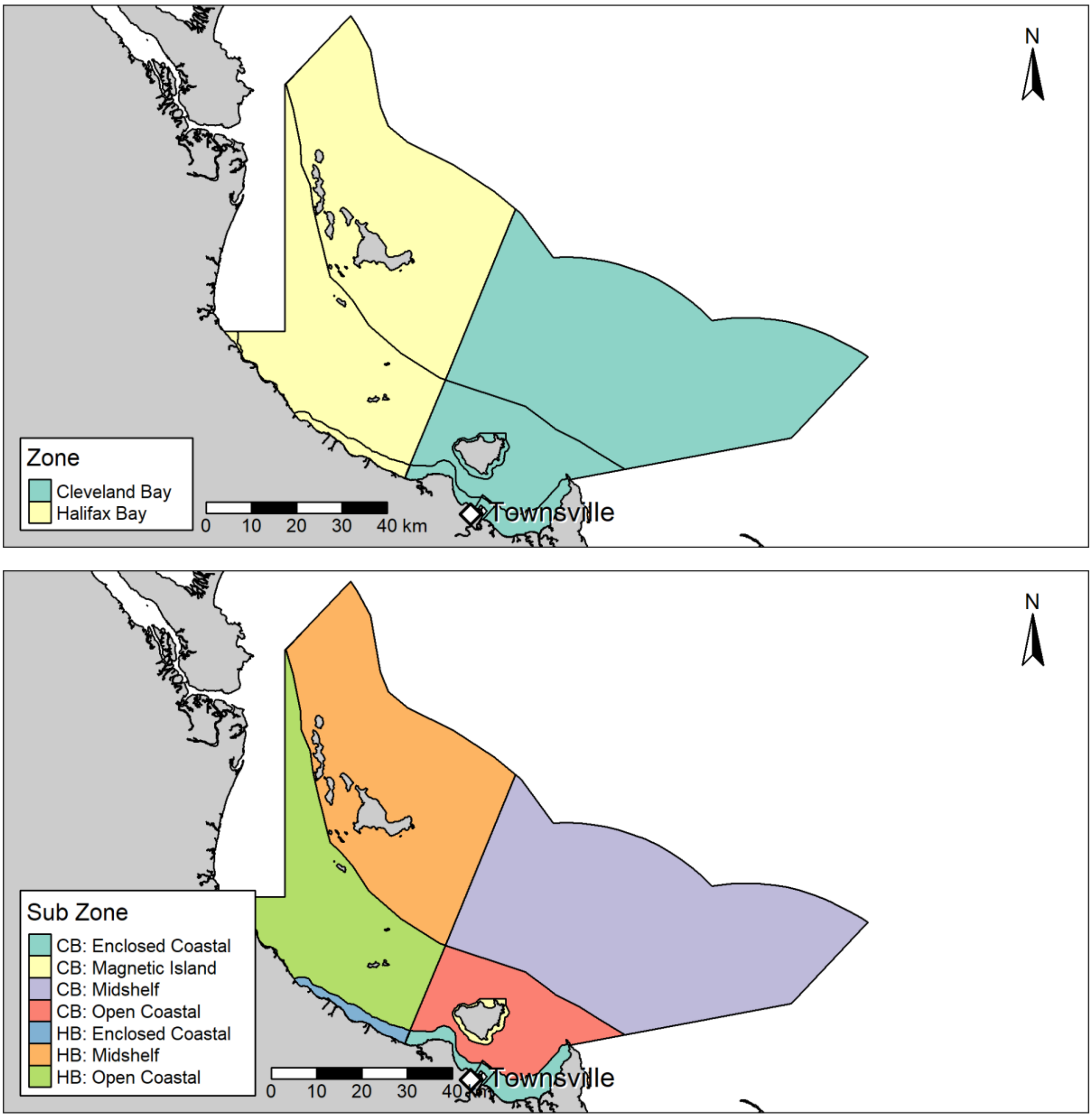


*Figure 11. Dry Tropics inshore marine zones and sub zones.*

## 12.1 Water Quality

The water quality index for the Inshore Marine Environment of the Dry Tropics regions consists of three indicator categories: Nutrients, Physical-Chemical Properties, and Chlorophyll *a*. All indicator categories use data provided by multiple partners of the DTPHW team. The water quality index is updated annually, with the most recent updated including data from the 2021–2022 financial year.

### 12.1.1 Monitoring Sites

In the 2021–2022 technical report, all water quality data was collected from 21 sites. Sites were grouped into eight geographic areas, six sub zones, and two zones as detailed in Table 53. Geographic areas each have unique water quality objectives and are grouped into a sub zone if they share the same water type. Site locations are presented in Appendix PP, and water quality objectives are presented in Appendix QQ, and Appendix TT.

*Table 53. Dry Tropics Inshore Marine water quality site summary.*

| Zone | Sub Zone | Geographic Area | Site[18] |
|---|---|---|---|
| Cleveland Bay | Enclosed Coastal | Enclosed Coastal: Inside Port Zone | 1, 2, 3 |
| | | Enclosed Coastal: Outside Port Zone | 4, 5, 6, 7, 8 |
| | Open Coastal | Open Coastal: Inside Port Zone | 9 |
| | | Open Coastal: Outside Port Zone | 10, 11, 12 |
| | Magnetic Island | Magnetic Island | 13, 14, 15 |
| Halifax Bay | Enclosed Coastal | Enclosed Coastal | 16, 17 |
| | Open Coastal | Open Coastal | 18, 19 |
| | Midshelf | Midshelf | 20, 21 |

### 12.1.2 Overall Summary: Inshore Water Quality

Scores for the water quality index have improved dramatically since the 2018–2019 Technical Report. In Cleveland Bay water quality has increased from a score of 36 (poor) in 2018–2019, to a score of 83 (very good) in 2019–2020 and has remained stable (81) since then. Halifax Bay water quality has increased from a score of 45 (moderate) to a score of 67 (good). However, scores for the water quality index have remained relatively consistent over the last three reporting periods. In Cleveland Bay the index decreased from 83, to 81 but kept a grade of "very good", and in Halifax Bay the index increased from 60 to 70 between 2019–2020 and 2020–2021, before decreasing to 67 in 2021–2022 (Table 54).

*Table 54. Current and previous water quality scores and grades for the Dry Tropics Inshore Marine Environment.*

| Zone | Nutrients | Phys-Chem Properties | Chlorophyll | Water Quality 2021–2022 | Water Quality 2020–2021 | Water Quality 2019–2020 | Water Quality 2018–2019 |
|---|---|---|---|---|---|---|---|
| CB | 78 | 74 | 92 | 81 | 81 | 83 | 36 |
| HB | 61 | 65 | 77 | 67 | 70 | 60 | 45 |

**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.

#### 12.1.2.1 *Key Messages*

- There has been no change in grade since the previous report card (although the score for Halifax Bay decreased from 70 to 67).

[18] Sites have been de-identified.

- All indicator categories have a grade of good or very good.
- The inclusion of additional indicators (TP and FRP) would create a net gain in scores across both zones.

### 12.1.3 Nutrients

For the 2021–2022 technical report the nutrients indicator category is comprised of four indicators, Nitrogen Oxides (NOx), Particulate Nitrogen (PN), Particulate Phosphorus (PP), and Total Phosphorus (TP). Total Nitrogen (TN), and Filterable Reactive Phosphorus (FRP), have been included as the exploration of a potential new indicators, however, are not included in the aggregation of indicators to the indicator category level.

#### 12.1.3.1 *Results: Inshore Nutrients*

Mean or median values (depending on the indicator) are compared against the relevant water quality objectives. Values are standardised before the comparison and aggregation of indicators (Lonborg 2016). Unstandardised values, sample frequency, and water quality objectives are presented in Appendix QQ, standardised scores are shown in Table 55. Some water quality objectives have been adjusted by local experts where necessary, these values are marked within tables, and unadjusted values can be found in Appendix RR.

##### 12.1.3.1.1 Cleveland Bay

Cleveland Bay received a nutrient indicator category score of 78 (good). Within the zone, two of three sub zones received nutrient indicator category scores of 100 (very good). However, the Magnetic Island Sub Zone received a score of 18 (very poor). All three indicators in this sub zone (NOx, PN, and PP) were graded as “poor” or “very poor” with scores of 0, 15, and 40 respectively (Table 55).

A low nutrients indicator category score in the Magnetic Island Sub Zone relative to other sub zones could be attributed to several factors. Considerations include, the use of different indicators and water quality objectives (WQOs), different sampling times and frequency, or differences in sampling programs and analysis methods (e.g. LORs) (Appendix QQ). Equally, nutrient pollution sources such as septic systems and large infrastructure projects in close proximity may be a core driver of a low grade and score. For three of four indicators, no comparison across all sub zones can be made, however the NOx indicator was collected at all sites and can be used to explore each of these factors.

The WQO for NOx in the Magnetic Island Sub Zone were 2–9x “stricter” than other sub zones and applying WQOs used in other sub zones may influence scores, however the WQOs have been specifically designed to be representative of desired water quality for each area. Further, NOx concentration was 3x higher in the Magnetic Island Sub Zone and signifies a measurable difference, regardless of objective values (Appendix QQ). Although samples were collected more frequently in the Magnetic Island Sub Zone, analysis revealed it was just as likely these additional samples recorded lower concentration values as they were to record higher concentration values (Appendix QQ). However, the specific time of day may have also played a role (e.g., sampling at low tide vs high tide) and further analysis of this variable is required.

*Table 55. Standardised scores and grades for the nutrient indicator category and indicators comprising the nutrient indicator category in the Dry Tropics Inshore Marine Environment.*

| Zone | Sub Zone | Area | NOx | PN | PP | TP | TN[19] | FRP[20] | Nutrients Area | Nutrients Sub Zone | Nutrients Zone |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cleveland Bay | Enclosed Coastal | Inside Port Zone | 100 | NA | NA | 100 | 100 | 100 | 100 | 100 | 78 |
| | | Outside Port Zone | 100 | NA | NA | 100 | 100 | 100 | 100 | | |
| | Open Coastal | Inside Port Zone | 100 | NA | NA | 100 | 100 | 100 | 100 | 100 | |
| | | Outside Port Zone | 100 | NA | NA | 100 | 81 | 100 | 100 | | |
| | Magnetic Island | Magnetic Island | 0 | 15 | 40 | NA | NA | 100 | | 18 (E) | |
| Halifax Bay | Enclosed Coastal | Enclosed Coastal | 0 | NA | NA | 100 | NA | 100 | | 61 | 61 |
| | Open Coastal | Open Coastal | 57 | 32 | 75 | NA | NA | 96 | | 57 | |
| | Midshelf | Midshelf | 64 | 45 | 83 | NA | NA | 96 | | 66 | |

**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.

[19] TN is included only as an indicator. TN is not aggregated within the nutrient indicator category.

[20] FRP is included only as an indicator. FRP is not aggregated within the nutrient indicator category.

The unique location and characteristics of the Magnetic Island Sub Zone are likely the main driver of a low NOx score. Although other sub zones are also in close proximity to large-scale infrastructure (e.g., Magnetic Island Marina and Townsville Port), the frequency of smaller infrastructure such as private septic systems is notably higher. Additionally, no other sites sample NOx so far offshore, and the sub zone is likely more exposed to large southern influences such as the Burdekin River (Appendix PP).

Overall, the sub zone frequently receives low scores and grades for the NOx indicator, and consistently records NOx concentrations at or above the water quality guideline levels (Appendix PP). Whereas other sub zones have generally recorded decreasing NOx concentrations over time, with values rarely meeting or exceeding the WQOs (Appendix XX, Figure 74).

##### 12.1.3.1.2 Halifax Bay

Halifax Bay Inshore received a nutrient indicator category score of 61 (good). Within the zone, two sub zones received nutrient indicator category grades of “good” and one sub zone received a grade of “moderate” (Table 55).

There is less contrast in the nutrient indicator category for sub zones in Halifax Bay, and for three of the four indicators, no complete comparison across all sub zones can be made. However, the NOx indicator was collected at all sites and can be used to explore the results. Similar to Cleveland Bay, differences in NOx scores and grades could be attributed to different water quality objectives (WQOs), sampling times, and sampling frequency. Although WQOs did vary, this variation was slight, and the main difference was in mean concentrations (Appendix QQ). Differences in sampling time and frequency were also minimal and showed no clear impact (Appendix ZZ). However, the specific time of day that the sample was collected may also play a role and further analysis is required.

The location of each sub zone may have influenced results and a trend of decreasing NOx concentrations and increasing NOx scores is apparent when moving offshore (Table 55, Appendix PP, Appendix QQ). The trend is visible to a lesser extent in the PN and PP indicators, however both indicators are only measured at two of three sites. Although aspects of the trend are apparent in previous reporting periods, temporal resolution is extremely limited, with results for the Enclosed Coastal Sub Zone only available for the previous reporting period (Appendix PP, Appendix XX).

Overall, this distribution suggests the sources of NOx and other nutrient indicators may be land based in origin with similar factors such as septic systems and runoff as core drivers. However, the mid and outer sub zones of Halifax Bay zone may also be more exposed to large southern influences such as the Burdekin River.

##### 12.1.3.1.3 New Indicators

Two new indicators (FRP and TN) were collected for the 2021–2022 reporting period. Although not included in the aggregation of indicators to produce the nutrients indicator category (Table 55), a secondary analysis has been conducted to review their effect (Appendix EEE). It was found that including these indicators created a net gain in nutrient scores, Cleveland Bay increased from 78 to 83, and Halifax Bay increased from 61 to 72. The FRP indicator had a positive effect at all sub zones, while the TN indicator reduced the nutrient score in one geographic area (Cleveland Bay Open Coastal Outside Port Sub Zone) and had no effect on any other sub zone. The inclusion of the FRP indicator resulted in multiple grade increases, at both the sub zone and zone level, the largest of which was the increase in Magnetic Island from a very poor grade (18) to a moderate grade (44). The inclusion of the FRP indicator in future reports would allow additional comparison of the same indicator across all sub zones.

### 12.1.4 Physical Chemical Properties

For the 2021–2022 technical report the physical-chemical properties indicator category is comprised of three indicators, Turbidity (NTU), Total Suspended Solids (TSS), and Secchi Depth (Secchi).

#### 12.1.4.1 *Results: Inshore Physical-Chemical Properties*

Mean or median values (depending on the indicator) are compared against the relevant water quality objectives. Values are standardised before the comparison and aggregation of indicators (Lonborg 2016). Unstandardised values, sample frequency, and water quality objectives are presented in Appendix TT, standardised scores are shown in Table 56. Some values have been adjusted by local experts where necessary, these values are marked within the tables, and unadjusted values can be found in Appendix UU.

*Table 56. Standardised scores and grades for the physical-chemical properties indicator category and indicators comprising the physical-chemical properties indicator category in the Dry Tropics Inshore Marine Environment.*

| Zone | Sub Zone | Area | Turbidity | TSS | Secchi | Physical-Chemical Properties | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Area | Sub Zone | Zone |
| Cleveland Bay | Enclosed Coastal | Inside Port Zone | 100 | 100 | 92 | 97 | 70 | 75 |
| | | Outside Port Zone | 0 | 3 | 83 (A) | 34 | | |
| | Open Coastal | Inside Port Zone | 100 | 100 | 100 | 100 | 75 | |
| | | Outside Port Zone | 39 | 54 | 39 | 43 | | |
| | Magnetic Island | Magnetic Island | 77 | 85 | 80 | | 81 | |
| Halifax Bay | Enclosed Coastal | Enclosed Coastal | 58 | 74 | NA | | 66 | 65 |
| | Open Coastal | Open Coastal | 77 | 72 | 6 | | 57 | |
| | Midshelf | Midshelf | 100 | 77 | 30 | | 72 | |

**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.

#### 12.1.4.1.1 Cleveland Bay

Cleveland Bay received a physical-chemical properties indicator category score of 75 (good). Within the zone, all sub zones received grades of “good” or “very good” however scores and grades for each indicator varied ranging from 0 to 100 for Turbidity, 3 to 100 for TSS, and 39 to 100 for Secchi (Table 56). 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 TT). Equally, spatial variations such as proximity to large river outflows, distance offshore, and proximity to the Cleveland Bay shipping channel may be a core driver of 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 TSS and Secchi were similar in the Open Coastal Outside Port Zone and Open Coastal Inside Port Zone areas, but differences in WQOs resulted in significantly different standardised scores (Table 56, Appendix TT, Appendix WW). However, WQOs have been specifically designed to be representative of desired water quality for the area, and further, differences are not always responsible for the variation. For example, the “very poor” scores for Turbidity and TSS in the Enclosed Coastal Outside Port Zone area were the result of very high mean values for each indicator, rather than variations in WQOs (Table 56, Appendix TT).

Very poor scores received by the Turbidity and TSS indicators in the Enclosed Coastal Outside Port Zone area are likely driven by a combination of spatial and temporal factors. For both indicators more than 4x as days of grab sampling was conducted, with additional days regularly recording higher Turbidity and TSS values (Appendix AAA, Figure 85, Appendix BBB, Figure 86). These additional sampling days may have picked up on events that were missed in other geographic areas such as dredging that has occurred during the Channel Upgrade program. Interestingly, the secchi indicator in the same geographic area (Enclosed Coastal Outside Port Zone) also did not have the additional sampling and received a notably higher score (Table 56, Appendix CCC). However, while the Turbidity and TSS indicators did receive more days of samples than secchi, the indicators also received samples across more sites. Specifically, Turbidity and TSS were recorded at sites 4, 5, 6, 7, 8, and 9, while secchi was only recorded at site 9 (Appendix PP). These additional sites were in close proximity to the mouth of Sandfly Creek, and downstream of the Cleveland Bay Waste Treatment plant and may have been negatively influenced.

#### 12.1.4.1.2 Halifax Bay

Halifax Bay received a physical-chemical properties indicator category score of 65 (good). Within the zone, two sub zones received nutrient indicator category grades of “good” and one sub zone received a grade of “moderate” (Table 56).

Across Halifax Bay a spatial trend of improved water quality further offshore is apparent, particularly for the Turbidity indicator, with a clear change in grade at each sub zone and similar stepped progression in mean values (Table 56, Appendix TT). Although the standardised grades for TSS in each sub zone do not display this trend, the mean values suggest a similar improvement in concentration between the enclosed and Open Coastal Sub Zones (Appendix TT). The secchi indicator is only measured at two of three sub zones but does show the same trend of improvement further offshore.

Overall, this distribution suggests the sources of decreased water clarity may be predominantly land based in origin, similar to nutrient indicators. Sediment run off and river flow are likely influences.

### 12.1.5 Chlorophyll *a*

#### 12.1.5.1 *Results: Inshore Chlorophyll* a

Mean chlorophyll *a* values are compared against the relevant water quality objectives. Values are standardised before the comparison and aggregation of indicators (Lonborg 2016). Unstandardised values, sample frequency, and water quality objectives are presented in Appendix TT, standardised scores are shown in Table 57. Some values have been adjusted by local experts where necessary, these values are marked within the tables, and unadjusted values can be found in Appendix TT.

*Table 57. Standardised scores and grades for the chlorophyll* a *indicator in the Dry Tropics Inshore Marine Environment.*

| Zone | Sub Zone | Area | Chlorophyll *a* Area | Chlorophyll *a* Sub Zone | Chlorophyll *a* Zone |
|---|---|---|---|---|---|
| Cleveland Bay | Enclosed Coastal | Inside Port Zone | NA | 100 | 92 |
| | | Outside Port Zone | 100 | | |
| | Open Coastal | Inside Port Zone | NA | NA | |
| | | Outside Port Zone | NA | | |
| | Magnetic Island | Magnetic Island | | 83 | |
| Halifax Bay | Enclosed Coastal | Enclosed Coastal | | 100 | 77 |
| | Open Coastal | Open Coastal | | 75 | |
| | Midshelf | Midshelf | | 54 | |

**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.

##### 12.1.5.1.1 Cleveland Bay

Cleveland Bay received a chlorophyll *a* indicator category score of 92 (very good). The Magnetic Island and Enclosed Coastal sub zones received grades of "very good" and the Open Coastal Sub Zone was not graded (Table 57). Mean values were below objectives in all locations (Appendix TT).

##### 12.1.5.1.2 Halifax Bay

Halifax Bay received chlorophyll *a* score of 77 (good). The Enclosed Coastal Water Sub Zone received a score of 100, the Open Coastal Waters Sub Zone received a score of 75, and the Midshelf Sub Zone received a score of 54. Interestingly, across the zone there appears to be a reversal of the spatial trend found in the other indicator categories (improvement further offshore). At each sub zone the grade decreases, from very good in the Enclosed Coastal Sub Zone to moderate in the Midshelf Sub Zone (Table 57).

#### 12.1.5.2 *Overlap with the Wet Tropics Technical Report*

The Dry Tropics reporting region shares sites 19, 20, 21, and 22 with the Wet Tropics reporting region (Table 53, Appendix PP). Underlying data is identical, however differences in aggregation and reporting style result in minor discrepancies in the final presentation of results (Appendix DDD).

### 12.1.6 Confidence Scores

Overall, there was low confidence in the results due to limited spatial and temporal sampling for some indicators in both bays (Table 58). 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. More sampling, both along the coast and further offshore, would enable a more accurate understanding of the water quality within the inshore area.

*Table 58. 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 and hydrology index for the Inshore Marine Environment of the Dry Tropic region consists only of habitat specific indicator categories and is therefore referred to throughout as the habitat index. 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 2022, Thompson 2023).

### 12.2.1 Overall Summary: Inshore Habitat

Habitat in Cleveland Bay received a score of 57 (good). Scores have improved on all previous years and show a recovery of habitat health to pre-2019 levels. Habitat in Halifax Bay, declined from all previous reporting periods but remained moderate with a score of 45. These results provide insight into the mixed habitat health of the Inshore Marine Environment, and several factors play a role in the grades and scores of this indicator, such as the residual impact of the 2019 flooding event (Table 59).

*Table 59. Standardised score for the Inshore Marine Environment habitat index.*

| Zone | Coral | Seagrass | Habitat Index | | | |
|---|---|---|---|---|---|---|
| | | | 2021–2022 | 2020–2021 | 2019–2020 | 2018–2019 |
| Cleveland Bay | 41 | 73 | 57 | 54 | 48 | 56 |
| Halifax Bay | 45 | ND | 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.

#### 12.2.1.1 *Key Messages*

- Habitat in Cleveland Bay has received its highest score in the past four years of 57.
- Habitat (coral) in Halifax Bay has received its lowest score in the past four years of 45.
- Seagrass in Cleveland Bay has almost recovered to pre-2019 flood conditions.

- Coral in Cleveland Bay has fluctuated between moderate and poor for the past four years.
- There remains a significant amount of macroalgae recorded at five of seven sites.

### 12.2.2 Coral

Coral data within the Dry Tropics Inshore Marine Environment was primarily collected by the Great Barrier Reef Marine Monitoring Program (MMP), and the Australian Institute of Marine Science's Long-term Monitoring Program (LTMP). Additional sampling was conducted by the citizen scientist group Reef Check Australia (RCA). Coral was monitored primarily between May 2022 and July 2022 as this allows most influences resulting from summer disturbances such as tropical cyclones and thermal induced coral bleaching to be realised. The coral indicator category is comprised of five indicators that make up the final score for each sample location. These five indicators are hard coral composition, percentage of hard coral cover, percentage change of hard coral, juvenile coral density, and macroalgae density. These five indicators are only measured by the MMP and LTMP while the coral monitoring conducted by RCA only measures the percentage of hard coral cover indicator. This is reflected in the scores shown below (Table 61).

#### 12.2.2.1 *Monitoring Sites*

Cleveland Bay and Halifax Bay were sampled for the Inshore Marine Environment coral assessment. 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, with two sites sampled twice by different monitoring programs (Pandora Reef and Havannah Reef) (Table 60). Reef locations are shown in Appendix FFF, noting that the Palms West Reef consists of two sites.

*Table 60. 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*

*The discussion of these results has been sourced from the Marine Monitoring Program Annual Report for inshore coral reef monitoring 2021–22 report*[21]*.*

"The coral indicator category score for the Dry Tropics Inshore Marine Environment has declined from a peak reached in 2020 and remains moderate in 2022. The decline is due primarily to Juvenile coral and Macroalgae scores. In contrast, the mean cover of corals across the region in 2022 reached its highest level since the inception of the MMP in 2005, despite exposure to high water temperatures that led to coral bleaching in 2020 and 2022. While attaining the highest level of coral cover observed during 18 years of monitoring is clearly a positive indication of the resilience of coral reefs in the region, low scores for the Macroalgae indicator suggest ongoing environmental pressures are limiting the condition of some reefs (Table 61)" (Thompson 2023).

*Table 61. 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 | 75 | 48 | 56 | 20 | 0 | 40 |
| | 2 | ND | 68 | ND | ND | ND | ND |
| | 3 | ND | 34 | ND | ND | ND | ND |
| | 4 | ND | 83 | ND | ND | ND | ND |
| | 5 | ND | 36 | ND | ND | ND | ND |
| Cleveland Bay | | 75 | 51 | 56 | 20 | 0 | 41 |
| Halifax Bay | 6 | 100 | 64 | 46 | 19 | 93 | 64 |
| | 7 | 0 | 47 | 60 | 43 | 100 | 50 |
| | 8 | 75 | 28 | 51 | 29 | 16 | 40 |
| | 9 | 50 | 50 | 51 | 23 | 0 | 35 |
| | 10 | 0 | 74 | 26 | 53 | 0 | 3 |
| | 11 | 100 | 17 | 50 | 88 | 0 | 51 |
| Halifax Bay | | 54 | 47 | 47 | 43 | 35 | 45 |

**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.

#### 12.2.2.2.1 Hard Coral Composition

"The composition indicator declined slightly from a high in 2020 but remains on the boundary between moderate and good in 2022. In general, the steady rise in this indicator through to 2020 tracked the recovery of sensitive corals impacted by TC Yasi and subsequent flood plumes of 2011. Moderate scores for this indicator demonstrate coral community composition remains consistent with the observed in the first years of monitoring.

[21] AIMS MMP data can be found [here].

#### 12.2.2.2.2 Percentage of Hard Coral Cover

There were modest gains in hard coral cover at Havannah, Palms West, and Pandora. Increases were attributed to recovery of *Acropora*, *Montipora*, *Isopora spp*, and a suite of low-abundance genera. The largest decline in coral cover occurred at Palms East, where cover declined from 45.5% in 2021 to 43.1% in 2022. Bleached corals were not observed at this reef and the cause of this decline appears to have been white syndrome disease amongst *Acropora.*

#### 12.2.2.2.3 Percentage Change of Hard Coral

The cover change indicator score for the region has remained moderate with a slight upward trend indicating recovery from the 2020 bleaching event and an ongoing positive balance between losses and gains in cover in recent years.

#### 12.2.2.2.4 Juvenile Density

Juvenile coral density has declined, particularly the Acropora spp., at all reefs measured since 2020. Juvenile density has always been variable among the Dry Tropics reefs but the consistent decline since the 2020 and 2022 bleaching events raise the potential for thermal stress to be impacting early life-history phases of corals. Thermal stress has been shown to lead to reproduction decreasing over subsequent spawning seasons (Ward 2002, Johnston 2020). Furthermore, historic recovery from acute events in the region has been shown to be slow and monitoring of coral settlement during the early years of the MMP indicated sporadic but generally low supply of larvae (Sweatman 2007, Cheal 2013, Davidson 2019). Both low larval supply, and low settlement, may logically contribute to the low density of juveniles on most reefs. Preliminary hydrodynamic modelling (Luick 2007, CSIRO 2023) and differences in population genetics of corals (Mackenzie 2004) indicate limited connectivity between inshore and offshore reefs, meaning local fluctuations are likely to directly influence larval supply.

#### 12.2.2.2.5 Macroalgae

The Macroalgae indicator has continued to decline and remains poor. Very poor scores were recorded at both Havannah and Pandora sites, and Geoffrey Bay where the cover of macroalgae increased or remained at high levels. The macroalgal communities are dominated by large brown species of the genus *Lobophora* and/or *Sargassum*. The high prevalence of macroalgae on many reefs are likely to be suppressing the recovery potential of coral communities. Except for Palms East, and Palms West, macroalgae are common among the reef's algae, as reflected in the poor score for Macroalgae. Although there is substantial variation in the mechanism and strength of interactions between macroalgae and the early life history stages of corals, it can be generally assumed that macroalgae will negatively influence the density of juvenile corals (Viera 2020, Doropoulos 2021). The causes for the recent increase in macroalgae are unknown." (Thompson 2023).

#### 12.2.2.2.6 Overall

In Cleveland Bay, the grade for the coral indicator category was moderate, with a score of 41. This is an improvement on the score and grade from the previous reporting period of 36 (poor), a decline on the 2019–2020 reporting period score of 44, and an improvement in 2018–2019 score of 38. In Halifax Bay, the grade for the coral indicator category was moderate, with a score of 45. This is a decline on the score from all previous reporting periods (48, 50, 52) (Table 62). A key driving factor may be the increased risk of coral bleaching demonstrated by the DHWs risk matrix (Figure 8) due to sea surface temperature increases. These results show a mixed trend of overall coral health as reefs have been exposed to pressures, such as increased water temperatures that contributed to coral bleaching in 2020 and continues to influence coral bleaching in 2022.

*Table 62. Inshore Marine Environment coral indicator category scores for current and previous technical reports.*

| Zone | Coral Standardised Score | | | |
|---|---|---|---|---|
| | 2021–2022 | 2020–2021 | 2019–2020 | 2018–2019 |
| Cleveland Bay | 41 | 36 | 44 | 38 |
| Halifax Bay | 45 | 48 | 50 | 52 |

**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.

#### 12.2.2.3 *Back Calculated Scores*

As the number of coral sites sampled for the 2021–2022 technical report has been updated. Previous results have been back calculated and updated in Table 62, while the original results can still be found in Appendix GGG.

### 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 2022)[22]. The LTSMP monitors seagrass annually during the dry season (September – October), when seagrasses are generally at the peak of distribution and abundance. The 2021–2022 technical report uses data collected during September to October in 2021.

#### 12.2.3.1 *Monitoring Sites*

In 2021–2022 seagrass was only monitored in Cleveland Bay. Across Cleveland Bay, ten seagrass meadows are monitored in the LTSMP, and are divided into three spatially distinct groups, Magnetic Island meadows, Cape Pallarenda/Strand meadows, and Cleveland Bay meadows (Table 63). Discussions will focus on these groups. Meadow locations are provided in Appendix HHH.

[22] The [Port of Townsville Seagrass Monitoring Program 2021] report can be found online.

*Table 63. Overview of the Long-term Seagrass Monitoring Program (LTSMP) meadows. Adapted from (Mckenna 2022).*

| 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*

*The discussion of these results has been sourced from the Port of Townsville Seagrass Monitoring Program 2021 report.*

"The seagrass indicator category is comprised of three indicators that make up the final score for each meadow. These indicators are biomass, area, and species composition. The final score for each meadow is calculated as the lowest individual score of the three indicators, except when species composition is the lowest score. When species composition is the lowest score the final meadow score is calculated as the average of the two lowest indicator scores (e.g., meadow 12 in (Table 64)." (Mckenna 2022).

*Table 64. Seagrass indicator scores for all meadows in the Cleveland Bay Inshore Marine Environment.*

| Region | ID | Biomass | Area | Species Comp. | Meadow Score |
|---|---|---|---|---|---|
| Magnetic Island | 3 | 72 | 86 | 100 | 72 |
| | 4 | 79 | 90 | 100 | 79 |
| | 5 | 59 | 72 | 99 | 59 |
| | 6 | 68 | 79 | 97 | 68 |
| Cape Pallarenda – Strand | 10 | 77 | 58 | 77 | 58 |
| | 12 | 96 | 100 | 80 | 88 |
| | 14 | 83 | 89 | 99 | 83 |
| | 15 | 76 | 83 | 88 | 76 |
| Cleveland Bay | 16 | 88 | 68 | 97 | 68 |
| | 17/18 | 79 | 93 | 97 | 79 |
| Overall | | | | | 73 |

**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.

#### 12.2.3.2.1 Magnetic Island seagrass meadows

"There are four monitoring meadows around Magnetic Island (Table 64, Appendix HHH). These meadows range from intertidal to deep-water (>8m below MSL) meadows. The seagrass indicator category score for all meadows in this area was of moderate or better condition for the 2021–2022 report.

The area indicator for all monitoring meadows around Magnetic Island was rated as good or very good compared to their historical baselines. In 2021 all meadows around Magnetic Island maintained a similar footprint to that of 2020 (Table 64).

The meadow biomass (density) indicator was in moderate or better condition for all Magnetic Island monitoring meadows. The intertidal Cockle Bay meadow (Meadow 5) was the only meadow that decreased in condition from good in 2020 to moderate in 2021. This decrease in biomass occurred relatively evenly across the meadow. Individual meadow biomass ranged from 1.69 g DW $m^2$ to 7.82 g DW $m^2$ around the island (Table 64).

The species composition indicator at all meadows was also above baseline conditions, with a species mix that reflected a very good condition in all meadows. The only notable change in species composition that occurred around the island was in the Cockle Bay Reef meadow (Meadow 5) where there was a substantial increase in the contribution of *Thalassia hemprichii* to the meadow. There was a corresponding decrease in the presence of *Cymodocea serrulata* in the meadow. These two stable species are very similar in biomass, so it is unlikely that this shift in dominant species was the cause of the biomass decline seen in the meadow (Table 64).

#### 12.2.3.2.2 Cape Pallarenda–Strand seagrass meadows

There are four monitoring meadows that make up the Cape Pallarenda–Strand region (meadows 10, 12, 14, 15) (Table 64, Figure 90). The seagrass indicator category for all meadows in this area was of moderate or better condition for the 2021–2022 report.

The biggest spatial changes between 2020 and 2021 across all monitoring meadows occurred in this region (area indicator). The intertidal/shallow subtidal *H. uninervis* meadow between Cape Pallarenda and Kissing Point (Meadow 12) increased to its largest recorded area in the program; 320ha. Most of the expansion of this meadow occurred at the deeper margins of the meadow and through the middle of the meadow where historically it has been patchy. The meadow adjacent to Meadow 12: the shallow subtidal *H. spinulosa* meadow, between Cape Pallarenda and Breakwater Marina (Meadow 14) also expanded in its distribution by up to 50%, changing in condition from good in 2020 to very good in 2021 for area. Most of the expansion of this meadow also occurred at the deeper margins of the meadow, with the meadow extending out to 5.2m below mean sea level (Table 64).

Meadow biomass across all meadows in this region remained in moderate or better condition, similar to 2020. For Meadow 12, along with the area indicator, there was a corresponding increase in meadow biomass to one of the highest meadow densities recorded for the meadow in the program; 5.36 g DW $m^2$. Much of the biomass increase occurred in the northern half of the meadow where higher density, continuous cover seagrass occurred. There were no other notable changes in meadow biomass for the other meadows in the region (Table 64).

Species composition for all four meadows in the region was in good or very good condition in 2021. Species composition has been relatively stable in the inshore *H. uninervis* meadow (12). In 2021 there was a higher proportion of *H. uninervis* 'wide' morphological form in the meadow which likely contributed to the increase in meadow biomass. Species composition in the adjacent subtidal *H. spinulosa* meadow has also been stable but the dominant species has switched through the years between *H. spinulosa* and *H. uninervis*. For the intertidal Shelley Beach (meadow 10), *Z. muelleri* species composition has been in good or very good condition since 2017. Similarly, species composition in the 'Strand' meadow (15) has been in very good condition for the last two years, with *H. uninervis* the dominant species over these years (Table 64).

##### 12.2.3.2.3 Cleveland Bay seagrass meadows

There are two monitoring meadows in Cleveland Bay: the intertidal *Z. muelleri* meadow (16) and the shallow subtidal *H. uninervis* meadow (17/18). These meadows are the largest coastal meadows in Townsville. Both meadows were in an overall good condition in 2021 in both programs (Table 64).

At the adjacent subtidal *H. uninervis* meadow (meadow 17/18), meadow biomass rebounded from a low in 2019, to be in good condition in 2020 and has remained in good condition through 2021. The area of this meadow has also been on an upward trajectory over the last several years. Much of this increase has been the result of meadow expansion at the deeper margins of the meadow. The species composition in the meadow has been stable since 2018. *Halodule uninervis* accounts for around 50% of the meadow biomass (Table 64)." (Mckenna 2022).

##### 12.2.3.2.4 Overall

In Cleveland Bay, the grade for seagrass monitoring meadows was good, with a score of 73. This is a slight improvement on the score from the previous reporting period (71) and a large improvement on the 2019–2020 reporting period score (52). These results show an upward trend of growth and recovery over the past three reporting periods for overall seagrass health (Table 65).

*Table 65. Standardised score for the seagrass indicator category.*

| Zone | Seagrass Standardised Score | | | |
|---|---|---|---|---|
| | 2021–2022 | 2020–2021 | 2019–2020 | 2018–2019 |
| Cleveland Bay Inshore Marine Zone | 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.

### 12.2.4 Confidence Scores

Confidence in the seagrass and coral indicator categories was high to very high. Seagrass had a rank of 5 out of 5, and the coral indicator had a rank of 3, and 4 (Cleveland Bay was not as well represented as Halifax Bay). Across both zones, the coral indicator received a maturity score of 3 as methods have been peer reviewed and published. Validation and directness both received a 3 as extensive on ground validation and direct measurement of corals occurs, and measured error received a 2 as some components of the indicator do not have their error quantified. Cleveland Bay received a representativeness score of 1.5 as although fives reefs are sampled, at four of these sites only one of the five coral indicators are measured. While Halifax Bay received a representativeness score of 2 as all five indicators are measured at six sites. The seagrass indicator category received a perfect confidence score, with a 3 in every category due to an extensive, and mature monitoring methodology, with more than ten years of monitoring across 10 distinct meadows.

*Table 66. 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.

Dry Tropics Partnership for Healthy Waters
Waterways Report Card 2023

# TECHNICAL REPORT

## PART 6: Offshore Marine Results

Reporting on data collected 2021 - 2022

JULY 2023 | Dry Tropics Partnership for Healthy Waters (DTPHW)

Written by Adam Shand and Dinny Taylor

# 13 Offshore Marine Environment

The Offshore Marine Environment in the Dry Tropics region consists of only one zone (the Offshore Marine Zone). In this zone water quality, and habitat and hydrology indices are reported. The extent of the zone is shown in Figure 12, and results are presented below.

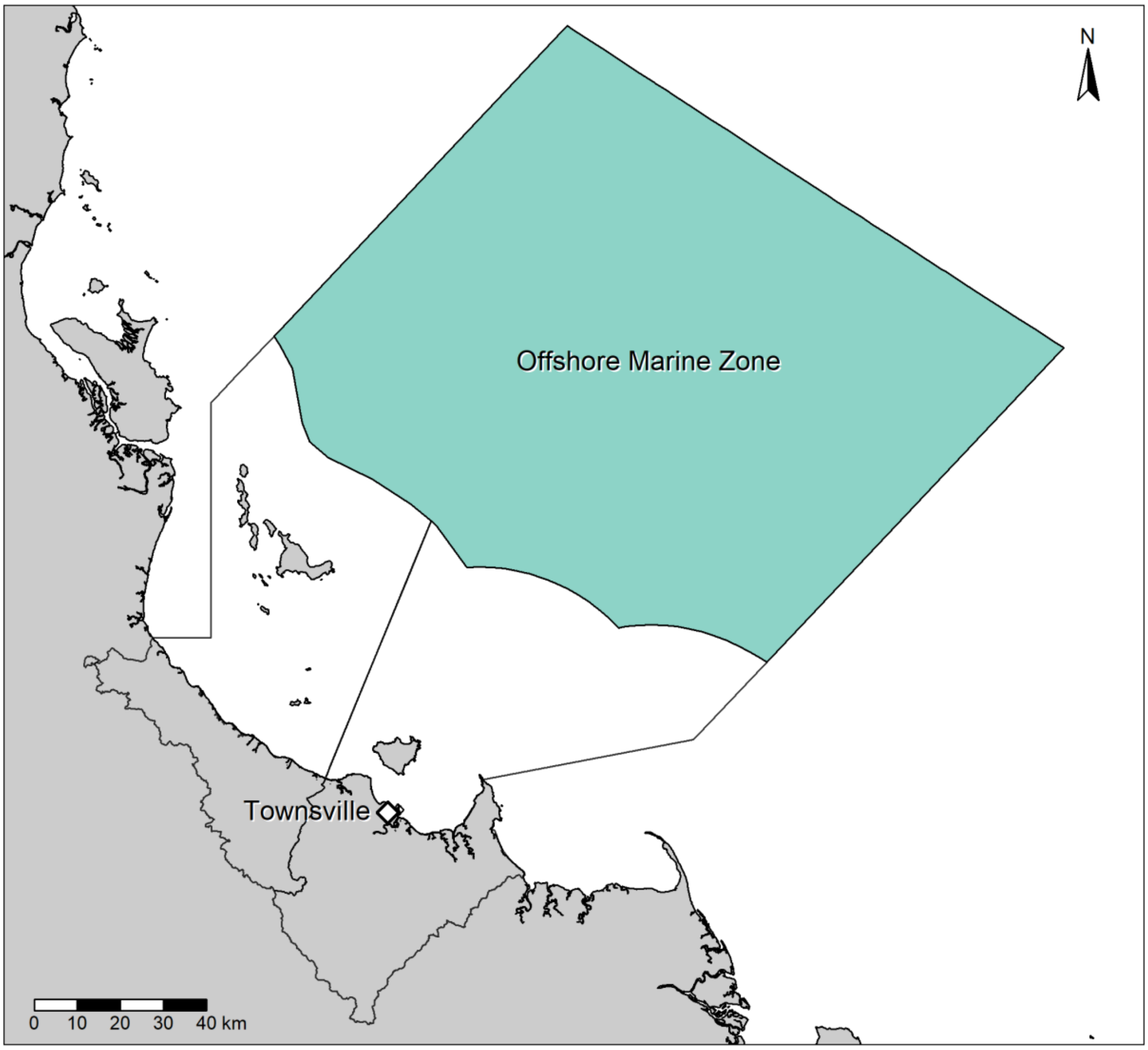


*Figure 12. Dry Tropics offshore marine zone.*

## 13.1 Water Quality

The 2021–2022 reporting period was the second year with no water quality monitoring program in place to allow for reporting on offshore water quality. 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 67). The scores were similar for all reporting years.

*Table 67. Current and previous water quality scores and grades for the Dry Tropics Offshore Marine Zone.*

| Zone | Water Quality | | | |
|---|---|---|---|---|
| | 2021–2022 | 2020–2021 | 2019–2020 | 2018–2019 |
| Offshore Marine | NA | NA | 100 | 97 |

**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.

During 2019–2020 there were limitations in the technical support for maintaining the MWQ 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 reporting offshore water quality as from the 2022–2023 reporting year.

## 13.2 Habitat

The habitat and hydrology index for the Offshore Marine Zone of the Dry Tropic region consists only of the coral indicator category and is therefore referred to throughout as the habitat index. The coral indicator category sources its results from AIMS' Long-Term Monitoring Program (LTMP). In the Dry Tropics region this data is updated every year with the most recent update occurring in 2022 (publication of 2021–2022 data).

### 13.2.1 Overall Summary: Offshore Habitat

Overall, the habitat index in the Offshore Marine Zone received it highest score in the past four reporting periods of 64. This is slightly higher than the previous report period of 62, and higher than the 2019–2020 and 2018–2019 reporting periods of 54 and 59. These results show the continued recovery of coral health in the Offshore Marine Zone after several years of disturbances (Table 68).

*Table 68. Standardised score for the Offshore Marine Zone habitat index.*

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

**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.

#### 13.2.1.1 *Key Messages*

- The habitat index received its highest score in the past four years of 64.
- Coral continues to recover from moderate conditions in the previous reporting periods.
- Juvenile density was graded as very good at 8 of 9 reefs surveyed.
- All coral reefs had an overall grade of moderate or good.

### 13.2.2 Coral

Coral data within the Dry Tropics Offshore Marine Zone was primarily collected by the Australian Institute of Marine Science's LTMP. The LTMP is an annual survey conducted by AIMS and over its 35+ year history the program has surveyed more than 490 reefs. In previous reporting years additional coral monitoring has been conducted by Reef Check Australia (RCA), however no additional sampling occurred during 2021–2022 due to a limited budget. Coral was monitored between Feb 2022 and Mar 2022. In the Offshore Marine Zone, the coral indicator category is comprised of three indicators that make up the final score for each sample location. These three indicators are change in coral cover, percentage of coral cover, and juvenile density.

#### 13.2.2.1 *Monitoring Sites*

The coral indicator category was monitored at nine locations in the Offshore Marine Zone of the Dry Tropics region. All sites were monitored as part of the LTMP, and all sites monitored for the 2021–2022 reporting period were monitored in previous report periods. However, it should be noted that some reefs that were sampled in previous report periods are no longer part of the LTMP sampling design (Page 70., Appendix III).

#### 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. Across the nine reefs surveys these indicators ranged from very poor to very good, and the overall coral indicator score for each reef ranged from moderate to good. The change in coral cover indicator was moderate for six of nine reefs, poor at Davies Reef, and good at Knife Reef and Rib Reef. Interestingly the percentage of coral cover was moderate at only four reefs (including Davies Reef), however was poor or very poor at three reefs – including Rib Reef. The percentage of coral cover was good at Chicken Reef and Knife Reef. The juvenile density was good at John Brewer Reef and very good at all other reefs. The combination of these indicators suggests that most coral reefs are either in good condition or show clear signs of recovery (Table 69).

*Table 69. 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 | 70 | 100 | 74 |
| Davies Reef | 35 | 55 | 100 | 63 |
| Dip Reef | 48 | 47 | 100 | 65 |
| Helix Reef | 48 | 43 | 100 | 63 |
| John Brewer Reef | 51 | 17 | 74 | 47 |
| Kelso Reef | 45 | 37 | 100 | 60 |
| Knife Reef | 66 | 70 | 100 | 78 |
| Myrmidon Reef | 41 | 58 | 100 | 66 |
| Rib Reef | 61 | 20 | 100 | 60 |
| **Offshore Marine Zone** | 49 | 46 | 97 | 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 100.

#### 13.2.2.3 *Back Calculated Scores*

The LTMP updated the sampling design for 2021–22 onwards. For the Dry Tropics region, the LTMP previously included 16 reefs with a subset monitored in alternating years. The updated sampling design has reduced the number of surveyed reefs to nine and conducts surveys at all reefs every year. Details of the changes to the reefs that are surveyed are presented in the methods technical report. Whilst this change reduces the number of reefs monitored it has the distinct advantage of increasing the frequency of sampling from a two-year to one-year cycle. The previous design involved rolling scores forward for reefs not sampled in a given year and meant that there was a lag in the condition assessment for reefs not surveyed for the reporting year.

As the number of coral sites sampled for the 2021–2022 technical report has been updated, results in previous technical reports have been superseded. Previous results have been back calculated and updated in Table 68. Results for previous years prior to back calculation can be found in Appendix JJJ. The update had limited impact on the final results, only changing the 2019–2020 score: from 56 down to 54.

### 13.2.3 Confidence Scores

The overall confidence of the coral indicator category was high with a rank of 4 out of 5. Across Offshore Marine Zone, the coral indicator received a maturity score of 3, Validation and directness both received a 3 as extensive on ground validation and direct measurement of corals occurs, however measured error received a 1 as some components of the indicator do not have their error quantified. Finally, the representativeness component of the coral indicator category was 2 as there are several reefs that are not part of the LTMP surveys.

*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 | 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.

Dry Tropics Partnership for Healthy Waters
Waterways Report Card 2023

# TECHNICAL REPORT

## PART 7: Litter Results

Reporting on data collected 2021 - 2022

JULY 2023 | Dry Tropics Partnership for Healthy Waters (DTPHW)

Written by Adam Shand and Dinny Taylor

# 14 Litter

The litter index is comprised of a single indicator to assess the “pressure” that the amount of 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, Dry Tropics Partnership for Healthy Waters, 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, so the results may be different from those previously reported. 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). The recalculated results for the model, and the 2019–2020, 2020–2021 years are provided in the Methods Appendix and in Section 14.2 below respectively.

## 14.1 Monitoring Sites

There were 20 litter collection sites for the 2021–2022 period, and these are shown in Figure 13,

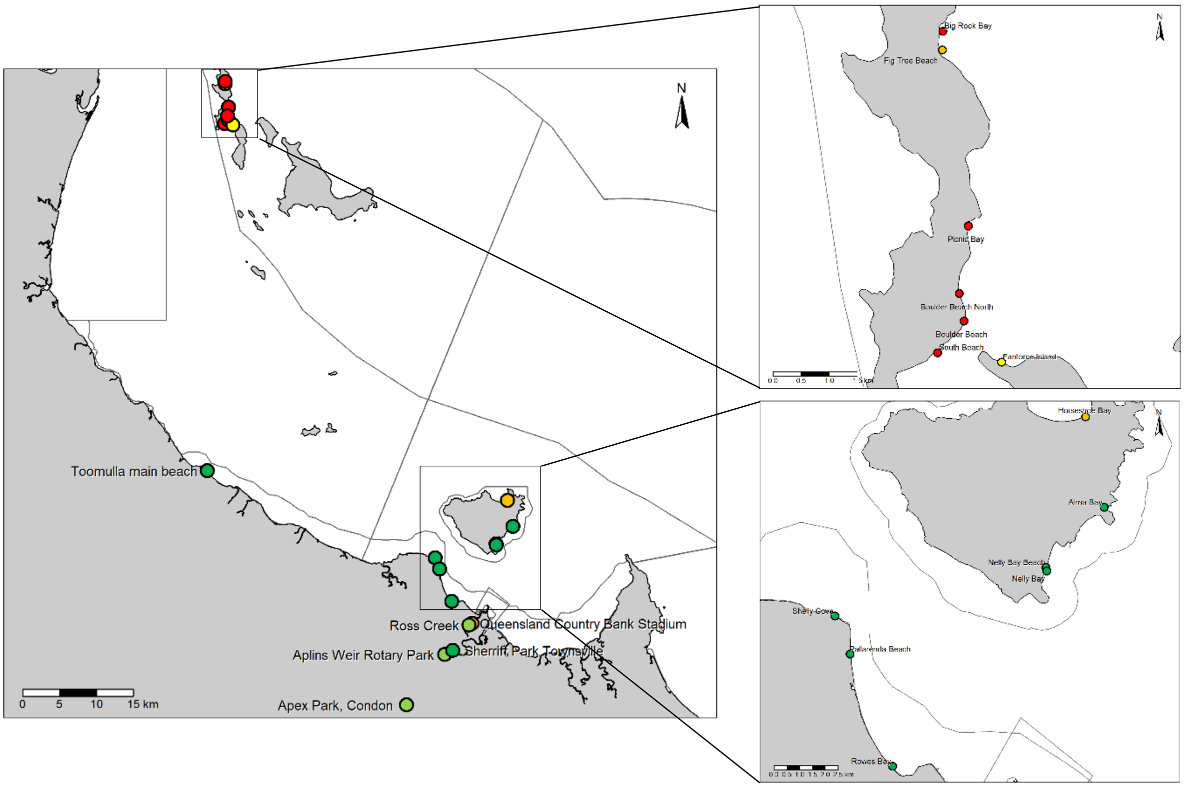


*Figure 13: Litter Collection Locations for 2021-2022*

where the colours indicate the grade. There were seven sites in Cleveland Bay, eight sites in the Halifax Bay, and five 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.

## 14.2 Comparison with previous years

Table 71 presents a comparison of the 2021–2022 year for the litter index with previous years.

*Table 71: Comparison of Litter Index for 2021–2022 with previous years*

| Zone | Site | Scores and Grades | | |
|---|---|---|---|---|
| | | 2019–2020 | 2020–2021 | 2021–2022 |
| Halifax Bay | North West Beach, Pelorus Island | 88 (VLP) | NA | NA |
| | West Beach, Pelorus Island | 75 (LP) | NA | NA |
| | North Beach, Orpheus Island | 5 (VHP) | NA | NA |
| | Big Rock Bay, Orpheus Island | 24 (HP) | 9 (VHP) | 11 (VHP) |
| | Fig Tree Beach, Orpheus Island | NA | 19 (VHP) | 21 (HP) |
| | Picnic Bay, Orpheus Island | 1 (VHP) | 14 (VHP) | 3 (VHP) |

| Zone | Site | Scores and Grades 2019–2020 | 2020–2021 | 2021–2022 |
|---|---|---|---|---|
| | Boulder Beach North, Orpheus Island | NA | NA | 16 ( VHP ) |
| | Yanks Jetty, Orpheus Island | 69 ( LP ) | 80 ( VLP ) | NA |
| | Boulder Beach, Orpheus Island | NA | NA | 2 ( VHP ) |
| | South Beach, Orpheus Island | 42 ( MP ) | NA | 11 ( VHP ) |
| | Fantome Island, Northern End | NA | 14 ( VHP ) | 36 ( HP ) |
| | Ollera Beach | 40 ( MP ) | NA | NA |
| | Rollingstone Beach | 50 ( MP ) | NA | NA |
| | Toomulla Beach | 52 ( MP ) | NA | NA |
| | Toomulla main beach | NA | NA | 78 ( LP ) |
| | Saunders Beach | 66 ( LP ) | NA | NA |
| | Bushland Beach, Townsville | NA | 65 ( LP ) | NA |
| Cleveland Bay | Myrmidon Reef | NA | 95 ( VLP ) | NA |
| | Horseshoe Bay, Magnetic Island | NA | NA | 34 ( HP ) |
| | Arthur Bay, Magnetic Island | NA | 43 ( MP ) | NA |
| | Alma Bay, Magnetic Island | 46 ( MP ) | 61 ( LP ) | 68 ( LP ) |
| | Alma Bay, Magnetic Island UW | 93 ( VLP ) | 96 ( VLP ) | NA |
| | Geoffrey Bay, Magnetic Island | NA | 77 ( LP ) | NA |
| | Geoffrey Bay Reef, Magnetic Island UW | 88 ( VLP ) | NA | NA |
| | Nelly Bay Beach, Magnetic Island | 52 ( MP ) | 73 ( LP ) | 69 ( LP ) |
| | Nelly Bay, Magnetic Island UW | 99 ( VLP ) | 98 ( VLP ) | 97 ( VLP ) |
| | Shelly Beach, Pallarenda | 61 ( LP ) | 31 ( HP ) | NA |
| | Shelly Cove, Cape Pallarenda Conservation Park | 65 ( LP ) | 68 ( LP ) | 87 ( VLP ) |
| | Pallarenda Beach | NA | NA | 69 ( LP ) |
| | Kissing Point, Townsville | NA | 75 ( LP ) | NA |
| | Rowes Bay | 71 ( LP ) | 72 ( LP ) | 83 ( VLP ) |
| | Strand Park, Townsville | 60 ( LP ) | 71 ( LP ) | NA |
| | Strand Waterpark Beach | NA | 81 ( VLP ) | NA |
| Ross | Three Mile Creek, Pallarenda | NA | 36 ( HP ) | NA |
| | Strand Rock Pool, Townsville | NA | 46 ( MP ) | NA |
| | Queensland Country Bank Stadium | NA | 25 ( HP ) | 22 ( HP ) |
| | Ross Creek, Townsville | NA | NA | 45 ( MP ) |
| | South Townsville Recreational Boat Park | NA | 33 ( HP ) | NA |
| | Anderson Park, Townsville | NA | NA | 87 ( VLP ) |
| | Sherriff Park Townsville | NA | NA | 69 ( LP ) |
| | Aplins Weir Rotary Park | 41 ( MP ) | 35 ( HP ) | 66 ( LP ) |
| | Apex Park, Condon | NA | NA | 60 ( LP ) |

**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.

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 northern beaches of Townsville have had low litter pressure on the occasion's collections have occurred there.
- Queensland Country Bank Stadium (high pressure) during events continues to have the highest litter pressure in the Ross litter zone, whilst Ross Creek has moderate pressure.
- Horseshoe Bay has the highest litter pressure on Magnetic Island.

## 14.4 Results

Litter pressure results are presented in Table 72. In the Ross Freshwater Basin Anderson Park had the lowest pressure and Queensland Country Bank Stadium had the highest pressure. Bins are provided by the Townsville City Council at all of the locations where litter collection occurs within the Ross Freshwater Basin. Queensland Country Bank Stadium litter collections occur during events, in the area external to the entrance gates surrounding the stadium (pers. com. K-M Coulter-Atkins, previously TBF now DTPHW, 2023).

For the Magnetic Island sites within Cleveland Bay, Horseshoe Bay had the highest pressure (HP) and Nelly Bay had the lowest pressure, with the underwater site better than the shore zone. For the Townsville sites within Cleveland Bay, Shelly Cove and Rowes Bay had very low pressure, while Pallarenda Beach had low pressure.

Fantome Island had high pressure but was the lowest pressure of the sites within the Palm Island group of Halifax Bay. All of the Orpheus Island sites (Table 72) had 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. This is reflected in the proportion of litter that is sea sourced provided by the AMDI Land Sea Source Index (LSSI). The only main land site in Halifax Bay for the Dry Tropics region was Toomulla main beach, which had low pressure.

*Table 72: Litter Index Results for 2021–2022*

| Zone | Site | Score and Grade | Land sourced (%) | Sea sourced (%) |
|---|---|---|---|---|
| Halifax Bay | Big Rock Bay, Orpheus Island | 11 ( VHP ) | 13 | 87 |
| | Fig Tree Beach, Orpheus Island | 21 ( HP ) | 16 | 84 |
| | Picnic Bay, Orpheus Island | 3 ( VHP ) | 15 | 85 |
| | Boulder Beach North, Orpheus Island | 16 ( VHP ) | 16 | 84 |
| | Boulder Beach, Orpheus Island | 2 ( VHP ) | 12 | 88 |
| | South Beach, Orpheus Island | 12 ( VHP ) | 18 | 82 |
| | Fantome Island, Northern End | 36 ( HP ) | 13 | 87 |
| | Toomulla main beach | 78 ( LP ) | 31 | 69 |
| Cleveland Bay | Horseshoe Bay, Magnetic Island | 34 ( HP ) | 38 | 62 |
| | Alma Bay, Magnetic Island | 68 ( LP ) | 49 | 51 |
| | Nelly Bay Beach, Magnetic Island | 69 ( LP ) | 22 | 78 |
| | Nelly Bay, Magnetic Island UW | 97 ( VLP ) | 0 | 100 |
| | Shelly Cove, Cape Pallarenda Conservation Park | 87 ( VLP ) | 71 | 30 |
| | Pallarenda Beach | 69 ( LP ) | 79 | 21 |
| | Rowes Bay | 83 ( VLP ) | 79 | 21 |
| Ross | Queensland Country Bank Stadium | 22 ( HP ) | 100 | 0 |
| | Ross Creek, Townsville | 45 ( MP ) | 100 | 0 |
| | Anderson Park, Townsville | 87 ( VLP ) | 100 | 0 |
| | Sherriff Park Townsville | 69 ( LP ) | 100 | 0 |
| | Aplins Weir Rotary Park | 66 ( LP ) | 100 | 0 |
| | Apex Park, Condon | 60 ( LP ) | 100 | 0 |

**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.

## 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 negative binomial mixed model for data across a much larger region than solely the 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 up 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 73: 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.

# 15 References


Australian Government. 2023. *Reef Water Quality Report Card.* https://reportcard.reefplan.qld.gov.au/home?report=overview&year=611f443aba3074128316eb07.

—. 2022. *Water Quality Australia.* Accessed 2023. https://www.waterquality.gov.au/issues#:~:text=During%20rainfall%20events%2C%20stormwater%20flows,and%20low%20dissolved%20oxygen%20levels.

Bureau of Meteorology. 2022. *Australian Water Outlook.* https://awo.bom.gov.au/products/historical/precipitation/4.5,-27.481,134.221/nat,-25.609,134.362/r/d/2023-02-14.

—. 2022. *Gridded Climatology Data.* http://www.bom.gov.au/climate/averages/climatology/gridded-data-info/gridded_datasets_summary.shtml.

Bureau of Meterology. 2023. *Townsville Weather.* 16 January. http://www.bom.gov.au/places/qld/townsville/.

Cheal, AJ., Emslie, M., MacNeil, MA., Miller, I., Sweatman, H. 2013. "Spatial variation in the functional characteristics of herbivorous fish communities and the resilience of coral reefs." *Ecological Applications* 174-188.

City of Townsville. 2022. "Heritage services information sheet number 6." *citylibraries.*

Climate Council. 2021. *StormsCoastal Flooding.* 30 November. https://www.climatecouncil.org.au/steamy-stormy-climate-change-summer-2021-22/.

Climate Policy Watcher. 2023. *The Ocean As A Buffer Of Temperature Change.* May. https://www.climate-policy-watcher.org/climate-dynamics/the-ocean-as-a-buffer-of-temperature-change.html.

CSIRO. 2023. *CSIRO Connectivity Interface.*

Davidson, J., Thompson, A., Logan, M., Schaffelke, B. 2019. "High spatio-temporal variability in Acroporidae settlement to inshore reefs of the Great Barrier Reef." *PLos ONE.*

DeFries, R., Hansen, A., Turner, B., Reid, R. & Liu, J. 2007. "Land use change around protected areas: management to balance human needs and ecological function. ." *Ecological Applications* 1031-1038.

Department of Agriculture, Fisheries and Forestry. 2023. *Land Use and Management.* https://www.agriculture.gov.au/abares/aclump/land-use/alum-classification.

Department of Climate Change, Energy, the Environmental and Water. 2023. *Review of the impact of introduced ornamental fish species that have established wild populations in Australia.* https://www.dcceew.gov.au/environment/invasive-species/publications/review-impacts-introduced-ornamental-fish-species-wild-populations.

Department of Environment and Science. 2019. *Environmental Protection (Water and Wetland Biodiversity) Policy 2019.* https://environment.des.qld.gov.au/management/water/policy.

Department of Environment and Science. 2018. *Environmental Protection Policy (Water) 2009 Mapping procedural guide Management intent and water type mapping methodology.* Brisbane: Queensland Government.

Department of Environment and Science. 2022. "Urban Water Stewardship Framework Implementation Manual." Brisbane.

Department of Environment, Land, Water and Planning. n.d. *Water and Catchments.* Accessed March 31st, 2020. https://www.water.vic.gov.au/.

—. 2023. *Water and Catchments.* https://www.water.vic.gov.au/.

Department of the Environment and Energy. 2016. *Coastal wetlands—Mangroves and saltmarshes.* Canberra: Commonwealth of Australia.

Doropoulos, C., Gomez-Lemos, LA., Salee, K., McLaughlin, MJ., Tebben, J., Van Koningsveld, M., Feng, M., Babcock, RC. 2021. "Limitations to coral recovery along an environmental stress gradient." *Ecological Applications.*

Drewry. J. J., Newham. L. T. H., Greene. R. S. B., Jakeman. A. J., Croke. B. F. W. 2006. "A reivew of nitrogen and phosphorus export to waterways: context for catchment modelling." *Marine and Freshwater Research* 757-774.

Dry Tropics Partnership for Healthy Waters. 2023. *Methods for the Townsville Dry Tropics Partnership for Healthy Waters Annual Report Cards.* Townsville: Dry Tropics Partnership for Healthy Waters.

Environmental Protection Authority. 2017. *Global Climate Change.* https://archive.epa.gov/climatechange/kids/impacts/effects/ecosystems.html.

Faulks, L., Gilligan, D., Beheregaray, L. 2011. "The role of anthropogenic vs. natural in-stream structures in determining connectivity and genetic diversity in an endangered freshwater fish, Macquarie perch (Macquaria australasica)." *Evolutionary Applications* 589-601.

Glanville, Katharine, interview by Adam Shand. 2023. *A Review of the Freshwater Wetland Extent Indicator Category* (March).

Glynn, P. W., and L. D'Croz. 1990. "Experimental evidence for high temperature stress as the cause of El Nino-coincident coral mortality." *Coral Reefs* 181-191.

Great Barrier Reef Marine Park Authority. 2009. *Water Quality Guidelines for the Great Barrier Reef Marine Park.* Townsville: Australian Government.

Healy, Al, interview by Adam Shand. 2023. *A Review of the Freshwater Riparian Extent Indicator Category* (March).

Hill, S., Cumpston, Z., Vigiola, G. Q. 2021. *Australia State of the Environment: Urban.* https://soe.dcceew.gov.au/urban/introduction.

Hoffmann, C. C., Kjaergaard, C., Uusi-Kamppa, J., Hansen, H. C. B. 2009. "Phosphorus Retention in Riparian Buffers: Review of Their Efficiency." *Journal of Environmental Quality* 1942-1955.

IPCC. 2022. *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* IPCC.

IUCN. 2017. *Ocean Warming.* November. https://www.iucn.org/resources/issues-brief/ocean-warming#:~:text=The%20ocean%20absorbs%20most%20of,for%20marine%20fishes%20and%20mammals.

Johnston, EC., Counsell, CWW., Sale, TL., Burgess, SC., Toonen, RJ. 2020. "The legacy of stress: Coral bleaching impacts reproduction years later." *Functional Ecology* 2315-2325.

Lonborg, C. et al. 2016. *Marine Monitoring Program: Annual Report for inshore water quality monitoring 2014 to 2015. Report for the Great Barrier Reef Marine Park Authority.* Townsville: Australian Institute of Marine Science and JCU TropWATER.

Luick, JL., Mason, L., Hardy, T., Furnas, MJ. 2007. “Circulation in the Great Barrier Reef Lagoon using numerical tracers and in situ data.” *Continental Shelf Research* 757-778.

Mackenzie, JB., Munday, PL., Willis, BL., Miller, DJ., Van Oppen, MJH. 2004. “Unexpected patterns of genetic structuring among locations but not colour morphs in Acropora nasuta (Cnidaria; Scleractinia).” *Molecular Ecology* 9-20.

McGrane, S. 2016. “Impacts of urbanisation on hydrological and water quality dynamics, and urban water management: a review.” *Hydrological Sciences Journal* 61 (13): 2295-2311. doi:10.1080/02626667.2015.1128084.

Mckenna, S., Van De Wetering, C., Wilkinson, J. 2022. *Port of Townsville Seagrass Monitoring Program 2022.* Cairns: Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER).

Moore, M. 2016. “Freshwater & Estuary Fish Barrier Metrics Report - Final Report for Healthy Rivers to Reef Partnership.” Mackay: Healthy Rivers to Reef Partnership.

Moran, D., Waterhouse, J., Gruber, R., Logan, M., Petus, C., Howley, C., Lewis, S., Tracey, D., Langlois, L., Tonin, H., Skuza, M., Costello, P., Davidson, J., Gunn, K., Wright, M., Zagorskis, I., Kroon, F., Neilen, A., Lefevre, C., Shanahan, M. 2023. *Marine Monitoring Program: Annual Report for inshore water quality monitoring 2020-2021.* Townsville: Great Barrier Reef Marine Park Authority.

National Geographic. 2017. *Heavier Rainfall Will Increase Water Pollution in the Future.* July. Accessed 2023. https://www.nationalgeographic.com/science/article/water-quality-hypoxia-environment-rain-precipitation-climate-change.

Natural Resources Defense Council. 2022. *Are the Effects of Global Warming Really that Bad?* May. https://www.nrdc.org/stories/are-effects-global-warming-really-bad#:~:text=Higher%20temperatures%20are%20worsening%20many,wetter%20and%20dry%20areas%20drier.

New South Wales Government. 2023. *Australian Climate Change Observations.* Jan. https://www.climatechange.environment.nsw.gov.au/australian-climate-change-observations#:~:text=Current%20outlook%20for%20Australia&text=hot%20days%20will%20become%20hotter,events%20will%20become%20more%20intense.

NOAA. 2023. *Coral Reef Watch.* https://coralreefwatch.noaa.gov/product/5km/methodology.php#dhw.

—. 2023. *Current Year-to-date Composites.* 18 Januay. https://coralreefwatch.noaa.gov/product/5km/index_5km_composite.php.

Office of Great Barrier Reef. 2021. “Urban Water Stewardship Framework factsheet.” Brisbane.

Queensland Government. 2023. *QSpatial.* https://qldspatial.information.qld.gov.au/catalogue/.

—. 2023. *Wetland data - version 5 - Queensland series.* https://www.data.qld.gov.au/dataset/wetland-data-version-5-queensland-series.

Scarth, P., M Byrne, T Danaher, B Henry, R Hassett, J Carter, and Timmers P. 2006. “State of the paddock:monitoring condition and trend in groundcover across Queensland.” Canberra: Proceedings of the 13th Australasian Remote Sensing Conference, November 2006.

Schulze, K., Knights, K., Coad, L., Geldmann, J., Leverington, F., Eassom, A., Marr, M., Butchart, S. H. M., Hockings, M., Burgess, N. D. 2017. “An assessment of threats to terrestrial protected areas.” *Conservation Letters.*

Sweatman, H., Thompson, A., Delean, S., Davidson, J., Neale, S. 2007. *Status of inshore reefs of the Great Barrier Reef 2004.* Townsville: Australian Institute of Marine Science.

Thompson, A., Davidson, J., Logan, M., Thompson, C.,. 2023. *Marine Monitoring Program Annual Report for Inshore Coral Reef Monitoring: 2021-22. Report for the Great Barrier Reef Marine Park Authority.* Townsville: Great Barrier Reef Marine Park Authority.

Townsville City Council, Queensland Government, Australian Government. 2010. *Black Ross (Townsville) Water Quality Improvement Plan.* Townsville: Townsville City Council.

United Nations. 2023. *Causes and Effects of Climate Change.* 18 January. https://www.un.org/en/climatechange/science/causes-effects-climate-change.

Venables, William N, and Tegan Whitehead. 2019. *A Proposal for Litter Scores and Grades.* paper, na: unpublished.

Viera, C. 2020. “Lobophora–coral interactions and phase shifts: summary of current knowledge and future directions.” *Aquatic Ecology* 1-20.

Ward, S., Harrison, P., Hoegh-Guldberg, O. 2002. “Coral bleaching reduces reproduction of scleractinian corals and increases susceptibility to future stress.” *Proceedings 9th International Coral Reef Symposium.* Bali, Indonesia.

WaterNSW. 2022. “Factsheet: What is a dam?” *Water NSW.* https://www.waternsw.com.au/education/learning-about-water/dams-and-weirs.

Dry Tropics Partnership for Healthy Waters
Waterways Report Card 2023

# TECHNICAL REPORT

## PART 8: Appendices

Reporting on data collected 2021 - 2022

JULY 2023 | Dry Tropics Partnership for Healthy Waters (DTPHW)

Written by Adam Shand and Dinny Taylor

# 16 Appendices

## Appendix A. All Indicators, Indicator Categories, and Indices

*Table 74. All indicators, indicator categories, and indices used in the 2021–2022 Technical Report and Report Card.*

| Indicator | Indicator Category | Index | Zone |
|---|---|---|---|
| Dissolved Inorganic Nitrogen | Nutrients | Water Quality | Freshwater |
| Total Phosphorus | Nutrients | Water Quality | Freshwater |
| Turbidity | Phys-Chem | Water Quality | Freshwater |
| High/Low DO | Phys-Chem | Water Quality | Freshwater |
| Change in riparian extent | Riparian vegetation | Habitat and Hydrology | Freshwater |
| Change in wetland extent | Wetlands | Habitat and Hydrology | Freshwater |
| Fish barriers | Artificial barriers | Habitat and Hydrology | Freshwater |
| Impoundment length | Artificial barriers | Habitat and Hydrology | Freshwater |
| Fish | Fish | Fish | Freshwater |
| Total Phosphorus | Nutrients | Water Quality | Estuary |
| DIN | Nutrients | Water Quality | Estuary |
| High/Low DO | Phys-Chem | Water Quality | Estuary |
| Turbidity | Phys-Chem | Water Quality | Estuary |
| Change in mangrove and saltmarsh extent | Mangrove and Saltmarsh Extent | Habitat | Estuary |
| Change in riparian extent | Riparian Vegetation | Habitat | Estuary |
| Total Phosphorus | Nutrients | Water Quality | Inshore Marine |
| Nitrogen Oxides | Nutrients | Water Quality | Inshore Marine |
| Total Nitrogen | Nutrients | Water Quality | Inshore Marine |
| Filterable Reactive Nitrogen | Nutrients | Water Quality | Inshore Marine |
| Total Suspended Solids | Phys-Chem | Water Quality | Inshore Marine |
| Turbidity | Phys-Chem | Water Quality | Inshore Marine |
| Secchi Depth | Phys-Chem | Water Quality | Inshore Marine |
| Chlorophyll-a | Chlorophyll-a | Water Quality | Inshore Marine |
| Composition | Coral | Habitat | Inshore Marine |
| Change in cover | Coral | Habitat | Inshore Marine |
| Juvenile Density | Coral | Habitat | Inshore Marine |
| Macroalgae cover | Coral | Habitat | Inshore Marine |
| Cover | Coral | Habitat | Inshore Marine |
| Biomass | Seagrass | Habitat | Inshore Marine |
| Meadow area | Seagrass | Habitat | Inshore Marine |
| Species composition | Seagrass | Habitat | Inshore Marine |
| Change in cover | Coral | Habitat | Offshore Marine |
| Juvenile density | Coral | Habitat | Offshore Marine |
| Cover | Coral | Habitat | Offshore Marine |

# Appendix B. Climatic and Land Use, Additional Material

**Land Use**

Land use data[23] 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 Dry Tropics is summarised in Table 75 and visualised in Figure 4.

Land use follows a 3-level hierarchical structure with six primary classes:

- Conservation and Natural Environments
- Intensive Uses (such as urban development)
- Production From Dryland Agriculture and Plantations
- Production From Irrigated Agriculture and Plantations
- Production From Relatively Natural Environments
- Water

The Dry Tropics region includes the largest city in North Queensland (Townsville), and land use reflects this, with large areas of intensive use and urban development. The effect of intensive land uses are cited as a major driver of environmental change, often resulting in impervious surfaces, artificial barriers, and changes to waterways, all of which impact water quality and water flow (Hill 2021, McGrane 2016). In 2021, 296.54km$^2$ (or 10.2%) of the Dry Tropics region was classified as intensive use. Intensive land use in Dry Tropics region has increased by 53.14km$^2$ (1.9%) since 1999 (from 243.40km$^2$, 8.3%), however has only increased by 6.19km$^2$ (0.4%) since 2016 (from 290.35km$^2$, 9.9%) (Table 75). Increases are most visible in the Ross Basin, west of the CBD (Figure 4).

The conservation and natural environment land use category includes national parks, wilderness areas, and natural areas of land owned/used by the Australian Defence Force. Given sufficient size this category can act as a cornerstone for biodiversity and provide a host of ecosystem services (DeFries 2007, Schulze 2017). This land use is the second largest in the Dry Tropics, in 1999 conservation and natural environment land use covered approximately 835.63km$^2$ (or 28.6%) of the Dry Tropics, in 2016 this increased to 1026.13km$^2$ (or 35.1%), and in 2021 increased to 1030.98km$^2$ (35.5%) (Table 75). A large proportion of this expansion has occurred along the hinterlands and coastal plain of the Black Basin (Figure 4).

Both dryland agriculture, and irrigated agriculture are a very small proportion of the land use in the Dry Tropics region. Dryland agriculture and plantations include forest plantations and cropping. This accounts for only 1.74km$^2$ (0.1%) of the Dry Tropics and has decreased from a total of 2.63km$^2$ (0.1%) in 1999, however did spike in 2016 with an area of 3.17km$^2$ (0.1%). Irrigated agriculture include almost identical land use types (forest plantations, cropping, etc.) although they are irrigated. This accounts for 33.44km$^2$ (1.2%) of the Dry Tropics and has increased from a total of 31.75km$^2$ (1.1%) in 1999. Similarly, this land use type also spiked in 2016, covering 35.75km$^2$ (1.2%) (Table 75). Irrigated agriculture is visible to the west of the Ross River Dam (Figure 4).

By area the most substantial land use category is production from relatively natural environments, which includes grazing and wood production from native forests. This land use type covered 1375.00km$^2$ (or 47.3%) of the Dry Tropics region in 2021. However, has noticeably declined from 1999 levels of 1636.67km$^2$ (56.0%), and from 2016 levels of 1397.60km$^2$ (47.8%) (Table 75). The

[23] All land use data was downloaded from QSpatial's [Catalogue] (Queensland Government 2023).

reduction has been driven by the expansion of conservation and natural environments land use in the Black Basin hinterlands, and the expansion of intensive land use in the Ross Basin (Figure 4).

The water land use type reduced slightly from 169.67km$^2$ in 2016, to 169.12km$^2$ in 2021 (Figure 4) (Table 75).

*Table 75. Total area and percentage of region for land use classes in the Dry Tropics region in 1999 and 2021 at the primary level.*

| Land Use | 2021 | | 2016 | | 1999 | |
|---|---|---|---|---|---|---|
| | % | km$^2$ | % | km$^2$ | % | km$^2$ |
| Conservation and Natural Environments | 35.5 | 1030.98 | 35.1 | 1026.13 | 28.6 | 835.63 |
| Intensive Uses | 10.2 | 296.54 | 9.90 | 290.35 | 8.3 | 243.40 |
| P. f. Dryland Agriculture and Plantations | 0.1 | 1.74 | 0.1 | 3.17 | 0.1 | 2.63 |
| P. f. Irrigated Agriculture and Plantations | 1.2 | 33.44 | 1.2 | 35.75 | 1.1 | 31.75 |
| P. f. Relatively Natural Environments | 47.3 | 1375.00 | 47.8 | 1397.60 | 56.0 | 1636.67 |
| Water | 5.8 | 169.12 | 5.8 | 169.67 | 5.9 | 172.76 |

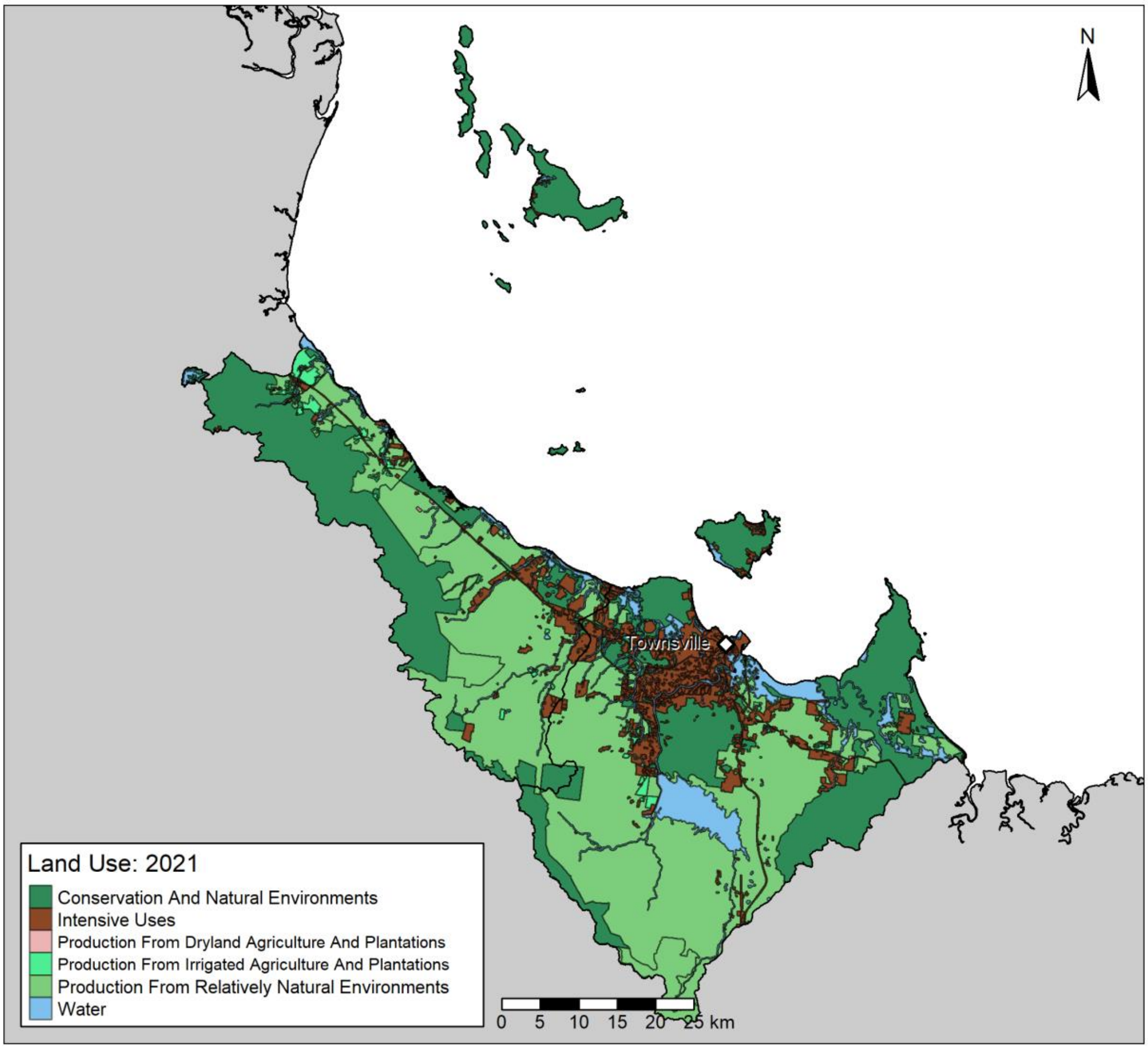


*Figure 14. Land use categories in the Dry Tropics region in 2021 shown at the primary level.*

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 2021 and 30th June 2022, the Dry Tropics region recorded a wide range of weather events. There was no major flooding, no cyclones, and no change to the current La Niña event (Bureau of Meterology 2023, Climate Council 2021). However, multiple heatwaves were experienced, periods of extremely high and low rainfall were recorded, water temperature was above average, and the chance of coral bleaching was above average (Bureau of Meterology 2023, NOAA 2023). Below key influences are explored in detail.

**Rainfall**

The amount of rainfall directly influences the quality of water, especially in urban environments such as the Dry Tropics, where impervious surfaces allow high levels of runoff. During rainfall events, stormwater can rapidly enter the natural environment carrying high levels of nutrients, sediments, and heavy metals, producing high biological oxygen demand, low dissolved oxygen levels, and increasing levels of pollution (Australian Government 2022, National Geographic 2017). In rural and agricultural locations rainfall has also been linked to the excessive loss of land-based nutrients through run off, particularly in areas with inadequate riparian buffers (Drewry. J. J. 2006).

Monthly rainfall[24] across the Dry Tropics region was unevenly distributed, with monthly percentile rainfall in the Ross and Black basins ranging from "very much below average" (1st – 10th percentiles) to the "highest 1%" (99th percentile) on record. Both of these extremes were recorded during the wet season that is typically experienced during summer months (Nov – Apr). This reporting period the wet season occurred uncharacteristically late, with a drier than usual February and March followed by high rain in April and May. In contrast the "dry season" that typically occurs during winter (May – Oct) recorded no months with below average rainfall for either basin (Table 17).

*Table 76. Monthly rainfall percentiles in the Ross Basin and the Black Basin grouped into seven categories.*

| Basin | 2021 | | | | | | 2022 | | | | | | 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%

The spatial variation of annual rainfall was similarly uneven across the Ross and Black basins, with areas of high rainfall receiving up to 1000mm more annually than areas of low rainfall. Rainfall was the greatest in the hinterlands of the Black Basin with up to 2000mm, while the least amount of rainfall was recorded on the southern plateau of the Ross Basin with only 800 to 1000mm (Figure 5).

The annual rainfall anomaly (the amount +/- of rain that fell in comparison to the long-term mean) revealed that, although the Black Basin contained the area with the greatest amount of rainfall, a large area of the Black Basin in the north received less rain that usual. In contrast, the southern end of the Black Basin and centre of the Dry Tropics region received more rain than the long-term mean, and across the entire Ross Basin, no area received less rain that the long-term mean (Figure 5).

[24] All rainfall data was downloaded from the BOM's [Australian Water Outlook] portal (Bureau of Meteorology 2022).

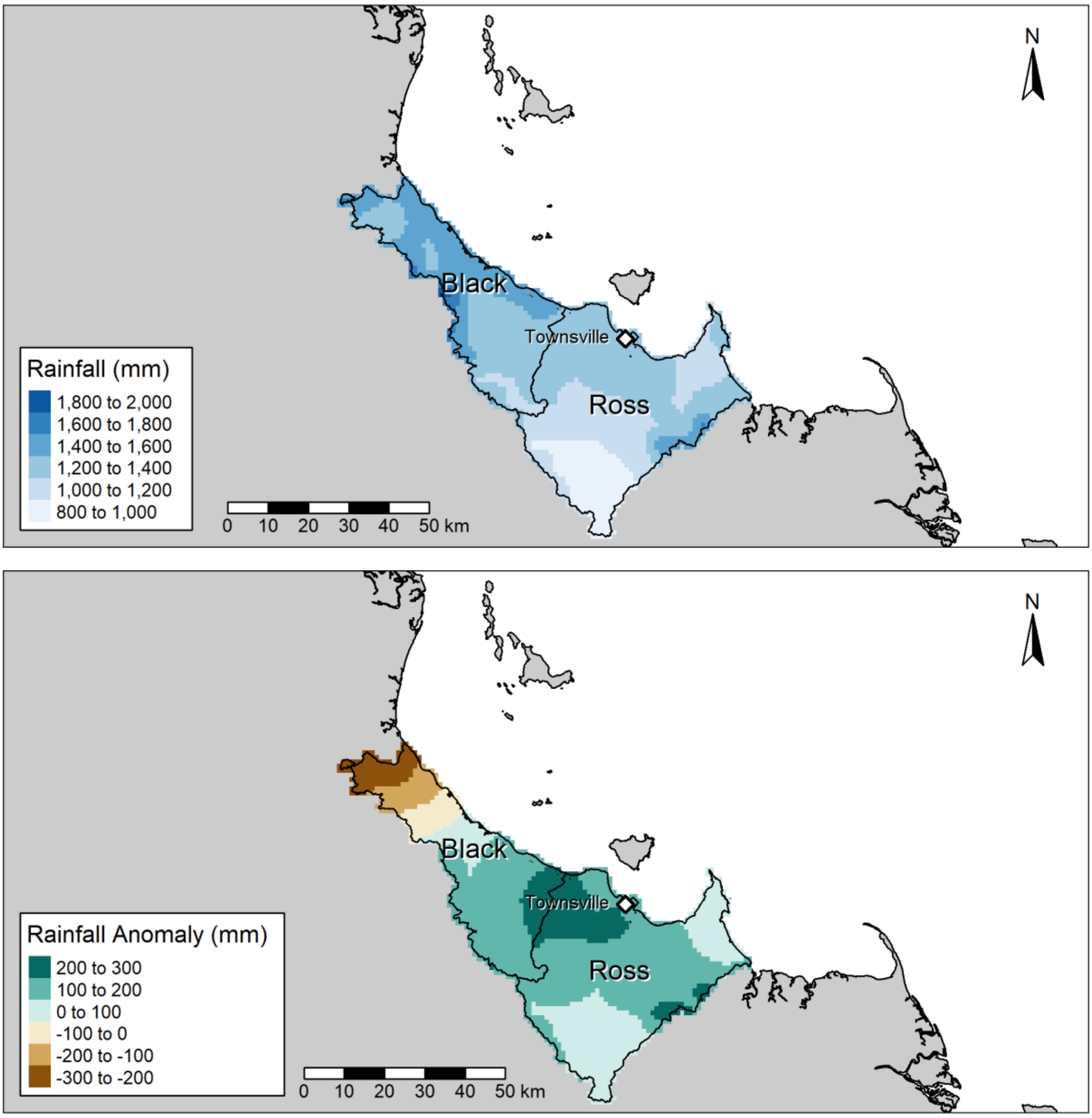


*Figure 15. Total annual rainfall and rainfall anomaly in the Ross and Black Basin.*

For the 2021–2022 reporting period the total annual rainfall in the Ross Basin was 1166mm, this was 137mm (or 113%) more than the long-term mean of 1029mm. In the Black Basin total annual rainfall was 1383mm, which was 57mm (104%) more than the long-term mean of 1326mm (Table 18). This represents an increase from last year in the Ross Basin (Appendix C), and a decrease from last year in the Black Basin (Appendix D).

*Table 77. Annual rainfall summary statistics for the Ross Basin and Black Basin.*

| Basin | Annual Rainfall | Long-term mean (ltm) | Anomaly (+/- ltm) | Percentage of the ltm |
|---|---|---|---|---|
| Ross | 1166mm | 1029mm | +137mm | 113% |
| Black | 1383mm | 1326mm | +57mm | 104% |

**Air Temperature**

Mean annual air temperature has a direct impact on the overall climatic conditions experienced in the Dry Tropics region. Warmer temperatures affect the oceans, weather patterns, plants, and animals. Increased temperatures can change the distribution and habitable range of species and reduce their abundance and density (Environmental Protection Authority 2017). Higher temperatures worsen many types of disasters including storms, heat waves, floods, and droughts, and are causing sea level rise and ocean acidification (Natural Resources Defense Council 2022, New South Wales Government 2023).

Mean monthly air temperature[25] in the Dry Tropics basin was consistently equal to or greater than average every month of the reporting period across both the Ross and Black basins. For five months of the year each basin recorded their "highest 1%" air temperature on record, in only two months were monthly air temperature recorded as "average", and in the remaining five months air temperature was recorded as either "above average" or "very much above average". The "highest 1%" temperatures were recorded in July, August, and October, indicating a warmer than usual winter, and notably in March and April which coincided with a large spike in rainfall (Rainfall, Table 19).

*Table 78. Monthly air temperature percentiles in the Ross Basin and the Black Basin grouped into seven categories.*

| Basin | 2021 | | | | | | 2022 | | | | | | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | |
| Ross | Highest 1% | Highest 1% | Average | Highest 1% | Very much above average | Above Average | Very much above average | Above Average | Highest 1% | Highest 1% | Very much above average | Average | Highest 1% |
| Black | Highest 1% | Highest 1% | Average | Highest 1% | Very much above average | Above Average | Very much above average | Above Average | Highest 1% | Highest 1% | Very much above average | Average | Highest 1% |

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

Annual air temperature varied spatially, with a maximum mean annual temperature of more 26°C in both basins and a minimum mean temperature of ~22°C in the Ross Basin and ~21°C in the Black Basin. The highest temperatures were recorded along the coastline and lower lying areas of each basin, in contrast, cooler mean annual temperatures were recorded on the southern and western edges of the basins where elevation increases. This is particularly apparent across the inland ridge of the Black Basin (Figure 6).

Annual temperature anomalies show that all areas within the Dry Tropics regions recorded mean temperatures above the long-term mean, with a difference of ~1.30°C to ~1.50°C throughout. There was no measurable change in anomaly when moving from coast to ridgeline, suggesting the spatial trend visible in the annual mean air temperature plot is a standard occurrence, however, temperature anomalies did increase consistently from south to north, particularly in the most northern reaches of the Black Basin (Figure 6).

[25] All air temperature data was downloaded from BOM's [Gridded Climatology Data] portal (Bureau of Meteorology 2022)

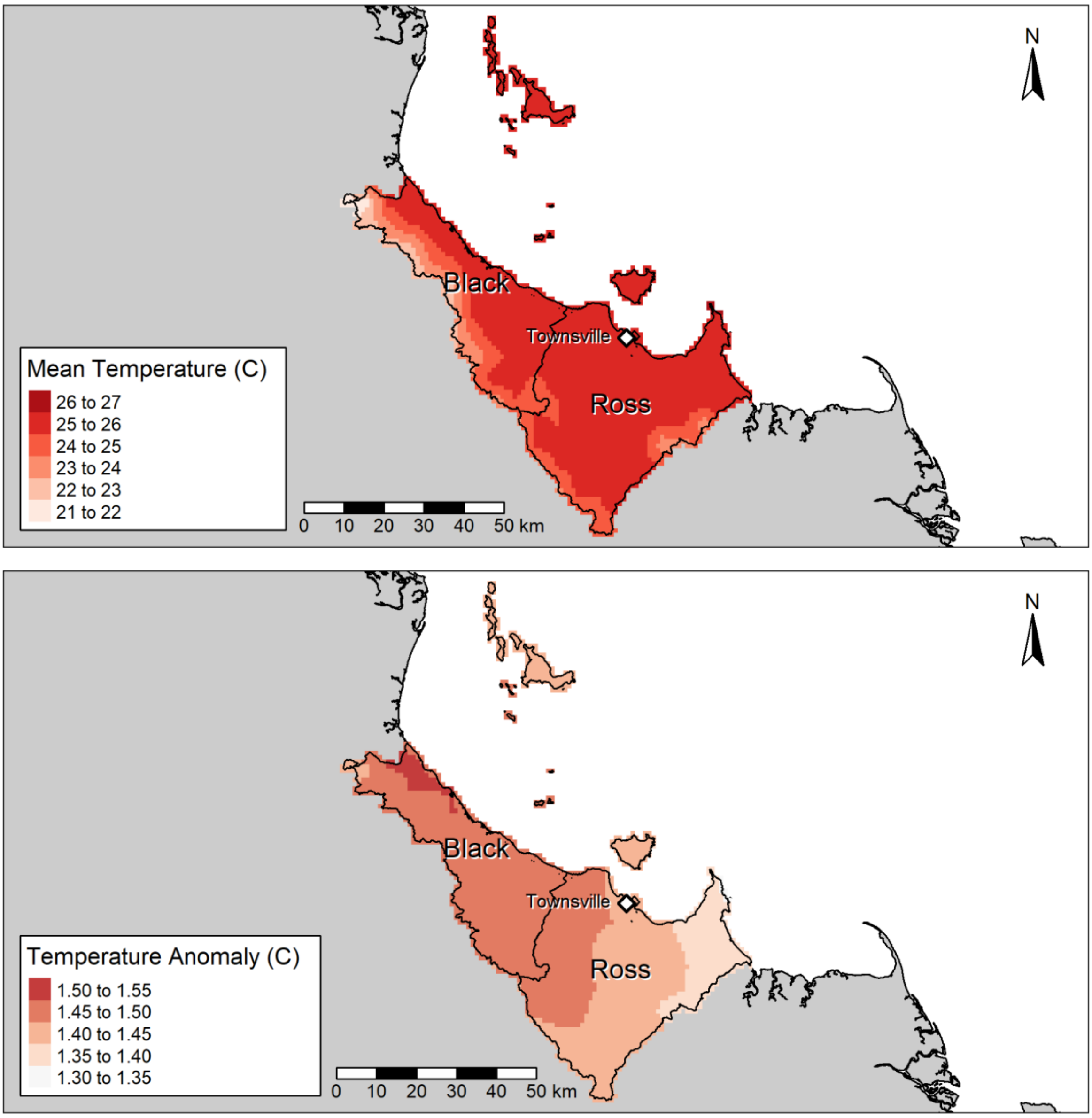


*Figure 16. Total annual air temperature and air temperature anomaly in the Ross and Black Basin.*

During the 2021–2022 reporting period the mean annual air temperature in the Ross Basin was 25.4°C, this was 1.4°C (or 106%) more than the long-term mean of 24.0°C. In the Black Basin mean annual air temperature was 24.9°C, which was 1.4°C (106%) more than the long-term mean of 23.5°C (Table 18). This represents an increase from last year in the Ross Basin (Appendix E), and an increase from last year in the Black Basin (Appendix F).

*Table 79. Annual air temperature summary statistics for the Ross Basin and the Black Basin.*

| Basin | Annual Air Temperature | Long-term mean (ltm) | Anomaly (+/- ltm) | Percentage of the ltm |
|---|---|---|---|---|
| Ross | 25.4°C | 24.0°C | +1.4°C | 106% |
| Black | 24.9°C | 23.5°C | +1.4°C | 106% |

## Sea Surface Temperature

The world's oceans absorb a significant amount of excess heat produced from greenhouse gases and play an important role in the global climate. Without this oceanic buffer, global temperatures would have risen significantly more than they have so far. However, long-term increases in sea surface temperatures (as a proxy for ocean temperature), threaten food security, cause more extreme weather events, lead to a loss of coastal protection, result in ocean acidification, and increase the rate of sea level rise (Climate Policy Watcher 2023, IUCN 2017).

Monthly sea surface temperature[26] in the Dry Tropics marine region was "very much above average" or the "highest 1%" on record for ten months of the year. In only two months of the year was monthly sea surface temperature "average" or "above average". Three of the four "highest 1%" months were recorded consecutively during October, November, and December before cooling down for the following two months and then rising again in March and April. This roughly aligns with monthly air temperatures spikes recorded from October to December, followed by a decrease in the following three months, and then a subsequent increase again (Air Temperature, Table 21).

*Table 80. Monthly air temperature percentiles in the Ross Basin and the Black Basin grouped into seven categories.*

| Region | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dry Tropics | | | | | | | | | | | | | |

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

Annual sea surface temperature in the Dry Tropics marine region varied spatially, with an annual maximum mean temperature of more than ~27.4°C and annual minimum mean temperature of ~26.4°C. The highest temperatures were recorded in the northern most reaches of the marine region and gradually decreased southward. Interestingly the lowest temperatures were recorded about 30km offshore of the coastline, starting at the Palm Island group heading southeast (Figure 7).

Annual sea surface temperature anomalies further highlighted that lower temperatures recorded approximately 30km offshore were not a frequent occurrence. Annual temperature anomalies ranged from about +0.75°C to more than +1.1°C, with the largest temperature anomalies occurring directly on the coastline. These anomalies suggest that the near coastal waters were abnormally warm during the 2021–2022 reporting period (Figure 7).

[26] All sea surface temperature data was downloaded from NOAA's [Coral Reef Watch] portal (NOAA 2023)

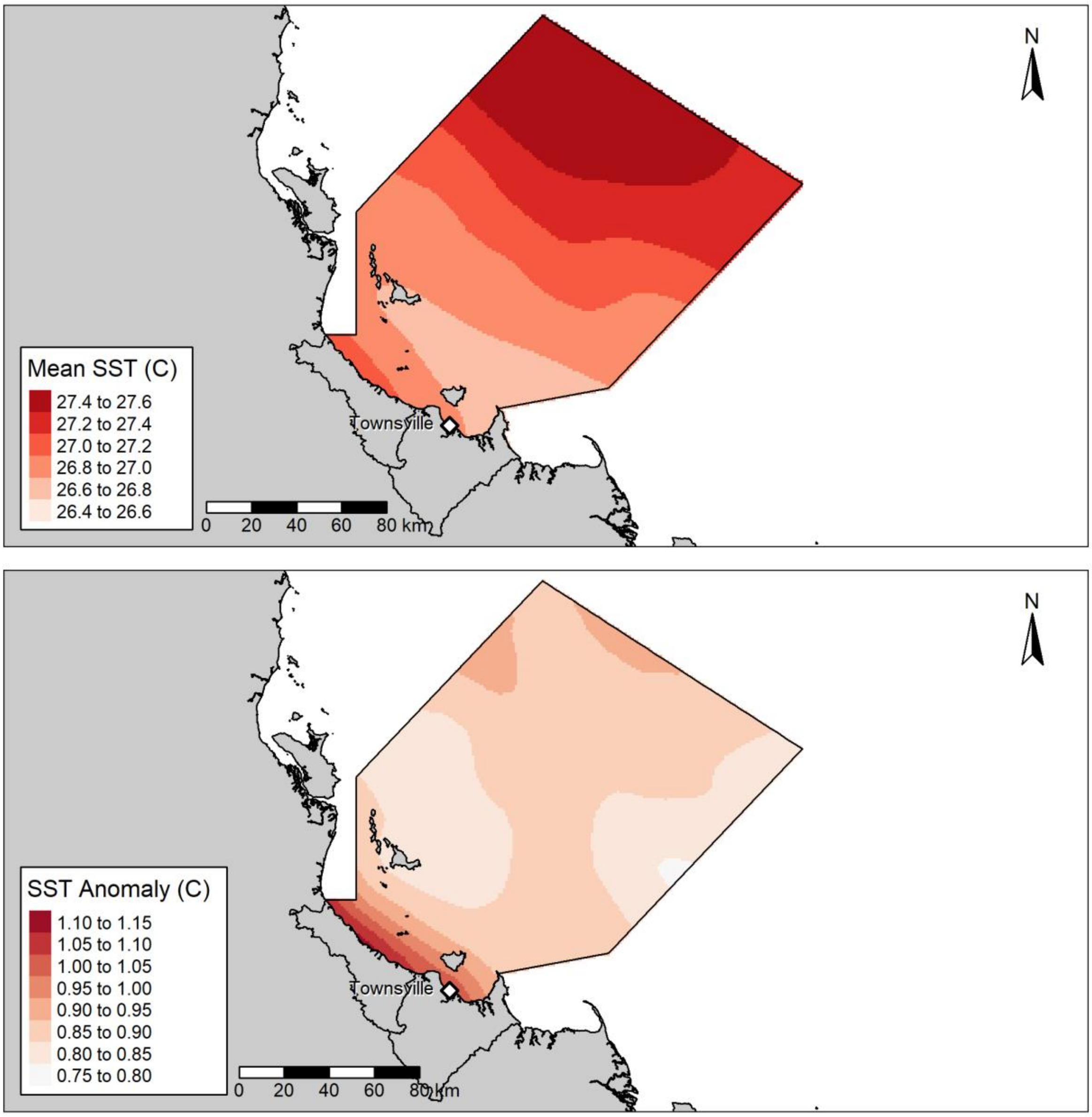


*Figure 17. Total annual sea surface temperature and sea surface temperature anomaly in the Dry Tropic marine region.*

Over the 2021–2022 reporting period the mean annual sea surface temperature in the Dry Tropics marine region was 27.1°C, this was +0.8°C (or 103%) more than the long-term mean of 26.3°C, and represents an increase from last year in the Dry Tropics marine region (Appendix G, Table 22).

*Table 81. Annual sea surface temperature summary statistics for the Dry Tropics marine region.*

| Region | Annual Sea Surface Temperature | Long-term mean (ltm) | Anomaly (+/- ltm) | Percentage of the ltm |
|---|---|---|---|---|
| Dry Tropics | 27.1°C | 26.3°C | +0.8°C | 103% |

## Coral Bleaching (Degree Heating Weeks)

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[27] (NOAA 2023). The DHW dataset shows the accumulated heat stress experienced by corals in the prior three months and is a cumulative measure of both intensity and duration of heat stress. Temperatures exceeding 1°C above the usual summertime maximum are sufficient to cause stress, including bleaching, and are the basis of a degree heating week. A DHW of 2 is equivalent to one week of Hot Spot values persistently at 2°C, or two weeks of Hot Spot values persistently at 1°C above usual summertime maximum temperatures. DHWs over 4 °C have been shown to cause significant coral bleaching, and values over 8°C have caused severe bleaching and significant mortality (NOAA 2023).

In 2021–2022, coral bleaching risk in the Dry Tropics marine region ranged from "possible" to "highly likely", with no region showing low risk. DHWs ranged from 4 to 6, up to >8 and highly likely bleaching risk (>8 DHWs) was predominantly recorded in the coastal waters, and at the eastern edge of the region (Figure 8). The greater number of DHWs inshore aligns with the records of increased annual sea surface temperature and increased annual sea surface temperature anomalies in the same location (Sea Surface Temperature, Figure 7). Further, the 2021–2022 period has recorded a greater number of DHWs than four of the past five years (Appendix H)

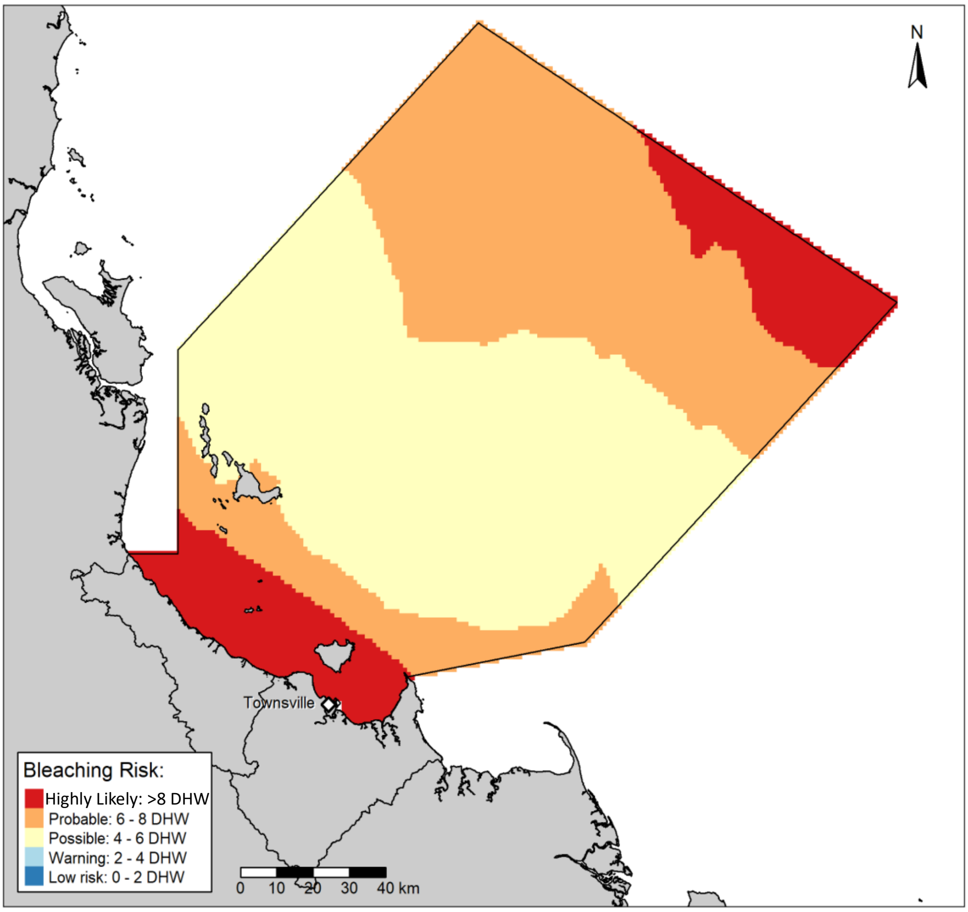


*Figure 18. Total annual degree heating weeks (bleaching events) in the Dry Tropic marine region.*

[27] All degree heating week data was downloaded from NOAA's [Coral Reef Watch] portal (NOAA 2023)

# Appendix C. Ross Basin Long-Term Annual Rainfall Trends

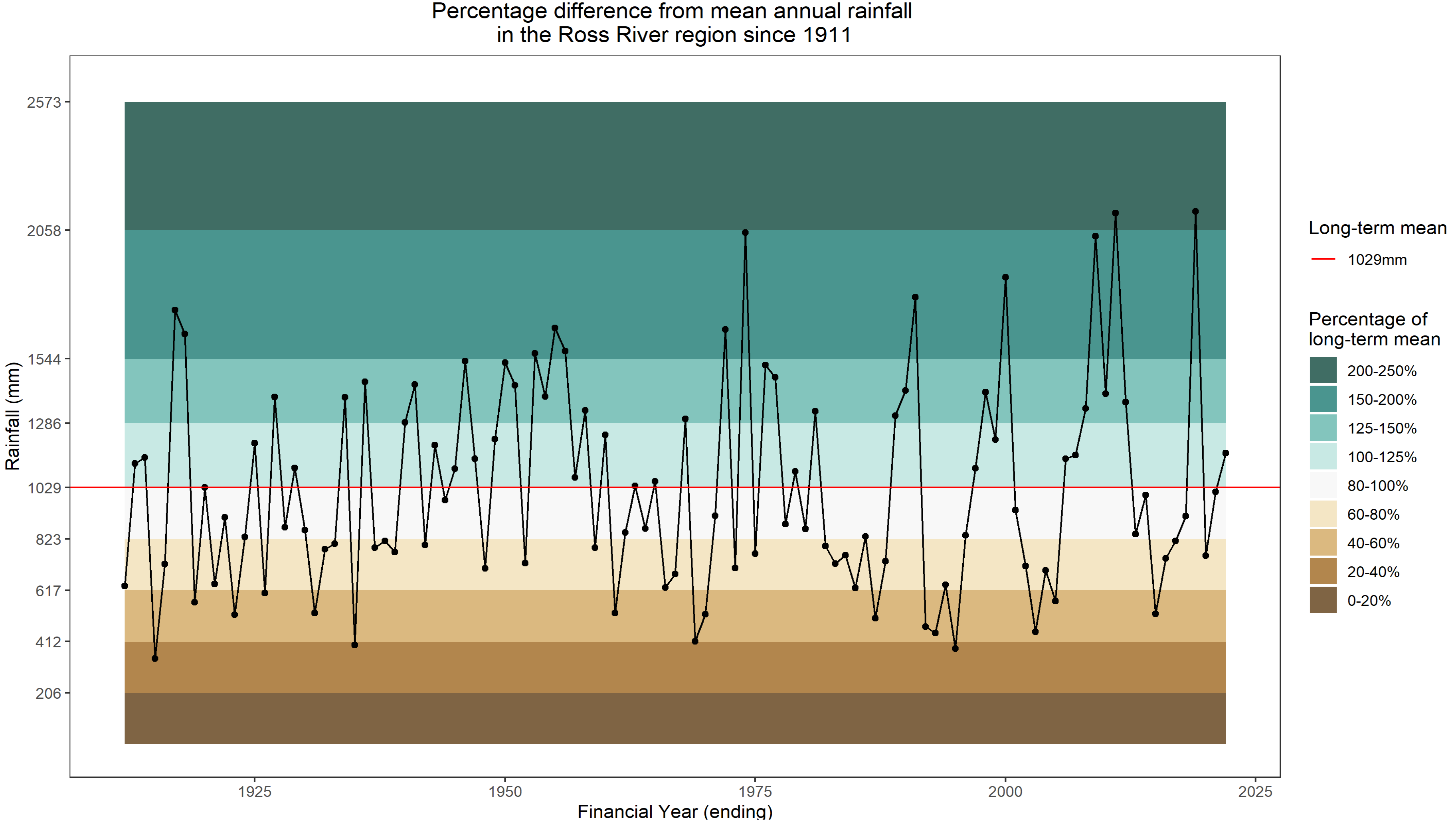


*Figure 19. Ross Basin long-term annual rainfall trends.*

# Appendix D. Black Basin Long-Term Annual Rainfall Trends

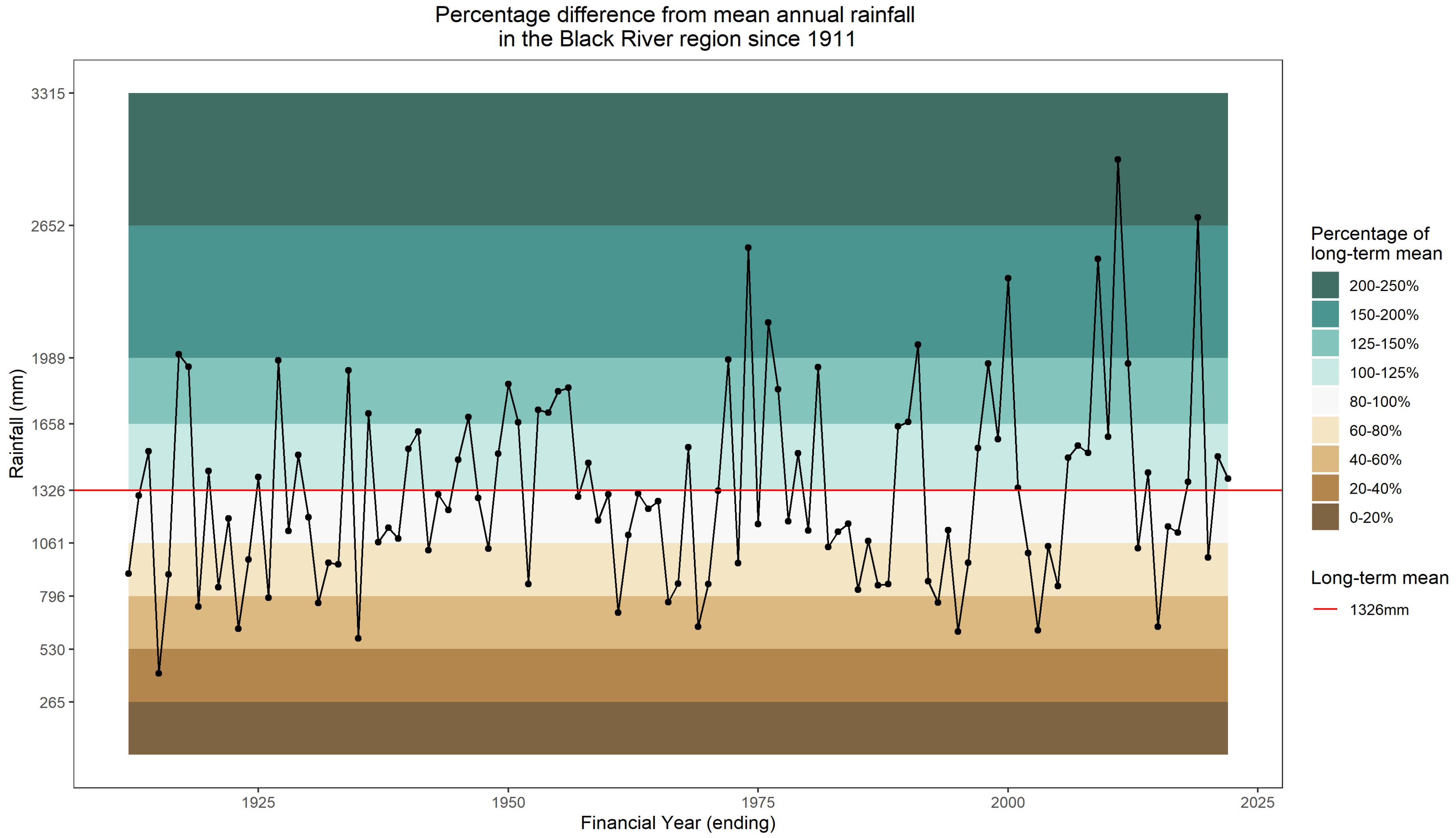


*Figure 20. Black Basin long-term annual rainfall trends.*

# Appendix E. Ross Basin Long-Term Annual Air Temperature

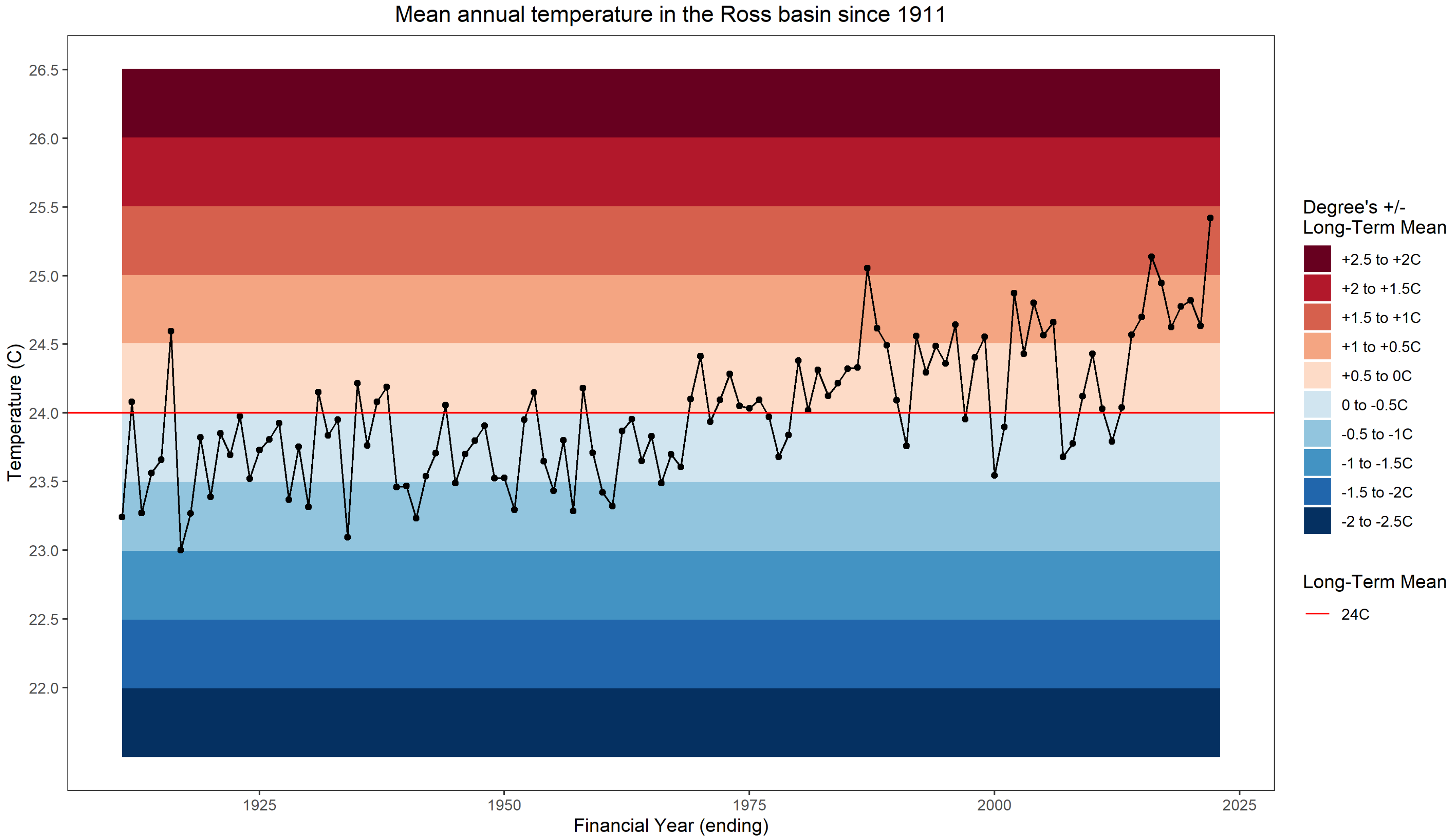


*Figure 21. Ross Basin long-term annual air temperature trends.*

# Appendix F. Black Basin Long-Term Annual Air Temperature

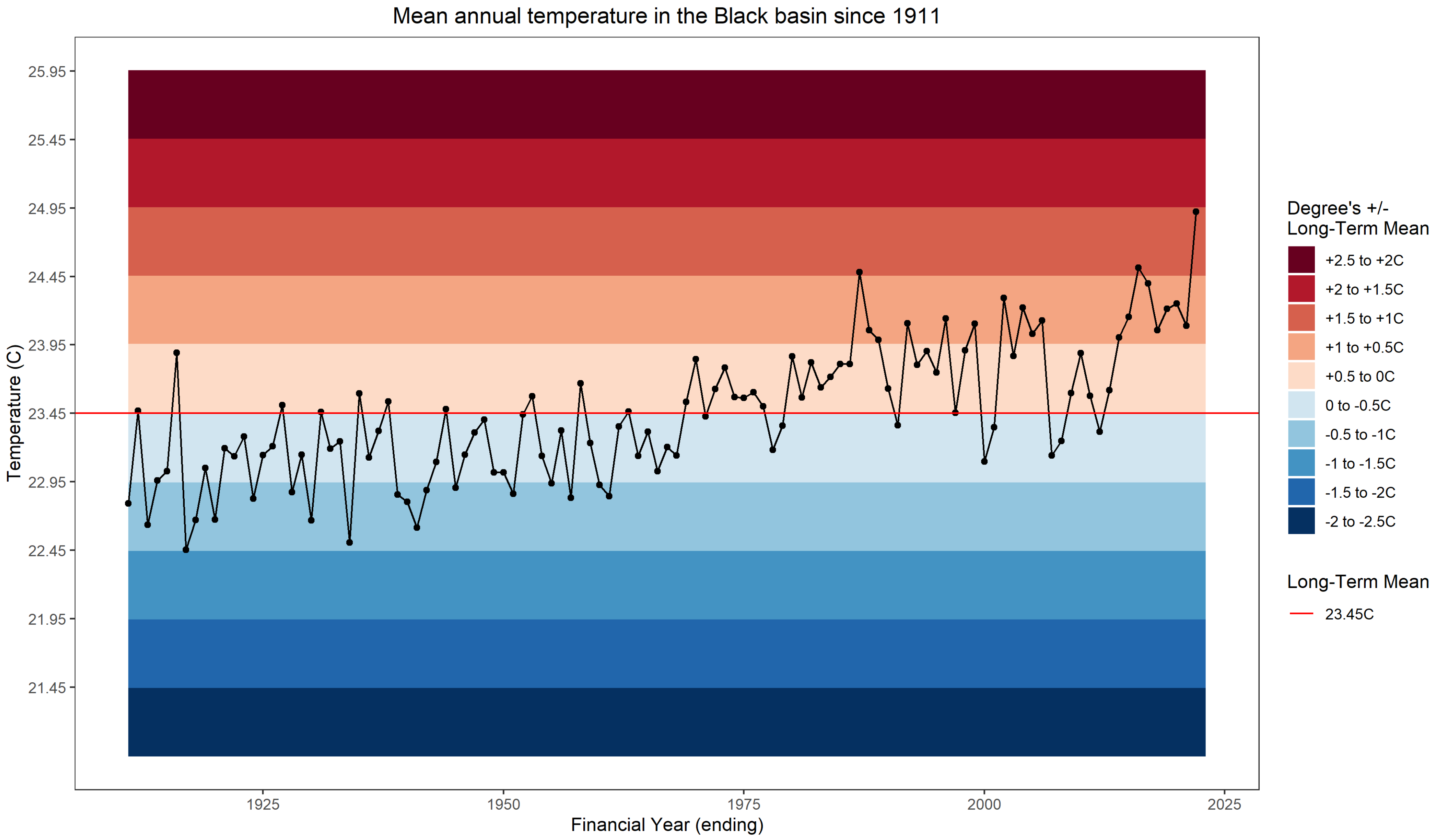


*Figure 22. Black Basin long-term annual air temperature trends.*

# Appendix G. Dry Tropics Marine Waters Long-Term Annual Sea Surface Temperature

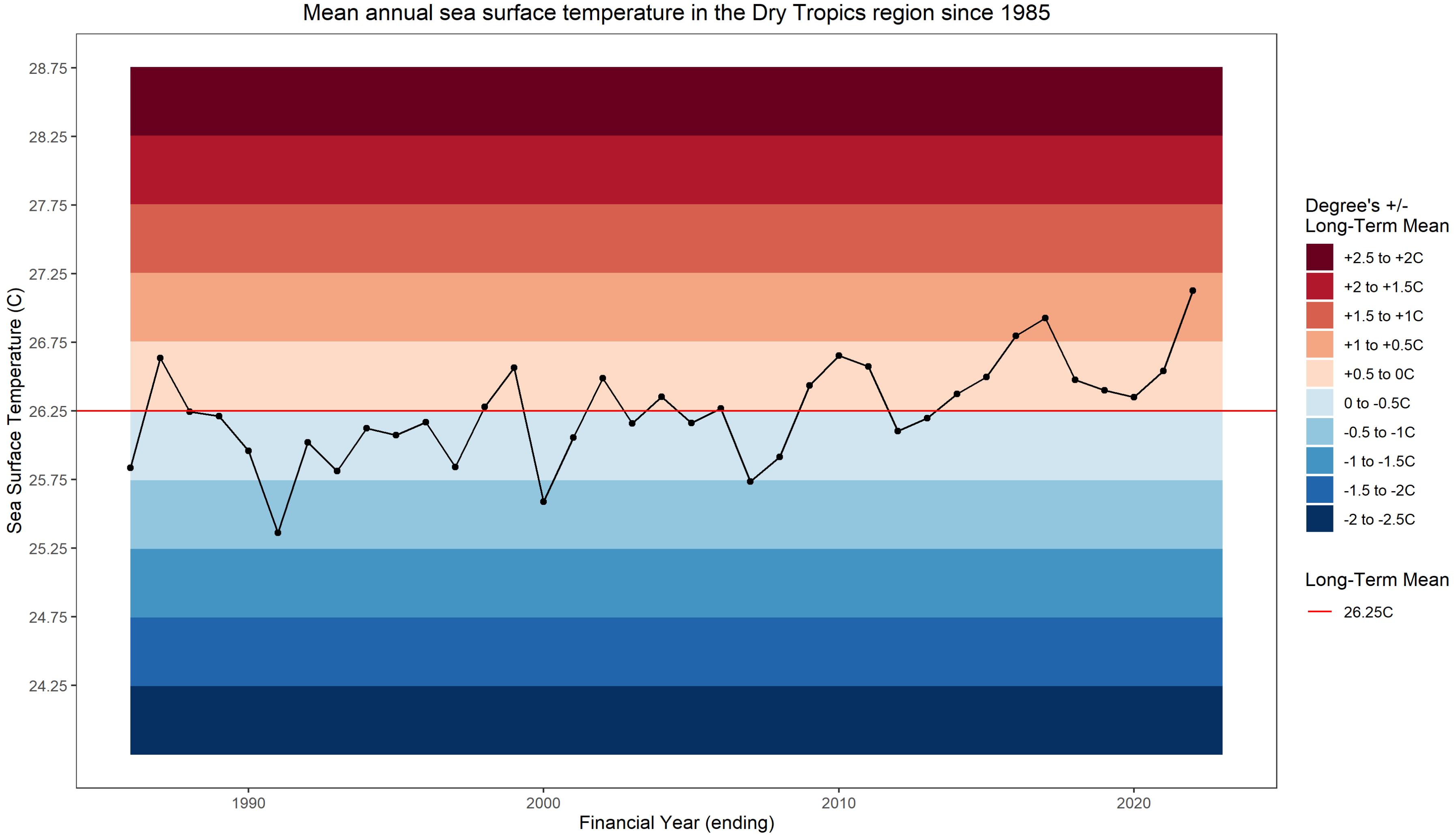


*Figure 23. Black Basin long-term annual sea surface temperature trends.*

## Appendix H. Dry Tropics Marine Waters 5-year Historic Degree Heating Week Maps

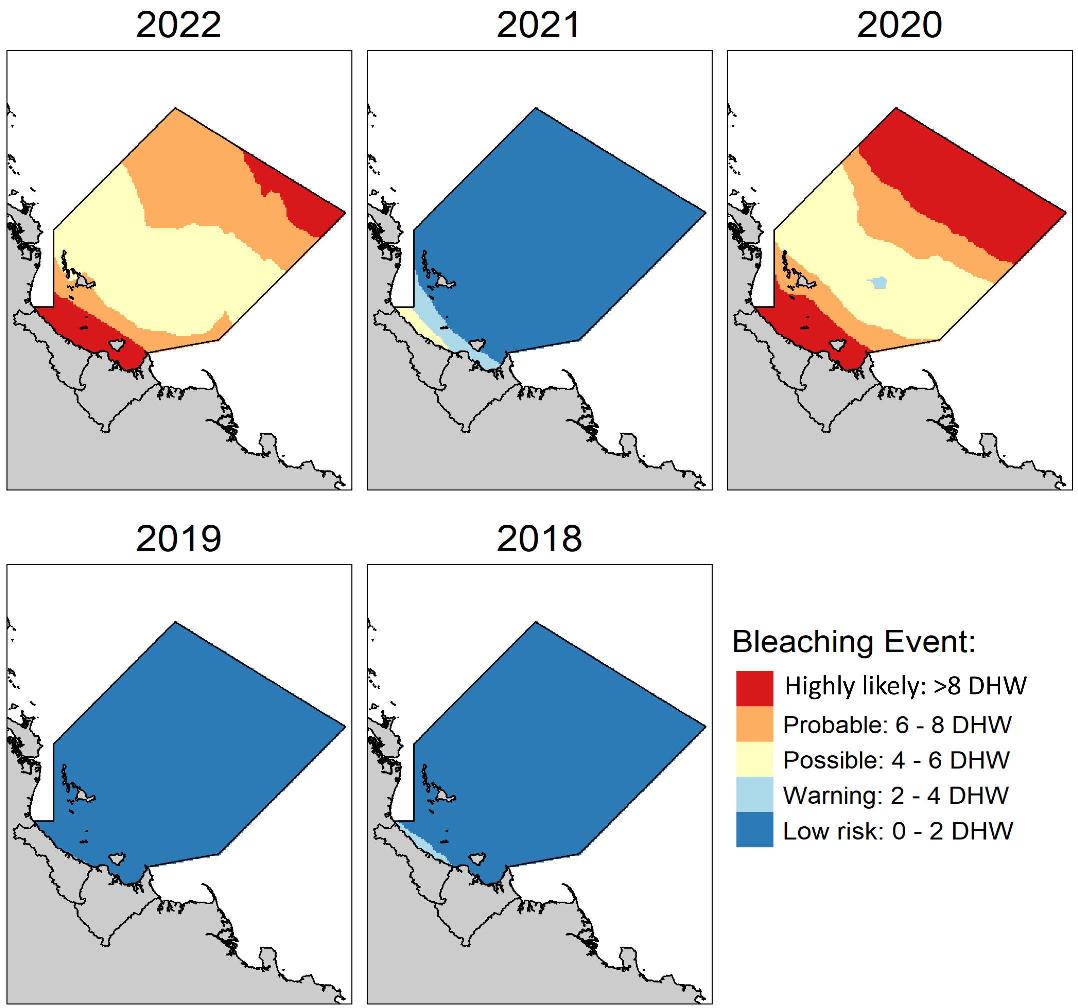


*Figure 24. Dry Tropics Marine Region 5-year Historic Degree Heating Week Map.*

# Appendix I. Freshwater Quality Sampling Locations

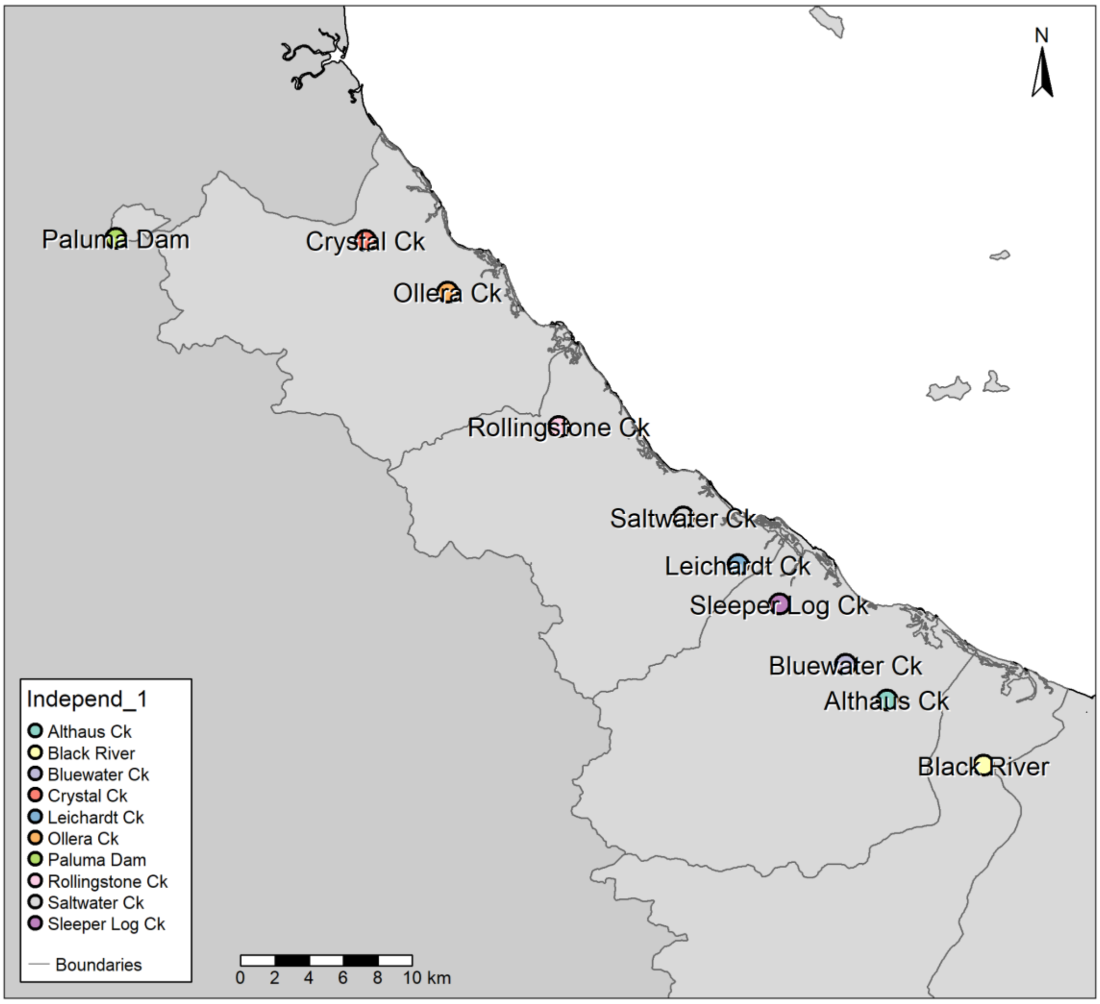


*Figure 25. Black Freshwater Basin water quality site locations.*

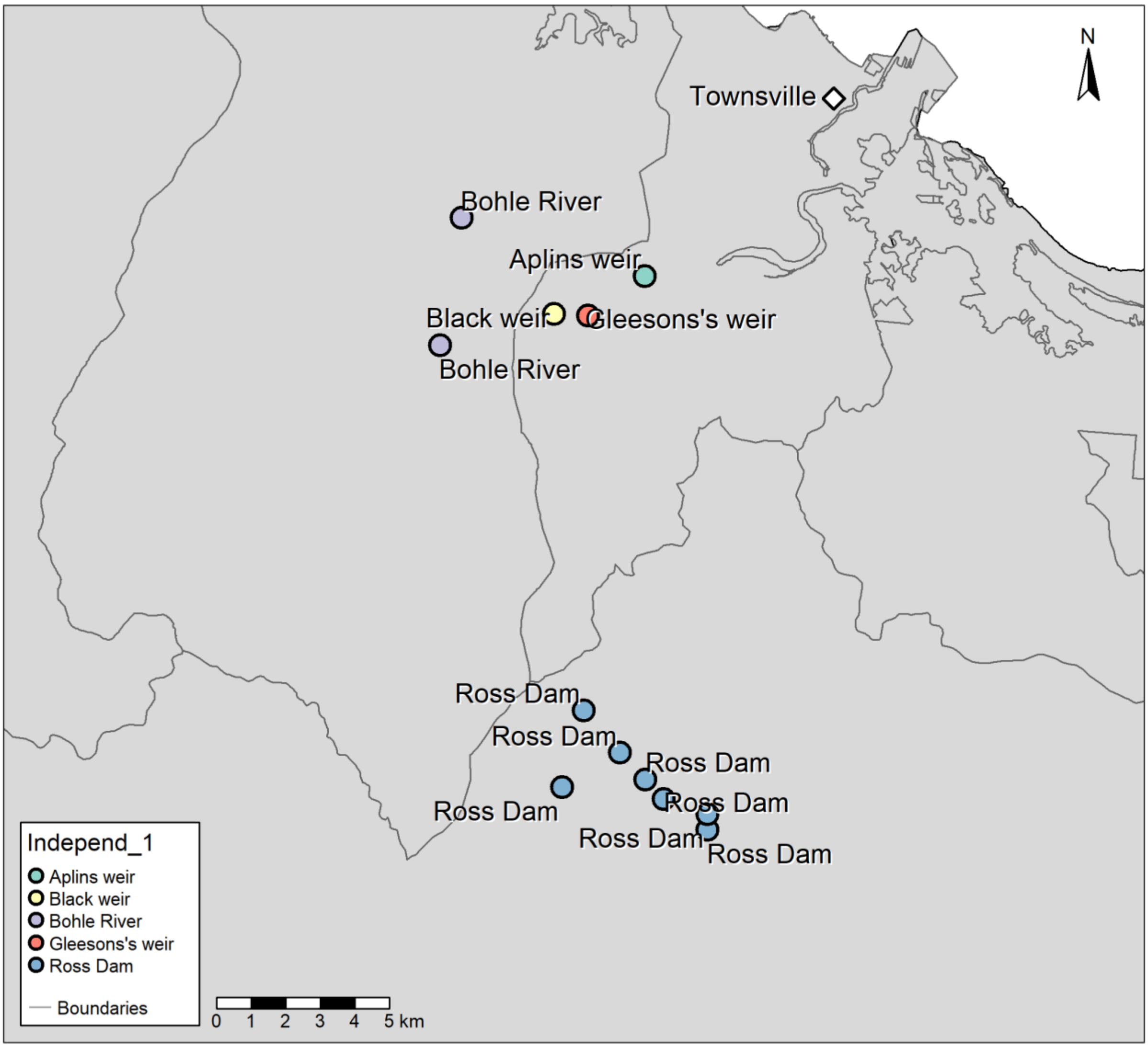


*Figure 26. Ross Freshwater Basin water quality site locations.*

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

*Table 82. Number of samples, number of months sampled, median, water quality objective values, and scaling factors for DIN, TP and FRP in the Dry Tropics Freshwater Environments.*

| Watercourse | DIN (mg/L) | | | | | TP (mg/L) | | | | | FRP (mg/L) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N.Samples | N.Months | Median | WQO | SF | N.Samples | N.Months | Median | WQO | SF | N.Samples | N.Months | Median | WQO | SF |
| Ross Lake | 151 | 12 | 0.015 | 0.02 | 0.38 | 150 | 12 | 0.03 | 0.03 | 0.46 | 132 | 12 | 0.005 | 0.01 | NA |
| Aplin's Weir | 54 | 12 | 0.020 | 0.02 | 0.38 | 0 | 0 | NA | 0.03 | 0.46 | 54 | 12 | 0.005 | 0.02 | NA |
| Gleesons Weir | 11 | 11 | 0.015 | 0.02 | 0.38 | 0 | 0 | NA | 0.03 | 0.46 | 11 | 11 | 0.005 | 0.02 | NA |
| Blacks Weir | 11 | 11 | 0.030 | 0.02 | 0.38 | 10 | 10 | 0.01 | 0.03 | 0.46 | 11 | 11 | 0.005 | 0.02 | NA |
| Bohle Mid-Field | 11 | 11 | 0.200 | 0.08 | 0.38 | 11 | 11 | 3.2 | 0.05 | 0.46 | 11 | 11 | 3.2 | 0.02 | NA |
| Bohle Far-Field | 11 | 11 | 0.082 | 0.08 | 0.38 | 11 | 11 | 1.4 | 0.05 | 0.46 | 11 | 11 | 1 | 0.02 | NA |
| Black River | 52 | 11 | 0.012 | 0.02 | 0.05 | 11 | 11 | 0.020 | 0.02 | 0.03 | 51 | 11 | 0.012 | 0.02 | NA |
| Althaus Ck | 8 | 8 | 0.005 | 0.02 | 0.05 | 8 | 8 | 0.022 | 0.02 | 0.03 | 8 | 8 | 0.005 | 0.02 | NA |
| Bluewater Ck | 11 | 11 | 0.006 | 0.02 | 0.05 | 10 | 10 | 0.011 | 0.02 | 0.03 | 11 | 11 | 0.003 | 0.02 | NA |
| Sleeper Log Ck | 11 | 11 | 0.005 | 0.02 | 0.05 | 11 | 11 | 0.016 | 0.02 | 0.03 | 11 | 11 | 0.003 | 0.02 | NA |
| Leichhardt Ck | 11 | 11 | 0.006 | 0.02 | 0.05 | 11 | 11 | 0.011 | 0.02 | 0.03 | 11 | 11 | 0.003 | 0.01 | NA |
| Saltwater Ck | 11 | 11 | 0.003 | 0.02 | 0.05 | 11 | 11 | 0.009 | 0.02 | 0.03 | 11 | 11 | 0.002 | 0.01 | NA |
| Rollingstone Ck | 11 | 11 | 0.008 | 0.02 | 0.05 | 10 | 10 | 0.009 | 0.02 | 0.03 | 11 | 11 | 0.002 | 0.01 | NA |
| Ollera Ck | 9 | 9 | 0.004 | 0.02 | 0.05 | 9 | 9 | 0.009 | 0.02 | 0.03 | 9 | 9 | 0.003 | 0.01 | NA |
| Crystal Ck | 11 | 11 | 0.012 | 0.02 | 0.05 | 10 | 10 | 0.007 | 0.02 | 0.03 | 11 | 11 | 0.002 | 0.01 | NA |
| Paluma Lake | 0 | 0 | NA | 0.02 | 0.05 | 11 | 11 | 0.010 | 0.03 | 0.06 | 11 | 11 | 0.005 | 0.01 | NA |

**Key:** = Mean/Median is lower than the guideline value | = Mean/Median is higher than the guideline value.

# Appendix K. Freshwater Quality Nutrients Scores Historic Comparison

*Table 83. Dry Tropics freshwater water quality historic nutrient indicator scores.*

| Basin | Sub Basin | Watercourse | DIN 2021–2022 | DIN 2020–2021 | DIN 2019–2020 | TP 2021–2022 | TP 2020–2021 | TP 2019–2020 |
|---|---|---|---|---|---|---|---|---|
| Ross | Upper Ross | Ross Lake | 90 (A) | 90 (A) | 68 (B) | 61 (B) | 90 (A) | 61 (B) |
| | Lower Ross | Aplin's Weir | 61 (B) | 59 (C) | 66 (B) | ND | ND | ND |
| | | Gleesons Weir | 90 (A) | 62 (B) | 74 (B) | ND | ND | ND |
| | | Blacks Weir | 59 (C) | 61 (B) | 59 (C) | 90 (A) | 90 (A) | 70 (B) |
| | | | 70 (B) | 60 (C) | 66 (B) | 90 (A) | 90 (A) | 70 (B) |
| | Bohle River | Bohle Mid-Field | 36 (D) | 43 (C) | 0 (E) | 0 ( E ) | 0 (E) | 0 (E) |
| | | Bohle Far-Field | 60 (C ) | 66 (B) | 29 (D) | 0 ( E ) | 0 (E) | 0 (E) |
| | | | 48 (C ) | 54 (C) | 15 (E) | 0 ( E ) | 0 (E) | 0 (E) |
| | | | 66 (B) | 68 (B) | 49 (C) | 37 ( D ) | 60 (C) | 33 (D) |
| Black | Black River | Black River | 63 (B) | 61 (B) | 78 (B) | 61 (B) | 54 (C) | 9 (E) |
| | Bluewater Ck | Althaus Ck | 90 (A) | 67 (B) | 74 (B) | 48 (C ) | 90 (A) | 90 (A) |
| | | Bluewater Ck | 66 (B) | 63 (B) | 90 (A) | 90 (A) | 73 (B) | 66 (B) |
| | | Sleeper Log Ck | 71 (B) | 74 (B) | 62 (B) | 90 (A) | 90 (A) | 90 (A) |
| | | | 75 (B) | 68 (B) | 75 (B) | 76 (B) | 84 (A) | 82 (A) |
| | Rollingstone Ck | Leichhardt Ck | 90 (A) | 74 (B) | 90 (A) | 90 (A) | 76 (B) | 55 (C) |
| | | Saltwater Ck | 90 (A) | 70 (B) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| | | Rollingstone Ck | 62 (B) | 0 (E) | 64 (B) | 90 (A) | 90 (A) | 90 (A) |
| | | | 80 (B) | 48 (C) | 81 (A) | 90 (A) | 85 (A) | 78 (B) |
| | Crystal Ck | Ollera Ck | 71 (B) | 66 (B) | 63 (B) | 90 (A) | 90 (A) | 90 (A) |
| | | Crystal Ck | 69 (B) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| | | | 70 (B) | 78 (B) | 76 (B) | 90 (A) | 90 (A) | 90 (A) |
| | Paluma Lake | Paluma Lake | NA | 63 (B) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| | | | 74 (B) | 63 (B) | 79 (B) | 82 (A) | 83 (A) | 76 (B) |

**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).

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

*Table 84. Number of samples, number of months sampled, median, water quality objective values, and scaling factors for Turbidity, High DO, Low DO,  in the Dry Tropics Freshwater Environments.*

| Watercourse | Turbidity | | | | | | | | High DO | | Low DO | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N.Samples | N.Months | Median | WQO | SF | N.Samples | N.Months | Median | WQO | SF | WQO | SF |
| Ross Lake | 133 | 12 | 8 | 10 | 35 | 151 | 12 | 96 | 110 | 120 | 90 | 70 |
| Aplin's Weir | 12 | 12 | 3 | 10 | 35 | 11 | 11 | 88 | 110 | 120 | 90 | 70 |
| Gleesons Weir | 11 | 11 | 1 | 10 | 35 | 10 | 10 | 74 | 110 | 120 | 90 | 70 |
| Blacks Weir | 11 | 11 | 2 | 10 | 35 | 10 | 10 | 76 | 110 | 120 | 90 | 70 |
| Bohle Mid-Field | 11 | 11 | 12 | 22 | 35 | 10 | 10 | 77 | 110 | 120 | 85 | 70 |
| Bohle Far-Field | 11 | 11 | 8 | 22 | 35 | 10 | 10 | 80 | 110 | 120 | 85 | 70 |
| Black River | 10 | 10 | 2 | 5 | 10 | 11 | 11 | 108 | 105 | 120 | 90 | 70 |
| Althaus Ck | 7 | 7 | 15 | 5 | 10 | 8 | 8 | 100 | 105 | 120 | 90 | 70 |
| Bluewater Ck | 10 | 10 | 3 | 5 | 10 | 11 | 11 | 93 | 105 | 120 | 90 | 70 |
| Sleeper Log Ck | 10 | 10 | 12 | 5 | 10 | 11 | 11 | 77 | 105 | 120 | 90 | 70 |
| Leichhardt Ck | 10 | 10 | 3 | 5 | 10 | 11 | 11 | 90 | 105 | 120 | 90 | 70 |
| Saltwater Ck | 10 | 10 | 2 | 5 | 10 | 11 | 11 | 98 | 105 | 120 | 90 | 70 |
| Rollingstone Ck | 10 | 10 | 0 | 5 | 10 | 11 | 11 | 83 | 105 | 120 | 90 | 70 |
| Ollera Ck | 8 | 8 | 2 | 5 | 10 | 9 | 9 | 69 | 105 | 120 | 90 | 70 |
| Crystal Ck | 10 | 10 | 1 | 5 | 10 | 11 | 11 | 96 | 105 | 120 | 90 | 70 |
| Paluma Lake | 11 | 11 | 2 | 10 | 20 | 11 | 11 | 88 | 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.

# Appendix M. Freshwater Quality Physical-Chemical Properties Scores Historic Comparison

*Table 85. Dry Tropics freshwater water quality historic physical-chemical indicator scores.*

| Basin | Sub Basin | Watercourse | Turbidity | | | High DO | | | Low DO | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2021–2022 | 2020–2021 | 2019–2020 | 2021–2022 | 2020–2021 | 2019–2020 | 2021–2022 | 2020–2021 | 2019–2020 |
| Ross | Upper Ross | Ross Lake | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| | Lower Ross | Aplin's Weir | 90 (A) | 90 (A) | 90 (A) | 80 (B) | 90 (A) | 90 (A) | 55 (C) | 74 (B) | 90 (A) |
| | | Gleesons Weir | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 11 (E) | 50 (C) | 73 (B) |
| | | Blacks Weir | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 19 (E) | 26 (D) | 56 (C) |
| | | | 90 (A) | 90 (A) | 90 (A) | 86 (A) | 90 (A) | 90 (A) | 28 (D) | 50 (C) | 73 (B) |
| | Bohle River | Bohle Mid-Field | 67 (B) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 26 (D) | 0 (E) | 0 (E) |
| | | Bohle Far-Field | 66 (B) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 40 (D) | 37 (D) | 0 (E) |
| | | | 66 (B) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 33 (D) | 18 (E) | 0 (E) |
| | | | 82 (A) | 90 (A) | 90 (A) | 88 (A) | 90 (A) | 90 (A) | 40 (D) | 52 (C) | 51 (C) |
| Black | Black River | Black River | 90 (A) | 69 (B) | 90 (A) | 47 (C) | 53 (C) | 62 (B) | 90 (A) | 90 (A) | 90 (A) |
| | Bluewater Ck | Althaus Ck | 0 (E) | 12 (E) | 90 (A) | 90 (A) | 69 (B) | 4 (E) | 90 (A) | 90 (A) | 81 (A) |
| | | Bluewater Ck | 90 (A) | 90 (A) | 90 (A) | 79 (B) | 90 (A) | 90 (A) | 66 (B) | 77 (B) | 11 (E) |
| | | Sleeper Log Ck | 0 (E) | 90 (A) | 70 (B) | 90 (A) | 90 (A) | 90 (A) | 20 (E) | 76 (B) | 32 (D) |
| | | | 30 (D) | 64 (B) | 83 (A) | 86 (A) | 90 (A) | 90 (A) | 59 (C) | 81 (A) | 41 (C) |
| | Rollingstone Ck | Leichhardt Ck | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 61 (B) | 61 (B) | 27 (D) |
| | | Saltwater Ck | 75 (B) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 66 (B) | 90 (A) |
| | | Rollingstone Ck | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 40 (D) | 74 (B) | 51 (C) |
| | | | 85 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 63 (B) | 67 (B) | 56 (C) |
| | Crystal Ck | Ollera Ck | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 0 (E) | 59 (C) | 0 (E) |
| | | Crystal Ck | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 73 (B) | 75 (B) |
| | | | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 45 (C) | 66 (B) | 37 (D) |
| | Paluma Lake | Paluma Lake | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 55 (C) | 90 (A) | 69 (B) |
| | | | **70 (B)** | **80 (B)** | **88 (A)** | **85 (A)** | **85 (A)** | **79 (B)** | **60 (C)** | **75 (B)** | **53 (C)** |

**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)

# Appendix N. Freshwater Quality 2021–2022 Boxplots

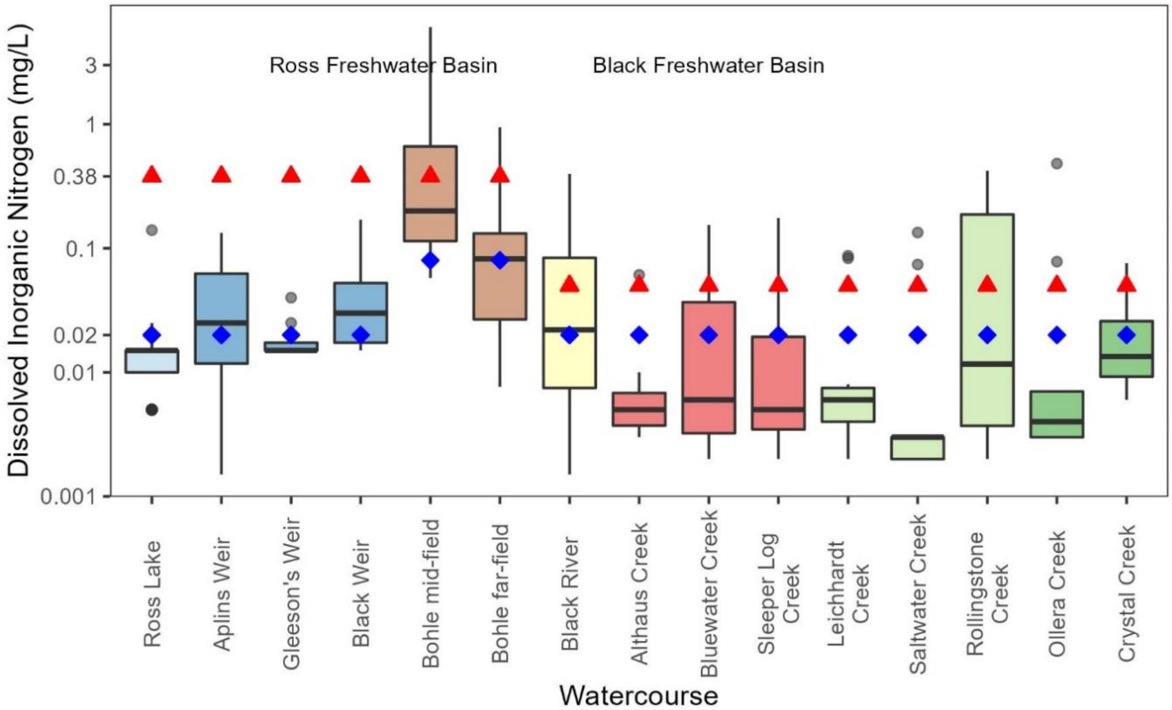


*Figure 27: Dissolved Inorganic Nitrogen (DIN) (mg/L) Boxplot: red triangles indicate the scaling factor, blue diamonds indicate the water quality objective.*

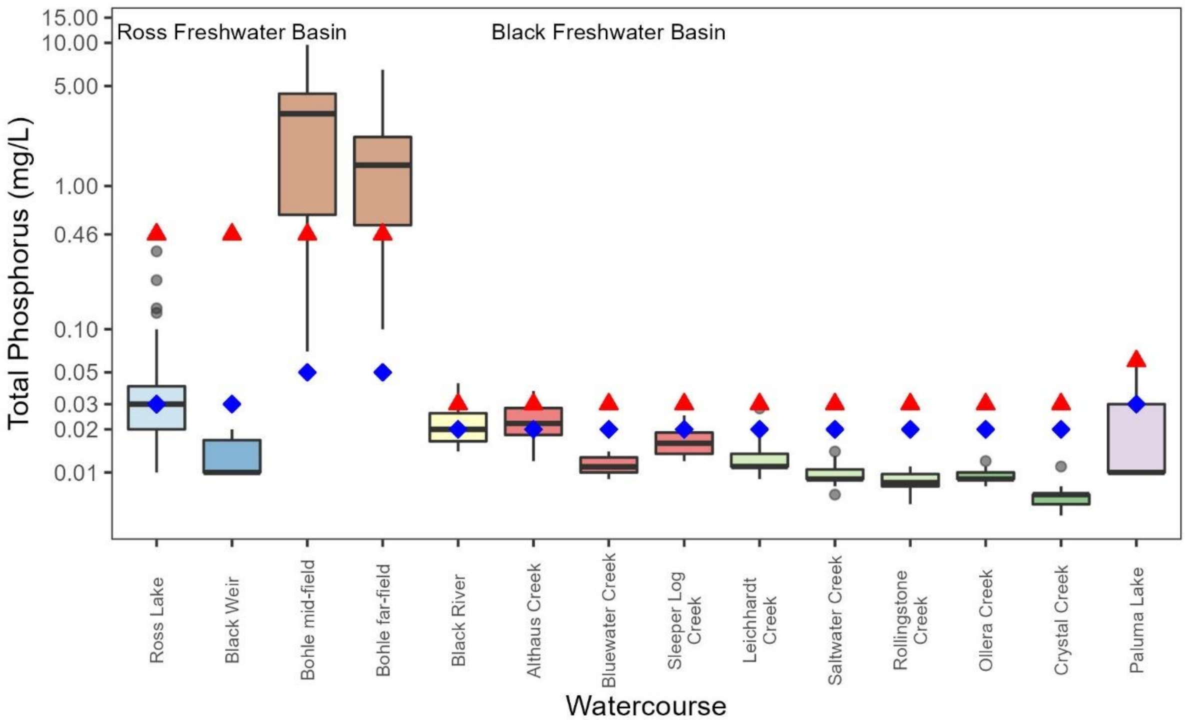


*Figure 28: Total Phosphorus (TP) (mg/l) boxplot: red triangles indicate the scaling factor, blue diamonds indicate the water quality objective.*

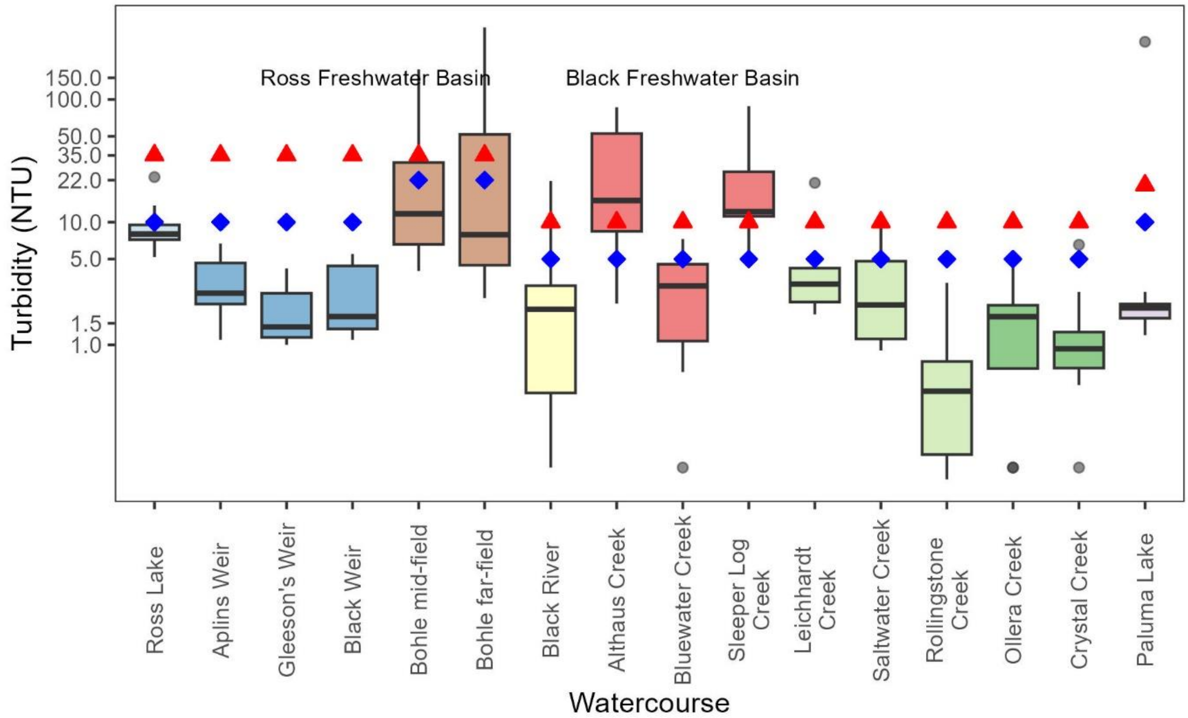


*Figure 29: Turbidity (NTU) boxplot: red triangles indicate the scaling factor, blue diamonds indicate the water quality objective.*

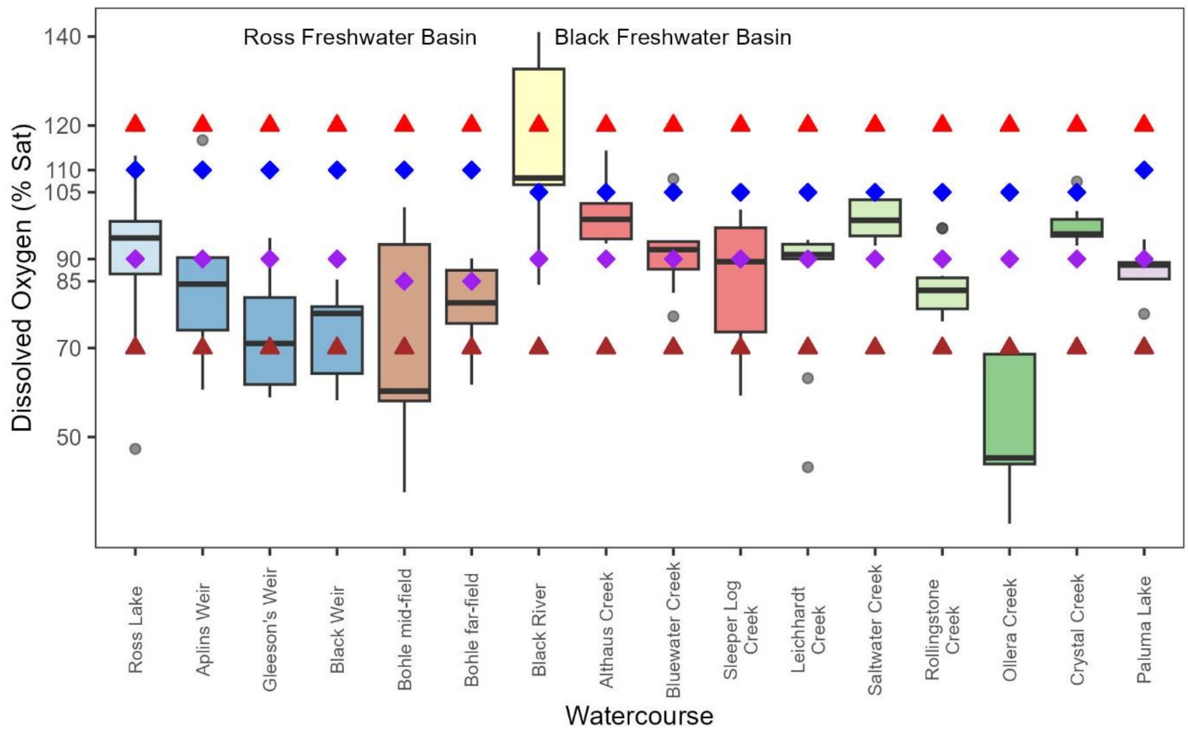


*Figure 30: Dissolved Oxygen (DO) (% Saturation) boxplot: red triangles indicate the high DO scaling factor, blue diamonds indicate the high DO water quality objective, purple diamonds indicate the low DO water quality objective, and brown triangles indicate the low DO scaling factor.*

# Appendix O. Fresh Water Quality Line Plots

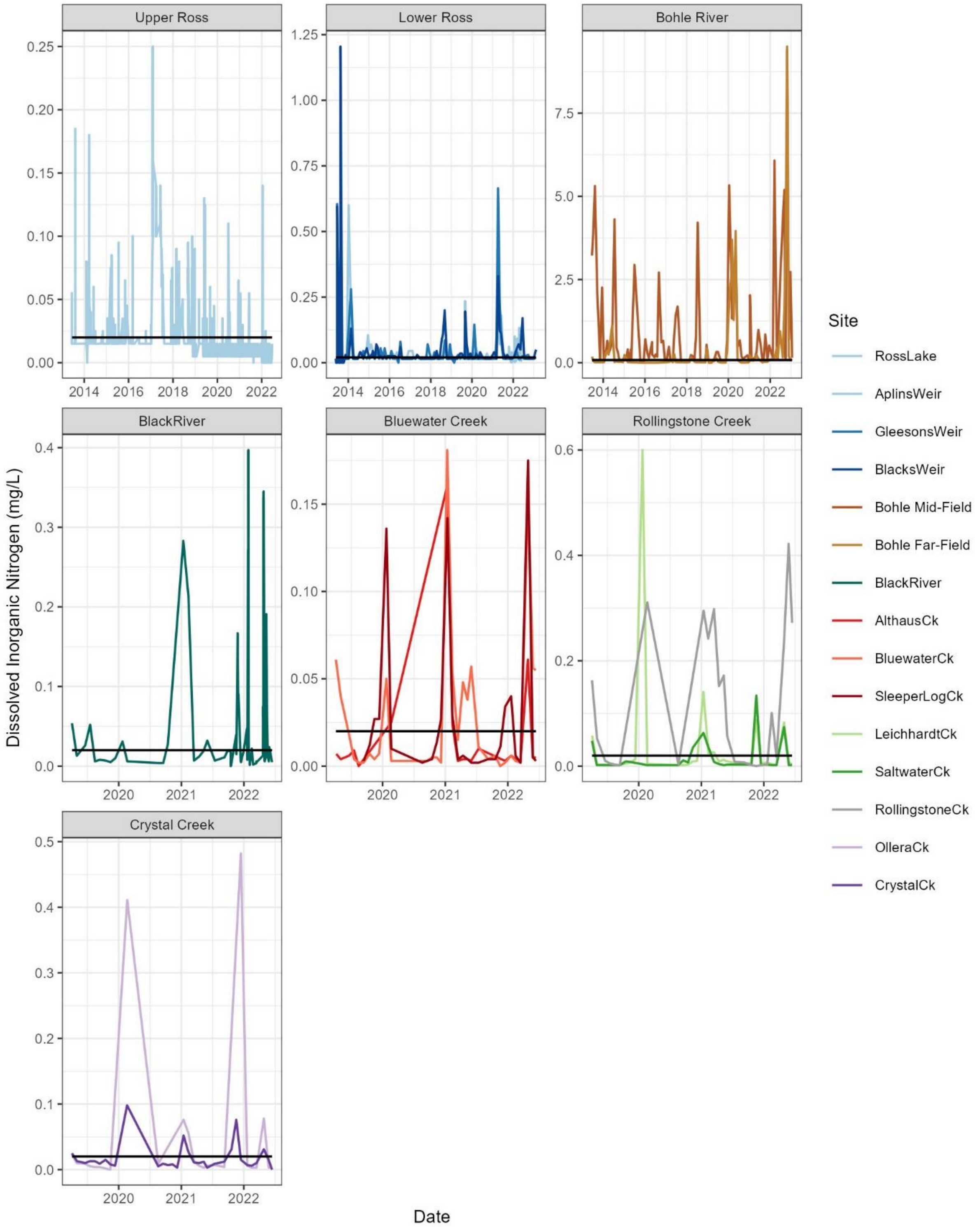


*Figure 31: Historical concentrations of dissolved inorganic nitrogen (DIN) in the freshwater sub basins.*

Black line indicates the water quality objective.

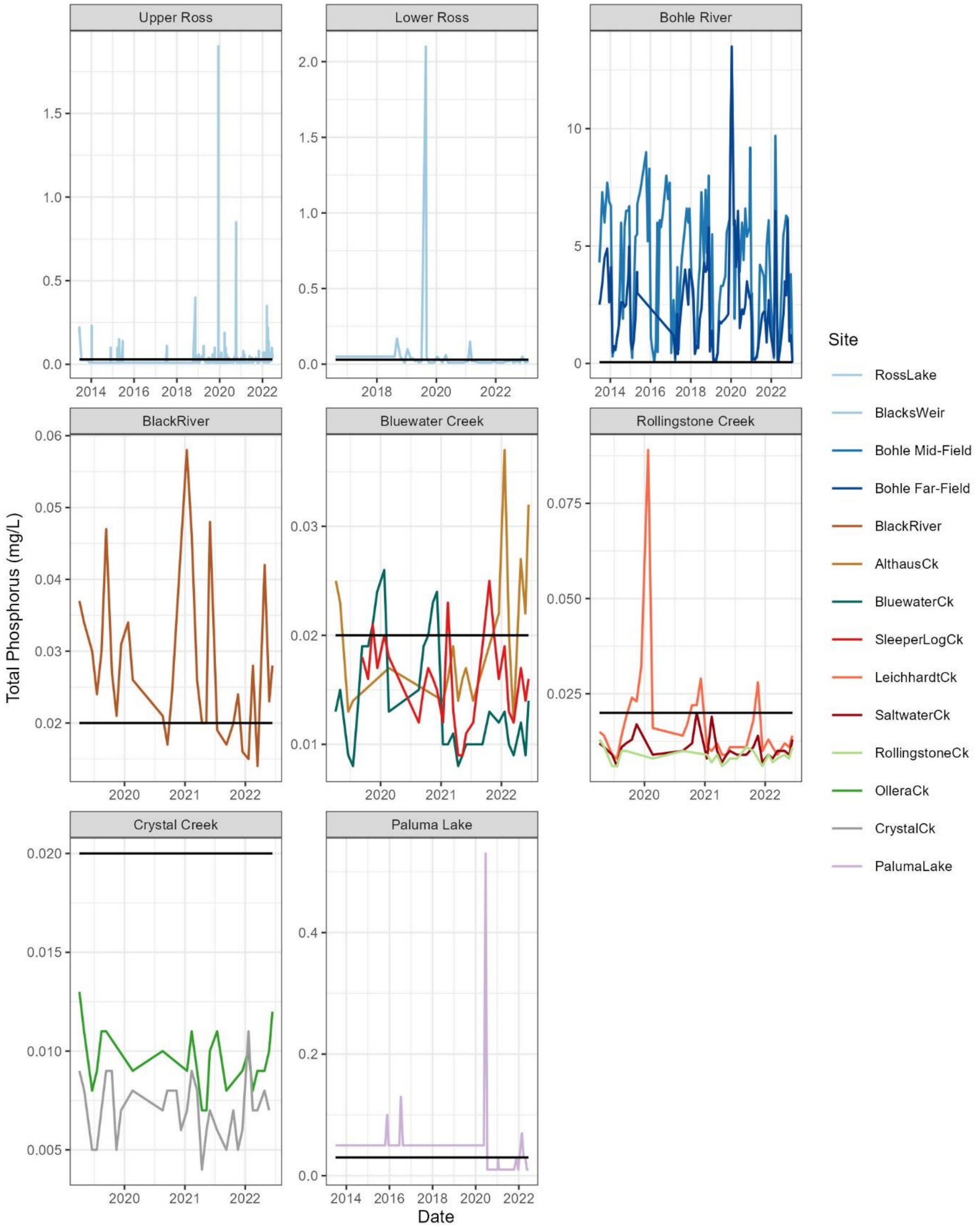


*Figure 32: Historical data for total phosphorus in the freshwater sub basins.*

Black line indicates the water quality objective.

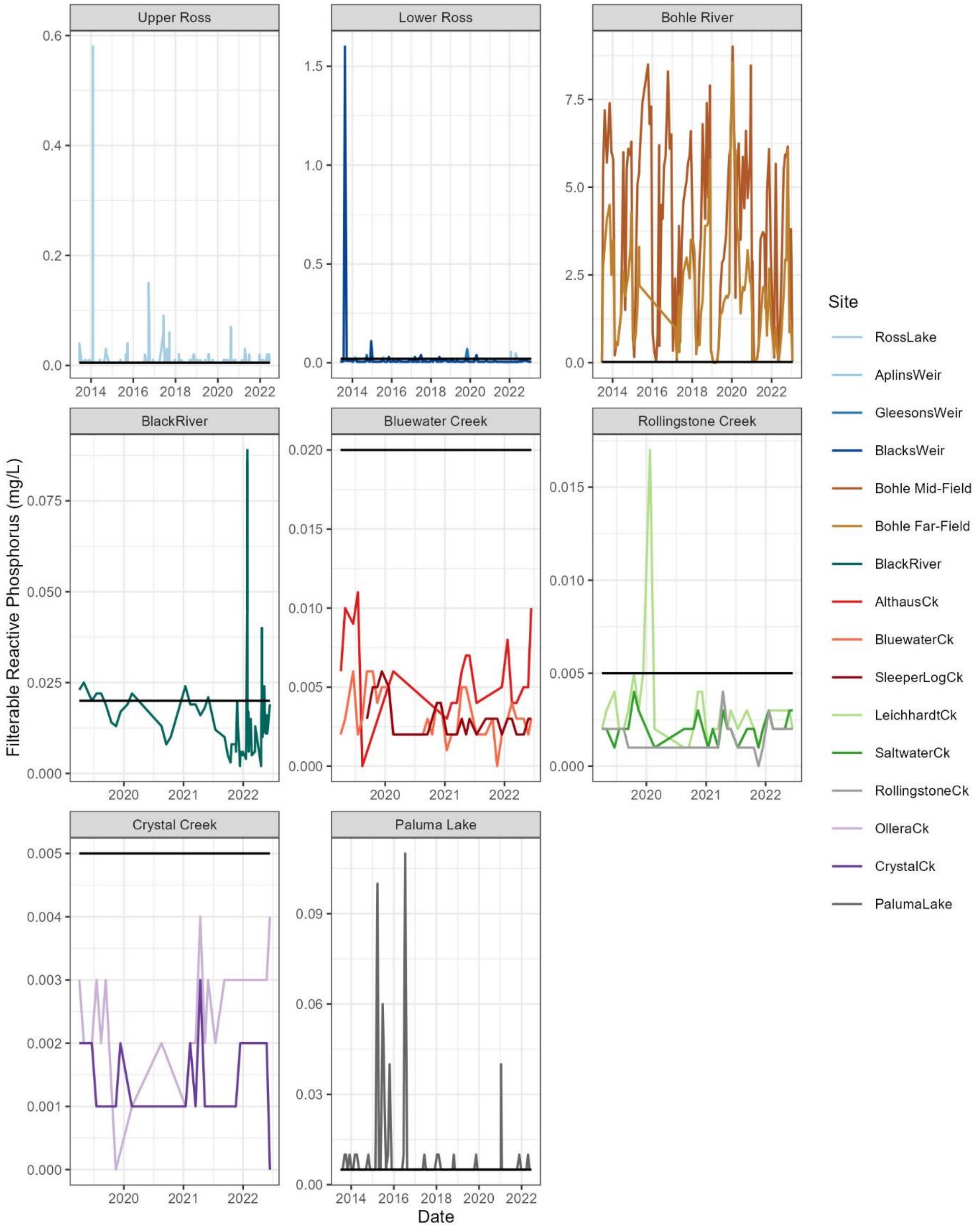


*Figure 33: Historical concentrations of filterable reactive phosphorus (FRP) in the freshwater sub basins.*

Black line indicates the water quality objective.

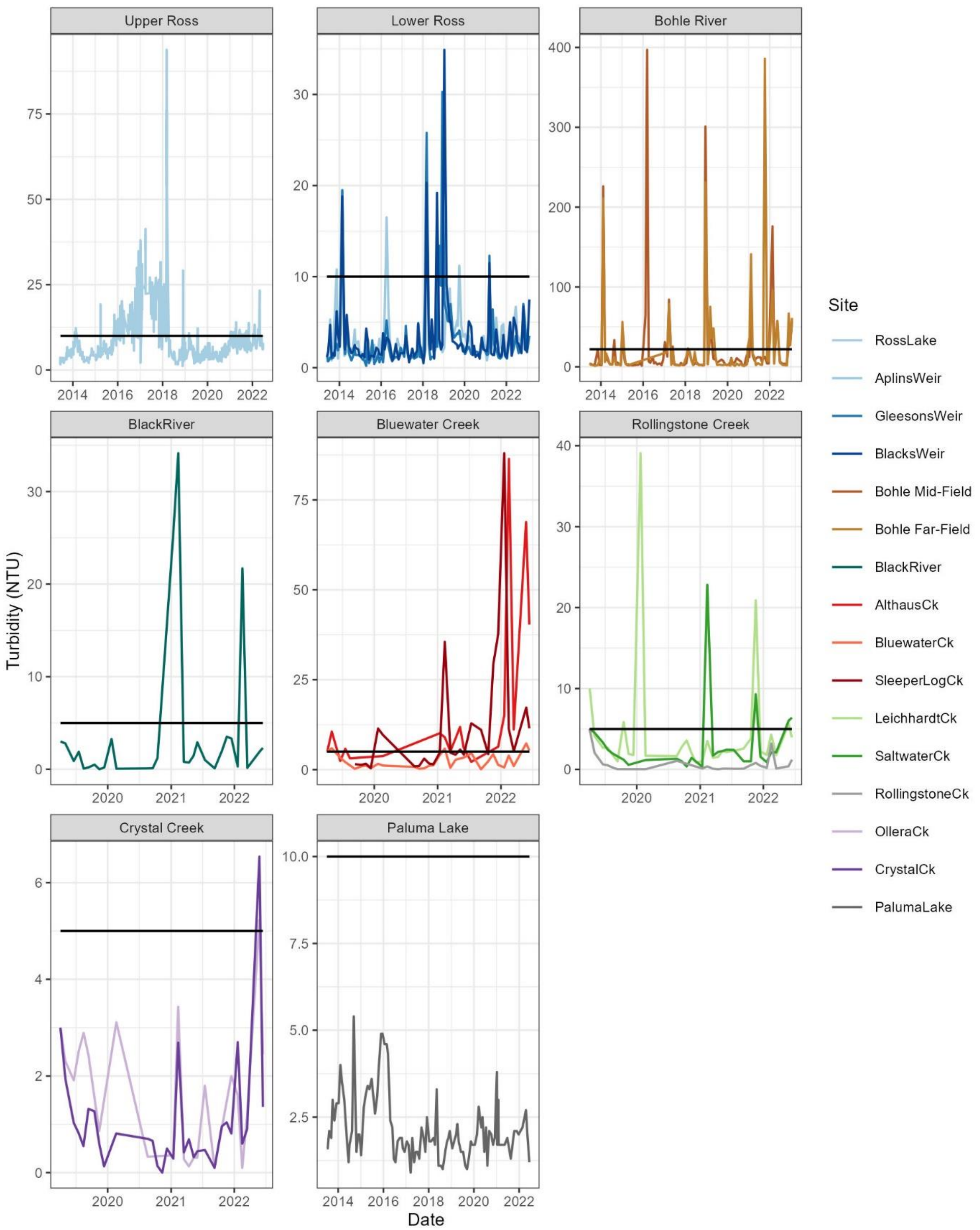


*Figure 34: Historical turbidity in the freshwater sub basins.*

Black line indicates the water quality objective.

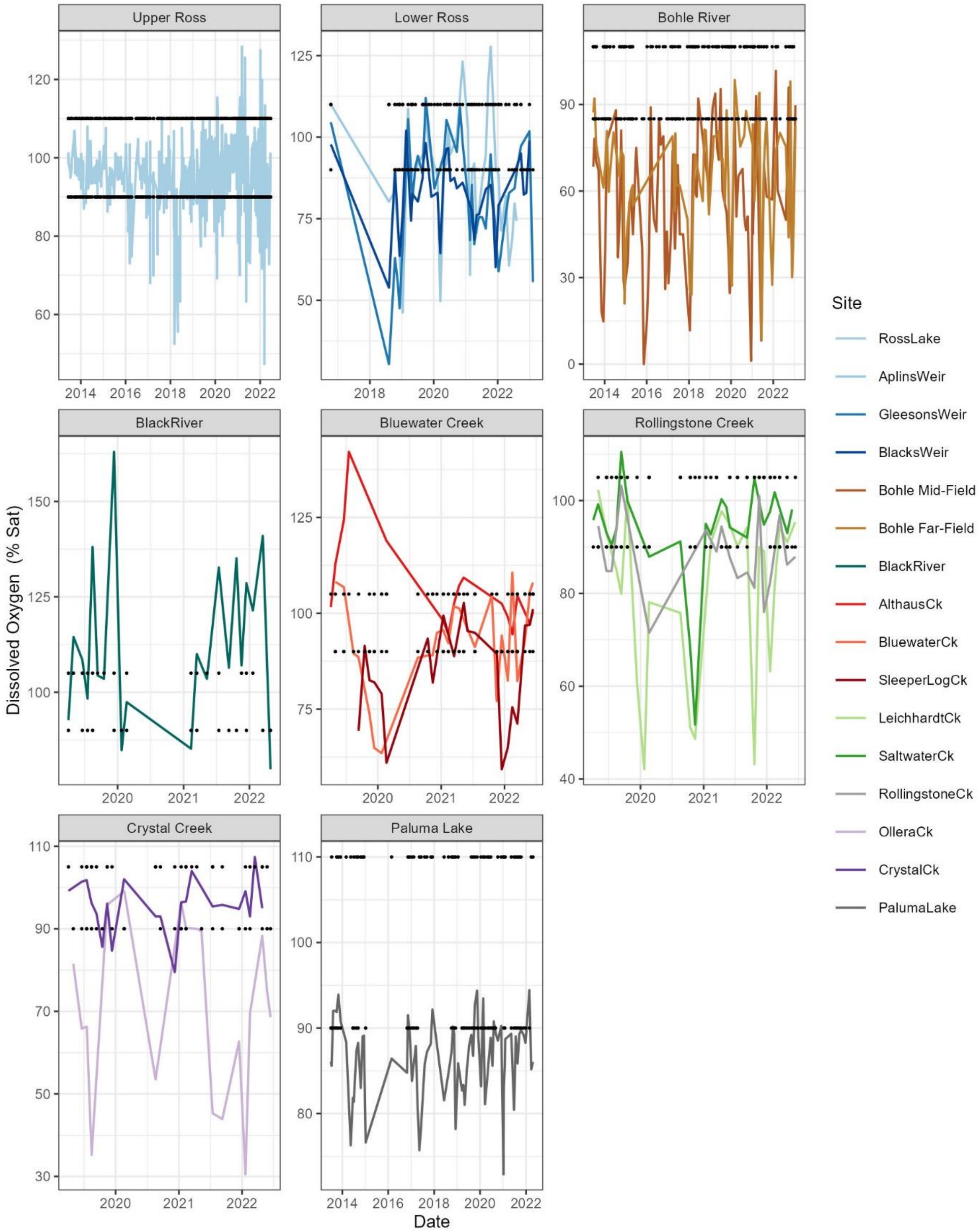


*Figure 35: Historical dissolved oxygen in the freshwater sub basins.*

Black points indicate the water quality objectives (high DO and low DO).

# Appendix P.Freshwater Riparian Extent: Assessed Area in the Dry Tropics Region

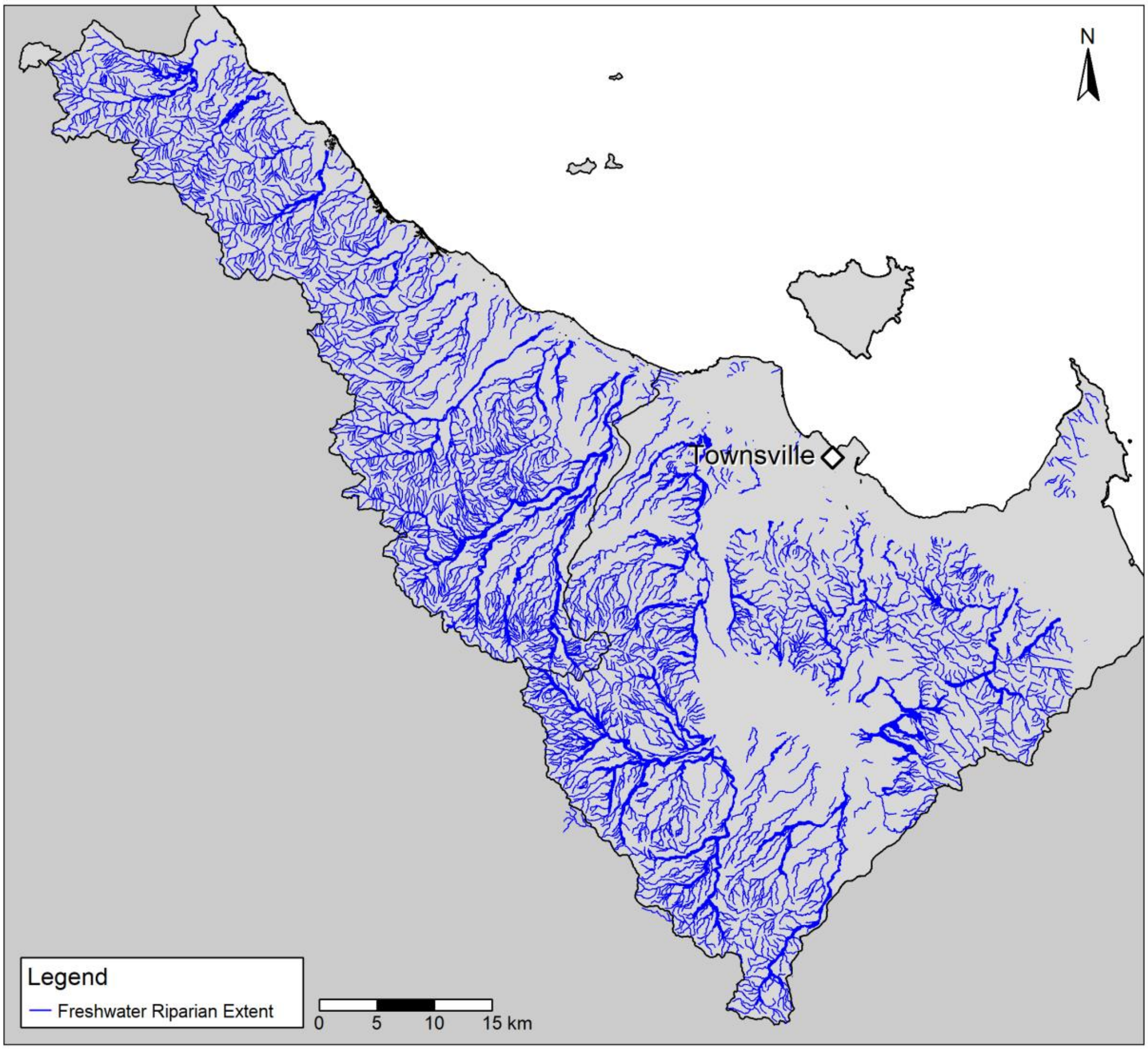


*Figure 36. Freshwater riparian extent assessed for vegetation in the Dry Tropics region.*

# Appendix Q. Freshwater Wetland Extent: Assessed Area in the Dry Tropics Region

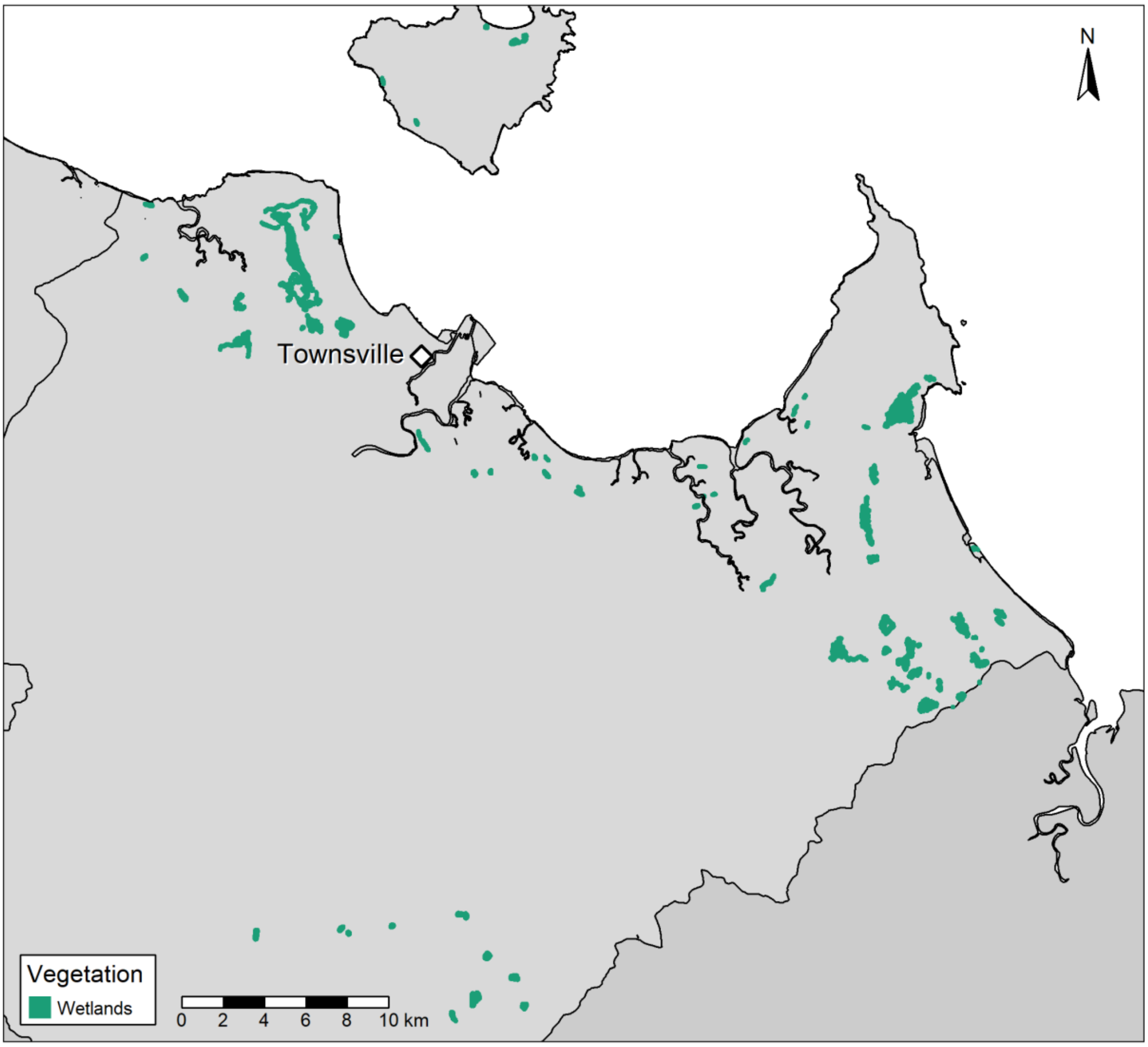


*Figure 37. Freshwater wetlands assessed in the Ross freshwater zone of the Dry Tropics region.*

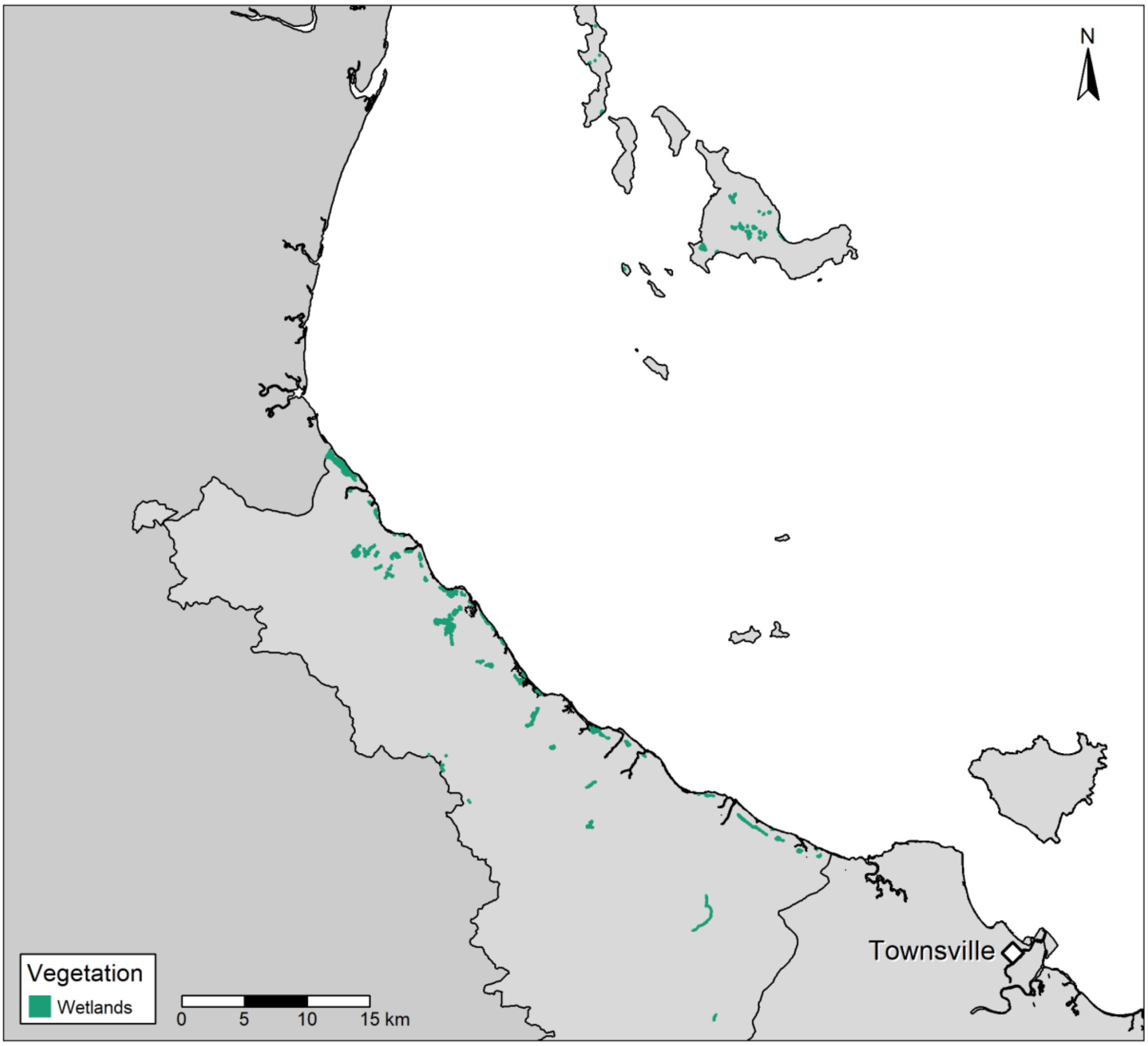


*Figure 38. Freshwater wetlands assessed in the Black freshwater zone of the Dry Tropics region.*

# Appendix R. Freshwater Impoundment Length Assessed Area in the Dry Tropics Region

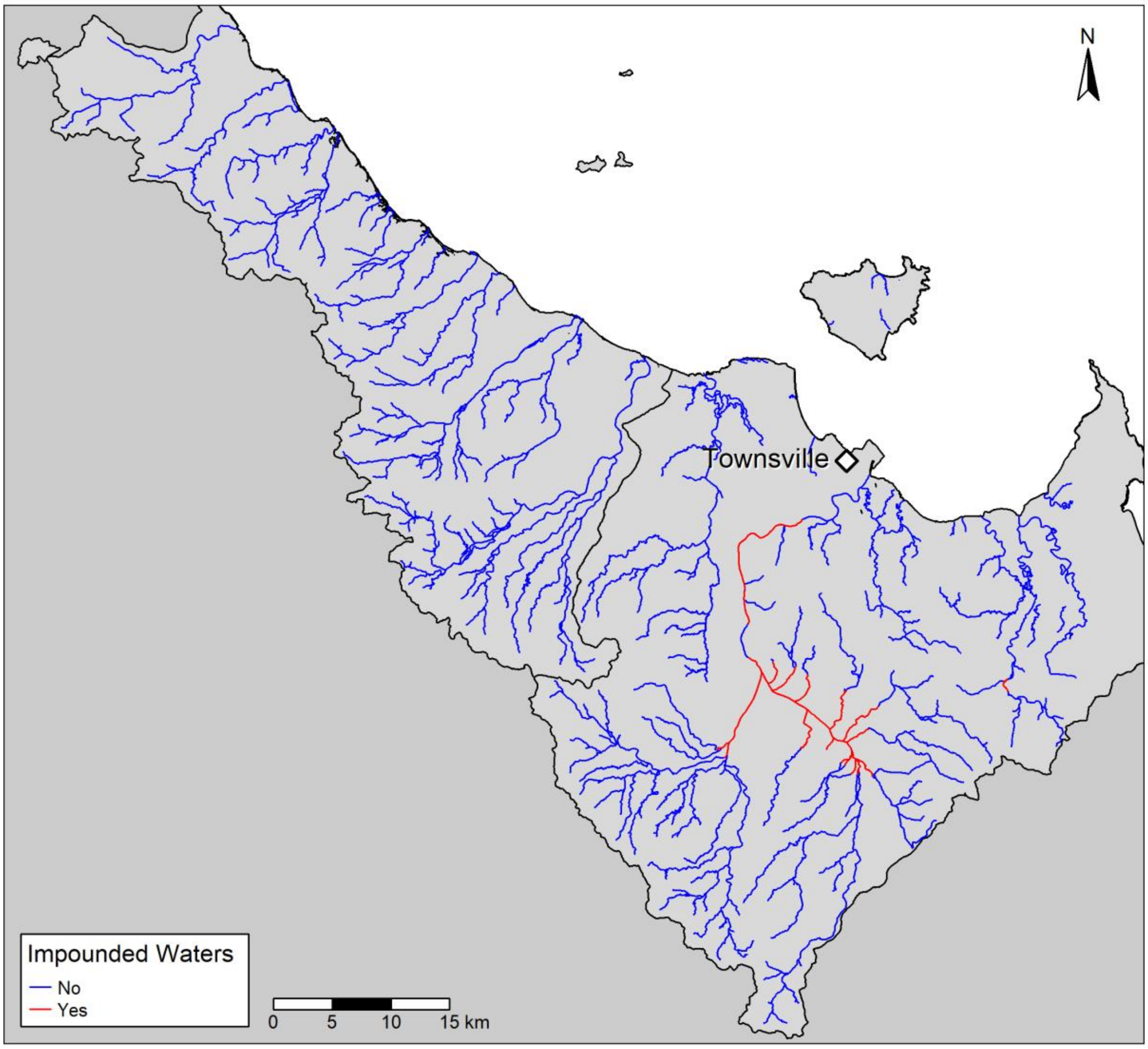


*Figure 39. Impounded and non-impounded waters in the Dry Tropics region.*

# Appendix S. Freshwater Fish Barrier Locations in the Dry Tropics Region

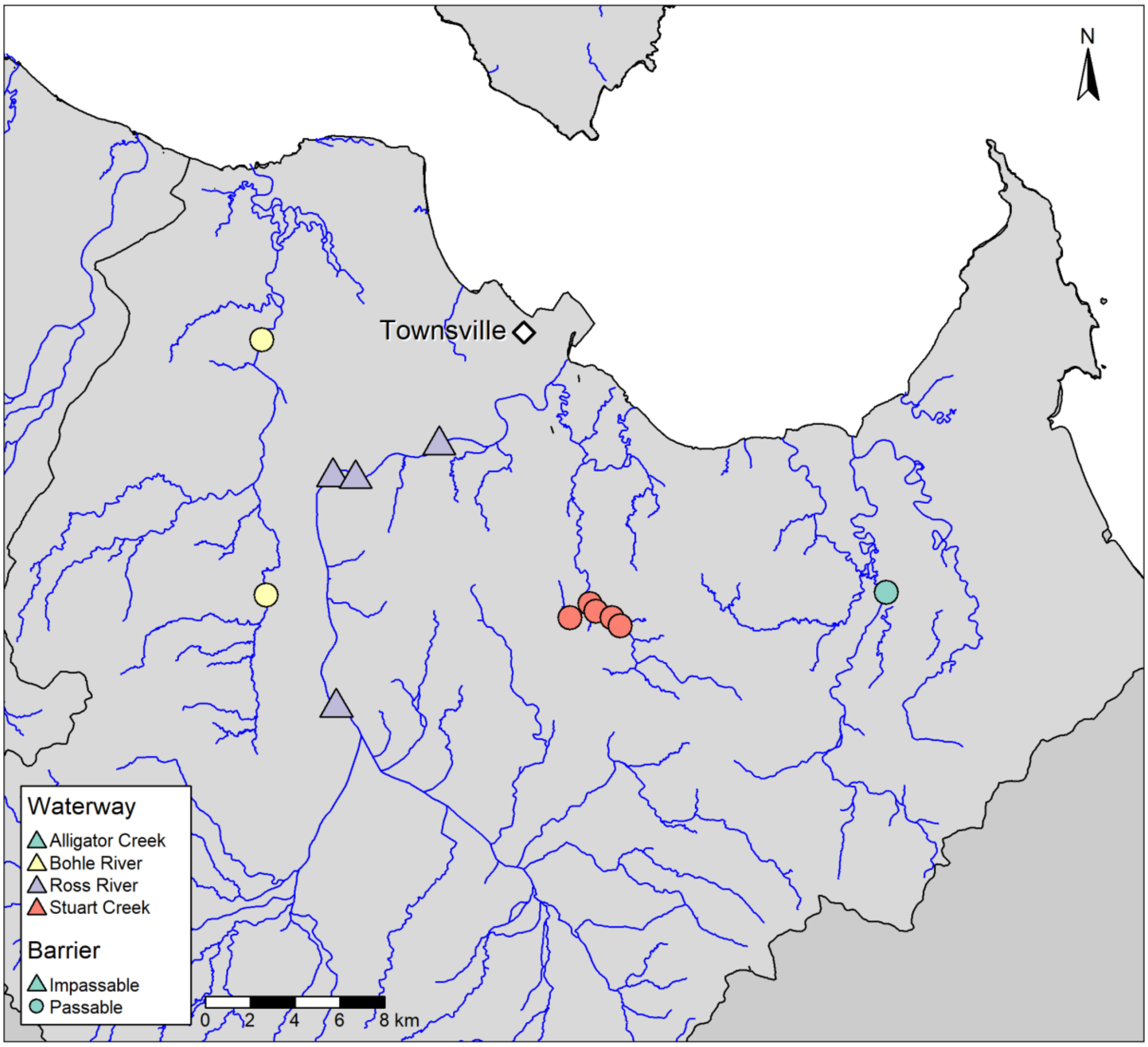


*Figure 40. Fish barriers located on major and high importance waterways in the Dry Tropics region.*

# Appendix T. Freshwater Wetland Extent Standardised Scores Pre- and Post-Back Calculation

*Table 86. Standardised scores for the habitat and hydrology index pre back calculation*

| Basin | Wetland Extent | |
|---|---|---|
| | Post-Back Calculation | Pre-Back Calculation |
| Ross Freshwater | 60 (C) | 59 (C) |
| Black Freshwater | 57 (C) | 55 (C) |

**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

# Appendix U. Freshwater Habitat and Hydrology Updates

*Table 87. Standardised scores for the habitat and hydrology index and the three indicator categories that compose the index in the Ross Freshwater Basin and Black Freshwater Basin. Updated wetland extent and updated aggregation method.*

| Basin | Riparian Extent | Wetland Extent | Artificial Barriers | Habitat and Hydrology Index | | |
|---|---|---|---|---|---|---|
| | | | | 2021–2022 | 2020–2021 | 2019–2020 |
| Ross freshwater | 44 (C) | 60 (C) | 49 (C) | 51 (C) | 51 (C) | 51 (C) |
| Black freshwater | 56 (C) | 57 (C) | 100 (A) | 71 (B) | 71 (B) | 71 (B) |

**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

*Table 88. Standardised scores for the habitat and hydrology index and the three indicator categories that compose the index in the Ross Freshwater Basin and Black Freshwater Basin. Old Wetland Extent and updated aggregation method.*

| Basin | Riparian Extent | Wetland Extent | Artificial Barriers | Habitat and Hydrology Index | | |
|---|---|---|---|---|---|---|
| | | | | 2021–2022 | 2020–2021 | 2019–2020 |
| Ross freshwater | 44 (C) | 59 (C) | 49 (C) | 50 (C) | 50 (C) | 50 (C) |
| Black freshwater | 56 (C) | 55 (C) | 100 (A) | 70 (B) | 70 (B) | 70 (B) |

**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

*Table 89. Standardised scores for the habitat and hydrology index and the three indicator categories that compose the index in the Ross Freshwater Basin and Black Freshwater Basin. Updated wetland extent and old aggregation method.*

| Zone | Habitat (Combined Riparian and Wetland Extent) | Artificial Barriers | Habitat and Hydrology Index | | |
|---|---|---|---|---|---|
| | | | 2021–2022 | 2020–2021 | 2019–2020 |
| Ross freshwater | (44 + 60)/2 = 52 (C) | 49 (C) | 50 (C) | 50 (C) | 50 (C) |
| Black freshwater | (56 + 57)/2 = 56 (C) | 100 (A) | 78 (B) | 78 (B) | 78 (B) |

**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

*Table 90. Standardised scores for the habitat and hydrology index and the three indicator categories that compose the index in the Ross Freshwater Basin and Black Freshwater Basin. Old wetland extent and old aggregation method.*

| Zone | Habitat (Combined Riparian and Wetland Extent) | Artificial Barriers | Habitat and Hydrology Index | | |
|---|---|---|---|---|---|
| | | | 2021–2022 | 2020–2021 | 2019–2020 |
| Ross freshwater | (44 + 59)/2 = 51 (C) | 49 (C) | 50 (C) | 50 (C) | 50 (C) |
| Black freshwater | (56 + 55)/2 = 55 (C) | 100 (A) | 77 (B) | 77 (B) | 77 (B) |

**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

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

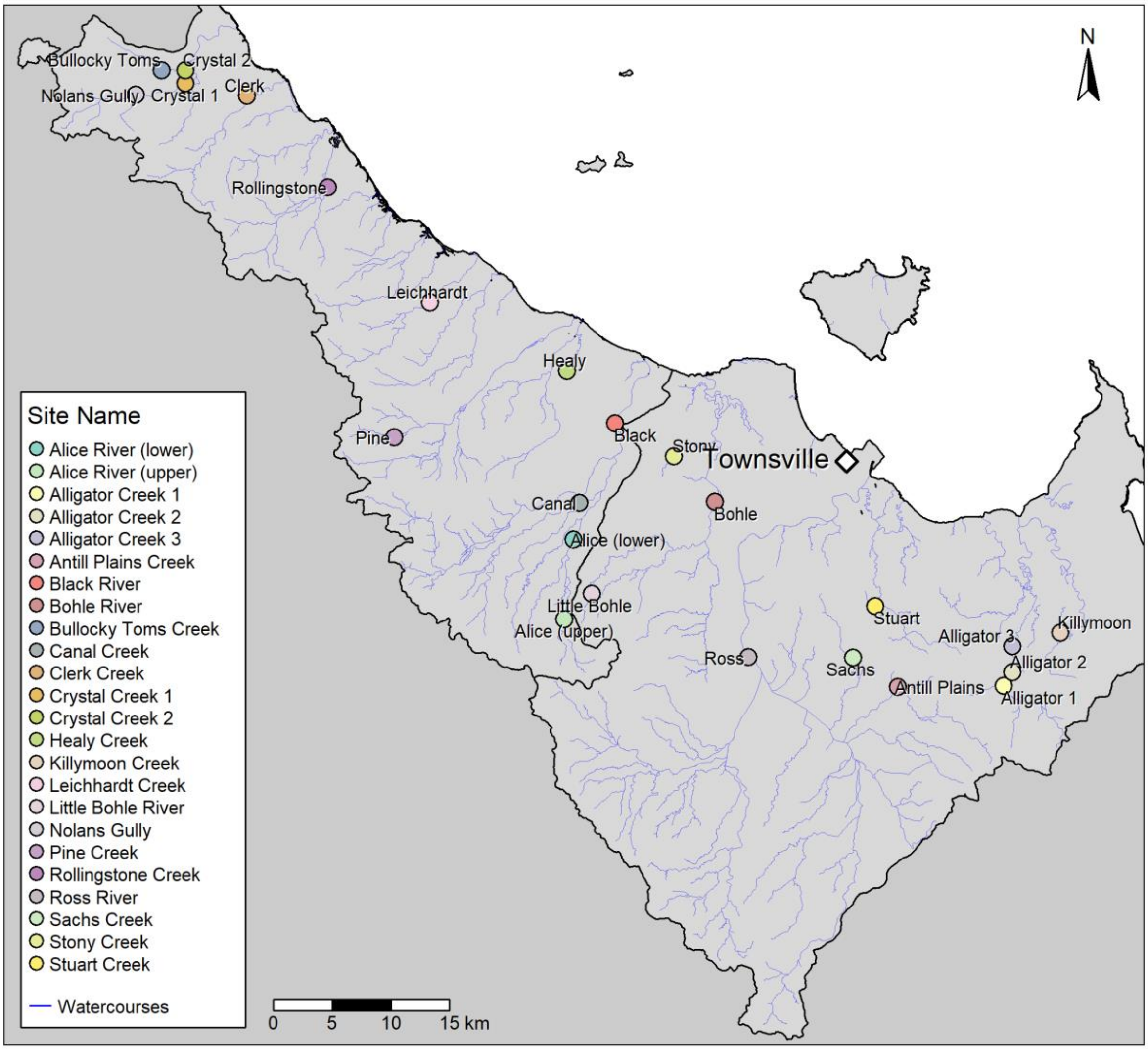


*Figure 41. Fish monitoring locations in the Dry Tropics region.*

# Appendix W.Key of Freshwater Fish Species Found in the Dry Tropics Region

*Table 91. Key of freshwater fish species found in the Dry Tropics region .*

| Key | Species | Basin | Classification |
|---|---|---|---|
| 1 | Northern perchlet | Both | Indigenous |
| 2 | Barred grunter | Ross | Indigenous |
| 3 | Long-finned eel | Both | Indigenous |
| 4 | Roman-nose goby | Both | Indigenous |
| 5 | Fly-specked hardyhead | Both | Indigenous |
| 6 | Mouth almighty | Both | Indigenous |
| 7 | Empire gudgeon | Both | Indigenous |
| 8 | Northern carp gudgeon (undescribed) | Ross | Indigenous |
| 9 | Jungle perch | Both | Indigenous |
| 10 | Barramundi | Both | Indigenous |
| 11 | Spangled perch | Both | Indigenous |
| 12 | Indo-Pacific tarpon | Ross | Indigenous |
| 13 | Eastern rainbowfish | Both | Indigenous |
| 14 | Southern, purple-spotted gudgeon | Both | Indigenous |
| 15 | Bony bream | Ross | Indigenous |
| 16 | Butter jew | Ross | Indigenous |
| 17 | Hyrtl's tandan | Both | Indigenous |
| 18 | Swamp eel | Both | Indigenous |
| 19 | Greenback mullet | Ross | Indigenous |
| 20 | Rendahl's tandan | Ross | Indigenous |
| 21 | Speckled goby | Ross | Indigenous |
| 22 | Seven-spot archerfish | Ross | Indigenous |
| 23 | Giant mottled eel | Black | Indigenous |
| 24 | Bunaka | Black | Indigenous |
| 25 | Silver biddy | Black | Indigenous |
| 26 | Snake-head gudgeon | Black | Indigenous |
| 27 | False Celebes goby | Black | Indigenous |
| 28 | Mangrove jack | Black | Indigenous |
| 29 | Scaleless goby | Black | Indigenous |
| 30 | Gambusia | Both | Alien |
| 31 | Guppy | Both | Alien |
| 32 | Mozambique tilapia | Both | Alien |
| 33 | Sleepy cod | Ross | Translocated |

# Appendix X. Presence/Absence of Fish Species in Waterways Across the Ross Freshwater Basin

*Table 92. Fish species present within waterways across the Ross Freshwater Basin.*

| Waterway | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 30 | 31 | 32 | 33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little Bohle River | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Bohle River | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Sachs Creek | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Killymoon Creek | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Alligator Creek | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Site 1* | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Site 2* | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Site 3* | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stuart Creek | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Ross River | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| Stony Creek | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| Antill Plains Creek | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

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

# Appendix Y. Presence/Absence of Fish Species in Waterways Across the Black Freshwater Basin.

*Table 93. Fish species present within waterways across the Black Freshwater Basin.*

| Waterway | 1 | 23 | 3 | 4 | 24 | 5 | 25 | 26 | 6 | 27 | 7 | 9 | 10 | 11 | 28 | 13 | 14 | 17 | 18 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pine Creek | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Black River | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Rollingstone Creek | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| Healy Creek | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Canal Creek | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| Crystal Creek | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| *Site 1* | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Site 2* | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| Leichhardt Creek | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| Bullocky Toms Creek | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Alice River | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| *Site 1* | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Site 2* | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| Nolan's Gully | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Clerk Creek | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 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 Z. Distribution of Fish Data Across All Monitoring Sites in The Ross Freshwater Basin and Black Freshwater Basin

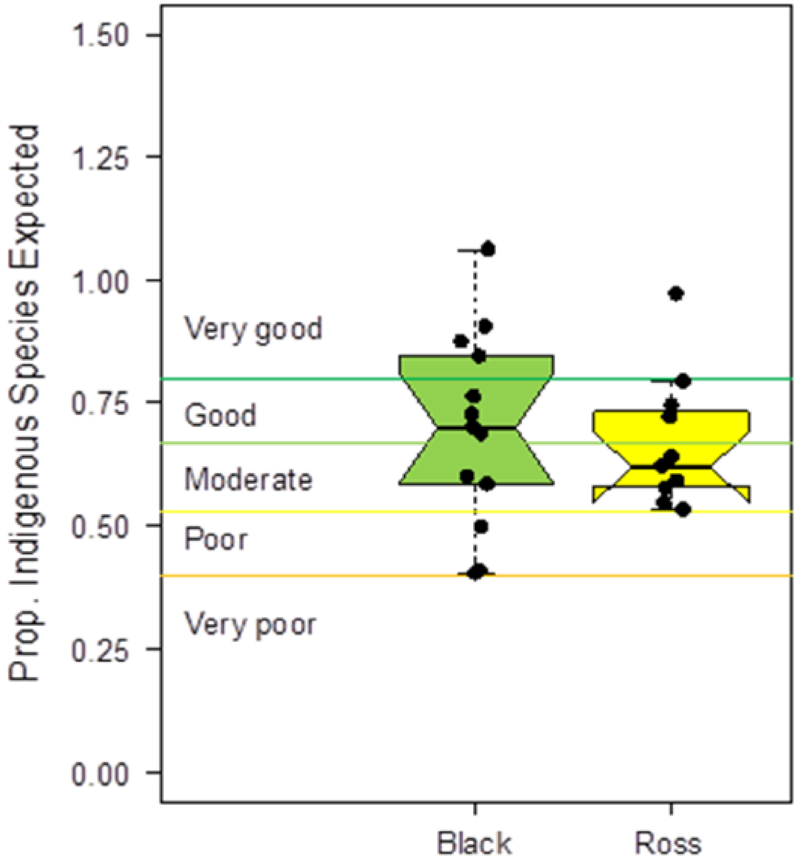


*Figure 43. Proportion of Indigenous Species Expected (POISE) in waterways across the Dry Tropic region.*

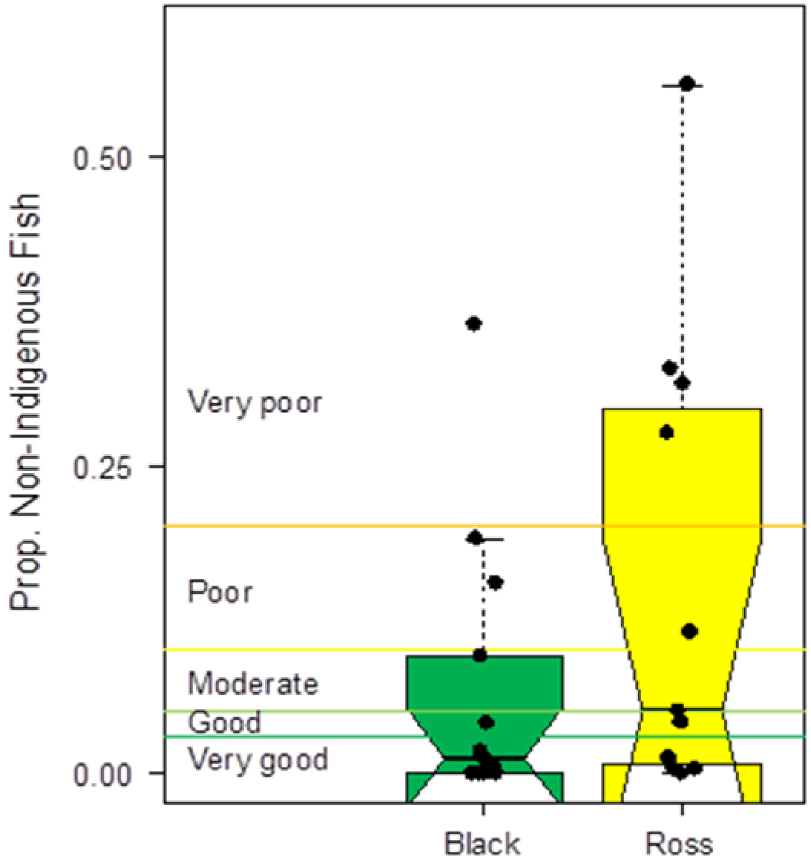


*Figure 42. Proportion of Non-Indigenous Species Expected in waterways across the Dry Tropics region.*

# Appendix AA. Estuarine Water Quality Sampling Locations

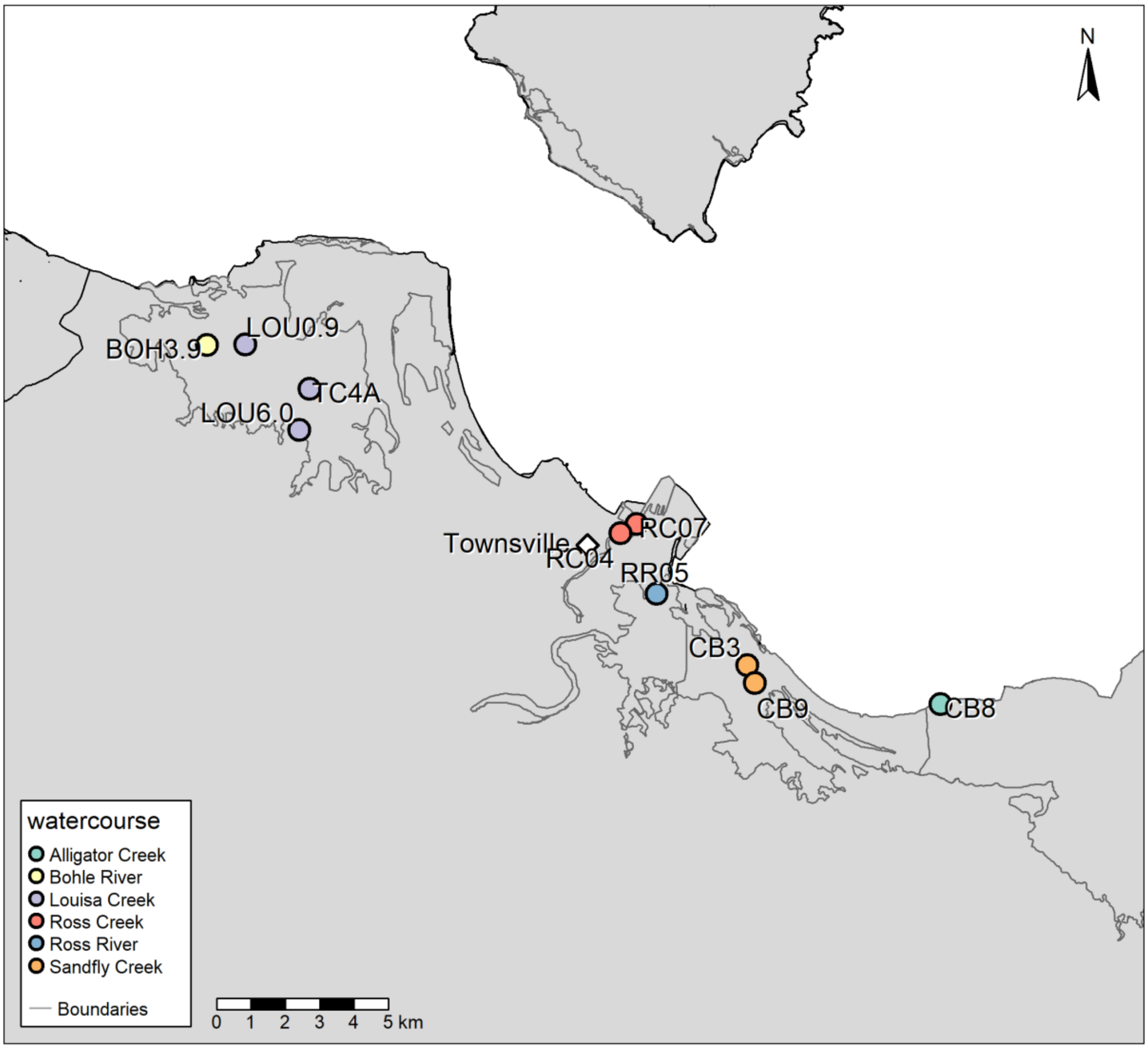


*Figure 44. Ross Estuarine Basin water quality site locations.*

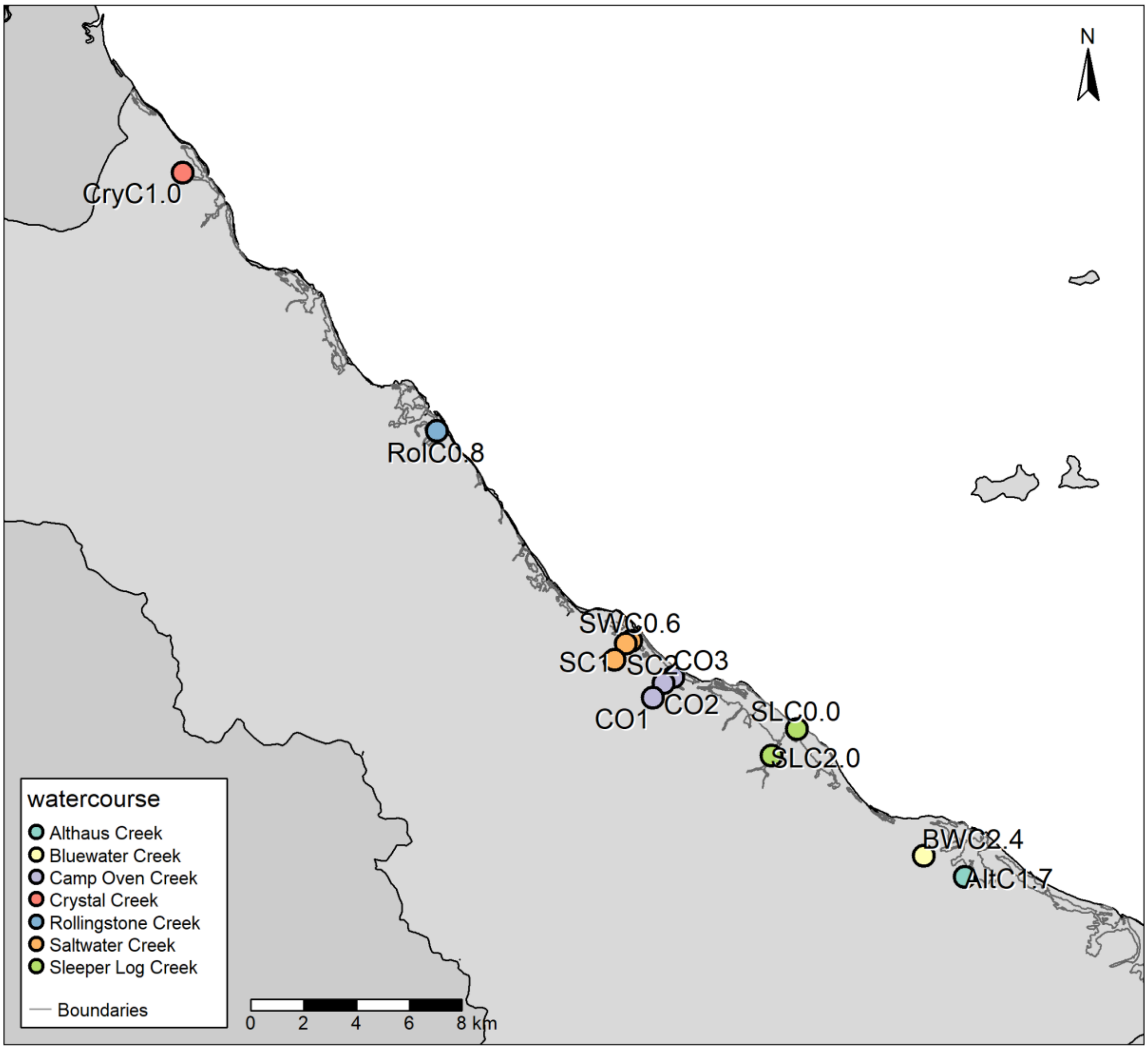


*Figure 45. Black Estuarine Basin water quality site locations.*

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

*Table 94. Number of samples, number of months sampled, median, water quality objective values, and scaling factors for DIN in the Dry Tropics Estuarine Environments.*

| Watercourse | Site | DIN (mg/L) Number of Months | Number of Unique Months | Annual Median | WQO | SF | LOR |
|---|---|---|---|---|---|---|---|
| Bohle River | BOH3.9 | 12 | 12 | 0.011 | 0.07 | 0.09 | 0.006 |
| Louisa Creek | LOU0.9 | 12 | 12 | 0.015 | 0.07 | 0.09 | 0.006 |
| | LOU6.0 | 12 | 12 | 0.043 | 0.07 | 0.09 | 0.006 |
| | TC4A | 12 | 12 | 0.043 | 0.07 | 0.09 | 0.006 |
| Ross Creek | RC04 | 5 | 4 | 0.008 | 0.07 | 0.09 | 0.002 |
| | RC07 | 5 | 4 | 0.006 | 0.07 | 0.09 | 0.002 |
| Ross River | RR05 | 5 | 4 | 0.007 | 0.07 | 0.09 | 0.002 |
| Sandfly Creek | CB3 | 14 | 12 | 0.066 | 0.07 | 0.09 | 0.006 |
| | CB9 | 12 | 12 | 0.017 | 0.07 | 0.09 | 0.006 |
| Alligator Creek | CB8 | 12 | 12 | 0.005 | 0.07 | 0.09 | 0.006 |
| Althaus Creek | AltC1.7 | 11 | 11 | 0.01 | 0.02 | 0.09 | 0.002 |
| Bluewater Creek | BWC2.4 | 11 | 11 | 0.011 | 0.02 | 0.09 | 0.002 |
| Sleeper Log Creek | SLC0.0 | 8 | 8 | 0.004 | 0.02 | 0.09 | 0.002 |
| | SLC2.0 | 7 | 7 | 0.004 | 0.02 | 0.09 | 0.002 |
| Camp Oven Creek | CO1 | 13 | 12 | 0.01 | 0.02 | 0.09 | 0.002 |
| | CO2 | 13 | 12 | 0.008 | 0.02 | 0.09 | 0.002 |
| | CO3 | 13 | 12 | 0.009 | 0.02 | 0.09 | 0.002 |
| Saltwater Creek | SWC0.6 | 11 | 11 | 0.004 | 0.02 | 0.09 | 0.002 |
| | SC1 | 13 | 12 | 0.026 | 0.02 | 0.09 | 0.002 |
| | SC2 | 13 | 12 | 0.017 | 0.02 | 0.09 | 0.002 |
| Rollingstone Creek | RolC0.8 | 11 | 11 | 0.019 | 0.02 | 0.09 | 0.002 |
| Crystal Creek | CryC1.0 | 10 | 10 | 0.012 | 0.02 | 0.09 | 0.002 |

**Key:** ■ = Mean/Median is lower than the guideline value | ■ = Mean/Median is higher than the guideline value.

*Table 95. Number of samples, number of months sampled, median, water quality objective values, and scaling factors for TP in the Dry Tropics Estuarine Environment.*

| Watercourse | Site | TP (mg/L) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Number of Months | Number of Unique Months | Annual Median | WQO | SF | LOR |
| Bohle River | BOH3.9 | 12 | 12 | 0.025 | 0.05 | 0.09 | 0.01 |
| Louisa Creek | LOU0.9 | 12 | 12 | 0.035 | 0.05 | 0.09 | 0.01 |
| | LOU6.0 | 12 | 12 | 0.115 | 0.05 | 0.09 | 0.01 |
| | TC4A | 12 | 12 | 0.09 | 0.05 | 0.09 | 0.01 |
| Ross Creek | RC04 | 5 | 4 | 0.005 | 0.05 | 0.09 | 0.005 |
| | RC07 | 5 | 4 | 0.002 | 0.05 | 0.09 | 0.005 |
| Ross River | RR05 | 5 | 4 | 0.009 | 0.05 | 0.09 | 0.005 |
| Sandfly Creek | CB3 | 14 | 12 | 0.025 | 0.05 | 0.09 | 0.01 |
| | CB9 | 12 | 12 | 0.007 | 0.05 | 0.09 | 0.01 |
| Alligator Creek | CB8 | 12 | 12 | 0.005 | 0.05 | 0.09 | 0.01 |
| Althaus Creek | AltC1.7 | 11 | 11 | 0.021 | 0.025 | 0.04 | 0.003 |
| Bluewater Creek | BWC2.4 | 11 | 11 | 0.011 | 0.025 | 0.04 | 0.003 |
| Sleeper Log Creek | SLC0.0 | 8 | 8 | 0.014 | 0.025 | 0.04 | 0.003 |
| | SLC2.0 | 7 | 7 | 0.011 | 0.025 | 0.04 | 0.003 |
| Camp Oven Creek | CO1 | 13 | 12 | 0.002 | 0.025 | 0.04 | 0.005 |
| | CO2 | 13 | 12 | 0.002 | 0.025 | 0.04 | 0.005 |
| | CO3 | 13 | 12 | 0.008 | 0.025 | 0.04 | 0.005 |
| Saltwater Creek | SWC0.6 | 11 | 11 | 0.009 | 0.025 | 0.04 | 0.003 |
| | SC1 | 13 | 12 | 0.002 | 0.025 | 0.04 | 0.005 |
| | SC2 | 13 | 12 | 0.002 | 0.025 | 0.04 | 0.005 |
| Rollingstone Creek | RolC0.8 | 11 | 11 | 0.009 | 0.025 | 0.04 | 0.003 |
| Crystal Creek | CryC1.0 | 10 | 10 | 0.016 | 0.025 | 0.04 | 0.003 |

**Key:** ■ = Mean/Median is lower than the guideline value | ■ = Mean/Median is higher than the guideline value.

## Appendix CC. Estuarine Water Quality Nutrients Scores Historic Comparison

*Table 96. Dry Tropics estuarine water quality historic nutrient indicator scores.*

| Watercourse | Site | DIN | | | | TP | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2021–2022 | 2020–2021 | 2019–2020 | 2018–2019 | 2021–2022 | 2020–2021 | 2019–2020 | 2018–2019 |
| Bohle River | BOH3.9 | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| Louisa Creek | LOU0.9 | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 66 (B) | 90 (A) | 90 (A) | 90 (A) |
| | LOU6.0 | 73 (B) | 68 (B) | 65 (B) | 0 (E) | 0 (E) | 0 (E) | 0 (E) | 0 (E) |
| | TC4A | 75 (B) | 68 (B) | 67 (B) | 0 (E) | 0 (E) | 0 (E) | 0 (E) | 0 (E) |
| Ross Creek | RC04 | 90 (A) | 90 (A) | 90 (A) | 0 (E) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| | RC07 | 90 (A) | 90 (A) | 90 (A) | 0 (E) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| Ross River | RR05 | 90 (A) | 90 (A) | 90 (A) | 0 (E) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| Sandfly Creek | CB3 | 63 (B) | 90 (A) | 90 (A) | 63 (B) | 90 (A) | 90 (A) | 90 (A) | 30 (D) |
| | CB9 | 90 (A) | 90 (A) | 90 (A) | 77 (B) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| Alligator Creek | CB8 | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| Althaus Creek | AltC1.7 | 90 (A) | 69 (B) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 72 (B) | 90 (A) |
| Bluewater Creek | BWC2.4 | 63 (B) | 53 (C) | 70 (B) | 46 (C) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| Sleeper Log Creek | SLC0.0 | 90 (A) | 90 (A) | NA | NA | 90 (A) | 90 (A) | NA | NA |
| | SLC2.0 | 90 (A) | 90 (A) | NA | NA | 90 (A) | 90 (A) | NA | NA |
| Camp Oven Creek | CO1 | 72 (B) | 90 (A) | NA | NA | 90 (A) | 90 (A) | NA | NA |
| | CO2 | 90 (A) | 90 (A) | NA | NA | 90 (A) | 70 (B) | NA | NA |
| | CO3 | 79 (B) | 90 (A) | NA | NA | 90 (A) | 90 (A) | NA | NA |
| Saltwater Creek | SWC0.6 | 90 (A) | 90 (A) | 66 (B) | 57 (C) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| | SC1 | 56 (C) | 90 (A) | NA | NA | 90 (A) | 90 (A) | NA | NA |
| | SC2 | 66 (B) | 90 (A) | NA | NA | 90 (A) | 90 (A) | NA | NA |
| Rollingstone Creek | RolC0.8 | 61 (B) | 36 (D) | 49 (C) | 8 (E) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| Crystal Creek | CryC1.0 | 65 (B) | 27 (D) | 58 (C) | 27 (D) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |

**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).

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

*Table 97. Number of samples, number of months sampled, median, water quality objective values, and scaling factors for Turbidity in the Dry Tropics Estuarine Environment.*

| Watercourse | Site | Turbidity (NTU) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Number of Months | Number of Unique Months | Annual Median | WQO | SF | LOR |
| Bohle River | BOH3.9 | 12 | 12 | 10.3 | 20 | 45 | 0.1 |
| Louisa Creek | LOU0.9 | 12 | 12 | 10.85 | 20 | 45 | 0.1 |
| | LOU6.0 | 12 | 12 | 19.6 | 20 | 45 | 0.1 |
| | TC4A | 12 | 12 | 18.15 | 20 | 45 | 0.1 |
| Ross Creek | RC04 | 5 | 4 | 3.165 | 20 | 45 | 0.1 |
| | RC07 | 5 | 4 | 3.56 | 20 | 45 | 0.1 |
| Ross River | RR05 | 5 | 4 | 2.975 | 20 | 45 | 0.1 |
| Sandfly Creek | CB3 | 13 | 12 | 16.25 | 20 | 45 | 0.1 |
| | CB9 | 12 | 12 | 18.8 | 20 | 45 | 0.1 |
| Alligator Creek | CB8 | 12 | 12 | 12.55 | 20 | 45 | 0.1 |
| Althaus Creek | AltC1.7 | 10 | 10 | 20.04 | 8 | 15 | 0.1 |
| Bluewater Creek | BWC2.4 | 10 | 10 | 5.8 | 8 | 15 | 0.1 |
| Sleeper Log Creek | SLC0.0 | 8 | 8 | 10.965 | 8 | 15 | 0.1 |
| | SLC2.0 | 8 | 8 | 6.185 | 8 | 15 | 0.1 |
| Camp Oven Creek | CO1 | 13 | 12 | 3.916 | 8 | 15 | 0.1 |
| | CO2 | 13 | 12 | 9.402 | 8 | 15 | 0.1 |
| | CO3 | 13 | 12 | 18.001 | 8 | 15 | 0.1 |
| Saltwater Creek | SWC0.6 | 10 | 10 | 6.94 | 8 | 15 | 0.1 |
| | SC1 | 12 | 11 | 2.021 | 8 | 15 | 0.1 |
| | SC2 | 13 | 12 | 4.38 | 8 | 15 | 0.1 |
| Rollingstone Creek | RolC0.8 | 10 | 10 | 5.385 | 8 | 15 | 0.1 |
| Crystal Creek | CryC1.0 | 10 | 10 | 14.15 | 8 | 15 | 0.1 |

**Key:** ■ = Mean/Median is lower than the guideline value | ■ = Mean/Median is higher than the guideline value.

*Table 98. Number of samples, number of months sampled, median, water quality objective values, and scaling factors for High DO in the Dry Tropics Estuarine Environment.*

| Watercourse | Site | High DO (% Saturation) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Number of Months | Number of Unique Months | Annual Median | WQO | SF | LOR |
| Bohle River | BOH3.9 | 12 | 12 | 94.775 | 105 | 120 | 0 |
| Louisa Creek | LOU0.9 | 12 | 12 | 90.29 | 105 | 120 | 0 |
| | LOU6.0 | 12 | 12 | 67.505 | 105 | 120 | 0 |
| | TC4A | 12 | 12 | 65.22 | 105 | 120 | 0 |
| Ross Creek | RC04 | 4 | 3 | 88 | 105 | 120 | 0 |
| | RC07 | 4 | 3 | 92.2 | 105 | 120 | 0 |
| Ross River | RR05 | 4 | 3 | 90.6 | 105 | 120 | 0 |
| Sandfly Creek | CB3 | 13 | 12 | 92.115 | 105 | 120 | 0 |
| | CB9 | 12 | 12 | 91.825 | 105 | 120 | 0 |
| Alligator Creek | CB8 | 12 | 12 | 89.805 | 105 | 120 | 0 |
| Althaus Creek | AltC1.7 | 11 | 11 | 111.7 | 105 | 120 | 0 |
| Bluewater Creek | BWC2.4 | 11 | 11 | 104.1 | 105 | 120 | 0 |
| Sleeper Log Creek | SLC0.0 | 8 | 8 | 95.8 | 105 | 120 | 0 |
| | SLC2.0 | 8 | 8 | 91.5 | 105 | 120 | 0 |
| Camp Oven Creek | CO1 | 13 | 12 | 76.285 | 105 | 120 | 0 |
| | CO2 | 13 | 12 | 85.731 | 105 | 120 | 0 |
| | CO3 | 13 | 12 | 91.966 | 105 | 120 | 0 |
| Saltwater Creek | SWC0.6 | 11 | 11 | 94.3 | 105 | 120 | 0 |
| | SC1 | 13 | 12 | 100.325 | 105 | 120 | 0 |
| | SC2 | 13 | 12 | 91.817 | 105 | 120 | 0 |
| Rollingstone Creek | RolC0.8 | 11 | 11 | 96.3 | 105 | 120 | 0 |
| Crystal Creek | CryC1.0 | 11 | 11 | 97.1 | 105 | 120 | 0 |

**Key:** = Mean/Median is lower than the guideline value | = Mean/Median is higher than the guideline value.

*Table 99. Number of samples, number of months sampled, median, water quality objective values, and scaling factors for Low DO in the Dry Tropics Estuarine Environment.*

| Watercourse | Site | Low DO (% Saturation) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Number of Months | Number of Unique Months | Annual Median | WQO | SF | LOR |
| Bohle River | BOH3.9 | 12 | 12 | 94.775 | 85 | 70 | 0 |
| Louisa Creek | LOU0.9 | 12 | 12 | 90.29 | 85 | 70 | 0 |
| | LOU6.0 | 12 | 12 | 67.505 | 85 | 70 | 0 |
| | TC4A | 12 | 12 | 65.22 | 85 | 70 | 0 |
| Ross Creek | RC04 | 4 | 3 | 88 | 85 | 70 | 0 |
| | RC07 | 4 | 3 | 92.2 | 85 | 70 | 0 |
| Ross River | RR05 | 4 | 3 | 90.6 | 85 | 70 | 0 |
| Sandfly Creek | CB3 | 13 | 12 | 92.115 | 85 | 70 | 0 |
| | CB9 | 12 | 12 | 91.825 | 85 | 70 | 0 |
| Alligator Creek | CB8 | 12 | 12 | 89.805 | 85 | 70 | 0 |
| Althaus Creek | AltC1.7 | 11 | 11 | 111.7 | 85 | 70 | 0 |
| Bluewater Creek | BWC2.4 | 11 | 11 | 104.1 | 85 | 70 | 0 |
| Sleeper Log Creek | SLC0.0 | 8 | 8 | 95.8 | 85 | 70 | 0 |
| | SLC2.0 | 8 | 8 | 91.5 | 85 | 70 | 0 |
| Camp Oven Creek | CO1 | 13 | 12 | 76.285 | 85 | 70 | 0 |
| | CO2 | 13 | 12 | 85.731 | 85 | 70 | 0 |
| | CO3 | 13 | 12 | 91.966 | 85 | 70 | 0 |
| Saltwater Creek | SWC0.6 | 11 | 11 | 94.3 | 85 | 70 | 0 |
| | SC1 | 13 | 12 | 100.325 | 85 | 70 | 0 |
| | SC2 | 13 | 12 | 91.817 | 85 | 70 | 0 |
| Rollingstone Creek | RolC0.8 | 11 | 11 | 96.3 | 85 | 70 | 0 |
| Crystal Creek | CryC1.0 | 11 | 11 | 97.1 | 85 | 70 | 0 |

**Key:** ■ = Mean/Median is lower than the guideline value | ■ = Mean/Median is higher than the guideline value.

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

*Table 100. Dry Tropics estuarine water quality historic physical chemical indicator scores.*

| Watercourse | Site | Turbidity | | | | High DO | | | | Low DO | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2021–2022 | 2020–2021 | 2019–2020 | 2018–2019 | 2021–2022 | 2020–2021 | 2019–2020 | 2018–2019 | 2021–2022 | 2020–2021 | 2019–2020 | 2018–2019 |
| Bohle River | BOH3.9 | 66 (B) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 75 (B) |
| Louisa Creek | LOU0.9 | 73 (B) | 75 (B) | 90 (A) | 80 (B) | 90 (A) | 74 (B) | 90 (A) | 90 (A) | 90 (A) | 64 (B) | 90 (A) | 58 (C) |
| | LOU6.0 | 61 (B) | 65 (B) | 90 (A) | 76 (B) | 90 (A) | 0 (E) | 90 (A) | 5 (E) | 90 (A) | 0 (E) | 90 (A) | 0 (E) |
| | TC4A | 64 (B) | 65 (B) | 90 (A) | 70 (B) | 90 (A) | 0 (E) | 90 (A) | 4 (E) | 90 (A) | 0 (E) | 90 (A) | 0 (E) |
| Ross Creek | RC04 | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | NA | NA |
| | RC07 | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | NA | NA |
| Ross River | RR05 | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 70 (B) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | NA | NA |
| Sandfly Creek | CB3 | 90 (A) | 79 (B) | 53 (C) | 58 (C) | 90 (A) | 90 (A) | 90 (A) | 74 (B) | 90 (A) | 90 (A) | 90 (A) | 73 (B) |
| | CB9 | 62 (B) | 59 (C) | 51 (C) | 60 (C) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| Alligator Creek | CB8 | 90 (A) | 69 (B) | 90 (A) | 41 (C) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 90 (A) |
| Althaus Creek | AltC1.7 | 0 (E) | 0 (E) | 3 (E) | 90 (A) | 33 (D) | 90 (A) | 68 (B) | 90 (A) | 28 (D) | 90 (A) | 90 (A) | 90 (A) |
| Bluewater Creek | BWC2.4 | 90 (A) | 90 (A) | 7 (E) | 90 (A) | 76 (B) | 90 (A) | 73 (B) | 90 (A) | 0 (E) | 90 (A) | 90 (A) | 90 (A) |
| Sleeper Log Creek | SLC0.0 | 35 (D) | 78 (B) | NA | NA | 90 (A) | 90 (A) | 90 (A) | 90 (A) | NA | NA | NA | NA |
| | SLC2.0 | 90 (A) | 90 (A) | NA | NA | 90 (A) | 90 (A) | 90 (A) | 70 (B) | NA | NA | NA | NA |
| Camp Oven Creek | CO1 | 78 (B) | 90 (A) | NA | NA | 90 (A) | 25 (D) | 90 (A) | 90 (A) | NA | NA | NA | NA |
| | CO2 | 48 (C) | 46 (C) | NA | NA | 90 (A) | 61 (B) | 90 (A) | 90 (A) | NA | NA | NA | NA |
| | CO3 | 0 (E) | 53 (C) | NA | NA | 90 (A) | 74 (B) | 90 (A) | 90 (A) | NA | NA | NA | NA |
| Saltwater Creek | SWC0.6 | 68 (B) | 77 (B) | 90 (A) | 48 (C) | 76 (B) | 90 (A) | 90 (A) | 90 (A) | 75 (B) | 90 (A) | 90 (A) | 90 (A) |
| | SC1 | 90 (A) | 90 (A) | NA | NA | 64 (B) | 90 (A) | 90 (A) | 90 (A) | NA | NA | NA | NA |
| | SC2 | 90 (A) | 90 (A) | NA | NA | 90 (A) | 90 (A) | 90 (A) | 90 (A) | NA | NA | NA | NA |
| Rollingstone Creek | RolC0.8 | 69 (B) | 65 (B) | 73 (B) | 10 (E) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 64 (B) | 90 (A) | 90 (A) | 90 (A) |
| Crystal Creek | CryC1.0 | 7 (E) | 68 (B) | 90 (A) | 41 (C) | 90 (A) | 90 (A) | 90 (A) | 90 (A) | 69 (B) | 90 (A) | 34 (D) | 90 (A) |

**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).

# Appendix FF. Estuarine Water Quality 2021–2022 Boxplots

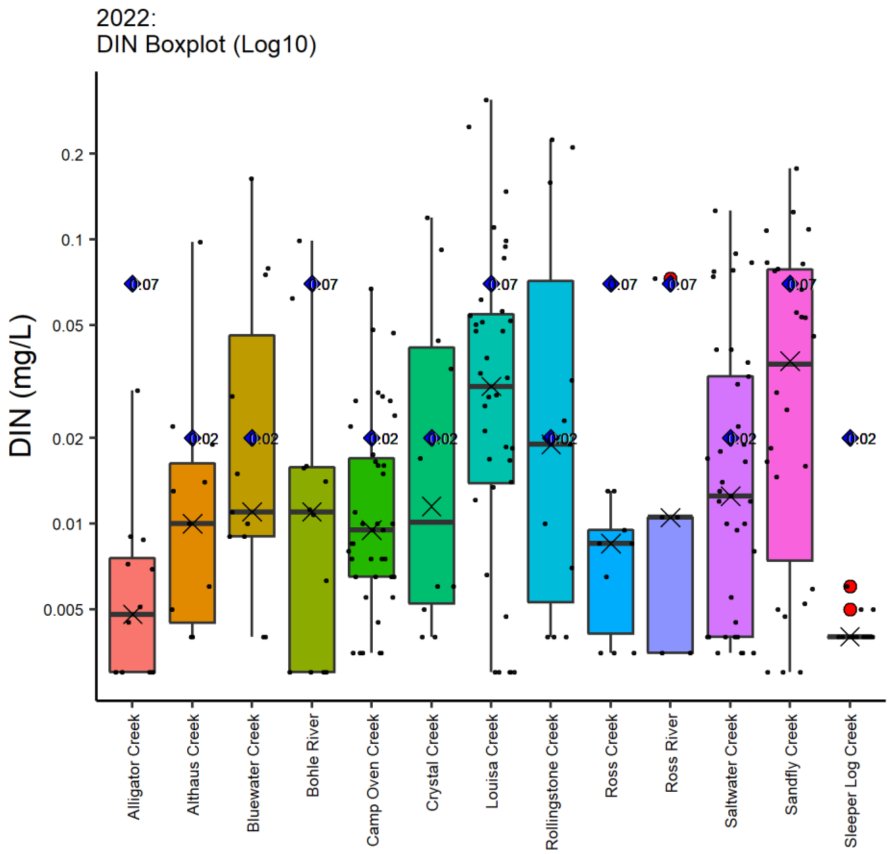


*Figure 47. Dry Tropics estuarine water quality boxplots: DIN. Blue diamond's indicate water quality guidelines, red circles indicate outliers, and the black cross indicates the value compared to the guideline value (median).*

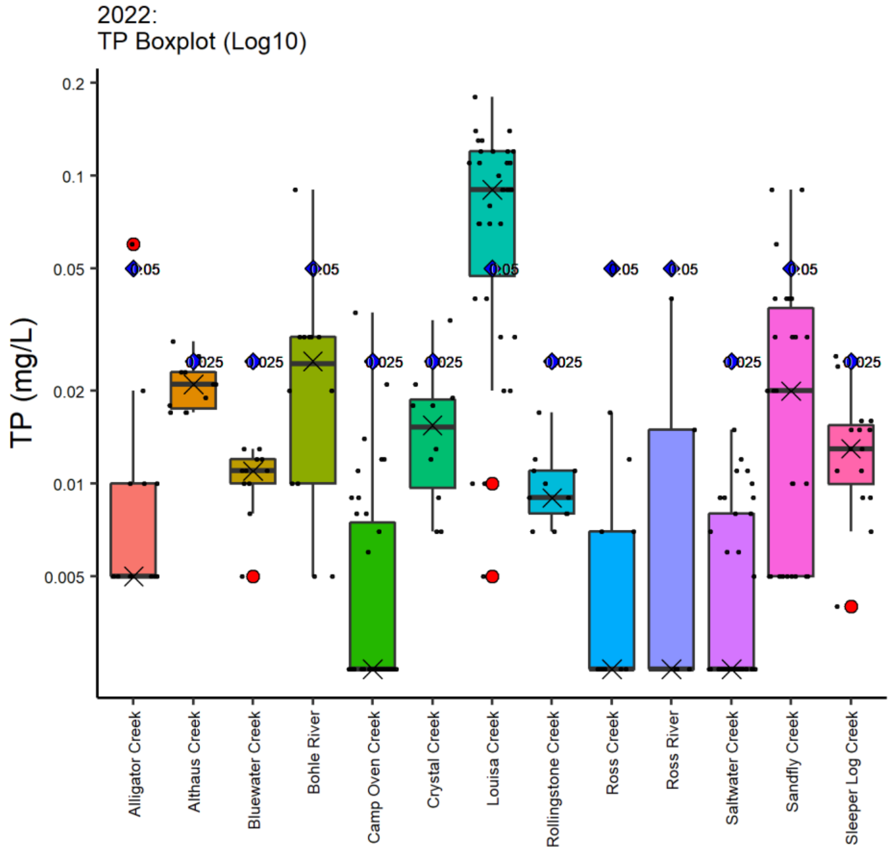


*Figure 46. Dry Tropics estuarine water quality boxplots: TP. Blue diamond's indicate water quality guidelines, red circles indicate outliers, and the black cross indicates the value compared to the guideline value (median).*

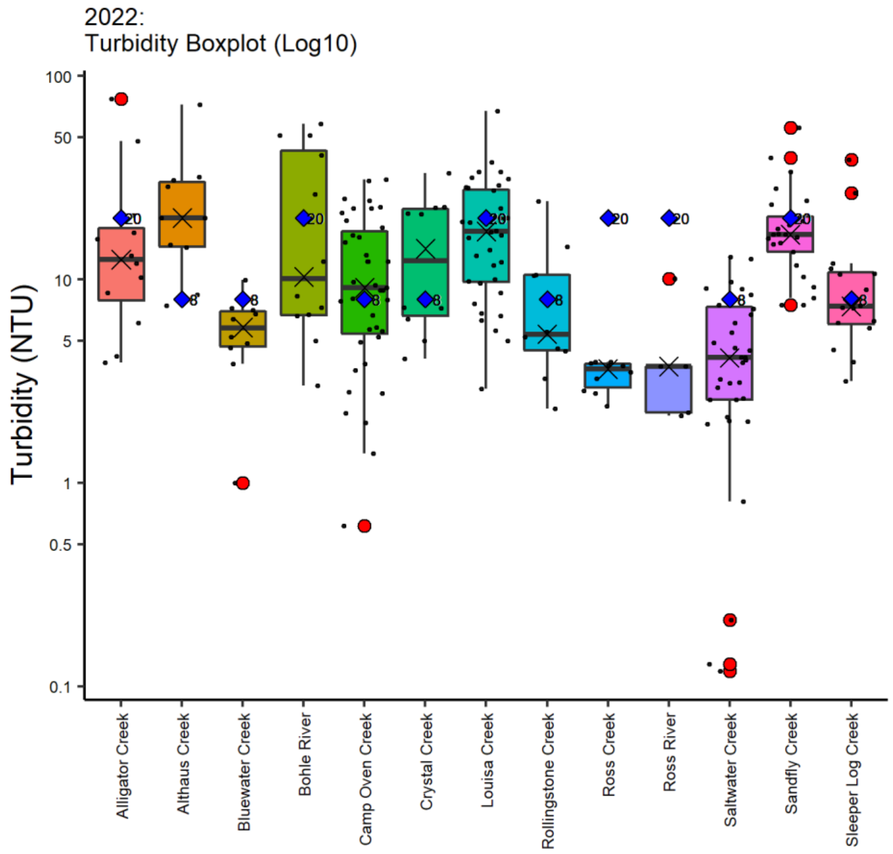


*Figure 48. Dry Tropics estuarine water quality boxplots: Turbidity. Blue diamond's indicate water quality guidelines, red circles indicate outliers, and the black cross indicates the value compared to the guideline value (median).*

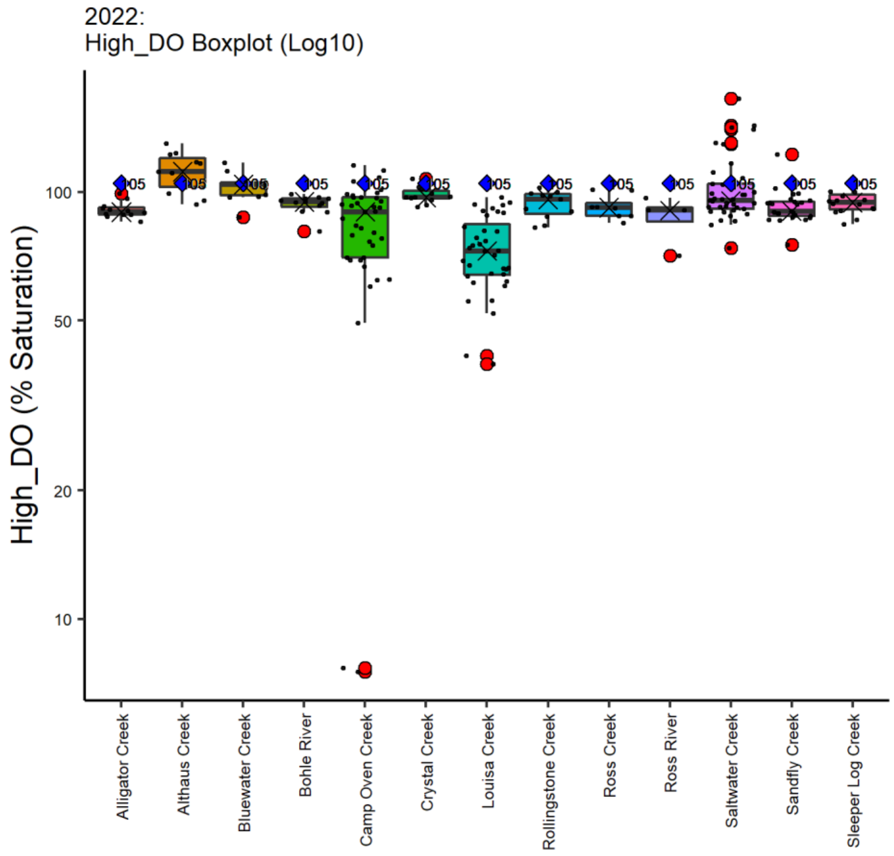


*Figure 49. Dry Tropics estuarine water quality boxplots: High DO. Blue diamond's indicate water quality guidelines, red circles indicate outliers, and the black cross indicates the value compared to the guideline value (median).*

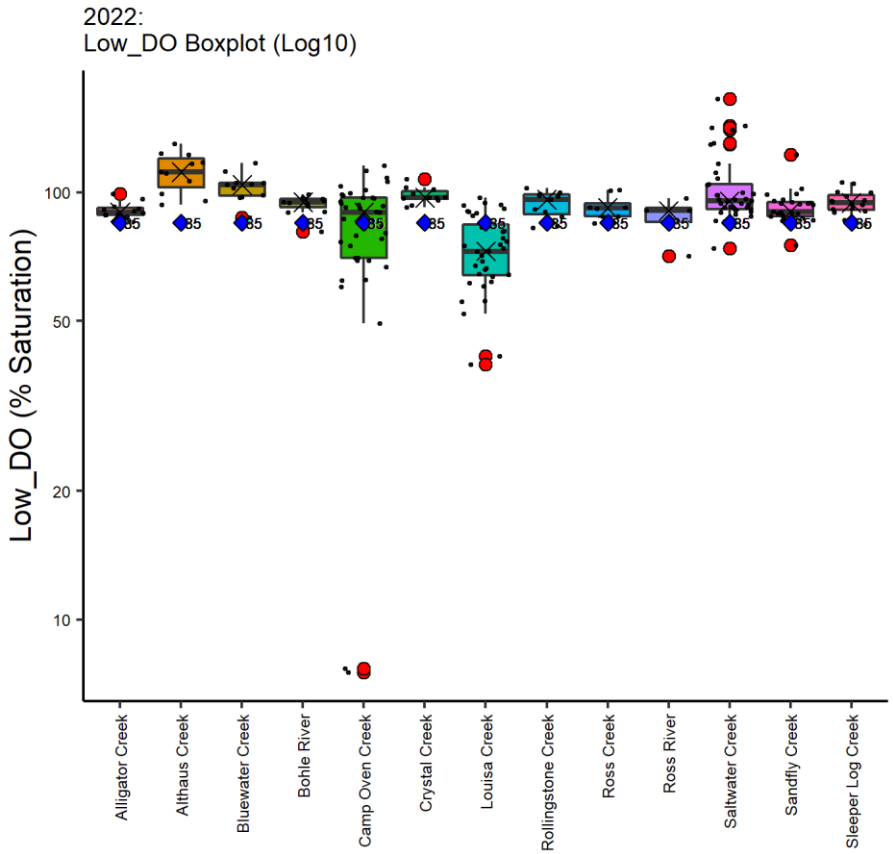


*Figure 50. Dry Tropics estuarine water quality boxplots: Low DO. Blue diamond's indicate water quality guidelines, red circles indicate outliers, and the black cross indicates the value compared to the guideline value (median).*

# Appendix GG.Estuarine Water Quality Line Plots

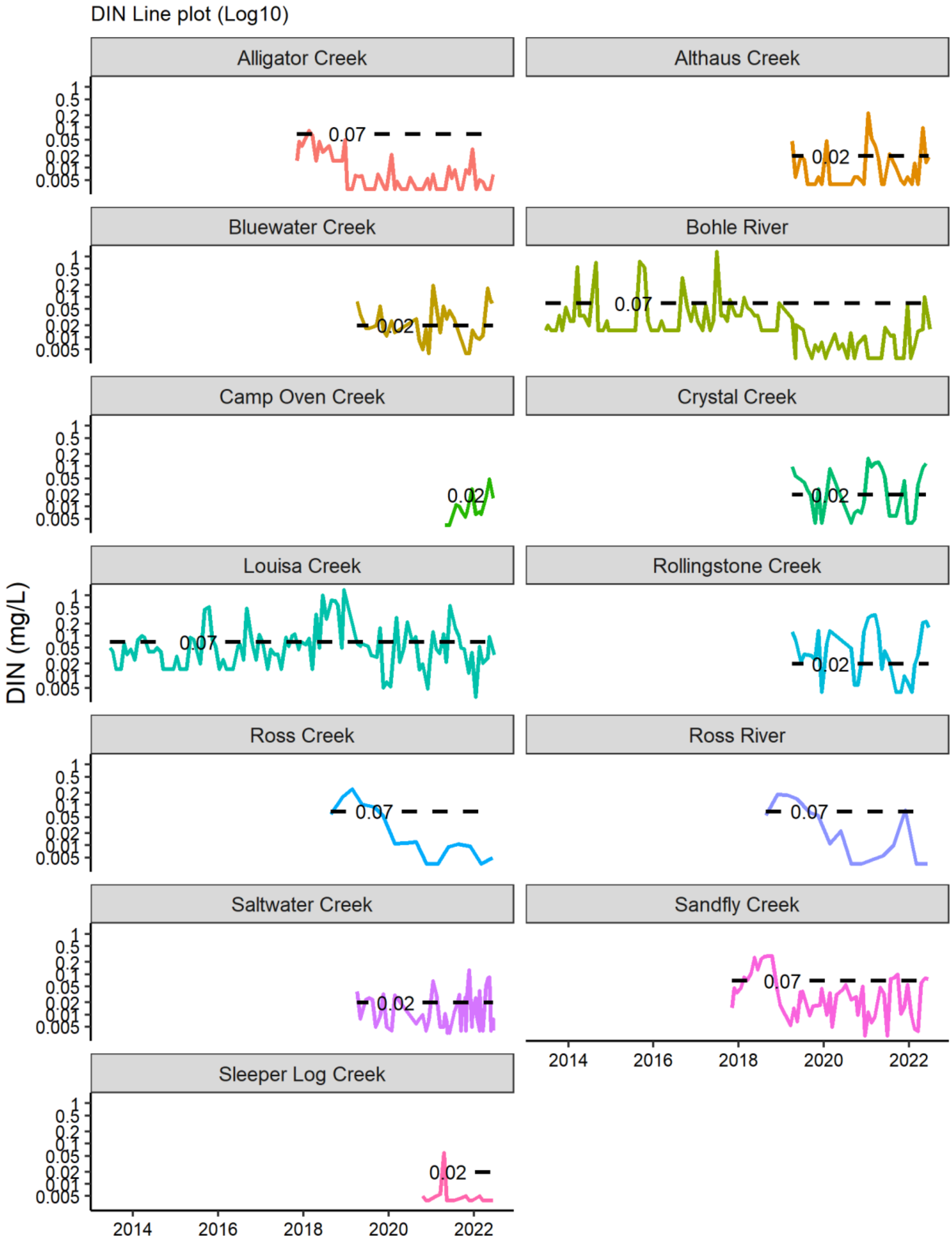


*Figure 51. Dry Tropics estuarine water quality line plots: DIN. The dashed line indicates water quality guidelines.*

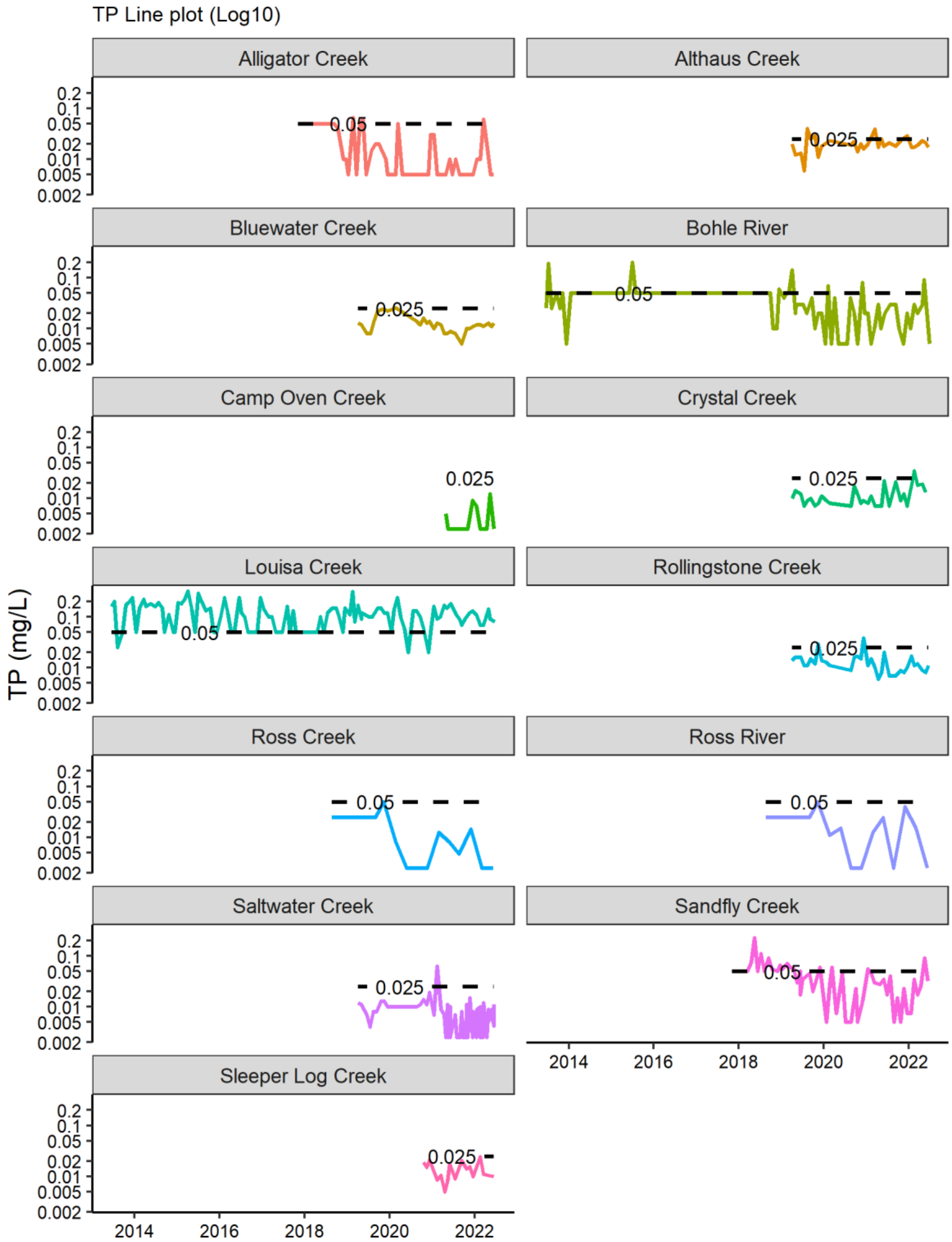


*Figure 52. Dry Tropics estuarine water quality line plots: TP. The dashed line indicates water quality guidelines.*

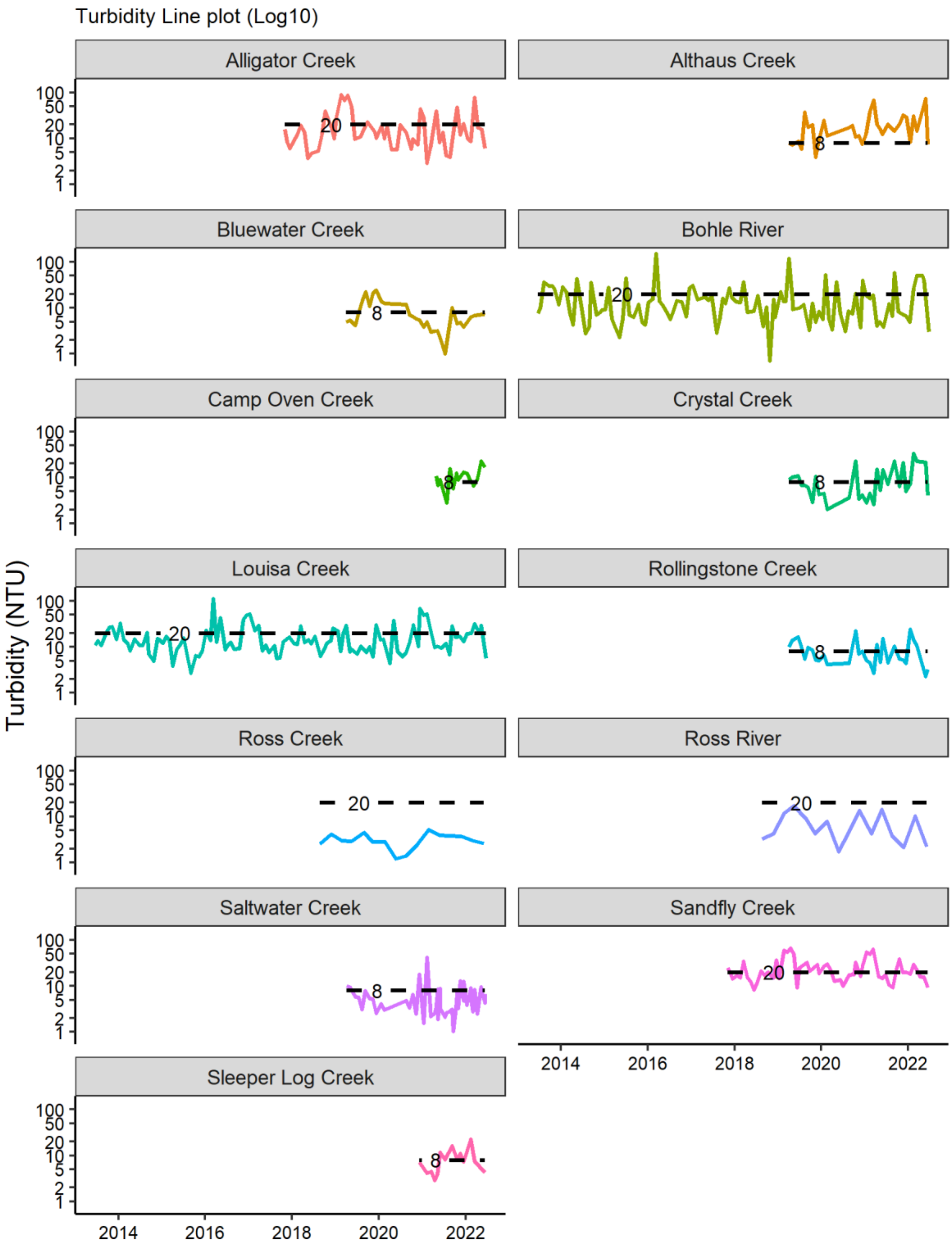


*Figure 53. Dry Tropics estuarine water quality line plots: NTU. The dashed line indicates water quality guidelines.*

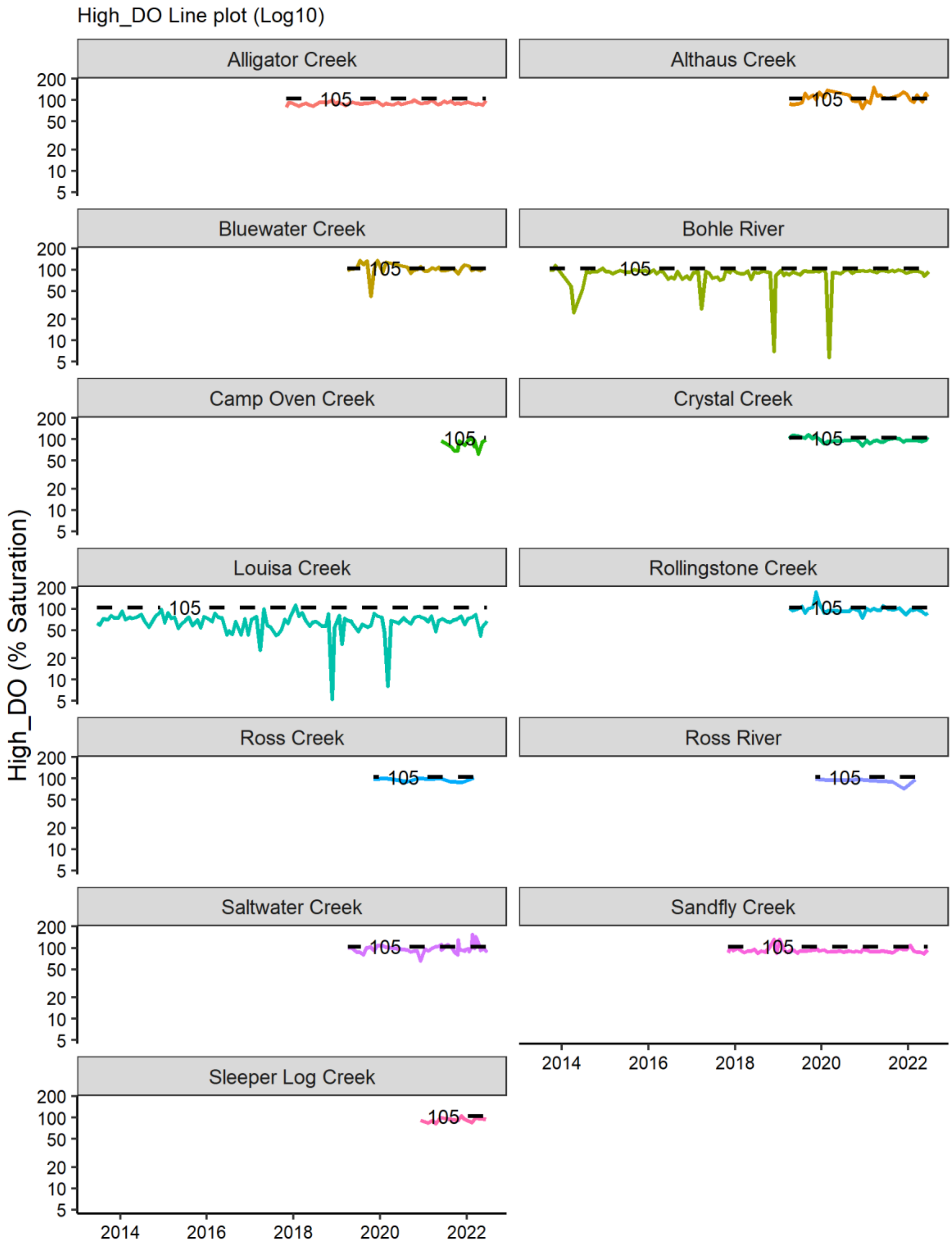


*Figure 54. Dry Tropics estuarine water quality line plots: High DO. The dashed line indicates water quality guidelines.*

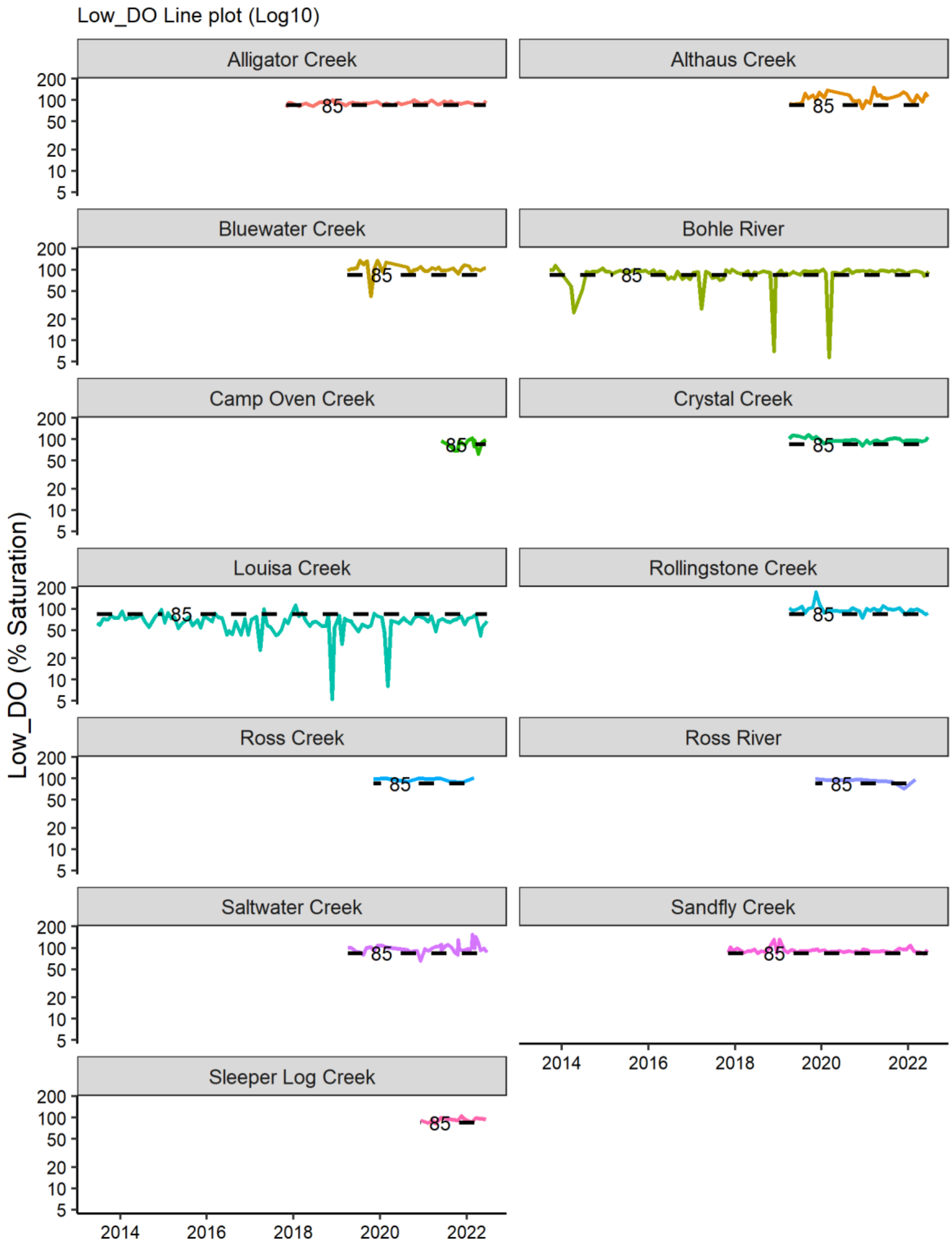


*Figure 55. Dry Tropics estuarine water quality line plots: Low DO. The dashed line indicates water quality guidelines.*

# Appendix HH.Estuarine Water Quality Special Analysis of TP in the Ross Estuarine Basin

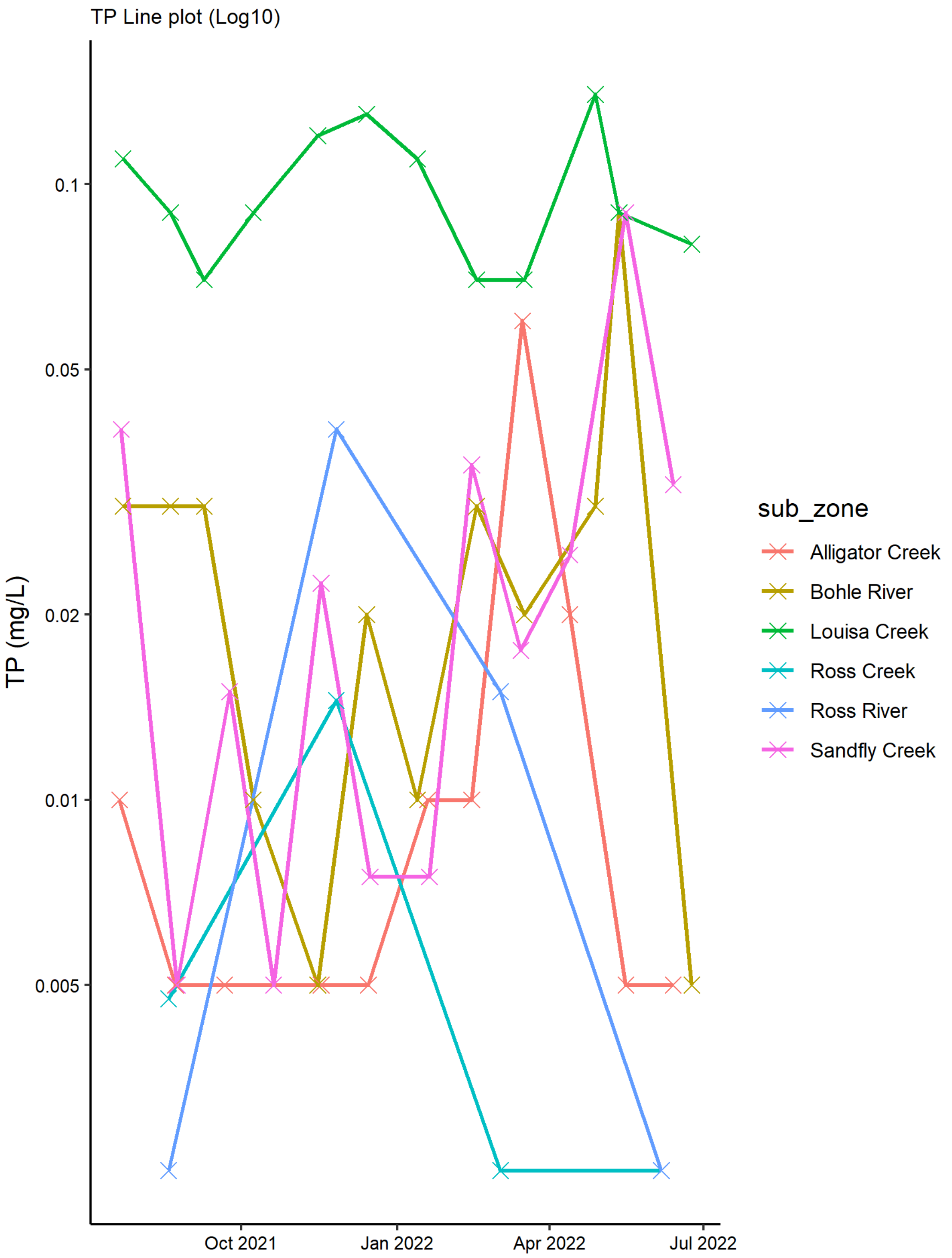


*Figure 56. Dry Tropics Estuarine water quality special analysis line plot of TP in the Ross Estuarine Basin for the 2021-2022 reporting year. Crosses mark specific times a sample was collected.*

## Appendix II. Estuarine Mangrove and Saltmarsh Extent: Assessed Area in the Dry Tropics Region

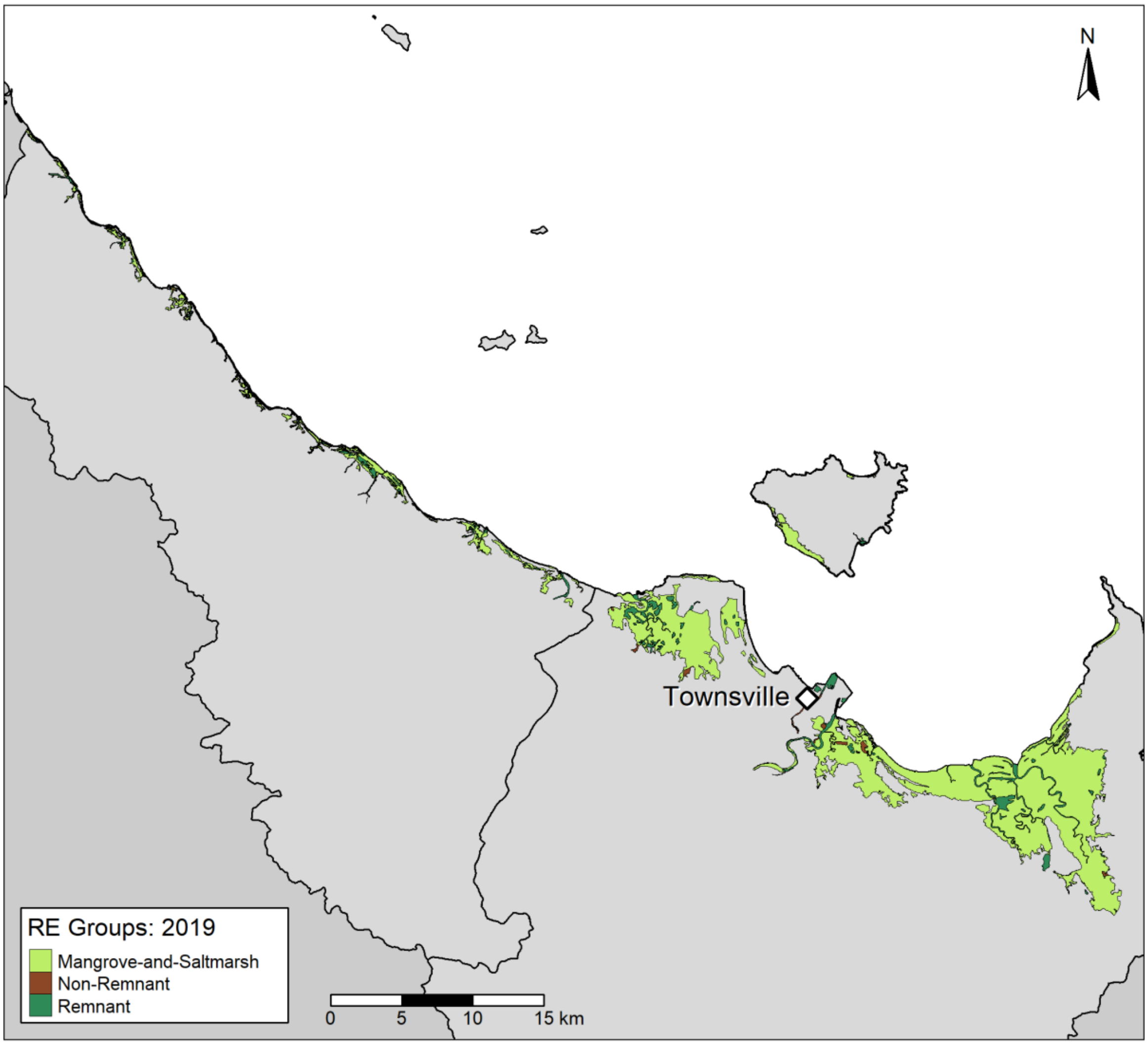


*Figure 57. Total area of the Dry Tropics region that was assessed for changes in Mangrove and Saltmarsh extent.*

# Appendix JJ. Estuarine Riparian Extent: Assessed Area in the Dry Tropics Region

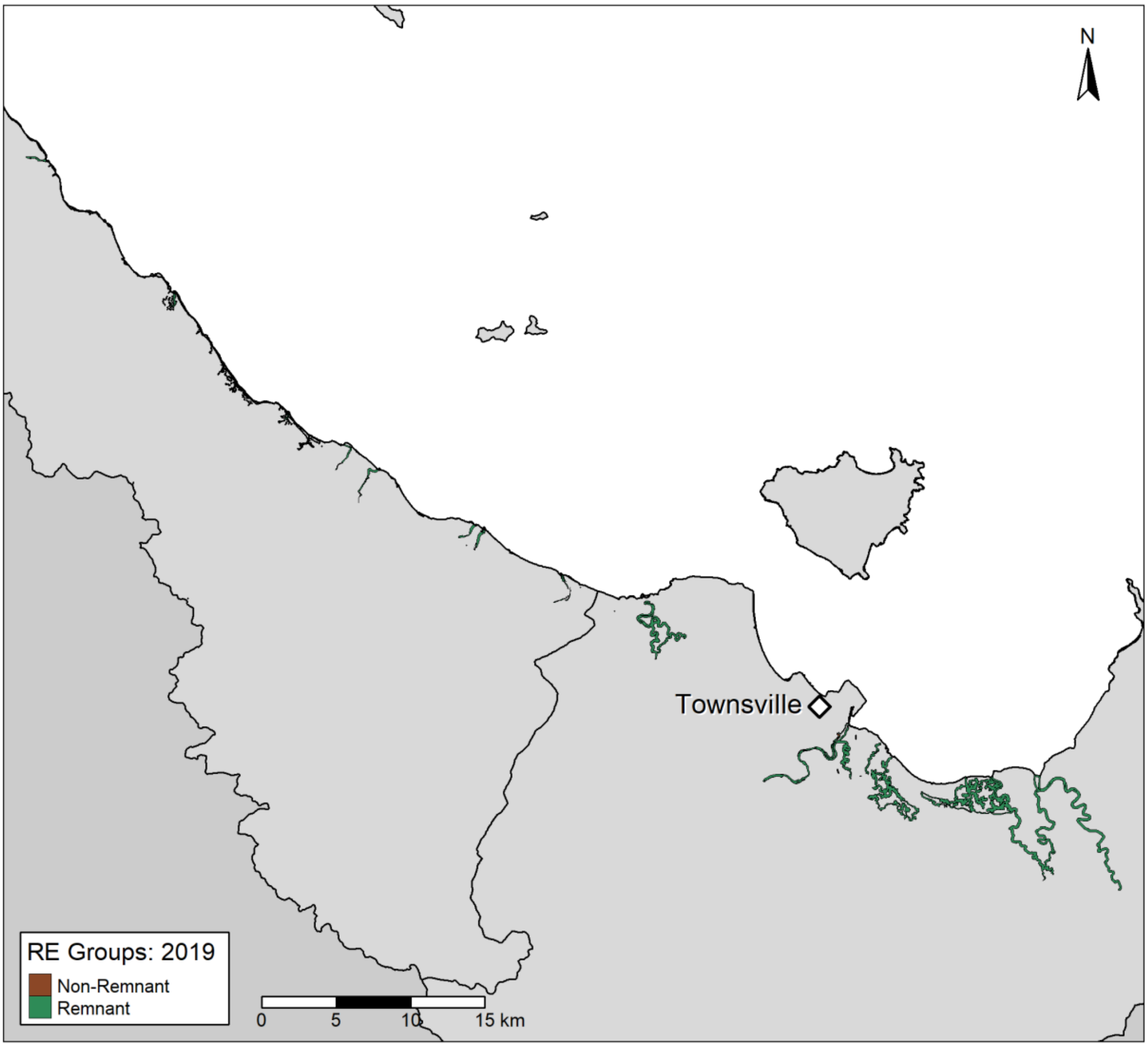


*Figure 58. The estuarine riparian buffer zone in the Dry Tropics region that was assessed for changes in total vegetation.*

# Appendix KK. Ross Estuarine Area Mangrove and Saltmarsh Vegetation Change

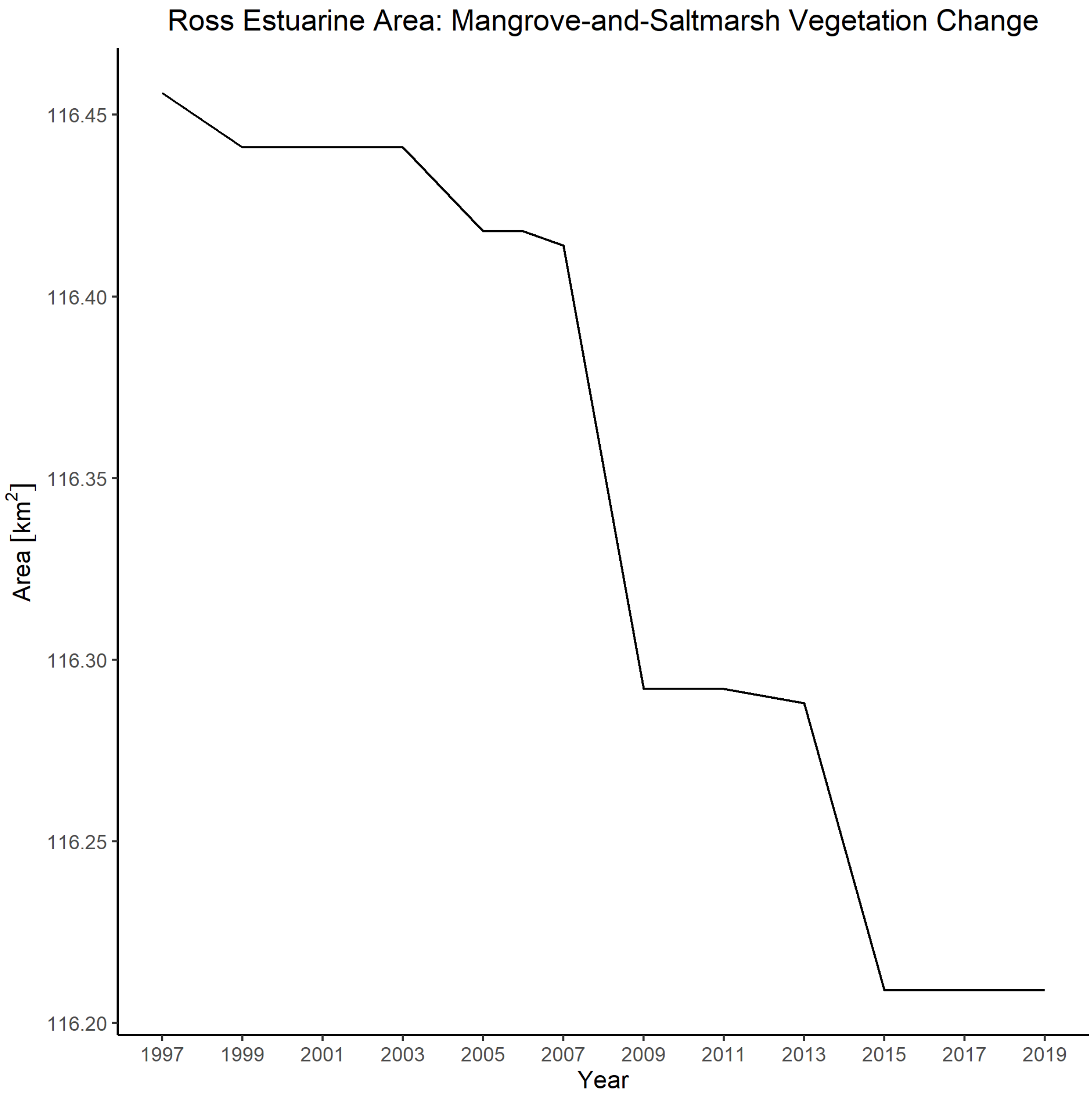


*Figure 59. Ross Estuarine Area Mangrove and Saltmarsh Vegetation Change.*

# Appendix LL. Black Estuarine Area Mangrove and Saltmarsh Vegetation Change

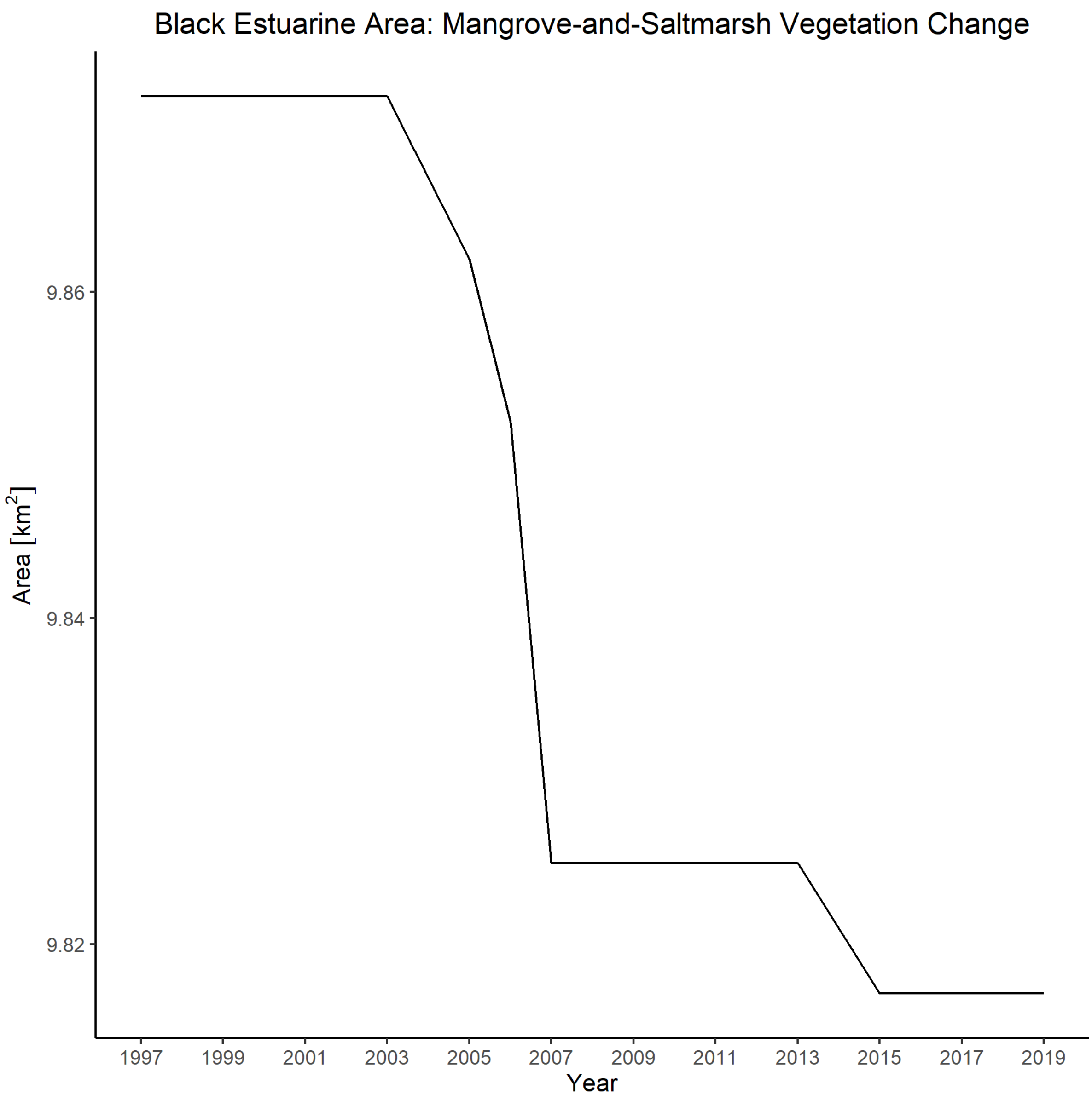


*Figure 60. Black Estuarine Area Mangrove and Saltmarsh Vegetation Change.*

# Appendix MM. Ross Estuarine Riparian Vegetation Change

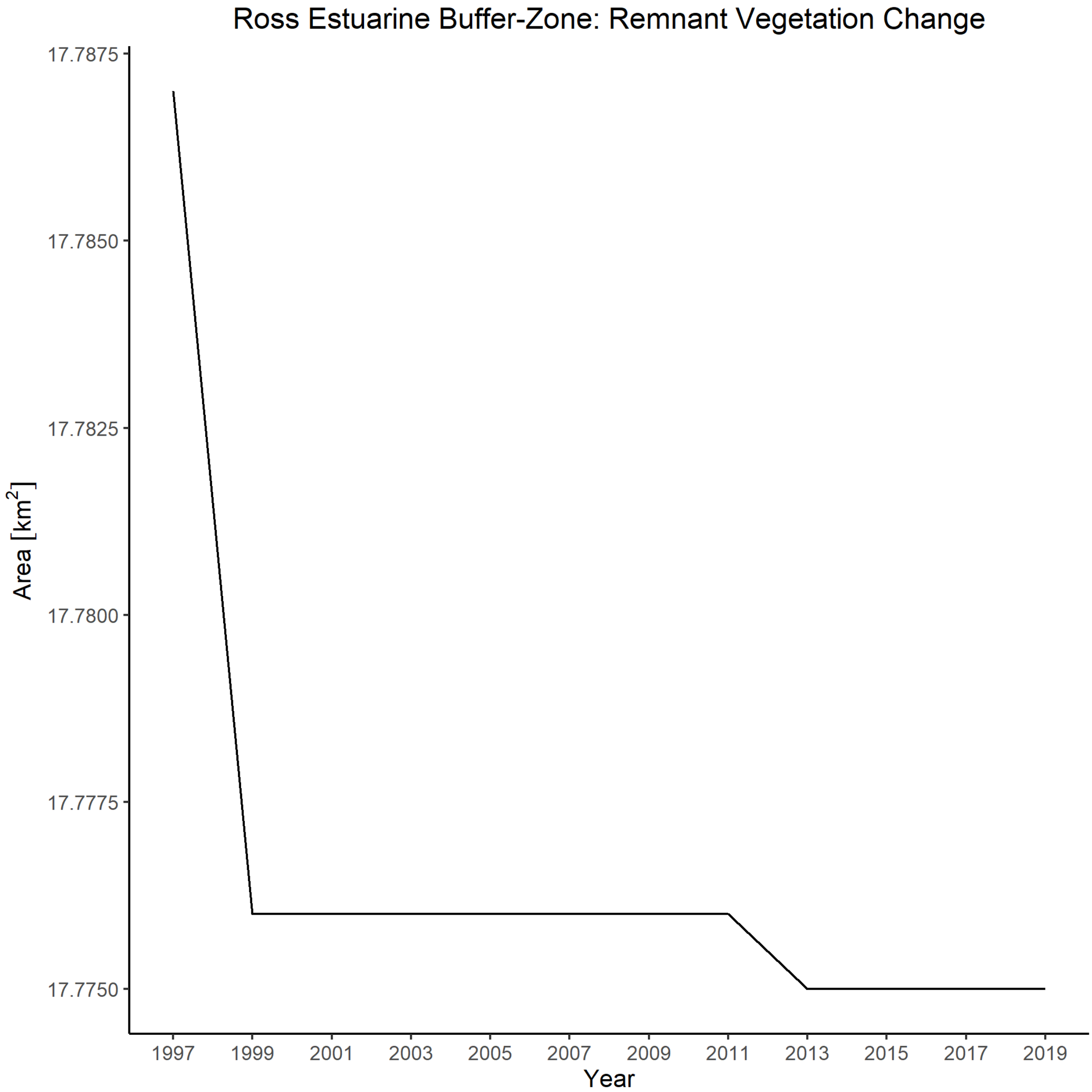


*Figure 61. Ross Estuarine Riparian Vegetation Change.*

# Appendix NN. Black Estuarine Riparian Vegetation Change

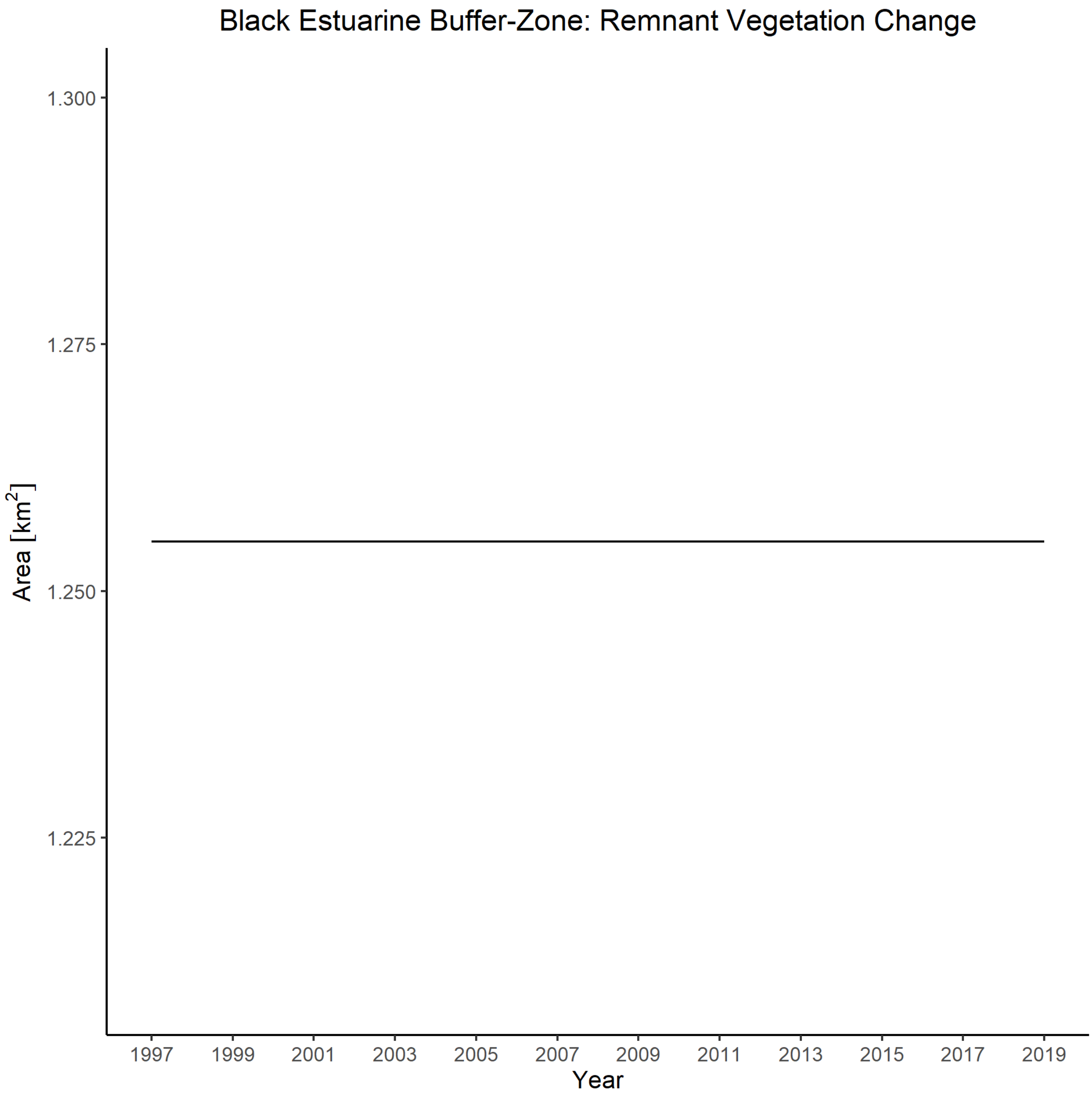


*Figure 62. Black Estuarine Riparian Vegetation Change.*

# Appendix OO. Estuarine Habitat Scores Pre and Post Back-Calculation

*Table 101. Estuarine indicator category scores post back calculation.*

| Basin | Mangrove and Saltmarsh | Riparian Extent | Habitat Index 2021–2022 |
|---|---|---|---|
| Ross Estuarine | 67 (B) | 80 (B) | 73 (B) |
| Black Estuarine | 63 (B) | 80 (B) | 71 (B) |

*Table 102. Estuarine indicator category scores pre back calculation.*

| Basin | Mangrove and Saltmarsh | Habitat Index | |
|---|---|---|---|
| | | 2020–2021 | 2019–2020 |
| Ross Estuarine | 71 (B) | 71 (B) | 71 (B) |
| Black Estuarine | 77 (B) | 77 (B) | 77 (B) |

# Appendix PP. Inshore Marine Water Quality Sampling Locations

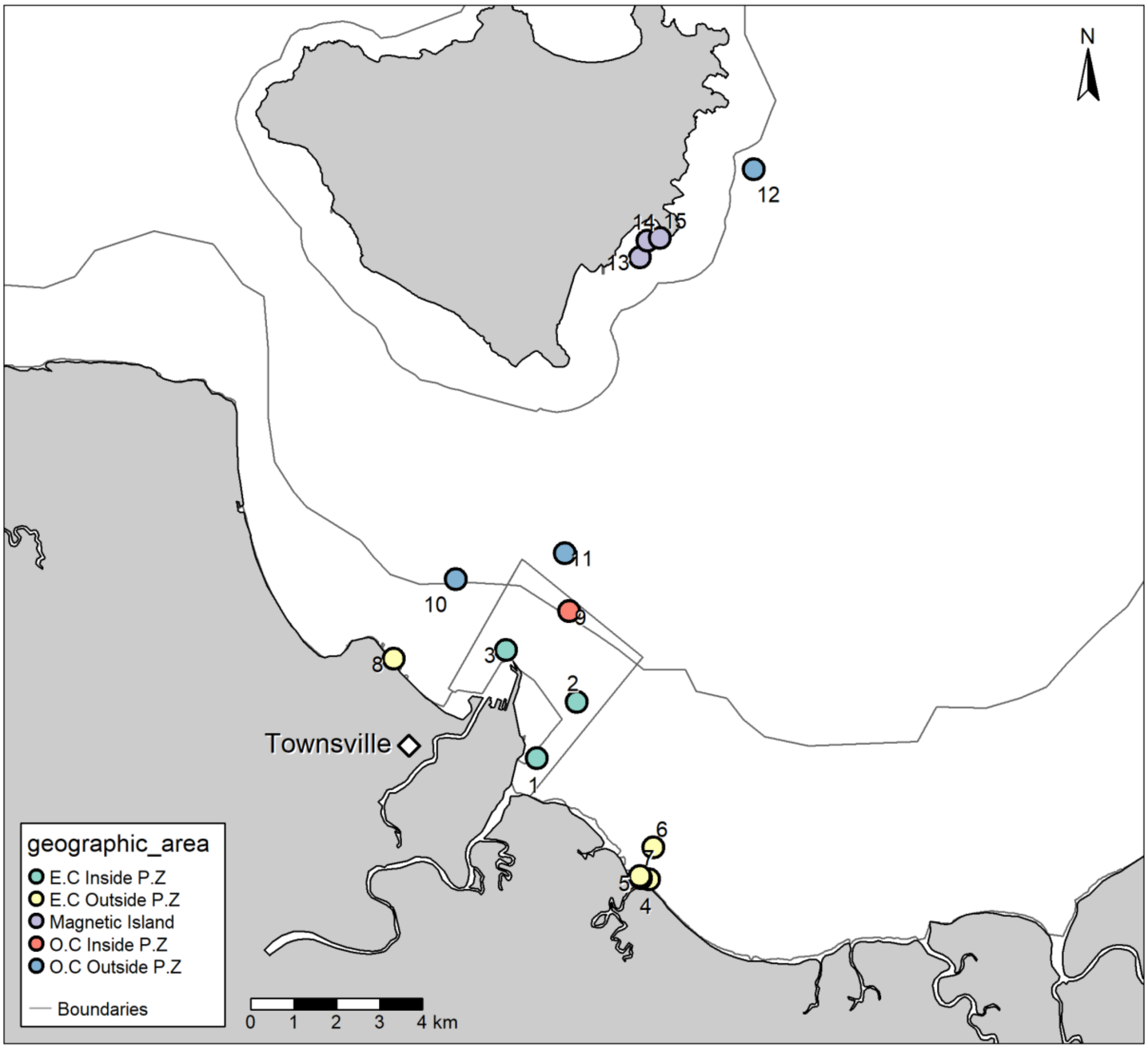


*Figure 63. Cleveland Bay inshore marine zone water quality site locations.*

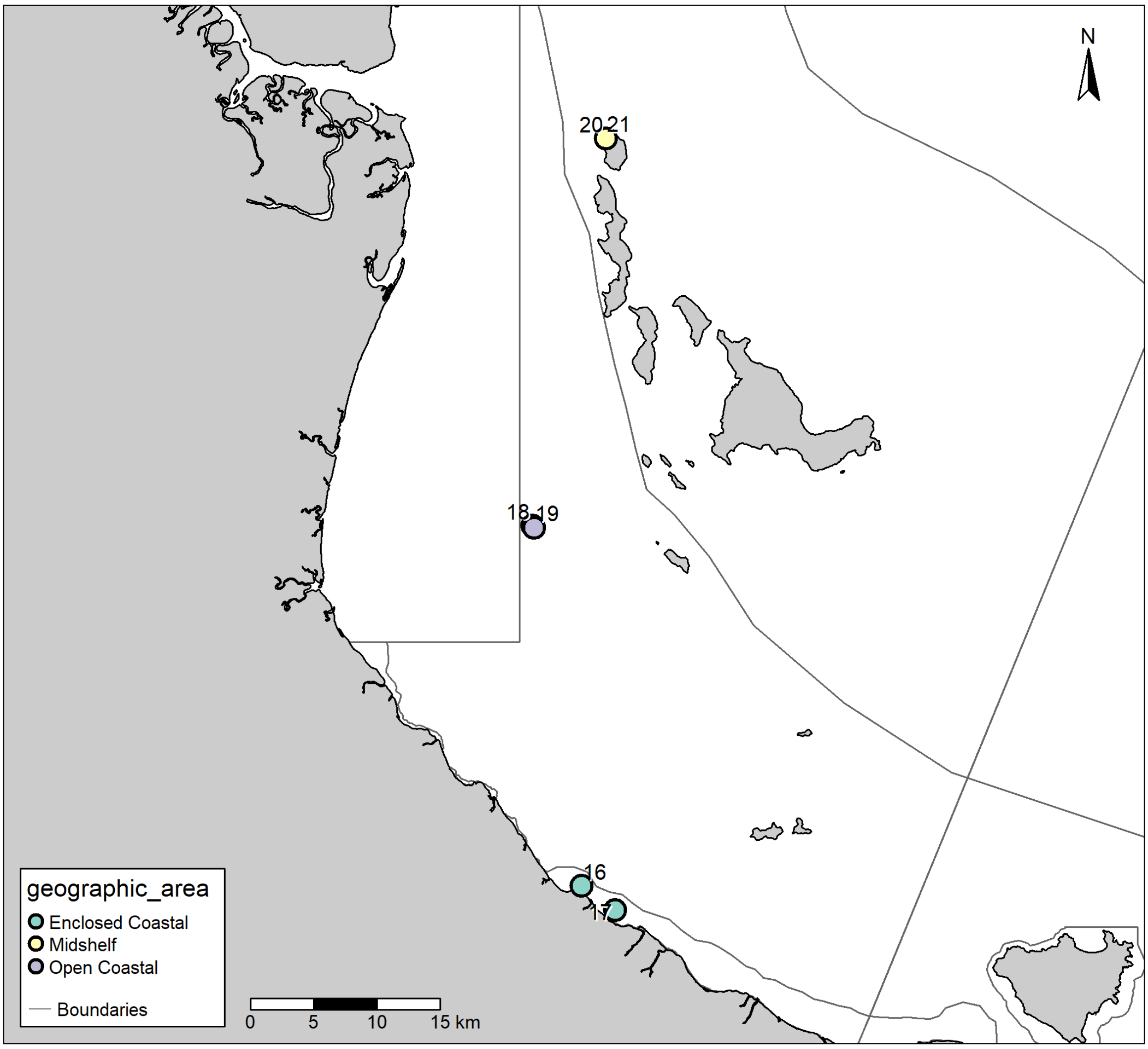


*Figure 64. Halifax Bay inshore marine zone water quality site locations.*

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

*Table 103. Number of samples, days sampled, mean, median and water quality objective values for nitrogen based nutrient indicators in the Dry Tropics Inshore Marine Environment.*

| Area | NOx (mg/L) | | | | PN (ug/L) | | | | TN[28] (mg/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N. Samples | Sample Days | Mean | WQO | N. Samples | Sample Days | Mean | WQO | N. Samples | Sample Days | Mean | WQO |
| CB: E.C.IPZ | 12 | 4 | 0.001 | 0.009 | NA | NA | NA | NA | 12 | 4 | 0.11 | 0.22 |
| CB: E.C.OPZ | 4 | 4 | 0.001 | 0.009 | NA | NA | NA | NA | 4 | 4 | 0.105 | 0.22 |
| CB: O.C.IPZ | 4 | 4 | 0.001 | 0.009 | NA | NA | NA | NA | 4 | 4 | 0.090 | 0.22 |
| CB: O.C.OPZ | 8 | 4 | 0.001 | 0.002 | NA | NA | NA | 20.0 | 8 | 4 | 0.091 | 0.13 |
| CB: Mag. Is. | 10 | 10 | 0.003 | 0.001[29] | 10 | 10 | 35.55 | 21.0[29] | NA | NA | NA | 0.20[29] |
| HB: E.C.W | 22 | 11 | 0.097 | 0.003 | NA | NA | NA | NA | NA | NA | NA | 0.10 |
| HB: O.C | 10 | 10 | 0.0021 | 0.002 | 10 | 10 | 27.98 | 20.0 | NA | NA | NA | 0.13 |
| HB: Mid | 10 | 10 | 0.0018 | 0.002[29] | 10 | 10 | 24.16 | 20.0 | NA | NA | NA | 0.10 |

**Key:** ■ = Mean/Median is lower than the guideline value | ■ = Mean/Median is higher than the guideline value.

[28] TN is included only as an indicator. TN is not aggregated within the nutrient indicator category.

[29] These values have been adjusted via expert opinion to accurately reflect local conditions and requirements.

*Table 104. Number of samples, number of days sampled, mean, median and water quality objective values for phosphorous based nutrient indicators in the Dry Tropics Inshore Marine Environment.*

| Area | PP (ug/L) | | | | TP (mg/L) | | | | FRP[30] (mg/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N. Samples | Sample Days | Mean | WQO | N. Samples | Sample Days | Median | WQO | N. Samples | Sample Days | Mean | WQO |
| CB: E.C.IPZ | NA | NA | NA | NA | 12 | 4 | 0.0025 | 0.030 | 12 | 4 | 0.0005 | 0.011 |
| CB: E.C.OPZ | NA | NA | NA | NA | 4 | 4 | 0.0025 | 0.030 | 4 | 4 | 0.0005 | 0.011 |
| CB: O.C.IPZ | NA | NA | NA | NA | 4 | 4 | 0.0025 | 0.030 | 4 | 4 | 0.0005 | 0.011 |
| CB: O.C.OPZ | NA | NA | NA | 2.80 | 8 | 4 | 0.0025 | 0.020 | 8 | 4 | 0.0005 | 0.007 |
| CB: Mag. Is. | 10 | 10 | 3.57 | 2.80[29] | NA | NA | NA | 0.020[29] | 10 | 10 | 0.0012 | 0.003 |
| HB: E.C.W | NA | NA | NA | NA | 22 | 11 | 0.0025 | 0.014 | 22 | 11 | 0.0005 | 0.006 |
| HB: O.C | 10 | 10 | 2.19 | 2.80 | NA | NA | NA | 0.020 | 10 | 10 | 0.0011 | 0.002 |
| HB: Mid | 10 | 10 | 1.89 | 2.80 | NA | NA | NA | 0.014[29] | 10 | 10 | 0.0011 | 0.002 |

**Key:** ■ = Mean/Median is lower than the guideline value | ■ = Mean/Median is higher than the guideline value.

[30] FRP is included only as an indicator. FRP is not aggregated within the nutrient indicator category.

# Appendix RR. Inshore Marine Water Quality Nutrients: Water Quality Objective Values Pre- and Post-Adjustment

*Table 105. Dry Tropics Inshore Marine Environment water quality objectives (Nutrients). PRE-ADJUSTMENT. Red boxes highlight values that have changed.*

| Area | EPP Site Code | NOx(mg/L) (mean) | PN (ug/L) (mean) | PP (ug/L) (mean) | TP (mg/L) (median) | TN (mg/L) (mean) | FRP (mg/L) (mean) |
|---|---|---|---|---|---|---|---|
| Enclosed Coastal: Inside Port Zone | MD2241 | 0.009 | NA | NA | 0.030 | 0.22 | 0.011 |
| Enclosed Coastal: Outside Port Zone | MD2242.enclosed | 0.009 | NA | NA | 0.030 | 0.22 | 0.011 |
| Open Coastal: Inside Port Zone | MD2241 | 0.009 | NA | NA | 0.030 | 0.22 | 0.011 |
| Open Coastal: Outside Port Zone | MD2242.open | 0.002 | 20.0 | 2.80 | 0.020 | 0.13 | 0.007 |
| Magnetic Island | SD2244.open | 0.000 | 17.0 | 2.80 | 0.01 | 0.105 | 0.001 |
| Enclosed Coastal | Halifax Bay Enclosed Coastal | 0.003 | NA | NA | 0.014 | 0.10 | 0.006 |
| Open Coastal | SD3124 | 0.002 | 20.0 | 2.80 | 0.020 | 0.13 | 0.002 |
| Midshelf | HEV3124 | 0.000 | 20.0 | 2.80 | 0.011 | 0.10 | 0.002 |

*Table 106. Dry Tropics Inshore Marine Environment water quality objectives (Nutrients). POST-ADJUSTMENT. Red boxes highlight values that have changed.*

| Area | EPP Site Code | NOx(mg/L) (mean) | PN (ug/L) (mean) | PP (ug/L) (mean) | TP (mg/L) (median) | TN (mg/L) (mean) | FRP (mg/L) (mean) |
|---|---|---|---|---|---|---|---|
| Enclosed Coastal: Inside Port Zone | MD2241 | 0.009 | NA | NA | 0.030 | 0.22 | 0.011 |
| Enclosed Coastal: Outside Port Zone | MD2242.enclosed | 0.009 | NA | NA | 0.030 | 0.22 | 0.011 |
| Open Coastal: Inside Port Zone | MD2241 | 0.009 | NA | NA | 0.030 | 0.22 | 0.011 |
| Open Coastal: Outside Port Zone | MD2242.open | 0.002 | 20.0 | 2.80 | 0.020 | 0.13 | 0.007 |
| Magnetic Island | SD2244.open | 0.001 | 21.0 | 2.80 | 0.020 | 0.20 | 0.003 |
| Enclosed Coastal | Halifax Bay Enclosed Coastal | 0.003 | NA | NA | 0.014 | 0.10 | 0.006 |
| Open Coastal | SD3124 | 0.002 | 20.0 | 2.80 | 0.020 | 0.13 | 0.002 |
| Midshelf | HEV3124 | 0.002 | 20.0 | 2.80 | 0.014 | 0.10 | 0.002 |

# Appendix SS.Inshore Marine Water Quality Nutrient: Scores Historic Comparison

*Table 107. Dry Tropics Inshore Marine Environment water quality nutrient indicator and indicator category scores.*

| Area | 2021–2022 | | | | | | 2020–2021 | | | | | | 2020–2019 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NOx | PN | PP | TP | TN | FRP | NOx | PN | PP | TP | TN | FRP | NOx | PN | PP | TP | TN | FRP |
| CB: E.C.IPZ | 100 | NA | NA | 100 | 100 | 100 | 100 | NA | NA | 100 | 100 | 100 | 100 | NA | NA | 100 | 52 | 100 |
| CB: E.C.OPZ | 100 | NA | NA | 100 | 100 | 100 | 100 | NA | NA | 100 | 100 | 100 | 100 | NA | NA | 100 | 55 | 100 |
| CB: O.C.IPZ | 100 | NA | NA | 100 | 100 | 100 | 100 | NA | NA | 100 | 100 | 100 | 100 | NA | NA | 100 | 35 | 100 |
| CB: O.C.OPZ | 100 | NA | NA | 100 | 81 | 100 | 100 | NA | NA | 100 | 81 | 100 | 100 | NA | NA | 100 | 0 | 100 |
| CB: Mag. Is. | 0 | 15 | 40 | NA | NA | NA | 0 | 28 | 46 | NA | NA | NA | 25 | 13 | 38 | NA | NA | NA |
| HB: E.C.W | 0 | NA | NA | 100 | NA | 100 | 23 | NA | NA | 100 | NA | 100 | No data provided. | | | | | |
| HB: O.C | 57 | 32 | 75 | NA | NA | NA | 56 | 41 | 39 | NA | NA | NA | 43 | 0 | 65 | NA | NA | NA |
| HB: Mid | 64 | 45 | 83 | NA | NA | NA | 33 | 48 | 76 | NA | NA | NA | 35 | 1 | 68 | NA | NA | NA |

**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.

# Appendix TT. Phys-Chem and Chlorophyll *a*: Sample Frequencies, Means, Medians, and WQOs

*Table 108. Number of samples, mean, median, and water quality objective values for physical-chemical properties indicators in the Dry Tropics Inshore Marine Environment.*

| Area | Turbidity (NTU) | | | | TSS (mg/L) | | | | Secchi (m)[31] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N. Samples | Sample Days | Median | WQO | N. Samples | Sample Days | Mean | WQO | N. Samples | Sample Days | Mean | WQO |
| CB: E.C.IPZ | 12 | 4 | 2.18 | 4.9 | 12 | 4 | 9.33 | 22.0 | 12 | 4 | 1.74 | 1.0 |
| CB: E.C.OPZ | 52 | 17 | 12.15 | 4.9 | 52 | 17 | 28.92 | 15.0 | 4 | 4 | 1.48 | 1.0 |
| CB: O.C.IPZ | 4 | 4 | 2.29 | 4.9 | 4 | 4 | 9.00 | 22.0 | 4 | 4 | 2.10 | 1.0 |
| CB: O.C.OPZ | 323 | 315 | 3.93 | 3.0 | 8 | 4 | 10.87 | 10.0 | 8 | 4 | 2.33 | 3.0 |
| CB: Mag. Is. | 669 | 365 | 2.03 | 2.7[32] | 10 | 10 | 2.43 | 3.7[32] | 10 | 10 | 4.19 | 3.0[32] |
| HB: E.C.W | 22 | 11 | 6.25 | 6.0 | 22 | 11 | 11.95 | 15.0 | NA | | NA | 1.5 |
| HB: O.C | 365 | 365 | 1.13 | 1.5 | 10 | 10 | 1.65 | 2.0 | 10 | 10 | 5.34 | 10.0 |
| HB: Mid | 345 | 345 | 0.63 | 1.5[32] | 10 | 10 | 1.51 | 2.0 | 10 | 10 | 6.96 | 10.0 |

**Key:** ■ = Mean/Median is lower than the guideline value | ■ = Mean/Median is higher than the guideline value.

[31] 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.

[32] These values have been adjusted via expert opinion to accurately reflect local conditions and requirements.

*Table 109. Number of samples, mean and water quality objective values for the Chlorophyll a indicator in the Dry Tropics Inshore Marine Environment.*

| Area | Chlorophyll *a* (ug/L) | | | |
|---|---|---|---|---|
| | **N. Samples** | **Sample Days** | **Mean** | **Obj.** |
| CB: E.C.IPZ | NA | NA | NA | 2.60 |
| CB: E.C.OPZ | 46 | 13 | 1.26 | 2.60 |
| CB: O.C.IPZ | NA | NA | NA | 2.60 |
| CB: O.C.OPZ | NA | NA | NA | 1.00 |
| CB: Mag. Is. | 375 | 365 | 0.56 | 0.84[33] |
| HB: E.C.W | 22 | 11 | 0.68 | 2.00 |
| HB: O.C | 375 | 365 | 0.35 | 0.45 |
| HB: Mid | 355 | 346 | 0.49 | 0.45 |

**Key:** ■ = Mean/Median is lower than the guideline value | ■ = Mean/Median is higher than the guideline value.

[33] These values have been adjusted via expert opinion to accurately reflect local conditions and requirements.

# Appendix UU. Inshore Marine Water Quality Physical-Chemical Properties and Chlorophyll a: Water Quality Objective Values Pre- and Post-Adjustment

*Table 110. Dry Tropics Inshore Marine Environment water quality objectives (Physical-Chemical Properties and Chlorophyll a). PRE-ADJUSTMENT. Red boxes highlight values that have changed.*

| Area | EPP Site Code | Turbidity (NTU) (median) | TSS (mg/L) (mean) | Secchi (m) (mean) | Chl *a* (ug/L) (mean) |
|---|---|---|---|---|---|
| Enclosed Coastal: Inside Port Zone | MD2241 | 4.9 | 22.0 | 1.0 | 2.60 |
| Enclosed Coastal: Outside Port Zone | MD2242.enclosed | 4.9 | 15.0 | 1.0 | 2.60 |
| Open Coastal: Inside Port Zone | MD2241 | 4.9 | 22.0 | 1.0 | 2.60 |
| Open Coastal: Outside Port Zone | MD2242.open | 3.0 | 10.0 | 3.0 | 1.00 |
| Magnetic Island | SD2244.open | 1.3 | 1.9 | 4 | 0.59 |
| Enclosed Coastal | Halifax Bay Enclosed Coastal | 6.0 | 15.0 | 1.5 | 2.00 |
| Open Coastal | SD3124 | 1.5 | 2.0 | 10.0 | 0.45 |
| Midshelf | HEV3124 | 0.8 | 2.0 | 10.0 | 0.45 |

*Table 111. Dry Tropics Inshore Marine Environment water quality objectives (Physical-Chemical Properties and Chlorophyll a). POST-ADJUSTMENT. Red boxes highlight values that have changed.*

| Area | EPP Site Code | Turbidity (NTU) (median) | TSS (mg/L) (mean) | Secchi (m) (mean) | Chl *a* (ug/L) (mean) |
|---|---|---|---|---|---|
| Enclosed Coastal: Inside Port Zone | MD2241 | 4.9 | 22.0 | 1.0 | 2.60 |
| Enclosed Coastal: Outside Port Zone | MD2242.enclosed | 4.9 | 15.0 | 1.0 | 2.60 |
| Open Coastal: Inside Port Zone | MD2241 | 4.9 | 22.0 | 1.0 | 2.60 |
| Open Coastal: Outside Port Zone | MD2242.open | 3.0 | 10.0 | 3.0 | 1.00 |
| Magnetic Island | SD2244.open | 2.7 | 3.7 | 3.0 | 0.84 |
| Enclosed Coastal | Halifax Bay Enclosed Coastal | 6.0 | 15.0 | 1.5 | 2.00 |
| Open Coastal | SD3124 | 1.5 | 2.0 | 10.0 | 0.45 |
| Midshelf | HEV3124 | 1.5 | 2.0 | 10.0 | 0.45 |

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

*Table 112. Dry Tropics Inshore Marine Environment water quality physical-chemical properties indicator and indicator category scores.*

| Area | 2022–2021 | | | | 2021–2020 | | | | 2020–2019 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NTU | TSS | Secchi | Chla | NTU | TSS | Secchi | Chla | NTU | TSS | Secchi | Chla |
| CB: E.C.IPZ | 100 | 100 | 92 | NA | 90 | 85 | 94 | NA | 75 | 100 | 78 | NA |
| CB: E.C.OPZ | 0 | 3 | 83 | 100 | 0 | 13 | 100 | 94 | 0 | 17 | 79 | 100 |
| CB: O.C.IPZ | 100 | 100 | 100 | NA | 100 | 98 | 100 | NA | 100 | 100 | 100 | NA |
| CB: O.C.OPZ | 38 | 54 | 39 | NA | 14 | 76 | 57 | NA | 62 | 82 | 48 | NA |
| CB: Mag. Is. | 77 | 85 | 80 | 83 | 73 | 86 | 78 | 83 | 78 | 100 | 90 | 81 |
| HB: E.C.W | 58 | 74 | NA | 100 | 100 | 84 | NA | 100 | No data provided | | | |
| HB: O.C | 77 | 72 | 6 | 75 | 73 | 64 | 16 | 69 | 89 | 93 | 6 | 67 |
| HB: Mid | 100 | 77 | 30 | 54 | 93 | 92 | 39 | 61 | 100 | 100 | 34 | 69 |

**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.

# Appendix WW. Inshore Marine Water Quality 2021–2022 Boxplots

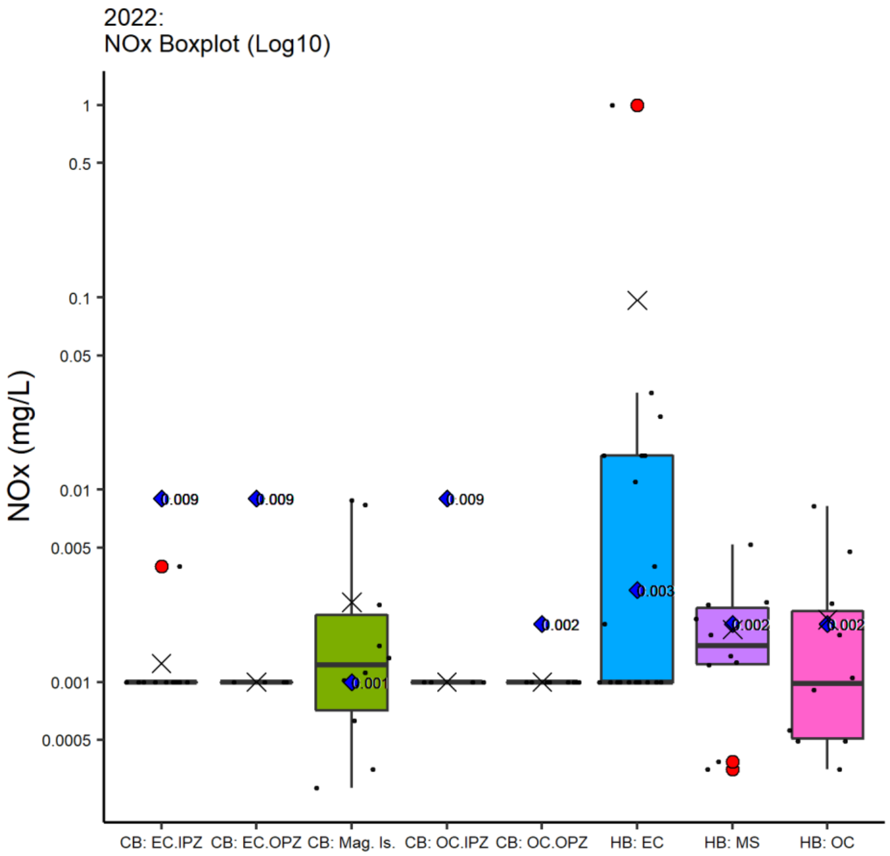


*Figure 66. Dry Tropics inshore marine water quality boxplots: NOx. Blue diamonds indicate water quality guidelines, red circles indicate outliers, and the black cross indicates the value compared to the guideline value (mean).*

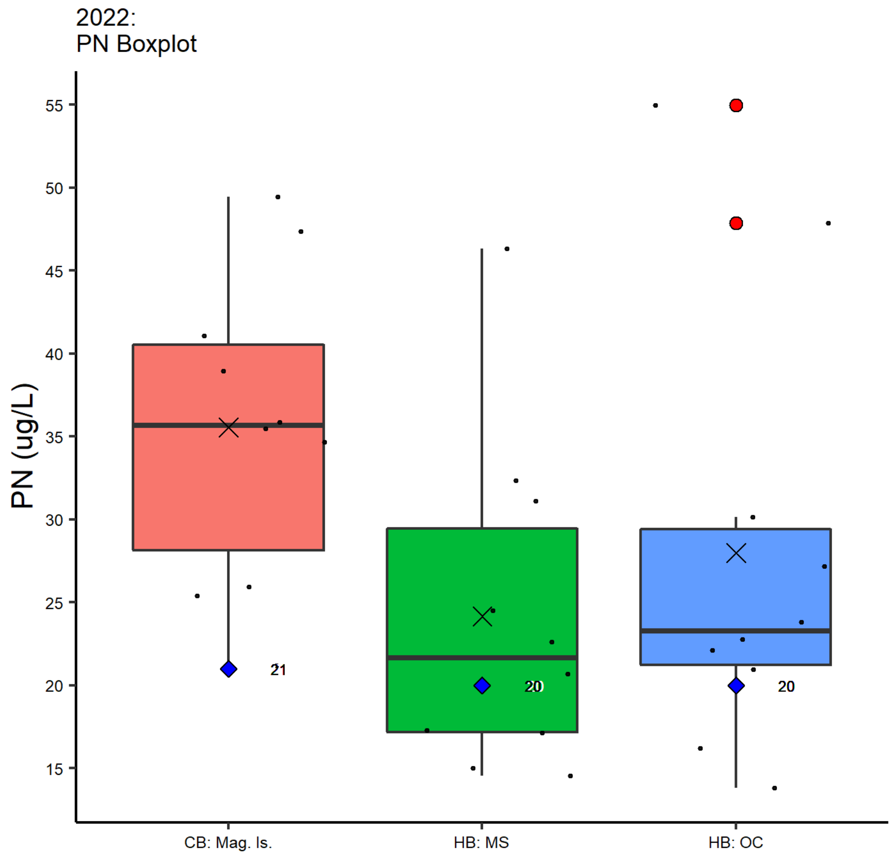


*Figure 65. Dry Tropics inshore marine water quality boxplots: PN. Blue diamonds indicate water quality guidelines, red circles indicate outliers, and the black cross indicates the value compared to the guideline value (mean).*

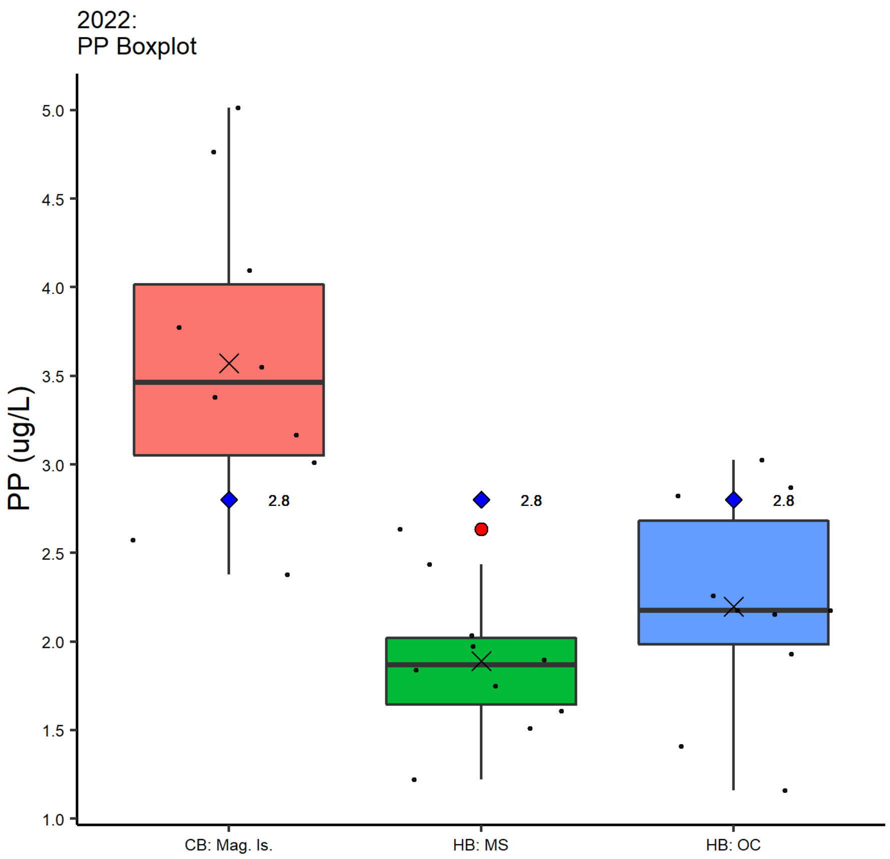


*Figure 67. Dry Tropics inshore marine water quality boxplots: PP. Blue diamonds indicate water quality guidelines, red circles indicate outliers, and the black cross indicates the value compared to the guideline value (mean).*

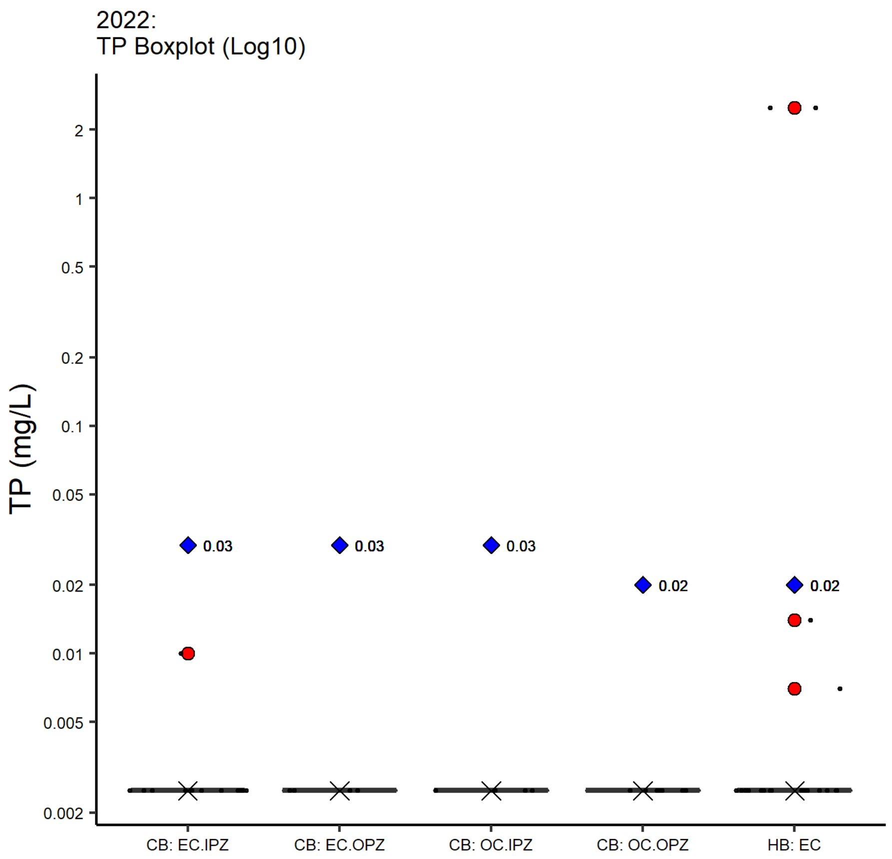


*Figure 68. Dry Tropics inshore marine water quality boxplots: TP. Blue diamonds indicate water quality guidelines, red circles indicate outliers, and the black cross indicates the value compared to the guideline value (median).*

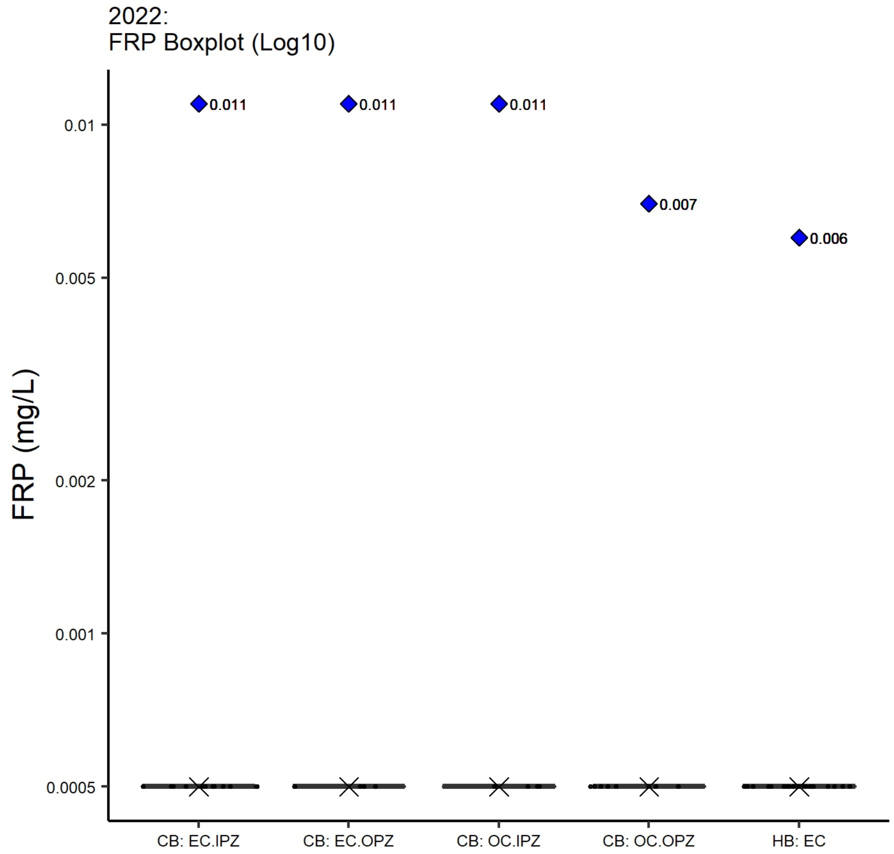


*Figure 70. Dry Tropics inshore marine water quality boxplots: FRP. Blue diamonds indicate water quality guidelines, red circles indicate outliers, and the black cross indicates the value compared to the guideline value (mean).*

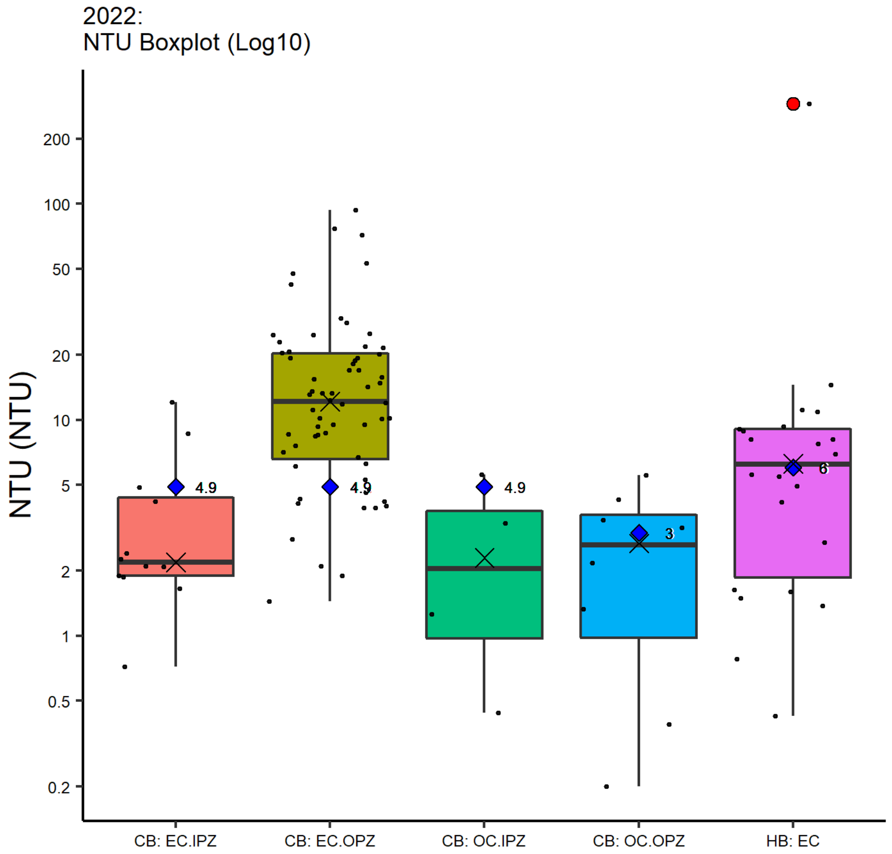


*Figure 69. Dry Tropics inshore marine water quality boxplots: NTU. Blue diamonds indicate water quality guidelines, red circles indicate outliers, and the black cross indicates the value compared to the guideline value (median).*

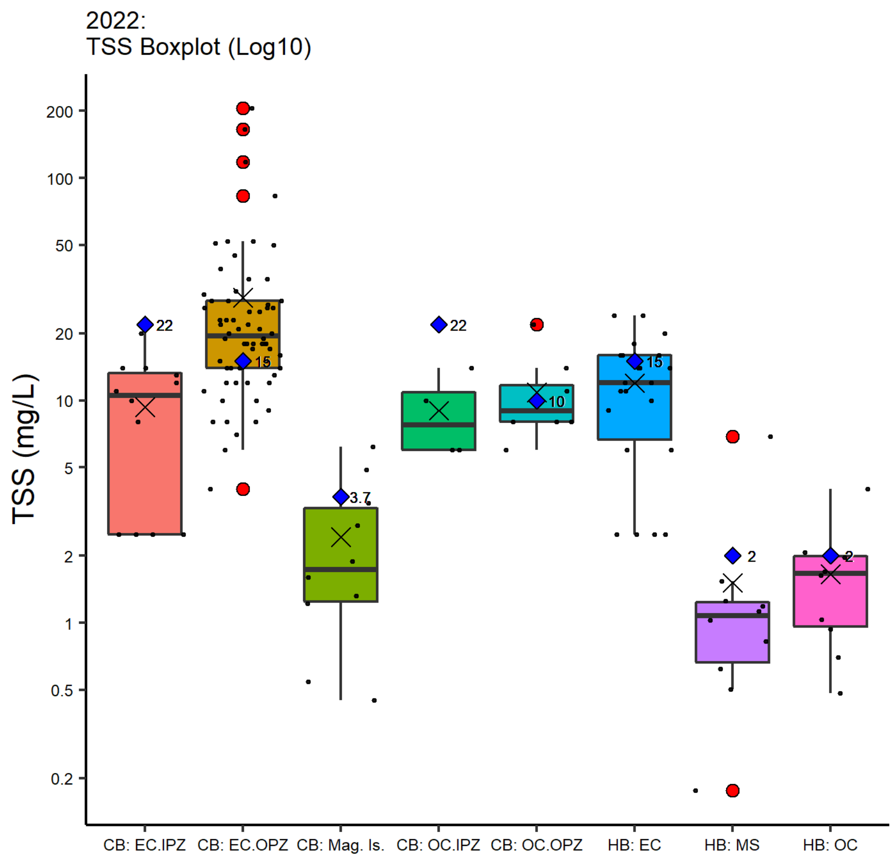


*Figure 72. Dry Tropics inshore marine water quality boxplots: TSS. Blue diamonds indicate water quality guidelines, red circles indicate outliers, and the black cross indicates the value compared to the guideline value (mean).*

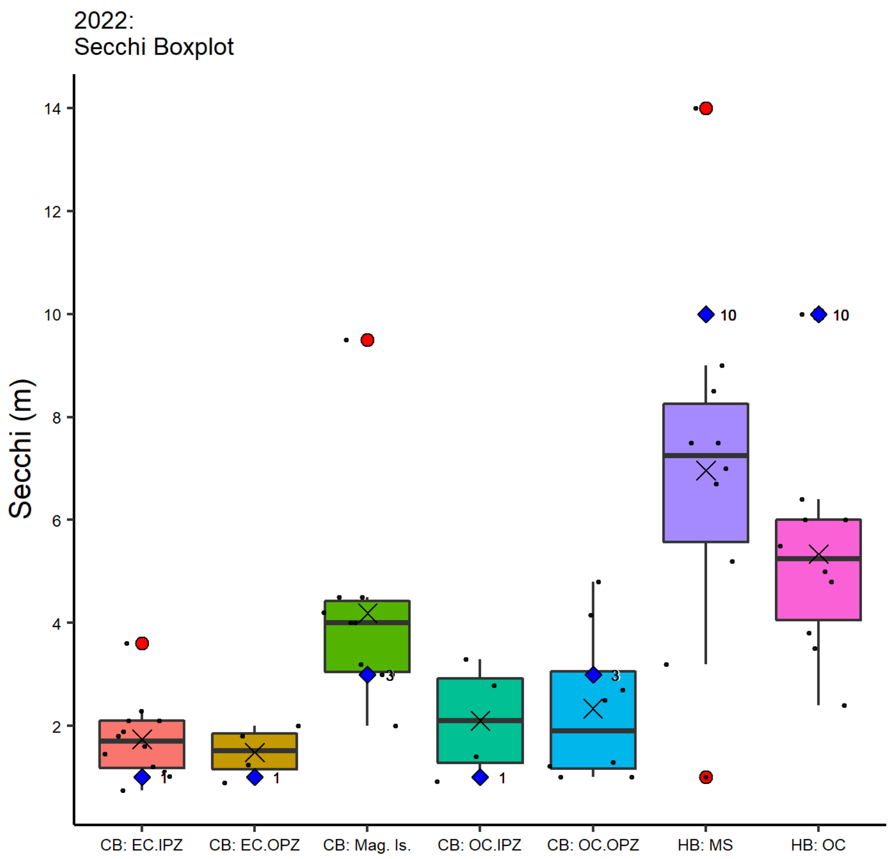


*Figure 71. Dry Tropics inshore marine water quality boxplots: Secchi. Blue diamonds indicate water quality guidelines, red circles indicate outliers, and the black cross indicates the value compared to the guideline value (mean).*

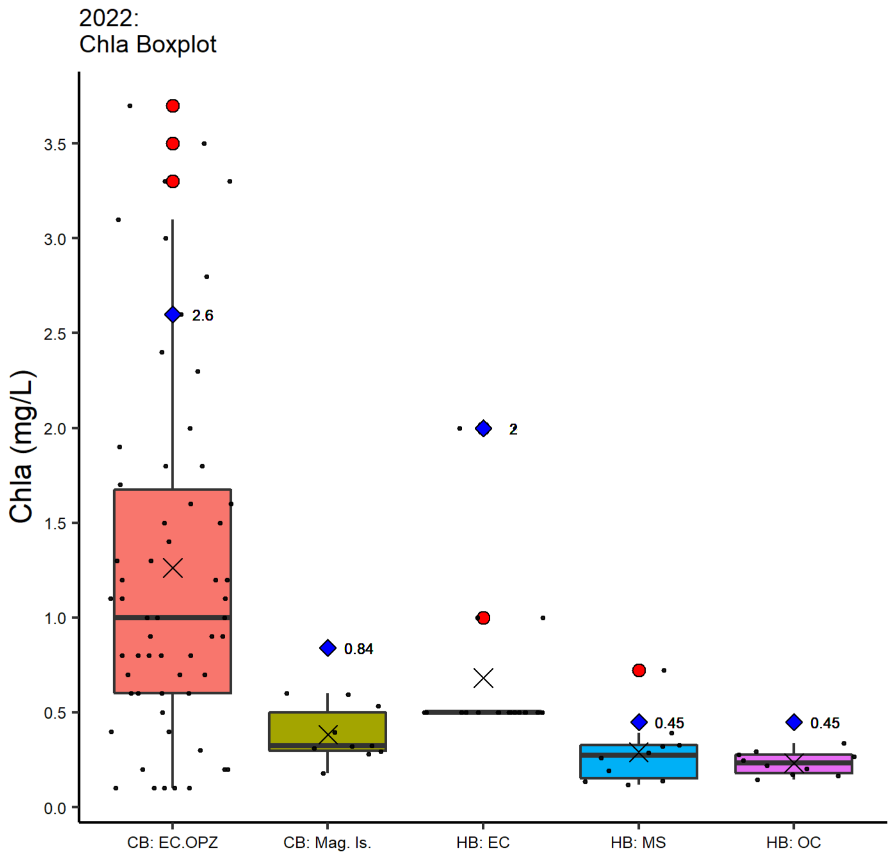


*Figure 73. Dry Tropics inshore marine water quality boxplots: Chla. Blue diamonds indicate water quality guidelines, red circles indicate outliers, and the black cross indicates the value compared to the guideline value (mean).*

# Appendix XX. Inshore Marine Water Quality Line Plots


*Figure 74. Dry Tropics inshore marine water quality line plots: NOx. The dashed line indicates water quality guidelines.*

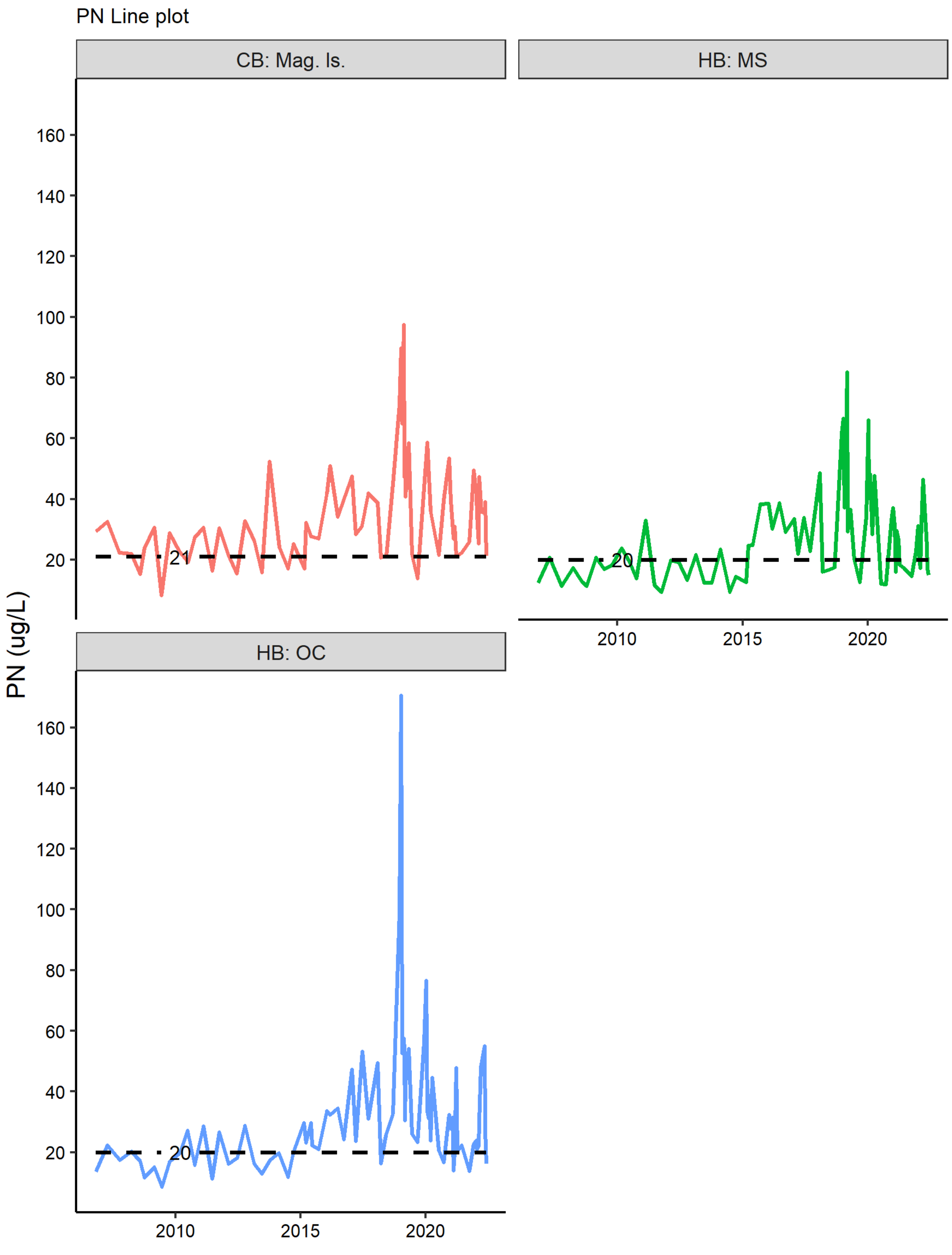


*Figure 75. Dry Tropics inshore marine water quality line plots: PN. The dashed line indicates water quality guidelines.*

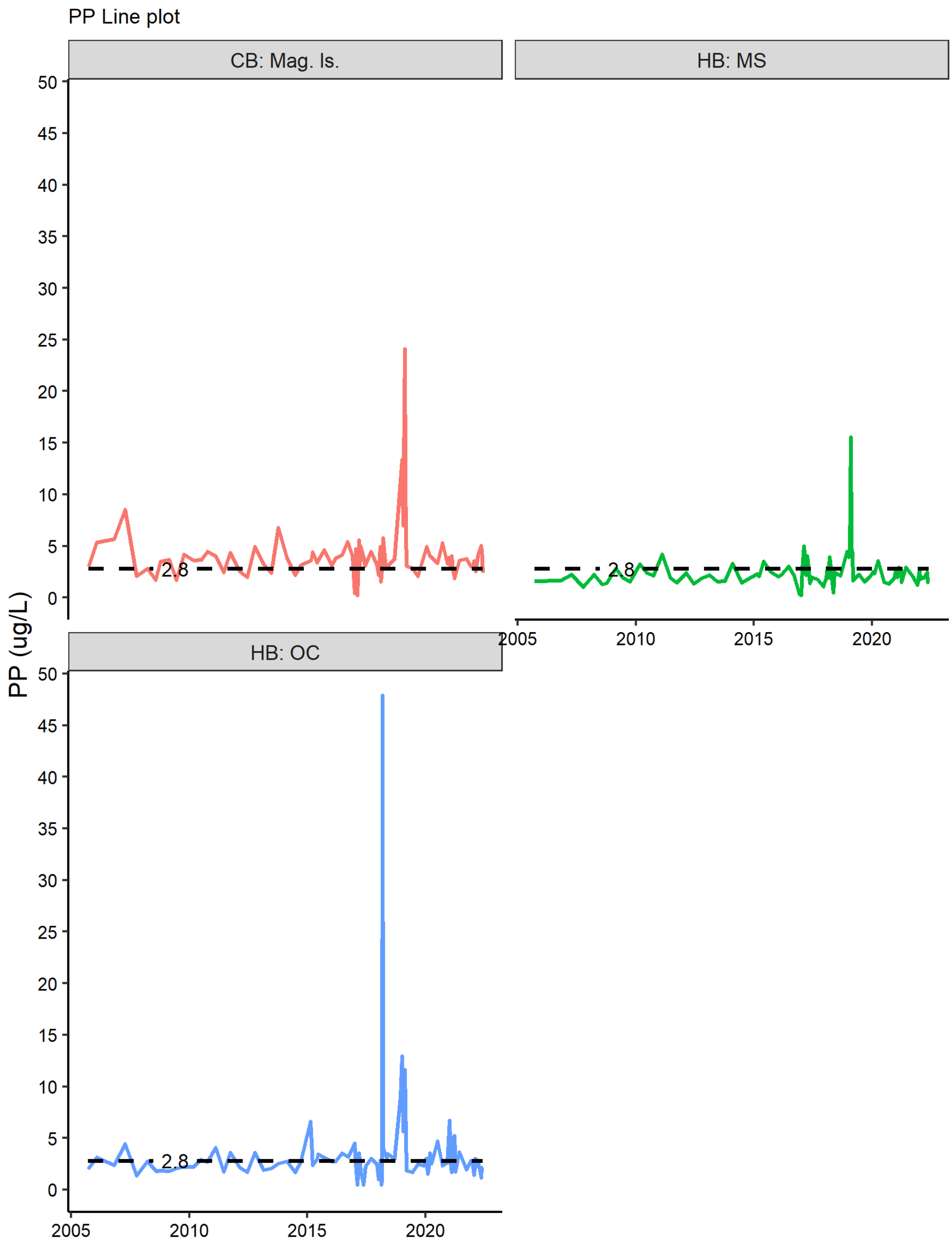


*Figure 76. Dry Tropics inshore marine water quality line plots: PP. The dashed line indicates water quality guidelines.*

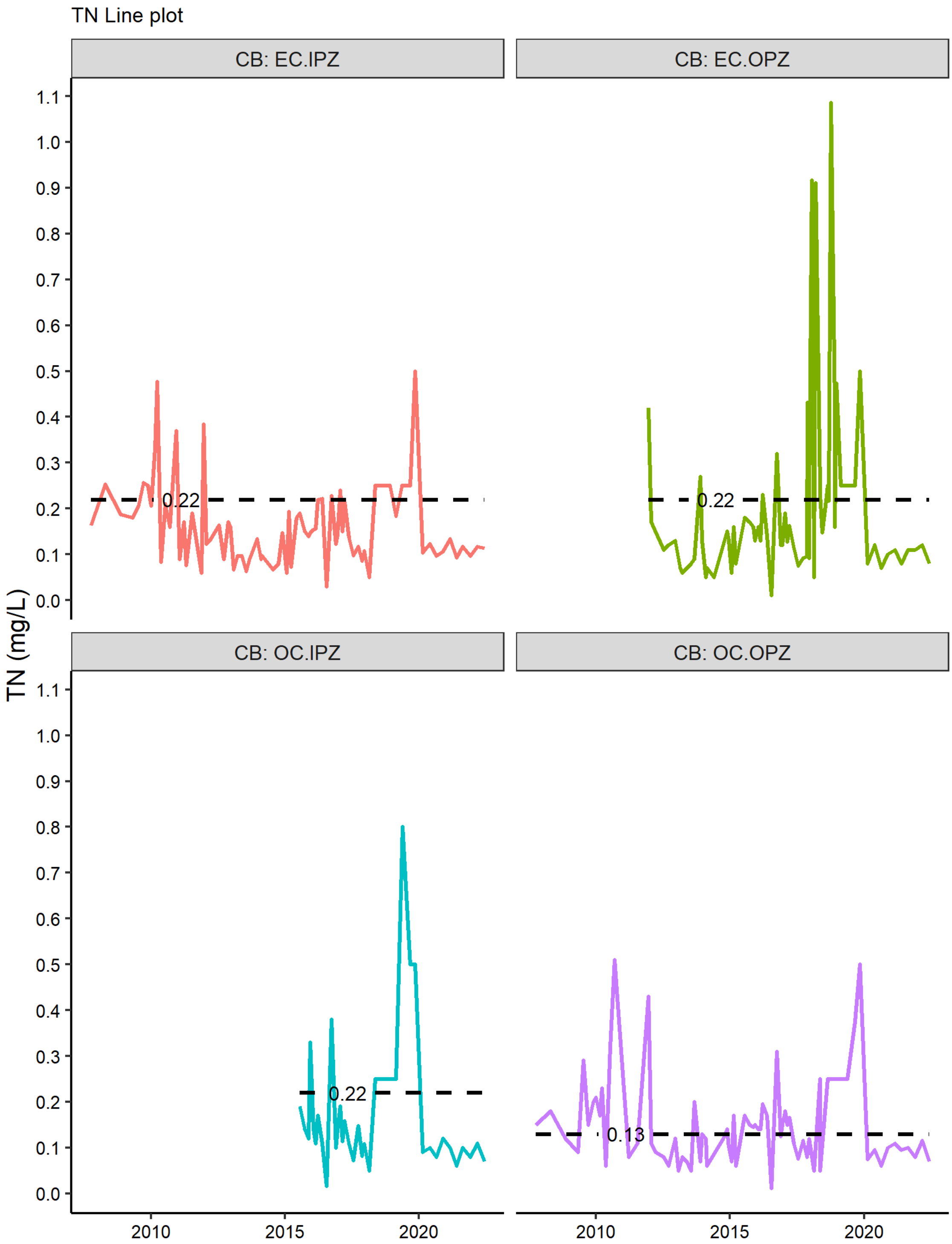


*Figure 77. Dry Tropics inshore marine water quality line plots: TN. The dashed line indicates water quality guidelines.*

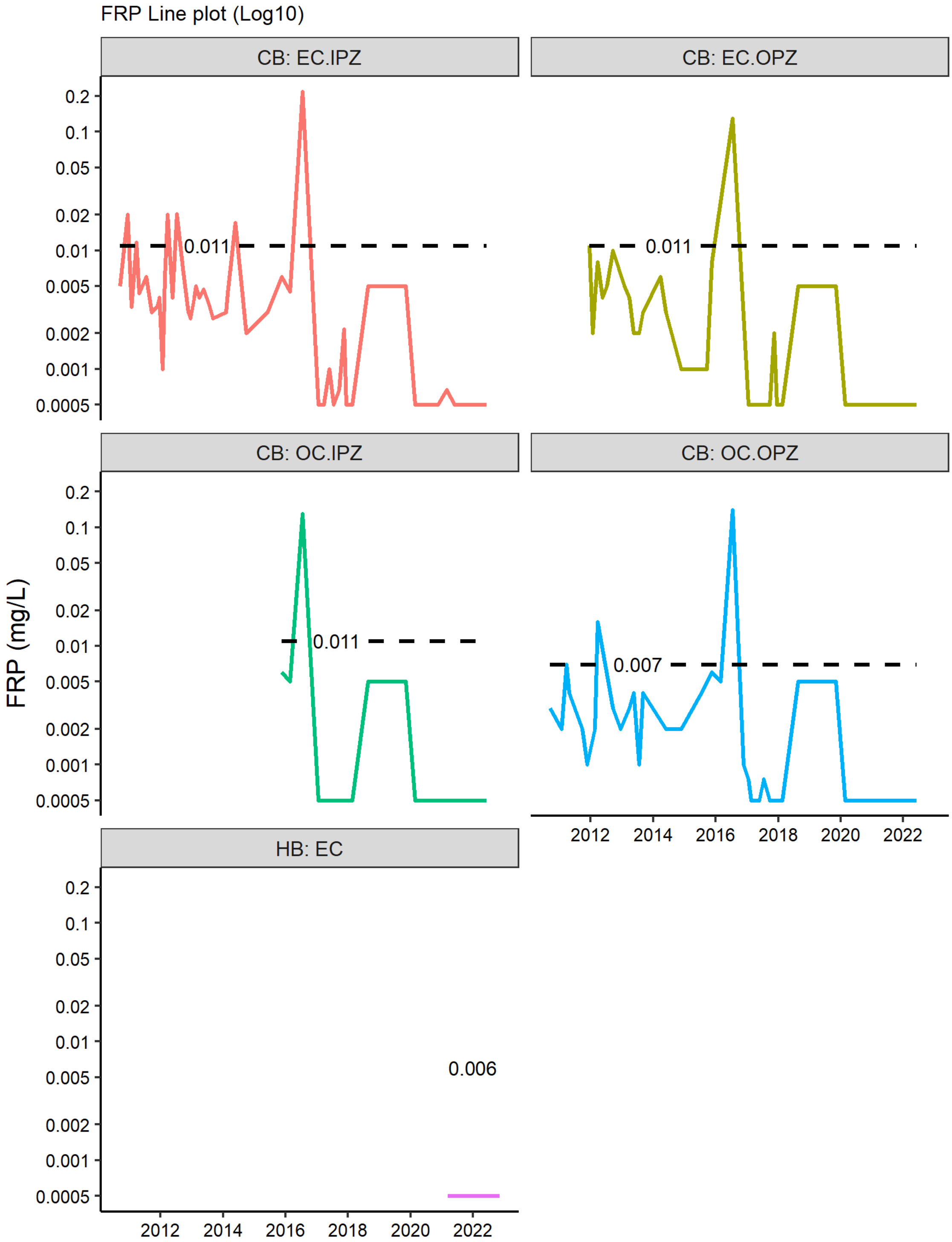


*Figure 78. Dry Tropics inshore marine water quality line plots: FRP. The dashed line indicates water quality guidelines.*

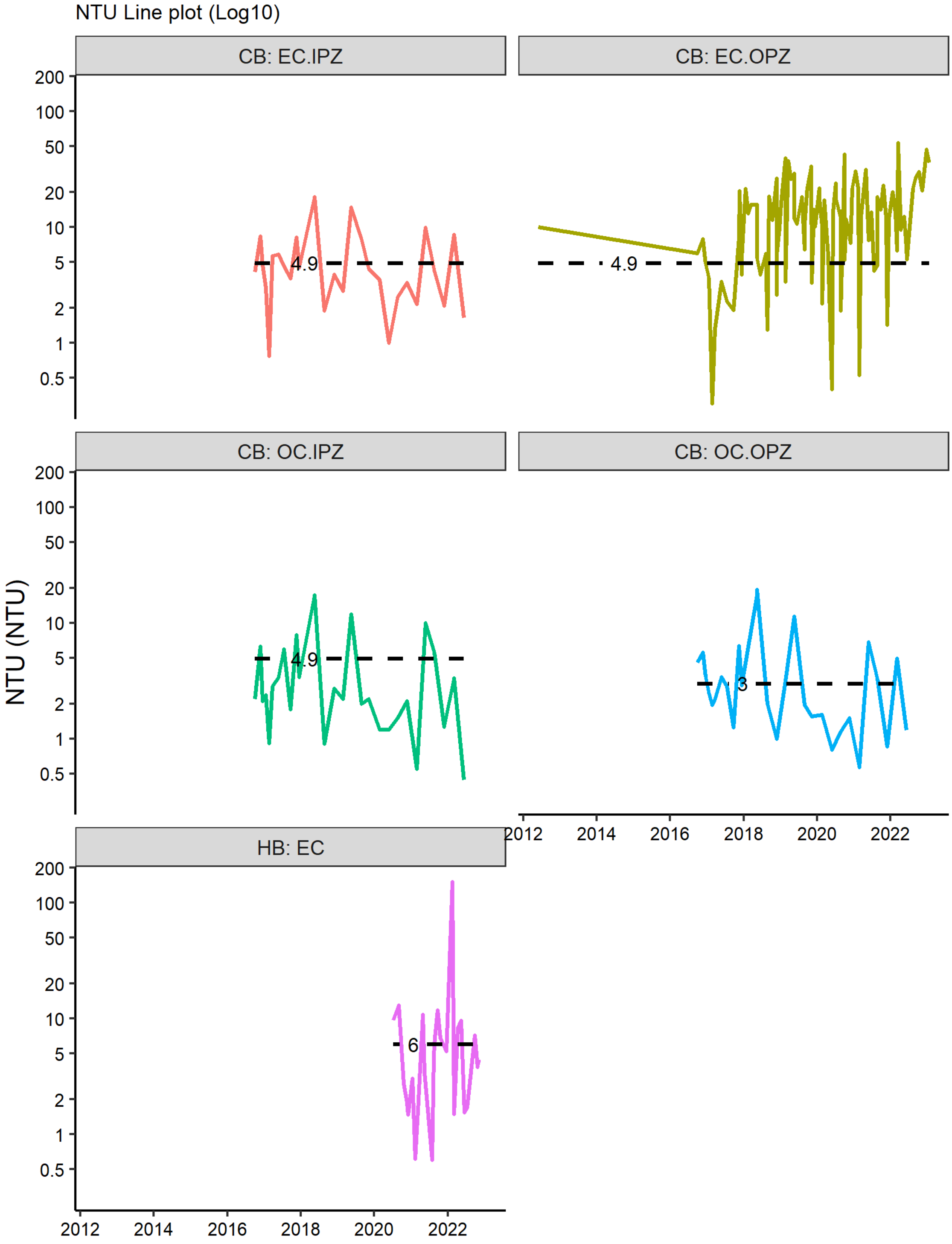


*Figure 79. Dry Tropics inshore marine water quality line plots: NTU. The dashed line indicates water quality guidelines.*

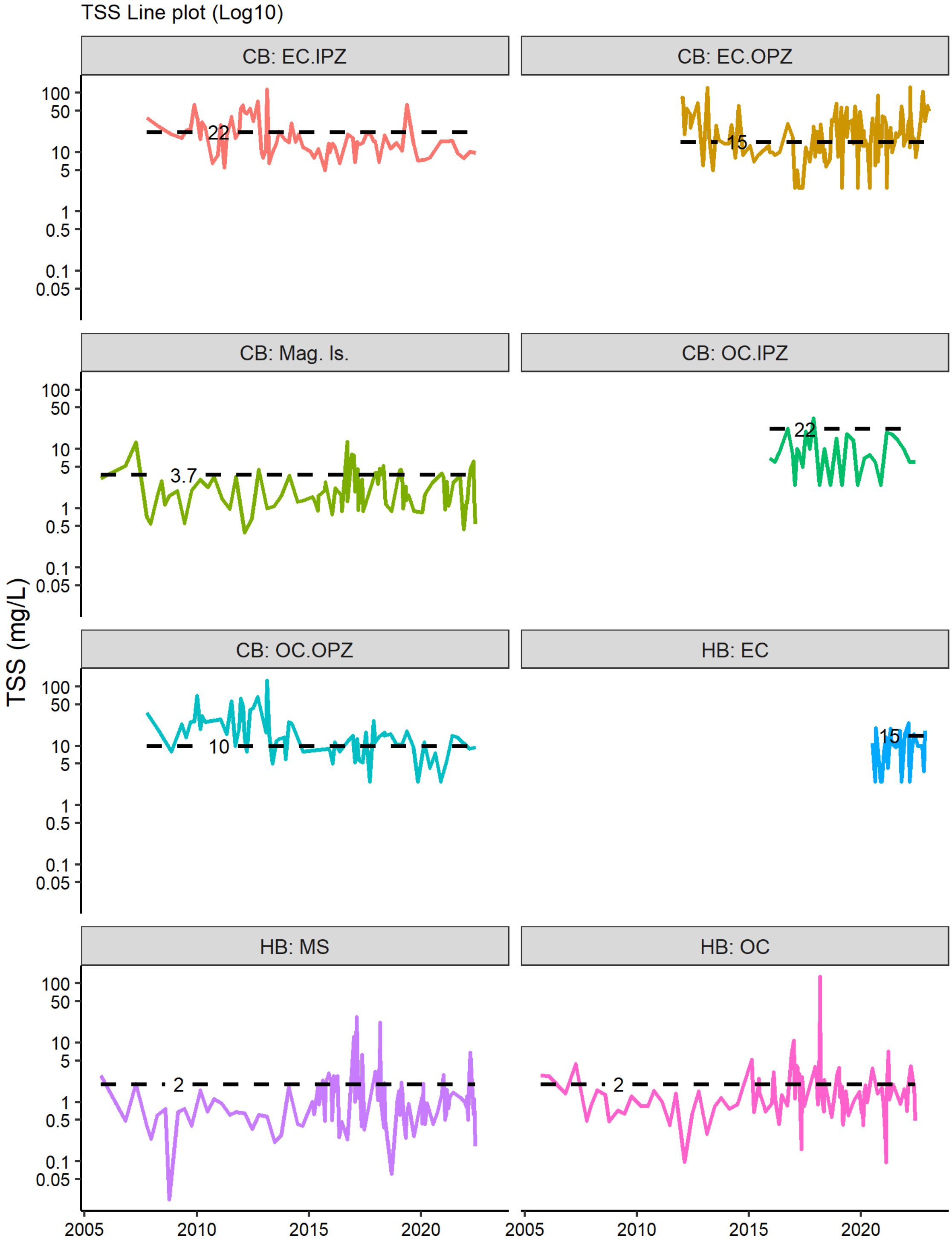


*Figure 80. Dry Tropics inshore marine water quality line plots: TSS. The dashed line indicates water quality guidelines.*

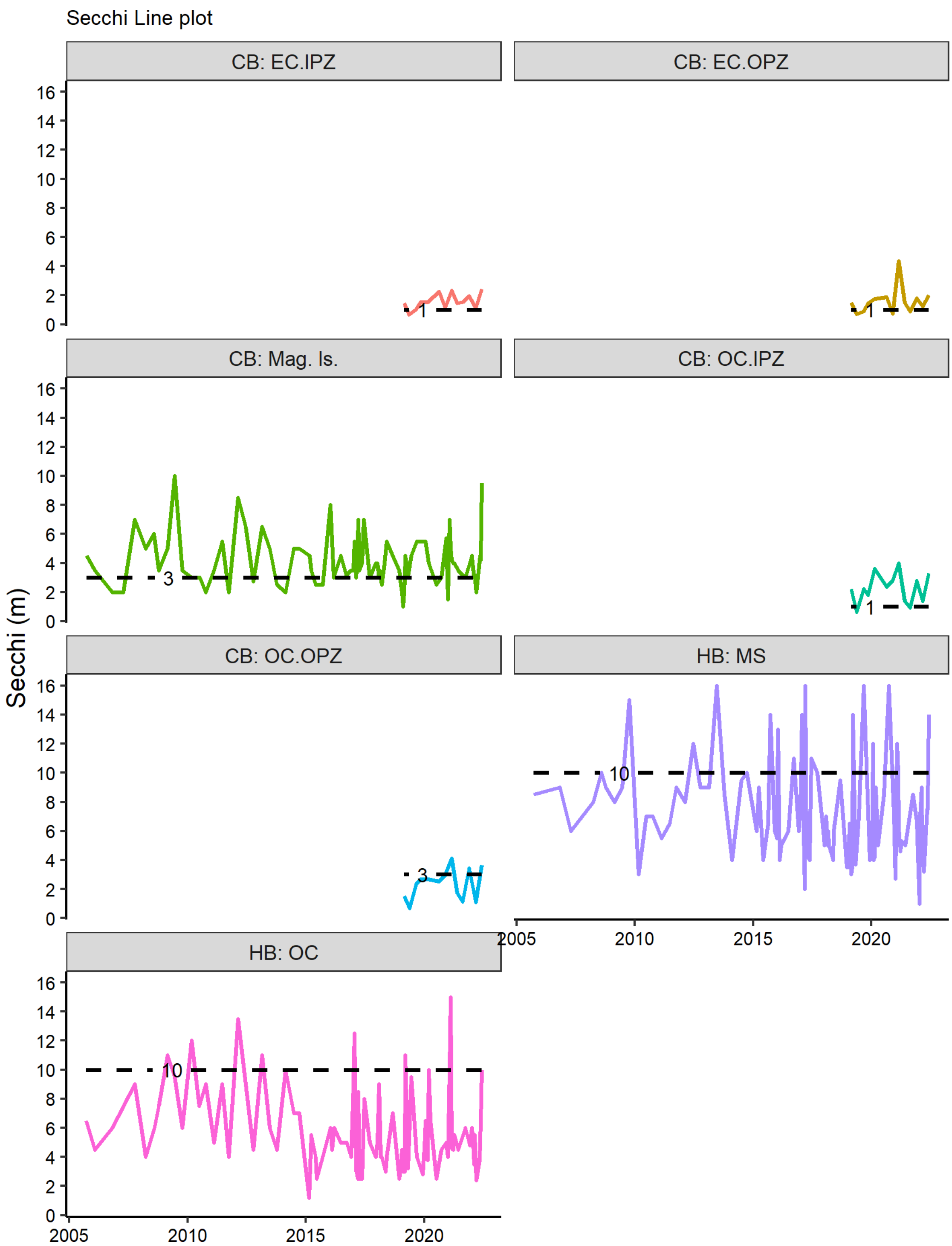


*Figure 81. Dry Tropics inshore marine water quality line plots: Secchi. The dashed line indicates water quality guidelines.*

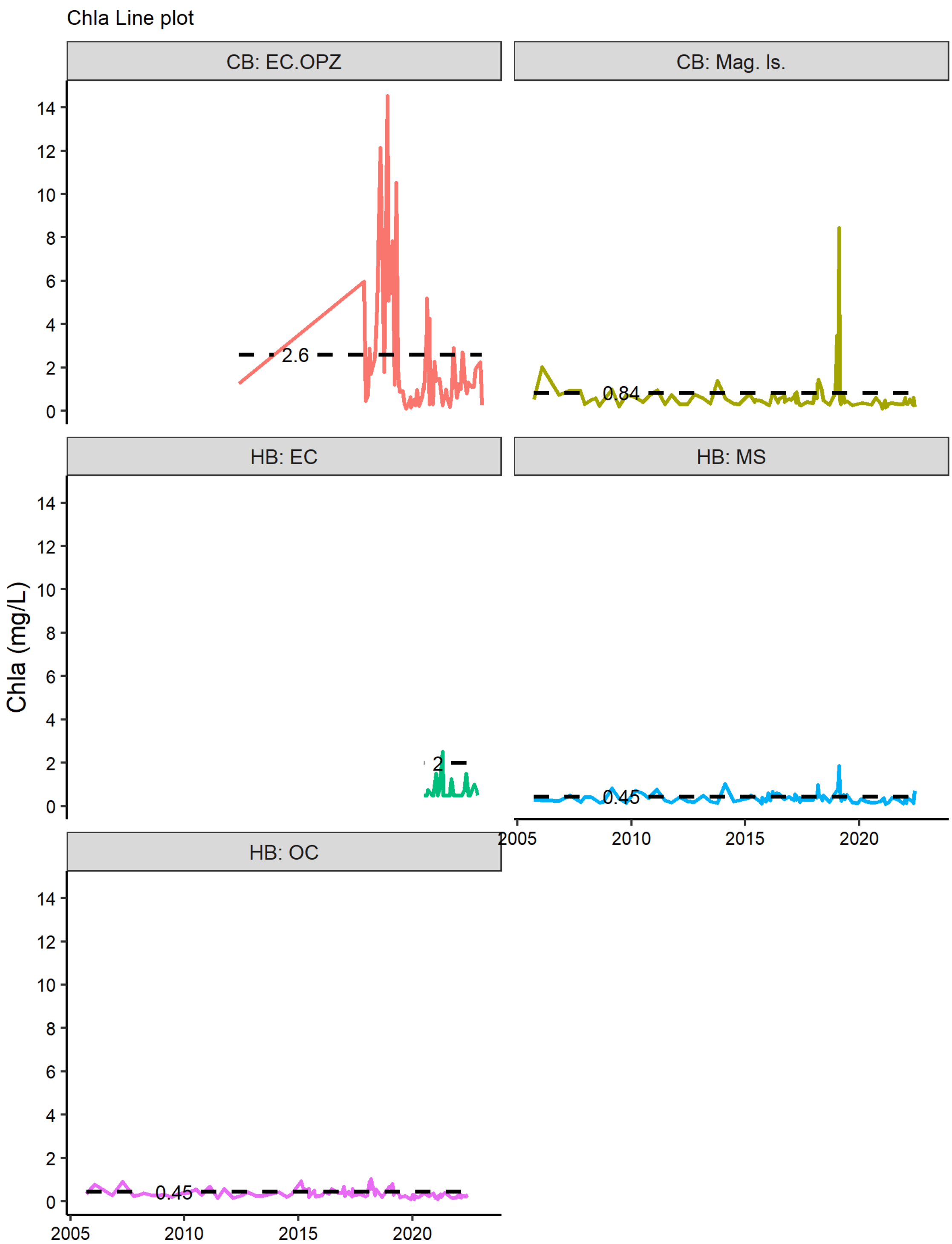


*Figure 82. Dry Tropics inshore marine water quality line plots: Chla. The dashed line indicates water quality guidelines.*

# Appendix YY. Inshore Marine Water Quality Special Analysis of NOx in Cleveland Bay

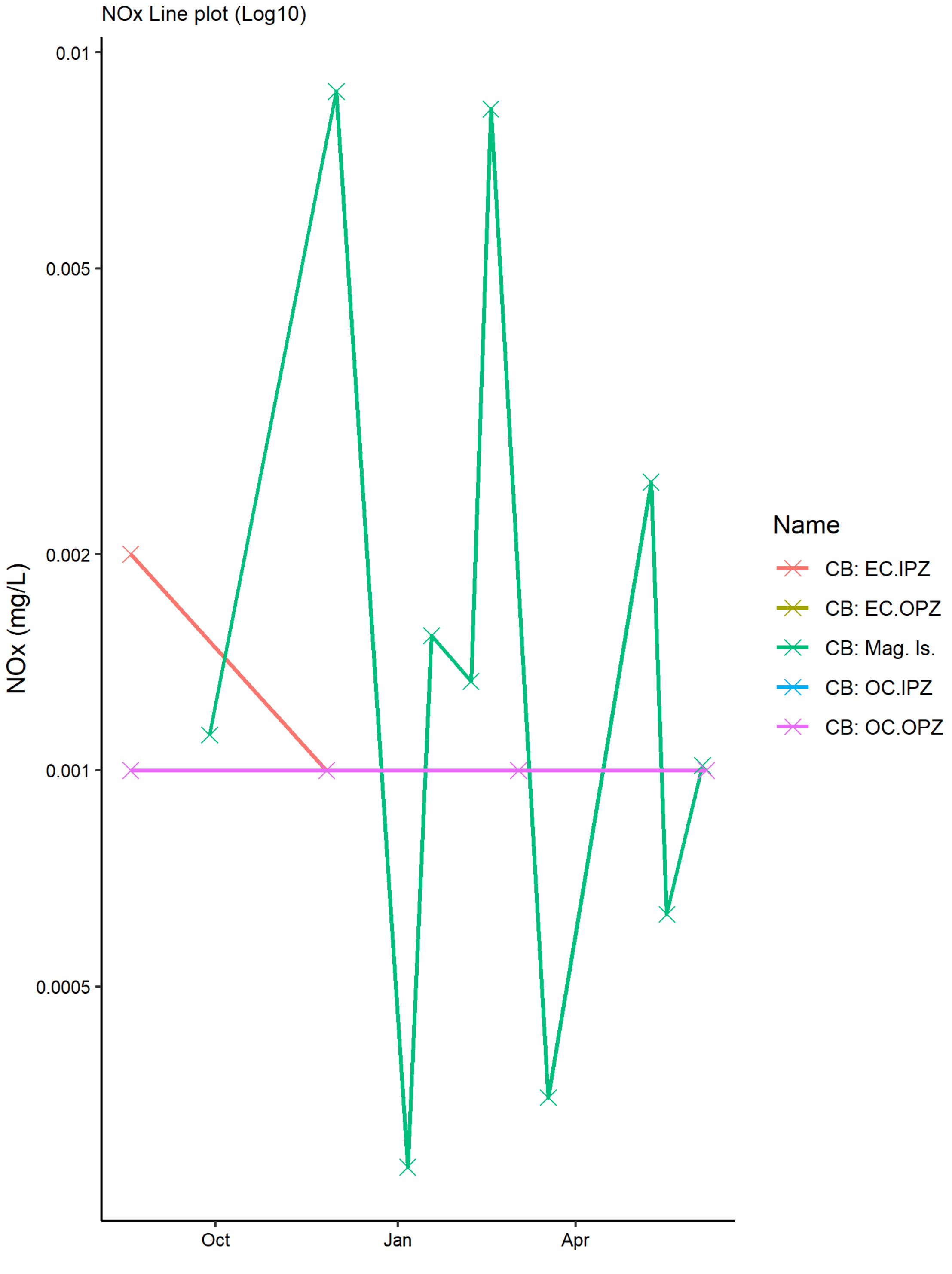


*Figure 83. Dry Tropics inshore marine water quality special analysis line plot of NOx in Cleveland Bay for the 2021-2022 reporting year. Crosses mark specific times a sample was collected.*

# Appendix ZZ. Inshore Marine Water Quality Special Analysis of NOx in Halifax Bay

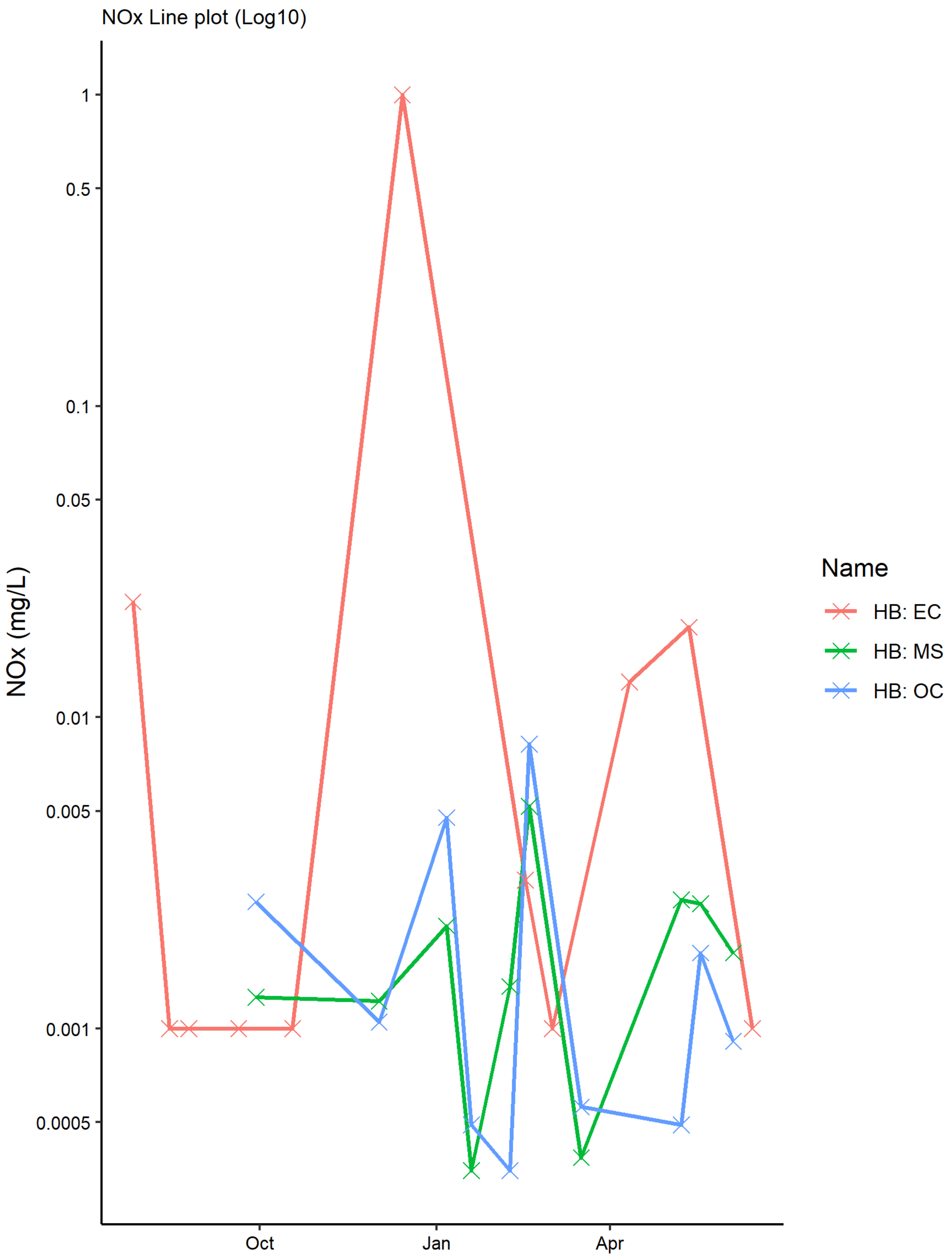


*Figure 84. Dry Tropics inshore marine water quality special analysis line plot of NOx in Halifax Bay for the 2021-2022 reporting year. Crosses mark specific times a sample was collected.*

# Appendix AAA. Inshore Marine Water Quality Special Analysis of Turbidity in Cleveland Bay

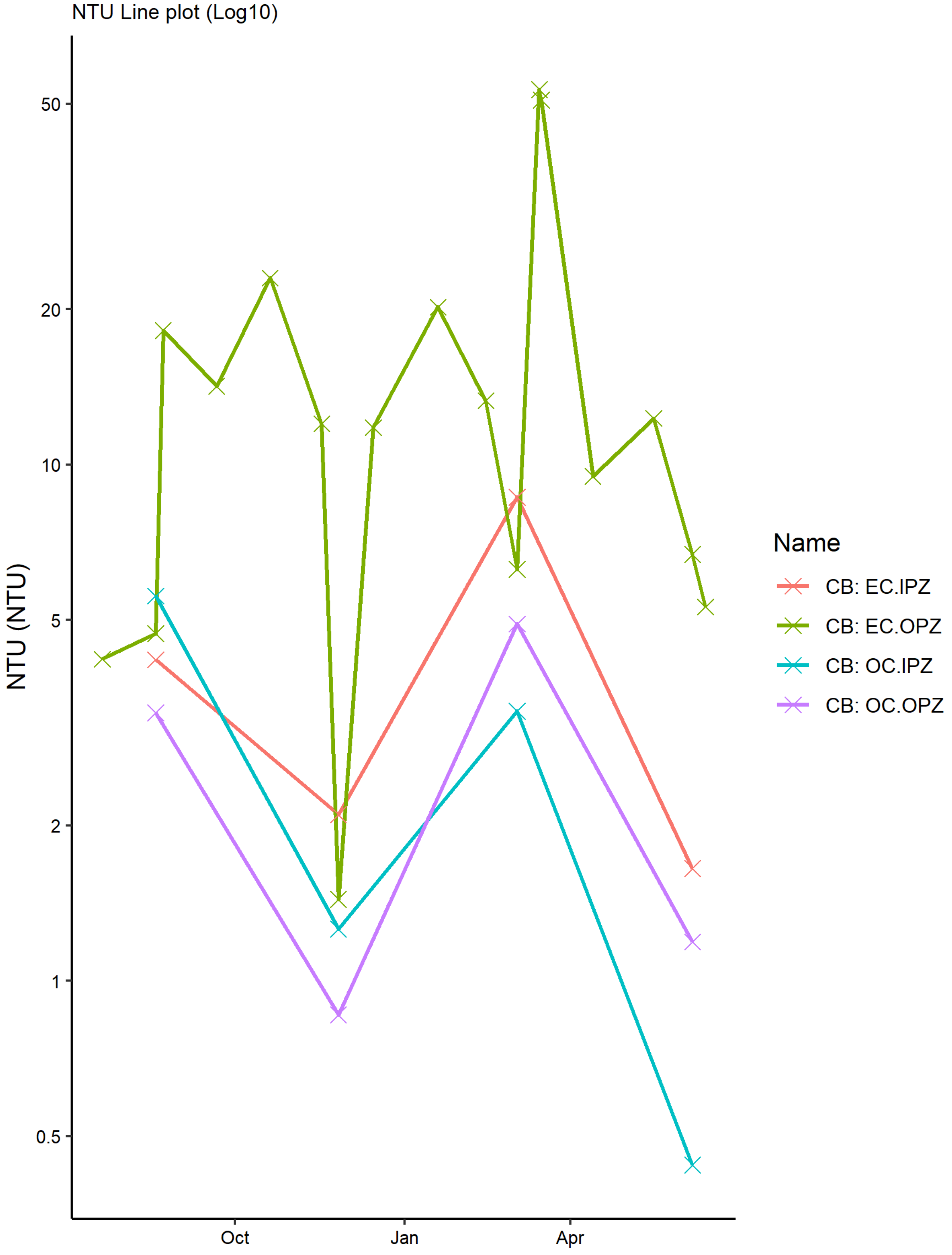


*Figure 85. Dry Tropics inshore marine water quality special analysis line plot of Turbidity in Cleveland Bay for the 2021-2022 reporting year. Crosses mark specific times a sample was collected.*

# Appendix BBB. Inshore Marine Water Quality Special Analysis of TSS in Cleveland Bay

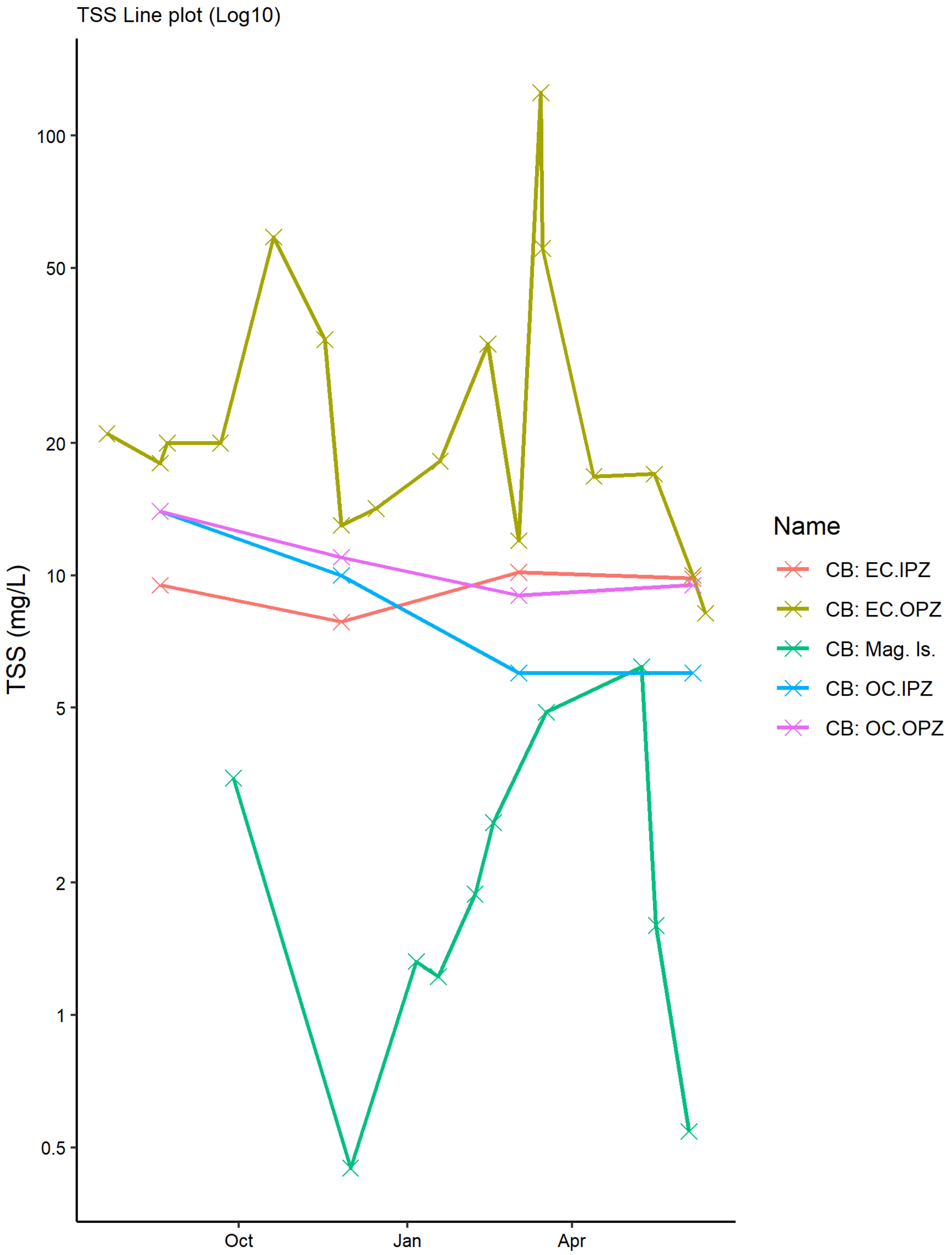


*Figure 86. Dry Tropics inshore marine water quality special analysis line plot of TSS in Cleveland Bay for the 2021-2022 reporting year. Crosses mark specific times a sample was collected.*

## Appendix CCC. Inshore Marine Water Quality Special Analysis of Secchi in Cleveland Bay

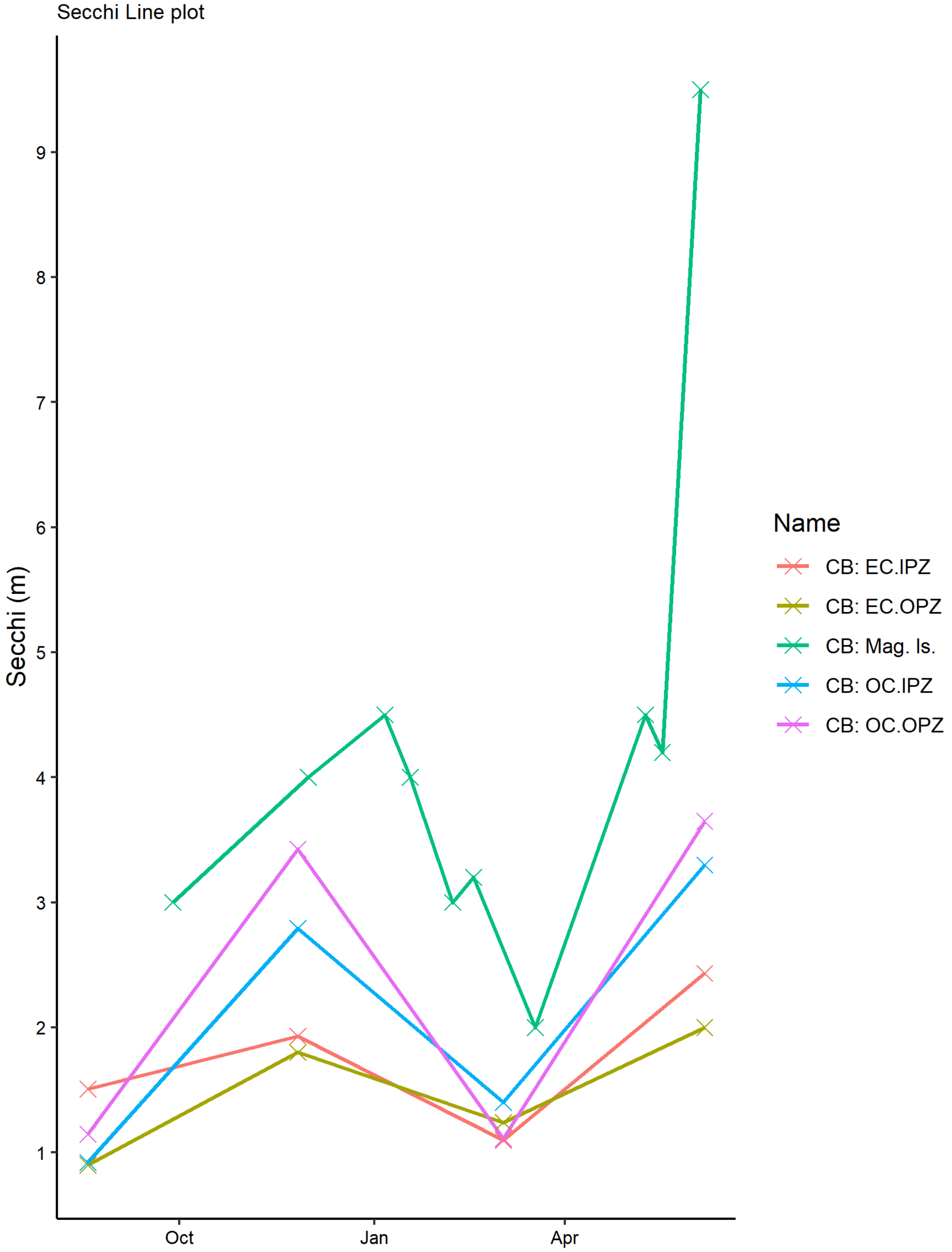


*Figure 87. Dry Tropics inshore marine water quality special analysis line plot of Secchi in Cleveland Bay for the 2021-2022 reporting year. Crosses mark specific times a sample was collected.*

## Appendix DDD. Comparison of Dry Tropics and Wet Tropics Site Overlaps

*Table 113. Comparison of Dry Tropics and Wet Tropics site overlaps. Note that the difference occurs in the averaging of sub zones for the Wet Tropics technical report. Red boxes highlight values that have changed.*

| Region | Zone | Sub Zone | Code/Site | NOx | PN | PP | Nutrients | Mean Nutrients | Score |
|---|---|---|---|---|---|---|---|---|---|
| Wet Tropics | Palm | NA | 21 | 0.09 | -0.27 | 0.57 | 0.13 | 0.03 | 61 |
| | | | 19 | -0.08 | -0.48 | 0.35 | -0.07 | | |
| Dry Tropics | Halifax Bay (without Enclosed Coastal) | Midshelf | 21 | 0.09 | -0.27 | 0.57 | 0.13 | NA | 66 |
| | | Open Coastal | 19 | -0.08 | -0.48 | 0.35 | -0.07 | | 57 |

# Appendix EEE. Inshore Marine Water Quality Nutrients Results including FRP and TN

*Table 114. Scores for the nutrient indicator category in the Dry Tropics Inshore Marine Environment. Including FRP and TP. Red boxes highlight values that have changed.*

| Zone | Sub Zone | Area | NOx | PN | PP | TP | TN | FRP | Nutrients Area | Nutrients Sub Zone | Nutrients Zone |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cleveland Bay | Enclosed Coastal Waters | Inside Port Zone | 100 (A) | NA | NA | 100 (A) | 100 (A) | 100 (A) | 100 (A) | 100 (A) | 83 (A) |
| | | Outside Port Zone | 100 (A) | NA | NA | 100 (A) | 100 (A) | 100 (A) | 100 (A) | | |
| | Open Coastal Waters | Inside Port Zone | 100 (A) | NA | NA | 100 (A) | 100 (A) | 100 (A) | 100 (A) | 98 (A) | |
| | | Outside Port Zone | 100 (A) | NA | NA | 100 (A) | 81 (A) | 100 (A) | 95 (A) | | |
| | Magnetic Island | Magnetic Island | 0 (E) | 15 (E) | 40 (D) | NA | NA | 100 (A) | | 44 (C) | |
| Halifax Bay | Enclosed Coastal Waters | E.C.W | 0 (E) | NA | NA | 100 (A) | NA | 100 (A) | | 74 (B) | 72 (B) |
| | Open Coastal Waters | O.C.W | 57 (C) | 32 (D) | 75 (B) | NA | NA | 96 (A) | | 68 (B) | |
| | Midshelf | Midshelf | 64 (B) | 45 (C) | 83 (A) | NA | NA | 96 (A) | | 74 (B) | |

*Table 115. Scores for the nutrient indicator category in the Dry Tropics Inshore Marine Environment. NOT including FRP and TP.*

| Zone | Sub Zone | Area | NOx | PN | PP | TP | TN[34] | FRP[35] | Nutrients Area | Nutrients Sub Zone | Nutrients Zone |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cleveland Bay | Enclosed Coastal Waters | Inside Port Zone | 100 (A) | NA | NA | 100 (A) | 100 (A) | 100 (A) | 100 (A) | 100 (A) | 78 (B) |
| | | Outside Port Zone | 100 (A) | NA | NA | 100 (A) | 100 (A) | 100 (A) | 100 (A) | | |
| | Open Coastal Waters | Inside Port Zone | 100 (A) | NA | NA | 100 (A) | 100 (A) | 100 (A) | 100 (A) | 100 (A) | |
| | | Outside Port Zone | 100 (A) | NA | NA | 100 (A) | 81 (A) | 100 (A) | 100 (A) | | |
| | Magnetic Island | Magnetic Island | 0 (E) | 15 (E) | 40 (D) | NA | NA | 100 (A) | | 18 (E) | |
| Halifax Bay | Enclosed Coastal Waters | E.C.W | 0 (E) | NA | NA | 100 (A) | NA | 100 (A) | | 61 (B) | 61 (B) |
| | Open Coastal Waters | O.C.W | 57 (C) | 32 (D) | 75 (B) | NA | NA | 96 (A) | | 57 (C) | |
| | Midshelf | Midshelf | 64 (B) | 45 (C) | 83 (A) | NA | NA | 96 (A) | | 66 (B) | |

[34] TN is included only as an indicator. TN is not aggregated within the nutrient indicator category.

[35] FRP is included only as an indicator. FRP is not aggregated within the nutrient indicator category.

# Appendix FFF.Inshore Marine Coral Sampling Locations

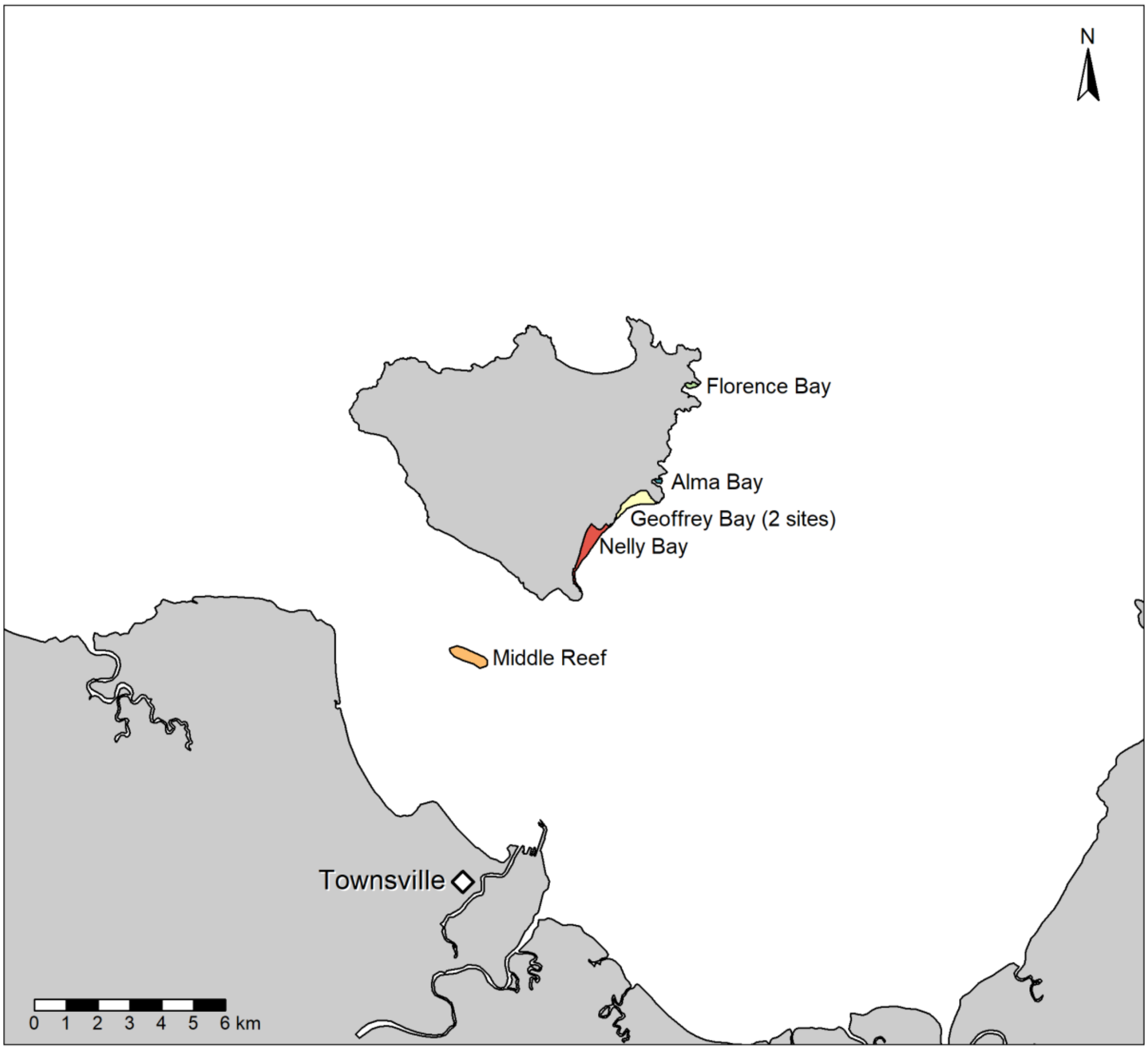


*Figure 88. Coral reef sampling locations in the Cleveland Bay Inshore marine zone.*

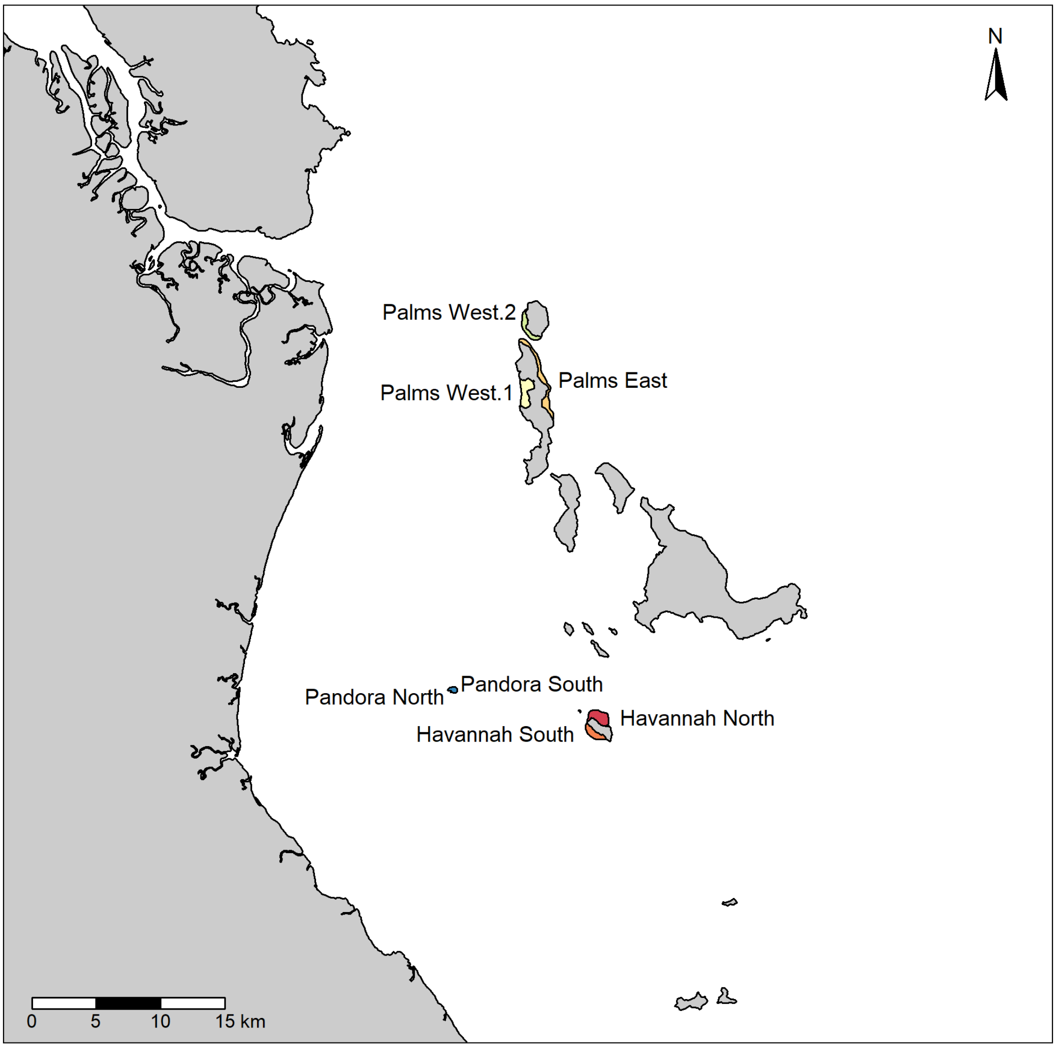


*Figure 89. Coral reef sampling locations in the Halifax Bay Inshore marine zone.*

# Appendix GGG. Inshore Marine Coral Historic Scores

*Table 116. Inshore Marine Environment coral indicator category scores for previous technical report. After back calculation. Red boxes highlight values that have changed.*

| Zone | Coral Standardised Score | | |
|---|---|---|---|
| | 2020–2021 | 2019–2020 | 2018–2019 |
| Cleveland Bay | 36 (D) | 44 (C) | 38 (D) |
| Halifax Bay | 48 (C) | 50 (C) | 52 (C) |

**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.

*Table 117. Inshore Marine Environment coral indicator category scores for current and previous technical reports. Prior to back calculations*

| Zone | Coral Standardised Score | | |
|---|---|---|---|
| | 2020–2021 | 2019–2020 | 2018–2019 |
| Cleveland Bay | 36 (D) | 44 (C) | 38 (D) |
| Halifax Bay | 49 (C) | 52 (C) | 52 (C) |

**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.

# Appendix HHH. Inshore Marine Seagrass Meadow Locations

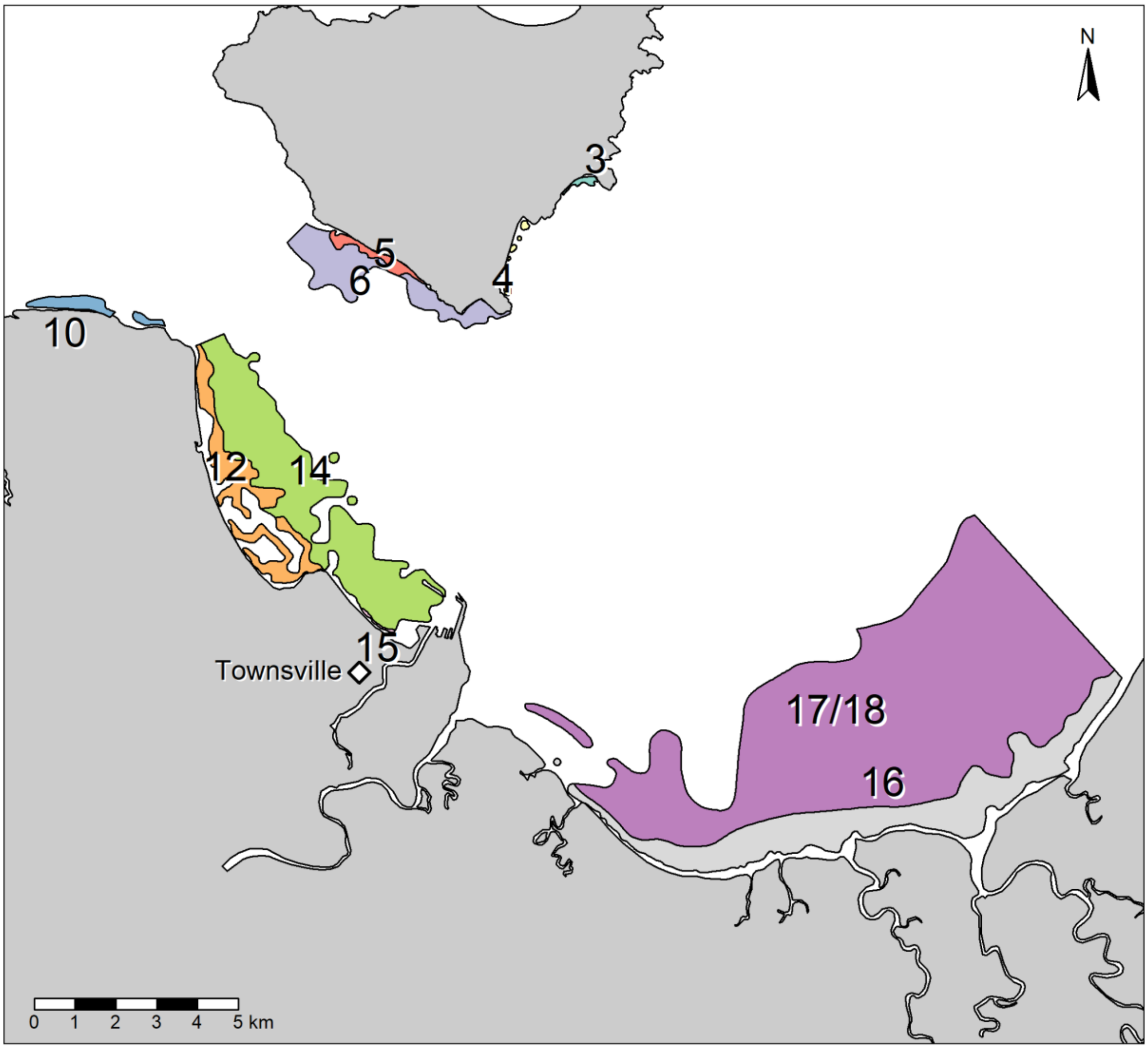


*Figure 90. Seagrass meadow sampled for the LTSMP assessment.*

# Appendix III. Offshore Marine Coral Sampling Locations

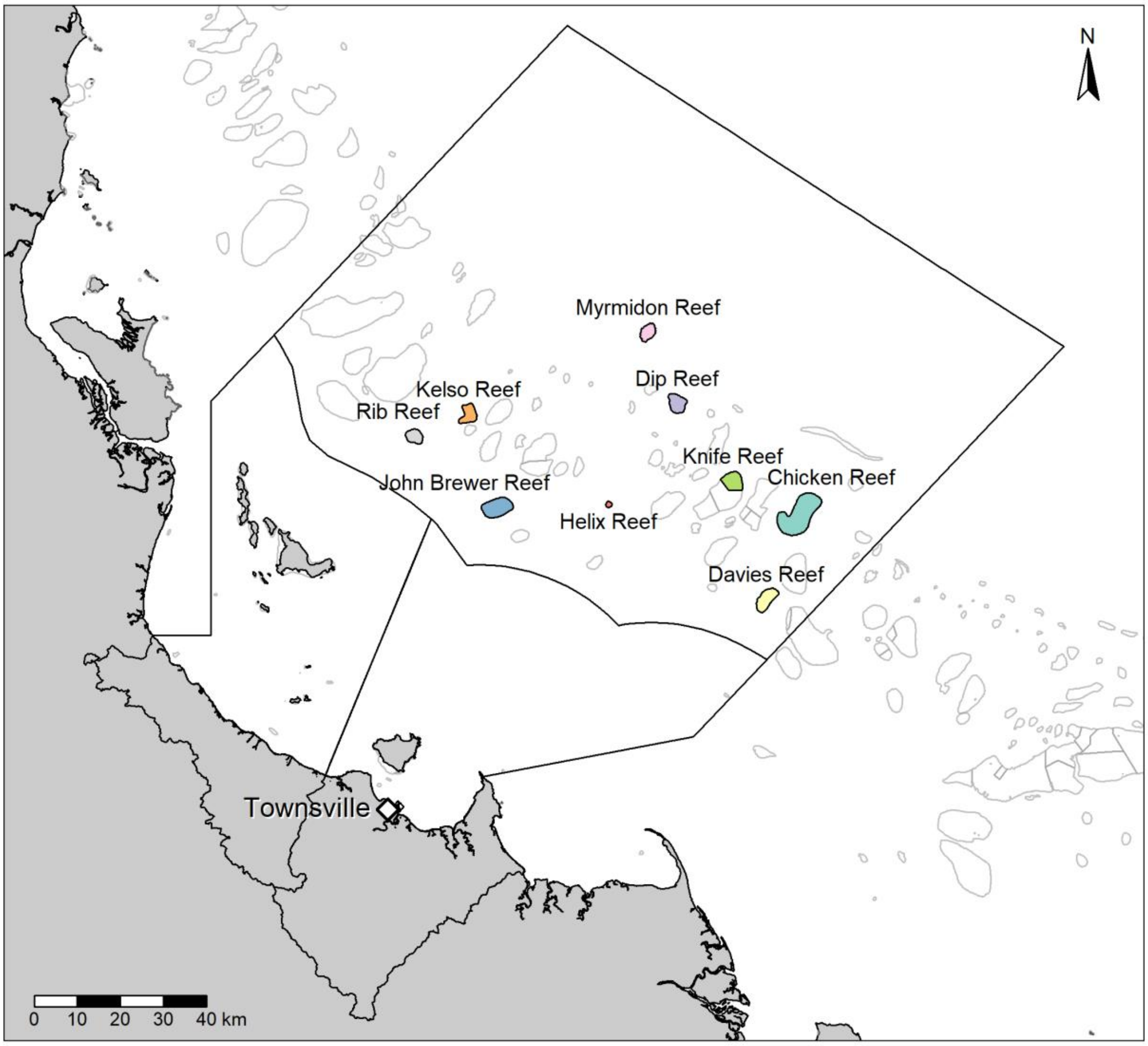


*Figure 91. Offshore marine coral sampling locations in the Dry Tropics region.*

# Appendix JJJ. Offshore Marine Coral Historic Scores

*Table 118. Standardised score for the Offshore Marine Zone habitat index. After back calculation. Red boxes highlight values that have changed.*

| Zone | Habitat Index | | |
|---|---|---|---|
| | **2020–2021** | **2019–2020** | **2018–2019** |
| Offshore Marine | 62 (B) | 54 (C) | 59 (C) |

**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.

*Table 119. Standardised score for the Offshore Marine Zone habitat index. Prior to back calculations*

| Zone | Habitat Index | | |
|---|---|---|---|
| | **2020–2021** | **2019–2020** | **2018–2019** |
| Offshore Marine | 62 (B) | 56 (C) | 59 (C) |

**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.

## Appendix KKK. Report Change Log

The table below lists section number, page and paragraph number, and summary of updates for the 2021–2022 technical report to assist reviewers.

| **Section** | **Page Number** | **Details** |
|---|---|---|
| 1. General | | |
| 1.1 Authorship Statement | p. ii | Dates. |
| 1.2 Current DTPHW Members | Table 1.<br>p. ii | Update member details |
| 1.3 Acknowledgements | p. ii | More detailed acknowledgements |
| 2. Executive Summary | p. iii | Dates.<br>Climate" changed to "Climate and Land Use". |
| 2.1 The Dry Tropics Partnership | Table 2<br>Figure 1<br>Table 3<br>p. iii – iv | Partnership summary refined:<br>Text updated.<br>New tables (table 2 and table 3).<br>New Map (Figure 1). |
| 2.2 Climate and Land Use (Previously Climate) | p. v | "Climate" changed to "Climate and Land Use".<br>Updates to each driver/factor (e.g., amount of rainfall). |
| 2.3 State and Condition of the Environment | Table 4<br>p. v | Dates.<br>New table to summarise indices and zones |
| 2.3.1 to 2.3.5 (Executive Summary of each section of results) | p. vii – ix | All dates, results, and key messages updated (excluding repeat data e.g., the Fish index). |
| 4. Glossary of Terms | P xiii | Definitions updated. |
| 7. Introduction | | Dates.<br>Partnership summary refined (new map, text changed to tables). |
| 7.1 Overview | p. 1 | Dates |
| 7.2 Report Card Zones | Table 11.<br>Figure 2<br>p.1 – 2 | Partnership summary refined:<br>Text updated.<br>New table (table 1).<br>New Map (Figure 2). |
| 7.3 Purpose of This Document | p. 2 | Dates |
| 8 Methods | | |
| 8.2 Scoring | p. 3 | Minor text clarification |
| 8.3 Presentation | Figure 3.<br>p. 4 | Additional Coastal added to figure 3 |
| 9 Climate and Land use (Previously Climate)<br>9.1, 9.2, 9.2.1 – 9.2.4, 9.3 | p. 7 – 16<br>Tables 16 – 22 | Entire section rewritten; everything new.<br>Urban environment<br>Rainfall |

| Section | Page Number | Details |
|---|---|---|
| | Figures 4 – 8<br>Appendix B – G | Air Temperature<br>Sea Surface Temperature<br>Coral Bleaching |
| 10. Freshwater Basin | p. 18 – 24 | Text clarification and date changes<br>Freshwater basins mapped including sub basins. |
| 10.1 Freshwater Water Quality | p. 18 – 24 | Sample locations map moved to appendix.<br>Introduction of the sub basin aggregation, has no impact on weighted scores at basin level.<br>Tables updated to include sub basin.<br>Detailed table (watercourse level) of indicator category to overall water quality removed.<br>Historical comparison provided in appendix. |
| 10.2 Habitat and Hydrology | p. 25 | Text clarifications<br>Wetland Extent specified as its own indicator category |
| 10.2.1.1 Freshwater Riparian Extent Monitoring Sites | p. 25<br>Appendix L. | Data sources provided.<br>New figure created (placed in Appendix L.) |
| 10.2.1.2 Results Freshwater Riparian Extent | Table 27.<br>p. 25 – 26 | Text clarification: context for additional years of data<br>New Table with additional data (Table 27). |
| 10.2.2 Freshwater Wetland Extent | p. 26 | Text update acknowledging changes to assessed area. Notes the inclusion of back calculations. |
| 10.2.2.1 Freshwater Wetland Extent Monitoring Sites | p. 26<br>Appendix P. | Text update acknowledging changes to assessed area.<br>New figure created (placed in Appendix P.) |
| 10.2.2.2 Results Freshwater Wetland Extent | Table 29 – 30<br>p. 26 – 27 | Text clarification: context for additional years of data<br>New Table with additional data (Table 29).<br>The wetland extent indicator category now has its own indicator category table (table 30) |
| 10.2.2.3 Change to Assessed Area | p. 27<br>Appendix S. | New section<br>Dedicated sub section to explore the impact of changes to the assessed area |
| 10.2.3 Artificial Barriers | | |
| 10.2.3.1 Monitoring Sites | p. 27 – 28<br>Appendix R. | Text updated to provide data sources.<br>Text update acknowledging changes to assessed area.<br>New figure created (placed in Appendix R.) |
| 10.2.3.2 Results Impoundment Length | Table 31<br>p. 28 | Minor changes to assessed area (no change to score) |
| 10.2.3.2 Results Fish Barriers | p. 28 | Text clarification: No changes |

| Section | Page Number | Details |
|---|---|---|
| 10.2.4 Results Freshwater Habitat and Hydrology | p. 30 | Text update to acknowledge changes to assessed area, distinction of Wetland Extent as its own indicator category, and back calculations |
| 10.2.4.1 Change to Aggregation and Wetland Extent indicator | p. 30<br>Appendix T. | New section<br>Dedicated sub section to explore the impact of separating Wetland Extent as its own indicator category |
| 10.2.5 Confidence Scores | Table 36.<br>p. 31. | Text updated to clarify derivation of confidence scores.<br>Artificial Barriers Included in the same table (table 36). |
| 10.3 Fish | p. 32 | Text clarification.<br>No changes to results |
| 10.3.3. Confidence scores | p. 34 | Text updated to clarify derivation of confidence scores. |
| 11. Estuarine Environment | Figure 10.<br>p. 36 | New map created to provide overview of Estuarine Environment |
| 11.1 Water Quality | | |
| 11.1.1 Monitoring Sites | Table 41.<br>p. 37 | New level of aggregation added “Sub Basin”, this has no impact on weighted scores at basin level (used for additional reporting context in separate documents). |
| 11.1.2 Nutrients | p. 37 – 40 | Results and discussion updated for the 2021–2022 report. Additional material moved to appendix |
| 11.1.3 Physical Chemical Properties | p. 40 – 43 | Results and discussion updated for the 2021–2022 report. Additional material moved to appendix |
| 11.1.3 Final Results | p. 43 | Results and discussion updated for the 2021–2022 report |
| 11.2 Habitat | p. 45 | Text clarifications providing data sources |
| 11.2.1 Mangrove and Saltmarsh Extent | p. 45 | Target vegetation types listed |
| 11.2.1.1 Monitoring Sites | p. 45<br>Appendix HH. | New figure created (placed in Appendix HH.) |
| 11.2.1.2 Results | Table 48 – 49<br>p. 26 – 27<br>Appendix JJ, KK | Text clarification: context for additional years of data<br>New Table with additional data (Table 48).<br>Results and discussion update for the 2021–2022 report (table 49).<br>Additional graphs for historic data (place in Appendix JJ, KK) |
| 11.2.2 Estuarine Riparian Extent | p. 46 | New Indicator Category, all sections new |

| Section | Page Number | Details |
|---|---|---|
| 11.2.2.1 Monitoring Sites | p. 46<br>Appendix II. | New figure created (placed in Appendix HH.) |
| 11.2.2.2 Results | Table 50 – 51<br>p. 26 – 27<br>Appendix LL, MM | Entire section is new.<br>Results and discussion update for the 2021–2022 report (table 51).<br>Additional graphs for historic data (place in Appendix JJ, KK) |
| 11.2.3 Final Results: Estuarine Habitat | Table 52.<br>p. 47 | Results and discussion updated for the 2021–2022 report (table 52).<br>New indicator category added. |
| 11.2.3.1 Back Calculated Scores | p. 47 – 48<br>Appendix NN | New section<br>Dedicated sub section to explore the impact of introducing the new indicator category. |
| 11.2.4 Confidence scores | p. 48 | Text updated to clarify derivation of confidence scores. |
| 12 Inshore Marine | Figure 11,<br>p. 50 | New map created to provide overview of inshore environment |
| 12.1 Water Quality | p. 51. | Text note that acknowledges the separation of the Halifax open coastal and midshelf sub zones (acknowledgement will be removed post ISP). |
| 12.1.1 Monitoring Sites | p. 51<br>Appendix PP, SS | New figure created (placed in Appendix PP and SS.) |
| 12.1.2 Nutrients | p. 51 – 54 | Results and discussion updated for the 2021–2022 report. Additional material moved to appendix |
| 12.1.3 Physical Chemical Properties | p. 54 – 56 | Results and discussion updated for the 2021–2022 report. Additional material moved to appendix |
| 12.1.4 Chlorophyll a | p. 57 | Results and discussion updated for the 2021–2022 report. Additional material moved to appendix |
| 12.1 Final Result Inshore Water Quality | p. 57 – 58 | Results and discussion updated for the 2021–2022 report. Additional material moved to appendix |
| 12.1.5.1 Overlap with the Wet Tropics Report | p. 58.<br>Appendix CCC | Dedicated sub section to acknowledge the overlap with the Wet Tropics Report and differences between each report |
| 12.2 Habitat | | |
| 12.2.1 Coral | | |
| 12.2.1.1 Monitoring Sites | p. 59<br>Appendix EEE | New figure created (placed in Appendix EEE.) |
| 12.2.1.2 Results | p. 60–61 | Text clarification to acknowledge the original source of results discussion. |

| Section | Page Number | Details |
|---|---|---|
| | | Source of data provided.<br>Results and discussion updated for the 2021–2022 report. |
| 12.2.1.3 Back Calculated Scores | p. 62<br>Appendix FFF | New section<br>Dedicated sub section to acknowledge and explore the impact of changing coral sites (additional material in appendix FFF) |
| 12.2.2 Seagrass | | |
| 12.2.2.1 Monitoring Sites | Table 63<br>p. 62<br>Appendix GGG | Table (63) updated and refined from previous version.<br>New figure created (placed in Appendix GGG.) |
| 12.2.2.2 Results | p. 62 – 64 | Text clarification to acknowledge the original source of results discussion.<br>Source of data provided.<br>Results and discussion updated for the 2021–2022 report. |
| 12.2.3 Final Results Inshore Habitat | p. 65 | Results and discussion updated for the 2021–2022 report. |
| 12.2.4 Confidence scores | p. 65 | Text updated to clarify derivation of confidence scores.<br>Coral maturity confidence score increased.<br>Seagrass measured error confidence score increased.<br>All overall sores increased. |
| 13. Offshore Marine | Figure 12, p. 67 | New map created to provide overview of offshore environment |
| 13.1 Water Quality | p. 67 – 68 | No updates to results or data. Text and table clarifications reflect this |
| 13.2.2.1 Monitoring Sites | p. 68<br>Appendix HHH | Text updated to acknowledge the change in sampling sites<br>New figure created (placed in Appendix HHH.) |
| 13.2.1.2 Coral Results | p. 68–69 | Results and discussion updated for the 2021–2022 report. |
| 13.2.2 Overall results | p. 69 | Results and discussion updated for the 2021–2022 report. |
| 13.2.2.1 Back Calculated Scores | p. 69 – 70 | New section<br>Dedicated sub section to acknowledge and explore the impact of changing coral sites (additional material in appendix LLL) |
| 13.2.3 Confidence scores | p. 70 | Text updated to clarify derivation of confidence scores. |

| Section | Page Number | Details |
|---|---|---|
| | | Coral measured error confidence score increased. |
| Litter | p. 72 – 75 | Model updated with new data (~2012–2019).<br>Separate model for each partnership region fit and highlighted different results in areas of overlap. Combined model for all partnership regions to be developed.<br>Landuse category included in zone definition within model<br>Land Sea Source Index (AMDI) included with results for further information. |