Wet Tropics Waterways

WET TROPICS REPORT CARD 2023

WATERWAY ENVIRONMENT RESULTS

REPORTING ON DATA: JULY 2021-JUNE 2022

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Wet Tropics Report Card 2023 (reporting on data July 2021 to June 2022)

WATERWAY ENVIRONMENTS: RESULTS

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This report was prepared by Richard Hunt, Technical Officer for Wet Tropic Waterways, with significant support and review from the Regional Report Cards Technical Working Group, reviewed by the Reef Water Quality Protection Plan Independent Science Panel and endorsed by the partnership of Wet Tropics Waterways.

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1. EXECUTIVE SUMMARY

The results presented in this document describe the state and condition for freshwater basin, estuarine, inshore marine and offshore marine environments. The results include scaled scores and grades for indicators, indicator categories, indices, and overall reporting zones, within each environment. The 2021-22 reporting year provides updated results for all indicators reported annually, where data is available, and also for longer-term indicators that are scheduled for update and have new data available. The indicator category and index groupings of indicators updated for 2021-22 are presented in Table i.

Table i. The indicator categories and indices updated in 2021-22 for each of the four environments.

Environment	Index	Indicator category
Basins	Water quality	All indicator categories
	Habitat & hydrology	Flow
Estuaries	Water quality	All indicator categories
	Habitat & hydrology	Mangroves and salt marsh (extent and shoreline condition indicators)*
		Riparian vegetation*
		Fish barriers (Daintree, Dickson Inlet and Barron zones only)*
		Flow
		Seagrass (Trinity Inlet and Moresby zones only)
Inshore marine	Water quality	All indicator categories
	Coral	All indicator categories
	Seagrass	All indicator categories (North and South zones only)
Offshore marine	Coral	All indicator categories

* indicates long-term indicators.

Comparisons between years must take into account any differences in monitoring, methodology and addition of indicators. The inshore marine monitoring has remained more consistent than basin, estuary and offshore marine monitoring over the reporting years and this facilitates direct comparison of the state and condition of these waterways between reporting periods. The reporting of offshore marine coral condition was modified for 2021-22 onwards due to an update in the sampling design which has decreased the number of reefs surveyed and increased the survey frequency to every year. The reporting of offshore marine water quality has been suspended as of 2020-21 due to decommissioning of the Marine Water Quality dashboard. This means that the reporting of offshore coral condition, and water quality when it is recontinued with the planned introduction of a new monitoring system for 2022-23, must account for the methodological changes when comparing with results from previous years.

The overall scores and grades across all waterway environments and reporting zones for 2021-22 range between ‘moderate’ to ‘very good’. These results are produced from the aggregation of multiple indicators which are affected by a wide range of conditions and impacts, including climate, and are examined further within this report. Confidence levels associated with the results are based on assessment of the methods and analyses and are also presented. This document is intended to be read in conjunction with the methods technical report WTW 2023 available for download here,

which details indicator selection, data collection, data analysis and scoring procedures for all indicators, and methods for scoring confidence.

Climate

For the 2021-22 period annual rainfall totals for the Wet Tropics were in the average percentile range for all basins. Rainfall anomaly, using difference from long-term average, was highest in coastal areas of the Mulgrave basin and lowest in areas of the Johnstone, Tully, Murray and lower Herbert basins. Over monthly time frames the rainfall during the wet season (December to March), was mostly either average or below average, whilst rainfall was very much above average in September (Barron, Mulgrave and Russell) and April or May (all basins except Russell, Johnstone and Tully). Rainfall in April and May was associated with low pressure troughs on the east coast of Queensland that brought heavy rainfall to areas of the Tropical North Queensland coast. Annual discharge of the major rivers was similar to the long-term mean in all basins, corresponding to the average annual rainfall range across all basins.

Sea surface temperatures for the Wet Tropics inshore and offshore zones were above long-term average summer maximums with all areas above the low likelihood for coral bleaching. Areas with a likelihood of severe coral bleaching occurred in coastal waters in the Palm Island and South inshore zones.

Waterways

The index and overall scores and grades for the 2021-22 reporting period and the overall scores and grades from previous years are presented for each waterway environment in the Tables ii –v below for quick reference. The indices of each waterway environment are comprised of multiple indicators and the scores and grades are presented in full at the relevant sections and in Appendix F for previous years. Selected key messages for results of particular interest are provided and refer to indicators which are presented in detail within the results sections.

The following standardised scoring ranges and grades have been applied: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100 | ■ nd indicates no data available.

Basins

The assessment of basins is based upon water quality, comprising of nutrients (dissolved inorganic nitrogen and filterable reactive phosphorus), sediments (total suspended solids) and pesticide risk; habitat and hydrology, comprising of habitat extent (riparian and wetlands), habitat modification (impoundment length), flow, and invasive weeds; and fish, comprising of native species and introduced species (translocated and non-Australian).

Wet Tropics Waterways

Table ii. Basin index and overall results for 2021-22 and overall results for preceding years.

Basins	Water quality	Habitat and hydrology	Fish	21-22	20-21	19-20	18-19	17-18	16-17	15-16
Daintree	87	78	nd	83	83	85	82	81	81	81
Mossman	64	68	77	69	72	74	63	67	63	55
Barron	75	45	48	56	54	54	61	61	64	63
Mulgrave	69	66	84	73	74	73	68	71	64	64
Russell	74	69	92	78	79	75	75	75	70	68
Johnstone	70	60	72	67	70	71	67	67	68	68
Tully	65	62	90	72	75	72	61	64	64	61
Murray	57	55	80	64	63	61	57	59	55	54
Herbert	70	59	85	71	70	71	59	66	66	67

Basin key messages

- Overall condition of basins was 'good' other than the Daintree graded 'very good' and Barron graded 'moderate'. For all basins water quality or fish were the highest scoring indices.

Water quality

- Water quality was lowest for the Murray Basin.
- The Murray had the highest pesticide risk (graded 'poor'), although the pesticide score improved from the previous year. All other basins monitored for pesticides were graded 'good' (low risk) or 'very good' (very low risk).
- Since water quality reporting began for the Murray Basin in 2018-19, it has consistently scored the poorest of all basins for water quality primarily due to its high pesticide risk.
- For all basins, grades for total suspended solids (TSS) were either good or very good. During baseflow conditions the highest TSS concentrations occurred in the Mulgrave at the end of August which coincided with the onset of heavy rainfall. .
- Dissolved inorganic nitrogen remained the poorest scoring indicator. The Murray declined in grade from 'moderate' to 'poor' and had the poorest score due to multiple guideline exceedances occurring during high flow periods.
- Over the eight reporting years the Mulgrave Basin has scored the poorest for dissolved inorganic nitrogen.
- Filterable reactive phosphorus grades improved from 'moderate' to 'good' for the Mossman and Murray. All other basins remained 'good', except the Johnstone which remained 'moderate'.

Habitat and hydrology

- 2021-22 was drier than the previous year for basins in the south of the region.
- The flow indicator scores for basins in 2021-22 were mostly lower than in 2020-21.
- Flow assessment sites in all basins were graded either 'good' or 'very good' except for Rudd Creek at Gunnawarra in the Herbert Basin which was 'moderate'.
- The score for Rudd Creek at Gunnawarra may have been compromised due to a substantial gap in the daily discharge data.

Estuaries

The assessment of estuaries is based upon water quality, comprising of nutrients (dissolved inorganic nitrogen and filterable reactive phosphorus), physical-chemical (turbidity and dissolved oxygen), chlorophyll *a*, and pesticide risk; and habitat and hydrology, comprising of habitat extent (riparian and mangrove-saltmarsh), fish barriers, flow, and seagrass.

Table iii. Estuary index and overall results for 2021-22 and overall results for preceding years.

Estuary	Water quality	Habitat and hydrology	21-22	20-21	19-20	18-19	17-18	16-17	15-16	14-15
Daintree	79	59	**69**	**73**	**76**	**70**	**72**	**70**	**70**	nd
Dickson Inlet	71	65	**68**	**77**	**77**	**79**	**77**	**69**	**74**	nd
Barron	46	55	**51**	**62**	**57**	**53**	**54**	**55**	**46**	**62**
Trinity Inlet	73	54	**64**	**64**	**63**	**56**	**57**	**64**	**66**	**59**
Russell-Mulgrave	72	67	**69**	**73**	**75**	**68**	**70**	**72**	**72**	**75**
Johnstone	67	56	**61**	**70**	**69**	**65**	**65**	**65**	**57**	nd
Moresby	67	52	**60**	**66**	**70**	**66**	**65**	**67**	**66**	**53**
Hinchinbrook Channel	73	65	**69**	**72**	**78**	**74**	**77**	**81**	**78**	nd

Estuary key messages

- Overall condition for all estuaries remained 'good' except for the Barron and Moresby which declined to 'moderate'.

Water quality

- Water quality was the highest scoring index for all estuaries except for the Barron.
- Water quality declined from 'very good' to 'good' for the Daintree and Dickson Inlet estuaries, and from 'good' to 'moderate' for the Barron estuary. All other estuaries remained 'good'.
- Estuaries with pesticide monitoring (Daintree, Russell-Mulgrave and Johnstone) were at low or very low risk from pesticide toxicity.
- Chlorophyll *a* declined in grade from the previous year for Daintree ('very good' to 'moderate'), Dickson Inlet ('very good' to 'good'), Moresby and Hinchinbrook Channel ('good' to 'moderate'), and Barron ('good' to 'poor'). Chlorophyll *a* in the Barron returned to more typical poorer condition as observed in years prior to 2020-21.
- DIN declined from 'very good' to 'good' for the Daintree, from 'moderate' to 'poor' for the Barron and Russell-Mulgrave, and remained 'poor' for the Johnstone. The other estuaries were unchanged and graded 'good' or 'very good'.
- Dissolved oxygen for Trinity Inlet improved from 'poor' to 'moderate' but it remained the estuary with the lowest score for dissolved oxygen over the last six years.
- The dissolved oxygen grade declined from the previous year for Dickson Inlet, Barron, Johnstone and Moresby. Grades for Daintree, Russell-Mulgrave and Hinchinbrook Channel were unchanged.
- With the exception of the Barron, turbidity was graded 'very good' for all estuaries with grades unchanged from the previous year. Turbidity for Barron declined from 'very good' to 'good'.

Habitat and hydrology

- The shoreline mangrove habitat score was lowest for Dickson Inlet (60), which was graded 'moderate' condition, and highest for Hinchinbrook Channel (83) which was graded 'very good'.
- Updates to mangrove and saltmarsh extent and riparian extent indicators showed no further habitat loss since 2017.
- The 2021-22 update of the fish barrier indicator for Daintree, Dickson Inlet and Barron resulted in five barriers added to the Daintree estuary (grade remained 'good'), one barrier added to Dickson inlet (grade declined from 'very good' to 'good') and 13 barriers added to the Barron estuary (grade declined from 'good' to 'moderate').
- For flow, the Barron and Johnstone estuaries were graded 'good' and the Russell-Mulgrave was graded 'very good', indicating flows to the estuaries were not substantially altered from reference condition.
- Seagrass in Trinity Inlet declined to poor condition, despite many of the meadows having very good scores for two out of three indicators. In the Moresby estuary the condition grade remained 'very poor'.

Inshore

The assessment of inshore is based upon water quality, comprising of water clarity (total suspended solids and turbidity), nutrients (oxidised nitrogen, particulate nitrogen and particulate phosphorus), and chlorophyll *a*; coral, comprising of change in coral cover, juvenile density, macroalgae cover, coral cover, and composition; and seagrass, comprising of biomass, area, and species composition or percent cover and resilience.

Table iv. Inshore marine index and overall results for 2021-22 and overall results for preceding years.

Inshore zone	Water Quality	Coral	Sea-grass	Fish	21-22	20-21	19-20	18-19	17-18	16-17	15-16
North	81	51	60	nd	64	57	60	60	54	48	52
Central	62	58	nd	nd	60	61	67	59	57	57	62
South	60	60	40	nd	53	51	56	47	41	37	44
Palm Island	68	45	nd	nd	56	55	59	56	51	57	59

Inshore marine key messages

- Overall inshore grades since the previous year improved for the North zone ('moderate' to 'good'), declined for Central zone ('good' to 'moderate'), and were unchanged for the South and Palm Island zones (both 'moderate').

Water quality

- The water quality index score increased for all zones from the previous year with improvements in grade for the North ('good' to 'very good') and the Central ('moderate' to 'good'). The South zone remained 'moderate' and the Palm Island zone remained 'good'.
- Water clarity scores increased in all four zones following a decline in 2020-21, with the most substantial increase occurring in the North zone.
- Nutrients had the poorest scores of the water quality indicator categories in all zones although the scores increased in all zones compared to the previous year.

- The Central and South zones displayed spatial trends in water quality with highest concentrations of nutrients, total suspended solids and chlorophyll *a* occurring at sites closest to the river mouths and tending to decrease with distance of sites from the river mouths.
- Notable longer-term trends in water quality over the last several years include improvement of chlorophyll *a* for both the Central and South zones; improvement of nutrients for the Palm Island zone; and an improvement in water clarity grades for all zones.

Coral

- In the North zone the condition of coral has remained 'moderate' but improved in score from the previous year. Coral cover has continued to increase, whilst macroalgae cover remained high at two sites but was very low at the other sites.
- In the Central zone the condition of coral has declined from 'good' to 'moderate'. High cover of macroalgae at some sites substantially reduced the score for this indicator, whilst coral cover score increased to its highest value of all reported years.
- In the South zone the condition of coral declined slightly, with the grade returning to 'moderate'. Coral cover increased slightly at all sites, although juvenile density decreased with the transition of juveniles to adults. High macroalgae cover persisted at several sites.
- In the Palm Island zone the condition of coral remained 'moderate' but the score decreased to it is lowest value. Declines in juvenile density occurred at all sites, and macroalgae cover increased or was sustained at several sites. High sea surface temperatures and coral bleaching occurred during the 2021-22 summer months, impacting soft corals.
- Crown-of-thorns starfish were observed above outbreak levels at two reef sites in the Central zone, however, the numbers were notably lower than for 2019-20.

Seagrass

- North zone inshore seagrass improved in condition from the previous year, and whilst the grade remained 'moderate', the score of 60 was just below the threshold for a grade of 'good'.
- South zone inshore seagrass remained in poor condition with the score of 40 unchanged from the previous year.
- The North and South zone grades have remained unchanged for the past five years but the increasing scores for both zones over this time indicates a general improvement in condition.

Offshore

The offshore zone is assessed from the water quality index and the coral index. The water quality index has not been available for 2020-21 and 2021-22, consequently an overall offshore score and grade has not been available since 2019-20. The coral index is comprised of juvenile density, change in coral cover, and coral cover whilst up until 2019-20 the water quality index was comprised of total suspended solids and chlorophyll *a.*

Table v. Offshore marine index and overall results for 2021-22 and overall results for preceding years.

Water quality Score	Coral Score	21-22	20-21	19-20	18-19	17-18	16-17	15-16
nd	62	Insufficient data	Insufficient data	**70**	**73**	**75**	**83**	**84**

Offshore marine key messages

- Due to the lack of water quality monitoring, there was insufficient data to provide an overall grade and score for the offshore zone.

Water quality

- For 2021-22 there was no water quality monitoring program in place to allow reporting of offshore water quality for a second year.

Coral

- Hard coral cover increased to its highest level since 2017.
- During the summer, high sea surface temperatures occurred in the offshore zone. The next round of surveys will further assess the extent of heat stress and coral bleaching on coral condition.
- The 2021-22 reef surveys recorded no potential, incipient or active crown of thorns starfish outbreaks in the offshore zone.
- All reefs have shown a general improvement in coral cover following impacts from heat stress and crown-of-thorns starfish between 2016 and 2018.

Confidence

The assessment of waterway condition and state also includes a measure of the confidence surrounding the data and analysis used for the indicators and indicator categories that constitute the indices. Assessment of confidence is based upon five criteria covering the maturity of the method (stage of development), level of data validation, representativeness (spatial and temporal factors, and sample size), directness of measurements, and measured error. The confidence rank is based on the score of the summed criteria. Confidence of an index is the average of the contributing indicator categories. Table v presents the confidence ranks of the indices for each of the waterway environments. Confidence at the indicator and indicator category level is presented in the relevant section of the report.

Table vi. Confidence ranks of the indices for each waterway environment.

Environment	Water quality	Habitat and hydrology	Fish	Coral	Seagrass
Basin	3	3	3	-	-
Estuary	2 to 4	3	nd	-	-*
Inshore	3	-	nd	4	3
Offshore	nd	-	nd	4	-

Confidence rank: 1 (very low); 2 (low); 3 (moderate); 4 (high); 5 (very high). nd indicates no data available, - indicates index is not applicable. * note that estuary seagrass is included in the habitat and hydrology index.

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Terms and Acronyms

AIMS	Australian Institute of Marine Science
Basin	An area of land where surface water runs into smaller channels, creeks or rivers and discharges into a common point. A basin may include unconnected sub-basins which discharge at separate points.
Biomass	The total quantity or weight of organisms over a given area or volume.
BoM	Bureau of Meteorology
Chl-*a*	Chlorophyll-*a*: a measure used to estimate phytoplankton biomass. It is widely considered a useful proxy to measure nutrient availability and the productivity of a system.
CTF	Cease-to-flow
CV	Coefficient of variation
DES	Department of Environment and Science, Queensland
DHW	Degree heating weeks
DIN	Dissolved inorganic nitrogen
DO	Dissolved oxygen
EC	Enclosed coastal marine water body
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 if it is stable and sustainable - that is, if it is active and maintains its organisation and autonomy over time and is resilient to stress.
Estuary environment	The aquatic environment at the interface between freshwater and marine ecosystems and includes mid-estuary (ME) and lower-estuary (LE) waters (WTHWP 2018).
Fish (as an index)	Fish community health is assessed and included in the ecosystem health assessments (coasters). Inclusion in the report card will contribute to an assessment of the health of local fish communities.
Fish Barriers (as an indicator)	Fish barriers relate to any man-made barriers which prevent or delay connectivity between key habitats which has the potential to impact migratory fish populations, decrease the diversity of freshwater fish communities and reduce the condition of aquatic ecosystems (Moore, 2016).

Flow (as an indicator)	Flow relates to the degree that the natural river flows have been modified in the region's waterways. This is an important indicator due to its relevance to ecosystem and waterway health.
FNQROC	Far North Queensland Regional Organisation of Councils
FRP	Filterable Reactive Phosphorus
GBR	Great Barrier Reef
GBR CLMP	Great Barrier Reef Catchment Loads Monitoring Program
GBR Report Card	Great Barrier Reef Report Card developed under the Reef 2050 Water Quality Improvement Plan (2018).
GBRMPA	Great Barrier Reef Marine Park Authority
GV	Guideline Value
Impoundment length	An indicator used in the 'instream habitat modification' indicator for freshwater basins in the region. This index reports on the proportion (%) of the linear length of the main river channel when inundated at the Full Supply Level of an artificial instream structures such as dams and weirs.
Index	Is generated by indicator categories (e.g. the water quality index is made up of nutrients, water clarity, chlorophyll-*a* and pesticides indicator categories)
Indicator	A measure of one component of an environmental dataset (e.g. particulate nitrogen)
Indicator category	Is generated by one or more indicators (e.g. water clarity made up of total suspended solids and turbidity)
Inshore marine environment	Includes enclosed coastal (EC), open coastal (OC) and mid-shelf (MS) waters, extending east to the boundary with the offshore waters (WTHWP 2018).
In-stream Habitat Modification (as an indicator)	This basin indicator category is made up of two indicators: fish barriers and impoundment length.
IQQM	Integrated water quantity and quality simulation model – used to model pre-development flow for the flow tool score calculations.
LE	Lower estuary water type
LTMP	Long-Term Monitoring Program
Macroalgae (cover)	An indicator used in part to assess coral health. Macroalgae is a collective term used for seaweed and other benthic (attached to the bottom) marine algae that are generally visible to the naked eye.
ME	Mid-estuary water type

Measure	A measured value that contributes to an indicator score for indicators that are comprised of multiple measurements (e.g. flow, estuary fish barriers).
MMP	Great Barrier Reef Marine Monitoring Program – A collaboration between GBRMPA, JCU and AIMS. This provides water quality, coral and seagrass data for the inshore zones of the report card.
MS	Mid-shelf marine water body
MWQ	Marine water quality (MWQ) dashboard and data – Bureau of Meteorology.
NAMAC	Natural Asset Management Advisory Committee
NO_x	Oxidised nitrogen (nitrate and nitrite)
OC	Open coastal marine water body
Offshore marine environment	Includes all offshore waters within the Wet Tropics NRM marine region.
Overall Score	The overall scores for each reporting zone used in the report card are generated by an index or an aggregation of indices.
P2R	Paddock to Reef Integrated Monitoring, Modelling and Reporting Program
Palustrine wetlands	Primarily vegetated non-channel environments of less than eight hectares. Examples of palustrine wetlands include billabongs, swamps, bogs, springs, etc.
Pesticides (as an indicator)	Incorporating up to 22 herbicides and insecticides with different modes of action. A list of the relevant chemical components is provided in the Methods Report.
Pesticide Risk Metric	Refers to the methodology for estimation of ecological risk associated with pesticide pollution.
Phys-chem	The physical-chemical indicator category that includes two indicators: dissolved oxygen (DO) and turbidity.
PN	Particulate nitrogen
POISE	Proportion of indigenous fish species expected
PONI	Proportion of non-indigenous fish
PONSE	Proportion of native (fish) species expected
PP	Particulate phosphorus
Pre-clearing	Pre-clearing vegetation is defined as the vegetation or regional ecosystem present before clearing. This generally equates to terms such as ‘pre-1750’ or ‘pre-European’ used elsewhere (Neldner et al., 2019).

Pre-development flow	The pattern of waterflows, during the simulation period, using the IQQM computer program as if there were no dams or other water infrastructure in the plan area, and no water was taken under authorisations in the plan area. (Queensland Government 2016).
PRM	Pesticide Risk Metric
PSII herbicides	Photosystem II inhibiting herbicides (Ametryn, Atrazine, Diuron, Hexazinone, Tebuthiuron, Bromacil, Fluometuron, Metribuzin, Prometryn, Propazine, Simazine, Terbuthylazine, Terbutryn)
PSII-HEq	Photosystem II herbicide equivalent concentrations, derived using relative potency factors for each individual PSII herbicide with respect to a reference PSII herbicide, diuron (Gallen *et al.* 2014).
QPSMP	Queensland Ports Seagrass Monitoring Program
Queensland Government	The Queensland Government includes several departments that provide data sources and support for the report card. Key departments for the report card are the Department of Environment and Sciences (includes management of the GBR CLMP), the Department of Regional Development, Manufacturing and Water (includes management of water monitoring), and the Department of Resources (includes management of Queensland Spatial).
REMP	Receiving Environment Monitoring Plan
Resilience (MMP seagrass indicator)	Measure of the capacity of seagrass to cope with disturbances.
Riparian Extent (as an indicator)	An indicator used in the assessments of both basin and estuarine zones. This indicator uses mapping resources to determine the extent of the vegetated interface between land and waterways in the region.
SF	Scaling factor - A value used to set scoring range limits for indicators.
Standardised condition score	The transformation of indictor scores into the Wet Tropics Report Card scoring range of 0 to 100.
TSS	Total suspended solids
Waterway	All freshwater, estuarine and marine bodies of water, including reefs, and storm drains, channels and other human-made structures in the WT region.
Water quality guideline	For purposes of waterway assessment, the term water quality guideline refers to values for condition assessment of water quality drawn from a range sources including water quality objectives scheduled under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (DES 2020), and water quality guideline values obtained from the Queensland Water Quality Guidelines (DEHP 2009), the GBRMPA Guidelines (GBRMPA 2010) and the ANZG (2018).

Water quality objective (WQO)	Water quality objective refers to values for condition assessment of water quality scheduled under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (DES 2020).
WTW	Wet Tropics Waterways (previously known as Wet Tropics Healthy Waterways Partnership WTHWP)

2. INTRODUCTION

2.1. General

Wet Tropics Waterways was launched in July 2016 with the release of the 'Pilot Report Card' in December 2016 which reported on the 2014-15 year. Report cards have been released annually since the release of the pilot report card with the current 'Report Card 2023' reporting on the 2021-22 year (1 July 2021 to 30 June 2022) and from here on is referred to as the Report Card. The Report Card includes water quality and ecosystem state and condition assessments for freshwater, estuarine, inshore marine and offshore marine environments. In some cases where seasonal monitoring programs extend outside of the financial year period, for example inshore coral, the data from the whole monitoring period is included. For monitoring programs that collect data less frequently than annually (e.g. wetland extent) then the most recent data set is included.

The summary scores from 2015-16, to 2020-21 are presented alongside the 2021-22 scores in each waterway environment section. The complete scores for each waterway environment are presented in full at the relevant section for 2021-22 and in Appendix F for previous years. For details on the design of the Report Card program including reporting zones for the waterway environments, refer to the Program Design (WTHWP 2018) and for details of the methods applied for the Report Card refer to the current methods technical report (WTW 2022).

2.2. Purpose of this Document

The purpose of this document is to provide detailed results of monitoring and assessment activities to support the Report Card. The results presented in this document are assessments of the state and condition for freshwater basin, estuarine, inshore marine and offshore marine environments. A log of the updates applied for 2021-22 results technical report is presented in Appendix H.

This document presents scaled scores and grades for indicators, indicator categories, indices, and for overall reporting zones within each environment. Key messages are presented for indicators that have been updated for the current reporting period. Included in this document are the confidence scores associated with the results, which are based on assessment of the methods and analyses, used to obtain the data. The data collection periods for indicators, indicator categories and indices are presented in the methods technical report (WTW 2023).

2.3. Terminology and Scoring

The Report Card assesses different indicators of ecosystem health to report on overall state and condition. Scores for indicators are aggregated depending on the aspect of the ecosystem they are assessing, such as water quality, coral or fish. The terminology used in this document for defining the level of aggregation of indicators is as follows.

- An indicator is a measured variable (e.g. particulate nitrogen) or generated from more than one measure, for example the flow indicator is generated from multiple hydrological measures.
- Indicator categories (e.g. nutrients) are generated by the averaging of indicators.

- Where an indicator category is represented by a single indicator, the indicator category score is equal to the indicator score.
- Indices (e.g. water quality) are generated by the averaging of indicator categories.
- Overall score is generated by the averaging of indices.

Overall scores and scores for indices are represented in the report card and website by a coaster (Figure 1). Presentation of the coaster can be without the indicator category outer ring as in the case of the Report Card publication. The overall scores are produced from a high level of aggregation which means these scores will be slow to change. It is important to take notice of the scores for indicators and indicator categories which can change more over time than overall scores.

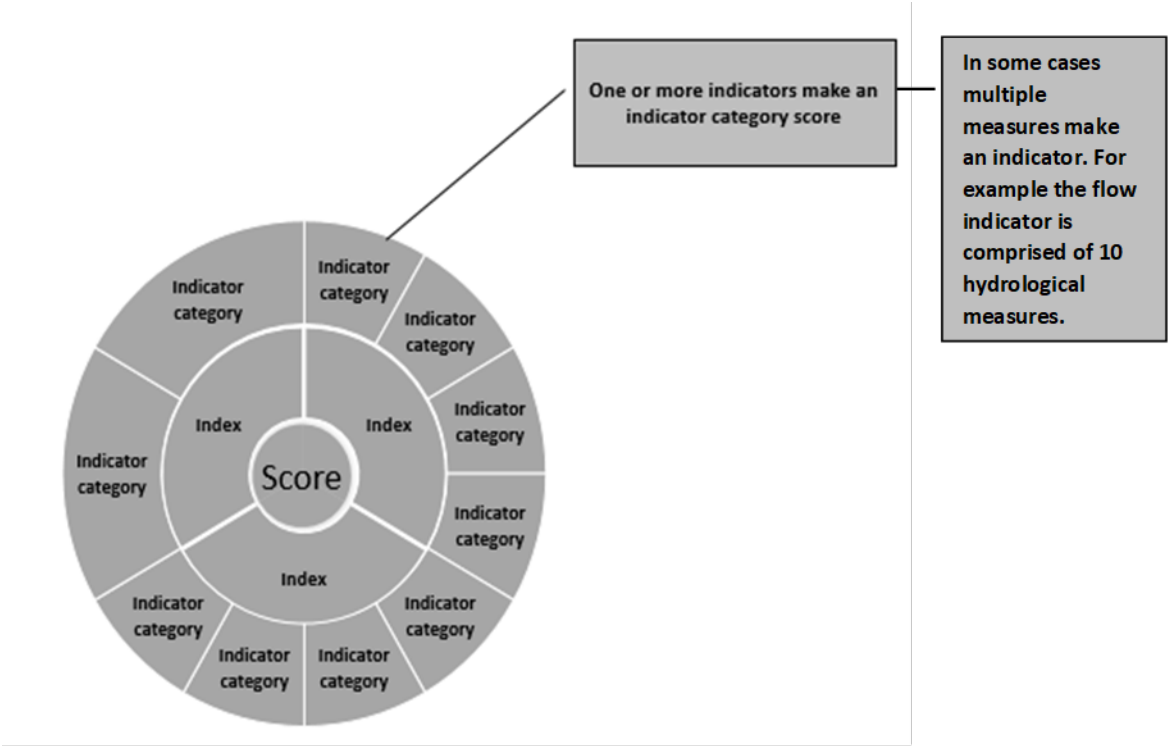

Figure 1 Terminology used for defining the level of aggregation of indicators.

Scoring of indicators is conducted using scales developed for setting scoring ranges according to the report card grading system of 'very poor', 'poor', 'moderate', 'good' and 'very good'. Indicator scales are specific to indicators and are converted (if required) to a standardised scale of between 0 -100 (Table 1). In some cases the specific indicator scoring ranges are aligned with the standardised scoring range (e.g. basin nutrients) whilst other specific indicators' scoring ranges differ from the standardised scoring range (e.g. basin pesticides) and require conversion to the standardised scoring ranges. The indicator results tables present both the specific indicator scores and the standardised indicator scores. The standardised scale allows for the aggregation of indicators, indicator categories and indices and is calculated to one decimal place to allow for differentiation between grades. For presentation in the summary tables the scores are then rounded down and presented as integers.

Table 1 Standardised scoring ranges and corresponding condition grades.

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

Values for condition assessment of water quality are drawn from a range of sources including water quality objectives scheduled under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 Wet Tropics basins (DES 2020) and water quality guideline values obtained from the Queensland Water Quality Guidelines (DEHP 2009), the GBRMPA Guidelines (GBRMPA 2010) and the ANZG (2018). Further explanation on which values were used for condition assessment is outlined in Appendix B . For the purposes of this assessment and to simplify terminology, all values obtained from these sources will be referred to as water quality guideline values.

The assessment results in the Report Card were rated in terms of the confidence surrounding the analysis. Confidence scores range from 4.5 to 13.5 and are assigned a confidence ranking from 1 (low) to 5 (high) totalled for each index.

Further details of the terminology and levels of aggregation and confidence scoring are provided in the methods technical report (WTW 2023).

3. CLIMATIC INFLUENCES IN THE REGION

For the 2021-22 period annual rainfall totals for the Wet Tropics region were highest in the Russell Basin and lowest in the upper Herbert Basin (Figure 2). Annual rainfall was above the long term mean across most of the Mulgrave Basin, with coastal areas receiving 400-600 mm above the long-term mean, and higher than average annual rainfall also occurred in areas of the Barron and Russell basins adjacent to the Mulgrave Basin (Figure 2). Annual rainfall for all other areas of the region was at or below the long term mean range, with areas of the Johnstone, Tully, Murray and lower Herbert basins having the lowest rainfall anomaly of between -400 to -200 mm (Figure 2).

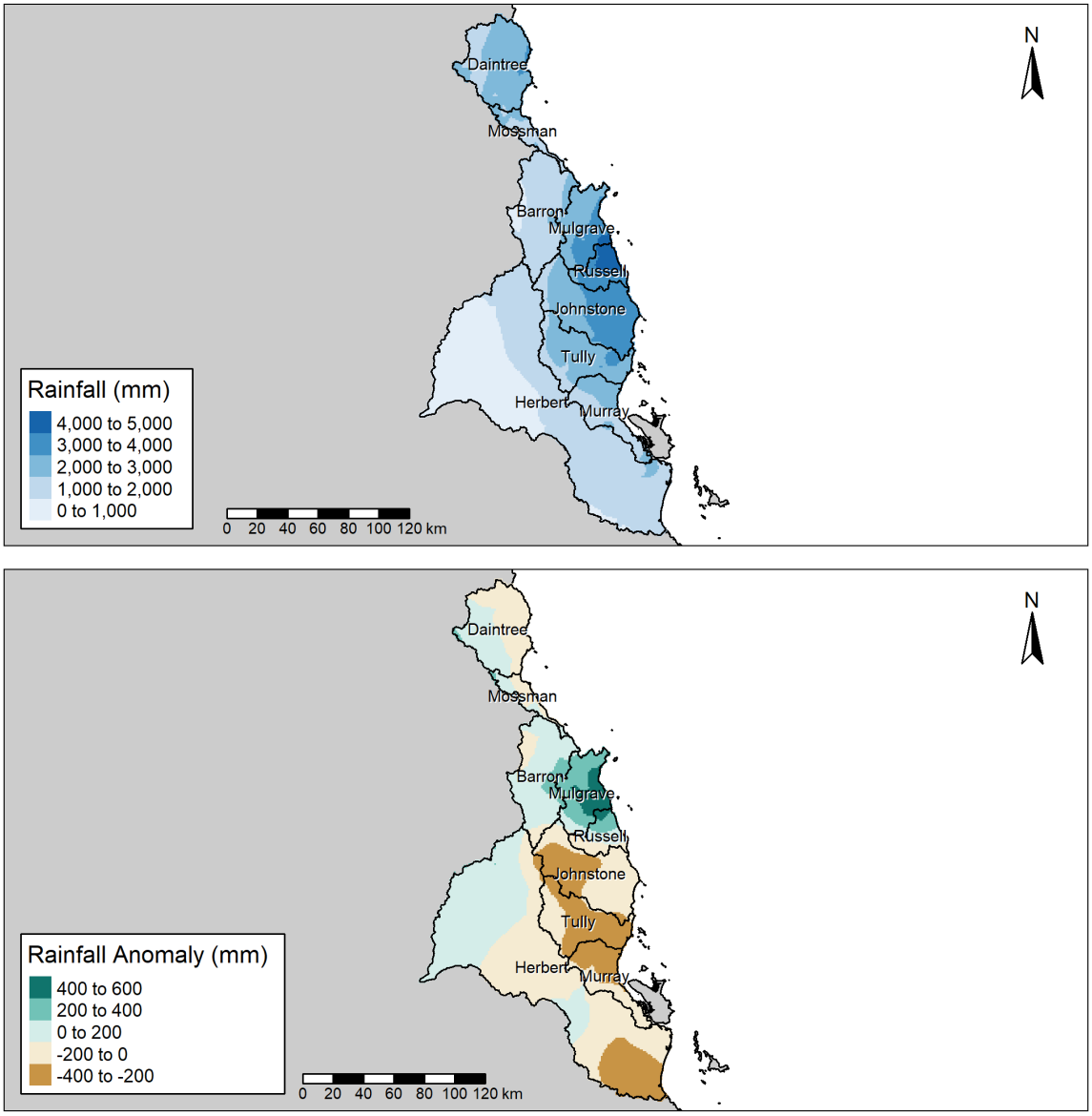

Figure 2 Annual rainfall total (top) and rainfall anomaly of total annual rainfall from long-term mean annual rainfall (bottom) for the Wet Tropics region during 2021-22.
Data for the map was sourced from the Bureau of Meteorology Australian Water Outlook (https://awo.bom.gov.au/) which uses a long-term mean based upon historical rainfall records from 1911 to 2017.

The annual rainfall percentile category was average (between the 30th and 70th percentiles) for all basins (Table 2 and Figure 3). In terms of historical rainfall record, the annual totals for 2021-22 for all basins except the Daintree showed a decrease from the preceding year with the Daintree increasing slightly (Appendix A, Figure 17). The 2021-22 annual rainfall totals for all basins were close to their long-term annual means in comparison to the variability observed in the historical rainfall records since 1911 (Appendix A, Figure 17).

Table 2 Annual rainfall statistics for basin areas of the Wet Tropics for 2021-22.

	Total (mm)	Long-term mean (mm)	Percentile of long-term mean	Anomaly (mm +/- long-term mean)	Percentage of long-term mean
Daintree	2287	2276	51	11	100%
Mossman	1960	1939	46	21	101%
Barron	1516	1439	55	77	105%
Mulgrave	2933	2592	67	341	113%
Russell	3808	3701	51	107	103%
Johnstone	2865	3043	35	-177	94%
Tully	2442	2682	31	-240	91%
Murray	2032	2260	33	-228	90%
Herbert	1198	1246	42	-48	96%

Data was sourced from the Bureau of Meteorology Australian Water Outlook using historical data for 1911-2017.

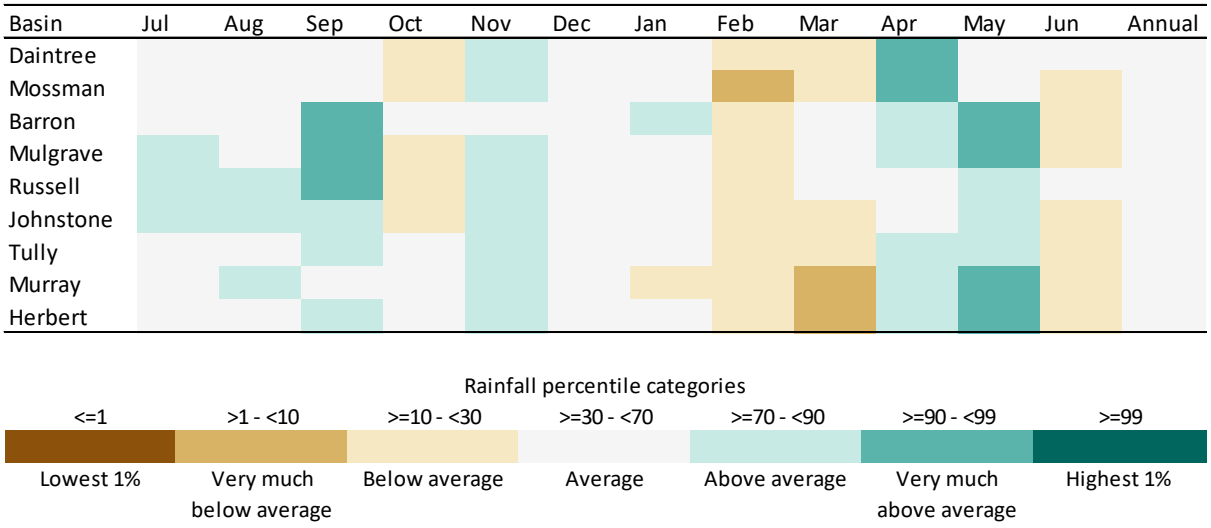

Figure 3 Monthly rainfall percentiles and annual mean percentiles for basin areas of the Wet Tropics (2021-22).
Data was sourced from the : Bureau of Meteorology Australian Water Outlook using historical data for 1911-2017.

The percentiles of monthly rainfall totals were either average (30th to <70th percentile), below average 10th to <30th percentile or above average (70th to <90th percentile) for most months across all basins. September was very much above average rainfall for the Barron, Mulgrave and Russell basins, whilst all basins except for Russell, Mossman and Johnstone had rainfall very much above average in either April or May. During late April and into May low pressure troughs on the east coast

of Queensland brought heavy rainfalls to the Tropical North Queensland coast, with highest multi-day totals observed around the Daintree region in April and flooding affecting areas across the region in May (BoM 2022). February, which is one of the wettest months of the year, was below average for all basins, with the Mossman very much below average.

Annual discharge of the major rivers at monitoring sites for all basins was similar to long-term discharge (Figure 4), corresponding to the average annual rainfall range across all basins. Discharge was slightly lower than the long-term mean for the Barron, Russell, Tully and Herbert river sites, and above the long-term mean for the Daintree and the Johnstone River at Coquette Point sites, with discharge at all other monitoring sites very close to the long-term mean.

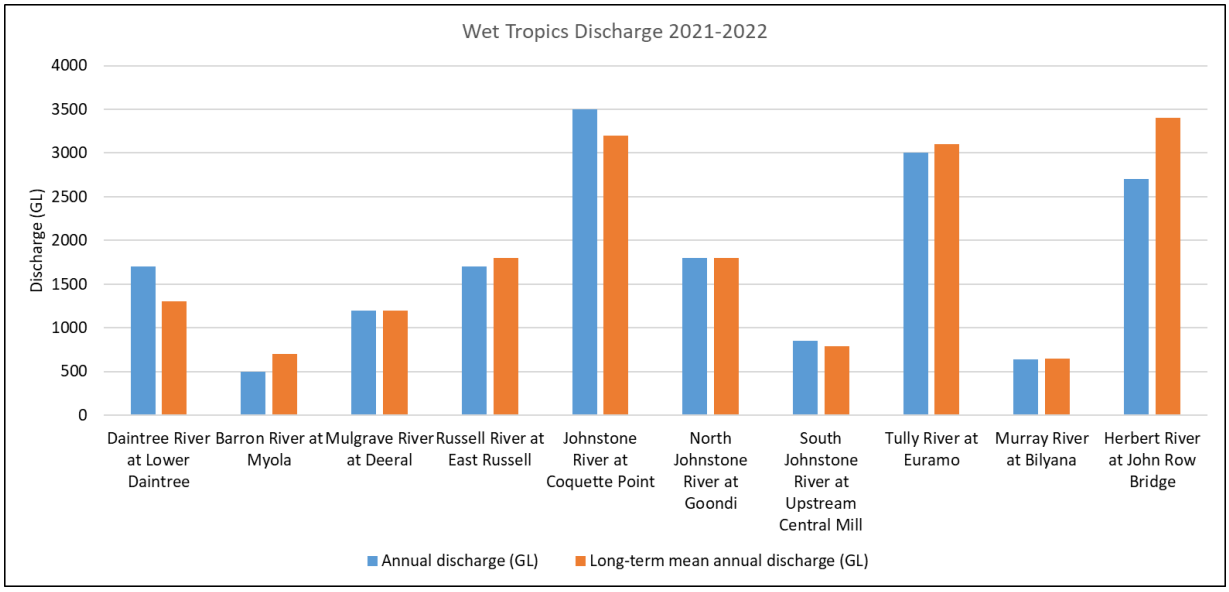

Figure 4 Long-term mean annual discharge and discharge for 2021 – 2022 recorded from gauging stations at the most downstream locations of the major river channel for freshwater basins.
*Long-term mean annual discharge is based on historical gauging station records until present from the Department of Regional Development, Manufacturing and Water (water-monitoring.information.qld.gov.au) and Department of Environment and Science. Historical flow records dated from 1957 for the Barron at Myola, 1972 for the Tully River at Euramo and 1915 for the Herbert River at Ingham. For recently constructed gauging stations modelled data was used from 1986 until they became operational which was 2018 for the Murray, 2017 for the Daintree, 2015 for Johnstone River at Coquette Point and 2013 for the Mulgrave and Russell.

During 2021-22 sea surface temperatures for the Wet Tropics inshore and offshore zones were above long-term average summer maximums, and all areas were above the low likelihood for coral bleaching (Figure 5). Areas with a likelihood of severe coral bleaching occurred in coastal waters in the Palm Island and South inshore zones. Areas of probable coral bleaching occurred in the south-west corner of the offshore zone and in the west of the Palm Island and South inshore zones. Sea surface temperature anomalies were greater than the previous year but not as large as 2019-20.

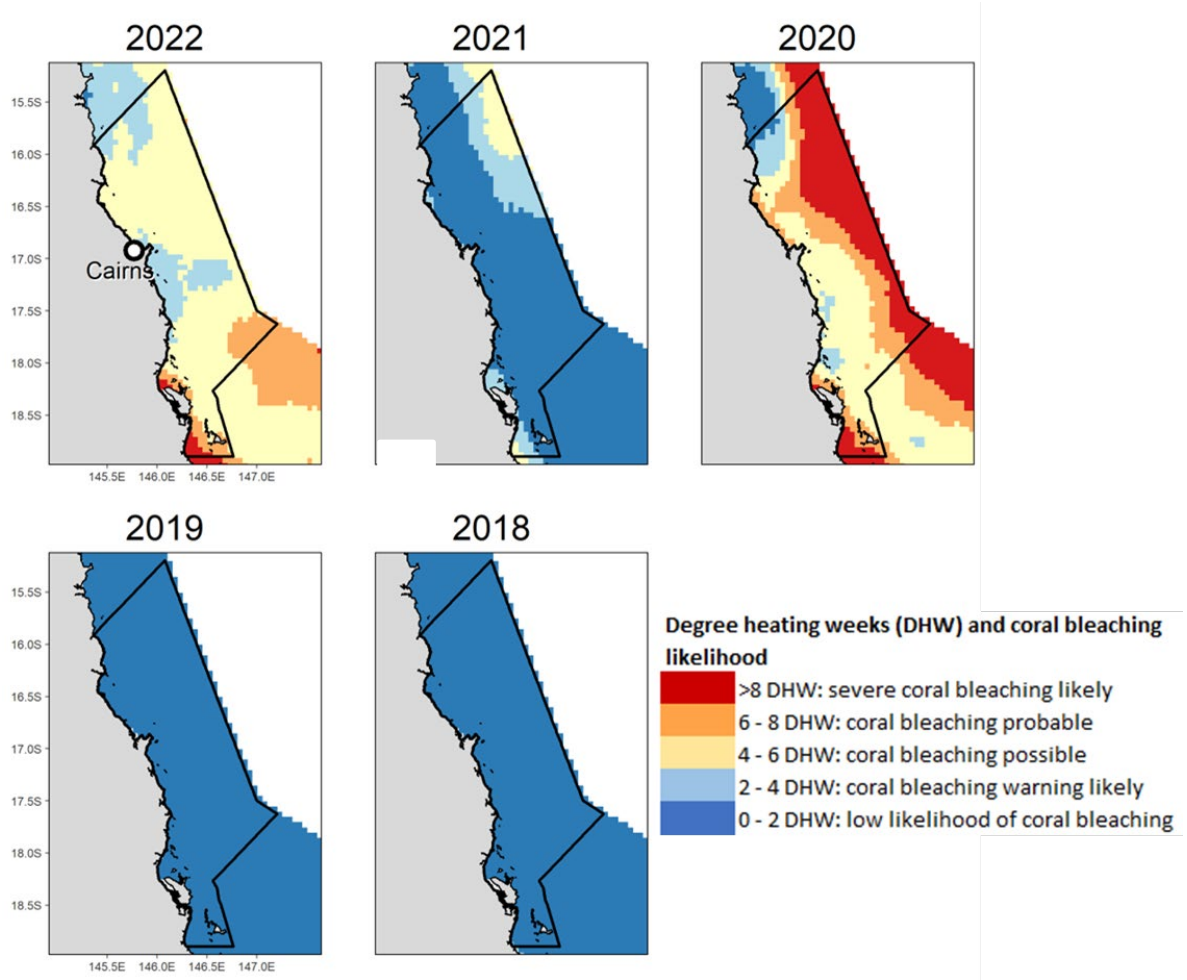

Figure 5 Annual degree heating week estimates likelihood of coral bleaching from 2017-18 to 2021-22 for the Wet Tropics inshore and offshore marine environments. Data are the annual maximum degree heating week estimates for each ~25 km^2 pixel. Data were sourced from NOAA coral reef watch.

Note: Degree heating week (DHW) is an accumulated measurement of sea surface temperature 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.

Key messages

- Annual rainfall across the region relative to the long-term average was highest in the coastal area of the Mulgrave basin and lowest in areas of the Johnstone, Tully, Murray and lower Herbert basins.
- Annual rainfall totals for all basins were within the average rainfall percentile category.
- During the months associated with the wet season (December to March), rainfall was mostly either average or below average.
- During months associated with dry season, rainfall was very much above average in September (Barron, Mulgrave and Russell) and April or May (all basins except Russell, Johnstone and Tully)
- Rainfall in April and May was associated with low pressure troughs on the east coast of Queensland that brought heavy rainfall to areas of the Tropical North Queensland coast.

- Annual discharge of the major rivers was similar to the long-term mean in all basins.
- Sea surface temperatures for the Wet Tropics inshore and offshore zones were above long-term average summer maximums with all areas above the low risk level for coral bleaching.
- Areas of severe coral bleaching risk level occurred in coastal waters in the Palm Island and South inshore zones.

4. FRESHWATER BASINS

The freshwater basin reporting zones and the water quality site locations are shown in Figure 6. An additional site (GBR CLMP) is shown in the upper catchment of the Tully Basin; this is used as a reference site for water quality but is not included in the Report Card condition assessment.

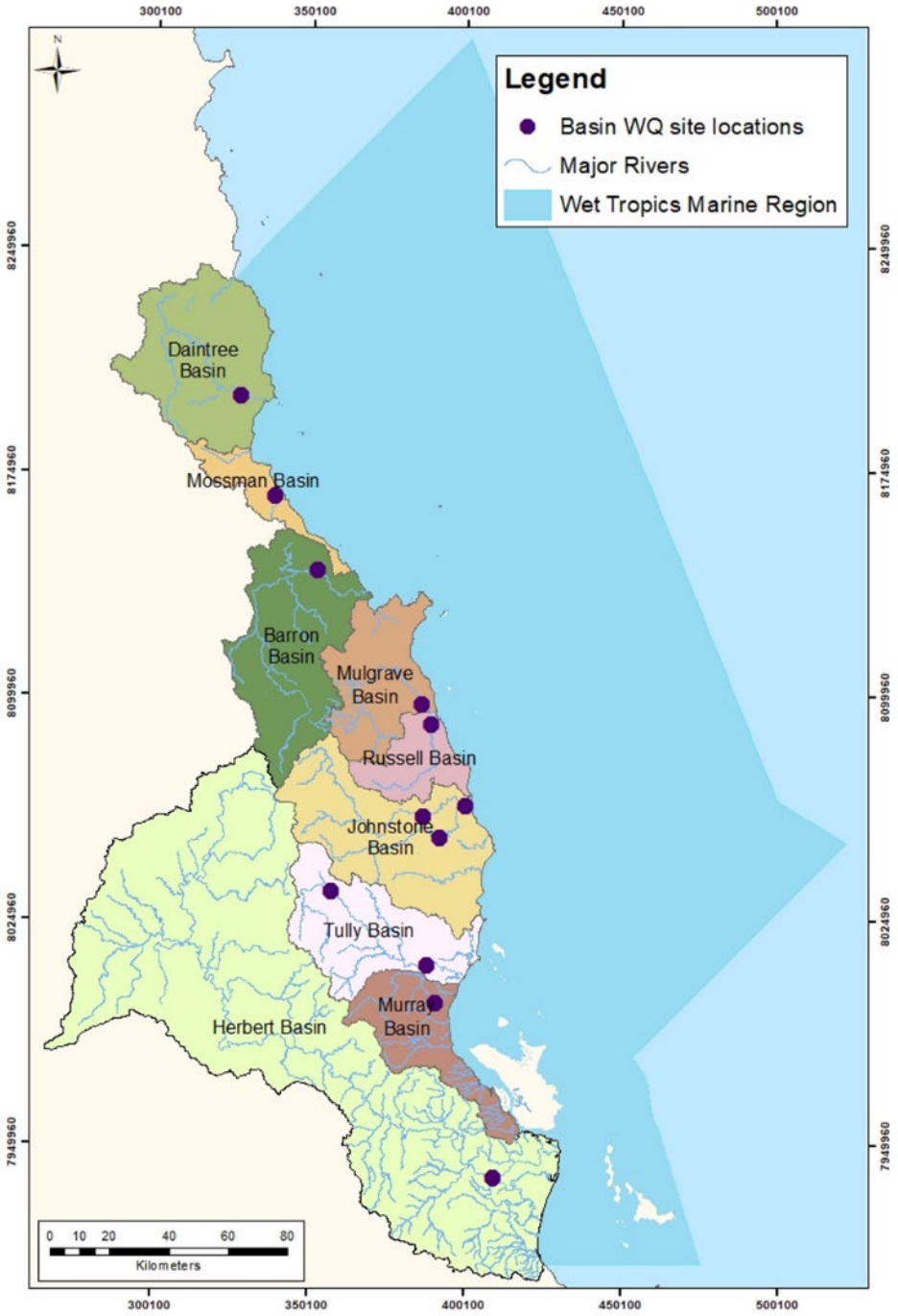

Figure 6 Freshwater basin water quality (WQ) monitoring site locations and basin reporting zones. The site in the upper Tully Basin is used as a GBR CLMP reference site and is not used for the Report Card condition assessment. The most downstream site in the Johnstone Basin is located in the estuary zone at Coquette Point. It is used for assessment of pesticides only for the Johnstone Basin.

The position of the water quality monitoring sites in relation to primary land use in the Wet Tropics region is shown in Figure 7 and provides a graphical presentation of land use upstream of the sites, which potentially affects the water quality of the samples collected. Note that the impact of land use downstream of the sampled sites, or in separate sub-basins, is not reflected in the water quality samples. The land use map also provides context for the habitat and hydrology indicators including riparian vegetation extent and wetland extent. Figure 7 shows the location of the Tully Gorge GBR CLMP reference site and its isolation from disturbed landscapes.

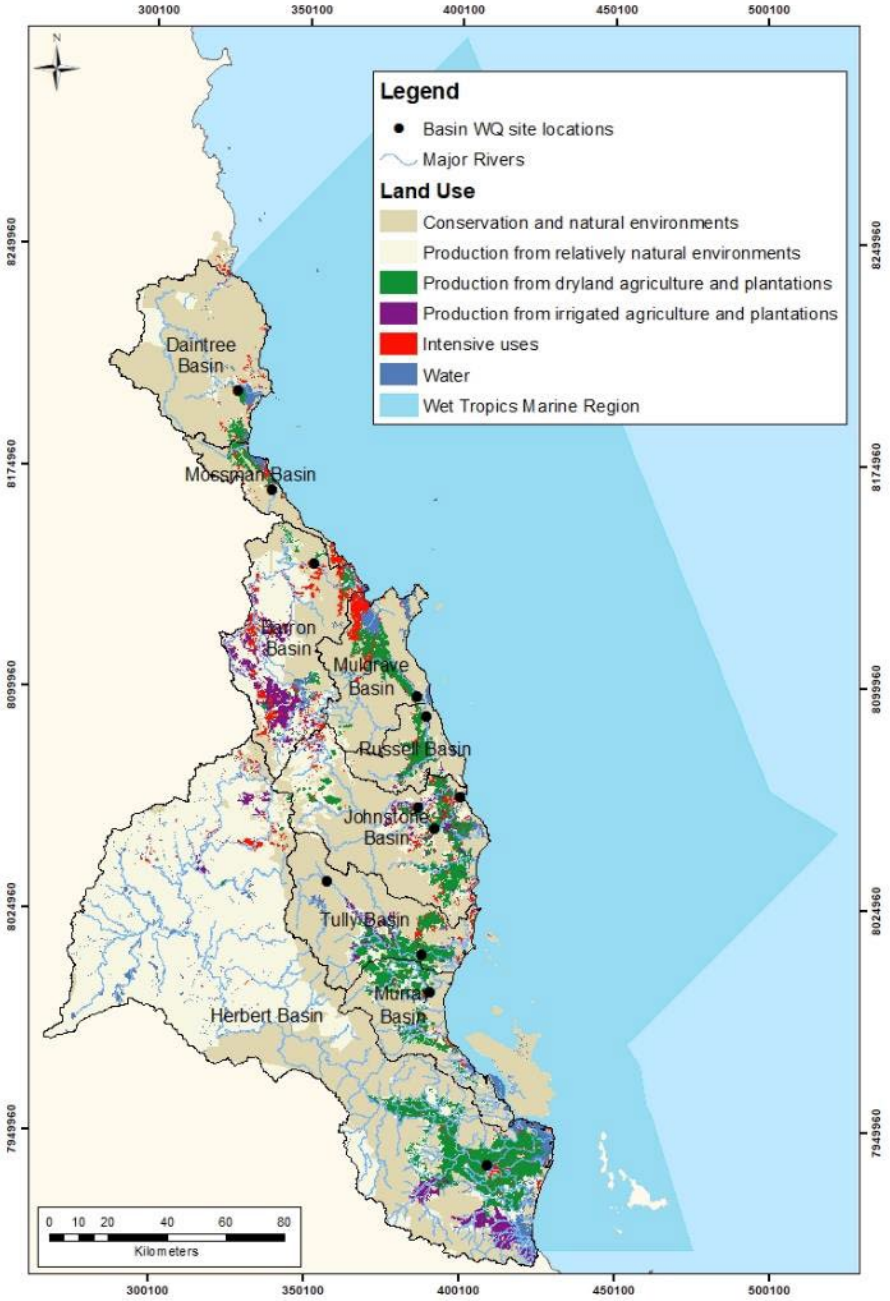

Figure 7 Location of freshwater basin water quality (WQ) monitoring site locations and primary land use in the Wet Tropics region. Source: Queensland Land Use Mapping Program Wet Tropics NRM region 2015 land use data set. http://qldspatial.information.qld.gov.au/

4.1. Water Quality

The methods for scoring water quality are described in the methods technical report (WTW 2023). The water quality index is comprised of sediment (total suspended solids), nutrients, (dissolved inorganic nitrogen and filterable reactive phosphorus) and pesticides (pesticide risk).

The water quality index grades for 2021-22 were the same as the previous year for all basins (Table 3). The Daintree had the highest score (87) and graded 'very good', the Murray had the lowest score (57) and graded 'moderate', whilst all other basins were graded 'good'. The most substantial change in water quality index score from the previous year occurred for the Murray (49 to 57) with improved scores for sediment and pesticides, which offset a decline in the nutrient score (Table 5 and Table 99). The water quality scores tend to reflect the proportion of land use in catchments upstream of monitoring sites that is natural or relatively natural versus land uses developed for production (Figure 7), with the Daintree having the highest proportion of natural land use and the highest score and the Murray having the lowest proportion of natural land use and the lowest score.

Table 3 Basin water quality index scores and grades for all reporting years

	Water quality						
Basin	**21-22**	**20-21**	**19-20**	**18-19**	**17-18**	**16-17**	**15-16**
Daintree	87	88	91	84	82	nd	nd
Mossman~	64	66	78	69	71	nd	nd
Barron	75	70	69	74	78	81	82
Mulgrave	69	73	69	66	66	63	62
Russell	74	75	67	75	68	70	73
Johnstone	70	75	78	75	69	72	79
Tully	65	71	71	68	63	66	65
Murray	57	49	49	59	nd	nd	nd
Herbert	70	66	73	61	71	76	80

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. nd indicates no data or insufficient data available. ~Mossman River was assessed for base-flow only.

Pesticides

The pesticide risk metric (PRM) values (expressed as percentage of species protected) for 2021-22 represents the average pesticide risk over the wet season for 182 days when exposed to a mixture of up to 22 different pesticides, including nine PSII herbicides (Photosystem II inhibitors), 10 non PSII herbicides and three insecticides. The wet season is determined as commencing when a rise in river water level occurs, but which is co-incident with an increase in aqueous pesticide concentrations (Warne et al. 2020). For each basin the PRM scores and standardised scores are presented in Table 4 and the proportion of the three pesticide categories that contribute to the pesticide risk metric is presented in Figure 8. The standardised scores for pesticides are also presented in Table 5 alongside the other water quality indicator scores, and in Table 99 to Table 104 for the previous years (2015-16 to 2020-21). Sampling for pesticides was expanded in 2017-18 and 2018-19 in order to populate the Pesticide Risk Baseline, and dropped back to a more routine sampling regime in 2019-20 and 2020-21 which did not include the Barron or Mossman basins. Pesticide monitoring was conducted in the Mossman River during 2021-22 hence the scores and grades are available for reporting. Pesticide

monitoring was also conducted at several sub-catchment sites across the Wet Tropics region for 2021-22. The relative contribution of chemicals to pesticide risk are presented for these additional sites alongside the routine sampling sites for 2021-22 and sampling sites for previous years in Appendix B p. 101, and the contribution of pesticide chemicals with respect to land use is discussed.

Note that for 2016-17 and 2015-16 the PRM was calculated from 13 PSII herbicides. The back calculated PRM for 2016-17 for the 22 pesticides was provided for reference in the results technical report for 2017-18 (WTW 2019).

Table 4 The percentage of species protected for basins using the pesticide risk metric, based upon 22 pesticides, and the standardised pesticide scores for the 2021-22 reporting period.

	Pesticide risk metric	
Basin	**Percent species protected**	**Standardised score**
Daintree	>99	**93**
Mossman	95.6	**64**
Barron	nd	nd
Mulgrave	98.2	**77**
Russell	96.7	**69**
North Johnstone	>99	-
Johnstone (Coquette Point)	96.7	**69**
Tully	95.3	**62**
Murray	89.6	**40**
Herbert	96.6	**69**

Pesticide risk metric scoring range: Very Poor = <80% (very high risk)| Poor = <90 to 80% (high risk)| Moderate = <95 to 90% (moderate risk)| Good = <99 to 95% (low risk)| Very Good = ≥99% (very low risk). **Standardised scoring range:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. Note: the North Johnstone is a sub-basin of the Johnstone Basin and only the Coquette Point site is used for scoring the Johnstone Basin. nd indicates no data or insufficient data available, - indicates not applicable as North Johnstone is not used to calculate the basin water quality score.

Additional information is provided in Appendix E about the pesticide risk metric, how pesticides can interact with waterway ecosystems and how to interpret the scoring ranges including per cent of species protected.

The pesticide risk score and grade for the Mossman basin improved from 60 ('moderate') from the last monitoring period in 2018-19 to 64 ('good') in 2021-22. The 2021-22 pesticide grades for all other basins (Table 5) were unchanged from the previous year except for the North Johnstone which improved from 'good' to 'very good' (Table 5, Table 99). Whilst the Murray remained the basin with the highest pesticide risk score, with its 'poor' grade distinct from all other reported basins (graded either 'good' or 'very good'), the pesticide risk did improve from the previous year with the standardised score increasing from 23 to 40 which represents a rise from 81% to over 89% species protected.

The proportional contribution of pesticide categories for all sites was highest for 'PSII herbicides' except for Mulgrave for which 'Other herbicides' was highest (Figure 8). Since 2020-21 the proportion of 'PSII herbicides' increased at all monitoring sites except for the Mulgrave, for which the proportion of 'Other herbicides' increased. The proportion of insecticides (predominantly

imidacloprid) decreased at all sites since 2020-21. Note that Mossman wasn't sampled in 2020-21, and the proportional contribution of pesticide categories was not presented for the Daintree and North Johnstone due to the very low concentrations recorded.

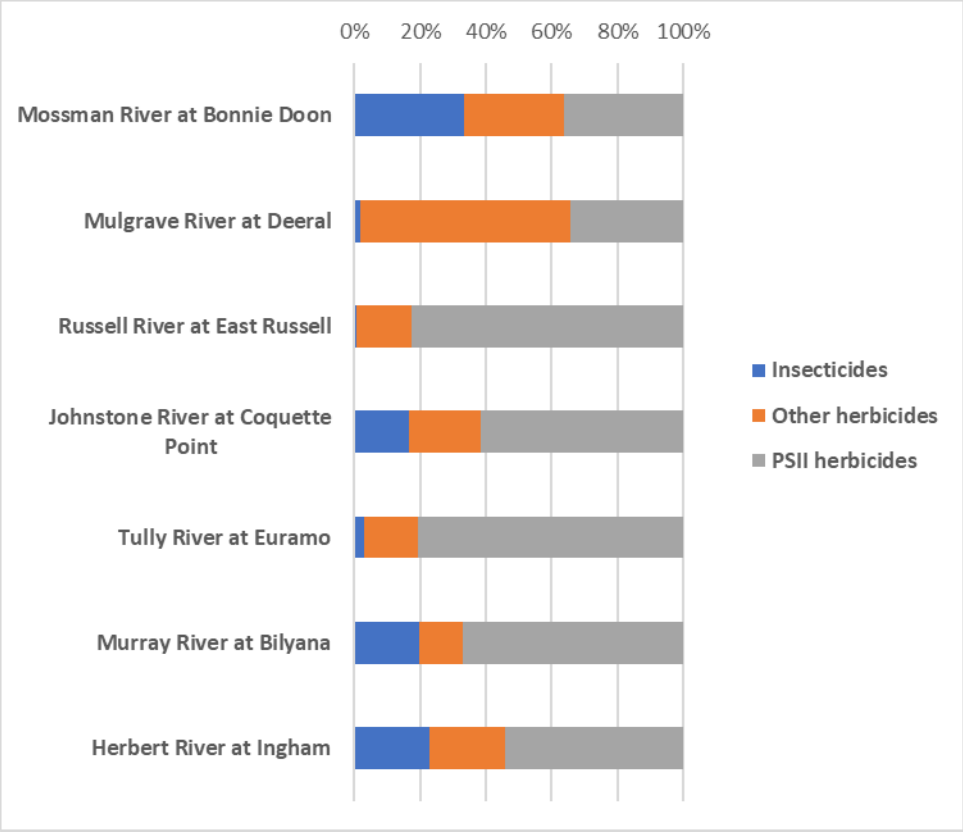

Figure 8 Percentage of pesticide categories contributing to the pesticide risk metric measure of percent species affected for basins.

Note: Daintree and North Johnstone were excluded due to the very low concentrations recorded.

See Appendix B p. 101 'Basin pesticides: risk and chemical contribution' for more information on the pesticide results including the relative contribution of chemicals to pesticide risk and additional sampling sites for 2021-22.

Key messages: pesticides

- The Murray continued to have the poorest condition with respect to pesticide toxicity, and was the only basin that did not receive a grade of 'good' or 'very good'.
- The Daintree and North Johnstone sites had the lowest concentrations of pesticides, and therefore, the lowest toxicity risk.
- The proportional contribution of insecticides decreased since the previous year for the Mulgrave, Russell, Johnstone (both sites), Tully, Murray and Herbert.
- Contribution of imidacloprid to pesticide risk was at its lowest compared to previous years for the Russell, North Johnstone, Tully, Murray and Herbert.

Sediment and nutrients

The scores and grades for water quality indicators, indicator categories and water quality index for 2021-22 are presented in Table 5. The complete water quality scores for 2020-21 back to 2015-16 are presented in Appendix G Table 99 to Table 104. The water quality monthly values for TSS, DIN and FRP concentrations along with scores and grades are presented separately for high flow and base-flow conditions in Appendix B (Table 62 to Table 71). Box and whisker plots of all data points for TSS, DIN and FRP concentrations of each basin for high flow and base-flow are presented in Appendix B (Figure 18 to Figure 20). Note that water quality sampling for the Mossman Basin was limited to lower flow conditions only, whilst for the Daintree Basin site water quality reporting for base-flow periods began in 2019-20, and added to the reporting for high flow periods, which began in 2017-18. Further information is available in the methods technical report (WTW 2023).

Table 5 Basin water quality index, indicator category and indicator scores and grades for the 2021-22 reporting period and water quality index results for preceding years.

Basin	Sediment	Nutrients			Pesticides	Water quality
	TSS	DIN	FRP	**Nutrients**		
Daintree	**90**	84	76	**80**	**93**	**87**
Mossman~	**90**	49	64	**57**	**64**	**64**
Barron	**80**	72	68	**70**	nd	**75**
Mulgrave	**80**	33	70	**51**	**77**	**69**
Russell	**90**	58	71	**65**	**69**	**74**
Johnstone	**81**	68	50	**59**	**69**	**70**
Tully	**79**	40	66	**53**	**62**	**65**
Murray	**90**	24	62	**43**	**40**	**57**
Herbert	**83**	43	76	**60**	**69**	**70**

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. nd indicates no data or insufficient data available. *Pesticide score was calculated from monitoring at the Coquette Point GBR CLMP site on the Johnstone River downstream of the South Johnstone and North Johnstone confluence. ~Mossman River was assessed for base-flow only. For each basin DIN and FRP indicator values are averaged to provide the nutrient indicator category score (presented in bold) and the three indicator categories (sediment, nutrients and pesticides) are averaged to provide the WQ score (all presented in bold).

The 2021-22 year did not have a strong contrasting dry season and wet season since monthly rainfall during typically dry season months (September, April and May) was higher than average whilst wet season rainfall had months with substantially lower than average rainfall (February and March) (Figure 3). This resulted in more 'dry season' months exhibiting higher flows than in other years and produced high flow conditions more spread across the year.

The Mulgrave Basin has had the most 'poor' grades for DIN among all nine basins over the eight years of reporting by the Wet Tropics report card. Whilst the majority of the basin land use is conservation and natural environments, substantial areas in the river valleys are used to grow sugarcane. The Mulgrave Basin has the fourth highest annual rainfall total in the Wet Tropics region and areas of its lowlands are characterised by substantial subsurface water flow (Bartley *et al*. 2017). The main anthropogenic source of DIN in the Mulgrave River catchment is derived from fertiliser applied in sugarcane production (ReefPlan) and both surface and sub-surface run-off from cane paddocks is a major pathway of DIN entering waterways (Bartley *et al*. 2017). Investment in a number of projects to reduce DIN run-off and improve water quality in the catchment is ongoing

with a range of partners working with farmers to achieve the projects' outcomes. Continued monitoring and reporting will identify changes in water quality resulting from these activities although there will likely be a lag time between on-ground actions and detectable changes in water quality.

The Murray River catchment is a relatively small area compared to the catchments of the major rivers in the other basins, and it has a relatively low discharge (Figure 4) with a high proportion of upstream area under agricultural land use (Figure 22). As discussed in Appendix B (p. 101) these characteristic of the Murray catchment are likely to contribute to its high pesticide risk and also may contribute to the poor score for DIN. The highest guideline exceedances of DIN were during high flow months (Table 65) when most rainfall runoff occurred, which is a major pathway for DIN to enter waterways (Bartley *et al*. 2017).

Key messages: sediment

- The Mulgrave and Tully declined from 'very good' to 'good' whilst the Russell and Murray improved from 'good' to 'very good' since the previous year. All other basin grades were unchanged.
- During baseflow conditions the highest TSS concentrations occurred in the Mulgrave at the end of August which coincided with heavy rainfall and the onset of high flow events in early September.
- During high flow conditions the highest TSS concentrations occurred in the Barron during January, February and March.
- Across all basins most monthly medians met the guideline values, which resulted in good or very good grades during both high flow and low flow conditions.

Key messages: nutrients

- DIN remained the poorest scoring water quality indicator for nutrients and sediment, and the Mulgrave Basin has scored the poorest for DIN overall during the eight reporting years.
- DIN grade improved from 'poor' to 'moderate' for the Mossman Basin, and the score increased substantially from 34 to 49 (base flow monitoring only). Basins that declined in grade from the previous year were the Barron ('very good' to 'good'), the Russell ('good' to 'moderate'), and the Murray ('moderate' to 'poor') which also had the poorest score (declining from 49 to 24) which resulted from multiple guideline exceedances occurring during high flow periods.
- FRP grades improved from 'moderate' to 'good' for the Mossman (score increased from 51 to 64) and the Murray (score increased from 60 to 62). All other basin scores were similar to the previous year and grades remained 'good', except the Johnstone which was the poorest scoring basin (50) and the grade remained 'moderate'.
- For the basins where both high flow and baseflow conditions are monitored (all basins except the Mossman), FRP had poorer scores during high flow conditions. This seasonal pattern also occurred for the two previous years (2019-20 and 2020-21).

The water quality index is a proxy for condition and is generated by comparing instantaneous water quality measurements (for example nutrient concentrations) against guideline values. The results do not directly relate to measurement of sediment, nutrient and pesticide loads. Programs that assess

pollutant loads, for example Paddock to Reef, also apply modelling to standardise the effects of rainfall and climate variation (Hateley et al. 2014). This means that, during drier years, condition assessments such as the water quality index may represent areas that are identified as high risk for water quality more favourably than loads assessments. Condition assessments should therefore not be used as a proxy for loads.

Confidence

Confidence scores and ranks for sediment, nutrients, pesticides and water quality index for freshwater basin water quality results are shown in Table 6. Confidence scores (1 – 3) for each criterion were weighted according to the 2017 updated methods for assessing confidence (WTHWP 2017). There was higher confidence in the sediment and nutrients results than in the pesticide results. For all three indicator categories 'representativeness' received the lowest score available (1 out of a possible 3). This was due to the low spatial representation of monitoring in the basins where monitoring mostly occurs at a single site and pesticides are monitored for only part of the year (wet season only).

Table 6 Confidence associated with sediment, nutrients and pesticides results in freshwater basins. Unless specified, confidence in results is the same across basins. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are the sum of the weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high).

Indicator category	Maturity of methodology (x0.36)	Validation (x0.71)	Represent-ativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final score	Rank
Sediment	3	3	1	3	2	8.7	3
Nutrients	3	3	1	3	2	8.7	3
Pesticides	1	2	1	2	2	6.6	2
Water quality index							
Basins with pesticide monitoring*	2	2.7	1	2.7	2	8.0	2
Basins without pesticide monitoring*	3	3	1	3	2	8.8	3

Rank based on final score: 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5. *All basins have pesticide monitoring except for the Barron. Pesticide monitoring in the Barron Basin ceased after the 2018-19 reporting year.

4.2. Habitat and Hydrology

The habitat and hydrology index scores and grades for all reporting years are presented in Table 7, and the index consists of instream habitat modification, flow, riparian extent, wetland extent and invasive weeds.

The habitat and hydrology index is comprised of four longer-term indicator categories that are scheduled to be updated every four years: wetland extent (to be updated for 2022-23), riparian extent, invasive weeds (updated for 2019-20), instream habitat modification (impoundment length (updated for 2018-19) and fish barrier indicators (in development)). Note that the riparian extent indicator has not been updated since reporting for the Wet Tropics commenced (2014-15 data) due to a lack of appropriate mapping data. The Program Design provides the full schedule for when new data are to be presented for longer-term indicators that are reported for periods longer than a year (WTHWP 2018). The annual scores for habitat and hydrology index from 2015-16 to 2016-17 represented changes resulting from the addition of indicators and not changes in existing indicator scores themselves. During this period invasive weeds reporting commenced in 2015-16 and flow reporting commenced in 2016-17, whilst riparian extent, wetland extent and impoundment length were not updated. Changes in scores between 2019-20 to 2021-22 were due to the annual update of the flow indicator, with all other indicators remaining unchanged.

Table 7 Basin habitat and hydrology index scores and grades for all reporting years

Basin	Habitat and hydrology						
	21-22	20-21	19 -20	18 -19	17 -18	16 -17	15 -16
Daintree	78	78	78	80	80	81	81
Mossman	68	72	68	56	63	63	55
Barron	45	44	46	47	45	47	43
Mulgrave	66	67	66	63	71	65	66
Russell	69	69	66	63	69	70	63
Johnstone	60	64	63	59	65	65	57
Tully	62	63	56	54	65	61	57
Murray	55	58	55	56	58	55	54
Herbert	59	60	56	57	61	56	54

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100.

Habitat modification (instream)

The habitat modification indicators were not updated for 2021-22. The habitat modification indicator category was based upon the impoundment length indicator only (updated for 2018-19), since the fish barrier condition indicator is still in development. Impoundment length scores and grades are provided in Table 8. There were no impoundments on streams of order three or higher in the Daintree, Mossman, Mulgrave, Russell, and Murray basins, and 0.1% impounded streams on the Johnstone and 0.4% on the Herbert, giving them condition scores ‘very good’. The Barron received a ‘poor’ with 7.7% of the total length of the streams (order three and above) impounded by artificial structures. The Barron and Tully have the lowest scores due to large water infrastructure such as Tinaroo Dam (Barron) and Koombooloomba Dam (Tully). The impoundment length indicator is updated every four years and was initially reported for the 2014-15 reporting period.

Table 8 Results for impoundment length indicator for basins.

Basin	Not impounded (km)	Impounded (km)	Total (km)	% total	Standardised score	Grade
Daintree	2,795	0	2,795	0.0	100	VG
Mossman	335	0	335	0.0	100	VG
Barron	791	66	857	7.7	36	P
Mulgrave	344	0	344	0.0	100	VG
Russell	174	0	174	0.0	100	VG
Johnstone	782	1	783	0.1	98	VG
Tully	461	22	483	4.6	57	M
Murray	351	0	351	0.0	100	VG
Herbert	3,290	13	3,304	0.4	92	VG

Impoundment (% total): Very Poor = ≥10% | Poor = 7 to <10% | Moderate = 4 to <7% | Good = <4 to 1% | Very Good <1%. **Standardised scoring range:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100

The score and grade for the habitat modification indicator category are presented in Table 9.

Table 9 Results for habitat modification indicator category for basins.

Basin	Fish barrier condition score	Impoundment length condition score	Habitat modification grade
Daintree	nd	100	VG
Mossman	nd	100	VG
Barron	nd	36	P
Mulgrave	nd	100	VG
Russell	nd	100	VG
Johnstone	nd	98	VG
Tully	nd	57	M
Murray	nd	100	VG
Herbert	nd	92	VG

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. nd indicates no data available.

Habitat extent

The habitat extent indicators were not updated for 2021-22.

The scoring and grading of habitat extent is based upon the percentage of habitat extent loss and applies formulas to convert the percent loss value to a standardised score (Table 10). Further information on the methods used for generating the habitat extent indicators are provided in the methods technical report (WTW 2022).

Table 10 Scoring ranges, grades and standardisation formula for the habitat extent indicators.

Percent of habitat loss	Grade	Scaling of scores for aggregation
≤5.0%	Very Good	VG = 81+ ABS((19 - ((score-0) *(19/4.9))))
>5.0-15.0%	Good	G= 61+ ABS((19.9 - ((score -5.1) *(19.9/9.9))))
>15-30.0%	Moderate	M=41+ ABS((19.9 -((score -15.1) *(19.9/14.9))))
>30-50%	Poor	P= 21+ ABS((19.9- ((score -30.1) * (19.9/19.9))))
>50%	Very Poor	VP=ABS((20.9 - ((score-50.1) *(20.9/49.9))))

The riparian extent percent loss since pre-clearing, and the scores and grades are shown for each basin in Table 11.

Table 11 Results for riparian vegetation extent indicator: percent loss from pre-clearing to 2013.

Basin	Riparian extent loss (%) to 2013	Standardised score	Grade
Daintree	0.0	99	VG
Mossman	11.5	68	G
Barron	11.1	68	G
Mulgrave	6.1	78	G
Russell	5.7	79	G
Johnstone	8.1	74	G
Tully	9.0	72	G
Murray	7.8	75	G
Herbert	3.9	85	VG

Riparian extent (% loss): Very Poor = >50% | Poor =>30 to 50% | Moderate = >15 to 30% | Good = >5 to 15% | Very Good ≤5%. **Standardised scoring range:** : ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. **Note**: These results are for extent of riparian (woody vegetation), not condition.

The Daintree and Herbert scored 'very good', with all other basins scoring 'good'. The midlands and uplands generally have better riparian extent due to protected areas and less development, whilst the lowlands are poorer due to development and land use. The riparian extent indicator is updated when riparian extent mapping updates are produced by the Remote Sensing Centre, Department of Environment and Science. The period of update for the Wet Tropics report card is generally every four years. However, the mapping data from 2017 onward has been undergoing considerable change to satellite imagery used and data processing to improve resolution and accuracy of vegetation mapping. The updated mapping is planned to be released in 2023 and this will also require revision to the riparian extent indicator to align with the new data sets.

The wetland extent percent loss since pre-clearing, and the scores and grades, along with the hectares lost since 2013, are shown for each basin in Table 12.

Table 12 Results for wetland extent indicator: percent wetland loss from pre-clearing to 2017 and hectares lost from 2013-2017.

Basin	Wetland Extent Loss (%) to 2017	Standardised Score	Grade	Hectares lost 2013 - 17
Daintree	15.8	60	M	0.0
Mossman	60.7	16	VP	0.6
Barron	73.2	11	VP	0.0
Mulgrave	37.6	33	P	3.0
Russell	37.4	33	P	0.0
Johnstone	45.2	25	P	0.0
Tully	57.8	17	VP	6.6
Murray	53.5	19	VP	37.3
Herbert	51.9	20	VP	31.6

Wetland extent (% loss): ■ Very Poor = >50% | ■ Poor =>30 to 50% | ■ Moderate = >15 to 30% | ■ Good = >5 to 15% | ■ Very Good ≤5%. **Standardised scoring range:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. **Note:** These results are for wetland extent (palustrine water bodies), not condition of wetlands.

The Daintree was graded 'moderate', with Mossman, Barron, Tully and Herbert graded 'very poor' and the remaining basins graded 'poor'. The largest wetland losses since 2013 occurred in the Murray and Herbert basins whilst some wetland losses since 2013 occurred in Tully, Mulgrave and Mossman basins. These results include a high level of historical loss of wetland extent since pre-clearing to 2017, due to development. Wetland loss is low in areas with no development or low levels of development, for example wetlands are largely intact in the upper freshwater catchment of the Daintree Basin. The wetland extent indicator is updated every four years. The next available update of wetland extent data will occur when Queensland Wetland data version 6 is released (due in 2023).

Note that for the 2018-19 reporting period the 2017 wetland extent data was obtained from the most recent Regional Ecosystems mapping (Version 5) and Queensland Wetland Data Version 5 as used for the Paddock to Reef Integrated Monitoring, Modelling and Reporting program (P2R). The Wetland extent data for 2013 was based on version 4 of the Regional Ecosystem mapping. Slight differences of wetland extent between these data are evident, for example the Daintree Basin was previously graded 'good' having a wetland extent loss of 14.6% based on version 4 of the Regional Ecosystem mapping for wetlands. There has been no wetland loss in the Daintree Basin since 2013 however the revised grade is now 'moderate' having a wetland extent loss of 15.8% based on the most recent Regional Ecosystem mapping (Version 5) and Queensland Wetland Data Version 5.

Invasive weeds (aquatic)

The invasive weeds indicator was not updated for 2021-22. Invasive weeds are assessed and results updated every four years. The most recent assessment was for 2019-20. An update on the status of measures for control of the Amazon frogbit (*Limnobium laevigatum*) in the Wet Tropics region during 20-21 is provided at the end of this section.

The assessment of invasive aquatic weeds divides the actual basin impact score by the potential basin impact score of the basins to produce the percent impact score for each basin which are converted to standardised scores (0-100) (Table 13). Invasive weeds had the greatest percent impact score in the Murray and Herbert basins (both 'very poor') with substantial percent impact scores in the Barron and Johnstone ('poor'). Daintree, Mulgrave and Russell were moderately impacted. The lowest impacts were recorded in the Tully ('good') and Mossman ('very good').

Table 13 Results for invasive weed indicator potential impact scores and grades for basins 2019-20.

Basin	Basin impact score	Potential impact score	Percent impact score	Standardised score	Grade
Daintree	1,174	8,692	13.5	54.4	M
Mossman	126	1,098	11.5	81.0	VG
Barron	1,962	12,512	15.7	34.7	P
Mulgrave	732	4,917	14.9	43.8	M
Russell	589	3,863	15.2	41.0	M
Johnstone	2,741	16,594	16.5	24.7	P
Tully	1,357	11,238	12.1	71.2	G
Murray	1,068	6,234	17.1	19.9	VP
Herbert	7,659	38,983	19.7	19.3	VP

Invasive weed percent impact score: Very Poor > 19.7 | Poor >17.3-19.7 | Moderate >16.1-17.3 | Good >13.4-16.1 | Very Good 0-13.4. **Standardised scoring range:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100.

Key messages: invasive weeds (results for 2019-20)

- An outbreak of the floating invasive macrophyte Amazon frogbit (*Limnobium laevigatum*) has occurred in the Barron since the previous assessment (2015-16). Mapping of Amazon frogbit in the Barron Basin from 2016 to 2019 has shown how rapidly new invasive weed species can spread through waterways (Figure 9). More information on Amazon frogbit effect on waterway health is available at https://weeds.dpi.nsw.gov.au/Weeds/Details/286.
- The 'very good' grade in the Mossman has followed the Douglas Shire Council's targeted control program of invasive aquatic weeds. The program has successfully removed salvinia (*Salvinia molesta*) and water hyacinth (*Eichornia crassipes*) from most known locations in water ways (including artificial impoundments) of the Mossman Basin.
- Surveying of invasive aquatic weeds has continued and expanded in many of the Wet Tropics basins resulting in greater detection of species distribution and increased mapping confidence.
- Over the 2019-20 reporting period Hinchinbrook Shire Council mounted an eradication response to an outbreak of hygrophila (*Hygrophila costata*) in the Herbert and has successfully contained the infestation. It is now in monitoring toward eradication.

The invasive aquatic weeds with the greatest presence in the Wet Tropics are presented in Table 14. All four species were present in all basins with the exception of water hyacinth which wasn't recorded in the Russell and Johnstone basins. Impacts and threats to waterway health for each species are provided in the table and further information on the invasive weeds method as well as species information with links to their assessment profiles is available in Sydes and Hunt (2017) from the WTW website (wettropicswaterways.org.au). Updates to the calculation of the invasive weeds indicator which included the addition of Amazon frogbit (*L. laevigatum*) are presented in the methods technical report (WTW 2022).

Table 14 Invasive aquatic weeds with greatest presence in the Wet Tropics and their impacts and threats.

Common name	Scientific name	Form	Habitat	Ecosystem components impacted and threats
Hymenachne	*Hymenachne amplexicaulis*	Emergent	Instream and riparian	Instream connectivity, hydrology (restriction of flows and increased flooding), biodiversity, community composition, water quality, aquatic food webs. Populations are capable of replacing native vegetation communities
Salvinia	*Salvinia molesta*	Free floating	Instream	Hydrology (restriction of flow including flood flows), biodiversity, community composition, water quality, aquatic food webs. Promotes disease vectors (e.g. mosquitoes). Promotes water loss through transpiration.
Water hyacinth	*Eichornia crassipes*	Free floating	Instream	Hydrology (restriction of flows including flood flows), biodiversity, community composition, water quality, aquatic food webs. Promotes disease vectors (e.g. mosquitoes). Promotes water loss through transpiration.
Pond apple	*Annona glabra*	Aquatic/ wetland tree	Instream and riparian, freshwater and brackish	Hydrology (restriction of flows), biodiversity, community composition, water quality, aquatic food webs. Populations are capable of replacing native vegetation communities.

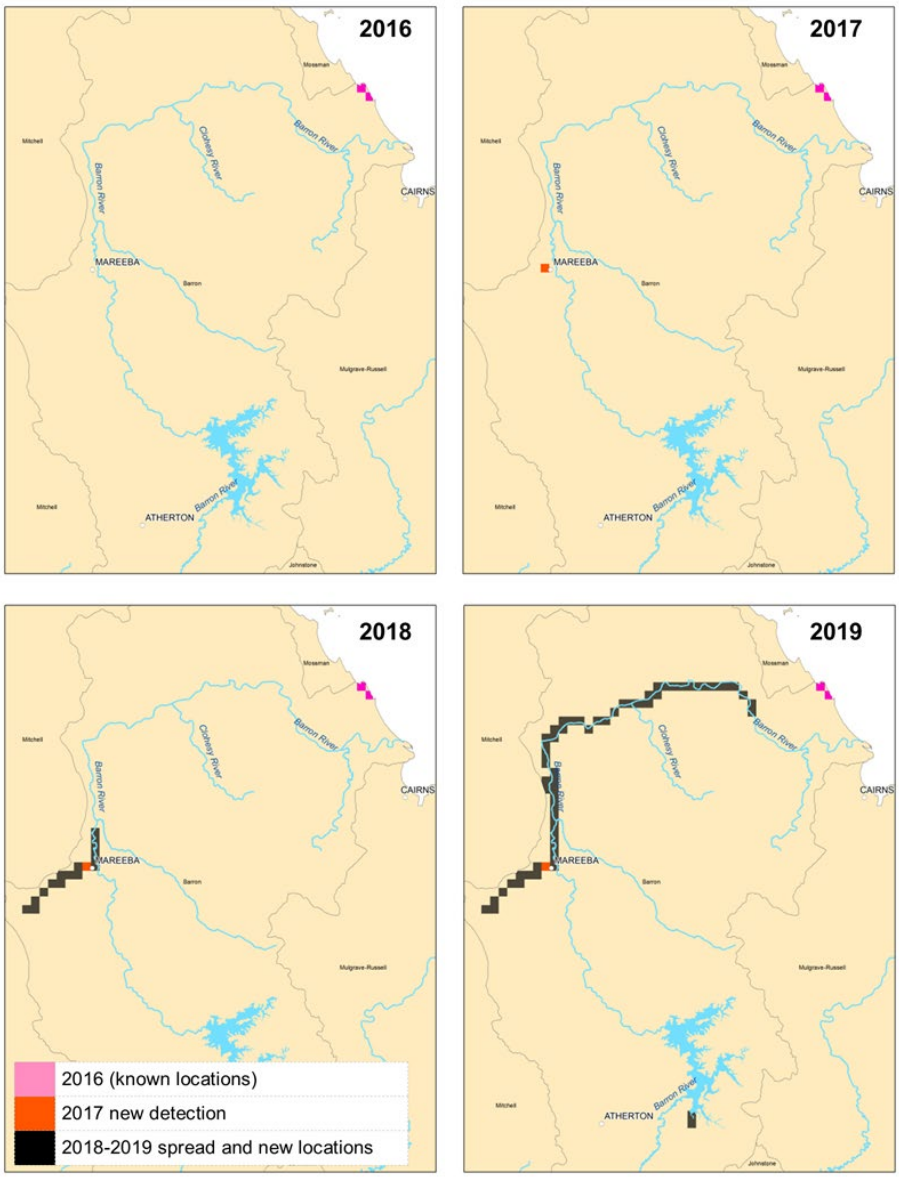

Figure 9 Distribution and spread of the invasive aquatic weed Amazon frogbit in the Barron Basin. (Source: Travis Sydes, FNQROC).

The recent invasion of Amazon frogbit was likely to have been started from human assisted introduction, most likely from the emptying of aquarium contents into a tributary of the Barron River near the Mareeba township. Despite a range of efforts from council and local contractors dense mats of Amazon frogbit developed in Granite Creek and Atherton Creek and the weed was transported downstream to the Barron River by high flows. An additional infestation was detected in Peterson Creek near Yungaburra upstream of the Tinaroo Falls Dam. There is a high risk that the Amazon frogibit could invade other basins in the Wet Tropics. Whilst further invasions could occur from human assisted dispersal it is also possible that viable seeds or vegetated fragments could be distributed to other basins by water birds. Since reporting the invasion of Amazon frogbit in the 2019-20 Wet Tropics report card the following actions have progressed (updated for 2021-22).

Development of a regional action plan led by regional stakeholders to address a range of issues

- Protecting clean catchments and preventing spread to new locations in the Wet Tropics and the Gulf catchments.
- Implementing regulatory approaches to restrict sale and accessibility through local laws and advocacy for inclusion in State legislation.
- Coordinating actions across stakeholders managing core infestations.
- Promoting awareness of impacts on World Heritage values in the Barron catchment and environmental impacts from the infestation on water quality and threatened species such as Myola tree frog.

On ground management

- Maintenance of sentinel sites to detect potential spread into the Mitchell River Catchment.
- Control and removal to prevent impacts on power generation infrastructure at Barron Gorge Hydroelectric Power Station.
- Detection and removal of minor infestations in adjoining catchment areas.

Research and management communications

- Registration by the APVMA of CLIPPER herbicide (Flumioxazin 15g tablet) for the control of Amazon frogbit in aquatic situations (see DAF factsheet below).
- Investigation into additional/alternative aquatic herbicide.
- Invasive biology research is underway at the Centre for Wet Tropics Agriculture in South Johnstone- this includes seed longevity and reproductive biology research as well as general invasive biology work.
- A fact sheet has been developed by Biosecurity Queensland: https://www.daf.qld.gov.au/__data/assets/pdf_file/0011/1572419/Amazon-frogbit-Limnobium-laevigatum.pdf
- Report on naturalisation in Victoria and overview of national status - https://sway.office.com/DpTTR90lZLFm5xMl?ref=email

Flow

All basins were assessed with the flow indicator for 2021-22 except for the Daintree Basin which was not assessable due to the lack of modelled pre-development data.

For the Wet Tropics region annual rainfall for all basins was within the average percentile range (Table 2, Figure 3). Monthly rainfall (Figure 3) leading up to the wet season was very much above average in September for the Barron, Mulgrave and Russell basin, and all basins except Russell, Johnstone and Tully had monthly rainfall very much above average post wet season in either April or May. During the wet season (December to March) in all basins, monthly rainfall was either average or below average, with only the Barron having a month (January) with above average rainfall.

The flow indicator includes an assessment of the rainfall type for the reporting year and then compares the flows from the reporting year to modelled pre-development flows from past years with the same rainfall type. This means that the flow metrics for the reporting year provide scores based upon previous years with similar rainfall totals. The results are to be interpreted within the

context of the prevailing rainfall conditions for the reporting year. Conditions over the reporting year were drier than the previous year in the southern half of the region, and similar to the previous year in the northern half of the region. The rainfall type, calculated by the flow indicator, changed from 'average' for the Johnstone and Tully, and 'wet' for the Murray and Herbert in the previous year, to 'dry' in 2021-22, and was unchanged (wet or average) for the other basins (Table 15). Note that some differences can occur between rainfall classification produced by the flow indicator tool and BoM climate reporting (Figure 3) due to differences between the analyses used to assess rainfall.

Table 15 Rainfall type and number of flow assessment sites for 2021-22, and standardised flow indicator basin scores and grades for the 2021-22 and previous years.

Basin	Rainfall type	Number of assessment sites	Score and grade 2021-22	Score and grade 2020-21	2019-20	2018-19	2017-18	2016-17
Daintree	-			nd	nd	nd	nd	nd
Mossman	Wet	1	75	95	75	61	95	95
Barron	Average	7	77	69	80	65	51	62
Mulgrave	Wet	2	78	80	75	55	93	61
Russell	Average	2	91	91	76	61	95	95
Johnstone	Dry	5	77	96	92	66	97	96
Tully	Dry	2	95	100	61	43	99	80
Murray	Dry	2	61	78	61	68	78	61
Herbert	Dry	12	80	86	66	69	92	62

Standardised scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. nd: no data available to assess the flow indicator for the Daintree Basin.

With the exception of one site, the flow assessments sites in all basins were graded either 'good' or 'very good' (Appendix C Table 86) which corresponds to the majority of flow measures being within 68% of the expected range (Stewart-Koster *et al.* 2018). For most flow assessment sites the flow categories of cease to flow, low flows, low to medium flows and high flows, as represented by the 10 flow measures (Appendix C Table 86), were not substantially altered from modelled pre-development in their capacity to provide key ecological values of water holes, low flow spawning fish, riffle habitats and fisheries production. The flow categories are representative of the conditions required for maintaining key hydraulic habitat and refuge within waterways. The only assessment site that was graded below 'good' was Rudd Creek at Gunnawarra in the Herbert Basin (Queensland Government gauging station number: 116016A), which was graded 'moderate' and scored 49. River height and discharge were not recorded at the Rudd Creek Gunnawarra gauging station from 8/5/22 to 15/2/22 but the flow indicator requires the complete daily flow record for the year. The period of missing data was filled using the River Assessment Package linear interpolation function (Marsh 2004), but this was clearly not effective as a substitute for the actual flow data since the period of missing data, which occurred during high rainfall events, was too long (Figure 10). Consequently, the flow measure scores for Rudd Creek at Gunnawarra flow assessment site may not have been accurate.

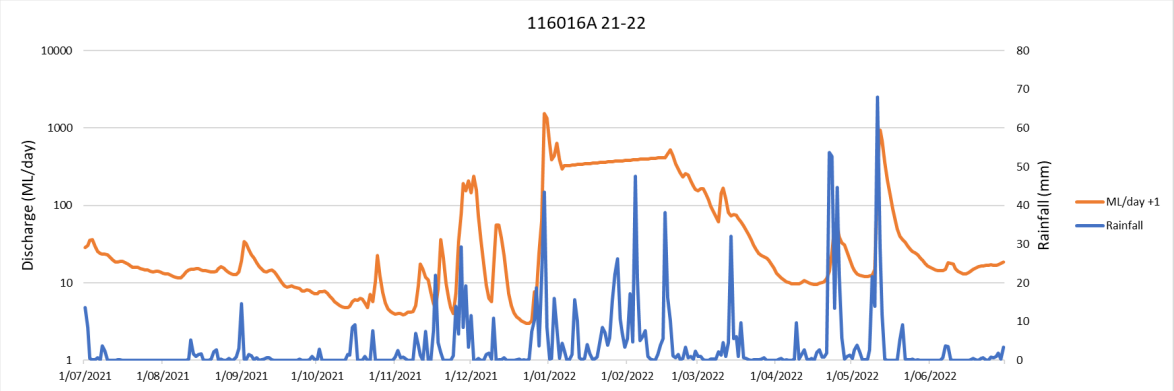

Figure 10 Discharge and rainfall at Rudd Creek at Gunnawarra Basin (Queensland Government gauging station number: 116016A) for 2021-22 with missing data from 8/1/22 to 15/2/22 added using linear interpolation using the River Assessment Package (Marsh *et al.* 2003). Note that discharge was transformed (+1) to allow for log scaling.

Key messages: flow

- Annual rainfall was within the average range for all basins, whilst rainfall type was 'dry' for basins in the south of the region and 'average' or 'wet' for basins in the north of the region.
- 2021-22 was drier than the previous year for basins in the south of the region.
- Flow assessment sites in all basins were graded either 'good' or 'very good' except for Rudd Creek at Gunnawarra in the Herbert Basin' which was 'moderate'.
- The score for Rudd Creek at Gunnawarra may have been compromised due to a substantial gap in the daily discharge data.
- Scores for basins in 2021-22 were mostly lower than the previous year.

Habitat and hydrology index

The 2021-22 scores and grades for basin habitat and hydrology indicator categories and index are presented in Table 16. The habitat and hydrology indicator categories and index scores for basins from 2020-21 back to 2015-16 are presented in Appendix F Table 105 to Table 110.

Table 16 Results for habitat and hydrology indicator categories and index for2021-22

Basin	Flow	Invasive weeds	Habitat modifi-cation	Riparian extent	Wetland extent	2021-22
Daintree	nd	54	100	99	60	**78**
Mossman	75	81	100	68	16	**68**
Barron	77	34	36	68	11	**45**
Mulgrave	78	43	100	78	33	**66**
Russell	91	41	100	79	33	**69**
Johnstone	77	24	98	74	25	**60**
Tully	95	71	57	72	17	**62**
Murray	61	19	100	75	19	**55**
Herbert	80	19	92	85	20	**59**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available. The habitat and hydrology index (scores in bold) is an average of the five indicator categories.

Confidence

Confidence for habitat and hydrology results are shown in Table 17. Confidence scores (1 – 3) for each criterion have been weighted according to the 2017 updated methods for assessing confidence (WTHWP 2017).

Table 17 Confidence associated with habitat and hydrology indicator results in basins. Unless specified, confidence in results is the same across basins. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are the sum of the weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high).

	Maturity of method-ology (x0.36)	Valid-ation (x0.71)	Represent-ativeness (x2)	Direct-ness (x0.71)	Measured error (x0.71)	Final	Rank
Impoundment length	2	2	3	2	1	10.2	4
Riparian extent	2	2	2	2	2	8.9	3
Wetland extent	3	2	3	2	2	11.3	4
Invasive weeds	2	2	3	2	2	10.9	4
Flow: Mossman, Mulgrave, Russell, Tully Murray	1	2	1	1	1	5.2	1
Flow: Barron, Johnstone, Herbert	1	2	2	1	1	7.2	2
Habitat and Hydrology							
Daintree	2.2	2	2.8	2	1.8	10.4	4
Mossman, Mulgrave, Russell, Tully Murray	1.9	2	2.4	1.8	1.5	9.3	3
Barron, Johnstone, Herbert	1.9	2	2.6	1.8	1.5	9.7	3

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

4.3. Fish

The basin fish index was not updated for 2021-22.

The basin fish assessment was conducted during 2019-20 in all basins except for the Daintree. The basin fish assessment commenced in the 2017-18 reporting period with assessments for the Mulgrave and Russell basins. For details of the methods and results of 2017-18 refer to WTW 2020a (methods) and WTW 2020b (results). The number of sites surveyed, the total number of fish species caught, and the number of alien species (species introduced into Australia) and translocated species (Australian species moved to areas outside their natural distribution) caught in the 2019-20 survey for each basin are presented in Table 18. The results for the proportion of indigenous fish species (POISE) caught and the proportion of non-indigenous fish species (PONI) caught (comprised of the proportion of alien fish and translocated fish measures) are presented as indicator scores and standardised scores in Table 19. Further results of the fish assessment in Appendix E present the list of fish species caught in the Wet Tropics region (Table 88), the fish species caught at the sites within each basin (Table 89 to Table 96), the number of translocated and alien species caught within each basin (Table 97) and box plots showing the distribution of sites for each basins in relation to the POISE and PONI indicators (Figure 25).

Table 18 The number of sites surveyed, the total number of species caught, and the number of alien and translocated species caught, for each basin during the 2019-20 fish assessment.

Basin	Number of sites	Number of species caught	Number of alien species caught	Number of translocated species caught
Mossman	13	22	2	0
Barron	11	29	2	13
Mulgrave	13	38	3	0
Russell	14	38	3	0
Johnstone	11	30	4	3
Tully	11	36	3	0
Murray	13	32	3	1
Herbert	28	41	5	3

It is important to note that 'Translocated' refers to Australian native species that were found in waterways within which they do not naturally occur, and 'Alien' refers to fish species from outside of Australia. Some species are indigenous to the lowland sections of some basins but have been translocated to upper sections above waterfalls. This is particularly the case for the Barron Basin as described in the key messages below.

Translocation of fish species in the Wet Tropics region has occurred for over 100 years and more recently this activity has been regulated with the introduction of permits for fish stocking in 1996 (Burrows 2004). The stocking of fish under permits in the Wet Tropics region has been conducted in lower river reaches of the Barron, Mulgrave, Russell, Johnstone, Tully, Murray and Herbert and also in the more heavily stocked impoundments of Tinaroo Falls Dam (Barron River, Atherton Tablelands) and Koombooloomba Dam (headwaters of the Tully River) (Burrows 2004). Fish species stocked under permits in these two impoundments in recent years are barramundi (*Lates calcarifer*) and sooty grunter (*Hephaestus fuliginosus*), with limited stocking of northern saratoga (*Scleropages jardini*) in Tinaroo Falls Dam (Queensland Government 2020). These species don not naturally occur at these locations. Of these species, barramundi is unable to develop self-sustaining populations in impoundments due to its life cycle requirement for migration to marine environments to reproduce, whilst sooty grunter has established self-sustaining populations in Koombooloomba Dam (Burrows 2004). There has been no evidence that northern saratoga became successfully established in Lake Tinaroo (Queensland Government 2020). These populations can potentially contribute to the number of translocated fish reported for the fish assessment if they move from impoundments into connected waterways that are surveyed.

Table 19 Results for the freshwater basin fish indicators index for 2019-20 and fish index results for 2017-18.

	Fish indicator scores				Standardised scores				
Basin	**POISE**	Prop Trans	Prop Alien	**PONI**	**POISE**	**PONI**	**Fish**		**Fish 17-18**
Mossman	0.63	0.00	0.00	0.00	55	100	77		
Barron	0.67	0.06	0.02	0.13	60	35	48		
Mulgrave	0.79	0.00	0.01	0.01	79	89	84		76
Russell	0.91	0.00	0.01	0.01	91	94	92		86
Johnstone	0.78	0.00	0.02	0.04	78	66	72		
Tully	0.80	0.00	0.00	0.00	81	100	90		
Murray	0.72	0.00	0.00	0.01	68	92	80		
Herbert	0.81	0.00	0.00	0.02	81	88	85		

Fish indicator scoring range POISE: Very Poor = 0 to <0.4 | Poor = 0.4 to <0.53 | Moderate = 0.53 to <0.67 | Good = 0.67 to <0.8 | Very Good = 0.8 – 1; **PropTrans, PropAlien, PONI:** Very Poor = >0.2 to 1 | Poor = >0.1 to 0.2 | Moderate = >0.05 to 0.1 | Good = >0.03 to 0.05 | Very Good = 0 to 0.03. **Standardised scoring range:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. Fish indicator scores are the proportion of indigenous species expected (POISE), and proportion of non-indigenous fish (PONI). The PONI indicator is the median of the proportion of translocated fish (PropTrans) and proportion of alien fish (PropAlien) measures summed for each site. nd indicates no data available.

From the Queensland Department of Agriculture and Fisheries fish stocking records in Wet Tropics basins for 2010 to 2018, the only species stocked during this period has been barramundi. The most recent stocking and the most fish stocked has been in impoundments with Tinaroo Falls Dam receiving the greatest numbers (Table 20). Numbers stocked into rivers was highest for the Herbert River but occurred in 2010 whilst lower numbers were stocked into the other river locations in the Mulgrave and Russell basins during 2012 (Table 20). The most likely influence of fish stocking on survey results would be linked to the impoundments in the Barron and Tully basins due to the high numbers stocked and the more recent stocking events. There were no barramundi recorded during assessments at sites within the Barron Basin and the species was only recorded at two Tully sites, both in lowland tributaries of the Tully River (Appendix E), demonstrating that stocked barramundi could not have had a substantial effect on report card results.

Table 20 Barramundi stocking locations, year and numbers stocked for the Wet Tropics region from 2010 to 2018.

Basin	Location	Year	Total stocked
Barron	Barron River	2012	500
	Tinaroo Falls Dam	2010-18	141007
	Copperlode Dam	2016-17	26925
Mulgrave	Trinity Inlet	2012	500
	Mulgrave River	2012	500
Russell	Russell River	2012	500
Tully	Koombooloomba Dam	2010-2018	15370
Herbert	Herbert River	2010	8741

Data source: Queensland Government (https://www.data.qld.gov.au/dataset/queensland-freshwater-fish-stocking-records)

Key messages: fish

- The Mossman and Barron basins had the lowest observed species diversity compared to expected, with both basins graded moderate for the POISE indicator.
- The Russell Basin had the highest observed species diversity compared to expected.
- All basins, except for the Barron and Johnstone, were graded 'very good' for the proportion of indigenous fish indicator meaning that there was very low presence of translocated and alien species.
- The Barron was graded 'poor' for the proportion of indigenous fish indicator, with translocated fish species rather than alien fish species representing most of the non-indigenous fish species present.
- Most of the Barron catchment is above the Barron Falls which is a natural barrier to fish movement. The upper-Barron catchment is located upstream of Tinaroo Falls which may have been a significant natural barrier to fish and is now the site of Tinaroo Falls Dam. Consequently, the species diversity of fish in the catchment upstream of the Barron falls is naturally depauperate. The stocking of fish species into the Barron has been common practice and the fish fauna upstream of Barron Falls is one of the most modified in Australia (Burrows 2004).
- The fish index for basins was 'very good' except for the Mossman, Johnstone and Murray graded 'good' and the Barron graded 'moderate'.
- Fish assemblages showed substantial spatial variation within each basin. Whilst the basin scores are based on the median values from all sites, at the site level the scores for both indicators varied considerably (Appendix D Figure 25).

Fish communities and risk to species from pesticides

Whilst the 2019-20 risk assessment of pesticides identified high risk to species of biota for the Murray River (graded 'poor' with 80 - <90% of species protected), the health of the waterways in terms of the fish index for the Murray basin was graded 'good'. The pesticide risk metric is based on the results of toxicity tests (generally under laboratory or mesocosm conditions) that provide measures of the effects of pesticides upon a wide range of (predominantly non-fish) species. The species most at risk from pesticides depends on the type of pesticides that they are exposed to. This occurs because pesticides are designed to kill or knock down 'pest' species. Ideally, pesticides target the pest organism with minimal effects on non-target organisms. For example, herbicides are designed to target plants (weeds); therefore (in general) they are a higher risk to other phototrophic species, i.e. algae and aquatic plants (including seagrass and coral), but a lower risk to animal species. In contrast, insecticides are designed to target insects, and therefore are (in general) a higher risk to aquatic insects and other arthropods (e.g. crabs, lobsters, prawns and copepods), but a lower risk to plant and other animal species. That said, many of the organisms upon which the effects of pesticides have been tested are likely to be components of fish habitat (e.g. aquatic algae and plants) and diet (e.g. aquatic macroinvertebrates). These indirect impacts to the non-target organisms in catchments exposed to pesticide risk are still unknown at this stage and require further investigation.

Additional information is provided in Appendix E about the pesticide risk metric, how pesticides can interact with waterway ecosystems and how to interpret the scoring ranges including per cent of species protected.

Confidence

Confidence fish indicator results for the 2019-20 period are shown in Table 21. Confidence scores (1 – 3) for each criterion have been weighted according to the 2017 updated methods for assessing confidence (WTHWP 2017).

Table 21 Confidence associated with fish indicator results in basins. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are the sum of the weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high).

	Maturity of methodology (x0.36)	Validation (x0.71)	Represent-ativeness (x2)	Direct-ness (x0.71)	Measured error (x0.71)	Final	Rank
Native richness	1	2	2	3	1	8.6	3
Pest fish abundance	1	2	2	3	1	8.6	3
Fish index	1	2	2	3	1	8.6	3

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

4.4. Overall basin scores and grades

The index and overall scores and grades for 2021-22 are presented in Table 22, and the overall scores and grades for each reporting year are presented in Table 23. The overall score is averaged from the water quality, habitat and hydrology and fish indices. When comparing overall scores and grades between years it is important to note that differences relate to the addition of indicators as

well as changes in scores over time. The habitat and hydrology index scores represent the addition of indicators for invasive weeds in 2015-16 (reported every four years) and flow in 2016-17 (updated annually), with updates to the wetland extent (2017-18), impoundment length (2018-19 but no change in score) and invasive weeds (2019-20). The riparian extent, (first reported for 2014-15) has not been updated as yet. The water quality index scores have been updated annually. Fish assessment reporting began in 2017-18 for the Mulgrave and Russell basins and was expanded in 2019-20 to all basins except for the Daintree Basin.

Table 22 Index and overall scores and grades for 2021-22. Overall basins scores and grades for all years.

Basins	Water quality	Habitat and hydrology	Fish	21-22
Daintree	**87**	**78**	nd	**83**
Mossman	**64**	**68**	77	**69**
Barron	**75**	**45**	48	**56**
Mulgrave	**69**	**66**	84	**73**
Russell	**74**	**69**	92	**78**
Johnstone	**70**	**60**	72	**67**
Tully	**65**	**62**	90	**72**
Murray	**57**	**55**	80	**64**
Herbert	**70**	**59**	85	**71**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100.

Table 23 Overall basins scores and grades for all years.

Basins	21-22	20-21	19-20	18-19	17-18	16-17	15-16
Daintree	83	83	85	82	81	81*	81*
Mossman	69¥	72¥	74¥	63	67	63*	55*
Barron	56¥	54¥	54¥	61	61	64	63
Mulgrave	73¥	74¥	73¥	68¥	71¥	64	64
Russell	78¥	79¥	75¥	75¥	75¥	70	68
Johnstone	67¥	70¥	71¥	67	67	68	68
Tully	72¥	75¥	72¥	61	64	64	61
Murray	64¥	63¥	61¥	57	59*	55*	54*
Herbert	71¥	70¥	71¥	59	66	66	67

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. *Scores do not include the water quality index and represent habitat and hydrology index only. ¥Score includes the fish index.

5. ESTUARIES

The locations of the estuary reporting zones are shown in Figure 11. Monitoring and assessment of estuarine indicators was conducted in the vicinity of the reporting zone locations as described in the methods technical report (WTW 2023).

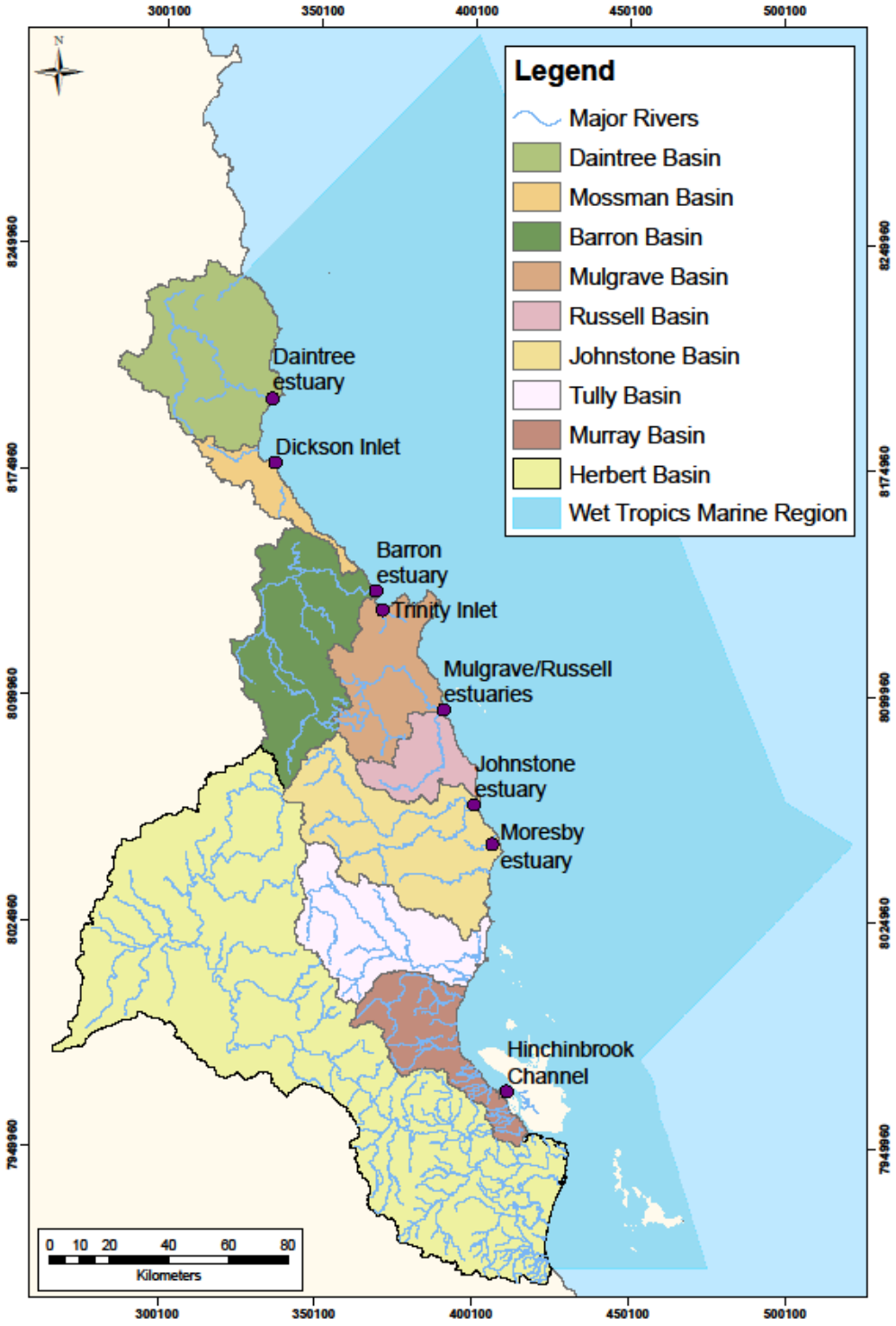

Figure 11 Location of estuary reporting zones.

5.1. Water Quality

Details of the monitoring frequency, indicators, and sample and site locations are provided in the methods technical report (WTW 2023). The water quality index is comprised of pesticides (pesticide risk), phys-chem (turbidity and dissolved oxygen), nutrients (dissolved inorganic nitrogen and filterable reactive phosphorus) and chlorophyll *a*.

The water quality index scores for 2021-22 were lower than the previous year for all estuaries except for Trinity Inlet which remained unchanged. All grades were 'good' except for the Barron which was 'moderate' and declined from 'good' the previous year. The Daintree and Dickson Inlet declined to 'good' following several years graded as 'very good'.

Table 24 Estuary water quality index scores and grades for all years.

Estuary	Water quality						
	21-22	20-21	19-20	18-19	17-18	16-17	15-16
Daintree	79	88	92	81	85	80	79
Dickson Inlet	71	82	81	83	80	64	nd
Barron	46	70	60	61	66	64	50
Trinity Inlet	73	73	70	58	65	78	83
Russell-Mulgrave	72	79	80	72	66	75	78
Johnstone	67	77	76	76	67	72	63
Moresby	67	76	83	80	79	81	78
Hinchinbrook Channel	73	79	85	77	82	90	85

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available.

Pesticides

For the three estuaries where pesticides are reported the monitoring sites are the GBR CLMP end of system sites as used for freshwater basins. Sampling for pesticides was expanded in 2017-18 and 2018-19 in order to populate the Pesticide Risk Baseline, and dropped back to a more routine sampling regime in 2019-20 which did not include the Barron estuary. The pesticide risk metric (PRM) value for the Russell-Mulgrave was calculated as the average value of the two basins. The PRM values (expressed as a percentage of species protected) represent the average pesticide risk over the wet season for 182 days when exposed to a mixture of up to 22 different pesticides, including nine PSII herbicides (Photosystem II inhibitors), 10 non PSII herbicides and three insecticides. The wet season is determined as commencing when a rise in river water level occurs, but which is co-incident with an increase in aqueous pesticide concentrations (Warne et al. 2020). For each estuary the PRM score is presented in Table 25 and the proportion of the three pesticide types that contribute to the pesticide risk metric is presented in Figure 12. The relative contributions of chemicals to pesticide risk for 2021-22 and previous years at the basin pesticide sites used for estuary reporting are presented in in Appendix B Figure 21 (note that results for Russell and Mulgrave are provided separately). The standardised scores for pesticides are presented in Table 25 and Table 26 for 2021-22 and in Table 112 to Table 117 for the previous reporting years. Note that for 2016-17 and 2015-16 the PRM was calculated from 13 PSII herbicides. The back calculated PRM for 2016-17 for the 22 pesticides was provided for reference in the results technical report for 2017-18 (WTW 2019).

Table 25 The percentage of species protected for estuaries using the pesticide risk metric, based upon 22 pesticides, and the standardised pesticide scores for the 2021-22 reporting period.

Estuary	Pesticide risk metric Percent species protected	Standardised score
Daintree	> 99	93
Russell-Mulgrave	97.5	73
Johnstone (Coquette Point)	96.7	69

Pesticide risk metric scoring range: Very Poor = <80% (very high risk)| Poor = <90 to 80% (high risk)| Moderate = <95 to 90% (moderate risk)| Good = <99 to 95% (low risk)| Very Good = ≥99% (very low risk). **Standardised scoring range:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. Note that the most recent result for the Barron estuary was for 2018-19 with > 99% percentage of species protected.

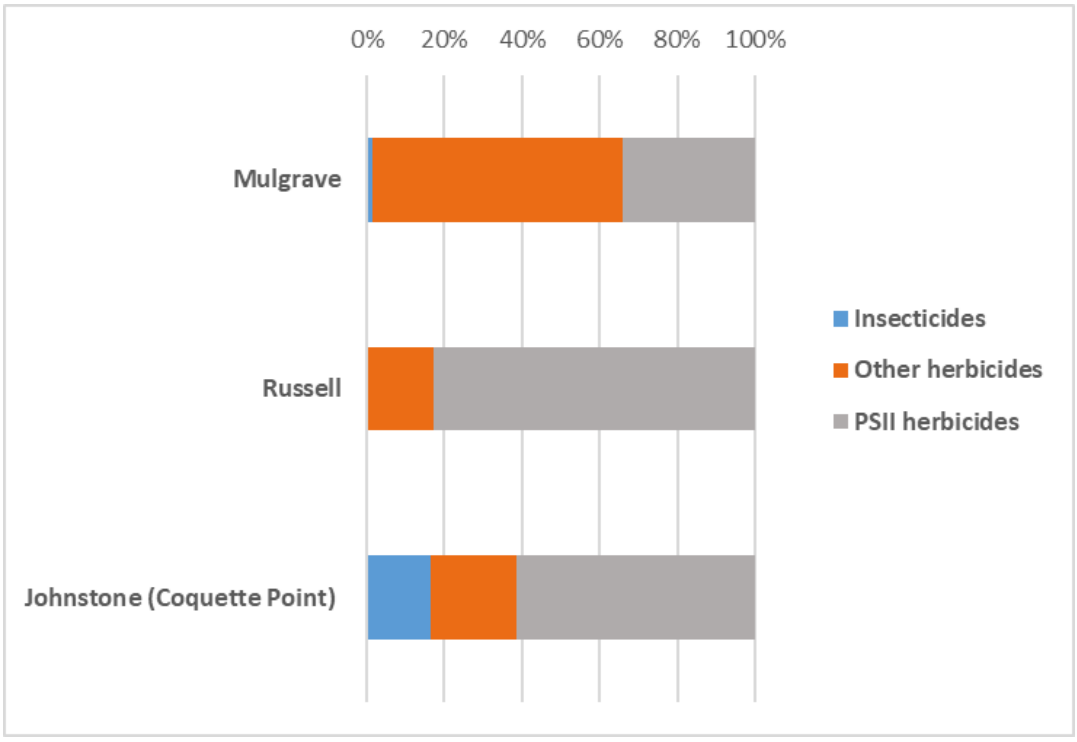

Figure 12 Percentage of pesticide categories contributing to the pesticide risk metric measure of percent species affected for estuaries.

Note: Daintree was excluded due to the very low concentrations recorded.

For pesticides in 2021-22 the Daintree estuary was graded 'very good' and the Russell-Mulgrave and Johnstone estuaries were graded 'good' which equates to pesticide toxicity of very low risk and low risk, respectively. In comparison to 2020-21, the pesticide scores decreased from 94 to 93 in the Daintree, whilst the Russell-Mulgrave and Johnstone both decreased from 75 to 73 and 69, respectively (Table 26 and Table 112). The proportion of pesticide categories differed from the previous year with PSII herbicides increasing for Russell and Johnstone and declining for the Mulgrave, whilst insecticides declined at all three sites, particularly the Johnstone. The major contributing chemicals were metolachlor (other herbicide) and diuron (PSII herbicide) for the Mulgrave, diuron for the Russell, and imidacloprid (insecticide) and diuron for the Johnstone (Appendix B p. 101).

Key messages: pesticides.

- Estuaries with pesticide monitoring (Daintree, Russell-Mulgrave and Johnstone) were at low risk or very low risk from pesticide toxicity.
- Grades for pesticides in 2021-22 remained the same for all three monitored estuaries.
- Scores declined for all three estuaries from the previous year.
- The proportion of insecticides decreased at all monitoring sites compared to the previous year.

Whilst there is no targeted monitoring of pesticides in the Hinchinbrook Channel, both the Murray River and Herbert River are monitored for pesticides and drain into the north and the south of the channel, respectively. The additional monitoring site for 2021-22 on Catherina Creek also drains into the Herbert River close to the river mouth (Appendix B Figure 23). The pesticide monitoring data, particularly the relative contribution of chemicals of these rivers (Appendix B Figure 21) can provide insight into pesticide types and risk of waters entering the channel noting that dilution of river discharge occurs when mixing with the enclosed coastal waters of the channel.

Additional information is provided in Appendix E about the pesticide risk metric, how pesticides can interact with waterway ecosystems and how to interpret the scoring ranges including per cent of species protected.

Chlorophyll *a*, nutrients and physical-chemical

The scores and grades for the water quality index for all reporting years are presented in Table 24. The scores and grades for the water quality indicators, indicator categories and water quality index for 2021-22 are presented in Table 26. The indicators, indicator categories and water quality indices for previous reporting years are presented in Appendix F Table 112 to Table 117. For estuary reporting zones where more than one water type is monitored, the annual scores and grades for chlorophyll *a*, turbidity, dissolved oxygen, DIN and FRP are aggregated from mid-estuary and lower estuary/enclosed coastal water types. The monthly means, condition scores and grades for each reporting zone are presented in Appendix B Table 72 to Table 79.

Table 26 Estuary water quality indicator, indicator category and index scores and grades for 2021-22. Water quality index scores and grades for all years.

Estuary	Chl *a*	Nutrients			Phys/Chem				Pest-icides	Water quality
	Chl *a*	DIN	FRP	**Nut-rients**	Turb-idity	DO Low	DO High	**Phys/ Chem**	Pest-icides	
Daintree	**55**	71	90	**80**	90	90	90	**90**	**93**	**79**
Dickson Inlet	**66**	65	80	**72**	90	59	90	**74**	**nd**	**71**
Barron	**30**	37	48	**43**	75	59	90	**67**	**nd**	**46**
Trinity Inlet	**64**	90	90	**90**	90	42	90	**66**	**nd**	**73**
Russell-Mulgrave	**90**	31	56	**44**	90	71	90	**80**	**73**	**72**
Johnstone	**90**	22	48	**35**	90	73	90	**73**	**69**	**67**
Moresby	**51**	66	90	**78**	90	56	90	**73**	**nd**	**67**
Hinchinbrook Channel	**47**	90	90	**90**	90	76	90	**83**	**nd**	**73**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. Risk metric scores for pesticide are from GBR CLMP sites as per freshwater basins. nd indicates no data available. For each estuary DIN and FRP indicator values are averaged to provide the Nutrient indicator category score (presented in bold) and that the turbidity and DO indicator scores (using the lowest of the two DO values) are averaged to provide the Phys/Chem indicator score (presented in bold). The indicator categories (Chl *a*, nutrients, Phys/Chem and Pesticides) are averaged to provide the WQ score (all presented in bold). **Note:** Pesticides are from GBR CLMP high flow data as per freshwater basins.

Since 2020-21, chlorophyll *a* declined from 'very good' for the Daintree and Dickson Inlet to 'moderate' and 'good', respectively, from 'good' to 'moderate' for the Moresby and Hinchinbrook Channel, and from 'good' to 'poor' for the Barron. Chlorophyll *a* in the Barron for 2021-22 returned to more typical condition in years previous to 2020-21 when it has consistently scored the poorest for chlorophyll *a* across all estuary zones, with grades varying between 'very poor' to 'moderate'. 2021-22 was the first reporting year where chlorophyll *a* declined to a 'moderate grade' for the Daintree, Moresby and Hinchinbrook Channel.

DIN declined from 'very good' to 'good' for the Daintree, from 'moderate' to 'poor' for the Barron and Russell-Mulgrave, and remained 'poor' for the Johnstone but the score decreased substantially from 37 to 22. Trinity Inlet and Hinchinbrook remained 'very good', Dickson Inlet and Moresby remained 'good'. There are examples of poorer scores for DIN occurring in estuaries, which represent higher concentrations, that do not correlate with the lower DIN concentrations reported for the upstream freshwater sites. Whilst the 'poor' score for DIN in the Russell-Mulgrave estuary was similar to the 'poor' score for the Mulgrave Basin end of system site (33), the 'poor' estuary scores for DIN of the Barron and Johnstone were distinct from the 'good' scores and lower DIN concentrations at the end of system freshwater sites of their basins. Higher DIN concentrations and poorer scores at estuary sites compared to the upstream freshwater sites may be a consequence of land use and activities such as wastewater treatment plants which can increase DIN inputs from the catchment area between the freshwater and estuary monitoring sites. There are also very different processes occurring within freshwater and estuarine environments, including tidal influences in estuaries, which affect nutrient concentrations.

Substantial decreases in the FRP score occurred for the Barron, Russell-Mulgrave and Johnstone estuaries, with some guideline exceedances coinciding with higher rainfall months post wet-season. The Barron declined from 'good' (73) to 'moderate' (43), Russell-Mulgrave declined from 'very good'

(90) to ‘moderate’ (56) and the Johnstone decline from ‘good’ (70) to ‘moderate’ (48). The grade for FRP remained ‘very good’ for Trinity Inlet, Moresby and Hinchinbrook Channel.

With the exception of the Barron, turbidity was graded ‘very good’ for all estuaries with grades unchanged from the previous year. Turbidity for Barron declined to ‘good’ (75) from ‘very good’ (90) the previous year.

The scores for dissolved oxygen increased slightly for the Russell-Mulgrave which remained ‘good’, the Daintree which remained ‘very good’, whilst Trinity Inlet improved from ‘poor’ (31) to ‘moderate’ (42) but remained the estuary with the lowest score for dissolved oxygen over the last six years. The scores for dissolved oxygen in all other estuary zones decreased from the previous year with declines in grade occurring for Dickson Inlet (‘very good’ to ‘moderate’), the Barron (‘good’ to ‘moderate’), the Johnstone (‘very good’ to ‘good’) and the Moresby (‘good’ to ‘moderate’).

Trinity Inlet is a relatively large estuary in the Wet Tropics comprised of a network of mangrove channels and receives freshwater flows from a small sub-catchment of the Mulgrave Basin. The Trinity Inlet sub-catchment also includes a substantial urban footprint with waterways such as Chinaman Creek and Wrights Creek draining areas with some of the highest levels of residential and industrial development within the Wet Tropics region. The limited supply of freshwater draining into the estuary and inputs from surrounding urban environment may result in lower dissolved oxygen saturation compared to smaller estuaries fed by catchments with greater freshwater flows and lower levels of urban development. An assessment of available long-term monitoring dissolved oxygen saturation data for Trinity Inlet collected by the Queensland Department of Environment and Science was presented in WTW 2022 (Appendix B p.132). The historical data was collected at sites across a greater spatial coverage of the estuary than the sites used for the Wet Tropics report card, which are located in the western arm and were established to inform the Receiving Environment Monitoring Plan (REMP) for Cairns Regional Council. The long-term monitoring sites show a gradient of dissolved oxygen saturation which is highest at downstream sites and lowest at upstream sites on the western arm. The gradient is likely due to a positive effect of tidal waters on dissolved oxygen saturation which reduces with distance from estuary mouth, the influence of land use development on water quality along the western arm, and the limited freshwater inflows.

Key messages: chlorophyll *a*, nutrients, physical-chemical.

- 2021-22 was the first reporting year where chlorophyll *a* declined to a ‘moderate grade’ for the Daintree, Moresby and Hinchinbrook Channel.
- Chlorophyll *a* in the Barron declined to more typical condition, with the lowest score of all estuary zones, which is consistent with most previous years following the ‘good’ grade in 2020-21.
- DIN declined from ‘very good’ to ‘good’ for the Daintree, from ‘moderate’ to ‘poor’ for the Barron and Russell-Mulgrave, and remained ‘poor’ for the Johnstone but the score decreased substantially from 37 to 22. The grades for the other estuaries remained unchanged.
- Substantial declines in FRP condition occurred for the Barron (‘good’ to ‘moderate’), the Russell-Mulgrave (‘very good’ to ‘moderate’) and the Johnstone (‘good’ to ‘moderate’).

- For dissolved oxygen Trinity Inlet improved from 'poor' to 'moderate' (42) but remained the estuary with the lowest score over the last six years.
- Declines in grade for dissolved oxygen occurred for Dickson Inlet ('very good' to 'moderate'), the Barron ('good' to 'moderate'), the Johnstone ('very good' to 'good') and the Moresby ('good' to 'moderate').

Confidence

Confidence scores are presented in Table 27. Confidence scores (1 – 3) have been weighted according to the 2017 updated methods for assessing confidence (WTHWP 2017). Confidence in pesticides is expected to improve as the methodology and analysis of the pesticide risk metric calculations progress in subsequent years.

Table 27 Confidence for water quality indicator categories and index in estuary reporting zones. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are the sum of the weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high).

	Maturity of methodology (x0.36)	Validation (x0.71)	Represent-ativeness (x2)	Directness (x0.71)	Measured error (x0.71)		
Indicator categories							
Phys-chem	3	3	1*, 1.5	3	1[#], 2		
Nutrients	3	3	1*, 1.5	3	1[#], 2		
Chl-*a*	3	3	1*, 1.5	3	1[#], 2		
Pesticides[$]	1	2.1	1	2.5	2		
Water quality Index						**Final score**	**Rank**
Daintree	2.5	2.9	1.4	2.8	2	**9.2**	**3**
Dickson Inlet	3	3	1	3	1	**8.1**	**2**
Barron	3	3	1	3	2	**8.8**	**3**
Trinity Inlet	3	3	1.5	3	2	**9.8**	**3**
Russell-Mulgrave	2.5	2.9	1	2.8	2	**8.4**	**3**
Johnstone	2.5	2.9	1	2.8	1.3	**7.9**	**2**
Moresby, Hinchinbrook Channel	3	3	1.5	3	2	**9.8**	**3**

[$]Pesticide scores apply to Daintree, Russell-Mulgrave and Johnstone estuaries. *The lower representativeness score applies to Dickson Inlet, Barron, Russell-Mulgrave and Johnstone estuaries due to a lower frequency of sampling events for their monitoring programs. [#]The lower measured error score applies to Dickson Inlet and the Johnstone estuary due to differences in quality assurance and quality control of the monitoring program.
Rank based on final score: 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

5.2. Habitat and Hydrology

The habitat and hydrology index consists of estuary fish barriers, flow, riparian extent, mangrove and saltmarsh extent, mangrove habitat and seagrass condition (for estuaries where it is known to be a

significant habitat). Of these, three are longer-term indicators that are intended to be updated every four years: mangrove and saltmarsh extent (updated for 2021-22), riparian extent (updated for 2021-22) and fish barriers (Daintree, Dickson Inlet and Barron updated for 2021-22). The indicator for shoreline mangrove habitat was introduced in 2020-21 and provides measures of condition to complement mangrove extent reporting. Initially, shoreline mangrove habitat was reported for the Daintree, Dickson Inlet, Barron, Trinity Inlet and Russell-Mulgrave estuaries. For 2021-22 shoreline mangrove habitat assessments were completed for all estuaries except the Johnstone.

The Program Design (WTHWP 2018) provides the full schedule for when new data are to be presented for longer-term indicators that are reported for periods longer than a year. The fish barrier results were incorporated from 2015-16, and the flow indicator, which commenced in 2016-17, has been updated annually. Seagrass indicators for Trinity Inlet and Moresby River have been updated each year.

The habitat and hydrology index scores and grades for all reporting years are presented in Table 28. The index scores have remained fairly consistent over reporting years with little change in grades (Table 28). For 2021-22 the largest change in score was for Dickson Inlet and the Johnstone, both decreasing from the previous year with the Johnstone declining from 'good' to 'moderate' and Dickson Inlet remaining 'good'.

Table 28 Estuary habitat and hydrology index grades and scores for all years.

Estuary	21-22	20-21	19-20	18-19	17-18	16-17	15-16
Daintree	59	59	60	60	60	60	60
Dickson Inlet	65	72	74	74	74	74	74
Barron	55	54	54	45	43	45	41
Trinity Inlet	54	54	57	55	50	50	48
Russell-Mulgrave	67	67	69	65	75	69	67
Johnstone	56	63	62	54	63	58	51
Moresby	52	56	58	54	51	53	54
Hinchinbrook Channel	65	65	71	71	72	72	72

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available.

Note that for the 2021-22 habitat extent reporting the 2019 mangrove and saltmarsh extent data and estuary riparian extent data was obtained from the most recent Regional Ecosystem mapping (Version 12.2). The habitat extent data for 2013 and 2017 was based upon previous versions of the Regional Ecosystem mapping. Some slight differences of habitat extent between version releases can occur due to updates in mapping accuracy which is not related to actual change in habitat extent.

Mangrove and saltmarsh

Mangrove and saltmarsh habitat extent

The mangrove and saltmarsh habitat extent indicator was updated for 2021-22 for all estuary zones. The procedures for scoring and grading habitat extent are outlined in Section 4.2 for basins and the same approach is used for estuaries. More details of the methods and procedures are provided in the methods technical report (WTW 2023).

The mangrove and saltmarsh extent loss from preclearing for 2019, 2017 and 2013, and the scores and grades for 2019 are shown in Table 29. The results show the historic loss of extent due to development which is particularly evident in the most urbanised reporting zones of Barron graded 'poor' and Trinity Inlet graded 'moderate' (Mitchell *et al*. 2009). More recently mangrove communities in the Barron and Trinity Inlet estuaries have been effectively managed to ensure no recent major new clearing and to allow for some revegetation. There has been no recent loss in extent of mangroves and saltmarsh in any of the estuaries with extent remaining unchanged between 2017 and 2019 (Table 29) and between 2013 and 2017 (WTW 2022). The Daintree, Russell-Mulgrave, Moresby and Hinchinbrook Channel were graded 'very good' whilst Dickson Inlet and Johnstone were graded 'good'. The assessment of area remaining for mangroves and saltmarsh as separate vegetation types (Table 30) shows that historically saltmarsh has lost more extent as a percentage of pre-clearing than mangroves across all estuaries.

Table 29 Mangrove and saltmarsh percent loss from pre-clearing for 2017 and 2019, change in extent between 2017 to 2019, and 2019 score and grade.

Estuary	Mangrove and saltmarsh extent loss from pre-clearing		Change	Score and grade
	2017 loss (%)	2019 loss (%)	2017-2019 (%)	2019
Daintree	1.6	1.6	0	93
Dickson Inlet	8.0	8.0	0	75
Barron	29.0	29.0	0	42
Trinity Inlet	20.9	20.9	0	53
Russell-Mulgrave	0.5	0.5	0	97
Johnstone	13.7	13.7	0	63
Moresby	4.0	4.0	0	84
Hinchinbrook Channel	4.3	4.3	0	83

Mangrove and saltmarsh extent (% loss): Very Poor = >50% | Poor =>30 to 50% | Moderate = >15 to 30% | Good = >5 to 15% | Very Good ≤5%. **Standardised scoring range:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. Note: these results are for mangrove and salt marsh extent, not condition of mangrove and saltmarsh habitat.

Table 30 Mangrove and saltmarsh pre-clearing, and 2019 area and extent remaining, presented as separate vegetation type.

	Mangroves			Saltmarsh		
Estuary	Area pre-clearing (km^2)	Area 2019 (km^2)	Extent remaining (%)	Area pre-clearing (km^2)	Area 2019 (km^2)	Extent remaining (%)
Daintree	22.6	22.2	98.6	0.1	0.0	41.5
Dickson Inlet	9.7	9.9	101.9	3.2	2.0	62.0
Barron	14.0	10.5	74.8	1.1	0.2	22.7
Trinity Inlet	38.9	32.3	83.0	4.7	2.2	47.0
Russell-Mulgrave	6.6	6.5	99.5	0.0	0.0	n/a
Johnstone	3.0	2.6	86.3	0.0	0.0	n/a
Moresby	32.2	31.0	96.4	0.7	0.5	76.3
Hinchinbrook Channel	180.7	175.0	96.8	16.1	13.3	83.0

Both mangrove and saltmarsh habitats are affected by changing climactic conditions including trends in rainfall and sea level. Rainfall and sea level can alter the extent of each of these habitats and also influence their proportion of relative cover. Changes in rainfall trends have been shown to increase mangrove extent in response to higher rainfall and cause die back in response to lower rainfall, with an opposing effect on tidal saltmarsh extent (Duke et al. 2019). Rises in sea level have been shown to impact tidal wetlands by reducing their seaward extent and causing landward migration, where topography allows (Albert et al. 2017).

Mangrove habitat

The shoreline mangrove habitat indicator is comprised of the following three measures and their associated features (listed in brackets): habitat structure (cover, stand density, stand maturity), canopy cover (cover) and habitat impact (mangrove damage, shoreline modification). The results from the seven estuaries that had shoreline mangrove assessments completed for 2021-22 are presented in Table 31 and the results from the first round of assessments completed for 2020-21 (Daintree, Dickson Inlet, Barron, Trinity Inlet and Russell-Mulgrave), are presented in Table 32. The 2021-22 assessments provide a more complete dataset for those estuaries that had assessments completed for 2020-21, as detailed in the methods (WTW 2023), noting that updated scores represent an increase in the length of the shoreline surveyed only with no other methodological changes. It is recommended that the 2021-2022 scores are used as a baseline that more accurately reflects the state and condition of shoreline mangrove habitats in Wet Tropics estuaries.

A full description of the shoreline mangrove habitat indicator is available from the WTW website.

Table 31 Shoreline mangrove habitat indicator, measure and feature results for 2021-22.

	Habitat structure				Canopy cover	Habitat impact			
	Cover	Density	Maturity	**Struct-ure**	Cover	Damage	Modif-ication	**Impact**	**Mangrove habitat**
Daintree	84	82	90	**85**	**66**	94	92	**93**	**81**
Dickson Inlet	75	75	80	**76**	**61**	48	37	**43**	**60**
Barron	79	79	82	**80**	**70**	79	60	**70**	**73**
Trinity Inlet	60	88	80	**76**	**70**	82	29	**55**	**67**
Russell-Mulgrave	73	74	80	**75**	**61**	75	69	**72**	**70**
Johnstone	nd	nd	nd	**nd**	**nd**	nd	nd	**nd**	**nd**
Moresby	86	90	90	**89**	**72**	100	72	**86**	**82**
Hinchinbrook Channel	96	81	85	**87**	**66**	99	94	**97**	**83**

Standardised scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data or insufficient data was available.

For 2021-22 the shoreline mangrove habitat indicator score was lowest for Dickson Inlet (60), which was graded 'moderate' condition, and highest for Hinchinbrook Channel (83) which was graded 'very good' condition. The Moresby and Daintree estuaries were also graded 'very good', whilst the Barron, Trinity Inlet and Russell-Mulgrave were graded 'good'.

The scores and grades for the estuaries assessed for 2020-21 are presented in Table 32 for reference. Given the adjustments to the 2021-22 estuary assessments, including increased length of shoreline surveyed as outlined in the methods (WTW 2023), differences in scores between assessment years may not reflect ecological change. It should also be noted that due to sampling errors inherent in ecological data collection there can be variations in scores between years that are unrelated to changes in actual condition. This should be considered when comparing results between assessments which repeat the same length and locations of shorelines surveyed. The time frame of change for the different measures should also be considered when comparing results between assessments. The measures of canopy cover, which captures change in the leaf canopy, and habitat impact, which captures human related loss, can change substantially year by year, whilst the habitat structure measure has a slower rate of change since it captures tree growth, position and density.

Table 32 Shoreline mangrove habitat indicator, measure and feature results for 2020-21.

	Habitat structure				Canopy cover	Habitat impact			
	Cover	Density	Maturity	**Struct-ure**	Cover	Damage	Modif-ication	**Impact**	**Mangrove habitat**
Daintree	90	97	95	**94**	**64**	100	83	**91**	**83**
Dickson Inlet	74	69	73	**72**	**71**	57	40	**48**	**64**
Barron	72	86	81	**80**	**71**	82	67	**75**	**75**
Trinity Inlet	59	86	76	**74**	**65**	59	29	**44**	**61**
Russell-Mulgrave	71	65	75	**70**	**56**	64	67	**66**	**64**
Johnstone	nd	nd	nd	**nd**	**nd**	nd	nd	**nd**	**nd**
Moresby	nd	nd	nd	**nd**	**nd**	nd	nd	**nd**	**nd**
Hinchinbrook Channel	nd	nd	nd	**nd**	**nd**	nd	nd	**nd**	**nd**

Standardised scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data or insufficient data was available.

Mangroves occur in low-energy coastal environments and are vulnerable to extreme weather events such as floods and cyclones. In 2019, record flooding in the Daintree River caused severe damage to shoreline mangrove habitats, particularly areas upstream of the lower estuary. Although habitat structure scored highly for the Daintree, the lower score for canopy cover, which measures canopy density, reflects the impacts of extreme weather events. The estuaries south of the Daintree River have had no recent climatic events that can cause declines in shoreline mangrove habitat. For these estuaries it is likely that loss of habitat structure and canopy cover is linked to estuary modification and elevated nutrient, sediment, and chemical pollution from catchment urban and agricultural land use (McKenzie 2021). The low score for canopy cover in the Russell-Mulgrave River where dynamic shoreline processes in Mutchero Inlet are causing mangrove shoreline habitat retreat, and narrow shoreline fringing mangroves along the Mulgrave estuary are impacted by a lack of estuary vegetation buffer zone exposing estuary habitats to impacts from adjacent agricultural land use (McKenzie 2021).

Habitat impact scores represent the degree of catchment and estuary land use modification and level of human estuary influence, with estuaries in more developed and populated areas typically having lower (worse) habitat impact scores. For 2021-22 Dickson Inlet received a ‘moderate’ habitat

impact grade and the lowest score (43) reflecting the relatively high levels of mangrove habitat damage and modification along shorelines, whilst Hinchinbrook Channel, which is the largest system and has relatively low levels of human disturbance along shorelines, had the least amount of habitat impact recorded.

Key messages: mangrove habitat

- The shoreline mangrove habitat indicator score was lowest for Dickson Inlet (60), which was graded 'moderate' condition and has relatively high levels of shoreline development.
- Hinchinbrook Channel scored highest for the shoreline mangrove habitat indicator (83) with a grade of 'very good' and low levels of shoreline disturbance and modification.

Mangrove and saltmarsh extent and mangrove habitat

When combining the shoreline mangrove habitat indicator and the mangrove and saltmarsh extent indicator into the indicator category for mangrove and saltmarsh habitat condition and extent (Table 33), Trinity Inlet and Barron River estuaries were graded 'moderate', whereas Dickson Inlet was graded 'good' and the Daintree, Russell-Mulgrave, Moresby and Hinchinbrook Channel systems were graded 'very good'. The Johnstone estuary was represented only by the mangrove and saltmarsh extent indicator score.

Table 33 Mangrove habitat and extent indicator category results.

	Shoreline mangrove habitat	Mangrove and saltmarsh extent	Habitat condition and extent
Daintree	81	93	87
Dickson	60	75	67
Barron	73	42	57
Trinity	67	53	60
Russell-Mulgrave	70	97	84
Johnstone	**nd**	63	63
Moresby	82	84	83
Hinchinbrook Channel	83	83	83

Standardised scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. nd indicates no data or insufficient data was available.

Estuarine riparian extent

The estuarine riparian extent indicator was updated for 2021-22 using the most recent release of the Regional Ecosystem data set (version 12.2: 2019 remnant and pre-clearing mapping). The procedures for scoring and grading habitat extent are outlined in Section 4.2 for basins and the same approach is used for estuaries. More details of the methods and procedures are provided in the methods technical report (WTW 2023).

The estuarine riparian vegetation extent scores and grades for 2019 are shown in Table 34 and report on the changes in extent and not the condition of the riparian vegetation.

Table 34 Estuarine riparian vegetation preclear area, percent loss from pre-clearing to 1997, 2013 2017 and 2019 and change in area for 1997 to 2019 and 2013 - 2019.

	Riparian extent area	Percent riparian extent loss since pre-clearing and riparian extent area (km^2)*				Riparian extent change (km^2)		Score and grade
Estuary	**Pre-clear-ing (km^2)**	**1997**	**2013**	**2017**	**2019**	**1997 - 2019**	**2013 - 2019**	**2019**
Daintree	3.7	45 (2.0)	43 (2.1)	43(2.1)	43(2.1)	+0.1	0	28
Dickson Inlet	0.7	25 (0.5)	24 (0.5)	24 (0.5)	24 (0.5)	0	0	49
Barron	2.0	48 (1.1)	48 (1.1)	48 (1.1)	48 (1.1)	0	0	22
Trinity Inlet	9.2	19 (7.5)	17 (7.7)	16 (7.7)	16 (7.7)	+0.2	0	58
Russell-Mulgrave	5.7	47 (3.0)	47 (3.0)	47 (3.0)	47 (3.0)	0	0	24
Johnstone	4.5	77 (1.0)	77 (1.1)	77 (1.1)	77 (1.1)	0	0	9
Moresby	2.2	12 (1.9)	12 (1.9)	12 (1.9)	12 (1.9)	0	0	66
Hinchinbrook Channel	11.1	22 (8.7)	22 (8.8)	22 (8.8)	22 (8.8)	+0.1	0	53

Riparian extent (% loss): Very Poor = >50% | Poor =>30 to 50% | Moderate = >15 to 30% | Good = >5 to 15% | Very Good ≤5%. **Standardised scoring range:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. *Riparian area extent (km^2) shown in brackets. Note: These results are for riparian extent (woody vegetation), not condition of riparian vegetation.

The grades ranged from 'very poor' for Johnstone to 'good' for Moresby. The results relate to historic loss of extent from pre-clearing to 2019 due to development including agricultural land use. The results show that since the first Queensland Herbarium assessments occurred in 1997, riparian extent in 2019 has increased slightly for the Daintree, Trinity Inlet and Hinchinbrook Channel whilst no change in extent has occurred between 2013 to 2019.

Fish barriers

The fish barrier indicator was updated for 2021-22 covering Daintree, Dickson Inlet and Barron estuaries using data from the Regional Lands Partnership fish barrier project (Moore *et al.* 2022) and for 2020-21 covering the Hinchinbrook Channel using data from the Fish Homes and Highways project (Moore *et al.* 2021). Trinity Inlet, Russel-Mulgrave, Johnstone and Moresby estuaries have not been updated since the 2015-16 assessment. Table 35 provides the scores and grades of the 2015-16 assessments for all estuaries and the updated 2021-22 and 2020-21 assessments. Across estuaries the most recent grades for estuary fish barriers ranged from 'moderate' (Barron and Hinchinbrook Channel) to 'very good' (Russell-Mulgrave and Johnstone). The lowest score for barrier density was Moresby and the lowest score for percentage of stream to first barrier was the Hinchinbrook Channel ('very poor'). There were no low passability barriers in the estuary assessment areas and all estuary zones scored 100 ('very good') for 'stream length to first low passability barrier'.

Table 35 Results for fish barrier indicators in estuaries for the 2021-22 update (Daintree, Dickson Inlet, Barron), the 2020-21 update (Hinchinbrook Channel), and the initial 2015-16 assessment. Assessments applied on Priority 3, 4 and 5 waterways as indicated.

Estuary	Reporting year	Barrier density (km per barrier on Priority 3, 4 and 5 waterways)	Stream length to the first barrier (% of total stream length) on Priority 3 and 4 waterways)	Stream length (% of total length) to the first low passability barrier on Priority 4 waterways	Fish barriers (standardised score)
Daintree	2021-22	5.8	75.2	no low pass barriers	61
	2015-16	6.5	76.2	no low pass barriers	61
Dickson Inlet	2021-22	15.0	81.3	no low pass barriers	80
	2015-16	No barriers	No barriers	no low pass barriers	100
Barron	2021-22	3.5	67.1	no low pass barriers	60
	2015-16	11.8	55.6	no low pass barriers	61
Trinity Inlet	2015-16	5.8	74.1	no low pass barriers	61
Russell-Mulgrave	2015-16	29.6	88.0	no low pass barriers	81
Johnstone	2015-16	19.8	90.7	no low pass barriers	81
Moresby	2015-16	2.6	82.1	no low pass barriers	61
Hinchinbrook Channel*	2020-21	15.2	11.9	no low pass barriers	60
	2015-16	28.6	71.2	no low pass barriers	80

Barrier density (km): Very Poor = 0 to 2km | Poor = >2 to 4km | Moderate = >4 to 8km | Good = >8 to 16km | Very Good >16km.

Stream to 1st barrier (%): Very Poor = 0 to <40% | Poor = 40 to <60% | Moderate = 60 to <80% | Good = 80 to <100% | Very Good 100%

Stream to 1st low passability barrier (%): Very Poor = 0 to 60% | Poor = >60 to 80% | Moderate = >80 to 90% | Good = >90 to <100% | Very Good 100%

Standardised scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. *Results for estuaries within updates since 2015-16 are in grey text and provided for reference. Updated results are presented in the table below.

The total stream length of priority 3 and 4 waterways and the number of barriers identified in the assessments for each estuary are presented in Table 36 based upon their most recent assessment.

Table 36 Total stream length of priority 3 and 4 waterways, and number of identified barriers for the most recent estuary fish barrier assessments.

Estuary and assessment year	Total stream length of priority 3 and 4 waterways	Number of barriers
Daintree (2021-22)	151	26
Dickson Inlet (2021-22)	15	1
Barron (2021-22)	60	17
Trinity Inlet (2015-16)	58	10
Russell-Mulgrave (2015-16)	266	9
Johnstone (2015-16)	197	10
Moresby (2015-16)	13	5
Hinchinbrook Channel (2020-21)	517	34

Daintree, Dickson Inlet and Barron 2021-22 update.

The 2021-22 update of fish barriers for the Daintree, Dickson Inlet and Barron estuaries added verified fish barries in all three estuaries to those included in the 2015-16 assessment. These additional barriers are not recent developments and were present during the 2015-16 assessment, but the mapping methods used in the initial assessment did not identify them. The updated grades and scores for fish barriers in the three estuary zones are presented in Table 35. None of the additional barriers were low passability and the grade for 'stream percentage to the first low passability barrier' for all three estuary zones has remained 'very good'. The 2021-22 assessment included field visits to previously inaccessible sites which were classed as barriers in the 2015-16 assessment based on Google Earth satellite imagery. From the field visits three sites listed as barriers were removed for the Daintree and one for the Barron. In addition, one site listed as a barrier for the Barron was removed after confirmation it was not located on a priority waterway when using the Queensland Globe watercourse mapping.

For the Daintree 2021-22 assessment five barriers were added. These barriers were not discernible as barriers using the original mapping and waterway layer for the 2015-16 assessment. All five are minor barriers on smaller waterways (priority 3) except the minor barrier at the mouth of Orsova creek which is a priority 4 waterway, and this barrier was immediately upstream of a much more substantial barrier on Stewart Creek. A total of 26 barriers were identified and included in the updated assessment for the Daintree estuary. These updates resulted in the 'km stream length per barrier' to decrease from 6.5 to 5.8 and the 'stream length to first barrier as a percentage of total stream length' to decrease from 76.2% to 75.2% however these changes did not alter the score, which remained on 61, or grade, which remained 'good' (Table 35).

Dickson Inlet had no barriers identified in the 2015-16 assessment but the use of the Queensland Globe inland waters watercourse layer expanded the waterways classified as priority. This additional mapping identified a single minor barrier on Crees Creek, which is a low gradient stream order 2 waterway, and resulted in a 'km stream length per barrier' of 15 ('good') and a 'stream length to first barrier as a percentage of total stream length' of 81.3% ('good') (Table 35). Overall Dickson Inlet declined from a score of 100 ('very good') to 81 ('good').

The 2021-22 assessment added 13 verified barriers for the Barron estuary. A total of 17 barriers have now been identified on priority waterways for the Barron estuary area. 10 of the additional barriers were identified due to the use of the Queensland Globe inland waters watercourse layer which included priority waterways (stream order 3 and 4) not displayed on the layer used for the 2015-16 assessment. The other three barriers were located on an unnamed stream order 1 waterway but which was within estuary waters (priority 5) close to Cairns Airport. The increase of identified barriers to 17 in the Barron estuary resulted in the 'km stream length per barrier' decreasing from 11.8 ('good') to 3.5 ('poor') whilst the 'stream length to first barrier as a percentage of total stream length' increased from 55.6% ('poor') to 67.1% ('moderate') due to field verification of a suspected but previously inaccessible barrier on Freshwater Creek which was confirmed as a bridge. Overall, the Barron estuary declined from 'good' (61) to 'moderate' (60) as a result of the updated assessment (Table 35).

Hinchinbrook Channel 2020-21 update.

The 2020-21 update of fish barriers for the Hinchinbrook Channel estuary added 16 verified fish barriers to the 18 fish barriers verified in the 2015-16 assessment. These additional barriers are not recent developments and were present during the 2015-16 assessment, but the mapping methods used in the initial assessment did not identify them. The updated grades and scores for fish barriers in the Hinchinbrook Channel are presented in Table 35. Due to the higher number of verified fish barriers the grade for barrier density has declined from 'very good' to 'good'. None of the additional barriers were low passability and the grade for 'stream percentage to the first low passability barrier' has remained 'very good'. Of the additional barriers seven were upstream of barriers identified in 2015-16 and three were located in the estuary network (priority 5 waterways) meaning they did not contribute to the scoring for 'stream percentage to first barrier' (WTW 2022). The remaining five additional barriers all contributed to lowering the scores for 'stream percentage to first barrier'. The most significant of these is a rock weir on the Herbert River used as a pump site (Fig 13) located approximately 29 km upstream of the Herbert River mouth. Whilst this barrier is drowned out during higher flows and is not visible from satellite imagery during these occasions (as was the case for the imagery data set used for the 2015-16 assessment), the head-loss during lower flows (~1 m) is a barrier to fish passage. The total assessable stream length for the Hinchinbrook Channel estuary is 517 km and this barrier has a total of 250 km of connected waterways upstream without fish barriers. Mitigating the effect of this barrier, for example by installation of a fishway, would increase the 'stream percentage to first barrier' to 60 and improve its grade to 'moderate' and improve the fish barrier indicator score to 70 ('good'). The other four barriers combined have a total of 60 km of connected waterways upstream without fish barriers.

Hinchinbrook Channel was most strongly influenced by the presence of fish barriers in the Herbert River catchment with 31 barriers, whilst the Murray Basin had only two verified fish barriers. It is important to note that only the assessable waterways (priority 3, 4 and 5) adjacent to Hinchinbrook Channel are included (WTW 2022), and the Murray River itself is outside of the assessment area.

Figure 13 Rock weir on the Herbert River used as a pump site approximately 29 km upstream of the Herbert River mouth. Source: Fish Homes and Highways, Terrain NRM 2021.

The Fish Homes and Highways project included funding for works to improve the passage of fish across barriers selected from prioritised fish barrier sites. The progress of fish barrier improvement works and their contribution to increasing scores for the fish barrier indicator in the Hinchinbrook Channel estuary zone will be reported upon in future technical reports.

Summary

The estuary fish barrier results show that the movement of fish from freshwater to estuary in the Wet Tropics is less impacted by physical barriers than other regions (for example Mackay Whitsunday (Moore 2016)) and reflect the absence of low passability man-made barriers, such as dams and weirs, in the estuary reporting zones. However, the actual connectivity of the waterway network may be affected by other impacts such as biological, chemical, and environmental barriers for example instream invasive weeds and poor water quality.

Key messages: fish barrier update for 2021-22

- The 2021-22 update of the fish barrier indicator for the Daintree, Dickson Inlet and Barron estuaries applied additional waterway mapping to the 2015-16 assessment resulting in more waterways classified as priority 3 and 4 and thereby assessable for fish barriers.
- Five barriers were added to the Daintree estuary (grade remained 'good'), one barrier was added to Dickson inlet (grade declined from 'very good' to 'good') and 13 were added to the Barron estuary (grade declined from 'good' to 'moderate').
- Field verification revealed that some sites with crossings counted as barriers for 2015-16 based on satellite imagery were confirmed to be absent of barriers (three in the Daintree and one in the Barron).

Flow

The flow indicator includes an assessment of the rainfall type for the reporting year and then compares the flows from the reporting year with modelled pre-development flows from past years with the same rainfall type. This means that the flow metrics for the reporting year provide scores based upon previous years with similar rainfall totals. The results are to be interpreted within the context of the prevailing rainfall conditions for the reporting year. The Barron, Russell-Mulgrave and Johnstone estuaries were graded as 'good', 'very good' and 'good', respectively, for flows during 2021-22, and the basins draining into the three estuaries were classified with an 'average' rainfall type for the Barron and Russell, 'wet' for the Mulgrave, and 'dry' for the Johnstone (Table 37).

For the Barron estuary the score increased marginally, from 75 in the previous year to 79. Flows to the Barron estuary are assessed from the Myola gauging station on the Barron River and the Freshwater Creek gauging station. The Myola flow assessment site represents approximately 90% of the gauged catchment draining to the Barron estuary and the score from each site is weighted by proportion of catchment area before aggregation. The score for the Myola flow assessment site increased from 75 in 2020-21 (WTW 2022) to 80 in 2021-22 whilst Freshwater Creek decreased from 80 to 61 (Appendix C Table 86). Both sites had high scores for measures of low flows and cease to flow, and for the second year in a row at the Freshwater Creek site these flow categories were not substantially altered from modelled pre-development in their capacity to provide key ecological values, unlike most previous years. Freshwater Creek serves as a water supply for the Cairns area, with Copperlode Dam and water extraction infrastructure located upstream of the flow assessment

site, and this water resource development has been linked to poorer scores across all flow categories in past years.

Flows for the Russell-Mulgrave remained 'very good' with all measures of flow across the three sites scoring highly. The Johnstone's decline in grade was due to lower scores for measures of medium and high flow that occurred at the North Johnstone site, whilst the South Johnstone site scored highly for all flow measures.

Details of the scores for each flow assessment site and the 10 measures of flow that constitute the site scores are provided in Appendix C Table 86. In all other Wet Tropics estuaries, the flow indicator was not assessable due to the lack of modelled pre-development data and additionally the lack of flow assessment sites for Dickson Inlet, Moresby and Hinchinbrook Channel.

Table 37 Rainfall type and number of flow assessment sites for 2021-22, and standardised estuary flow indicator score and grade for 2021-22 and the previous years.

Estuary	Rainfall type	Number of assessment sites	Flow					
			2021-22	2020-21	2019-20	2018-19	2017-18	2016-17
Daintree	-	-	nd	nd	nd	nd	nd*	nd*
Dickson Inlet	-	-	nd	nd	nd	nd	nd	nd
Barron	Average	3	79	75	93	57	49	59
Trinity Inlet	-	-	nd	nd	nd	nd	nd	nd
Russell-Mulgrave	Average/Wet	3	81	84	75	57	98	74
Johnstone	Dry	2	71	98	95	65	98	81
Moresby	-	-	nd	nd	nd	nd	nd	nd
Hinchinbrook Channel	-	-	nd	nd	nd	nd	nd	nd

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data or insufficient data was available.

Further information on the methods applied for the flow indicator are available in the full report for the flow indicator project (Stewart-Koster *et al.* 2018) and in the Wet Tropics Report Card methods technical report (WTW 2023). Both are available from the WTW website (wettropicswaterways.org.au).

Key messages: flow

- The Barron and Johnstone estuaries was graded 'good' and the Russell-Mulgrave was graded 'very good', indicating flows to the estuaries were not substantially altered from reference condition.
- The scores increased for the Barron from the previous year.
- The score for the Johnstone decreased since the previous year, with the grade declining from 'very good' to 'good'.
- All measures of low flow and cease to flow conditions at the Freshwater Creek site continued to score high for a second year in a row.

Seagrass

Seagrass condition scores and grades for 2021-22 and previous reporting years are presented in Table 38. The 2021-22 seagrass site scores and grades for the two reported estuaries are presented Table 39. Note that the seagrass site score is the minimum indicator value, unless species composition is zero, in which case it is the average of species composition (0) and the next lowest scoring indicator. The estuary condition score is the average of the site scores.

Table 38 Estuary seagrass condition score and grade for 2021-22 and previous years.

Estuary	21-22	20-21	19-20	18-19	17-18	16-17	15-16
Daintree	-	-	-	-	-	-	-
Dickson Inlet	nd	nd	nd	nd	nd	nd	nd
Barron	-	-	-	-	-	-	-
Trinity Inlet	38	42	54	46	31	30	21
Russell-Mulgrave	-	-	-	-	-	-	-
Johnstone	-	-	-	-	-	-	-
Moresby	0	18	25	8	0	7	13
Hinchinbrook Channel	nd	nd	nd	nd	nd	nd	nd

Seagrass score (QPSMP): ■ Very Poor = 0 to <20 | ■ Poor = 20 to <40 | ■ Moderate = 40 to <60 | ■ Good = 60 to <80 | ■ Very Good = 80 – 100. For further information on calculation of scores refer to the methods technical report (WTW 2022). ^ - indicates that it does not occur at the location. nd indicates no data available.

The seagrass condition at Trinity Inlet decreased from the previous year and the grade declined from 'moderate' to 'poor' whilst the seagrass condition declined substantially at the Moresby estuary and the grade remained 'very poor'.

Table 39 Estuary seagrass site scores and grades for 2021-22.

Estuary	Site	Biomass	Area	Species composition	Site score and grade
Trinity Inlet	CN20	93	26	100	26
	CN19	45	85	99	45
	CN33	44	93	100	44
Moresby	MH1	9	0	100	0
	MH2	0	0	0	0
	MH3	5	2	100	2
	MH4	0	0	0	0
	MH5	0	0	0	0

Seagrass score (QPSMP): ■ Very Poor = 0 to <20 | ■ Poor = 20 to <40 | ■ Moderate = 40 to <60 | ■ Good = 60 to <80 | ■ Very Good = 80 – 100. Note that the seagrass site score is the minimum indicator value, unless species composition is zero, in which case it is the average of species composition (0) and the next lowest scoring indicator.

Estuarine seagrass condition in Trinity Inlet has remained moderate for the past 3 years. In the Moresby the condition declined from poor in 2019-2020 to very poor.

Key messages: estuary seagrass

Trinity Inlet (1 intertidal meadow (CN20), 2 subtidal meadows (CN19, CN33)).

- Seagrass declined to poor condition, despite many of the meadows having very good scores for two out of three indicators.
- The reduced score was due to a decline in meadow area for intertidal meadow CN20, and biomass declines in subtidal meadows CN19 and CN33.
- These small meadows consist of pioneering, ephemeral species and have been highly variable during the life of the monitoring program.

Moresby Estuary – Mourilyan Harbour (4 intertidal meadows (MH1 – MH4), 1 subtidal meadow (MH5))

- Overall seagrass condition remained very poor.
- Seagrass was only present in 2 of the 5 monitoring meadows in Mourilyan Harbour. MH2 was not present during 2021-2022 monitoring. This is the fifth time that meadow has disappeared since 2014-2015.
- Mourilyan Harbour remains the only long-term monitoring location in the wet and dry tropics regions where recovery of the foundation species (*Zostera muelleri*) has not occurred following widespread seagrass loss that occurred along Queensland's east coast during 2009-2011 period.
- The continued absence of the foundation species *Zostera muelleri* is the principal factor leading to the ongoing poor/very poor condition of Mourilyan Harbour seagrasses.
- Assisted restoration is underway in the Moresby to return the foundation species *Zostera muelleri* to meadows MH1 and MH2 (see restoration update below).

Mourilyan Restoration Update:

Seagrass restoration trials continued in Mourilyan Harbour for the third consecutive year in 2022 through collaboration between TropWATER (JCU), Ozfish Unlimited, Mandubarra Land and Sea Rangers and Goondoi Land and Sea Rangers and relying on volunteers and in-kind funding from all partners. The project was again supported by funding from the Queensland Recreational Fishing Grant Program. Previous trials have seen the establishment and growth of several patches of seagrass through attachment of bare-rooted vegetative shoots to steel frames (occurring in 2020) (Figure 14) and individual anchors (nails or nuts – occurring in 2021). Trials of biodegradable mesh in 2021 were not as successful as the structure of the mesh held leaves out of the wet sediment on the mudflat at low tide and they were dried out in the sun. Trials in 2022 concentrated on individually anchored shoots with 23 experimental plots established. Survival was encouraging in almost all plots several months after planting, however, plots have yet to be monitored after the wet season where high rates of mortality can occur. Funding is being secured to expand the restoration efforts at the site from mid-2023. This restoration is intended to reinstate seagrass presence, but the recovery at meadow scale will largely rely on natural expansion of small transplanted patches through sexual and asexual reproduction over years.

Figure 14 Seagrass patch established from shoots tied to a steel frame in August 2020 – Image from November 2022 (Image: TropWATER).

Recommendations for estuary seagrass (Seagrass Ecology Group, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University)

- Address poor spatial representation at meadow scale. We recommend additional meadow scale monitoring in some zones. Monitoring at this larger scale shows a clearer picture of seagrass condition at scales appropriate to the regional report card. Recommended locations include:
  - Northern estuaries to complement Trinity Inlet monitoring (Dickson Inlet)
  - Southern estuaries (Hinchinbrook). The Hinchinbrook region is a particular priority.

Habitat and hydrology index

The scores and grades for estuary habitat and hydrology indicators, indicator categories and the index for 2021-22 are presented in Table 40. The indicators, indicator categories and indices for previous reporting years are presented in Appendix F Table 118 to Table 123.

Table 40 Results for estuary habitat and hydrology (H&H) indicator categories and index for the 2021-22.

Estuary	Mangrove & saltmarsh	Riparian extent	Flow	Fish barriers	Seagrass	H&H index
Daintree	87^	28	nd	61	-~	59
Dickson Inlet	67^	49	nd	80	nd	65
Barron	57^	22	79	60	-	55
Trinity Inlet	60^	58	nd	61	38	54
Russell-Mulgrave	84^	24	81	81	-	67
Johnstone	63	9	71	81	-	56
Moresby	83^	66	nd	61	0	52
Hinchinbrook Channel	83^	53	nd	**60**	nd	65

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. ~ - indicates that it does not occur at the location. nd indicates no data available. ^ indicates the estuaries that include the shoreline mangrove habitat indicator introduced in 2020-21.

To provide a reference of the effect on scores due to the addition of the shoreline mangrove habitat indicator to four of the estuary zones for 2021-22, the indicator category and index scores without the shoreline mangrove habitat indicator are presented in Table 41. Comparing the index scores of Table 40 and Table 41 shows that the addition of the shoreline mangrove habitat indicator decreased scores for Daintree (declining from 'good' to 'moderate'), Dickson Inlet, Russell-Mulgrave and Moresby, and increased the scores for Barron and Trinity inlet.

Table 41 Habitat and hydrology (H&H) indicator category and index results excluding the new shoreline mangrove habitat indicator.

Estuary	Mangrove & saltmarsh extent	Riparian extent	Flow	Fish barriers	Sea-grass	H&H index
Daintree	93	28	nd	61	-^	61
Dickson Inlet	75	47	nd	100	nd	74
Barron	42	23	75	61	-	51
Trinity Inlet	53	59	nd	61	42	53
Russell-Mulgrave	97	24	84	81	-	71
Johnstone	63	9	71	81	-	56
Moresby	84	66	nd	61	0	57
Hinchinbrook Channel	83	53	nd	**60**	nd	65

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100.

Confidence

Confidence scores for the 2021-22 reporting period are presented below. Confidence scores (1 – 3) have been weighted according to the 2017 updated methods for assessing confidence (WTHWP 2017).

Confidence scores for estuary seagrass monitoring are provided in Table 42. Confidence in species composition is slightly lower due to the maturity of the methodology, which has been peer reviewed but not published.

Table 42 Confidence associated with the seagrass indicators in estuary reporting zones. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis.

	Maturity of methodology (x0.36)	Validation (x0.71)	Represent-ativeness (x2)	Directness (x0.71)	Measured error (x0.71)
Biomass	3	3	2	3	2
Area	3	3	2	3	2
Sp. Composition	2	3	2	3	1
Seagrass	2.7	3	2	3	1.7

Confidence in the results for the five habitat and hydrology indicators for estuaries are presented in Table 43. Note: riparian extent in estuarine zones is assessed using a different method to freshwater zones and scores differently for confidence.

Table 43 Confidence associated with habitat and hydrology indicator results in the estuary reporting zones. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are the sum of the weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high).

	Maturity of methodology (x0.36)	Validation (x0.71)	Represent-ativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Score	Rank
Estuary fish barriers	1	2	3	2	2	10.6	4
Riparian extent	2	2	2	1	2	8.2	3
Mangrove & saltmarsh extent	2	2	2	1	2	8.2	3
Mangrove habitat	3	2	2	3	1	9.3	3
Seagrass*	2.7	3	2	3	1.7	10.4	4
Flow#	1	2	3	1	1	9.2	3
Habitat and hydrology index (Trinity Inlet and Moresby	**1.9**	**2.3**	**2.3**	**1.8**	**2.0**	**9.5**	**3**
Habitat and hydrology index (Barron, Russell-Mulgrave, Johnstone)	**1.7**	**2.0**	**2.5**	**1.3**	**1.7**	**9.1**	**3**
Habitat and hydrology index (other estuaries	**1.7**	**2.0**	**2.4**	**1.3**	**2.0**	**9**	**3**

*Seagrass applies to Trinity Inlet and Moresby only; #Flow applies to Barron, Russell-Mulgrave and Johnstone only. **Rank based on final score:** 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

5.3. Overall estuary scores and grades

The index and overall scores and grades for 2021-22 are presented in Table 44, and the overall estuary scores and grades for each reporting year are presented in Table 45. For 2016-17 to 2021-22 the overall score is aggregated from the water quality and habitat and hydrology indices. For 2014-15 and 2015-16 the estuaries represented by the habitat and hydrology index only were Moresby and Dickson Inlet, respectively. When comparing overall scores and grades between years it is important to note that differences relate to the addition of indicators as well as changes in scores over time. The habitat and hydrology index scores represent the addition of indicators for fish barriers in 2015-16, flow in 2016-17 and shoreline mangrove habitat for select estuaries from 2020-21. For habitat and hydrology, the flow indicator scores (reported for Barron, Russell-Mulgrave and Johnstone), seagrass indicator scores for Trinity Inlet and Moresby, and the water quality index scores for all estuaries have been updated annually.

Table 44 Estuary index and overall scores and grades for 2021-22.

Estuary	Water quality	Habitat and hydrology	Overall
Daintree	79	59	69
Dickson Inlet	71	65	68
Barron	46	55	51
Trinity Inlet	73	54	64
Russell-Mulgrave	72	67	69
Johnstone	67	56	61
Moresby	67	52	60
Hinchinbrook Channel	73	65	69

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100.

For 2021-22 all estuaries remained 'good' except for the Barron and Moresby which both declined from 'good' to 'moderate'. The decline in grades was primarily due to the poorer water quality conditions for the Barron and poorer seagrass condition for Moresby. The Johnstone estuary had a notable decline in score due to poorer water quality index and flow indicator scores but remained 'good'.

Table 45 Estuary overall scores and grades for all years.

Estuary	**21-22**	**20-21**	**19-20**	**18-19**	**17-18**	**16-17**	**15-16**	**14-15**
Daintree	69	73	76	70	72	70	70	nd
Dickson Inlet	68	77	77	79	77	69	74*	nd
Barron	51	62	57	53	54	55	46	62
Trinity Inlet	64	64	63	56	57	64	66	59
Russell-Mulgrave	69	73	75	68	70	72	72	75
Johnstone	61	70	69	65	65	65	57	nd
Moresby	60	66	70	66	65	67	66	53*
Hinchinbrook Channel	69	72	78	74	77	81	78	nd

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. *Estuaries do not include the water quality index and represent habitat and hydrology index only.

6. INSHORE MARINE

Reporting for the inshore zone includes results for water quality, coral and seagrass. The inshore zone includes enclosed coastal, open coastal and mid-shelf marine water types, extending east to the boundary with the offshore waters (Figure 15). This is consistent with the inshore zoning used by the Marine Monitoring Program (MMP) in the Wet Tropics region for their annual inshore monitoring reports, for example see Gruber *et al.* (2020).

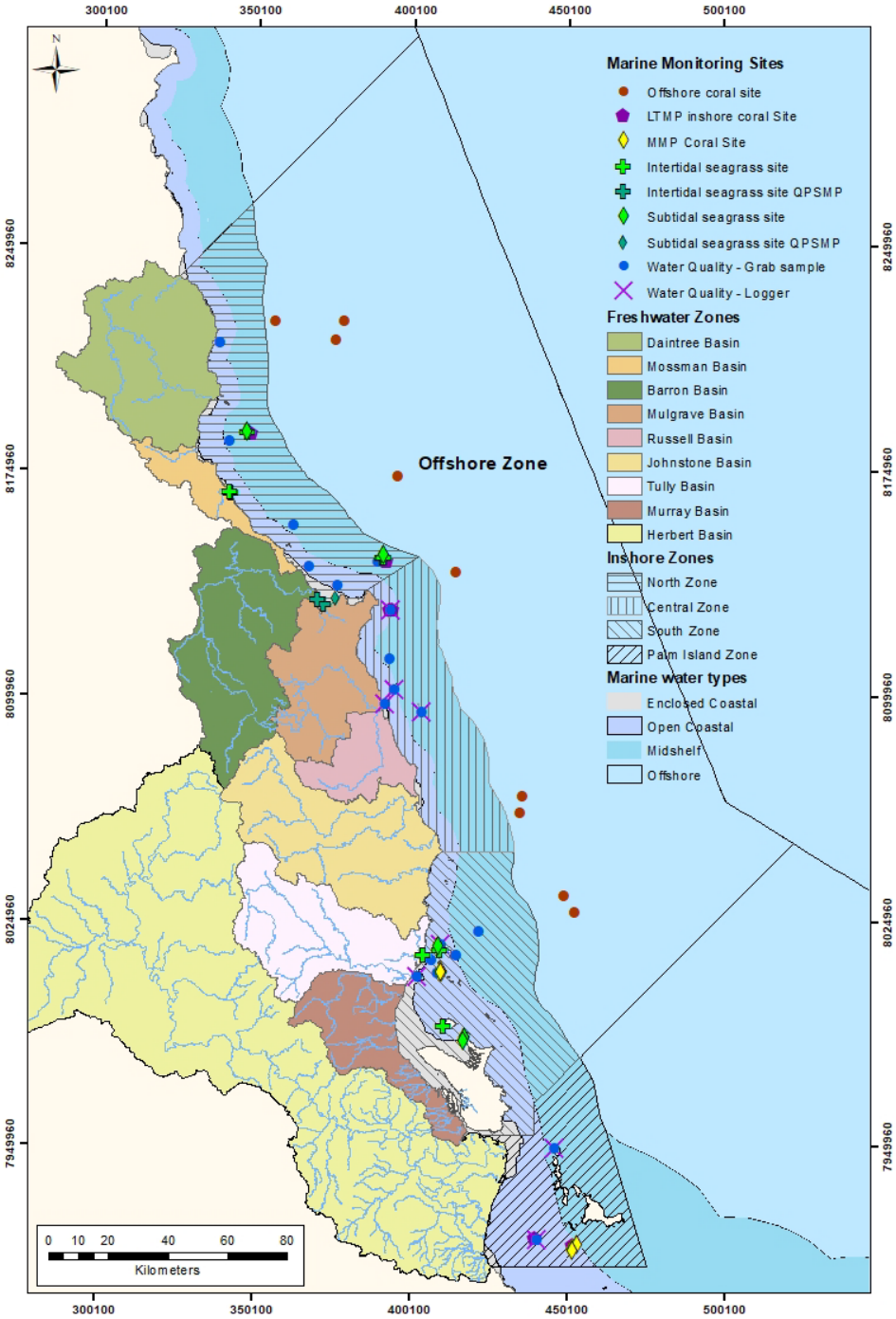

Figure 15 Reporting zones and monitoring sites for the inshore and offshore marine environments.

6.1. Water Quality

Inshore water quality index scores for all years are presented in Table 46 and the water quality indicator, indicator category and index scores for 2021-22 are presented in Table 47. On Table 47 an indicator category score may not be equal to the average of the contributing indicator scores for indicator categories that have multiple indicators (water clarity and nutrients). This is because the zone indicator category score is not calculated as the average of the zone indicator scores, instead, the indicator categories are first calculated for each site and then the site scores are averaged to provide the zone score. Inshore water quality indicator, indicator category and index scores for previous years are presented in Appendix F Table 124 to Table 129. The 2021-22 water quality indicator annual means for all inshore water quality monitoring sites and the indicator scores before standardisation are presented in Appendix B (Table 80 and Table 81). All inshore water quality scores are calculated from *in-situ* data from the MMP. The pesticide monitoring reported for inshore zones, which used passive samplers, was suspended as from the 2020-21 reporting period, although a list of pesticides assessed for inshore zones, relevant to previous years, is presented in the methods technical report (WTW 2023). The methods for scoring inshore marine water quality are provided in the methods technical report (WTW 2023).

The water quality index score improved for all zones from the previous year with the most substantial increases occurring for the North (72 to 81) and the South (52 to 60). The grade improved from 'good' to 'very good' for the North zone and from 'moderate' to 'good' for the Central zone, whilst the South zone remained 'moderate' and the Palm Island zone remained 'good'. Pesticide monitoring was suspended in 2019-20 for the North and Palm Island zones and in 2020-21 in the Central and South zones. The effect of the suspension of pesticide monitoring and reporting on the water quality index has been to lower the index scores since pesticides were high scoring and almost always graded 'very good' (Appendix F Table 126 to Table 129). More information on this effect on water quality index scores was presented in last year's results technical report (WTW 2022).

Table 46 Inshore water quality index grades and scores for all years.

Zone	21-22	20- 21	19-20	18-19	17-18	16-17	15-16
North	81	72	91	85	66	69	79
Central	62	60	74	58	53	58	64
South	60	52	72	44	47	47	60
Palm Island	68	62	65	60	53	64	69

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100.

Water clarity scores increased in all four zones following a decline in 2020-21, with the most substantial increase occurring in the North zone (69 to 84) which was due to the lower concentrations of total suspended solids (TSS) compared to the previous year (turbidity is not monitored in the North zone). For the Central, South and Palm Island zones the scores for TSS were similar to the previous year whilst scores for turbidity increased in all three zones, and the Central and South zones improving in grade for turbidity from 'moderate' to 'good'. Note that turbidity is monitored using loggers, which are present at both Palm Island zone sites, a subset of sites in the Central and South zones and that loggers are not deployed in the North zone. Chlorophyll *a* scores

were similar to the previous year and grades were unchanged with the North zone graded 'very good' and the other three zones graded 'good'.

Table 47 Inshore marine water quality indicator, indicator category and index results for 2021-22.

Zone	Water clarity			Chl *a*	Nutrients				Pest-icides	Water quality
	TSS	Tur-bidity	**Water clarity**	Chl *a*	NOx	PN	PP	**Nutrients**	Risk metric	
North	84		**84**	**83**	87	71	68	**75**	nd	**81**
Central	80	69	**76**	**65**	29	36	67	**45**	nd	**62**
South	61	65	**65**	**75**	41	18	63	**39**	nd	**60**
Palm Island	74	80	**77**	**65**	62	38	79	**61**	nd	**68**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. Nd indicates no data available. Note that the water clarity and nutrient indicator scores and indicator category scores (presented in bold) are calculated from the annual data for each site first and then site values are averaged to give the indicator or indicator category zone scores. For each zone the indicator category scores are averaged to provide the WQ score (also presented in bold).

Nutrients had the poorest scores of the water quality indicator categories in all zones although they increased in all zones compared to the previous year with the North and Palm Island improving from 'moderate' to 'good' and the Central improving from 'poor' to 'moderate'. The largest increase in the nutrient score occurred in the South zone (21 to 39) although the grade remained 'poor'. Of the three nutrient forms NO_x (oxidised nitrogen)was the highest scoring in the North zone and improved substantially from moderate (57) in the previous year to 'very good' (87). Particulate phosphorus (PP) was the highest scoring nutrient form for the other three zones and improved from 'moderate' to 'good' for the South zone and remained 'good' for the Central and Palm Island zones. NO_x was the lowest scoring indicator in the Central zone and remained moderate, whilst in the South zone the NO_x score increased substantially from 5 the previous year to 41, and the grade improved from 'very poor' to 'moderate'. Particulate nitrogen (PN) was the lowest scoring nutrient form for the South zone (remaining 'poor') and Palm Island zone (declining from 'moderate' to 'poor').

During 2021-22 annual mean concentrations of NO_x met guideline values in the North zone at five of the six sites, which contrasted with the previous year when only one site met the guideline value. In the North zone there was no spatial or temporal pattern evident for nutrient concentrations although concentrations of total suspended solids tended to decrease with distance from the coast.

In contrast to the North zone the Central and South zones displayed spatial trends in water quality. Highest annual mean concentrations of all three nutrients, TSS and chlorophyll *a* occurred at sites closest to the mouths of Russell-Mulgrave and Tully rivers for the Central zone and South zone, respectively, with concentrations tending to decrease with distance of sites from the river mouths along the northerly direction of the currents. Temporal patterns of nutrient and sediment concentrations at sites were less evident than in previous years when higher river discharge events occurred, for example 2018-19.

The Palm Island sites are influenced by flood plumes from the south and it is the Burdekin, as well as the Haughton and Ross river catchments that tend to directly affect water quality in the Palm Island inshore zone. The 2021-22, 2020-21 and 2019-20 years had moderate discharge from these river catchments whilst the Townsville and Burdekin floods in 2018-19 resulted in higher discharge, and

the very poor scores for nutrients in 2018-19 (Table 126) corresponded with these flood events. The Burdekin River typically has much higher PN loads during high discharge years (D. Moran pers. comm.). Whilst mean annual concentrations of NO_x and PP reduced compared to the previous year the concentrations of PN increased for 2021-22 and were similar in range to the Central zone, with highest concentrations occurring during wet season months.

Resuspension is also a factor that could influence nutrient concentrations and help explain variability noting that in the inshore the resuspended material is heavily influenced by catchment loads. The role of resuspension on water quality would need to be assessed systematically on a site-by-site basis and incorporate physical factors such as depth, currents, waves and wind speed.

Notable trends in inshore water quality over the longer term have been an improvement of chlorophyll *a* from 'poor' to 'good' for both the Central and South zones since 2017-18; continual improvement of nutrients from 'very poor' to 'good' for the Palm Island zone since 2018-19; consistently higher scores for the north zone compared to the other three zones for nutrients since 2015-16; and a general improvement in grades for water clarity for all zones since 2017-18.

Key messages: water quality

- Annual discharge from major rivers in Wet Tropics region were close to their long-term average whilst the Burdekin River, south of the Palm Island zone, had lower than average annual discharge.
- Water quality index improved in all zones from the previous year with the most substantial improvements in the North and South zones.
- Water clarity improved in all four zones following the decline in 2020-21. The North zone had the most substantial change and improved from 'good' to 'very good'..
- Nutrients had the poorest water quality scores in all zones with the South zone remaining 'poor', although the Central zone improved from 'poor' to 'moderate' and North and Palm Island zones improved from 'moderate' to 'good'.
- The score for NOx improved substantially in the North zone ('moderate' to 'very good') and the South zone ('very poor' to 'moderate').
- The Central and South zones displayed spatial trends in water quality with highest concentrations of nutrients, TSS and chlorophyll *a* occurring at sites closest to the river mouths and tending to decrease with distance of sites from the river mouths.
- For the Palm Island zone the concentrations of PN increased for 2021-22 and were similar in range to the Central zone, with highest concentrations occurring during wet season months.
- Notable longer-term trends in water quality over the last several years include improvement of chlorophyll *a* for both the Central and South zones; improvement of nutrients for the Palm Island zone; and an improvement in grades for water clarity for all zones.

In 2020 the guideline values for oxidised nitrogen (NOx) were updated for coastal and marine waters of the Wet Tropics and scheduled in the Environmental Protection (Water and Wetland Biodiversity) Policy 2019—the EPP (Water and Wetland Biodiversity) (DES 2020). For 2021-22 the guideline values have remained unchanged for the purposes of scoring inshore marine waters for the Wet Tropics report card, and this provides inshore marine water quality reporting that is consistent and comparable with all previous years. An account of recent inshore oxidised nitrogen guideline updates, and the effect of changes on indicator scores is provided in Appendix B (p. 114). Inshore

marine water quality guideline values used for scoring will be reviewed in the upcoming program design review (2023-25) which will allow for application of the most appropriate guidelines and a consistent approach across regional report cards.

Confidence

Confidence for the inshore marine water quality results for all zones are shown in Table 48. The lower confidence score for pesticides is due to the method being recently developed which has received less peer review than the more established methods for other water quality indicators. Confidence scores (1 – 3) have been weighted according to the 2017 updated methods for assessing confidence (WTHWP 2017) (Maturity of Methodology 0.36, Validation 0.71, Representativeness 2, Directness 0.71, Measured error 0.71).

Table 48 Confidence associated with the water quality indicators for inshore marine zones. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are the sum of the weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high).

	Maturity of methodology (x0.36)	Valid-ation (x0.71)	Represent-ativeness (x2)	Direct-ness (x0.71)	Measured error (x0.71)	Final	Rank
Nutrients	3	3	1	3	3	9.5	3
Chl-*a*	3	3	1	3	3	9.5	3
Water clarity	3	3	1	3	3	9.5	3
Pesticides	1	3	1	3	2	8.0	2
Water quality index	2.5	3	1	3	2.8	9.1	3

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

6.2. Coral

The grades and scores for the coral condition index for all years are presented in Table 49. For 2021-22 the coral index grades for the North and Palm Island zones remained 'moderate', whilst the Central and South zones declined from 'good' to 'moderate'. The changes in score were more pronounced than in the previous four years for both the North zone, which increased, and the Central zone, which decreased. The score change for the South zone was marginal, whilst the Palm Island zone recorded its lowest score (45) for all years.

Table 49 Inshore marine coral index scores and grades for all years.

Inshore Zone	21-22	20-21	19-20	18-19	17-18	16-17	15-16
North	51	44	44	44	51	46	46
Central	58	63	61	60	61	57	60
South	60	61	62	62	55	60	55
Palm Island	45	49	53	52	49	49	49

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

For 2021-22 the coral indicators and condition index for each inshore zone are presented in Table 50, whilst the coral indicator and condition index scores for each site are presented in Appendix G (Table 152) for reference. The following assessment of inshore coral condition is based on findings

from the Marine Monitoring Program report for inshore coral (Thompson *et al.* 2023) where more detailed assessment of the coral condition for sites in the Wet Tropics inshore zones is provided.

Table 50 Inshore marine coral indicators and index scores and grads for 2021-2022.

Inshore Zone	Juvenile	Macroalgae	Cover	Change	Composition	Coral index
North	38	55	65	70	30	51
Central	38	59	73	64	58	58
South	67	40	54	64	75	60
Palm Island	37	38	47	47	58	45

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

During 2021-22 in the Wet Tropics region there were no severe disturbance events to inshore coral communities such as cyclones, extensive and prolonged high seawater temperatures, or major floods.

Sea surface summer temperatures for the inshore zone were above long-term averages, with all areas above low likelihood for coral bleaching (Figure 5). Areas reaching probable bleaching and likely severe bleaching were limited to the south of the region, affecting the Palm Island and South inshore zones. Whilst only minimal bleaching was observed in these areas, recovery could have occurred by the time of the post-summer surveys.

The discharge for all major rivers in the region was close to their long-term averages with no major flooding events occurring (Figure 4). Flooding events can result in disturbance to coral communities such as in 2018-19 when high discharge from the Daintree River impacted coral cover on reefs at Snapper Island.

Crown-of thorns starfish were observed at three sites in the region, all within the Central zone. At two of these sites the densities were above outbreak levels, however, over recent years their population and impact on coral has been reduced by the Crown-of-thorns Starfish Control Program which has removed 24,354 individuals from coral monitoring reefs since 2013.

North zone

For the North zone, whilst the juvenile density score decreased, scores for the other four indicators increased which resulted in the higher coral condition score compared to the previous year. Although juvenile density remains 'poor' the condition has notably improved from 2019 and 2020, and the scores have risen with the increased abundance of juveniles at Snapper South (2 m) and Low Isle reefs. Since 2021 improvements in coral cover have been particularly evident at the Low Isles (from 36% to 55%), with the North zone increasing from 40% to 50%. Coral cover in the zone has gradually risen since 2015, despite impacts from the 2019 Daintree River flooding events. Although macroalgae cover continues to be high at Snapper North (2 m) and Snapper South (5 m), the indicator improved due to very low cover at other reef monitoring sites. The composition indicator remained poor due to lower representation of *Acropora* in the coral communities at Snapper North and Snapper South (2 m) compared to that recorded at these reefs prior to 2010.

Central zone

The decline in condition from 'good' in the previous year to 'moderate' for the Central zone was primarily due to the substantial decrease of the macroalgae score (74 to 59) whilst decreases in composition and cover change indicator scores also contributed. Dense mats of red macroalgae

species at Frankland West and High East (2 m) have resulted in low macroalgae scores for these sites, however the amount of cover from these macroalgae has been highly variable over reporting years. Although overall condition has declined for 2021-22 the coral cover indicator has risen to its highest score since the current MMP coral index was implemented (2006). The central zone has had relatively few severe disturbances since cyclone Yasi in 2011 and this has allowed hard coral cover to increase during the periods of low disturbance. The crown-of-thorns starfish have impacted the coral condition in the Central zone, which is the inshore zone where they have occurred in the highest numbers. The Great Barrier Reef Marine Park Authority's Crown-of-thorns Starfish Control Program has been effective in reducing crown of thorns starfish numbers on reefs in the central zone including the removal of 10,646 individuals from Fitzroy Island and the Frankland Group in the two years prior to the 2022 surveys. Although densities were above outbreak levels at the two High Island reef sites for the 2022 surveys, the overall numbers were much lower than recorded for 2020.

South zone

The slight decrease of the coral condition score for South zone occurred due to decreases of the juvenile density, cover change and composition indicators which offset increases for the macroalgae and coral cover indicators. Although the macroalgae indicator score slightly increased, the condition remained 'poor'. The reefs at Bedarra (2 m), Dunk North (2 m) and Dunk South (5 m) have very high cover of brown macroalgae, and high algal cover has persisted over multiple years, limiting the capacity for improvement. All sites in the South zone had an increase in coral cover since the previous year, although evidence of disease associated with disturbance events (e.g. thermal stress and high river discharge) may be limiting the rate of coral cover increase. The transition of juvenile corals to adults has contributed to the coral cover increase, however this has also contributed to a decrease of juvenile density.

Palm Island zone

The decline of coral condition in the Palm Island zone to the lowest score since reporting for the report card commenced was due to notable decreases of indicator scores for juvenile density, macroalgae (both declining from 'moderate' to 'poor') and coral composition (declining from 'good' to 'moderate'). Declines in juvenile density occurred at all reefs and were most apparent at deeper reef slopes of Palms East, Palms West, Pandora, and Lady Elliot and at shallow reefs of Lady Elliot. The macroalgae indictor has continued to decline, with increased or sustained high cover of macroalgae at Havannah North, Havannah, Lady Elliot (2 m), Pandora (2 m) and Pandora North. A mix of red and brown macroalgae species were common at Lady Elliot (2 m) whilst the other reef sites with high macroalgae cover were dominated by brown macroalgae species. During the summer period of 2021-22 a heat wave resulted in elevated sea surface temperatures with areas of probable bleaching and likely severe bleaching in the Palm Island zone. Bleached and partially bleached corals were still apparent at most sites during the winter surveys of 2022, with the highest area of impact observed at Palms West (2 m) at 10%. The bleaching had little effect on hard coral cover but loss of soft coral cover was substantial for all reefs, except Palms East (2 m) which had a slight increase. However, the largest coral cover decline occurred at Palms East, which was suspected to be due to disease, mainly affecting the hard coral *Acropora*. Hard coral cover increased slightly at Havannah, Palms West, Pandora, and Lady Elliot (2 m).

Key messages: inshore coral

- In the North zone the condition of coral has remained 'moderate' but improved in score from the previous year. Coral cover has continued to increase, whilst macroalgae cover remained high at two Snapper Island sites but was very low at the other sites.
- In the Central zone the condition of coral has declined from 'good' to 'moderate'. High cover of macroalgae at some sites substantially reduced the score for this indicator, whilst coral cover increased and the score has risen to its highest value.
- In the South zone the condition of coral has declined slightly, with the grade returning to 'moderate'. Coral cover increased slightly at all sites, although juvenile density decreased with the transition of juveniles to adults. The macroalgae score improved slightly but the indicator remains 'poor' with persistent high macroalgae cover at several sites.
- In the Palm Island zone the condition of coral remained 'moderate' but the score decreased to it is lowest value. Declines in juvenile density occurred at all sites, and macroalgae cover increased or was sustained at several sites. High sea surface temperatures and coral bleaching occurred during the 2021-22 summer months, with soft corals substantially impacted at most sites.
- Crown-of-thorns starfish were observed above outbreak levels at two reef sites in the Central zone, however the numbers were notably lower than for 2019-20.

Confidence

Confidence in the inshore marine coral results are shown in Table 51. Confidence scores (1 – 3) have been weighted according to the 2017 updated methods for assessing confidence (WTHWP 2017) (Maturity of Methodology 0.36, Validation 0.71, Representativeness 2, Directness 0.71, Measured error 0.71).

Table 51 Confidence scoring of the coral index for the inshore marine zones. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are the sum of the weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high).

Maturity of methodology (x0.36)	Validation (x0.71)	Represent-ativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final	Rank
3	3	2	3	1	10.1	4

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

6.3. Seagrass

The methods for reporting seagrass including the combined display approach for presenting results from the two seagrass programs (MMP and QPSMP) are provided in the methods technical report (WTW 2023). The inshore marine zone seagrass condition scores and grades for 2021-22 and previous years are presented in Table 52. The site scores and grades for the two reported inshore zones are presented in Table 53. Note that for the QPSMP the seagrass site score is the minimum of the indicator values unless species composition is zero, in which case it is the average of species composition (0) and the next lowest scoring indicator, whilst for the MMP the seagrass site score is the average of the indicator values. The condition score for an inshore zone is the average of the site scores. Seagrass indicator and condition scores for previous years are presented in Appendix F Table 138 to Table 141.

Table 52 Inshore marine zone seagrass condition results for 2020-21 and previous years.

Inshore zone	21-22	20-21	19-20	18-19	17-18	16-17	15-16
North	60#	57#	46	53	46	30	30
Central			nd	nd	nd	nd	nd
South	40#	40#	35	35	23	6	18
Palm Island			nd	nd	nd	nd	nd

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available. #The MMP updated seagrass condition indicators for 2020-21 with the removal of tissue nutrient status and replacement of reproductive effort with resilience. For further information on calculation of seagrass scores refer to methods technical report (WTW 2022). **Note:** as from 2016-17 results for inshore seagrass are provided by MMP as whole numbers within the 0-100 scoring range for zones that are represented solely by MMP seagrass data (South inshore zone). This ensures consistent reporting by the WT report card and MMP for scores that are on the boundary between grades and for which grades may be affected by the method used for the rounding of decimal places.

The 2021-22 reporting of MMP inshore seagrass is the second year using the updated indicators of seagrass condition, which replaced the reproductive effort indicator with a more holistic resilience indicator and removed the tissue nutrient status indicator. Further explanations of this update and a comparison of scoring using the previous and updated methods are provided in the results technical report for 2020-21 (WTW 2022) and the current methods technical report (WTW 2023).

The inshore seagrass scores are likely to be influenced by the monitoring programs that are present. Given that the QPSMP and MMP designs and indicators differ, the condition assessments are not directly comparable due to the different seagrass characteristics that are measured, and the different monitoring approaches. It is recommended to refer to the technical reports from each monitoring programs to assist the interpretation of the results in more detail. For the QPSMP refer to Reason *et al*. (2020) and for the MMP refer to the latest 'Marine Monitoring Program: Annual Report for inshore seagrass monitoring' available at https://elibrary.gbrmpa.gov.au/jspui/.

Table 53 Seagrass site scores and grades calculated from indicators from QPSMP and MMP for 2021-22.

Inshore zone	Site code	QPSMP			MMP		Site score and grade
		Biomass	Area	Species composition	Percent cover	Resil-ience	
North	CN13	80	93	100	nd	nd	80
	YP1 & YP2	nd	nd	nd	100	62	81
	CN34	65	73	84	nd	nd	65
	CN11	76	88	100	nd	nd	76
	GI1 & GI2	nd	nd	nd	81	45	63
	LI1	nd	nd	nd	25	6	16
	GI3	nd	nd	nd	87	85	86
	LI2	nd	nd	nd	25	5	15
South	LB1 & LB2	nd	nd	nd	0	30	15
	MS1 & MS2	nd	nd	nd	63	nd	63
	DI1 & DI2	nd	nd	nd	25	85	55
	GOI#	nd	nd	nd	nd	nd	nd
	DI3	nd	nd	nd	25	30	28

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available. Note that for the QPSMP the seagrass site score is the minimum of the indicator values, whilst for the MMP the seagrass site score is the average of the indicator values.

Inshore seagrass remained in moderate condition in the North zone with the score increasing from the previous year to just below the threshold for 'good', whilst seagrass in the South zone remained 'poor' with the score unchanged since the previous year. Both the North and South zones have remained on the same grade for the past five years although the scores have shown an increasing trend for both zones over this time indicating a general recovery from past disturbances.

North zone

Location of MMP sites and QPSMP meadows – Cairns (3 meadows: CN11, CN13, CN34), Yule Point (2 averaged intertidal sites: YP1, YP2), Green Island (2 averaged intertidal sites: GI1, GI2; 1 subtidal site: GI3), Low Isles (1 intertidal site: LI1; 1 subtidal site: LI2).

- Seagrass condition for inshore QPSMP monitoring meadows (Cairns Harbour) continued to improve after the La Niña associated declines in 2009 - 2011. The average grades for all condition indicators (biomass, area, species composition) were all 'good' or 'very good' in the past 3 years.
- Overall condition scores improved at the Green Island MMP sites in the past year, with intertidal seagrass in good condition and subtidal sites in very good condition. Seagrass at the Low Isles sites remained 'very poor' for the fourth year.

South zone

Location of MMP sites – Lugger Bay (2 averaged intertidal sites: LB1, LB2), Missionary Bay (2 averaged subtidal sites: MS1, MS2), Dunk Island (2 averaged intertidal sites: DI1, DI2; 1 subtidal site: DI3), Goold Island: GOI (suspended site). No QPSMP meadows.

- Seagrass condition maintained its poor status from last year.
- Missionary Bay seagrass cover reduced from 100% to 63%.
- Seagrass condition remains 'very poor' at Lugger Bay, but Dunk Island subtidal site DI3 has improved from 'very poor' to 'poor' condition.
- Overall resilience increased from 'poor' to 'moderate' due to Dunk Island's intertidal very good score.
- Goold Island has not been monitored for 6 years so is called a suspended site by the MMP.
- No meadow scale monitoring occurs in this zone - all seagrass monitoring is limited to smaller scale transect sites.

Key messages: inshore seagrass

- North zone inshore seagrass improved in condition from the previous year, and whilst the grade remained 'moderate', the score of 60 was just below the threshold for a grade of 'good'.
- South zone inshore seagrass remained in poor condition with the score of 40 unchanged from the previous year.
- The North and South zone grades have remained unchanged for the past five years but the increasing scores for both zones over this time indicates a general improvement in condition.

Recommendations for inshore seagrass (Seagrass Ecology Group, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University)

- *Address poor spatial representation at meadow scale in a number of zones.* We recommend additional meadow scale monitoring in some zones. Monitoring at this larger scale shows a clearer picture of seagrass condition at scales appropriate to the regional report card. Recommended locations include:
    a. Central zone inshore waters
    b. South zone inshore waters, particularly Hinchinbrook area

The following project may have the capacity to add long-term meadow scale monitoring of seagrass for the northern coastal area of the South zone.

Mandubarra Healing Country project (2022 – 2023):

In November 2022, Mandubarra Land and Sea Rangers and seagrass researchers from TropWATER, James Cook University (JCU) mapped benthic habitat within Mandubarra Sea Country and TUMRA along the coast from southern end of King Reef - Kurrimine Beach to the mouth of Liverpool Creek on Cowley Beach. The study was part of a collaborative Healing Country Grant with funding provided through the Great Barrier Reef Foundation. Large seagrass meadows were found throughout the survey area containing 5 different seagrass species. Green sea turtles were observed during the surveys and numerous dugong feeding trails could be seen in the coastal meadows at low tide (Figure 16). A report is being prepared for the funding body and is due for completion in mid-2023. TropWATER and Mandubarra Land and Sea Rangers are exploring possibilities of long-term monitoring of one of their meadows that would potentially add a key monitoring site in the Wet Tropics filling a gap in coastal seagrass condition score for the report card.

Figure 16 Mandubarra Rangers and JCU researchers on a seagrass field training day in Kurimine Beach 2022. Dugong feeding trails can be seen in the seagrass meadows in the foreground. (Image: TropWATER)

Confidence

Confidence in the inshore seagrass results is shown in Table 54 for the two monitoring programs. Confidence scores (1 – 3) have been weighted according to the 2017 updated methods for assessing confidence (WTHWP 2017) (Maturity of Methodology 0.36, Validation 0.71, Representativeness 2, Directness 0.71, Measured error 0.71).

Table 54 Confidence scoring of seagrass indices used in the MMP and QPSMP monitoring for inshore marine zones. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are the sum of the weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high).

	Maturity of methodology (x0.36)	Validation (x0.71)	Represent-ativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final	Rank
MMP Seagrass index	2.5	3	1	3	2	**8.6**	**3**
QPSMP Seagrass index	3	3	1	3	2	**8.8**	**3**

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

6.4. Overall inshore marine scores and grades

The index and overall inshore marine scores and grades for 2021-22 are presented in Table 55 and the overall scores and grades for previous years are presented in Table 56. The scores for inshore zones increased from the previous year except for the Central zone which decreased slightly and declined from 'good' to 'moderate', whilst the North zone improved from 'moderate' to 'good'. Grades for the South and Palm Island zones were unchanged from the previous year and remained 'moderate'.

Table 55 Inshore index and overall scores and grades for 2021-22.

Inshore zone	Water Quality	Coral	Seagrass	Fish	Overall
North	81	51	60	nd	64
Central	62	58	nd	nd	60
South	60	60	40	nd	53
Palm Island	68	45	nd	nd	56

Standardised scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. nd indicates no data available.

Table 56 Inshore overall scores and grades for all years.

Inshore zone	21-22	20-21	19-20	18-19	17-18	16-17	15-16
North	64	57	60	60	54	48	52
Central	60	61	67	59	57	57	62
South	53	51	56	47	41	37	44
Palm Island	56	55	59	56	51	57	59

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

7. OFFSHORE MARINE

The location of the offshore marine reporting zone and monitoring sites are shown in Figure 15.

7.1. Water Quality

The 2021-22 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 2020-21 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 57). The scores were similar for all reporting years. The water quality indicators and index for previous years are presented in full in Appendix F Table 142 to Table 145.

Table 57 Results for the water quality indicators and index for 2021-22 and the water quality index for previous years

Water quality indicator		Water quality index		Water quality index					
Chlorophyll-*a*	Water clarity (TSS)	21-22		20-21	19-20	18-19	17-18	16-17	15-16
nd	nd	nd		nd	98.7	99.1	99.0	99.5	99.4

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no or insufficient data available.

During 2019-20 there were limitations in the technical support for maintaining the MWQ processing scripts and satellite data streams. Consequently, the more recent data for the 2019-20 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 2022-23 reporting year.

7.2. Coral

The offshore coral indicator and index scores (Table 58) were based upon the surveys of the Long-Term Monitoring Program (LTMP) between September 2021 and May 2022 and represented 9 separate reefs in the Wet Tropics region as specified in the methods technical report (WTW 2023). The 2021-22 coral indicator and condition index scores for each reef are presented in Appendix G (Table 153)..

The LTMP sampling design was updated for 2021-22 onward (see Report Card update below), and means the offshore zone indicator and index results are no longer directly comparable with reported results from previous years. The back calculation of results using the updated survey design (Table 59) are now used for comparison with the 2021-22 results, consequently all results for the offshore coral section as from 2021-22 are now evaluated in relation to previous years using the back calculated results from the updated survey design. The offshore coral indicator and index scores for

years prior to 2021-22 are still presented in Appendix F Table 147 to Table 151 since they were the scores and grades that represented the offshore zone for the previous report cards.

The juvenile density and coral change indicators increased from the previous year, whilst coral cover marginally decreased. Overall these changes resulted in a an improvement in the coral index score to 'good'.

Table 58 Results for coral indicators and index for 2021-22.

Coral indicators			Coral index
Juveniles	Coral Cover	Coral Change	21-22
91	39	52	**61**

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

The following information and key messages on results of the offshore coral for 2021-22 were sourced from online publications from the AIMS Long-Term Monitoring Program for surveys in the Wet Tropics region available on the website page https://www.aims.gov.au/monitoring-great-barrier-reef/gbr-condition-summary-2021-22 and Reef Monitoring (aims.gov.au).

Hard coral cover along permanent transects in the offshore zones increased in 2021-22 to its highest since 2017, mirroring results reported for reef-wide manta tow surveys. Some reefs were surveyed before the summer of 2021-22 and some after, and during the summer high sea surface temperatures occurred in the offshore zone resulting in heat stress and extensive coral bleaching as observed from aerial surveys in March 2022. The extent of impacts on offshore coral will be more fully assessed with the next round of long-term monitoring surveys by AIMS.

Many reefs in the offshore zone have been impacted from recent outbreaks of crown-of-thorns starfish. The 2021-22 reef surveys recorded no potential, incipient or active crown-of-thorns starfish outbreaks in the offshore zone. The Great Barrier Reef Marine Park Authority's Crown-of-thorns Starfish Control Program, which actively removes individual starfish, is likely to have substantially contributed to the very low numbers.

Since the previous survey of the nine reefs, six reefs had an increase in coral cover, one remained unchanged and the other two reefs (Hastings and Farquharson) had a slight decline, whilst the density of juveniles either increased or remained stable at all reefs. All reefs have shown a general improvement in coral cover following impacts of heat stress during the 2016 and 2017 summers, which resulted in coral bleaching, with four reefs (Farquharson, Mackay, Peart and Taylor) also impacted by crown-of-thorns starfish outbreaks in 2018.

Key messages: offshore coral

- Hard coral cover increased to its highest level since 2016-17 for the offshore zone.
- During the summer high sea surface temperatures occurred in the offshore zone. The next round of surveys will further assess the extent of heat stress and coral bleaching on coral condition.
- The 2021-22 reef surveys recorded no potential, incipient or active crown of thorns starfish outbreaks in the offshore zone.

- All reefs have shown a general improvement in coral cover following impacts from heat stress and crown-of-thorns starfish between 2016 and 2018.

Report card update

The LTMP updated the sampling design for 2021-22 onwards. For the Wet Tropics region, the LTMP previously included 15 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 (WTW 2023).

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.

The updated LTMP sampling design has meant that offshore coral scores produced for 2021-22 onwards are not directly comparable to the scores using the previous design as presented in the report cards up to 2020-21 (Appendix F Table 147 to Table 151). The indicators and index scores and grades for offshore coral are presented in Table 59 for the previous sampling design, and for the updated sampling design, for which the scores and grades have been back calculated for the previous reporting years. This allows the condition of reefs to be assessed over time for the updated sampling design.

Differences between the indicator and index scores and grades are evident for the two sampling designs. The updated sampling design has typically produced higher indicator scores, and consistently higher index scores, since 2017-18 compared to the previous sampling design.

Table 59 Offshore coral scores and grades from the previous and the updated LTMP sampling design.

	Previous sampling design				Updated sampling design			
Year	Juveniles	Coral Cover	Coral Change	**Coral**	Juveniles	Coral Cover	Coral Change	**Coral**
2021-22	nd	nd	nd	nd	92	39	52	**61**
2020-21	65	32	52*	**50**	74	34	43	**54**
2019-20	62	29	37	**42**	73	29	51	**51**
2018-19	68	26	51	**48**	80	27	70	**59**
2017-18	71	28	53	**51**	77	25	67	**56**
2016-17	95	51	56	**67**	99	52	67	**73**
2015-16	96	60	54	**70**	97	61	66	**75**

Standardised scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. The coral index is shown in bold and is the average of the three contributing indicators. * indicated scores are not directly comparable to previous years. The Coral Change indicator is only estimated during years free from acute disturbances, such as cyclones, marine heat waves and outbreaks of crown-of-thorns starfish. Internal revision of disturbance categorisation at AIMS has led to more disturbances being categorised and this resulted in increased scores for the coral change indicator. nd indicates no data available.

Confidence

Confidence in the offshore coral results is shown in Table 60.

Table 60 Confidence scoring of the coral index for the offshore marine zone 2021-22. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are the sum of the weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high).

Maturity of methodology (x0.36)	Validation (x0.71)	Represent-ativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final	Rank
3	3	2	3	1	10.1	4

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

7.3. Overall offshore marine score and grade

For 2021-22 there was insufficient data to provide an overall grade and score for the offshore zone (Table 61). To produce an overall grade and score at least two of the three indices are required, based on decision rules for aggregation (WTW 2022). In all previous years the grade for offshore water quality has been 'very good'. It is expected that offshore water quality monitoring can recommence for the 2022-23 reporting year and onwards, which will allow overall offshore marine scores and grades to be reported. Note that for years prior to 2021-22 the previous LTMP sampling design for the offshore coral surveys was used for scoring and grading the coral index. As from 2021-22 the LTMP has applied an updated sampling design for the coral surveys.

Table 61 Offshore marine scores and grades of indices for 2021-22 and overall scores and grades for 2020-21 and previous years.

Water quality	Coral	Fish	21-22
nd	**61**	nd	ID

20-21	19-20	18-19	17-18	16-17	15-16
ID	70	73	75	83	84

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available. ID indicates insufficient data.

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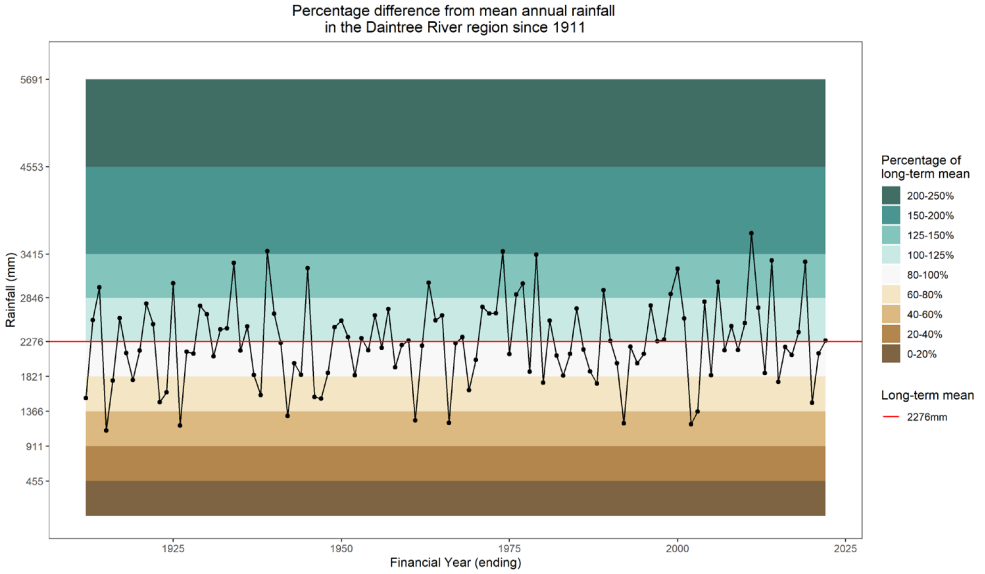
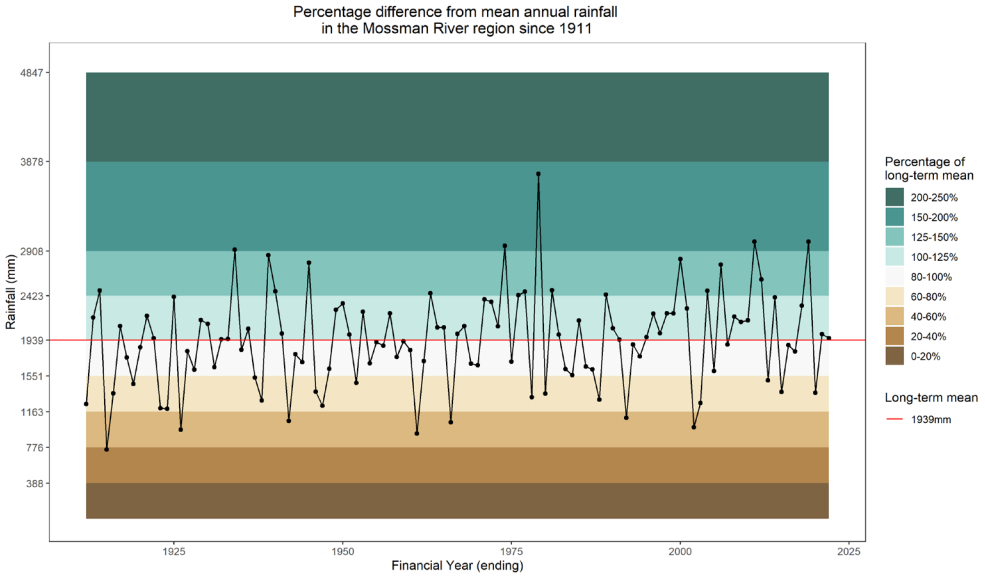
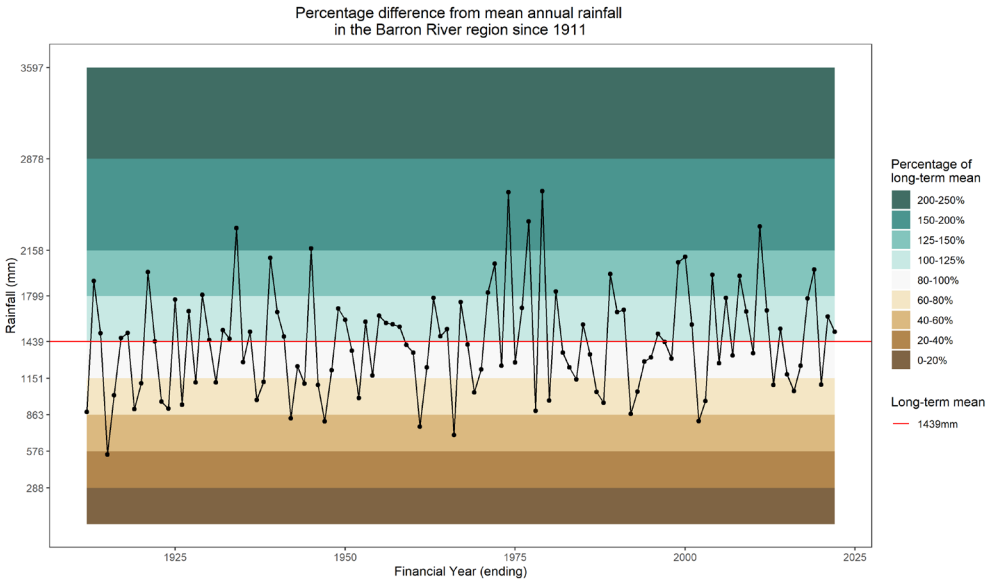
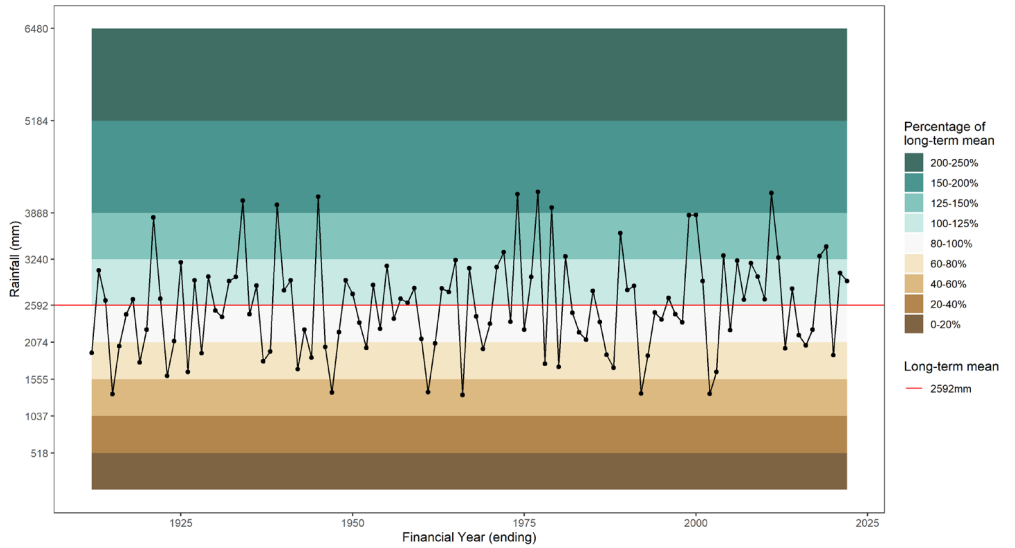
Appendix A. Long-term annual rainfall totals (1911 to 2022) for basin areas of the Wet Tropics



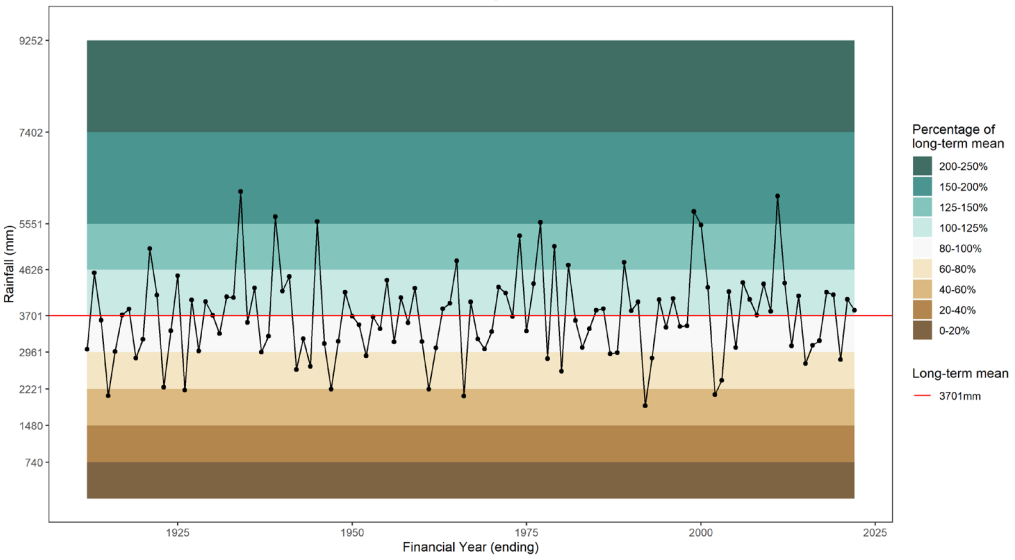




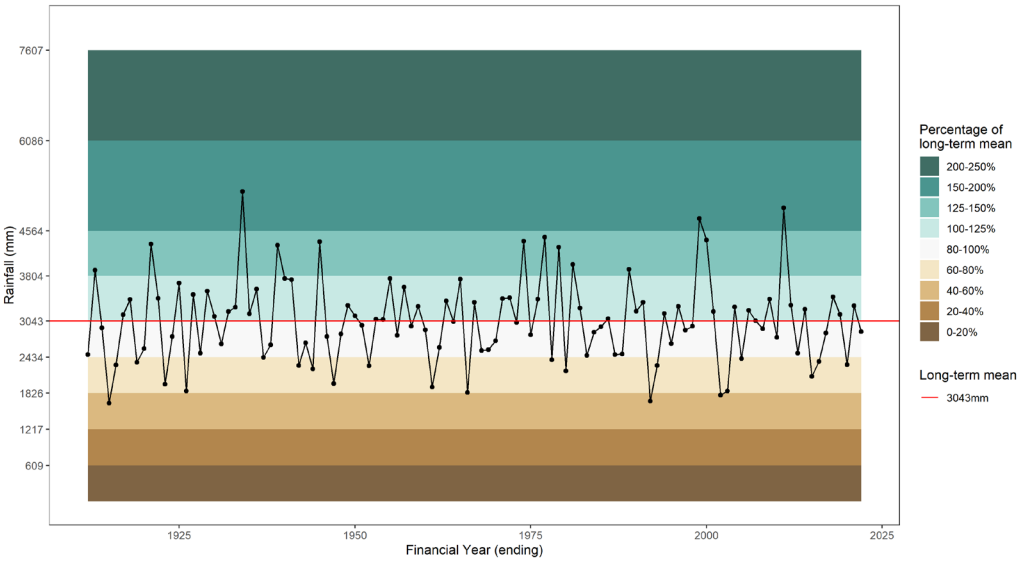
Percentage difference from mean annual rainfall in the Mulgrave River region since 1911



Percentage difference from mean annual rainfall in the Russell River region since 1911



Percentage difference from mean annual rainfall in the Johnstone River region since 1911



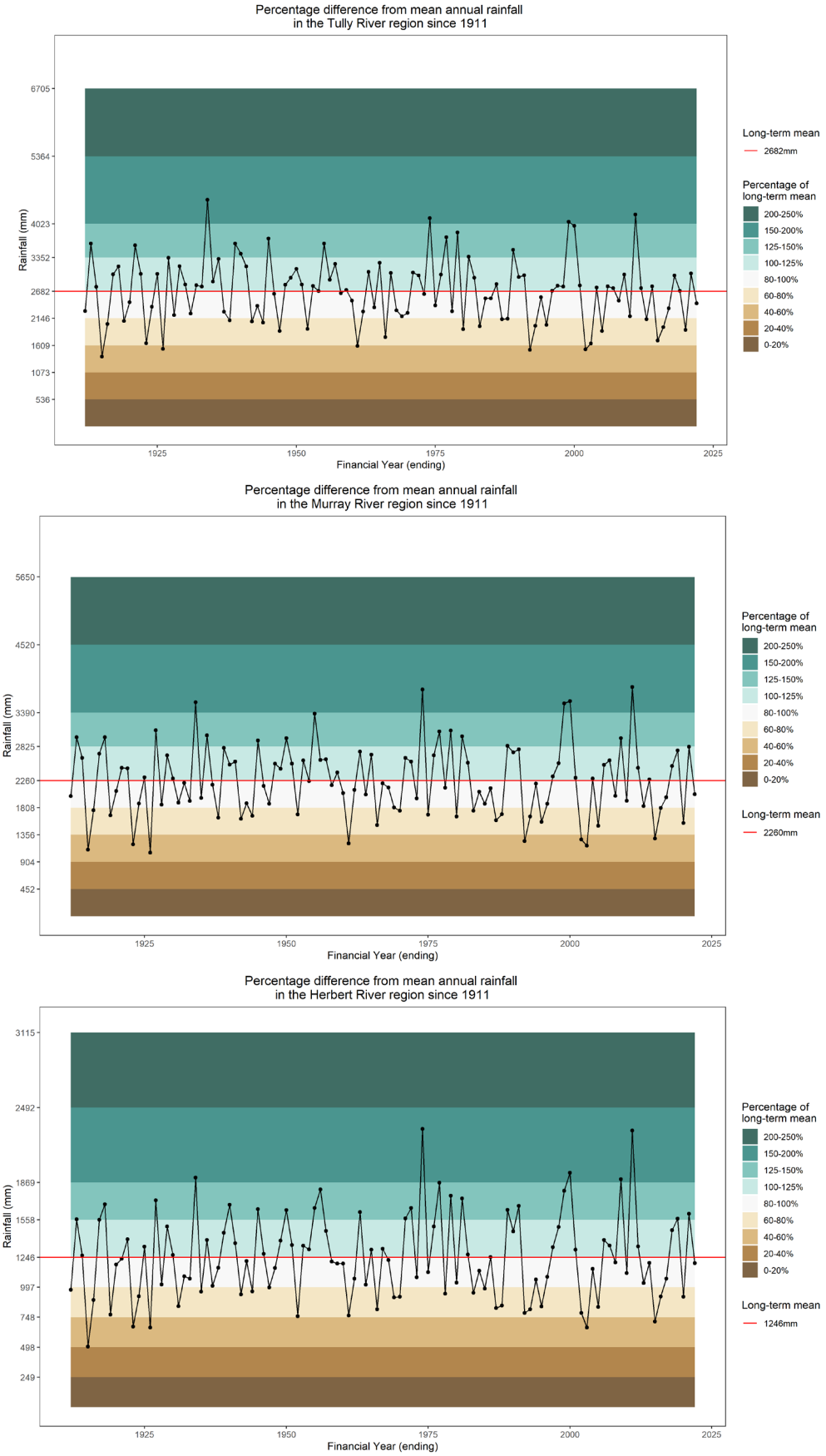


Figure 17. Annual rainfall totals, and long-term annual rainfall average (1911 to 2022) for basins of the Wet Tropics. Data sourced from the Bureau of Meteorology Australian Water Outlook .

Appendix B. Water quality data and scores for basins, estuaries and inshore marine reporting zones.

Freshwater basins and estuaries

For each basin the high flow data and low flow data were evaluated against the water quality objectives for high flow and base flows at the moderately disturbed level of protection scheduled under the EPP (Water and Wetland Biodiversity) 2019 for Wet Tropics basins (DES 2020) (Table 62 to Table 71). Water quality objectives are referred to as guideline values (GV) to maintain clarity of terms throughout this report. As noted in the methods technical report (WTW 2022) the scheduled high flow guideline values (GVs) were set as the 80th percentile of historical data from the upper Tully Gorge reference site which has naturally low FRP concentrations. Concentrations of FRP are diluted during rainfall run-off events as it takes longer to become soluble than other nutrients, for example DIN. The "moderately disturbed" values for base-flow conditions are derived from 50th percentiles of impacted end of system catchment sites which drain agricultural areas where phosphorus is applied in the form of fertiliser. Consequently, the FRP GVs are lower for high flows than for base-flows.

In the basin water quality tables, the months are listed only if monitoring occurred for the flow type (high flow or low flow) for that month. Sampling intensity is greater during wet season events and sampling is generally once per month during the dry season. For months where more than one sample was taken the water quality data for both high flow and base flow were calculated to monthly medians before the analysis, and consequently this procedure addressed any potential bias in the raw data relating to sampling intensity. The high flow and base-flow condition scores were multiplied by the proportion of days of the year that high flow or base flow conditions occurred and were then summed to provide the annual condition score (Table 62 to Table 71). The methods technical document provides full details of the method (WTW 2023). Box and whisker plots of water quality indicator concentrations for high flow and base-flow conditions are presented in Figure 18 to Figure 20 and were conducted on all data points collected during the reporting period and not on the monthly values used for generating scores.

For estuaries chlorophyll *a*, turbidity, dissolved oxygen, DIN and FRP were evaluated against the scheduled guidelines for the water type at which the sampling site was located (moderately disturbed mid-estuary or lower estuary/enclosed coastal) in accordance with the EPP (Water and Wetland Biodiversity) 2019 for Wet Tropics basins (DES 2020). For estuaries with both mid- estuary and lower estuary/enclosed coastal water types the annual scores were multiplied by the proportion of data values within each water type and then condition scores were summed. The medians, condition scores and grades for each reporting zone are presented in Table 72 to Table 79 below.

The following scoring ranges and grading apply to freshwater basin and estuary water quality and are described in the methods technical report (WTW 2023).

- TSS, DIN FRP, turbidity, DO, Chl *a*: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = assigned 90.
- Sediment, nutrients, phys-chem, pesticides: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100

Table 62 Daintree Basin water quality monthly values and scores for 2021-22 reporting period.

High flows (>25 m³/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	14	0.116	0.004	
	Aug	27.5	0.0415	0.0015	
	Dec	26.5	0.1215	0.004	
	Jan	20	0.119	0.004	
	Feb	23	0.076	0.003	
	Mar	1.4	0.0325	0.0055	
	Apr	41	0.1185	0.005	
	May	7	0.09	0.002	
	Jun	3	0.0315	0.0055	
	Seasonal	20	0.090	0.004	167
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		26.9	0.119	0.005	
Condition score		90.0	77.6	61.0	
Grade		VG	G	G	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	1	0.029	0.004	
	Aug	1	0.014	0.003	
	Oct	2	0.009	0.003	
	Nov	3	0.009	0.003	
	Jun	2			
	Seasonal	2	0.012	0.003	198
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		2	0.020	0.003	
Condition score		90.0	90.0	90.0	
Grade		VG	VG	VG	

Annual	**(high flow only)**	**TSS**	DIN	FRP	**Nutrients**
Score		90.0	84.3	76.7	80.5
Grade		VG	VG	G	G

n(days) is the number of high flow days or base-flow days for the reporting period. GV is guideline value, SF is the scaling factor, 80th %-tile is the 80th percentile of the monitoring data, No.≤ GV is the number of data points less than or equal to the guideline value, and percentile ≤ GV is the percentile of data points less than or equal to the guideline value. Full explanation of terms and scoring method are provided in WTW 2023.

Table 63 Mossman Basin water quality monthly values and scores for 2021-22 reporting period.

Base-flows (Mossman US)	Monthly value (mg/L)	TSS	DIN	FRP
	Aug	1	0.085	0.005
	Oct	1	0.08	0.005
	Feb	1	0.12	0.01
	May	27	0.03	0.005
	Aug	1	0.085	0.005
	Seasonal	1	0.080	0.005
GV (mg/L)		8	0.060	0.008
SF (mg/L)		74	0.261	0.013
80th %-tile (mg/L)		9	0.092	0.006
Condition score		77.5	54.8	90.0
Grade		G	M	VG

Base-flows (Mossman WWTP)	Monthly value (mg/L)	TSS	DIN	FRP
	Aug	1	0.120	0.010
	Oct	1	0.150	0.050
	Dec	7	0.130	0.040
	Feb	1	0.140	0.020
	May	12	0.040	0.020
	Seasonal	1	0.130	0.020
GV (mg/L)		8	0.060	0.008
SF (mg/L)		74	0.261	0.013
80th %-tile (mg/L)		8	0.142	0.042
Condition score		90.0	39.7	0.0
Grade		VG	P	VP

Base-flows (South Mossman)	Monthly value (mg/L)	TSS	DIN	FRP
	Aug	4	0.095	0.005
	Oct	6	0.120	0.005
	Dec	36	0.385	0.028
	Feb	5	0.150	0.010
	May	18	0.080	0.010
	Seasonal	6	0.120	0.010
GV (mg/L)		8	0.060	0.008
SF (mg/L)		74	0.261	0.013
80th %-tile (mg/L)		22	0.197	0.014
Condition score		63.6	42.7	36.5
Grade		G	M	P

Base-flows (Mossman DS)	Monthly value (mg/L)	TSS	DIN	FRP
	Aug	2	0.090	0.005
	Oct	4	0.110	0.005
	Dec	25	0.350	0.040
	Feb	1	0.180	0.010
	May	18	0.080	0.010
	Seasonal	4	0.110	0.010
GV (mg/L)		8	0.060	0.008
SF (mg/L)		74	0.261	0.013
80th %-tile (mg/L)		19	0.214	0.016
Condition score		65.8	45.8	36.5
Grade		G	M	P

Annual (base-flows)	**TSS**	DIN	FRP	**Nutrients**
Score	71.2	49.2	65.0	57.1
Grade	G	M	G	M

GV is guideline value, SF is the scaling factor, 80th %-tile is the 80th percentile of the monitoring data, No.≤ GV is the number of data points less than or equal to the guideline value, and percentile ≤ GV is the percentile of data points less than or equal to the guideline value. Mossman US refers to sites MR2 and MR4 which are in close proximity upstream of the confluence with South Mossman River. Mossman WWTP refers to site MR4.1 which is just downstream of the Mossman wastewater treatment plant discharge point and just upstream of the confluence with the South Mossman River. SMR refers to the site on the South Mossman River just upstream of the confluence with the Mossman River (SMR1). Mossman DS refers to sites MR5 located on the Mossman River just downstream of the confluence with the South Mossman River. Site details and explanation of terms and scoring method are provided in WTW 2023.

Table 64 Barron Basin water quality monthly values and scores for 2021-22 reporting period.

High flows (>8.2 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	July	6	0.166	0.006	
	Aug	5	0.141	0.005	
	Sep	13	0.102	0.006	
	Dec	14	0.124	0.008	
	Jan	117	0.173	0.011	
	Feb	84	0.098	0.021	
	Mar	83	0.131	0.006	
	May	49	0.123	0.006	
	Jun	5	0.010	0.004	
	Seasonal	14	0.124	0.006	199
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		83	0.151	0.009	
Condition score		71.9	57.7	50.8	
Grade		G	M	M	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Oct	7	0.036	0.003	
	Nov	6	0.018	0.003	
	Jan	8	0.048	0.006	
	Oct	7	0.036	0.003	
	Apr	8	0.064	0.002	
	Seasonal	7	0.036	0.003	166
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		8	0.051	0.004	
Condition score		90.0	90.0	90.0	
Grade		VG	VG	VG	

Annual (high flow and base flow)	**TSS**	DIN	FRP	**Nutrients**
	80.1	72.4	68.6	70.5
	G	G	G	G

n(days) is the number of high flow days or base-flow days for the reporting period. GV is guideline value, SF is the scaling factor, 80th %-tile is the 80th percentile of the monitoring data, No.≤ GV is the number of data points less than or equal to the guideline value, and percentile ≤ GV is the percentile of data points less than or equal to the guideline value. Full explanation of terms and scoring method are provided in WTW 2023.

Table 65 Mulgrave Basin water quality monthly values and scores for 2021-22 reporting period.

High flows >30 m^3/s	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
High flow	July	32	0.091	0.008	
	Sep	32	0.172	0.019	
	Dec	11	0.062	0.001	
	Jan	18	0.203	0.015	
	Mar	19	0.094	0.012	
	Apr	28	0.092	0.014	
	May	35	0.089	0.010	
	Seasonal	24	0.093	0.011	112
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		32	0.190	0.015	
Condition score		90.0	65.3	25.4	
Grade		VG	G	P	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	1	0.202	0.004	
	Aug	105	0.1975	0.0095	
	Oct	1	0.19	0.004	
	Nov	5	0.072	0.002	
	Dec	17	0.017	0.0005	
	Jan	2	0.153	0.005	
	Mar	2	0.249	0.006	
	Apr	2	0.275	0.0065	
	Jun	1	0.245	0.004	
	Seasonal	2	0.198	0.004	253
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile		10	0.247	0.006	
Condition score		76.3	19.2	90.0	
Grade		G	VP	VG	

Annual (high flow and base flow)	**TSS**	DIN	FRP	**Nutrients**
Score	80.5	33.4	70.2	51.8
Grade	G	P	G	M

n(days) is the number of high flow days or base-flow days for the reporting period. GV is guideline value, SF is the scaling factor, 80th %-tile is the 80th percentile of the monitoring data, No. ≤ GV is the number of data points less than or equal to the guideline value, and percentile ≤ GV is the percentile of data points less than or equal to the guideline value. Full explanation of terms and scoring method are provided in WTW 2023. The May TSS concentration for high flows coincided with rainfall very much above the average for May.

Table 66 Russell Basin water quality monthly values and scores for 2021-22 reporting period.

High flows (>39.5 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	14	0.13	0.005	
	Sep	40	0.098	0.007	
	Nov	15	0.116	0.002	
	Jan	19	0.308	0.007	
	Feb	12	0.174	0.006	
	Mar	14	0.11	0.009	
	Apr	16	0.105	0.007	
	May	22	0.091	0.006	
	Seasonal	16	0.113	0.007	165
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		21	0.156	0.007	
Condition score		90.0	61.5	48.2	
Grade		VG	G	M	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Aug	1	0.065	0.002	
	Oct	0.5	0.072	0.002	
	Nov	5.5	0.064	0.001	
	Dec	2	0.050	0.001	
	Jan	2	0.074	0.001	
	Mar	1	0.177	0.003	
	Apr	2	0.165	0.003	
	Jun	3	0.152	0.001	
	Seasonal	2	0.073	0.002	200
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		3	0.160	0.003	
Condition score		90.0	57.0	90.0	
Grade		VG	M	VG	

Annual (high flow and base flow)	**TSS**	DIN	FRP	**Nutrients**
Score	90.0	59.0	71.1	65.1
Grade	VG	M	G	G

n(days) is the number of high flow days or base-flow days for the reporting period. GV is guideline value, SF is the scaling factor, 80th %-tile is the 80th percentile of the monitoring data, No. ≤ GV is the number of data points less than or equal to the guideline value, and percentile ≤ GV is the percentile of data points less than or equal to the guideline value. Full explanation of terms and scoring method are provided in WTW 2023.

Table 67 North Johnstone sub-basin water quality monthly values and scores for 2021-22 reporting period.

High flows (>31.6 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Sep	73	0.112	0.009	
	Dec	1	0.066	0.010	
	Jan	33	0.109	0.010	
	Feb	2	0.094	0.004	
	Mar	38	0.147	0.009	
	April	6	0.148	0.006	
	May	35	0.135	0.008	
	Jun	10	0.137	0.007	
	Seasonal	22	0.124	0.008	216
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		37	0.143	0.009	
Condition score		90.0	57.9	39.3	
Grade		VG	M	P	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	1	0.075	0.004	
	Aug	1	0.071	0.003	
	Sep	1	0.039	0.002	
	Oct	1	0.027	0.003	
	Nov	2	0.015	0.005	
	Dec	1	0.046	0.009	
	Seasonal	1	0.043	0.004	149
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		1	0.071	0.005	
Condition score		90.0	73.2	90.0	
Grade		VG	G	VG	

Annual (high flow and base flow)	TSS	DIN	FRP	**Nutrients**
Score	90.0	64.1	60.0	62.1
Grade	VG	G	M	G

n(days) is the number of high flow days or base-flow days for the reporting period. GV is guideline value, SF is the scaling factor, 80th %-tile is the 80th percentile of the monitoring data, No. ≤ GV is the number of data points less than or equal to the guideline value, and percentile ≤ GV is the percentile of data points less than or equal to the guideline value. Full explanation of terms and scoring method are provided in WTW 2022.

Table 68 South Johnstone sub-basin water quality monthly values and scores, and Johnstone combined scores for 2021-22 reporting period.

High flows (>15.0 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
High flow	Jul	1	0.070	0.007	
	Sep	90	0.111	0.009	
	Dec	38	0.060	0.018	
	Jan	46	0.112	0.011	
	Feb	3	0.094	0.006	
	Mar	43	0.158	0.010	
	April	41	0.141	0.009	
	May	75	0.138	0.010	
	June	3	0.088	0.012	
	Seasonal	41	0.111	0.010	234
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		58	0.139	0.011	
Condition score		74.2	63.1	30.5	
Grade		G	G	P	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Aug	1	0.061	0.008	
	Sep	1	0.049	0.007	
	Oct	2	0.040	0.008	
	Nov	2	0.018	0.012	
	Dec	53	0.043	0.013	
	Seasonal	2	0.043	0.008	131
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		12	0.051	0.012	
Condition score		72.7	90.0	61.0	
Grade		G	VG	G	

Annual (high flow and base flow)	**TSS**	DIN	FRP	**Nutrients**
Score	73.7	72.8	41.4	57.1
Grade	G	G	M	M

Johnstone combined Annual (high flow and base-flow)	**TSS**	DIN	FRP	**Nutrients**
Score	81.8	68.5	50.7	59.6
Grade	VG	G	M	M

n(days) is the number of high flow days or base-flow days for the reporting period. GV is guideline value, SF is the scaling factor, 80th %-tile is the 80th percentile of the monitoring data, No. ≤ GV is the number of data points less than or equal to the guideline value, and percentile ≤ GV is the percentile of data points less than or equal to the guideline value. Full explanation of the terms and scoring method are provided in WTW 2023.

Table 69 Tully Basin water quality monthly values and scores for 2021-22 reporting period.

High flows (>61.2 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
High flow	Jul	26	0.147	0.006	
	Aug	259	0.156	0.010	
	Sep	67	0.187	0.007	
	Dec	36	0.294	0.003	
	Jan	20	0.177	0.004	
	Feb	41	0.161	0.009	
	Mar	55	0.162	0.009	
	Apr	40	0.154	0.010	
	May	62	0.139	0.007	
	Jun	2	0.134	0.001	
	Seasonal	41	0.159	0.007	194
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		63	0.179	0.009	
Condition score		71.2	46.8	45.7	
Grade		G	M	M	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	1	0.205	0.001	
	Nov	3	0.096	0.001	
	Seasonal	2	0.151	0.001	171
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		3	0.183	0.001	
Condition score		90.0	33.5	90.0	
Grade		VG	M	VG	

Annual (high flow and base-flow)	**TSS**	DIN	FRP	**Nutrients**
Score	80.0	40.6	66.4	53.5
Grade	G	M	G	M

n(days) is the number of high flow days or base-flow days for the reporting period. GV is guideline value, SF is the scaling factor, 80th %-tile is the 80th percentile of the monitoring data, No. ≤ GV is the number of data points less than or equal to the guideline value, and percentile ≤ GV is the percentile of data points less than or equal to the guideline value. Full explanation of the terms and scoring method are provided in WTW 2023.

Table 70 Murray Basin water quality monthly values and scores for 2021-22 reporting period.

High flows (>8.0 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
High flow	Jul	7	0.255	0.002	
	Sep	11	0.438	0.003	
	Nov	19	0.531	0.009	
	Jan	34	0.738	0.014	
	Feb	13	0.354	0.002	
	Mar	26	0.384	0.016	
	Apr	35	0.186	0.012	
	May	26	0.132	0.010	
	Seasonal	23	0.369	0.010	173
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		31	0.494	0.013	
Condition score		90.0	0.0	33.0	
Grade		VG	VP	P	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	4	0.183	0.002	
	Aug	6	0.083	0.001	
	Sep	2	0.121	0.001	
	Oct	5	0.093	0.001	
	Dec	10	0.094	0.001	
	Jun	3	0.217	0.003	
	Seasonal	5	0.108	0.001	192
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		6	0.183	0.002	
Condition score		90.0	46.5	90.0	
Grade		VG	M	VG	

Annual (high flow and base-flow)	**TSS**	DIN	FRP	**Nutrients**
Score	90.0	24.5	63.0	43.7
Grade	VG	P	G	M

n(days) is the number of high flow days or base-flow days for the reporting period. GV is guideline value, SF is the scaling factor, 80th %-tile is the 80th percentile of the monitoring data, No. ≤ GV is the number of data points less than or equal to the guideline value, and percentile ≤ GV is the percentile of data points less than or equal to the guideline value. Full explanation of the terms and scoring method are provided in WTW 2023.

Table 71 Herbert Basin water quality monthly values and scores for 2021-22 reporting period.

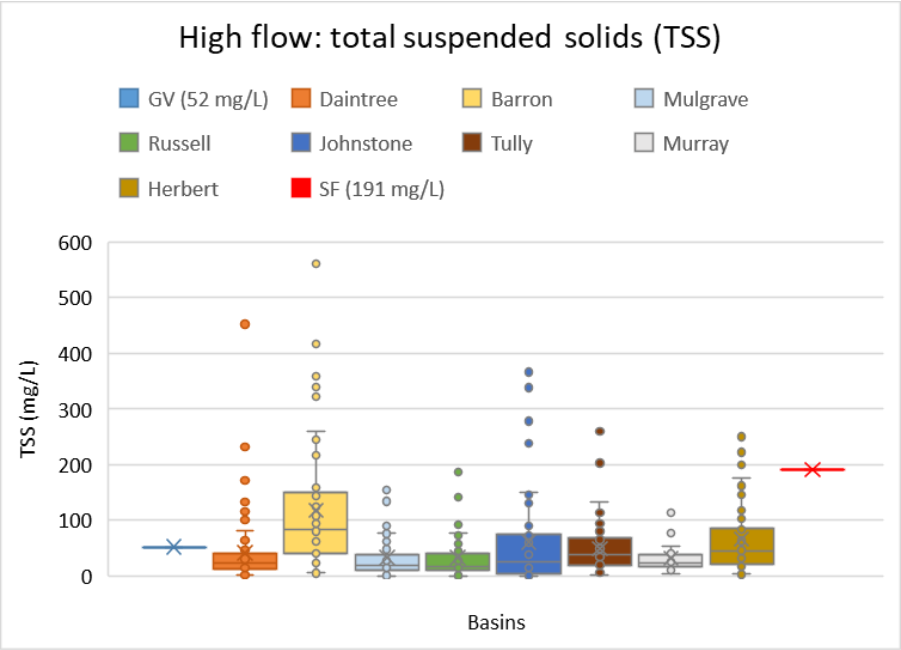
High flows (>44.2 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jan	63	0.150	0.008	
	Feb	46	0.082	0.006	
	Mar	22	0.074	0.005	
	Apr	75	0.094	0.012	
	May	34	0.158	0.006	
	Jun	3	0.298	0.003	
	Seasonal	40	0.122	0.006	127
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		63	0.158	0.008	
Condition score		71.4	58.4	50.8	
Grade		G	M	M	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	6	0.180	0.002	
	Aug	1	0.159	0.001	
	Sep	2	0.191	0.002	
	Oct	3	0.187	0.002	
	Nov	3	0.102	0.005	
	Dec	3	0.092	0.003	
	Jan	3	0.074	0.003	
	Mar	3	0.097	0.001	
	Apr	2	0.126	0.002	
	Jun	2	0.307	0.001	
	Seasonal	3	0.142	0.002	238
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		3	0.187	0.003	
Condition score		90.0	36.0	90.0	
Grade		VG	P	VG	

Annual (high flow and base-flows)	**TSS**	DIN	FRP	**Nutrients**
Score	83.5	43.8	76.3	60.1
Grade	VG	M	G	M

n(days) is the number of high flow days or base-flow days for the reporting period. GV is guideline value, SF is the scaling factor, 80th %-tile is the 80th percentile of the monitoring data, No. ≤ GV is the number of data points less than or equal to the guideline value, and percentile ≤ GV is the percentile of data points less than or equal to the guideline value. Full explanation of the terms and scoring method are provided in WTW 2023.

Figure 18 to Figure 20 provide box and whisker plots of water quality indicators for high flow and base-flow conditions. The mid-line is the median, the cross is the mean and the box depicts the upper and lower quartiles. The whiskers are the lowest and highest datum within 1.5 IQR (interquartile range) and outliers are datum above or below 1.5 IQR. To present the complete variation of data, the analysis was conducted on all data points collected during the reporting period and not on the monthly values used for generating scores.



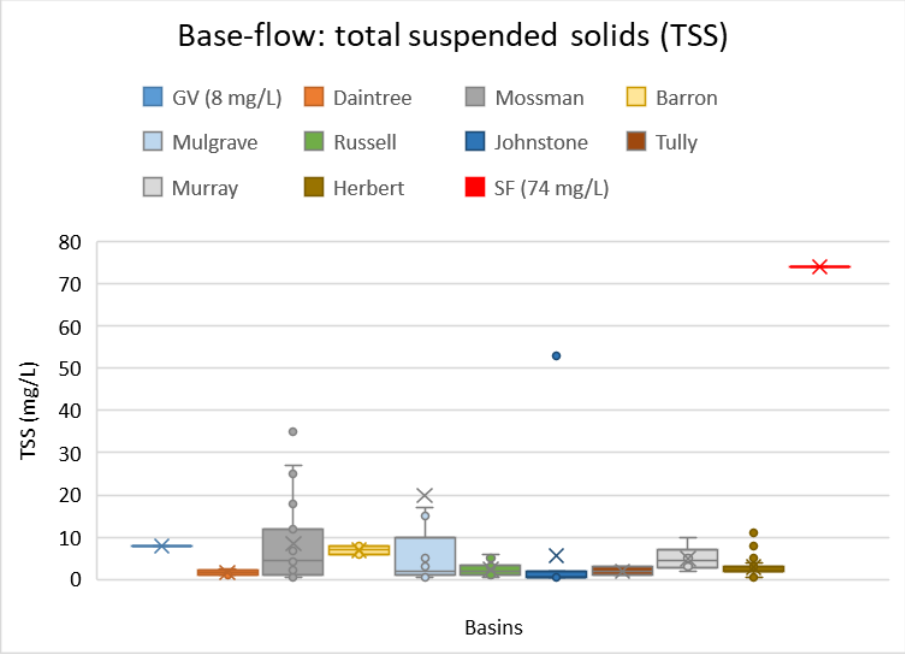


Figure 18 Box and whisker plots of total suspended solids (TSS) concentrations for base-flow and high flow conditions of basins. The mid-line is the median, the cross is the mean, the box depicts the upper and lower quartiles with 1.5 IQR (interquartile range) whiskers and outliers are above or below 1.5 IQR. The guideline value (GV) and scaling factor (SF) are presented. The base-flow data included an outlier value of 208 mg/L TSS for the Mulgrave Basin which is not shown in the plot.

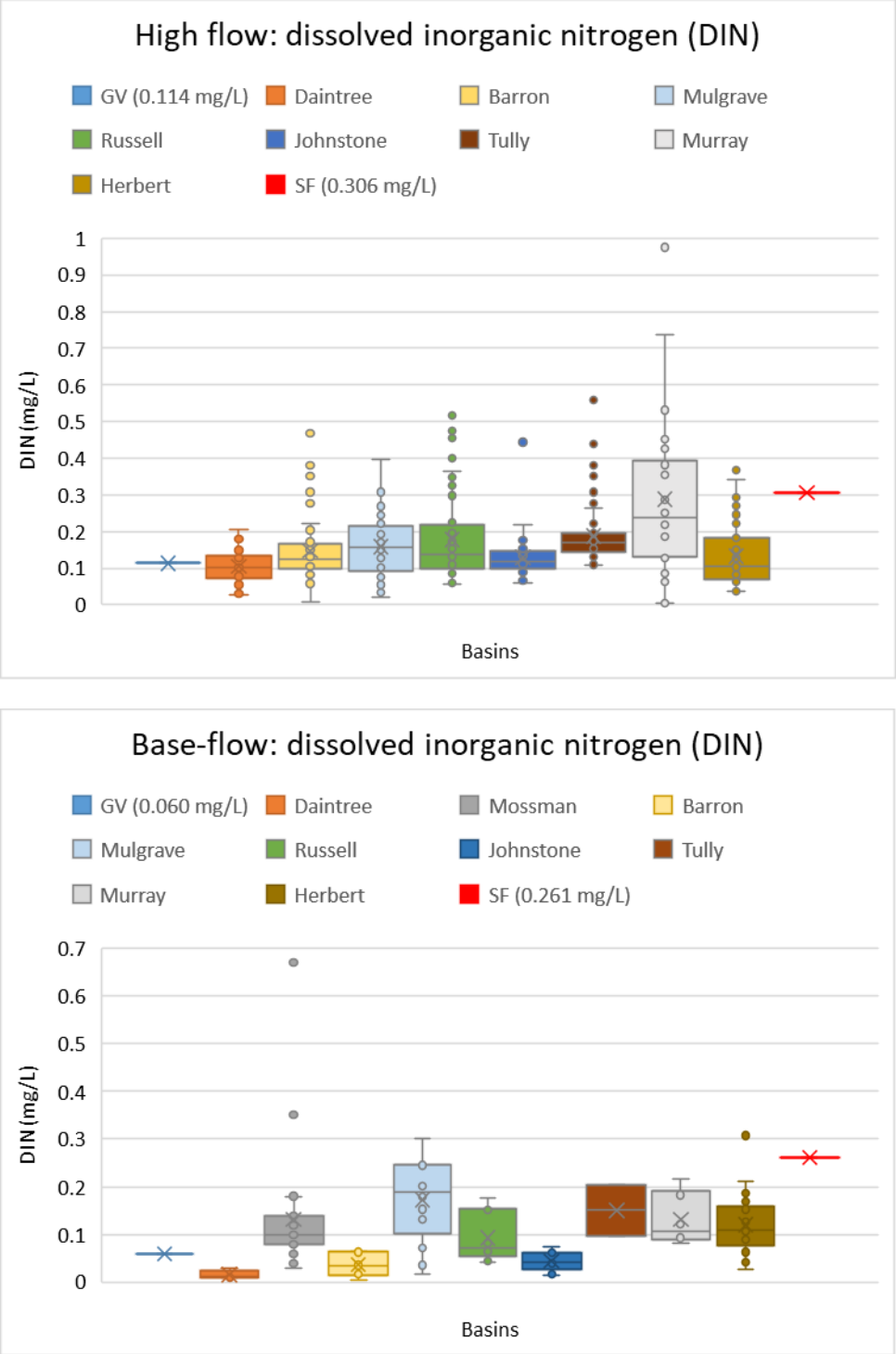
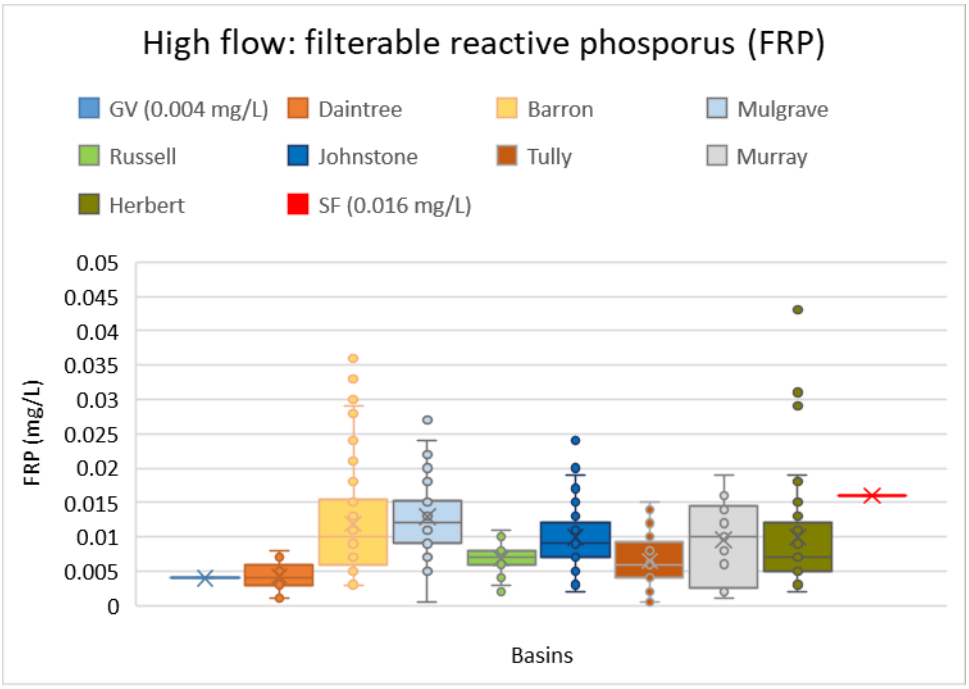


Figure 19 Box and whisker plots of dissolved inorganic nitrogen (DIN) concentrations for base-flow and high flow conditions of basins. The mid-line is the median, the cross is the mean, the box depicts the upper and lower quartiles with 1.5 IQR (interquartile range) whiskers and outliers are above or below 1.5 IQR. The guideline value (GV) and scaling factor (SF) are presented.



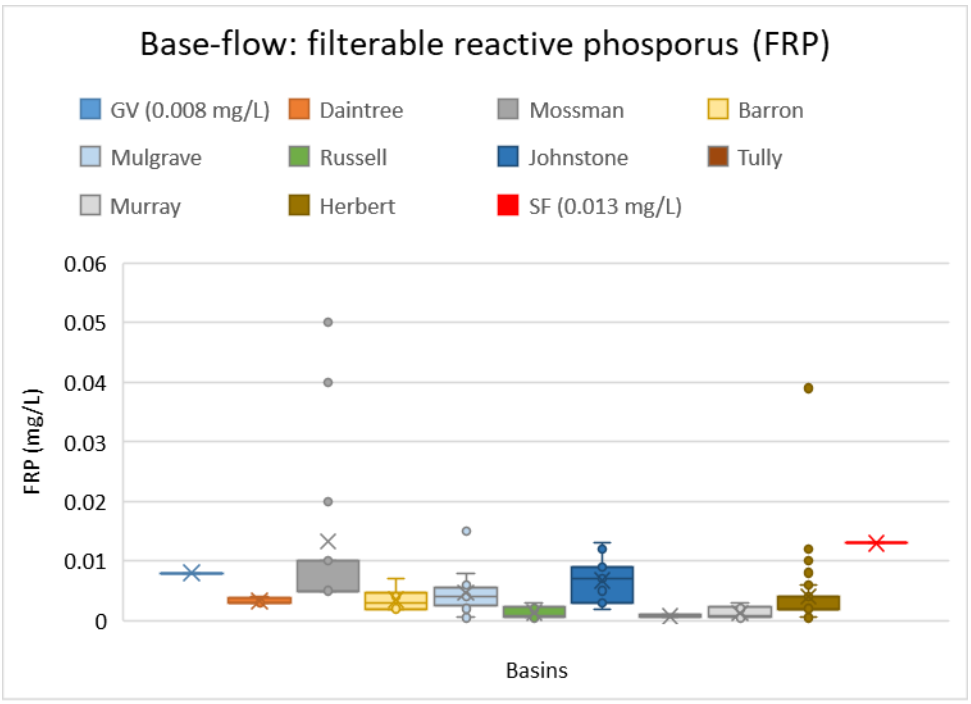


Figure 20 Box and whisker plots of filterable reactive phosphorus (FRP) concentrations for base-flow and high flow conditions of basins. The mid-line is the median, the cross is the mean, the box depicts the upper and lower quartiles with 1.5 IQR (interquartile range) whiskers and outliers are above or below 1.5 IQR. The guideline value (GV) and scaling factor (SF) are presented.

Basin pesticides: risk and chemical contribution

The basin pesticide results for 2021-22 are for the standard pesticide reporting sites which are part of GBRCLMP routine pesticide monitoring, as presented in section 4.1, and for additional sites monitored in 2021-22. The basin monitoring sites have been grouped on the three graphs (Figure 21) according to the ranges of Percent Affected (percent of species affected) to allow visualisation of the relative chemical contribution. The pesticide risk metric category range for the top graph is very low to medium risk, for the middle graph it is very low to low risk, and for bottom graph it is very low to very high risk. For 2021-22 all monitoring sites on the top and middle graphs pesticides were within very low risk (≤1% species affected) or low risk (1> - 5% species affected).

For the standard reporting sites the two main contributing chemicals to pesticide risk in the top graph during 2021-22 were imidacloprid and diuron, as in previous years. The Mulgrave, Russell, North Johnstone, Tully and Herbert, had contributions of imidacloprid at their lowest compared to previous years, whilst diuron contribution was in the mid to high range recorded for previous years. Johnstone River at Coquette point had contributions of imidacloprid in the lower ranges and diuron in the upper ranges compared to previous years. For 2021-22, Mossman, which was last reported for pesticides in 2018-19 had a higher imidacloprid contribution, and a similar diuron contribution compared to the two previous years. The Daintree standard reporting site (middle graph) continued with very low risk and contributing chemical types have varied between years. The contributions of imidacloprid and diuron for the Murray were their lowest compared to previous years (bottom graph).

Management practices reported for 2019-20 (WTW 2021) and 2020-21 (WTW 2022) from sugarcane industry support services in the central to southern production areas of the Wet Tropics have helped explain variation of chemical contributions to pesticide risk, particularly around activities that have reduced imidacloprid applications, and around conditions where herbicide contribution (mainly diuron) has varied. The 2021-22 results indicate that management practices aimed to regulate imidacloprid application to reduce its input into waterways have continued to have effect in the central to southern areas of the region. More information is available from the Reef 2050 Water Quality Improvement Plan case study for the Tully area that demonstrated recent changes in practice management which reduced use of imidacloprid has resulted in improvements in water quality.

The Murray basin continues to have the highest pesticide risk across the standard reporting sites of the Wet Tropics basins. Whilst the contributions of the two major chemicals, diuron and imidacloprid, were lower in 2021-22, the pesticide risk remained high (10 -20% percent affected). The higher pesticide risk at the Murray site compared to the other standard reporting sites may relate to its location on the relatively small catchment of the Murray River which has a low discharge (Figure 4) and a high proportion of upstream area under agricultural land use (Figure 22). In contrast, the adjacent end of systems sites of the Herbert River and Tully River have much larger catchment areas, considerably higher discharge (Figure 4) and have higher proportions of natural and relatively natural land in their upstream catchments (Figure 7). These different features could contribute to the substantially higher pesticide risk scores in the Murray where there is more agricultural pressure per unit catchment area coupled with lower area of total catchment runoff and lower capacity to dilute pesticide inputs.

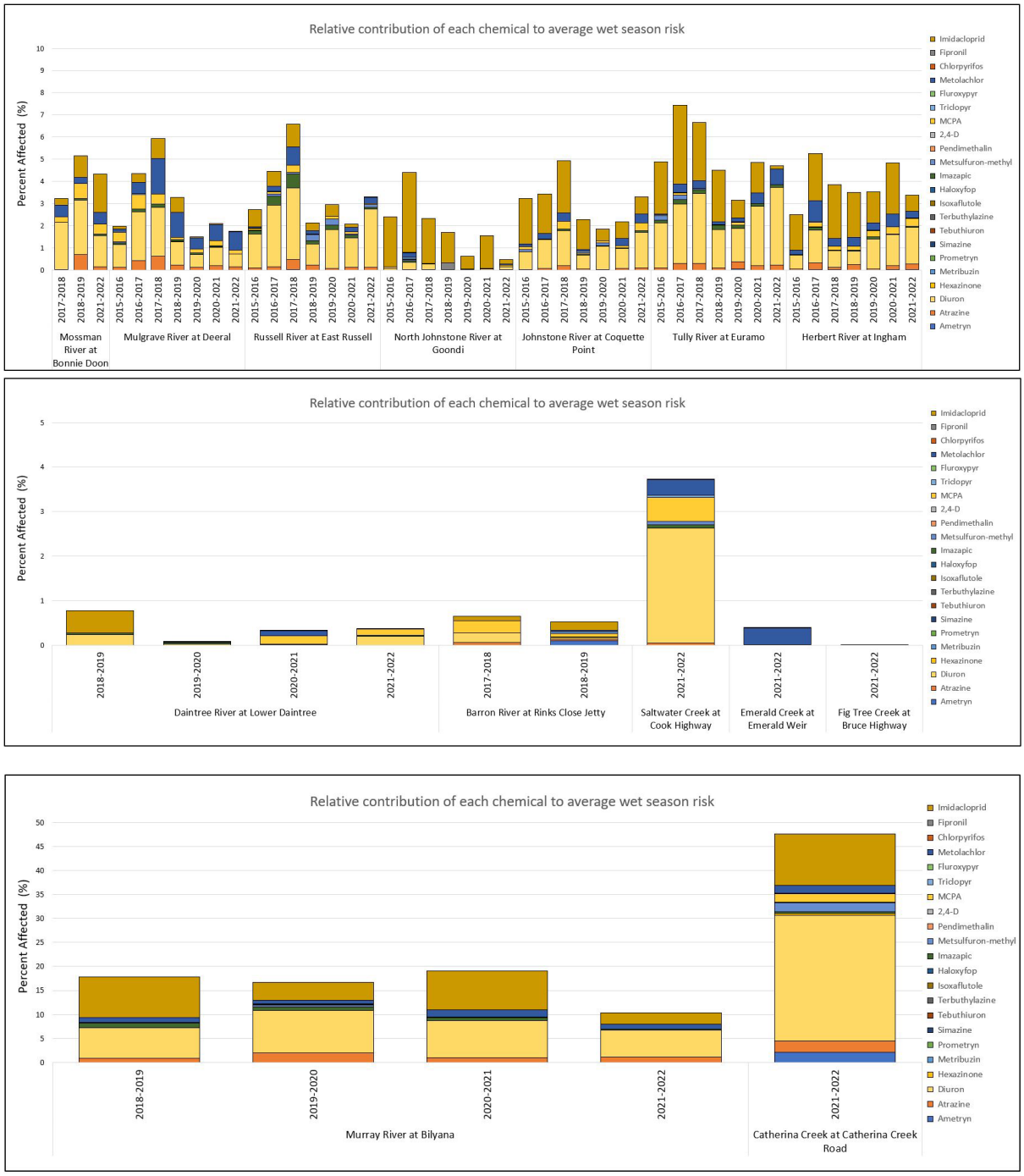


Figure 21 The relative contribution of pesticide types at standard basin reporting sites for all available reporting years and at additional sites for 2021-22. The top graph presents standard reporting sites (Mossman, Mulgrave, Russell, North Johnstone, Johnstone River at Coquette Point, Tully and Herbert), the middle graph presents standard reporting sites (Daintree and Barron) and additional sites (Saltwater Creek, Emerald Creek and Fig Tree Creek), and the bottom graph presents the Murray standard site and the Catherina Creek additional site. Of the full suite of 22 pesticides only those that contributed >0.1% of the toxicity are shown (the remainder had negligible contribution to toxicity). Note that the range of Percent Affected on the y axis varies between the graphs.

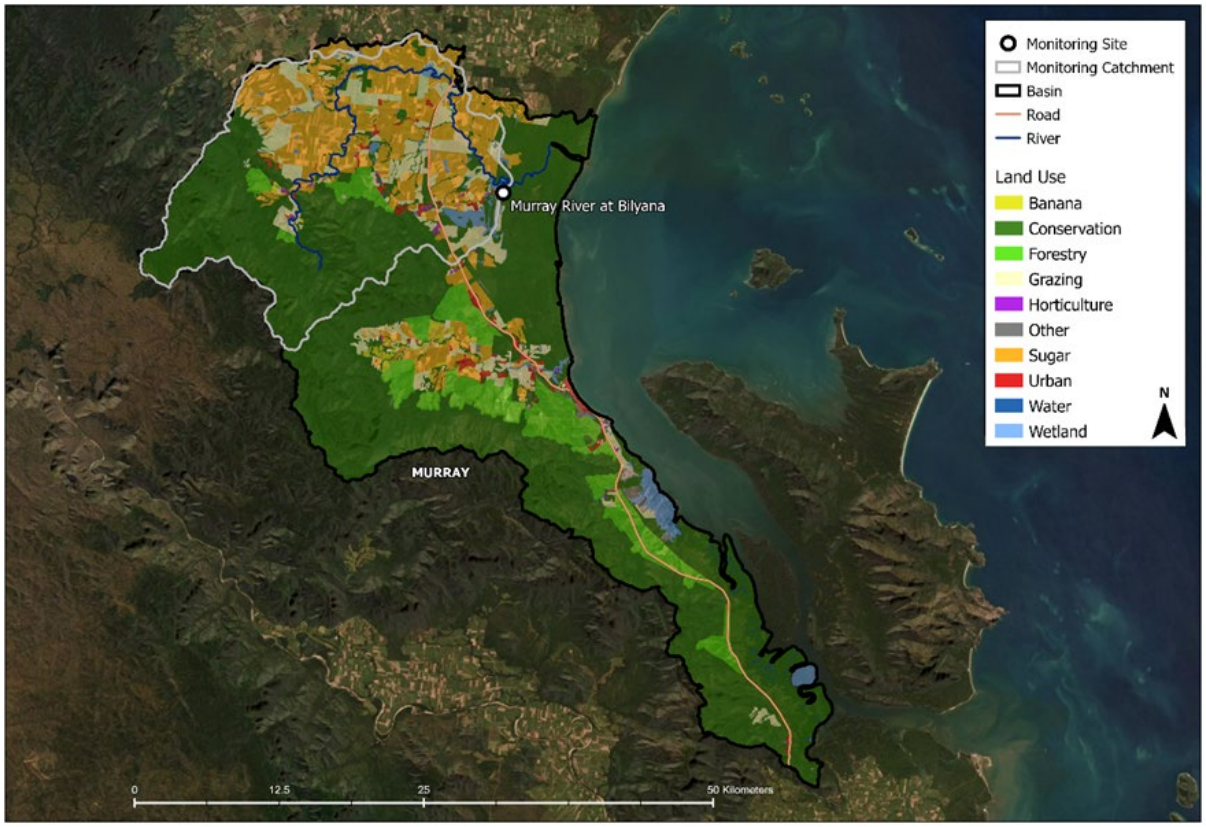


Figure 22 Land use of the Murray Basin and catchment area of the Murray River upstream of the monitoring site at Bilyana.

Land use and hydrology is likely to explain the differences recorded for pesticide risk and relative chemical contributions for the additional sites sampled in 2021-22. The site locations and their surrounding catchment are presented in Figure 23. The following summaries for each site describe the dominant land use and the pesticide risk including major chemical contributions.

- Saltwater Creek sub catchment draining to the coral sea north of Mossman River. Stream order 5, headwaters draining natural rainforest environment and lowland land use dominated by sugarcane production. Pesticide risk was low (similar to Mossman River site) and major chemical contribution was diuron.
- Emerald Creek sub-catchment draining into the Barron River on the Atherton Tablelands. Stream order 4 with headwaters draining natural forested environment, lowland land use dominated by grazing and horticulture. Pesticide risk was very low and major chemical contribution was metolachlor.
- Fig Tree Creek tributary draining into the Mulgrave River near Deeral. Stream order 2 with catchment dominated by natural rainforest environment. Pesticide risk was very low and no discernible major chemical contribution.
- Chatherina Creek tributary draining into the Herbert River downstream of Ingham. Stream order 2 with land use dominated by sugar cane, and upstream catchment of paddock

drainage channels connected to creek. Pesticide risk very high and major chemical contributions were from diuron and imidacloprid.

Figure 23. Additional pesticide sites for 2021-22 showing catchment area and land use. Top left - Saltwater Creek, top right – Emerald Creek, bottom left – Fig Tree Creek, bottom right – Catherina Creek.

Pesticide risk was highest at the Catherina Creek site which had the smallest area of catchment, the lowest capacity for catchment run-off, and greatest intensity of upstream agricultural land use. The lowest risk was at the Fig Tree Creek site which had a very low area of upstream agricultural land use with most catchment run-off draining from natural rainforest areas. The Emerald Creek site (very low pesticide risk) and Saltwater Creek site (low pesticide risk) had considerably larger catchments with greater run-off capacity, and upstream land use which included substantial areas of natural environments. Differences in pesticide risk and contributing chemicals between these two sites were likely a reflection of the area, intensity, and type, of upstream agricultural land use.

References

WTW (Wet Tropics Waterways) 2021. Wet Tropics Report Card 2020 (reporting on data 2019-20). Waterway Environments: Results. Wet Tropics Waterways and Terrain NRM, Cairns.

WTW (Wet Tropics Waterways) 2022. Wet Tropics Report Card 2022 (reporting on data 2020-21). Waterway Environments: Results. Wet Tropics Waterways and Terrain NRM, Cairns.

Table 72 Daintree estuary 2021-22.

Mid-estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual Median	3.1	0.028	0.002	3.1	85.0	85.0
GV	3.0	0.045	0.005	10.0	80.0	105.0
SF	5.0	0.200	0.010	20.0	50.0	111.0
80th or 20th %-tile	3.6	0.069	0.005	4.1	80.7	88.0
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	58.7	69.3	90.0	90.0	90.0	90.0
Grade	M	G	VG	VG	VG	VG
n	36	36	36	30	36	36

Enclosed coastal

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual Median	2.7	0.003	0.001	2.1	94.7	94.7
GV	2.0	0.025	0.005	10.0	85.0	105.0
SF	5.0	0.200	0.010	20.0	50.0	111.0
80th or 20th %-tile	3.7	0.026	0.001	3.6	87.5	97.5
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	46.1	79.7	90.0	90.0	90.0	90.0
Grade	M	G	VG	VG	VG	VG
n	12	12	12	10	12	12

Total estuary

	Chl *a*	DIN	FRP	**Nutrients**	Turbid-ity	DO Low	DO High	**Phys/ Chem**	**Pest-icides**	**WQ**
Score	55.5	71.9	90.0	80.9	90.0	90.0	90.0	90.0	93.0	79.9
Grade	M	G	VG	G	VG	VG	VG	VG	VG	G

n is the number of monthly values from all sites used to calculate the annual median. GV is guideline value, SF is the scaling factor, %-tile is the percentile of the monitoring data, No. ≤/≥ GV is the number of data points less/greater than or equal to the guideline value, and percentile ≤/≥ GV is the percentile of data points less/greater than or equal to the guideline value. Full explanations of the terms and scoring method are provided in WTW 2023. Condition scores weighted according to proportion of samples located in each water type: for nutrients, chlorophyll *a* and phys-chem mid-estuary = 0.75 and enclosed coastal = 0.25.

Table 73 Dickson Inlet 2021-22.

Mid-estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	2.3	0.019	0.002	2.8	74.7	74.7
GV	3.0	0.045	0.005	10.0	80.0	105.0
SF	5.0	0.200	0.010	20.0	50.0	111.0
80th or 20th %-tile	5.0	0.077	0.005	3.2	53.9	82.5
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	66.3	69.9	90.0	90.0	50.1	90.0
Grade	G	G	VG	VG	M	VG
n	15	14	14	15	15	15

Lower estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	1.5	0.033	0.005	3.1	90.9	90.9
GV	2.0	0.025	0.005	10.0	85.0	105.0
SF	5.0	0.200	0.010	20.0	50.0	111.0
80th or 20th %-tile	3.3	0.056	0.006	3.8	81.1	93.4
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	66.6	58.1	67.6	90.0	72.9	90.0
Grade	G	M	G	VG	VG	VG
n	10	10	10	10	10	10

Total estuary

	Chl *a*	DIN	FRP	**Nutrients**	Turbidity	DO Low	DO High	**Phys/ Chem**	**Pest-icides**	**WQ**
Score	66.4	65.0	80.7	72.8	90.0	59.3	90.0	74.6	nd	71.3
Grade	VG	G	G	G	VG	M	VG	G		G

n is the number of monthly values from all sites used to calculate the annual median. GV is guideline value, SF is the scaling factor, %-tile is the percentile of the monitoring data, No. ≤/≥ GV is the number of data points less/greater than or equal to the guideline value, and percentile ≤/≥ GV is the percentile of data points less/greater than or equal to the guideline value. Full explanations of the terms and scoring method are provided in WTW 2023. Condition scores weighted according to proportion of samples located in each water type: for nutrients mid-estuary = 0.58 and lower estuary = 0.42, for chlorophyll *a* and phys-chem mid-estuary = 0.6 and lower estuary = 0.4. nd indicates no data or insufficient data available.

Table 74 Barron estuary 2021-22.

Mid-estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	4.2	0.112	0.007	8.0	79.7	79.7
GV	3.0	0.045	0.005	10.0	80.0	105.0
SF	5.0	0.200	0.010	20.0	50.0	111.0
80th or 20th %-tile	4.9	0.240	0.0090	11.8	75.2	87.3
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	25.9	34.8	42.6	71.5	60.3	90.0
Grade	P	P	M	G	M	VG
n	24	24	24	24	24	24

Lower estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	2.6	0.056	0.003	6.8	81.3	81.3
GV	2.0	0.025	0.005	10.0	85.0	105.0
SF	5.0	0.200	0.010	20.0	50.0	111.0
80th or 20th %-tile	5.1	0.160	0.007	8.5	78.2	93.6
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	49.7	50.1	71.0	90.0	54.5	90.0
Grade	M	M	G	VG	M	VG
n	6	6	6	6	6	6

Total estuary

	Chl *a*	DIN	FRP	**Nutrients**	Turbidity	DO Low	DO High	**Phys/ Chem**	**Pest-icides**	**WQ**
Score	30.7	37.8	48.3	43.1	75.2	59.1	90.0	67.2	nd	47.0
Grade	P	P	M	M	G	M	VG	G		M

n is the number of monthly values from all sites used to calculate the annual median. GV is guideline value, SF is the scaling factor, %-tile is the percentile of the monitoring data, No. ≤/≥ GV is the number of data points less/greater than or equal to the guideline value, and percentile ≤/≥ GV is the percentile of data points less/greater than or equal to the guideline value. Full explanations of the terms and scoring method are provided in WTW 2023. Condition scores weighted according to proportion of samples located in each water type: for nutrients, chlorophyll *a* and phys-chem mid-estuary = 0.80 and lower estuary = 0.20. nd indicates no data or insufficient data available.

Table 75 Trinity Inlet 2021-22.

Mid-estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	3.0	0.016	0.001	3.4	70.5	70.5
GV	3.0	0.045	0.005	10.0	80.0	105.0
SF	5.0	0.200	0.010	20.0	50.0	111.0
80th or 20th %-tile	4.0	0.037	0.001	4.7	60.8	78.2
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	61.9	90.0	90.0	90.0	41.6	90.0
Grade	G	VG	VG	VG	M	VG
n	60	60	59	60	60	60

Lower estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	1.7	0.007	0.001	3.4	83.5	83.5
GV	2.0	0.025	0.005	10.0	85.0	105.0
SF	5.0	0.200	0.010	20.0	50.0	111.0
80th or 20th %-tile	1.8	0.008	0.001	9.1	82.4	90.4
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	90.0	90.0	90.0	90.0	58.3	90.0
Grade	VG	VG	VG	VG	M	VG
n	5	5	5	5	5	5

Total estuary

	Chl *a*	DIN	FRP	**Nutrients**	Turbidity	DO Low	DO High	**Phys/ Chem**	**Pest-icides**	**WQ**
Score	64.1	90.0	90.0	90.0	90.0	42.9	90.0	66.4	nd	73.5
Grade	G	VG	VG	VG	VG	M	VG	G		G

n is the number of monthly values from all sites used to calculate the annual median. GV is guideline value, SF is the scaling factor, %-tile is the percentile of the monitoring data, No. ≤/≥ GV is the number of data points less/greater than or equal to the guideline value, and percentile ≤/≥ GV is the percentile of data points less/greater than or equal to the guideline value. Full explanations of the terms and scoring method are provided in WTW 2023. Condition scores weighted according to proportion of samples located in each water type: for nutrients, chlorophyll *a* and phys-chem mid-estuary = 0.92 and lower estuary = 0.08. nd indicates non data or insufficient data available.

Table 76 Russell-Mulgrave 2021-22.

Mid-estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual Median	0.5	0.093	0.005	5.9	90.3	90.3
GV	3.0	0.045	0.005	10.0	80.0	105.0
SF	5.0	0.200	0.010	20.0	50.0	111.0
80th or 20th %-tile	0.5	0.101	0.006	6.0	85.1	92.2
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	90.0	42.0	61.0	90.0	90.0	90.0
Grade	VG	M	G	VG	VG	VG
n	3	3	3	3	3	3

Lower Estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	0.1	0.124	0.006	4.4	85.2	85.2
GV	2.0	0.025	0.005	10.0	85.0	105.0
SF	5.0	0.200	0.010	20.0	50.0	111.0
80th or 20th %-tile	0.1	0.166	0.008	7.0	77.3	91.4
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	90.0	26.4	54.8	90.0	61.5	90.0
Grade	VG	P	M	VG	G	VG
n	6	6	6	6	6	6

Total estuary

	Chl *a*	DIN	FRP	**Nutrients**	Turbidity	DO Low	DO High	**Phys/ Chem**	**Pest-icides**	**WQ**
Score	90.0	31.6	56.9	44.3	90.0	71.0	90.0	80.5	73.5	72.1
Grade	VG	P	M	M	VG	G	VG	G	G	G

n is the number of monthly values from all sites used to calculate the annual median. GV is guideline value, SF is the scaling factor, %-tile is the percentile of the monitoring data, No. ≤/≥ GV is the number of data points less/greater than or equal to the guideline value, and percentile ≤/≥ GV is the percentile of data points less/greater than or equal to the guideline value. Full explanations of the terms and scoring method are provided in WTW 2023. Condition scores weighted according to proportion of samples located in each water type: for mid-estuary, chlorophyll, nutrients and phys-chem = 0.33; for lower estuary chlorophyll, nutrients and phys-chem = 0.67.

Table 77 Johnstone estuary 2021-22.

Mid-estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	1.1	0.142	0.006	2.700	83.0	83.0
GV	3.0	0.045	0.005	10.0	80.0	105.0
SF	5.0	0.200	0.010	20.0	50.0	111.0
80th or 20th %-tile	1.5	0.179	0.0070	3.4	78.4	91.8
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	90.0	23.0	48.7	90.0	73.9	90.0
Grade	VG	P	M	VG	G	VG
n	18	31	31	19	14	14

Total estuary

	Chl *a*	DIN	FRP	**Nutrients**	Turbidity	DO Low	DO High	**Phys/ Chem**	**Pest-icides**	**WQ**
Score	90.0	23.0	48.7	35.9	90.0	73.9	90.0	73.9	69.5	67.3
Grade	VG	P	M	P	VG	G	VG	G	G	G

n is the number of monthly values from all sites used to calculate the annual median. GV is guideline value, SF is the scaling factor, %-tile is the percentile of the monitoring data, No. ≤/≥ GV is the number of data points less/greater than or equal to the guideline value, and percentile ≤/≥ GV is the percentile of data points less/greater than or equal to the guideline value. Full explanations of the terms and scoring method are provided in WTW 2023. nd indicates no data or insufficient data available.

Table 78 Moresby estuary 2021-22.

Mid-estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	3.3	0.036	0.001	1.6	74.4	74.4
GV	3.0	0.045	0.005	10.0	80.0	105.0
SF	5.0	0.200	0.010	20.0	50.0	111.0
80th or 20th %-tile	4.8	0.193	0.0010	2.8	62.9	87.2
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	52.6	62.1	90.0	90.0	49.5	90.0
Grade	M	G	VG	VG	M	VG
n	60	60	60	50	60	60

Lower Estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	2.8	0.003	0.001	1.6	92.2	92.2
GV	2.0	0.025	0.005	10.0	85.0	105.0
SF	5.0	0.200	0.010	20.0	50.0	111.0
80th or 20th %-tile	5.2	0.016	0.001	3.6	88.8	97.0
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	43.8	90.0	90.0	90.0	90.0	90.0
Grade	M	VG	VG	VG	VG	VG
n	12	12	12	10	12	12

Total estuary

	Chl *a*	DIN	FRP	**Nutrients**	Turbidity	DO Low	DO High	**Phys/ Chem**	**Pest-icides**	**WQ**
Score	51.1	66.8	90.0	78.4	90.0	56.3	90.0	73.1	nd	67.6
Grade	M	G	VG	G	VG	M	VG	G		G

n is the number of monthly values from all sites used to calculate the annual median. GV is guideline value, SF is the scaling factor, 80th %-tile is the 80th percentile of the monitoring data, No. ≤/≥ GV is the number of data points less/greater than or equal to the guideline value, and percentile ≤/≥ GV is the percentile of data points less/greater than or equal to the guideline value. Full explanations of the terms and scoring method are provided in WTW 2023. Condition scores weighted according to proportion of samples located in each water type: for mid-estuary, chlorophyll, nutrients and phys-chem = 0.83; for lower estuary chlorophyll, nutrients and phys-chem = 0.17. nd indicates non data or insufficient data available.

Table 79 Hinchinbrook Channel 2021-22.

Enclosed coastal

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual Median	2.7	0.002	0.001	2.4	91.3	91.3
GV	2.0	0.025	0.005	10.0	85.0	105.0
SF	5.0	0.200	0.010	20.0	50.0	111.0
80th or 20th %-tile	4.6	0.019	0.001	5.3	83.4	96.3
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	47.3	90.0	90.0	90.0	76.9	90.0
Grade	M	VG	VG	VG	G	VG
n	36	36	36	30	36	36

Total estuary

	Chl *a*	DIN	FRP	**Nutrients**	Turbidity	DO Low	DO High	**Phys/ Chem**	**Pest-icides**	**WQ**
Score	47.3	90.0	90.0	90.0	90.0	76.9	90.0	83.4	nd	73.6
Grade	M	VG	VG	VG	VG	G	VG	VG		G

n is the number of monthly values from all sites used to calculate the annual median. GV is guideline value, SF is the scaling factor, 80th %-tile is the 80th percentile of the monitoring data, No. ≤/≥ GV is the number of data points less/greater than or equal to the guideline value, and percentile ≤/≥ GV is the percentile of data points less/greater than or equal to the guideline value. Full explanations of the terms and scoring method are provided in WTW 2023. nd indicates non data or insufficient data available.

Inshore Marine

The annual means of inshore water quality indicators for sites within each reporting zones are presented in Table 80. The water quality scores for reach reporting zone before standardisation are presented in Table 81.

Table 80 Inshore marine water quality annual means and number of measurements taken by grab samples for each monitoring site for 2021-22.

Zone	Annual means by site	NO_x (µg/L)	PN (µg/L)	PP (µg/L)	TSS (mg/L)	Turbidity (NTU)	CHL *a* (µg/L))	No. Grab samples
North	C01	0.89	15.27	2.13	0.97		0.27	3
	C011	0.70	13.19	1.84	0.45		0.24	3
	C04	0.93	11.97	1.87	0.91		0.22	3
	C05	2.56	16.92	2.20	0.97		0.29	3
	C06	1.06	20.49	3.24	1.77		0.36	3
	C08	1.39	26.24	4.12	2.85		0.50	3
Central	RM1	2.52	19.65	1.75	0.54	1.0*	0.26#	5
	RM10	19.98	37.96	5.04	2.45	3.8*	0.87#	10
	RM3	2.71	25.53	2.29	1.42		0.34	10
	RM7	2.64	24.97	1.93	1.19	0.8*	0.39#	10
	RM8	2.79	28.47	2.43	1.34	1.1*	0.41#	10
South	TUL10 (EC)	16.23	55.88	6.67	6.89	4.8*	0.92#	11
	TUL2	1.35	28.83	1.74	1.38		0.33	11
	TUL3	2.64	34.47	3.01	2.03	2.5*	0.53#	11
	TUL5	1.59	30.46	2.42	1.93		0.29	11
	TUL6	4.78	35.80	3.46	2.23		0.41	11
	TUL8	3.47	33.80	3.14	2.49		0.39	11
Palm Is	BUR1	1.88	24.16	1.89	1.51	0.7*	0.49#	10
	BUR2	2.11	27.98	2.20	1.65	1.5*	0.35#	10

All sites are within open coastal waters except for TUL10 which is within enclosed coastal waters (EC). *indicates values derived solely from continuous logger measurements. #indicates values derived from continuous logger measurements and grab samples.

Table 81 Inshore marine water quality indicator scores for 2021-22 without standardisation.

	Water clarity		Chlorophyll *a*	Nutrients			Pesticides
Zone	TSS	Turbidity	CHL	NO_x	PN	PP	% species protected
North	0.61	nd	0.57	0.68	0.26	0.19	nd
Central	0.50	0.23	0.12	-0.53	-0.42	0.17	nd
South	0.02	0.13	0.37	-0.33	-0.70	0.06	nd
Palm	0.34	0.50	0.11	0.01	-0.38	0.46	nd

Scoring range for water clarity, chlorophyll *a* and nutrients: Very Poor = <-0.66 to -1 | Poor = <-0.33 to -0.66 | Moderate = <0 to -0.33 | Good = 0 to 0.5 | Very Good = >0.5 to 1. **Pesticide risk metric scoring range:** Very Poor = <80% | Poor = <90 to 80% | Moderate = <95 to 90% | Good = <99 to 95% | Very Good = ≤99%. nd indicates no data or insufficient data available.

Update to scheduled oxidized nitrogen guideline values.

Since the Wet Tropics report card was developed in 2016 (reporting on 2014-15) the scoring and grading of inshore water quality (enclosed coastal, open coastal and mid-shelf waters) has applied the guideline values used for the MMP Long-term trend inshore water quality index as published in Lønborg et al. 2016, Waterhouse et al. 2017, and Gruber et al. 2019. These guideline values were the most appropriate at the time and were based on published GBRMPA (2010) and scheduled Queensland Government (DEHP 2009) guideline values.

In 2020 the guideline values for oxidised nitrogen (NOx) were updated for coastal and marine waters of the Wet Tropics and scheduled in the Environmental Protection (Water and Wetland Biodiversity) Policy 2019—the EPP (Water and Wetland Biodiversity) (DES 2020). The updates involved a change from using a mean to a median of the sample data concentration values for comparison against the guideline values, and a substantial lowering of the NO_x concentration guideline value for open coastal and mid-shelf waters (Table 82). This update followed similar changes of the NO_x guideline values used for the MMP long-term trend inshore water quality index, applied as from the 2018-19 report (Gruber et al. 2020, p. 186-187) which cited: "This value {2.0 µg L^{-1}} was determined to be too high and not reflective of NO_x concentrations in the Reef lagoon. From the 2018–19 report onwards, a revised NOx GV of 0.35 µg L^{-1} was used for this version of the Index (provided by the Authority).".

Table 82 Oxidised nitrogen (NO_x) guideline values used for the Wet Tropics report card and introduced with the 2020 scheduled update.

		Guideline values for NO_x (ug/L)	
Water type	**Zone**	**Report card (2016 -)**	**Updated scheduled (2020)**
Enclosed coastal	All inshore zones	10 (mean)	10 (median)
Open coastal	North, Central South Palm Island	2 (mean) 2 (mean)	0.35 (median) 0.28 (median)
Mid-shelf	All inshore zones	2 (mean)	0.31 (median)

Updated scheduled values were sourced from Schedule 1 amendments for the Wet Tropics basins coastal waters approved in 2020 (Environmental Protection (Water and Wetland Biodiversity) Policy 2019). The guideline values are compared to either the test data mean (as per Wet Tropics report card methods (WTW 2023) or the median (as per the Environmental Protection (Water and Wetland Biodiversity) Policy 2019).

The effect of using the updated scheduled NO_x guideline values for scoring the 2021-22 inshore water quality, compared to using the Wet Tropics report card guideline values, was to substantially lower the score for NO_x in all zones and also lower the nutrients and water quality scores for the North, Central and Palm Island zone (Table 83).

Note that the 2021-22 NO_x, nutrient and water quality scores show that for the South zone the NO_x score is lower, whilst the nutrient and water quality scores are higher, when using the scheduled guidelines compared to Wet Tropics report card guideline values. This is due to the method of score aggregation used for inshore water quality. The nutrient indicator category is not calculated as the average of the contributing indicator scores for the zone (as they are presented in Table 83 for NO_x, and Table 47 for PN and PP), it is calculated as the average of the contributing indicators for each site and then the site nutrient scores are averaged to produce the zone score.

Table 83 Water quality results for 2021-22 using updated scheduled guideline values for inshore waters of the Wet Tropics region.

Zone	NO_x	Nutrients	Water quality
North	0	50	72
Central	0	36	59
South	24	44	62
Palm Island	0	42	61

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100.

Comparing the guideline values for scoring the NO_x indicator over all reporting years shows that the North, Central and Palm Island scores were usually substantially lowered for each year when using the updated scheduled guidelines (Figure 24). In contrast, the South zone has years where using the updated scheduled guidelines increased the score compared to using the Wet Tropics report card guideline values (e.g. 2017, 2018 and 2019). This is because the South zone is the only zone that includes enclosed coastal sites (two sites pre-2020, one site from 2020 onwards), and the guideline value of 10 µg L^{-1} for enclosed coastal waters was not changed in the scheduled updates. Since the median concentration of the sampled data, instead of the mean, is used to compare with the updated scheduled guideline value (which typically yields a lower concentration value than the mean), the enclosed coastal site scores increased, and the score for the South zone when averaged from all contributing sites increased. As example of how the mean and median can differ, the 2021-22 NO_x sample data for the South zone enclosed coastal site had a mean of 16.23 µg/L, corresponding to 'very poor', and a median of 4.76 µg/L, corresponding to 'very good'.

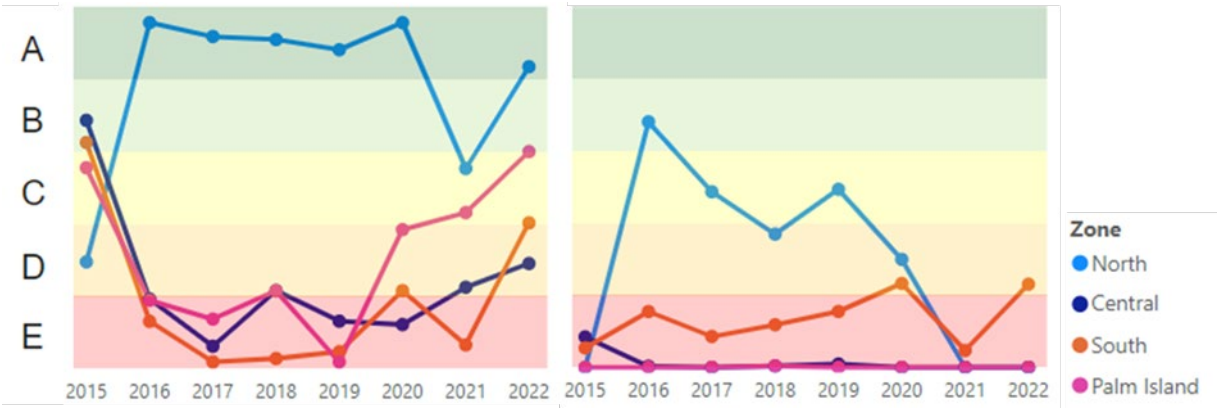


Figure 24 Time series of the oxidised nitrogen indicator scores and grades for each inshore zone using the Wet Tropics report card guideline values (left) and the updated scheduled guideline values.

Due to the effect of using the updated scheduled guidelines on scoring the NO_x indicator, the guideline values have remained unchanged for the purposes of scoring inshore marine waters. This provides inshore marine water quality reporting that is consistent and comparable with all previous years. Inshore marine water quality guideline values used for scoring will be reviewed in the upcoming program design review (2023-25) which will allow for application of the most appropriate guidelines and a consistent approach across regional report cards.

Appendix C. Flow indicator detailed results

To account for rainfall variation the flow indicator method assesses the historical rainfall records within each basin. Sites used to provide rainfall data from either station (S) or point (P) locations from the SILO website for each basin are presented in Table 84. The 2020-21 rainfall types for each basin are presented in Table 85.

Table 84 Rainfall data site details.

Basin & data type	Location	Latitude	Longitude	Elevation (m)
Mossman P2	Lower catchment	-16.45	145.4	18
Mossman P1	Mid catchment	-16.4	145.35	76
Barron P1	Upper Barron	-17.35	145.5	788
Barron P2	Tinaroo Falls Dam,	-17.15	145.55	796
Barron S3	Walkamin	-17.08	145.43	594
Barron P3	Biboohra	-16.9	145.4	386
Barron P4	Kuranda Railway	-16.8	145.65	325
Barron P5	Clohesy	-16.9	145.55	406
Barron P6	Upper Freshwater	-16.95	145.7	249
Mulgrave P3	Mulgrave Mill	-17.10	145.8	52
Mulgrave P4	Mt Sophia	-17.15	145.9	8
Mulgrave P5	Deeral	-17.2	145.9	131
Mulgrave P1	Behana Creek	-17.2	145.8	705
Mulgrave P2	Upper-mid Mulgrave	-17.2	145.75	471
Russell P2	Happy Valley	-17.35	145.9	99
Russell P3	Babinda PO	-17.35	145.95	14
Russell P4	Bellenden Kerr bottom	-17.25	145.9	291
Russell P1	Upper-mid Russell	-17.45	145.85	172
Johnstone N P2	Topaz - Towalla	-17.45	145.7	602
Johnstone S S2	Exp Station	-17.61	146.0	18
Johnstone P3	Innisfail	-17.5	146.0	10
Johnstone P1	mid upper Johnstone	-17.6	145.75	474
Tully P2	Kombooloomba	-17.85	145.6	792
Tully P3	Kareeya	-17.75	145.6	469
Tully P4	Sugar Mill	-17.95	145.95	122
Tul P1	Mid Tully	-17.9	145.75	58
Herbert P2	Evelyn State Forest	-17.55	145.5	1056
Herbert P3	Mt. Garnet PO	-17.7	145.1	664
Herbert P4	Gunnawarra	-17.95	145.15	638
Herbert P5	Gleneagle	-18.15	145.35	601
Herbert P6	Elphinstone Pocket	-18.5	146.0	47
Herbert P7	Victoria Sugar Mill	-18.65	146.2	12
Herbert P1	Lower mid Herbert	-18.3	145.7	618
Murray P1	Upper Murray	-18.1	145.8	69
Murray P2	Muenga Creek at Sings	-18.2	145.9	199
Murray P3	US Murray and Muenga	-18.15	145.85	812

The data type used for rainfall was either a station (S) or grid cell (P) and was extracted from the SILO database at https://www.longpaddock.qld.gov.au/silo/point-data/

Table 85 Basin rainfall type for 2021-22.

Basin	Rainfall value	Climate Type	Rainfall data sites	
			Patched point	Data drill
Mossman	4	Wet	-	2
Barron	3	Average	1	6
Murray	4	Wet	-	5
Russell	3	Average	-	4
Johnstone	2	Dry	1	3
Tully	2	Dry	-	4
Murray	2	Dry	-	3
Herbert	2	Dry	-	7

Note: rainfall value is assigned to the reporting year based upon rainfall records compared to historical average rainfall. The values are 1 – drought, 2 – dry, 3 average, and 4 – wet.

Table 86 presents the scores for all 10 flow measures, the 30th percentile and standardised score for each flow assessment site along with standardised score for each basin and estuary. Descriptions and definitions for each flow measure are presented in Table 87.

Table 86 Flow measure scores and summary scores for each flow assessment site for 2021-22.

	Gauging station number	CTF: Duration	CTF: Frequency	Below 10%ile: Duration	Below 10%ile: Frequency	Ratio dry/total	CV dry season	Above 50%ile: Duration	Above 50%ile: Frequency	Above 90%ile: Duration	Above 90%ile: Frequency	30th percentile	Standardised score	Gauge catchment (km^2)	Adjusted catchment (km^2)	Proportion	Satandardised score x proportion	Aggregated score	Climate type
Basin: Site																			
Mossman														106				75	Wet
Mossman River at Mossman	109001A	5	5	5	5	5	5	4	4	4	5	4.7	75	106		1.00	95.0		
Barron														2015				77	Average
Barron River at Myola	110001D	5	5	5	5	4	5	5	5	1	5	5.0	80	1945	687	0.34	25.6		
Barron River at Mareeba	110002D	5	5	5	5	1	5	5	5	1	4	4.7	75	836	555	0.28	16.8		
Barron River at Picnic Crossing	110003A	5	5	5	5	4	5	5	4	3	5	4.7	75	228	101	0.05	3.8		
Mazlin Creek at Railway Bridge	110018A	5	5	5	5	5	5	5	5	3	4	5.0	90	53	53	0.03	2.0		
Barron River at Bilwon	110020A	5	5	5	5	1	5	5	5	1	4	4.7	75	1258	422	0.21	12.8		
Barron River at Goonara Creek	110021A	5	5	5	5	4	5	5	4	5	5	5.0	95	127	127	0.06	6.0		
Freshwater Creek at Redlynch Estate	110104A	5	5	4	5	5	5	5	1	4	1	4.0	61	70	70	0.03	2.8		
Mulgrave														520				78	Wet
Mulgrave River at The Fisheries	111005A	5	5	5	5	4	5	5	5	1	5	5.0	80	357	357	0.69	54.9		
Mulgrave River at Peets Bridge	111007A	5	5	5	5	4	5	5	5	4	4	4.7	75	520	163	0.31	25.1		
Russell														354				91	Average
Russell River at Bucklands	111101D	5	5	5	5	4	5	5	4	5	5	5.0	95	315	315	0.89	84.5		
Babinda Creek at The Boulders	111105A	4	4	5	5	4	5	5	4	5	5	4.0	61	39	39	0.11	6.7		
Johnstone														1403				77	Average
Fisher Creek at Nerada	112002A	5	5	5	5	5	4	5	5	5	4	5.0	95	15	15	0.01	0.8		
North Johnstone River at Glen Allyn	112003A	5	5	5	5	5	5	5	5	5	5	5.0	100	165	165	0.12	11.2		
North Johnstone River at Tung Oil	112004A	5	5	5	5	5	4	3	4	5	3	4.0	61	925	745	0.53	53.1		

	Gauging station number	CTF: Duration	CTF: Frequency	Below 10%ile: Duration	Below 10%ile: Frequency	Ratio dry/total	CV dry season	Above 50%ile: Duration	Above 50%ile: Frequency	Above 90%ile: Duration	Above 90%ile: Frequency	30th percentile	Standardised score	Gauge catchment (km²)	Adjusted catchment (km²)	Proportion	Satandardised score x proportion	Aggregated score	Climate type
South Johnstone River at Upstream Central Mill	112101B	5	5	5	5	5	5	5	5	5	4	5.0	95	400	400	0.29	27.1		
Liverpool Creek at Upper Japoonvale	112102A	5	5	5	5	5	5	5	5	4	4	5.0	95	78	78	0.06	4.7		
Tully														1450				95	Average
Cochable Creek at Powerline	113004A	5	5	5	5	5	5	5	5	5	5	5.0	100	95	95	0.07	6.6		
Tully River at Euramo	113006A	5	5	5	5	5	5	5	4	5	4	5.0	95	1450	1355	0.93	93.4		
Murray														309				61	Wet
Murray River at Upper Murray	114001A	5	5	4	4	4	5	5	5	5	4	4.0	61	156	156	0.50	48.0		
Meunga Creek at Sing's	114002A	5	5	4	4	4	1	5	5	5	5	4.0	61	153	153	0.50	30.2		
Herbert														8581				80	Wet
Herbert River at Ingham	116001F	5	5	5	5	5	5	4	4	5	4	4.7	75	8581	970	0.11	11.3		
Herbert River at Glen Eagle	116004C	4	4	5	4	5	5	5	5	5	5	4.7	75	5236	3977	0.46	34.8		
Herbert River at Abergowrie	116006B	5	5	5	5	5	5	4	5	5	4	5.0	95	7454	1868	0.22	20.7		
Gowrie Creek at Abergowrie	116008B	5	5	4	4	5	5	4	5	5	5	4.7	75	124	124	0.01	1.2		
Blencoe Creek at Blencoe Falls	116010A	5	5	4	4	5	5	5	4	5	5	4.7	75	226	226	0.03	2.0		
Millstream at Ravenshoe	116011A	5	5	4	4	5	5	5	5	5	4	4.7	75	89	89	0.01	0.9		
Cameron Creek at 8.7km	116012A	5	5	5	5	5	5	5	5	5	4	5.0	95	360	360	0.04	4.2		
Millstream at Archer Creek	116013A	4	4	5	4	5	5	5	5	5	4	4.0	61	308	219	0.03	1.6		
Wild River at Silver Valley	116014A	5	5	5	4	4	1	5	5	5	4	4.0	61	591	591	0.07	6.5		
Blunder Creek at Wooroora	116015A	5	5	4	4	5	4	5	5	5	5	4.7	75	127	127	0.01	1.2		
Rudd Creek@Gunnawarra	116016A	2	4	2	2	4	5	5	5	5	5	3.4	49	127	127	0.01	1.1		
Stone River at Running Creek	116017A	4	5	4	4	1	4	5	4	4	5	4.0	61	157	157	0.02	1.1		

	Gauging station number	CTF: Duration	CTF: Frequency	Below 10%ile: Duration	Below 10%ile: Frequency	Ratio dry/total	CV dry season	Above 50%ile: Duration	Above 50%ile: Frequency	Above 90%ile: Duration	Above 90%ile: Frequency	30th percentile	Standardised score	Gauge catchment (km²)	Adjusted catchment (km²)	Proportion	Satandardised score x proportion	Aggregated score	Climate type
Estuary: Site																			
Barron																		79	Average
Barron River at Myola	110001D	5	5	5	5	4	5	5	5	1	5	5.0	80	1945	1945	0.97	72.4		
Freshwater Creek at Redlynch Estate	110104A	5	5	4	5	5	5	5	1	4	1	4.0	61	70	70	0.03	2.8		
Russell-Mulgrave																		81	Average-Wet
Mulgrave River at Peets Bridge	111007A	5	5	5	5	4	5	5	5	4	4	4.7	75	520	520	0.59	47.6		
Russell River at Bucklands	111101D	5	5	5	5	4	5	5	4	5	5	5.0	95	315	315	0.36	34.2		
Babinda Creek at The Boulders	111105A	4	4	5	5	4	5	5	4	5	5	4.0	61	39	39	0.04	2.7		
Johnstone																		71	Average
North Johnstone River at Tung Oil	112004A	5	5	5	5	5	4	3	4	5	3	4.0	61	925	925	0.70	69.8		
South Johnstone River at Upstream Central Mill	112101B	5	5	5	5	5	5	5	5	5	4	5.0	95	400	400	0.30	28.7		

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100.

Table 87 Abbreviations, description, seasonality and hydrologic definitions of the measures used for the flow indicator.

Abbreviation	Description	Season	Hydrologic definition
Below 10%ile: Duration	Low flow Duration	July-Jan	Total duration of flows which remain equal to or below a lower threshold for the reporting period (annual).
Below 10%ile: Frequency	Low flow Frequency	July-Jan	Count of the number of occurrences during which the magnitude of flow falls to or below the threshold during the reporting period (annual).
CV dry season	Low flow variability	July-Dec	Coefficient of variation (stdev/mean) of daily flow for dry season.
Ratio dry/total	Driest six Months	July-Dec	Proportion of annual discharge contributed during the months July-December.
CTF: Duration	Cease to flow Duration	All year	Total duration of where flow ceases during the reporting period (annual).
CTF: Frequency	Cease to flow Frequency	All year	Count of the number of occurrences during which flow ceases during the reporting period (annual).
Above 50%ile: Duration	Medium flow Duration	All year	Total duration of flows which remain equal to or above the 50th percentile threshold for the reporting period (annual)
Above 50%ile: Frequency	Medium flow Frequency	All year	Count of the number of occurrences during which the magnitude of flow passes from below to equal or above the 50th percentile threshold during the reporting period (annual).
Above 90%ile: Duration	High flow duration	All year	Total duration of flows which remain equal to or above the 90th percentile threshold for the reporting period (annual)
Above 90%ile: Frequency	High flow Frequency	All year	Total count of flows which remain equal to or above the 90th percentile threshold for the reporting period (annual)

References

Stewart-Koster, B., Bofu Yu, B., Balcombe, S., Kennard, M., Marsh, N. 2018 Development of Report Card flow Indicators for the Mackay-Whitsunday and Wet Tropics regions. Australian Rivers Institute, Griffith University and Truii Pty Ltd. Brisbane.

Appendix D. Basin fish assessment: key to species and species present at each site survey.

Table 88 Key to fish species codes (SppCode). Pest species codes are identified by an asterisk (*).

SppCode	Family	Genus	Species	Common name
AmbMio	Ambassidae	*Ambassis*	*miops*	Flagtail perchlet
AmbSp1	Ambassidae	*Ambassis*	*sp. 1*	Northern perchlet
AmbVac	Ambassidae	*Ambassis*	*vachellii*	Vachell's glassfish
AmnPer	Terapontidae	*Amniataba*	*percoides*	Barred grunter
AngAus	Anguillidae	*Anguilla*	*australis*	Southern short-finned eel
AngMar	Anguillidae	*Anguilla*	*marmorata*	Giant mottled eel
AngObs	Anguillidae	*Anguilla*	*obscura*	Pacific short-finned eel
AngRei	Anguillidae	*Anguilla*	*reinhardtii*	Long-finned eel
AwaAcr	Gobiidae	*Awaous*	*acritosus*	Roman-nose goby
BunGyr	Eleotridae	*Bunaka*	*gyrinoides*	Bunaka
ButBut	Eleotridae	*Butis*	*butis*	Crimson-tipped gudgeon
CaiRho	Melanotaeniidae	*Cairnsichthys*	*rhombosomoides*	Cairns rainbowfish
CraSte	Atherinidae	*Craterocephalus*	*stercusmuscarum*	Fly-specked hardyhead
DenAus	Ambassidae	*Denariusa*	*australis*	Penny fish
EleFus	Eleotridae	*Eleotris*	*fusca*	Brown spine-cheek gudgeon
EleMel	Eleotridae	*Eleotris*	*melanosoma*	Black spine-cheek gudgeon
GamHol*	Poecilidae	*Gambusia*	*holbrooki*	Gambusia
GerFil	Gerreidae	*Gerres*	*filamentosus*	Silver biddy
GiuMar	Eleotridae	*Giurus*	*margaritacea*	Snake-head gudgeon
GloApr	Apogonidae	*Glossamia*	*aprion*	Mouth almighty
GloAur	Gobiidae	*Glossogobius*	*aureus*	Golden Flathead Goby
GloBel	Gobiidae	*Glossogobius*	*bellendensis*	Mulgrave goby
GloGiu	Gobiidae	*Glossogobius*	*giuris*	Tank goby
GloIll	Gobiidae	*Glossogobius*	*illimus*	False Celebes goby
HepSpp	Terapontidae	*Hephaestus*	*fuliginosus/ tulliensis*	Sooty grunter/ Tully grunter
HypCom	Eleotridae	*Hypseleotris*	*compressa*	Empire gudgeon
HypSp1	Eleotridae	*Hypseleotris*	*sp. 1*	Northern carp gudgeon (undescribed)
KuhMar	Kuhlidae	*Kuhlia*	*marginata*	Spotted flagtail
KuhRup	Kuhlidae	*Kuhlia*	*rupestris*	Jungle perch
LatCal	Latidae	*Lates*	*calcarifer*	Barramundi
LeiUni	Terapontidae	*Leiopotherapon*	*unicolor*	Spangled perch
LutArg	Lutjanidae	*Lutjanus*	*argentimaculatus*	Mangrove jack
MegCyp	Megalopidae	*Megalops*	*cyprinoides*	Indo-Pacific tarpon
MelMac	Melanotaeniidae	*Melanotaenia*	*maccullochi*	McCulloch's rainbowfish
MelSpp	Melanotaeniidae	*Melanotaenia*	*spp.*	Eastern rainbowfish
MelTri	Melanotaeniidae	*Melanotaenia*	*trifasciata*	Banded rainbowfish
MesArg	Terapontidae	*Mesopristes*	*argenteus*	Silver grunter
MicBra	Syngnathidae	*Microphis*	*brachyurus*	Short-tailed pipefish
MogAds	Eleotridae	*Mogurnda*	*adspersa*	Southern purple-spotted gudgeon
MugCep	Mugilidae	*Mugil*	*cephalus*	Sea mullet

SppCode	Family	Genus	Species	Common name
MugNot	Gobiidae	*Mugilogobius*	*notospilus*	Freshwater mangrove goby
NemEre	Clupeidae	*Nematalosa*	*erebi*	Bony bream
NeoAte	Plotosidae	*Neosilurus*	*ater*	Butter jew
NeoHyr	Plotosidae	*Neosilurus*	*hyrtlii*	Hyrtl's tandan
NotRob	Tetrarogidae	*Notesthes*	*robusta*	Bullrout
OphSp1	Synbranchidae	*Ophisternon*	*sp. (undescribed)*	Swamp eel
OreMos*	Cichlidae	*Oreochromis*	*mossambicus*	Mozambique tilapia
OxyAru	Eleotridae	*Oxyeleotris*	*aruensis*	Aru gudgeon
OxyLin	Eleotridae	*Oxyeleotris*	*lineolata*	Sleepy cod
OxyNul	Eleotridae	*Oxyeleotris*	*nullipora*	Poreless gudgeon
OxySel	Eleotridae	*Oxyeleotris*	*selheimi*	Northern sleepy cod
PelMar*	Cichlidae	*Pelmatolapia*	*mariae*	Spotted tilapia
PoeRet*	Poecilidae	*Poecilia*	*reticulata*	Guppy
PorRen	Plotosidae	*Porochilus*	*rendahli*	Rendahl's tandan
PseGer	Pseudomugilidae	*Pseudomugil*	*gertrudae*	Spotted blue-eye
PseSig	Pseudomugilidae	*Pseudomugil*	*signifer*	Pacific blue-eye
RedBik	Gobiidae	*Redigobius*	*bikolanus*	Speckled goby
RedChr	Gobiidae	*Redigobius*	*chrysosoma*	Spot-finned goby
ScaArg	Scatophagidae	*Scatophagus*	*argus*	Spotted scat
SchHoe	Gobiidae	*Schismatogobius*	*hoesei*	Scaleless goby
SicLag	Gobiidae	*Sicyopterus*	*lagocephalus*	Red-tailed goby
SynHog	Soleidae	*Synclidopus*	*hogani*	Hogan's sole
TanTro	Plotosidae	*Tandanus*	*tropicanus*	Wet Tropics tandan
XipHel*	Poecilidae	*Xiphophorus*	*hellerii*	Swordtail
XipMac*	Poecilidae	*Xiphophorus*	*maculatus*	Platy

Table 89 Mossman Basin fish monitoring sites and species present from the most recent survey (2019-20). The numeral 1 indicates the species was sampled and the numeral 0 indicates the species was not sampled. Species marked with * are pest fish species.

Waterway	AmbMio	AngAus	AngMar	AngObs	AngRei	AwaAcr	BunGyr	EleFus	GloIll	HypCom	KuhMar	KuhRup	MelSpp	MicBra	MogAds	NotRob	*PoeRet	PseSig	RedBik	SchHoe	TanTro	*XipHel
Parker Creek	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	0	0	0
South Mossman River	0	0	0	0	1	1	0	0	0	1	0	1	1	0	1	0	0	1	0	0	1	0
Spring Creek	0	1	0	0	1	0	0	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0
Tributary of Ball Creek	0	0	0	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	1	0
Spring Creek	0	0	1	1	1	0	0	0	1	1	0	1	1	0	0	0	0	1	0	1	0	0
Flin Creek	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1
Cassowary Creek	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	1	0	0	1	0
Ball Creek	0	0	0	0	1	0	0	0	0	1	0	0	1	0	1	0	1	1	0	0	0	0
South Mossman River	0	0	0	0	1	1	1	0	1	1	0	1	1	1	1	0	0	1	0	1	1	0
Mossman River	0	0	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	1	1	0
Mossman River	0	0	0	0	1	1	1	0	1	1	0	1	0	0	0	0	0	1	1	1	1	0
Mossman River	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	1	0	1	0	0	1	0
Mossman River	1	0	0	0	1	1	1	0	0	1	0	1	1	0	1	1	0	1	0	1	1	0

Table 90 Barron Basin fish monitoring sites and species present from the most recent survey (2019-20). The numeral 1 indicates the species was sampled and the numeral 0 indicates the species was not sampled. Species marked with * are pest fish species.

Waterway	AmbMio	AmnPer	AngMar	AngRei	AwaAcr	BunGyr	CraSte	EleMel	GloApr	GloAur	GloIll	HepSpp	HypCom	KuhRup	LeiUni	MelSpp	MogAds	NemEre	NeoAte	NeoHyr	OxyLin	OxySel	*PelMar	*PoeRet	PorRen	PseSig	RedBik	SchHoe	TanTro
Severin Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1
Davies Creek	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	1
Oaky Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	1	0	0	0	0	0
Wright Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	1	1	1	0	0	0	1
Atherton Creek	0	0	0	1	0	0	1	0	1	0	0	1	0	0	1	1	1	0	1	0	0	0	0	1	0	0	0	0	0
Tinaroo Creek	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Varch Creek	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Poona Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Barron River	0	1	0	1	0	0	1	0	1	1	0	1	0	0	1	1	0	0	0	0	1	0	1	1	0	0	0	0	0
Freshwater Creek	1	0	1	1	1	1	0	1	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	1	0	1	1	1	0
Clohesy River	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	1	0	1	1	0	0	0	1	0	0	0	0	1

Table 91 Mulgrave Basin fish monitoring sites and species present from the most recent survey (2019-20). The numeral 1 indicates the species was sampled and the numeral 0 indicates the species was not sampled. Species marked with * are pest fish species.

Waterway	AmbMio	AmbSp1	AngMar	AngObs	AngRei	AwaAcr	BunGyr	CaiRho	CraSte	EleFus	EleMel	GerFil	GiuMar	GloApr	GloBel	GloGiu	GloIll	HepSpp	HypCom	KuhRup	LatCal	LutArg	MegCyp	MelSpp	MelTri	MesArg	MogAds	NemEre	NeoAte	NotRob	OxyAru	*PelMar	*PoeRet	PseSig	RedBik	SicLag	TanTro	*XipMac
Wright Creek	1	0	1	1	1	0	0	0	0	0	1	1	1	0	0	1	1	0	1	1	0	1	0	1	0	0	0	0	1	0	0	1	0	1	1	0	0	0
Little Mulgrave River	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	1	0	1	0
Mulgrave River	0	0	1	1	1	1	1	0	0	0	0	1	1	0	0	0	1	1	1	1	0	1	0	1	0	1	0	1	1	0	0	1	1	1	1	0	1	0
Gray Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Mulgrave River	0	0	0	1	1	1	0	0	1	0	0	0	0	1	0	0	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1	0	1	0
Little Mulgrave River	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	1	0
Fishery Creek	0	0	1	0	1	1	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0
Tributary of Mulgrave River	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Middle Creek	1	0	0	0	1	1	1	0	0	0	1	0	1	0	0	0	1	0	1	1	0	0	0	1	1	0	1	0	0	0	0	0	1	1	0	0	1	1
McDonnell Creek	0	0	1	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	1	1	0	0	1	0
Tributary of Behana Creek	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0
Mulgrave River	0	1	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	1	1	1	0	1	1	1	0	1	0	1	1	0	0	1	0	1	1	0	1	0
Tributary of Behana Creek	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Table 92 Russell Basin fish monitoring sites and species present from the most recent survey (2019-20). The numeral 1 indicates the species was sampled and the numeral 0 indicates the species was not sampled. Species marked with * are pest fish species.

Waterway	AmbMio	AmbSp1	AngMar	AngObs	AngRei	AwaAcr	BunGyr	CaiRho	CraSte	EleFus	EleMel	GiuMar	GloApr	GloBel	GloIll	HepSpp	HypCom	KuhRup	LatCal	LutArg	MelMac	MelSpp	MesArg	MogAds	NemEre	NeoAte	NotRob	OphSp1	OxyAru	*PelMar	*PoeRet	PorRen	PseSig	RedBik	SchHoe	SicLag	TanTro	*XipMac
Woopen Creek	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	1	0
Cane drain	0	1	1	0	1	1	0	1	1	1	0	1	0	0	0	0	1	0	0	0	1	1	0	1	0	1	0	0	1	0	1	0	1	0	0	0	0	1
Harvey Creek	0	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	1	0
Allison Creek	0	0	1	0	1	1	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0
Pugh Creek	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	1	0
Pugh Creek	0	0	1	0	1	0	0	1	1	0	0	0	1	1	1	1	1	0	0	0	0	1	0	1	0	0	0	1	1	0	0	0	1	0	1	0	1	0
Babinda Creek	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	1	0
Menzies Creek	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	1	0	0	0	0	0
Tributary of Babinda Creek	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	1	0
Cane drain	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	1	0	1	1	1	0	0	0	0	1
Russell River	0	1	0	0	1	1	1	0	1	0	0	1	1	0	1	1	1	0	1	0	0	1	0	1	0	1	1	0	1	1	0	0	1	0	0	0	1	1
Russell River	1	1	0	1	1	1	1	0	0	1	1	1	1	0	1	1	1	0	1	1	0	1	1	1	1	1	0	0	0	1	0	0	1	1	1	0	1	0
Russell River	0	0	0	0	1	1	0	0	1	0	0	0	1	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
Chooky Chooky Creek	0	0	1	0	1	1	0	0	1	0	0	0	1	1	1	0	1	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	1	0

Table 93 Johnstone Basin fish monitoring sites and species present from the most recent survey (2019-20). The numeral 1 indicates the species was sampled and the numeral 0 indicates the species was not sampled. Species marked with * are pest fish species.

Waterway	AmbMio	AmbSp1	AngMar	AngRei	AwaAcr	BunGyr	CaiRho	CraSte	EleFus	EleMel	GiuMar	GloApr	GloIll	HepSpp	HypCom	KuhRup	MelSpp	MogAds	MugNot	NeoAte	OphSp1	OxyAru	*PelMar	*PoeRet	PseSig	RedBik	SchHoe	TanTro	*XipHel	*XipMac
Tributary of Malanda Creek	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0
Malanda Creek	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
Cowley Creek	0	1	0	1	0	1	1	0	0	0	1	0	0	0	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0	1
North Beatrice River	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	1	0	0	0	1	1	0
South Maria Creek	0	0	0	1	1	0	1	0	0	0	1	0	0	0	1	0	1	1	0	1	1	0	0	0	1	0	0	1	0	0
Eel Creek	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	1	1	0	1	0	0	1	0	1	0	0	0	0	1
Tributary of Mena Creek	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	1	0	1
Muston Creek	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	1	0	0
Utchee Creek	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0
Liverpool Creek	0	0	1	1	1	0	0	1	0	0	0	0	1	1	0	1	1	1	0	0	0	0	0	0	0	1	0	1	1	0	0
Fitzgerald Creek	1	0	0	1	0	0	1	0	1	1	1	0	1	1	1	0	1	1	1	0	1	0	0	1	0	1	0	1	0	0

Table 94 Tully Basin fish monitoring sites and species present from the most recent survey (2019-20). The numeral 1 indicates the species was sampled and the numeral 0 indicates the species was not sampled. Species marked with * are pest fish species.

Waterway	AmbMio	AmbSp1	AngMar	AngObs	AngRei	AwaAcr	BunGyr	CraSte	DenAus	EleFus	EleMel	GiuMar	GloApr	GloIll	HepSpp	HypCom	KuhRup	LatCal	MelMac	MelSpp	MogAds	NeoAte	NeoHyr	NotRob	OphSp1	OxyAru	OxyNul	*PelMar	*PoeRet	PorRen	PseGer	PseSig	RedChr	SchHoe	TanTro	*XipMac
Cane drain	0	1	0	0	1	1	0	1	0	0	0	1	0	0	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Davidson Creek	0	1	0	0	1	1	0	1	0	0	0	0	1	1	1	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	1
Marquette Creek	0	1	0	0	1	1	0	0	0	0	0	0	1	1	1	1	0	0	0	1	1	0	1	1	0	1	0	0	0	0	0	1	0	1	1	1
Banyan Creek	0	1	0	0	1	1	0	1	0	0	0	0	0	1	1	1	1	1	0	1	1	0	0	1	0	1	0	1	0	0	0	1	0	0	1	0
Cane drain	0	1	0	0	0	0	0	1	1	0	0	0	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	0	0	1	1	0	0	0	0	1
Tributary of Python Creek	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hull River	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Tributary of Davidson Creek	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0
Banyan Creek	1	0	0	0	1	1	0	0	0	0	0	0	1	1	1	1	0	0	0	1	1	0	1	1	1	1	0	1	1	0	0	1	0	0	1	0
Tributary of Tully River	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Wongaling Creek	1	0	1	0	1	0	1	0	0	1	0	1	0	1	0	1	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0

Table 95 Murray Basin fish monitoring sites and species present from the most recent survey (2019-20). The numeral 1 indicates the species was sampled and the numeral 0 indicates the species was not sampled. Species marked with * are pest fish species.

Waterway	AmbMio	AmbSp1	AngRei	AwaAcr	CraSte	EleMel	GerFil	GiuMar	GloApr	GloIll	HepSpp	HypCom	KuhRup	LutArg	MegCyp	MelMac	MelSpp	MogAds	NeoAte	NeoHyr	NotRob	OphSp1	OxyNul	*PelMar	*PoeRet	PorRen	PseGer	PseSig	RedBik	SchHoe	TanTro	*XipMac
Stony Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cane drain	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0	0	1	0	0	0	0	0	1
Scrubby Creek	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0
Tributary of Woodfield Creek	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0
Cane drain	0	1	1	0	1	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1
Dallachy Creek	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	0	1	0	1	0	0	0	0	0	1	0	0	1	0
Cane drain	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	1	1	1	0	1	0	1	1	1	0	1	1	0	0	0	0	0
Murray River	0	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	1	1	0	1	0	1	0	0	1	0	0	1	0	0	0	0
Murray River	0	1	1	1	1	0	0	0	1	1	1	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	1	0	0	1	0
Murray River	0	1	1	0	0	0	0	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Meunga Creek	1	1	1	1	0	1	1	1	0	1	1	1	1	1	0	0	1	0	0	0	1	1	0	0	0	0	0	1	1	1	1	0
Tributary of Kennedy Creek	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tributary of Kennedy Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 96 Herbert Basin fish monitoring sites and species present from the most recent survey (2019-20). The numeral 1 indicates the species was sampled and the numeral 0 indicates the species was not sampled. Species marked with * are pest fish species.

Waterway	AmbSp1	AmbVac	AmnPer	AngMar	AngObs	AngRei	AwaAcr	ButBut	CraSte	EleMel	*GamHol	GerFil	GiuMar	GloApr	GloGiu	GloIll	HepSpp	HypCom	HypSp1	KuhRup	LatCal	LeiUni	LutArg	MelSpp	MogAds	MugCep	NeoAte	NeoHyr	NotRob	OphSp1	*OreMos	*PoeRet	PorRen	PseSig	RedBik	RedChr	ScaArg	SynHog	TanTro	*XipHel
Trebonne Creek	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Tributary of Herbert River	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Blunder Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Breakaway Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ashton Creek	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
White Adder Creek	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tributary of Jacky Jacky Creek	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hawkins Creek	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Mill Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wild River	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Stone River	1	0	1	1	0	1	1	0	1	0	0	0	0	1	0	1	0	1	0	0	0	1	0	1	1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0
Spring Creek (North Branch)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Robinson Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Wigwam Creek	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0
Blunder Creek	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Anabranch of Rudd Creek	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Gowrie Creek	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Waterway	AmbSp1	AmbVac	AmnPer	AngMar	AngObs	AngRei	AwaAcr	ButBut	CraSte	EleMel	*GamHol	GerFil	GiuMar	GloApr	GloGiu	GloIll	HepSpp	HypCom	HypSp1	KuhRup	LatCal	LeiUni	LutArg	MelSpp	MogAds	MugCep	NeoAte	NeoHyr	NotRob	OphSp1	*OreMos	*PoeRet	PorRen	PseSig	RedBik	RedChr	ScaArg	SynHog	TanTro	*XipHel
Wild River	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	1	0	0	1	1	0	0	0	0	0	1	0
Arnot Creek	0	1	0	0	0	1	1	1	1	1	0	1	1	0	1	0	0	1	0	0	0	0	1	1	1	1	0	0	0	0	0	1	0	1	1	1	1	0	0
Wild River	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Vine Creek	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Herbert River	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	1	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0
Palm Creek	1	0	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Blencoe Creek	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Herbert River	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Break-O-Day Creek	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Tin Creek	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Black Adder Creek	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Garrawalt Creek	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tributary of Kirrama Creek	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yuccabine Creek	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gowrie Creek	0	0	1	1	0	1	1	0	1	0	0	0	0	1	0	1	1	1	0	0	1	0	0	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0

Table 97 Translocated and alien fish species caught during the 2019-20 fish assessment for each Basin.

Origin and Common name	Moss-man	Barron	Russell	Mulgrave	John-stone	Tully	Murray	Herbert
Translocated								
Barred grunter	-	✓	-	-	-	-	-	-
Fly-specked hardyhead	-	✓	-	-	-	-	-	-
Mouth almighty	-	✓	-	-	✓	-	-	-
Golden Flathead Goby	-	✓	-	-	-	-	-	-
Sooty grunter	-	-	-	-	-	-	-	✓
Tully grunter	-	✓	-	-	✓	-	✓	-
Spangled perch	-	✓	-	-	-	-	-	✓
Bony bream	-	✓	-	-	-	-	-	-
Butter jew	-	✓	-	-	-	-	-	-
Hyrtl's tandan	-	✓	-	-	-	-	-	-
Sleepy cod	-	✓	-	-	-	-	-	-
Northern sleepy cod	-	✓	-	-	-	-	-	-
Rendahl's tandan	-	✓	-	-	-	-	-	-
Wet Tropics tandan	-	✓	-	-	✓	-	-	✓
Alien								
Gambusia	-	-	-	-	-	-	-	✓
Mozambique tilapia	-	-	-	-	-	-	-	✓
Spotted tilapia	-	✓	✓	✓	✓	✓	✓	-
Guppy	✓	✓	✓	✓	✓	✓	✓	✓
Swordtail	✓	-	-	-	✓	-	-	✓
Platy	-	-	✓	✓	✓	✓	✓	✓

'Translocated' refers to Australian native species that were found in waterways within which they do not naturally occur, and 'Alien' refers to fish species from outside of Australia. Note that some species are indigenous to the lowland sections of some basins but have been translocated to upper sections above waterfalls.

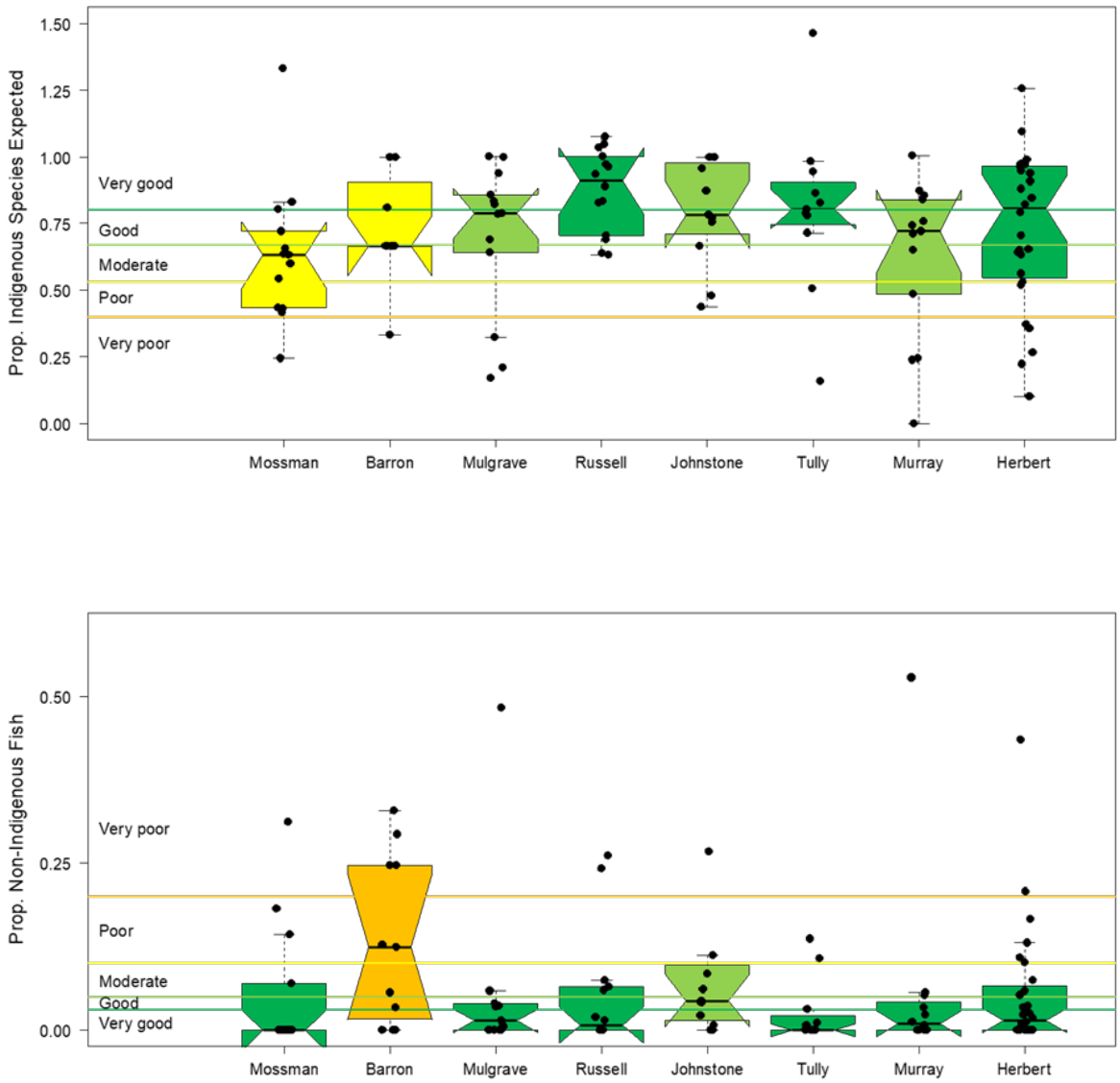


Figure 25 Box plots for sites within each basins in relation to the proportion of indigenous species expected indicator (top) and the proportion of non-indigenous fish indicator (bottom).

Interpretation of notched boxplots: the lowest line of the box is the first quartile (Q1), the upper line is third quartile (Q3) and the midline is the median; the lower whisker is Q1 - (1.5 * IQR) or lowest value within that range and the upper whisker is Q3 + (1.5 * IQR) highest value within that range, where IQR is the interquartile range (Q3-Q1); notch ≈ 95% confidence limit of median (median±(1.58*IQR)/sqrt(n)) and non-overlapping notches suggest significant differences.

Appendix E. Interpreting the pesticide risk values and risk categories

The pesticide risk metric is reported as the '% of species' protected from mixtures of pesticides detected in an ecosystem over the wet season (the period when pesticides most commonly occur in catchments and are present at their highest concentrations). How that percentage of species protected in the ecosystem is estimated is described in the methods technical report (WTW 2022) and elsewhere (Warne et al, In prep.). But in summary, ecotoxicity experiments provide an indication of how organisms in the ecosystem might respond when they are exposed to different concentrations of pesticides. By collating these (published) experimental data for multiple species, it is possible to derive (i.e. using species sensitivity distributions) the relationship between the concentration of a pesticide and the percentage of species it is likely to affect. Pesticide concentrations detected in an ecosystem can then be compared against the species sensitivity distribution to estimate the percentage of species being affected in the ecosystem. By expanding this process to account for the cumulative impact of multiple pesticides over the wet season, the risk of pesticides can be estimated (i.e. the Pesticide Risk Metric). The Pesticide Risk Metric can estimate the effect of mixtures of up to 22 pesticides frequently detected in waters discharging to the Great Barrier Reef, and from this, the percentage of species that should be protected from the concentrations of the 22 pesticides is estimated.

For example, a pesticide risk value of 95% species protection, means that 95% of aquatic species in an ecosystem should not experience harmful non-lethal or lethal effects (such as reduced growth or reproduction) resulting from exposure to pesticides present in that waterbody. It also means that the most sensitive 5% of aquatic species would be expected to experience some harmful non-lethal effects. The types of organisms that are most sensitive depends on the type of pesticides that they are exposed to, as pesticides are designed to affect specific types of organisms. For example, herbicides are designed to kill plants and therefore algae and aquatic plants (including seagrass and coral) are generally the most sensitive aquatic species to herbicides. Insecticides are designed to kill insects, and therefore, aquatic insects and crustaceans (e.g. crabs, lobsters, prawns and copepods), which are closely related to insects, are the most sensitive aquatic species. As pesticide concentrations increase:

- more species will experience harmful effects;
- the harmful effects will change from non-lethal to lethal; and
- what is affected will increase from individuals, to populations, to whole communities or ecosystems

Fish are relatively insensitive to herbicides and insecticides as they do not have the biochemical pathways that these pesticides affect. Therefore, based on the types and concentrations of pesticides currently being detected in the lower reaches of Great Barrier Reef catchments and the inshore marine ecosystems, it is unlikely that fish mortality or population decline would occur as a direct result of exposure to those pesticides. Rather sublethal and/or indirect effects could occur. For example, Kroon et al. (2013) found that barramundi and coral trout collected along the east coast of Queensland exhibited signs of endocrine disruption (a non-lethal effect) and the extent of this was related to the concentrations of a number of pesticides in the water where the fish were collected. In contrast, the effects on aquatic plants (such as algae and sea grasses) in lower reaches of Great Barrier Reef catchments and the inshore marine ecosystems are expected to be greater,

because they are more sensitive to herbicides, and herbicides are the main kinds of pesticides found in these waterways. This has been shown by Wood et al. (2018) who found that as herbicide concentrations increased, the number of sensitive algal species present in waterways decreased for at least the duration of the wet season. While concentrations of pesticides may not be sufficiently high to kill fish, they could be indirectly affected by pesticides through declines in their food (e.g. fish that eat plants or insects), and/or habitats (e.g. aquatic plants and sea grasses). Such indirect effects could decrease the amount of food and shelter available for organisms, including fish, further up food webs. Instability in a food web can lead to increased vulnerability of an ecosystem to other stressors (e.g. disease) and decrease ecosystem resilience.

The estimates of species protected were divided into five categories ranging from very low to very high risk (Table 98) that were aligned to the ecosystem protection levels used in the Australian and New Zealand Water Quality Guidelines (ANZG, 2018). The alignment of the percentage of species protected, pesticide risk categories and the ecosystem protection levels is shown in Table 98.

Table 98 The alignment of the percentage of protected species, risk category and ecosystem protection levels.

Pesticide risk value (% species protection)	Risk category	Ecosystem condition (ANZG, 2018)
≥ **99%**	Very Low	high conservation or ecological value systems
<99 to **95%**	Low	slightly to moderately disturbed systems
<95 to **90%**	Moderate	
<90 to **80%**	High	highly disturbed systems
<80%	Very High	

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Appendix F. Index, indicator category and indicator scores and grade tables for 2015-16 to 2020-21.

Basins

Water quality

Table 99 Basin water quality index, indicator category and indicator scores and grades for the 2020-21 reporting period.

Basin	Sediment	Nutrients			Pesticides	Water quality
	TSS	DIN	FRP	**Nutrients**		**20-21**
Daintree	**90**	90	73	**81**	**93**	**88**
Mossman~	**90**	34	51	**43**	**nd**	**66**
Barron	**63**	81	72	**76**	**nd**	**70**
Mulgrave	**90**	39	69	**54**	**75**	**73**
Russell	**80**	61	76	**68**	**75**	**75**
Johnstone	**90**	69	53	**61**	**75**	**75**
Tully	**90**	48	77	**62**	**61**	**71**
Murray	**71**	49	60	**55**	**23**	**49**
Herbert	**78**	43	73	**58**	**61**	**66**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data or insufficient data available. *Pesticide score was calculated from monitoring at the Coquette Point GBR CLMP site on the Johnstone River downstream of the South Johnstone and North Johnstone river confluence. ~Mossman River was assessed for base-flow only. For each basin DIN and FRP indicator values are averaged to provide the nutrient indicator category score (presented in bold) and that the three indicator categories (sediment, nutrients and pesticides) are averaged to provide the WQ score (all presented in bold).

Table 100 Basin water quality index, indicator category and indicator scores and grades for the 2019-20 reporting period.

Basin	Sediment	Nutrients			Pesticides	Water quality
	TSS	DIN	FRP	**Nutrients**		**19-20**
Daintree	**90**	90	82	**86**	**98**	**91**
Mossman~	**90**	56	76	**66**	**nd**	**78**
Barron	**67**	67	75	**71**	**nd**	**69**
Mulgrave	**72**	39	75	**57**	**78**	**69**
Russell	**68**	46	77	**62**	**71**	**67**
Johnstone	**90**	74	66	**70**	**76**	**78**
Tully	**84**	42	77	**60**	**70**	**71**
Murray	**71**	31	69	**50**	**27**	**49**
Herbert	**90**	46	76	**61**	**68**	**73**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data or insufficient data available. *Pesticide score was calculated from monitoring at the Coquette Point GBR CLMP site on the Johnstone River downstream of the South Johnstone and North Johnstone river confluence. ~Mossman River was assessed for base-flow only. For each basin DIN and FRP indicator values are averaged to provide the nutrient indicator category score (presented in bold) and that the three indicator categories (sediment, nutrients and pesticides) are averaged to provide the WQ score (all presented in bold).

Table 101 Basin water quality index, indicator category and indicator scores and grades for the 2018-19 reporting period.

Basin	Sediment	Nutrients			Pesticides	Water quality
	TSS	DIN	FRP	**Nutrients**		**18-19**
Daintree#	**68**	90	90	**90**	**85**	**84**
Mossman~	**90**	42	89	**66**	**60**	**69**
Barron	**55**	70	81	**76**	**89**	**74**
Mulgrave	**78**	49	72	**61**	**69**	**66**
Russell	**76**	58	90	**74**	**75**	**75**
Johnstone	**90**	72	69	**70**	**74***	**75**
Tully	**78**	42	90	**66**	**63**	**68**
Murray	**74**	53	77	**65**	**25**	**59**
Herbert	**81**	37	67	**52**	**68**	**61**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data or insufficient data available. *Pesticide score was calculated from monitoring at the Coquette Point GBR CLMP site on the Johnstone River downstream of the South Johnstone and North Johnstone river confluence. #Daintree River was assessed for high flows only. ~Mossman River was assessed for base-flow only. For each basin DIN and FRP indicator values are averaged to provide the nutrient indicator category score (presented in bold) and that the three indicator categories (sediment, nutrients and pesticides) are averaged to provide the WQ score (all presented in bold).

Table 102 Basin water quality index, indicator category and indicator scores and grades for the 2017-18 reporting period.

Basin	Sediment	Nutrients			Pesticides	Water quality
	TSS	DIN	FRP	**Nutrients**		**17-18**
Daintree#	**90**	70	61	**65**	**90**	**82**
Mossman~	**76**	44	89	**67**	**70**	**71**
Barron	**68**	78	80	**79**	**87**	**78**
Mulgrave	**90**	32	71	**52**	**57**	**66**
Russell	**90**	45	76	**60**	**54**	**68**
Johnstone	**73**	75	70	**72**	**61***	**69**
Tully	**80**	39	73	**56**	**54**	**63**
Murray	**nd**	nd	nd	**nd**	**nd**	**nd**
Herbert	**90**	32	83	**58**	**66**	**71**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data or insufficient data available. *Pesticide score was calculated from monitoring at the Coquette Point GBR CLMP site on the Johnstone River downstream of the South Johnstone and North Johnstone river confluence. #Daintree River was assessed for high flows only. ~Mossman River was assessed for base-flow only. For each basin DIN and FRP indicator values are averaged to provide the nutrient indicator category score (presented in bold) and that the three indicator categories (sediment, nutrients and pesticides) are averaged to provide the WQ score (all presented in bold).

Table 103 Basin water quality index, indicator category and indicator scores and grades for the 2016-17 reporting period using the previous pesticide assessment method.

Basin	Sediment	Nutrients			Pesticides	Water quality
	TSS	DIN	FRP	**Nutrients**		**Score**
Daintree	**nd**	nd	nd	**nd**	**nd**	**nd**
Mossman	**nd**	nd	nd	**nd**	**nd**	**nd**
Barron	**76**	90	84	**87**	**nd**	**81**
Mulgrave	**68**	37	72	**55**	**65**	**63**
Russell	**77**	44	90	**67**	**66**	**70**
Johnstone	**81**	70	57	**64**	**71***	**72**
Tully	**78**	41	79	**60**	**61**	**66**
Murray	**nd**	nd	nd	**nd**	**nd**	**nd**
Herbert	**90**	44	90	**67**	**71**	**76**

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. nd indicates no data or insufficient data available. *Pesticide score was calculated from monitoring at the Coquette Point GBR CLMP site on the Johnstone River downstream of the South Johnstone and North Johnstone river confluence. For each basin DIN and FRP indicator values are averaged to provide the nutrient indicator category score (presented in bold) and that the three indicator categories (sediment, nutrients and pesticides) are averaged to provide the WQ score (all presented in bold).

Table 104 Basin water quality index, indicator category and indicator scores and grades for the 2015-16 reporting period using the previous pesticide assessment method.

Basin	Sediment	Nutrients			Pesticides	Water quality
	TSS	DIN	FRP	**Nutrients**		**Score**
Daintree	**nd**	nd	nd	**nd**	**nd**	**nd**
Mossman	**nd**	nd	nd	**nd**	**nd**	**nd**
Barron	**89**	63	90	**76**	**nd**	**82**
Mulgrave	**71**	29	62	**45**	**71**	**62**
Russell	**90**	45	80	**63**	**66**	**73**
Johnstone	**90**	74	69	**72**	**76***	**79**
Tully	**80**	33	81	**57**	**57**	**65**
Murray	**nd**	nd	nd	**nd**	**nd**	**nd**
Herbert	**90**	59	90	**74**	**76**	**80**

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. nd indicates no data or insufficient data available. *Pesticide score was calculated from monitoring at the Coquette Point GBR CLMP site on the Johnstone River downstream of the South Johnstone and North Johnstone river confluence. For each basin DIN and FRP indicator values are averaged to provide the nutrient indicator category score (presented in bold) and that the three indicator categories (sediment, nutrients and pesticides) are averaged to provide the WQ score (all presented in bold).

Habitat and hydrology

Table 105 Results of habitat and hydrology index (H&H) and indicator categories for basins 2020-21

Basin	Flow	Invasive weeds	Habitat modification	Riparian extent	Wetland extent	H&H
Daintree	nd	54	100	99	60	**78**
Mossman	95	81	100	68	16	**72**
Barron	69	34	36	68	11	**44**
Mulgrave	80	43	100	78	33	**67**
Russell	91	41	100	79	33	**69**
Johnstone	96	24	98	74	25	**64**
Tully	100	71	57	72	17	**63**
Murray	78	19	100	75	19	**58**
Herbert	86	19	92	85	20	**60**

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. nd indicates no data available.

Table 106 Results of habitat and hydrology index (H&H) and indicator categories for basins 2019-20

Basin	Flow	Invasive weeds	Habitat modification	Riparian extent	Wetland extent	H&H
Daintree	nd	54	100	99	60	78
Mossman	75	81	100	68	16	68
Barron	80	34	36	68	11	46
Mulgrave	75	43	100	78	33	66
Russell	76	41	100	79	33	66
Johnstone	92	24	98	74	25	63
Tully	61	71	57	72	17	56
Murray	61	19	100	75	19	55
Herbert	66	19	92	85	20	56

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100. nd indicates no data available.

Table 107 Results of habitat and hydrology index (H&H) and indicator categories for basins 2018-19

Basin	Flow	Invasive weeds	Habitat modification	Riparian extent	Wetland extent	H&H
Daintree	nd	62	100	99	60	80
Mossman	61	36	100	68	16	56
Barron	65	56	36	68	11	47
Mulgrave	55	52	100	78	33	63
Russell	61	41	100	79	33	63
Johnstone	66	29	98	74	25	59
Tully	43	81	57	72	17	54
Murray	68	19	100	75	19	56
Herbert	69	19	92	85	20	57

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available.

Table 108 Results of habitat and hydrology index (H&H) and indicator categories for basins 2017-18

Basin	Flow	Invasive weeds	Habitat modification	Riparian extent	Wetland extent	H&H
Daintree	nd	62	100	99	60	80
Mossman	95	36	100	68	16	63
Barron	51	56	36	68	11	45
Mulgrave	93	52	100	78	33	71
Russell	95	41	100	79	33	69
Johnstone	97	29	98	74	25	65
Tully	99	81	57	72	17	65
Murray	78	19	100	75	19	58
Herbert	92	19	92	85	20	61

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available.

Table 109 Results of habitat and hydrology index (H&H) and indicator categories for basins 2016-17.

Basin	Flow	Invasive weeds	Habitat modification	Riparian extent	Wetland extent	H&H
Daintree	nd	62	100	99	61	81
Mossman	95	36	100	68	17	63
Barron	62	56	36	68	11	47
Mulgrave	61	52	100	78	34	65
Russell	95	41	100	79	35	70
Johnstone	96	29	98	74	26	65
Tully	80	81	57	72	17	61
Murray	61	19	100	75	21	55
Herbert	62	19	92	85	20	56

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available.

Table 110 Results of habitat and hydrology index (H&H) and indicator categories for basins 2015-16.

Basin	Flow	Invasive weeds	Habitat modification	Riparian extent	Wetland extent	H&H
Daintree	nd	62	100	99	61	81
Mossman	nd	36	100	68	17	55
Barron	nd	56	36	68	11	43
Mulgrave	nd	52	100	78	34	66
Russell	nd	41	100	79	35	63
Johnstone	nd	29	98	74	26	57
Tully	nd	81	57	72	17	57
Murray	nd	19	100	75	21	54
Herbert	nd	19	92	85	20	54

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

Fish

Table 111 Results for freshwater fish indicator and index for 2017-18.

	Fish indicator scores		Standardised scores		
Basin	Native species richness (PONSE)	Pest fish (Proportion of sample)	Native species richness (PONSE)	Pest fish (Proportion of sample)	Fish Index
Mulgrave	0.769	0.031	76	76	76
Russell	0.813	0.011	82	91	86

Estuaries

Water quality

Table 112 Estuary water quality indicator, indicator category and index scores and grades for 2020-2021.

Estuary	Chl *a*	Nutrients			Phys/Chem				Pest-icides	Water quality
	Chl *a*	DIN	FRP	**Nut-rients**	Turb-idity	DO Low	DO High	**Phys/ Chem**	Pest-icides	
Daintree	**86**	81	90	**85**	90	81	90	**85**	**94**	**88**
Dickson Inlet	**84**	71	nd	**71**	90	90	90	**90**	**nd**	**82**
Barron	**74**	46	73	**59**	90	65	90	**77**	**nd**	**70**
Trinity Inlet	**70**	90	90	**90**	90	31	90	**60**	**nd**	**73**
Russell-Mulgrave	**90**	52	90	**71**	90	69	90	**79**	**75**	**79**
Johnstone	**90**	37	70	**54**	nd	90	90	**90**	**75**	**77**
Moresby	**69**	70	90	**80**	90	68	90	**79**	**nd**	**76**
Hinchinbrook Channel	**64**	90	90	**90**	90	78	90	**84**	**nd**	**79**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. Risk metric scores for pesticide are from GBR CLMP sites as per freshwater basins. nd indicates no data available. For each estuary DIN and FRP indicator values are averaged to provide the Nutrient indicator category score (presented in bold) and that the turbidity and DO indicator scores (using the lowest of the two DO values) are averaged to provide the Phys/Chem indicator score (presented in bold). The indicator categories (Chl *a*, Nutrients, Phys/Chem and Pesticides) are averaged to provide the WQ score (all presented in bold). **Note:** Pesticides are from GBR CLMP high flow data as per freshwater basins.

Table 113 Estuary water quality indicator, indicator category and index scores and grades for 2019-2020.

Estuary	Chl *a*	Nutrients			Phys/Chem				Pest-icides	Water quality
	Chl *a*	DIN	FRP	**Nut-rients**	Turb-idity	DO Low	DO High	**Phys/ Chem**	Pest-icides	
Daintree	**90**	90	90	**90**	90	90	90	**90**	**98**	**92**
Dickson Inlet	**81**	76	90	**77**	90	69	90	**79**	**nd**	**81**
Barron	**46**	39	80	**60**	85	64	90	**74**	**nd**	**60**
Trinity Inlet	**66**	90	90	**90**	90	20	90	**55**	**nd**	**70**
Russell-Mulgrave	**90**	67	90	**78**	90	68	90	**79**	**74**	**80**
Johnstone	**90**	34	90	**62**	nd	nd	nd	**nd**	**76**	**76**
Moresby	**90**	69	90	**79**	90	69	90	**79**	**nd**	**83**
Hinchinbrook Channel	**77**	90	90	**90**	90	90	90	**90**	**nd**	**85**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. Risk metric scores for pesticide are from GBR CLMP sites as per freshwater basins. nd indicates no data available. For each estuary DIN and FRP indicator values are averaged to provide the Nutrient indicator category score (presented in bold) and that the turbidity and DO indicator scores (using the lowest of the two DO values) are averaged to provide the Phys/Chem indicator score (presented in bold). The indicator categories (Chl *a*, Nutrients, Phys/Chem and Pesticides) are averaged to provide the WQ score (all presented in bold). **Note:** Pesticides are from GBR CLMP high flow data as per freshwater basins.

Table 114 Estuary water quality indicator, indicator category and index scores and grades for 2018-19.

	Chl *a*	**Nutrients**			**Phys/Chem**				**Pest-icides**	**Water quality**
	Chl *a*	DIN	FRP	**Nut-rients**	Turb-idity	DO Low	DO High	**Phys/ Chem**	Pest-icides	
Daintree	**80**	72	90	**81**	67	90	90	**78**	**85**	**81**
Dickson Inlet	**90**	78	72	**75**	90	81	90	**85**	nd	**83**
Barron	**37**	41	57	**49**	73	64	90	**69**	**90**	**61**
Trinity Inlet	**45**	68	74	**71**	77	35	90	**56**	nd	**58**
Russell-Mulgrave	**90**	27	90	**59**	90	51	90	**70**	**70**	**72**
Johnstone	**90**	51	79	**65**	90	65	90	**77**	**74**	**76**
Moresby	**90**	65	90	**77**	79	66	90	**73**	nd	**80**
Hinchinbrook Channel	**65**	90	90	**90**	75	77	90	**76**	nd	**77**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. Risk metric scores for pesticide are from GBR CLMP sites as per freshwater basins. nd indicates no data available. For each estuary DIN and FRP indicator values are averaged to provide the Nutrient indicator category score (presented in bold) and that the turbidity and DO indicator scores (using the lowest of the two DO values) are averaged to provide the Phys/Chem indicator score (presented in bold). The indicator categories (Chl *a*, Nutrients, Phys/Chem and Pesticides) are averaged to provide the WQ score (all presented in bold). **Note:** Pesticides are from GBR CLMP high flow data as per freshwater basins.

Table 115 Estuary water quality indicator, indicator category and index scores and grades for 2017-18.

	Chl *a*	**Nutrients**			**Phys/Chem**				**Pest-icides**	**Water quality**
	Chl *a*	DIN	FRP	**Nut-rients**	Turb-idity	DO Low	DO High	**Phys/ Chem**	Pest-icides	
Daintree	**87**	76	90	**83**	71	90	90	**80**	**90**	**85**
Dickson Inlet	**90**	80	68	**74**	90	63	90	**76**	nd	**80**
Barron	**38**	48	57	**52**	85	90	90	**87**	**87**	**66**
Trinity Inlet	**57**	67	79	**73**	90	37	90	**63**	nd	**65**
Russell-Mulgrave	**90**	29	59	**44**	90	61	90	**75**	**55**	**66**
Johnstone	**90**	28	48	**38**	nd	78	90	**78**	**61**	**67**
Moresby	**90**	65	90	**77**	69	69	90	**69**	nd	**79**
Hinchinbrook Channel	**90**	90	90	**90**	61	73	90	**67**	nd	**82**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. Pesticide risk metric scores are from GBR CLMP sites as per freshwater basins. nd indicates no data available. For each estuary DIN and FRP indicator values are averaged to provide the Nutrient indicator category score (presented in bold) and that the turbidity and DO indicator scores (using the lowest of the two DO values) are averaged to provide the Phys/Chem indicator score (presented in bold). The indicator categories (Chl *a*, Nutrients, Phys/Chem and Pesticides) are averaged to provide the WQ score (all presented in bold). **Note:** Pesticides are from GBR CLMP high flow data as per freshwater basins.

Table 116 Estuary water quality indicator, indicator category and index scores and grades for 2016-17 using the previous method for pesticide assessment.

	Chl *a*	Nutrients			Phys/Chem				Pest-icides	Water quality
	Chl *a*	DIN	FRP	**Nut-rients**	Turb-idity	DO Low	DO High	**Phys/ Chem**	Pest-icides	
Daintree	**90**	65	55	**60**	90	90	90	**90**	nd	**80**
Dickson Inlet	**77**	77	nd	**77**	nd	39	90	**39**	nd	**64**
Barron	**60**	48	57	**52**	86	76	90	**81**	nd	**64**
Trinity Inlet	**90**	69	90	**79**	90	41	90	**65**	nd	**78**
Russell-Mulgrave	**90**	51	76	**64**	81	83	90	**82**	**66**	**75**
Johnstone	**90**	48	65	**56**	nd	nd	nd	nd	**71**	**72**
Moresby	**90**	61	90	**75**	90	66	90	**78**	nd	**81**
Hinchinbrook Channel	**90**	90	90	**90**	90	90	90	**90**	nd	**90**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. Pesticide risk metric scores are from GBR CLMP sites as per freshwater basins. nd indicates no data available. For each estuary DIN and FRP indicator values are averaged to provide the Nutrient indicator category score (presented in bold) and that the turbidity and DO indicator scores (using the lowest of the two DO values) are averaged to provide the Phys/Chem indicator score (presented in bold). The indicator categories (Chl *a*, Nutrients, Phys/Chem and Pesticides) are averaged to provide the WQ score (all presented in bold). **Note:** Pesticides are from GBR CLMP high flow data as per freshwater basins.

Table 117 Estuary Water quality indicator, indicator category and index scores and grades for 2015-16 using the previous method for pesticide assessment.

	Chl *a*	Nutrients			Phys/Chem				Pest-icides	Water quality
	Chl *a*	DIN	FRP	**Nut-rients**	Turb-idity	DO Low	DO High	**Phys/ Chem**	Pest-icides	
Daintree	**90**	63	72	**67**	90	74	90	**82**	nd	**79**
Dickson Inlet	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Barron	**8**	53	54	**54**	90	90	90	**90**	nd	**50**
Trinity Inlet	**90**	90	90	**90**	90	52	90	**71**	nd	**83**
Russell-Mulgrave	**90**	53	69	**61**	90	90	90	**90**	**71**	**78**
Johnstone	**90**	50	68	**59**	nd	29	90	**29**	**76**	**63**
Moresby	**90**	61	90	**75**	90	48	90	**69**	nd	**78**
Hinchinbrook Channel	**90**	90	90	**90**	74	76	90	**75**	nd	**85**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available. For each estuary DIN and FRP indicator values are averaged to provide the Nutrient indicator category score (presented in bold) and that the turbidity and DO indicator scores (using the lowest of the two DO values) are averaged to provide the Phys/Chem indicator score (presented in bold). The indicator categories (Chl *a*, Nutrients, Phys/Chem and Pesticides) are averaged to provide the WQ score (all presented in bold). **Note:** Pesticides are from GBR CLMP high flow data as per freshwater basins.

Habitat and hydrology

Table 118 Results for habitat and hydrology index (H&H) and indicator categories for the 2020-21 reporting period.

Estuary	Mangrove extent	Riparian extent	Flow	Fish barriers	Sea-grass	H&H
Daintree	88^	28	nd	61	-	59
Dickson Inlet	69^	47	nd	100	nd	72
Barron	57^	23	75	61	-	54
Trinity Inlet	57^	59	nd	61	42	54
Russell-Mulgrave	81^	24	84	81	-	67
Johnstone	63	9	98	81	-	63
Moresby	79	68	nd	61	18	56
Hinchinbrook Channel	84	51	nd	**60**	nd	65

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. *nd indicates no data available. - indicates that it does not occur at the location. nd indicates no data available. ^ indicates the estuaries that include the new shoreline mangrove habitat indicator introduced in 2020-21.

Table 119 Results for habitat and hydrology index (H&H) and indicator categories for the 2019-20 reporting period.

Estuary	Mangrove extent	Riparian extent	Flow	Fish barriers	Sea-grass	H&H
Daintree	93	28	nd	61	-	60
Dickson Inlet	75	47	nd	100	nd	74
Barron	39	23	93	61	-	54
Trinity Inlet	53	59	nd	61	54	57
Russell-Mulgrave	98	24	75	81	-	69
Johnstone	63	9	95	81	-	62
Moresby	79	68	nd	61	25	58
Hinchinbrook Channel	84	51	nd	80	nd	71

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. *nd indicates no data available. - indicates that it does not occur at the location.

Table 120 Results for habitat and hydrology index (H&H) and indicator categories for the 2018-19 reporting period.

Estuary	Mangrove extent	Riparian extent	Flow	Fish barriers	Sea-grass	H&H
Daintree	93	28	nd*	61	-	60
Dickson Inlet	75	47	nd	100	nd	74
Barron	39	23	57	61	-	45
Trinity Inlet	53	59	nd	61	46	55
Russell-Mulgrave	98	24	57	81	-	65
Johnstone	63	9	65	81	-	54
Moresby	79	68	nd	61	8	54
Hinchinbrook Channel	84	51	nd	80	nd	71

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. *nd indicates no data available. - indicates that it does not occur at the location.

Table 121 Results for habitat and hydrology index (H&H) and indicator categories for the 2017-18 reporting period.

Estuary	Mangrove extent	Riparian extent	Flow	Fish barriers	Seagrass condition	H&H
Daintree	93	25	nd*	61	-	60
Dickson Inlet	75	47	nd	100	nd	74
Barron	39	22	49	61	-	43
Trinity Inlet	53	57	nd	61	31	50
Russell-Mulgrave	98	24	98	81	-	75
Johnstone	63	9	98	81	-	63
Moresby	79	64	nd	61	0	51
Hinchinbrook Channel	84	51	nd	80	nd	72

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. *nd indicates no data available. - indicates that it does not occur at the location.

Table 122 Results for habitat and hydrology index (H&H) and indicator categories for the 2016-17 reporting period.

Estuary	Mangrove extent	Riparian extent	Flow	Fish barriers	Seagrass condition	H&H
Daintree	93	25	nd*	61	-	60
Dickson Inlet	75	47	nd	100	nd	74
Barron	39	22	59	61	-	45
Trinity Inlet	53	57	nd	61	30	50
Russell-Mulgrave	98	24	74	81	-	69
Johnstone	63	9	81	81	-	58
Moresby	79	64	nd	61	7	53
Hinchinbrook Channel	84	51	nd	80	nd	72

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available. - indicates that it does not occur at this location.

Table 123 Results for habitat and hydrology index (H&H) and indicator categories for the 2015-16 reporting period using the updated scoring methods.

Estuary	Mangrove extent	Riparian extent	Flow	Fish barriers	Seagrass condition	H&H
Daintree	93	25	nd	61	-	60
Dickson Inlet	75	47	nd	100	nd	74
Barron	39	22	nd	61	-	41
Trinity Inlet	53	57	nd	61	21	48
Russell-Mulgrave	98	24	nd	81	-	67
Johnstone	63	9	nd	81	-	51
Moresby	79	64	nd	61	13	54
Hinchinbrook Channel	84	51	nd	80	nd	72

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available. ^Decisions rules require ≥ 60% indictor categories (I.C.) for aggregation to index. - indicates that it does not occur at this location.

Inshore marine

Water quality

Table 124 Results for water quality indicators, indicator categories and index for inshore marine zones 2020-21

Zone	Water clarity			Chl *a*	Nutrients				Pest-icides	Water quality
	TSS	Tur-bidity	**Water clarity**	Chl *a*	NOx	PN	PP	**Nut-rients**	Risk metric	**20- 21**
North	69	nd	69	86	57	65	57	60	nd	72
Central	81	59	75	69	22	26	62	37	nd	60
South	58	60	62	75	5	18	48	21	nd	52
Palm Island	76	67	71	64	44	44	61	50	nd	62

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available. The indicator values are averaged to provide the water clarity and nutrient indicator category scores (presented in bold) and that the four indicator categories are averaged to provide the water quality index score (also presented in bold).

Table 125 Results for water quality indicators, indicator categories and index for inshore marine zones 2019-20.

Zone	Water clarity			Chl *a*	Nutrients				Pest-icides	Water quality
	TSS	Tur-bidity	**Water clarity**	Chl *a*	NOx	PN	PP	**Nutrients**	Risk metric	
North	96	nd	**96**	**91**	100	79	80	**86**	nd	**91**
Central	92	72	**89**	**75**	11	55	62	**43**	**89**	**74**
South	83	67	**82**	**71**	21	26	57	**42**	**91**	**72**
Palm Island	94	88	**91**	**68**	39	0	66	**37**	nd	**65**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available. The indicator values are averaged to provide the water clarity and nutrient indicator category scores (presented in bold) and that the four indicator categories are averaged to provide the water quality index score (also presented in bold).

Table 126 Results for water quality indicators, indicator categories and index for inshore marine zones 2018-19.

Zone	Water clarity			Chl *a*	Nutrients				Pest-icides	Water quality
	TSS	Tur-bidity	**Water clarity**	Chl *a*	NOx	PN	PP	**Nutrients**	Pest-icides	
North	88		**88**	**75**	92	76	69	**80**	**96**	**85**
Central	71	64	**70**	**52**	12	19	33	**21**	**89**	**58**
South	47	60	**54**	**24**	3	6	8	**7**	**91**	**44**
Palm Island	86	73	**80**	**66**	0	0	8	**2**	**91**	**60**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available. The indicator values are averaged to provide the water clarity and nutrient indicator category scores (presented in bold) and that the four indicator categories are averaged to provide the water quality index score (also presented in bold).

Table 127 Results for water quality indicators, indicator categories and index for inshore marine zones 2017-18.

Zone	Water clarity			Chl *a*	Nutrients				Pest-icides	Water quality
	TSS	Tur-bidity	**Water clarity**	Chl *a*	NOx	PN	PP	**Nutrients**	Pest-icides	
North	52	nd	**52**	**49**	95	69	36	**70**	**92**	**66**
Central	41	60	**41**	**36**	21	64	68	**53**	**84**	**53**
South	20	60	**31**	**36**	1	50	68	**34**	**88**	**47**
Palm Island	39	68	**57**	**46**	21	27	73	**42**	**86**	**53**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available. The indicator values are averaged to provide the water clarity and nutrient indicator category scores (presented in bold) and that the four indicator categories are averaged to provide the water quality index score (also presented in bold).

Table 128 Results for water quality indicators, indicator categories and index for inshore marine zones 2016-17.

Zone	Water clarity			Chl *a*	Nutrients				Pest-icides	Water quality
	TSS	Tur-bidity	**Water clarity**	**Chl *a***	NOx	PN	PP	**Nutrients**	Pest-icides	
North	69	nd	**69**	**47**	95	50	51	**68**	**93**	**69**
Central	48	63	**51**	**52**	4	57	78	**50**	**80**	**58**
South	10	62	**23**	**54**	0	23	70	**26**	**86**	**47**
Palm Island	5	87	**54**	**67**	12	59	67	**47**	**87**	**64**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. nd indicates no data available. The indicator values are averaged to provide the water clarity and nutrient indicator category scores (presented in bold) and that the four indicator categories are averaged to provide the water quality index score (also presented in bold).

Table 129 Results for water quality indicators, indicator categories and index for inshore marine zones 2015-16.

Zone	Water clarity			Chl *a*	Nutrients				Pesticides	Water quality
	TSS	Tur-bidity	**Water clarity**	Chl *a*	NOx	PN	PP	**Nutrients**	Pest-icides	
North	75	nd	75	**71**	100	72	52	**76**	**96**	**79**
Central	41	63	40	**64**	18	72	79	**61**	**93**	**64**
South	23	68	33	**64**	11	61	75	**47**	**96**	**60**
Palm Island	64	77	70	**62**	18	32	83	**49**	**93**	**69**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. The indicator values are averaged to provide the water clarity and nutrient indicator category scores (presented in bold) and that the four indicator categories are averaged to provide the water quality index score (also presented in bold).

Coral

Table 130 Results for coral indicators and coral index for the inshore marine zones 2020-21.

Inshore Zone	Juvenile	Macroalgae	Cover	Change	Composition	Coral 20-21
North	41	45	49	58	25	44
Central	36	74	70	68	65	63
South	72	34	49	68	81	61
Palm Island	44	45	45	48	63	49

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

Table 131 Results for coral indicators and coral index for the inshore marine zones 2019-20.

Inshore Zone	Juvenile	Macroalgae	Cover	Change	Composition	Coral 19-20
North	33	42	44	70	33	44
Central	40	65	74	64	61	61
South	78	44	46	74	75	62
Palm Island	51	55	43	50	66	53

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

Table 132 Results for coral indicators and coral index for the inshore marine zones 2018-19.

Inshore Zone	Juvenile	Macroalgae	Cover	Change	Composition	Coral condition
North	32	44	41	69	33	44
Central	41	64	66	73	58	60
South	87	41	43	72	75	62
Palm Island	45	45	44	61	67	52

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

Table 133 Results for coral indicators and coral index for the inshore marine zones 2017-18.

Inshore Zone	Juvenile	Macroalgae	Cover	Change	Composition	Coral condition
North	40	49	45	70	50	51
Central	38	73	62	74	58	61
South	81	40	34	66	58	55
Palm Island	51	32	37	60	63	49

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

Table 134 Results for coral indicators and coral index for the inshore marine zones 2016-17.

Inshore Zone	Juvenile	Macroalgae	Cover	Change	Composition	Coral condition
North	40	40	42	67	42	46
Central	30	76	58	80	42	57
South	89	46	32	74	58	60
Palm Island	55	32	33	59	67	49

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

Table 135 Results for coral indicators and coral index for the inshore marine zones 2015-16.

Inshore Zone	Juvenile	Macroalgae	Cover	Change	Composition	Coral condition
North	37	56	42	62	33	46
Central	40	67	72	70	53	60
South	95	35	31	66	50	55
Palm Island	59	31	36	50	70	49

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

Seagrass

Table 136 Inshore marine seagrass results for 2020-21.

Inshore zone	Biomass	Area	Species compo-sition	Percent cover	Resilience	Seagrass condition
North	77	85	93	43	47	57
Central	nd	nd	nd	nd	nd	nd
South	nd	nd	nd	31	32	40
Palm Island	nd	nd	nd	nd	nd	nd

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100.

Table 137 Inshore marine seagrass results for 2019-20

Inshore zone	Bio-mass	Area	Species compo-sition	Percent cover	Tissue nut-rients	Repro-ductive effort	Seagrass condition
North	70	84	85	36	38	20	46
Central	nd	nd	nd	nd	nd	nd	nd
South	nd	nd	nd	19	36	38	35
Palm Island	nd	nd	nd	nd	nd	nd	nd

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100.

Table 138 Inshore marine seagrass results for 2018-19.

Inshore zone	Biomass	Area	Species compo-sition	Percent cover	Tissue nutrients	Repro-ductive effort	Seagrass condition
North	62	92	71	43	37	63	53
Central	nd	nd	nd	nd	nd	nd	nd
South	nd	nd	nd	28	27	17	35
Palm Island	nd	nd	nd	nd	nd	nd	nd

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100.

Table 139 Inshore marine seagrass results for 2017-18.

Inshore zone	Biomass	Area	Species composition	Percent cover	Tissue nutrients	Repro-ductive effort	Seagrass condition
North	54	75	76	48	35	38	46
Central	nd	nd	nd	nd	nd	nd	nd
South	nd	nd	nd	19	39	0	23
Palm Island	nd	nd	nd	nd	nd	nd	nd

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100.

Table 140 Seagrass results for 2016-17.

Inshore zone	Biomass	Area	Species composition	Percent cover	Tissue nutrients	Reproductive effort	Seagrass condition
North	52	70	48	52	35	0	30
Central	nd	nd	nd	nd	nd	nd	nd
South	nd	nd	nd	0	43	8	6
Palm Island	nd	nd	nd	nd	nd	nd	nd

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100.

Table 141 Seagrass results for the 2015-16.

Inshore zone	Biomass	Area	Species Composition	Abundance	Tissue nutrients	Reproductive effort	Seagrass condition
North	40	48	71	40	31	25	30
Central	nd	nd	nd	nd	nd	nd	nd
South	nd	nd	nd	14	41	0	18
Palm Island	nd	nd	nd	nd	nd	nd	nd

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100.

Offshore marine

Water quality

Table 142 Results for water quality indicators and water quality index for the offshore marine environment 2018-19.

Chlorophyll-*a*	Water clarity (TSS)	Water quality
100	98.2	99.1

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100.

Table 143 Results for water quality indicators and water quality index for the offshore marine environment 2017-18.

Chlorophyll-*a*	Water clarity (TSS)	Water quality
99.9	98.1	99.0

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100.

Table 144 Results for water quality indicators and water quality index for the offshore marine environment 2016-17.

Chlorophyll-*a*	Water clarity (TSS)	Water quality
99.6	99.3	99.5

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100.

Table 145 Results for water quality indicators and water quality index for the offshore marine environment 2015-16.

Chlorophyll-*a*	Water clarity (TSS)	Water quality
99.7	99.1	99.4

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100.

Coral

Table 146 Results for coral indicators and coral index for the offshore marine environment 2020-21.

Juveniles	Coral Cover	Coral Change	Coral condition
65	32	52*	50

Standardised scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 – 100. *indicates scores are not directly comparable to previous years. The Coral Change indicator is only estimated during years free from acute disturbances, such as cyclones, marine heat waves and outbreaks of crown-of-thorns starfish. Internal revision of disturbance categorisation at AIMS has led to more disturbances being categorised and this resulted in increased scores for the coral change indicator.

Table 147 Results for coral indicators and coral index for the offshore marine environment 2019-20.

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

Table 148 Results for coral indicators and coral index for the offshore marine environment 2018-19.

Juveniles	Coral Cover	Coral Change	Coral condition
68	26	51	48

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

Table 149 Results for coral indicators and coral index for the offshore marine environment 2017-18.

Juveniles	Coral Cover	Coral Change	Coral condition
71	28	53	51

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

Table 150 Results for coral indicators and coral index for the offshore marine environment 2016-17.

Juveniles	Coral Cover	Coral Change	Coral condition
95	51	56	67

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

Table 151 Results for coral indicators and coral index for the offshore marine environment 2015-16.

Juveniles	Coral Cover	Coral Change	Coral condition
96	60	54	70

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

Appendix G. Coral reef site indicator and index scores

Table 152 Inshore coral indicator and index scores (2021-22) for each site.

Zone	Reef	Depth	Comp-osition	Cover	Change	Juve-nile	Macro-algae	Coral condition
North	Snapper North	2	0.00	0.40	0.74	0.07	0.00	0.24
	Snapper North	5	0.00	0.56	0.76	0.32	1.00	0.53
	Snapper South	2	0.00	0.65	0.74	0.44	0.88	0.54
	Snapper South	5	1.00	0.90	0.67	0.05	0.00	0.52
	Low Isles	5	0.50	0.74	0.57	1.00	0.86	0.73
	Green	5	nd	nd	nd	nd	nd	nd
Central	Fitzroy East	2	0.50	0.49	0.30	0.22	1.00	0.50
	Fitzroy East	5	0.00	0.72	0.76	0.49	0.93	0.58
	Fitzroy West	2	1.00	1.00	1.00	0.53	0.24	0.75
	Fitzroy West	5	0.50	0.85	1.00	0.57	0.76	0.74
	Fitzroy West LTMP	5	0.00	0.67	0.82	0.77	1.00	0.65
	Franklands East	2	1.00	0.87	0.46	0.33	0.87	0.71
	Franklands East	5	1.00	0.44	0.46	0.38	0.64	0.58
	Franklands West	2	0.50	0.89	0.71	0.29	0.00	0.48
	Franklands West	5	1.00	0.90	0.71	0.28	0.00	0.58
	High East	2	1.00	0.72	0.39	0.20	0.00	0.46
	High East	5	0.50	0.68	0.68	0.27	0.59	0.54
	High West	2	0.50	0.82	0.35	0.30	0.70	0.53
	High West	5	0.00	0.43	0.64	0.26	1.00	0.47
South	Barnards	2	1.00	0.78	0.75	0.40	0.99	0.78
	Barnards	5	1.00	0.73	0.45	0.72	0.93	0.77
	Bedarra	2	1.00	0.22	0.40	0.59	0.00	0.44
	Bedarra	5	0.50	0.36	0.77	1.00	0.74	0.67
	Dunk North	2	0.50	0.67	0.66	0.75	0.00	0.52
	Dunk North	5	0.50	0.52	0.61	1.00	0.46	0.62
	Dunk South	2	1.00	0.48	0.71	0.32	0.11	0.52
	Dunk South	5	0.50	0.57	0.74	0.59	0.00	0.48
Palm Island	Havannah	2	0.00	0.43	0.37	0.21	0.00	0.20
	Havannah	5	1.00	0.56	0.66	0.26	0.00	0.50
	Havannah North	5	1.00	0.17	0.50	0.88	0.00	0.51
	Lady Elliot	2	1.00	0.35	0.22	0.14	0.00	0.34
	Lady Elliot	5	0.50	0.59	0.54	0.54	0.41	0.52
	Palms East	2	1.00	0.58	0.38	0.13	1.00	0.62
	Palms East	5	1.00	0.70	0.53	0.25	0.86	0.67
	Palms West	2	0.00	0.51	0.95	0.40	1.00	0.57
	Palms West	5	0.00	0.43	0.25	0.45	1.00	0.43
	Pandora	2	0.50	0.23	0.40	0.16	0.00	0.26
	Pandora	5	1.00	0.33	0.63	0.43	0.31	0.54
	Pandora North	5	0.00	0.74	0.26	0.53	0.00	0.31

Note that scores are multiplied by 100 to fit the standardised report card scoring range. nd indicates no data available.

Table 153 Offshore coral indicator and index scores (2021-22) for each site.

Reef	Coral change	Coral cover	Juveniles	Coral condition
Agincourt Reef No.1	0.47	0.47	1.00	0.65
Farquharson Reef	0.21	0.14	0.66	0.34
Feather Reef	0.52	0.55	1.00	0.69
Hastings Reef	0.49	0.26	0.98	0.57
Mackay Reef	0.55	0.32	0.70	0.52
Peart Reef	0.66	0.42	1.00	0.69
St. Crispin Reef	0.63	0.63	1.00	0.76
Taylor Reef	0.68	0.21	0.87	0.59
Thetford Reef	0.48	0.51	1.00	0.66

Note that the Long Term Monitoring Program underwent a sampling redesign for 2021-22 onwards. This reduced the number of sites from 15 to 8 whilst surveys will occur every year at all sites. Details of the redesign are provided in the methods technical report (WTW 2023).

Appendix H. Log of updated 2021-22

The table below lists section, page and caption number, and summary of updates for the 2021-22 results technical report to assist reviewers.

Section number and title	Page, paragraph, caption number	Summary of update
General		Index summary scores and grades for all years presented in separate tables before full score and grade tables for reporting year (basins, estuaries, inshore)
1. EXECUTIVE SUMMARY	p. iii to ix	2021-22 score summary and selected key messages.
3. Climatic influences in the region	p. 9 - 14	Text, figures, tables and key messages.
	Appendix A Figure 17 p.83	Long term rainfall figure.
4. Freshwater basins		
4.1.Water Quality	p. 16 - 21	Text, tables, figures and key messages.
	Appendix B p. 87 - 100	Detailed results: text, tables and figures (box plots) for reference
	Appendix B p. 101 - 104	Basin pesticide sites contributing chemicals, additional sites and land use: text and figures.
4.2.Habitat and Hydrology		
Invasive weeds	p. 29	Update on Amazon frogbit
Flow	p. 29 - 31	Results text, tables, figure and key messages.
	Appendix C p. 116 - 121	Detailed results: table for reference.
Habitat and hydrology index	p. 31	Text, scoring and grading tables.
4.4.Overall basin scores and grades	p.37	Text and table update.
5. ESTUARIES		
5.1.Water Quality	p.39 - 44	Text, tables, figures and key messaging.
	Appendix B p. 105 - 112	Detailed results: tables for reference.
5.2.Habitat and Hydrology		
Mangrove and saltmarsh extent	p. 45 - 49	All estuaries updated with 2019 Regional Ecosystem mapping release. Text and tables.
Shoreline mangrove habitat	p. 46 - 49	Text, tables. Survey updates.
Estuary riparian extent	p. 49 - 50	All estuaries updated with 2019 Regional Ecosystem mapping release. Text and tables.
Fish barriers	p. 50 - 54	Daintree, Dickson Inlet and Barron update, text and table.

Section number and title	Page, paragraph, caption number	Summary of update
Flow	p. 54 - 56	Results text, table and key messaging.
	Appendix C p. 116 - 121	Detailed results: tables for reference.
Seagrass	P. 56 - 58	Results text, table, key messaging and recommendations (messaging provided by Alex Carter).
Habitat and hydrology index	p. 58	Results text, and tables. Confidence update for mangrove habitat.
	p. 59	Effect of shoreline mangrove habitat indicator on index scores.
5.3.Overall estuary scores and grades	p.61	Text and table update.
6. INSHORE MARINE		Map revised with updated offshore coral sampling design sites.
6.1.Water Quality	p.63 - 66	Results text, table, and key messaging
	p. 114 - Appendix B 66	Effect of updated NO_x guideline values on scores..
	Appendix B p. 113	Detailed results: tables for reference.
6.2.Coral	p. 66 - 69	Results text, table and key messaging (messaging provided based on MMP report).
	Appendix G p. 156	Inshore coral site list with indicator and condition index scores
6.3.Seagrass	p.69 - 73	Results text, table, key messaging and recommendations (messaging provided by Alex Carter). Detailed results now presented in Seagrass results section (previously Appendix D.)
6.4.Overall inshore marine scores and grades	p. 73	Results text and table.
7 OFFSHORE MARINE		
7.1.Water Quality	p.74	No water quality reporting for 2020-21
7.2.Coral	p.74 - 77	Results text, tables and key messaging (messaging from LTMP monitoring results published online).
	Appendix G p. 157	Offshore coral site list with indicator and condition index scores
7.3.Overall offshore marine score and grade	p.77	Results text and table.
Appendix G. Index, indicator category and indicator scores and grade tables for 2015-16 to 2020-21.	p.137 - 155	Results tables from all previous years.