Wet Tropics
Report Card 2022

Waterway Environments: **Results**

REPORTING ON DATA **JULY 2020** TO **JUNE 2021**

MARCH 2022

Wet Tropics Waterways

wettropicswaterways.org.au

Wet Tropics Waterways

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.

This report may be cited as: Wet Tropics Waterways 2022. Wet Tropics Report Card 2022 (reporting on data 2020-21). Waterway Environments: Results. Wet Tropics Waterways and Terrain NRM, Innisfail.

Report was compiled in March 2022.

1. EXECUTIVE SUMMARY

The overall scores and grades across all waterway environments and reporting zones for 2020-21 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. Comparisons between years must take into account any differences in monitoring, methodology and addition of indicators. The inshore marine and offshore marine monitoring has remained more consistent than basin and estuary 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 water quality has been suspended as of 2020-21 due to decommissioning of the Marine Water Quality dashboard. This means that when reporting of offshore water quality is recontinued with the planned introduction of a new monitoring system for 2021-22, it will need to take into account methodological changes when comparing with previous results.

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. 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 2022) 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 2020-21 period annual rainfall totals for the Wet Tropics region were predominantly 200 to 800 mm above the long-term mean, with highest rainfall anomaly along the coast from Cairns to Ingham in the south of the region. Annual rainfall was in the average range in all basins except for the Herbert which had above average rainfall. Monthly rainfall totals were often average with some months moderately above or below average, across all basins. January was wetter than average for all basins with very much above average rainfall in the southern basins. Rainfall during April was higher than average in all basins with Russell-Mulgrave basins recording rainfall in the highest 1% of long-term records for April. Annual discharge of the major rivers for all basins was higher than the long-term mean in all basins except for the Barron which was below the long-term mean. The Herbert River had considerably higher discharge than the long-term mean and this corresponded with the higher than average annual rainfall for the Herbert Basin. Rainfall and river discharge conditions can differ considerably between reporting years and these conditions can have strong influences on indicators, in particular the water quality of basin, estuary and inshore environments.

During 2020-21 sea surface temperatures for the Wet Tropics inshore and offshore zones were slightly above long-term averages and were generally lower than 2019-20. Sea surface temperatures were more even across the zones than previous years and the risk of severe thermal stress and coral bleaching events was substantially lower than in 2016-17 and 2019-20.

Waterways

The index and overall scores and grades for the 2020-21 reporting period and the overall scores and grades from previous years are presented for each waterway environment in the Tables i – iv 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 G 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).

Table i. Basin index and overall results for 2020-21 and overall results for preceding years.

Basins	Water quality	Habitat and hydrology	Fish	20-21		19-20	18-19	17-18	16-17	15-16
Daintree	88	78	nd	83		85	82	81	81	81
Mossman	66	72	77	72		74	63	67	63	55
Barron	70	44	48	54		54	61	61	64	63
Mulgrave	73	67	84	74		73	68	71	64	64
Russell	75	69	92	79		75	75	75	70	68
Johnstone	75	64	72	70		71	67	67	68	68
Tully	71	63	90	75		72	61	64	64	61
Murray	49	58	80	63		61	57	59	55	54
Herbert	66	60	85	70		71	59	66	66	67

Basin key messages

- Overall basin condition was ‘good’ for most basins with 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, where the particularly high pesticide risk contributed to poorer condition. All other basins monitored for pesticides had low or very low 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 Murray during the late dry season. During high flow conditions the highest TSS concentrations occurred in the Barron during January and April, coinciding with above average rainfall.

- Dissolved inorganic nitrogen remained the poorest scoring indicator for nutrients and sediment. Poorest scores typically occurred during baseflow conditions and scores were lowest for Mossman.
- Filterable reactive phosphorus grades declined for the Daintree, Mossman, Mulgrave and Murray. Poorer scores typically occurred during high flow conditions.

Habitat and hydrology

- Flow assessment sites in all basins were graded either 'good' or 'very good' and the Mossman, Tully and Herbert improved in grade from 'good' to 'very good'.
- Scores for flow improved for all basins except for the Barron which declined.
- 2020-21 was the first year that maximum scores occurred for all the low flow measures at the Freshwater Creek site (Barron Basin).

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 ii. Estuary index and overall results for 2020-21 and overall results for preceding years.

Estuary	Water quality	Habitat and hydrology	20-21	19-20	18-19	17-18	16-17	15-16	14-15
Daintree	88	59	73	76	70	72	70	70	nd
Dickson Inlet	82	72	77	77	79	77	69	74	nd
Barron	70	54	62	57	53	54	55	46	62
Trinity Inlet	73	54	64	63	56	57	64	66	59
Russell-Mulgrave	79	67	73	75	68	70	72	72	75
Johnstone	77	63	70	69	65	65	65	57	nd
Moresby	76	56	66	70	66	65	67	66	53
Hinchinbrook Channel	79	65	72	78	74	77	81	78	nd

Estuary key messages

- Overall condition for all estuaries was 'good' with the Barron improving from 'moderate'.

Water quality

- Water quality was the highest scoring index for all estuaries.
- Estuaries with pesticide monitoring (Daintree, Russell-Mulgrave and Johnstone) were at low or very low risk from pesticide toxicity.
- Chlorophyll a improved substantially in the Barron Estuary and for the first time was graded 'good' with all previous years ranging between 'very poor' and 'moderate'.
- Dissolved oxygen was graded 'good' or 'very good' for all estuaries except Trinity Inlet.
- The dissolved oxygen score and grade for Trinity Inlet improved from 'very poor' to 'poor', but it has been the poorest scoring estuary for dissolved oxygen over the last five years, and distinct from the better grades of the other estuaries.

- Turbidity was graded ‘very good’ for all estuaries with grades improving from ‘good’ in the previous year for Daintree, Barron, Trinity Inlet, Moresby and Hinchinbrook Channel.

Habitat and hydrology

- The shoreline mangrove habitat indicator score was lowest for Trinity Inlet (61), which was graded 'good’ condition, and highest in the Daintree River (83) which was graded 'very good’ where there is minimal human impact.
- The 2020-21 update of the fish barrier indicator for the Hinchinbrook Channel estuary added 15 verified fish barriers to the 18 fish barriers verified in the 2015-16 assessment, and the grade declined from ‘good’ to ‘moderate’.
- For flow, the Barron estuary was graded ‘good’ and the Russell-Mulgrave and Johnstone estuaries were graded ‘very good’, indicating flows to the estuaries were not substantially altered from reference condition.
- Estuary seagrass condition declined since 2019-20. For Trinity Inlet, seagrass meadows remained in moderate condition, but the overall zone score decreased. In the Moresby estuary the condition grade declined from ‘poor’ to ‘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 iii. Inshore marine index and overall results for 2020-21 and overall results for preceding years.

Inshore zone	Water Quality	Coral	Sea-grass	Fish	20-21	19-20	18-19	17-18	16-17	15-16
North	72	44	57	nd	57	60	60	54	48	52
Central	60	63	nd	nd	61	67	59	57	57	62
South	52	61	40	nd	51	56	47	41	37	44
Palm Island	62	49	nd	nd	55	59	56	51	57	59

Inshore marine key messages

- Overall inshore zone grades were unchanged from the previous year although scores in all zones declined since 2019-20.

Water quality

- Water quality index declined in all zones from the previous year with the most substantial declines in the North and South zones.
- Water clarity declined in all four zones following improvements and high scores in 2019-20.
- Nutrients had the poorest water quality scores in all zones with grades of ‘poor’ for the Central and South zones, and ‘moderate’ in the North and Palm Island zones.

- 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.
- Pesticide monitoring in all inshore zones was suspended as from 2020-21 and so do not contribute to the reported water quality scores for 2020-21.

Coral

- Coral condition in the North zone remained 'moderate'. Continuing limitations on condition include the low density of juvenile corals at Snapper Island, the very high cover of macroalgae at Snapper North, and low composition scores.
- Coral condition in the Central zone remained 'good' with a slight increase in score since 2019-20. Improvement in coral condition was due to higher rate of cover change, lower macroalgae cover and increased composition scores.
- Coral condition in the South zone declined slightly but the grade has remained good. Declines in coral condition were due to lower juvenile coral density, increased macroalgae cover and a reduced rate of cover change.
- Coral condition in the Palm Island zone remained 'moderate'. Limitations on coral condition included decline of juvenile density and composition, and increased macroalgae cover at some sites.
- Crown-of-thorns starfish were observed at some sites in the Central zone, however the numbers were notably lower than for 2019-20.

Seagrass

- In the North zone seagrass condition remained 'moderate' with some improvement in condition. Improved condition occurred at Cairns Harbour and Green Island, whilst condition at the Low Isles remained very poor for the third year.
- In the South zone seagrass condition was poor but with some improvement driven by an increase in seagrass cover at Missionary Bay to 100%. Seagrass condition remained very poor at Lugger Bay and Dunk Island.

Offshore

The assessment of offshore is based on water quality (not available for 2020-21) which up to 2019-20 comprised of total suspended solids and chlorophyll *a*; and coral, comprising of juvenile density, change in coral cover, and coral cover.

Table iv. Offshore marine index and overall results for 2020-21 and overall results for preceding years.

Water quality Score	Coral Score	20-21		19-20	18-19	17-18	16-17	15-16
nd	50	Insufficient data		70	73	75	83	84

Offshore marine key messages

- For 2020-21 there was no water quality monitoring program in place to allow reporting of offshore water quality.

Water quality

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

Coral

- The Wet Tropics offshore zone experienced a low disturbance year for 2020-21, there were minimal impacts from tropical cyclones, heat stress and crown-of-thorns starfish.
- Coral condition improved after declining to its poorest condition in 2019-20 compared to previous years.
- Coral cover remained the lowest scoring indicator with an overall grade of 'poor', although the score increased marginally from 29 to 32.
- The coral change indicator had the most substantial increase, improving from 'poor' to 'moderate' with seven reefs improving in grade.
- There were no crown-of-thorns starfish detected on the surveyed reefs.
- Bleaching of hard corals in 2020 only occurred at low levels across the survey sites, and was restricted to scattered individual colonies.
- Recovery from recent bleaching events in 2016, 2017 and 2020 was apparent with strong coral growth occurring at some sites.

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 v. 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.

TABLE OF CONTENTS

FIGURES

TABLES

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) Policy 2009, 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) Policy 2009.
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 2022' reporting on the 2020-21 year (1 July 2020 to 30 June 2021) 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 2019-20 are presented alongside the 2020-21 scores in each waterway environment section. The complete scores for each waterway environment are presented in full at the relevant section for 2020-21 and in Appendix G 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 2020-21 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 2022).

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.

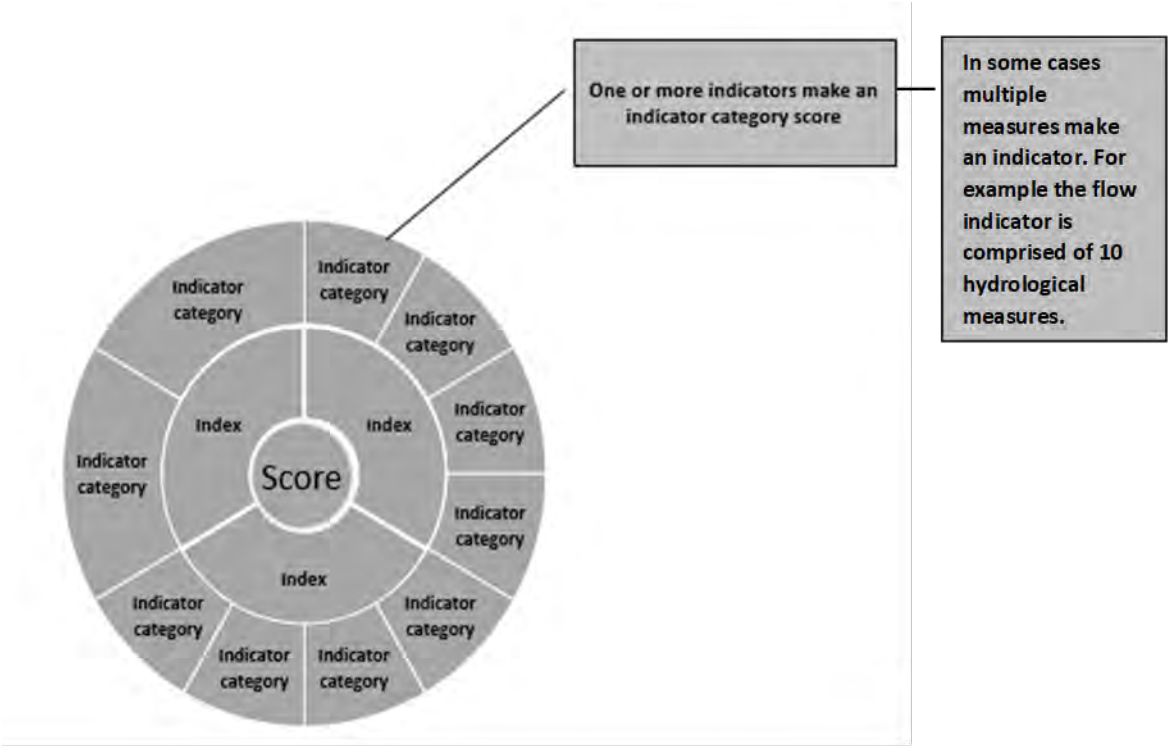


Figure 1 Terminology used for defining the level of aggregation of indicators.

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) Policy 2009 Wet Tropics basins (DEHP 2014) 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 2022).

3. CLIMATIC INFLUENCES IN THE REGION

For the 2020-21 period annual rainfall totals for the Wet Tropics region were predominantly 200 to 800 mm above the long-term mean, with highest rainfall anomaly along the coast from Cairns to Ingham in the south of the region. Rainfall was lower than the long-term average north of Cairns with lowest rainfall anomaly, between -100 to -200 mm, in the Daintree Basin (Figure 2).

Figure 2 Rainfall anomaly of total annual rainfall (2020-21) from long-term mean annual rainfall for the Wet Tropics region (Data source: Bureau of Meteorology).

Note: Map was sourced from the Bureau of Meteorology recent and historical rainfall maps (http://www.bom.gov.au/climate/maps/rainfall/?variable=rainfall&map=totals&period=week&region=nat&year=2022&month=02&day=15).http://www.bom.gov.au/water/rwi/#sf_tt/001/2019). The long-term mean was based upon historical rainfall records available from BoM rainfall mapping product (1960 to 1990).

The annual rainfall percentile category was average (between the 30th and 70th percentiles) for all basins except for the Herbert which was above average (between the 70th to 90th percentiles (Table 2 and Figure 3).

In terms of historical rainfall record and the five-year moving average, the annual totals for 2020-21 for all basins except the Daintree showed an increase from the preceding year, with wetter conditions across the region (Appendix A, Figure 16). The five-year moving average for the Daintree continued to decline and was equal to the long-term annual average, whilst the annual total increased but remained below the long-term average.

Table 2 Annual rainfall statistics for basin areas of the Wet Tropics for 2020-21.

	Total (mm)	Long-term mean (mm)	Percentile of long-term mean	Anomaly (mm +/- long-term mean)	Percentage of long-term mean
Daintree	2159	2364	30 to <70	-205	91%
Mossman	2053	1987	30 to <70	66	103%
Barron	1611	1489	30 to <70	122	108%
Russell-Mulgrave	3372	3035	30 to <70	337	111%
Johnstone	3300	3119	30 to <70	181	106%
Tully-Murray	2955	2762	30 to <70	193	107%
Herbert	1598	1312	70 to <90	286	122%

Note: decile ranking category descriptions are presented in the Figure 3 legend. Data was sourced from the Bureau of Meteorology Australian Water Outlook using historical data for 1911-2017.

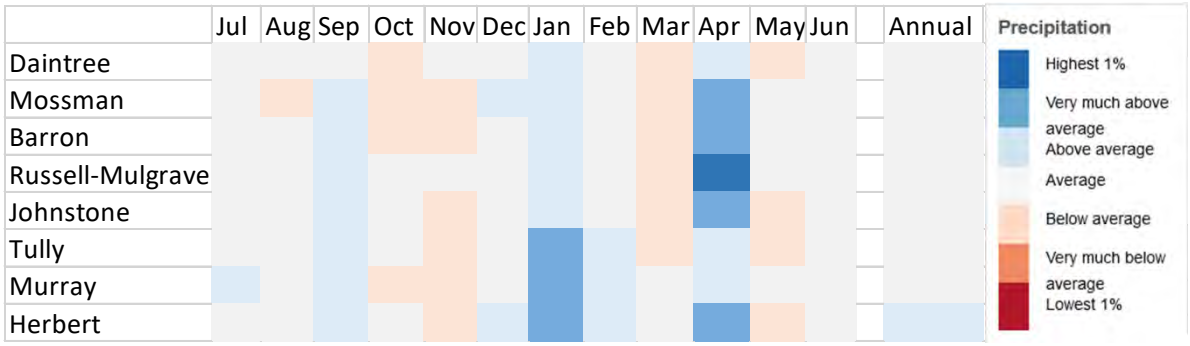


Figure 3 Monthly rainfall percentiles and annual mean percentiles for basin areas of the Wet Tropics (2020-21).
Data source: Bureau of Meteorology Australian Water Outlook using historical data for 1911-2017.

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. January was wetter than average for all basins with very much above average rainfall in the southern three basins (90th to <99th percentile). The rainfall during April was notable and was higher than average in all basins. The Russell-Mulgrave basins recoded rainfall in the highest 1% of long-term data for April. The rainfall events were produced from a coastal trough and low pressure system off the north tropical Queensland coast and rainfall was heaviest between Cairns and Innisfail, with widespread totals of 150 mm to 220 mm in the 24 hours to 9 am on the 5th April (BoM 2021).

Annual discharge of the major rivers for all basins was higher than the long-term mean in all basins except for the Barron which was less than average (Figure 4). The Herbert River had considerably higher discharge than the long-term mean and this corresponded with the higher than average annual rainfall for the Herbert Basin. All other rivers had annual discharge closer to the long-term mean, corresponding with the average annual rainfall conditions for their basins.

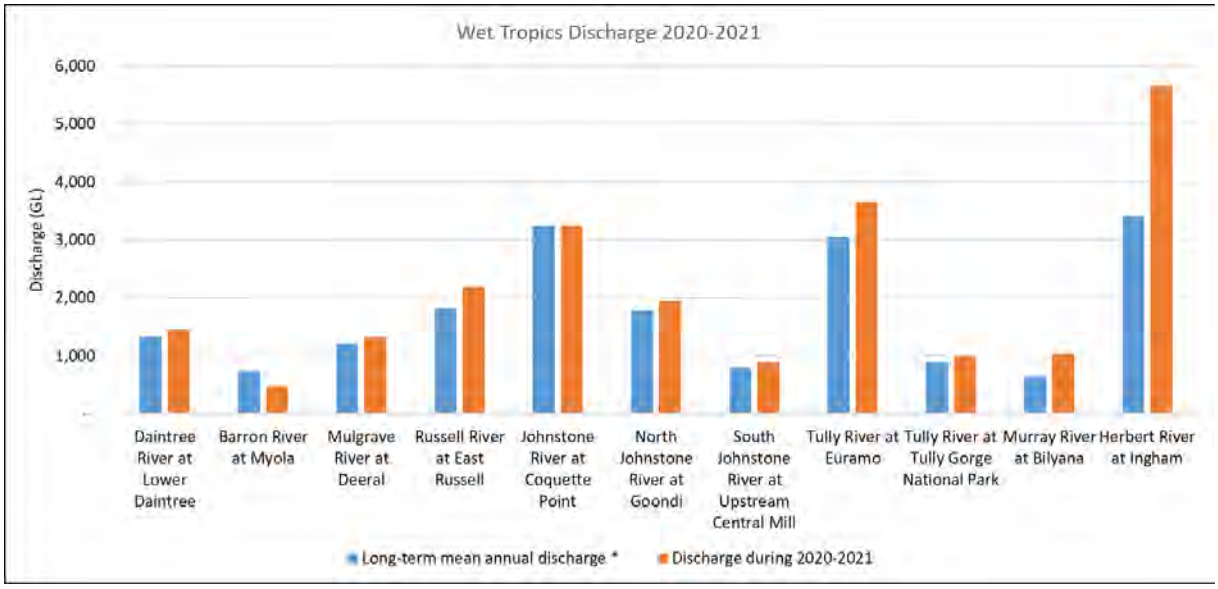


Figure 4 Long-term mean annual discharge and discharge during 2020 – 2021 recorded from gauging stations at the most downstream locations of the major river channel for freshwater basins.
*Long-term mean annual discharge is based on historical gauging station records until present from the Department 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 2020-21 sea surface temperatures for the Wet Tropics inshore and offshore zones were slightly above long-term average summer maximums but well below those observed in 2019-20 (Figure 5). Sea surface temperature anomalies were more even across the zones than previous years and the risk of severe thermal stress and coral bleaching events was lower than in 2016-17 and 2019-20.

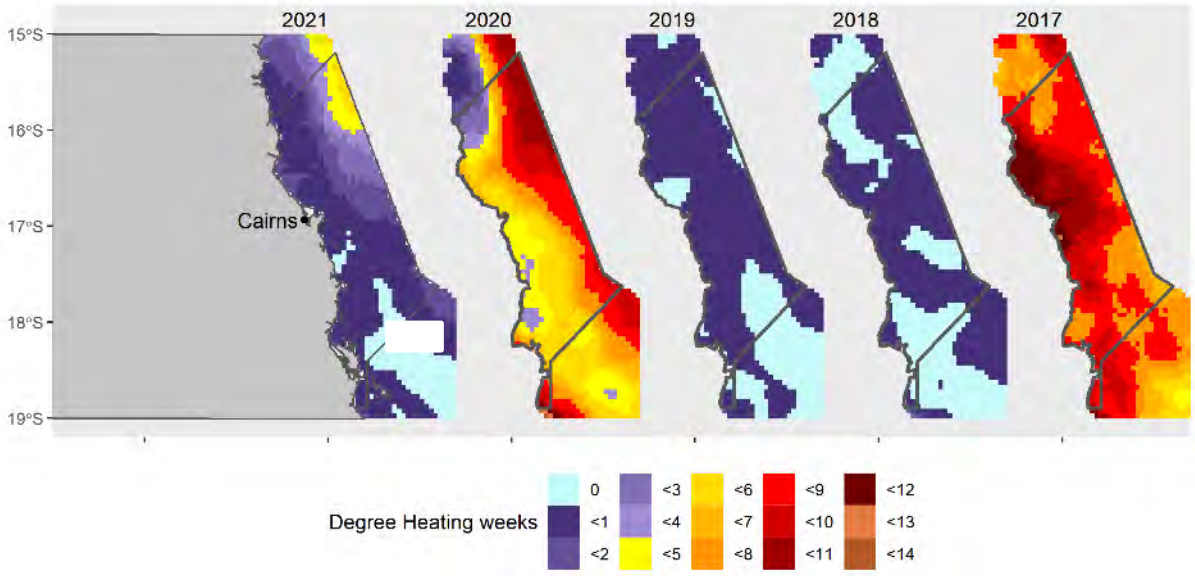


Figure 5 Annual degree heating week estimates from 2016-17 to 2020-21 for the Wet Tropics inshore and offshore marine environments. Data are the annual maximum degree heating week estimates for each ~25 km^2 pixel. Data were sourced from NOAA coral reef watch.

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 totals for the Wet Tropics region were predominantly above the long-term mean, particularly along the coast from Cairns to Ingham in the south of the region. Rainfall was lower than the long-term average north of Cairns.
- Conditions were considerably wetter across the region compared to the previous year.
- During the months associated with the wet season (December to March), January was the wettest month compared to the monthly average across all basins.
- A coastal trough and low pressure system off the north tropical Queensland coast during April produced higher than average rainfall across most of the region and rainfall was particularly heavy in the Russell-Mulgrave basin area.
- Annual discharge of the major rivers was higher than the long-term mean in all basins except for the Barron.
- The Herbert River had considerably higher discharge than the long-term mean corresponding with the higher than average annual rainfall for the Herbert Basin.
- Sea surface temperatures for inshore and offshore environments were slightly above long-term averages and the risk of severe thermal stress and coral bleaching events was lower than previous years.

2021-22 sea surface heat stress events

Since the end of the 2020-21 reporting cycle high temperatures during the summer of 2021-22 have resulted in heat stress events recorded across the Great Barrier Reef. The high sea surface temperatures represent a risk to coral reefs from bleaching events. Full extent of impacts on coral will only be known after the next round of long-term monitoring surveys by AIMS. The results of which will be presented in the 2021-22 technical report for the Wet Tropics region.

The following information was sourced from the GBRMPA Reef Health updates (https://www.gbrmpa.gov.au/the-reef/reef-health).

During March 2022, sea surface temperatures in parts of the Far North and inshore areas between Townsville and Rockhampton varied between 2–4°C above average. Most of the GBR Marine Park accumulated significant heat stress over the summer, with the central Reef experiencing the highest heat stress accumulation. Sea surface temperatures were between 0.5–2°C above average for mid-April 2022 throughout most of the Marine Park; and these temperatures were cooler than those experienced on the Reef than the previous summer months.

Aerial surveys across a representative sample of 750 reefs on the Great Barrier Reef were completed in late March 2022. Observed bleaching was largely consistent with the spatial distribution of the heat stress experienced. Coral bleaching was observed at multiple reefs in all four management areas (the Far Northern, Cairns–Cooktown, Townsville–Whitsunday and Mackay–Capricorn), confirming a mass bleaching event in early 2022, the fourth since 2016 and despite La Niña conditions.

It is important to note that bleached coral is stressed but still alive. If conditions moderate, bleached corals can recover from this stress, as was the case in 2020 when there was very low coral mortality associated with a mass bleaching event.

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.

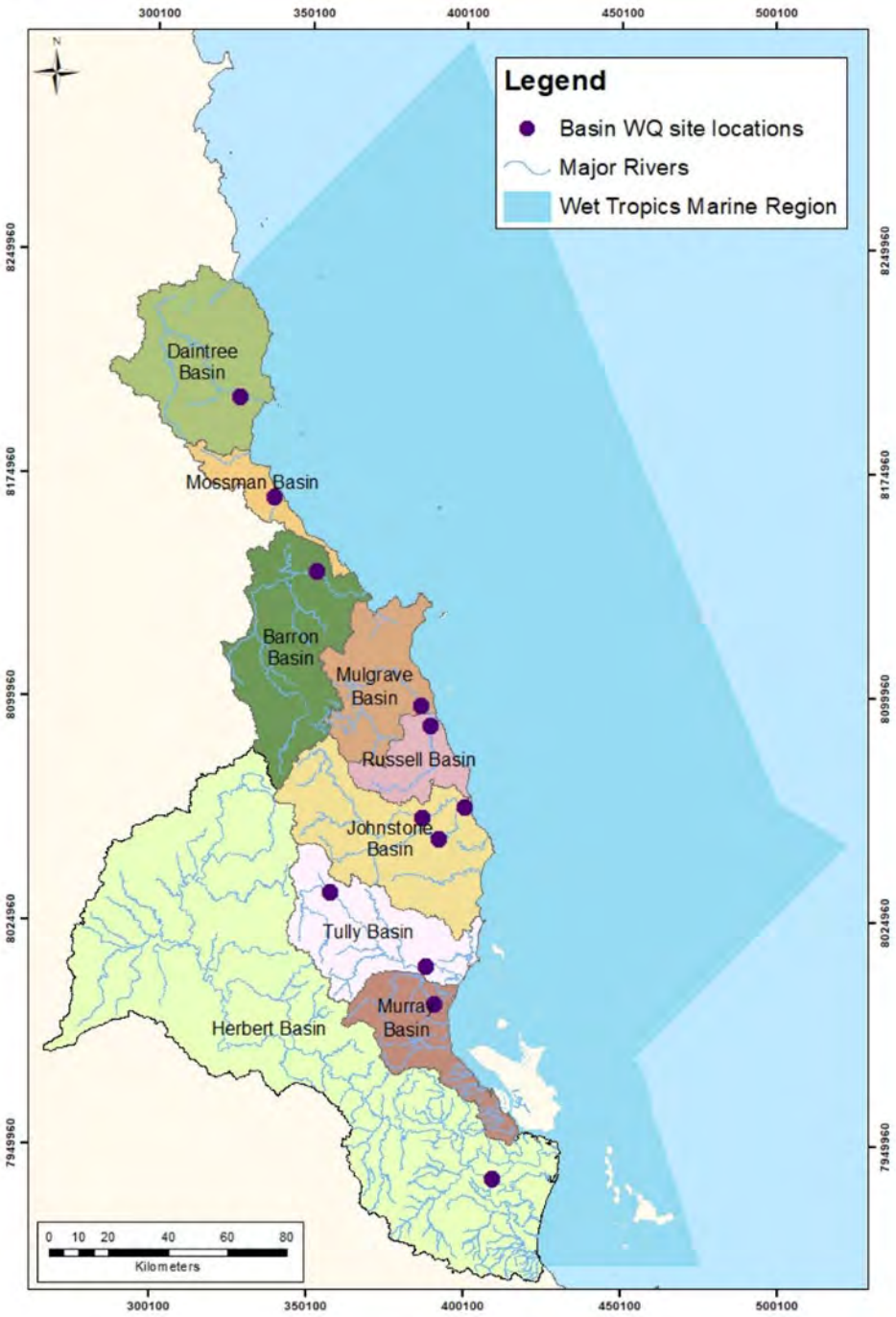


Figure 6 Freshwater basin water quality (WQ) monitoring site locations and basin reporting zones. The site in the upper Tully Basin is used as a GBR CLMP reference site and is not used for the Report Card condition assessment. The most downstream site in the Johnstone Basin is located in the estuary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

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.

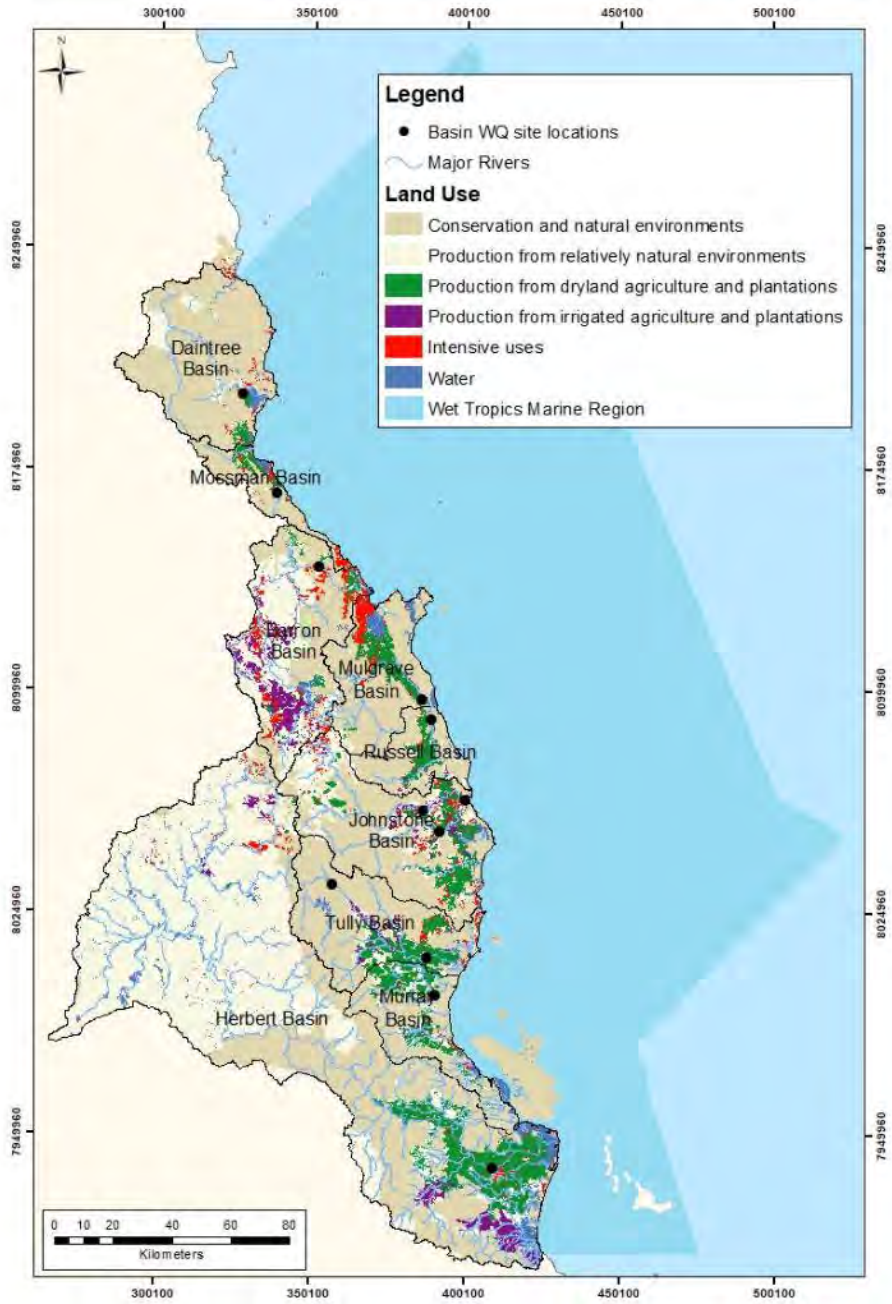


Figure 7 Location of freshwater basin water quality (WQ) monitoring site locations and primary land use in the Wet Tropics region. Source: Queensland Land use Mapping Program Wet Tropics NRM region 2015 land use data set. http://qldspatial.information.qld.gov.au/

4.1. Water Quality

The methods for scoring water quality are described in the methods technical report (WTW 2022).

Pesticides

The pesticide risk metric (PRM) values (expressed as percentage of species protected) for 2020-21 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 score is presented in Table 3 and the proportion of the three pesticide categories that contribute to the pesticide risk metric is presented in Figure 9. Comparisons of the relative contribution of pesticide chemicals at basin site results for 2020-21 and previous years are presented in Figure 10. The standardised scores for pesticides are presented in Table 4 and in Table 96 to Table 100 for the previous years (2019-20, 2018-19, 2017-18, 2016-17 and 2015-16). 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 or Mossman basins. 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 3 The percentage of species protected for basins using the pesticide risk metric, based upon 22 pesticides for the 2020-21 reporting period.

	Pesticide risk metric (% species protected)
Basin	**2020-21**
Daintree	>99
Mossman	nd
Barron	nd
Mulgrave	97.9
Russell	97.9
North Johnstone	98.5
Johnstone (Coquette Point)	97.8
Tully	95.1
Murray	81.0
Herbert	95.2

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). Note: the North Johnstone is a sub-basin of the Johnstone Basin and the Coquette Point site is used for scoring the Johnstone Basin. nd indicates no data or insufficient data available.

Additional information is provided in Appendix F 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.

Pesticide grades for 2020-21 (Table 4) were unchanged from the previous year (2019-20, Table 96) except for North Johnstone, which declined from 'very good' (very low risk) to 'good' (low risk),

although it remained the site with the second highest percentage of species protected, behind the Daintree. The 'poor' grade (high risk) for the Murray was distinct from all other reported basins, which were graded either 'good' or 'very good'.

The poor condition at the Murray site may relate to its location on the small catchment of the Murray River which has a relatively low discharge (Figure 4) and a high proportion of upstream area under agricultural land use (Figure 8). 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 capacity to dilute pesticide inputs.

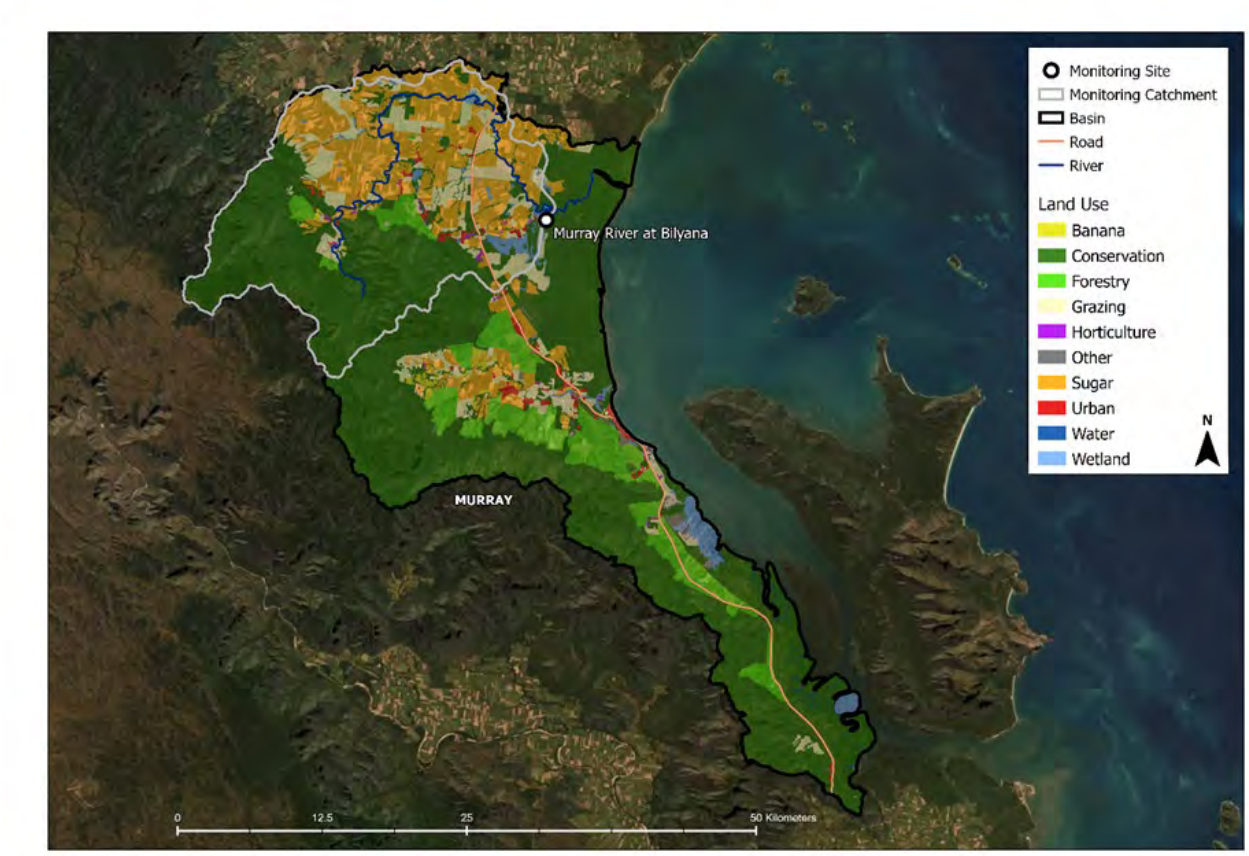


Figure 8 Land use of the Murray Basin and catchment area of the Murray River upstream of the monitoring site at Bilyana.

The proportional contribution of pesticide categories for all sites was highest for 'PSII herbicides' except for North Johnstone and Herbert for which 'Insecticides' was highest (Figure 9). Since 2019-20 the proportion of 'PSII herbicides' increased at the Russell site, and the proportion of 'Insecticides' increased at the Murray and Herbert sites, with proportions at the other sites remaining similar to 2019-20.

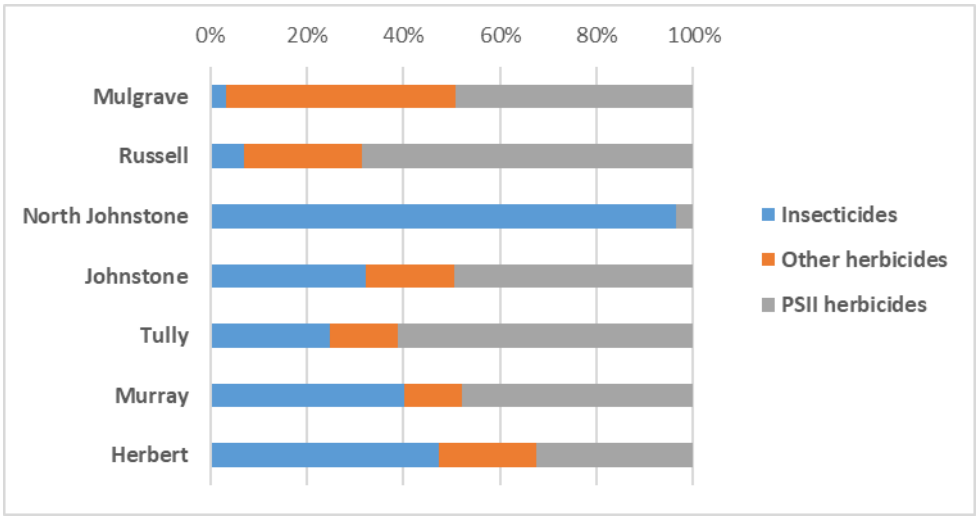


Figure 9 Percentage of pesticide categories contributing to the pesticide risk metric measure of percent species affected for basins.

Note: Daintree was excluded due to the very low concentrations recorded. The North Johnstone is a sub-basin of the Johnstone Basin and the Coquette Point site is used for scoring the Johnstone Basin.

The similarity of pesticide scores with the previous year occurred despite considerable differences in river discharge between the wetter conditions of 2020-21 and the drier conditions of 2019-20, for example the Herbert River annual total discharge for 2020-21 (approximately 5,600 GL) was three times higher than for 2019-20 (approximately 1500 GL). The Pesticide Risk Metric provides an estimate of end of system pesticide risk that is somewhat unaffected by annual rainfall variability. In the drier years, infrequent runoff events will result in high concentrations for relatively short periods of time in the waterway that affect a large proportion of species. On the other hand, in wetter years, extensive runoff over multiple events, will result in lower concentrations over longer timeframes in the waterway. Under both these exposure scenarios, the average risk is similar.

The North Johnstone pesticide monitoring site is likely to be influenced by the surrounding agricultural land which is dominated by banana plantations that extend some 25 km upstream. Banana production typically has very low rates of herbicide application and contrasts with cane production which often involves herbicide application. The contribution to pesticide risk at the North Johnstone site was predominantly from insecticides (mainly imidacloprid) with negligible contribution from herbicides (Figure 9). The contribution of imidacloprid to pesticide risk was similar to the Tully site, which has surrounding land use dominated by sugarcane production, but pesticide risk at the Tully site also had substantial contribution from herbicides, particularly diuron, which were absent at the North Johnstone site (Figure 10).

The relative contribution of imidacloprid to pesticide risk showed a decline in 2019-20 with detections of lower imidacloprid concentrations across waterways of the Wet Tropics (WTW 2021). The results for 2020-21 and all available previous years (Figure 10) show that the decline in contribution of imidacloprid to pesticide risk continued at the Russell and Mulgrave monitoring sites. However, the contribution of imidacloprid to pesticide risk at the Johnstone (both North Johnstone and Coquette Point), Tully, Murray and Herbert monitoring sites for 2020-21 increased above that reported for 2019-20 (Figure 10).

Management practices reported for 2020-21 from sugarcane industry support services for the Tully and Herbert basins include activities that may explain increases in imidacloprid contribution and the sustained herbicide contribution (particularly diuron) to pesticide risk and include the following.

Imidacloprid:

- general increase in grub pressure in grub prone areas;
- farm management and lease changes disrupting application cycles;
- putting more fallow area into production in response to the sugar price;
- conversion of cattle country to cane production.

Diuron:

- a switch back to diuron based herbicides following poor efficacy when using alternatives;
- use as an enhancement product at a low rate to improve the effectiveness of other products;
- above average rainfall early in the season (September) which increased weed pressure;
- follow up applications close to the wet season.

Continued pesticide monitoring is required to determine the effectiveness of changes in management practices and improved stewardship to reduce pesticides in major rivers over the next few years. Management practices and stewardship improvements related to imidacloprid use were discussed in the 2019-20 results technical report (WTW 2021).

Key messages: pesticides

- The Murray had 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 had the lowest concentrations of pesticides, and therefore, the lowest toxicity risk.
- The proportional contribution of insecticides increased in the Murray and Herbert since the previous year.
- The pesticide risk metric scores were similar to the previous years for most sites despite considerably higher rainfall and river discharge during the wet season of 2021-22 compared to 2019-20.
- Decline in contribution of imidacloprid to pesticide risk continued for the Russell and Mulgrave.
- Contribution of imidacloprid to pesticide risk increased for the Johnstone (both North Johnstone and Coquette Point), Tully, Murray and Herbert relative to 2019-20 but were lower or similar to levels in previous years.

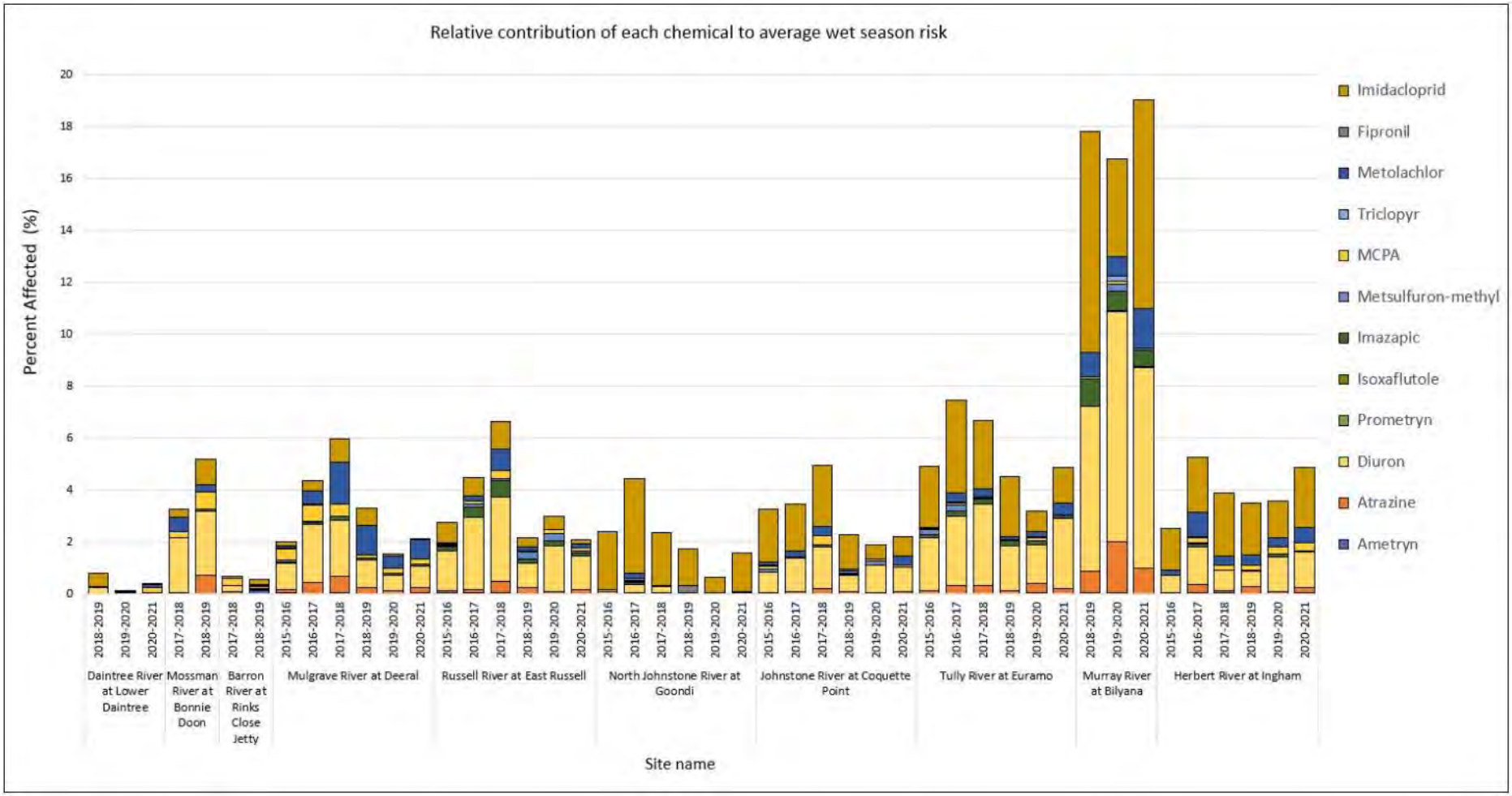


Figure 10 The relative contribution of pesticide types at basin sites for all available reporting years. Of the full suite of 22 pesticides only those that contributed >0.1% of the toxicity are shown (the remainder had negligible contribution to toxicity).

Sediment and nutrients

The scores and grades for water quality indicators, indicator categories and water quality index for 2020-21 and the water quality index for the five preceding reporting years are presented in Table 4. The complete water quality scores for 2019-20 back to 2015-16 are presented in Appendix G Table 96 to Table 100. 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 54 to Table 63). 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 17 to Figure 19). Note that water quality sampling for the Mossman Basin was limited to lower flow conditions only, whilst for the Daintree Basin site water quality monitoring for base-flow periods began in 2019-20, which added to the existing monitoring for high flow periods. Further information is available in the methods technical report (WTW 2022).

Table 4 Basin water quality index, indicator category and indicator scores and grades for the 2020-21 reporting period and water quality index results for preceding years.

Basin	Sediment	Nutrients			Pesticides	Water quality 20-21		Water quality				
	TSS	DIN	FRP	**Nutrients**				**19-20**	**18-19**	**17-18**	**16-17**	**15-16**
Daintree	90	90	73	81	93	88		91	84	82	nd	nd
Mossman ~	90	34	51	43	nd	66		78	69	71	nd	nd
Barron	63	81	72	76	nd	70		69	74	78	81	82
Mulgrave	90	39	69	54	75	73		69	66	66	63	62
Russell	80	61	76	68	75	75		67	75	68	70	73
Johnstone	90	69	53	61	75	75		78	75	69	72	79
Tully	90	48	77	62	61	71		71	68	63	66	65
Murray	71	49	60	55	23	49		49	59	nd	nd	nd
Herbert	78	43	73	58	61	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. *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).

Overall water quality indicator grades in 2020-21 were the same as the previous year for all basins (Table 4). The Daintree had the highest score (88) and graded ‘very good’, the Murray had the lowest score (49) and graded ‘moderate’ whilst all other basins were graded ‘good’. 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, with the Daintree having the highest proportion of natural land use (Figure 7) and the highest score and the Murray having the lowest proportion of natural land use (Figure 8) and the lowest score.

Key messages: sediment

- The Mulgrave improved from ‘good’ to ‘very good’ whilst the Herbert declined from ‘very good’ to ‘good’ since the previous. All other basin grades were unchanged.

- During baseflow conditions the highest TSS concentrations occurred in the Murray during the late dry season (October and November).
- During high flow conditions the highest TSS concentrations occurred in the Barron during January and April, coinciding with rainfall very much above average for both months. In contrast, the Russel and Mulgrave basins had considerably lower TSS concentrations than the Barron during high flow conditions even during April when monthly rainfall was in the highest 1%.

Key messages: nutrients

- DIN remained the poorest scoring water quality indicator for nutrients and sediment.
- DIN grades declined from 'moderate' to 'poor' for the Mossman basin, and improved from 'moderate' to 'good' for the Russell and 'poor' to 'moderate' for the Murray. Poorest scores occurred during baseflow conditions and scores were lowest for Mossman, with sites varying between 'moderate' to 'very poor', and for the Mulgrave and Herbert, where the majority of months during baseflow conditions had median DIN concentrations exceeding guideline values.
- FRP grades declined from 'good' to 'moderate' for the Mossman, Johnstone and Murray, and from 'very good' to 'good' for the Daintree, with all other basins remaining 'good'.
- 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 in 2019-20.

The water quality index is a proxy for condition 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 2020-21 freshwater basin water quality results are shown in Table 5. 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 5 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 Mossman and the Barron. Pesticide monitoring in the Mossman and Barron basins ceased after the 2018-19 reporting year.

4.2. Habitat and Hydrology

The habitat and hydrology index consists of instream habitat modification, flow, riparian extent, wetland extent and invasive weeds.

Habitat modification (instream)

The habitat modification indicators were not updated for 2020-21. 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 6. 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 6 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 7.

Table 7 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 2020-21.

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 8). Further information on the methods used for generating the habitat extent indicators are provided in the methods technical report (WTW 2022).

Table 8 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 scores and grades are shown in Table 9.

Table 9 Results for riparian vegetation extent indicator: percent loss from pre-clearing to 2013 for basins.

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 is generally every four years. However, the mapping data for 2017 is 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 mid-2021 and this will also require revision to the riparian extent indicator to align with the new data sets.

The wetland extent scores and grades (percent loss since pre-clearing), and the hectares lost since 2013, are shown in Table 10.

Table 10 Results for wetland extent indicator: percent wetland loss from pre-clearing to 2017 and hectares lost from 2013-2017 for basins.

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 be for percent loss to 2021.

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 2020-21. 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 11). 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 11 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 11). 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 12. 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 12 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.

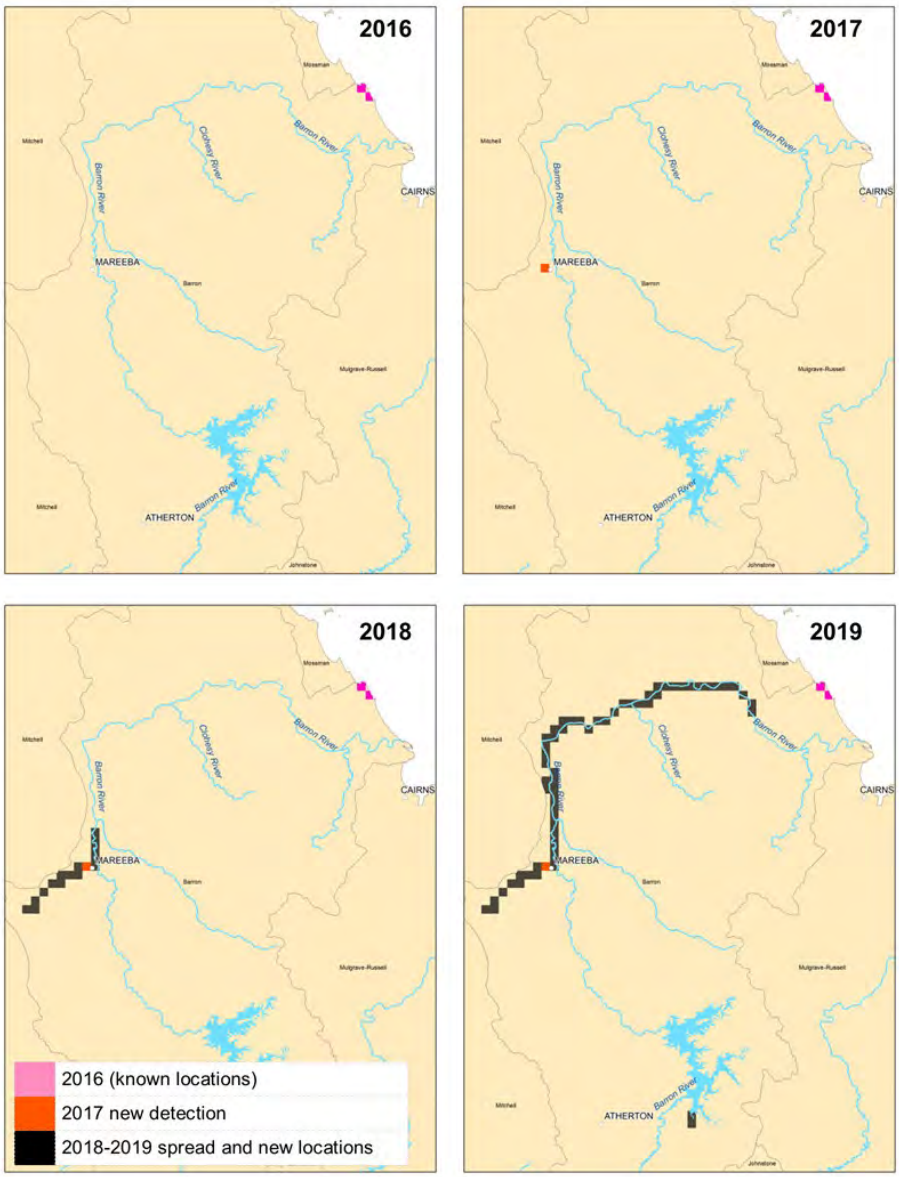


Figure 11 Distribution and spread of the invasive aquatic weed Amazon frogbit in the Barron Basin. (Source: Travis Sydes, FNQROC).

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.

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

- Potential spread to new locations in the Wet Tropics and to Mitchell catchment.
- Trading regulations to restrict sale and accessibility.
- Impacts on sites including Barron hydro station raised by CleanCo Queensland.
- Potential impacts on World Heritage values in the Barron catchment.
- Ecological and environmental impacts from the infestation.

Legislative tools to restrict sale and distribution

- Emergency declaration under local law initially in Tableland Regional Council and Mareeba Shire Council. Local declaration in train in Douglas Shire Council and Hinchinbrook Shire Council. Pending inclusion in Cairns Regional Council.
- Listing in local law in Cassowary Coast Regional Council (currently with State for interest checks).
- Petition (650+ signatories) has been raised to Qld Parliament requesting declaration (tabled 15/06/2021: https://www.parliament.qld.gov.au/Work-of-the-Assembly/Petitions/Petition-Details?id=3502) from SEQ.
- Inclusion consultation papers for aquatic weeds shortlist for declaration under the biosecurity act (Biosecurity Queensland).

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).
- 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 project developed by the FNQROC & NAMAC has been approved for inclusion in the Land Protection Fund Research Prospectus – the project will pilot an aquarium weed risk assessment process in the Wet Tropics.
- A pestfact has been developed by Biosecurity Queensland: https://www.daf.qld.gov.au/__data/assets/pdf_file/0011/1572419/Amazon-frogbit-Limnobium-laevigatum.pdf
- A field day to demonstrate the control of Amazon frogbit is planned post wet season 2022.
- 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 2020-21 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 was average for all basins except the Herbert which was above average (Table 2, Figure 3). Monthly rainfall (Figure 3) leading up to the wet season was around average with some monthly totals below or above average. Rainfall was above average for all basins in January with the southern basins (Tully, Murray and Herbert) very much above average. Rainfall during April was also above average for all basins with the Russell-Mulgrave rainfall in the highest 1% of historical data from

1911 to 2017.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. The rainfall type calculated by the flow indicator was 'average' for the Barron, Russell, Johnstone and Tully, and 'wet' for the Mossman, Mulgrave, Murray and Herbert (Table 13). 2020-21 was wetter than the previous year when most basins had a 'dry' rainfall type. Scores were higher than the previous year for all basins except for the Barron which declined from 80 to 69, with Mossman, Tully and Herbert improving in grade from 'good' to 'very good' (Table 13). Note that some differences can occur between rainfall classification produced by the flow indicator tool and BoM climate reporting (Table 2). This is due to differences between basin boundaries (BoM merges the Tully and Murray, and the Russell and Mulgrave basins), spatial coverage and the analysis applied to assess rainfall.

Table 13 Rainfall type and number of flow assessment sites for 2020-21, and standardised flow indicator basin scores and grades for the 2020-21 and previous years.

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

The flow assessments sites in all basins were all graded either 'good' or 'very good' (Appendix C Table 79) 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 79), 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 lowest score for assessment sites was 61 and this score occurred for sites in the Barron, Russell, Murray and Herbert basins.

The duration and frequency of cease to flow measures for the Herbert River at Glen Eagle (116004C), which scored a 1 in in 2019-20, scored a maximum of 5 for 2020-21 and the site score improved from 61 to 75. The poorer scores for measures of low flow periods at this site are a feature of drier years; for years with a 'wet' rainfall type, such as 2020-21 during which rainfall in the Herbert basin was above average (Table 2, Figure 3), the scores for measures of low flows have been consistently high.

For Freshwater Creek, all the low flow measures scored a maximum of five (Appendix C Table 79). For all years which can be assessed by the flow tool at this site (dating back to 2001), at least one low flow measure has scored a 1 out 5. This means that for 2020-21 the capacity of low flows at Freshwater Creek to support low flow spawning fish, critical hydraulic habitat and longitudinal connectivity was not substantially altered from predevelopment conditions. The poorer scores for high flow conditions during 2020-21, with measures of both duration and frequency of flow above the 90th percentile scoring a 1 out of 5 (Appendix C Table 79), was similar to previous years. The alteration of high flows from modelled pre-development conditions is likely to be a result of the impoundment and water extraction activity. A reduction of high flows can impact fisheries production (Stewart-Koster *et al.* 2018). 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 (Freshwater Creek gauging station).

Key messages: flow

- Annual rainfall was average for all basins except the Herbert which was above average, whilst rainfall type was 'average' for four basins and 'wet' for four basins.
- 2020-21 was wetter than the previous year when most basins had a 'dry' rainfall type.
- Flow assessment sites in all basins were graded either 'good' or 'very good'.
- Scores were higher than the previous year for all basins except for the Barron which declined from 80 to 69.
- The Mossman, Tully and Herbert improved in grade from 'good' to 'very good'.
- 2020-21 was the first year of assessment that maximum scores occurred for all the low flow measures at the Freshwater Creek site.

Habitat and hydrology index

The 2020-21 scores and grades for basin habitat and hydrology indicator categories and index, and the habitat and hydrology index for the previous reporting years are presented in Table 14. The habitat and hydrology indicator categories and index scores for basins from 2019-20 back to 2015-16 are presented in Appendix G Table 102 to Table 105.

The habitat and hydrology index is comprised of four longer-term indicator categories that are scheduled to be updated every four years: wetland extent, riparian extent (to be updated for 2021-22), 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 2020-21 were due to the annual update of the flow indicator, with all other indicators remaining unchanged.

Table 14 Results for habitat and hydrology indicator categories and index for2020-21 and habitat and hydrology index results for preceding years.

Basin	Flow	Invasive weeds	Habitat modifi-cation	Riparian extent	Wetland extent	2020 -21	2019 -20	2018 -19	2017 -18	2016 -17	2015 -16
Daintree	nd	54	100	99	60	**78**	**78**	**80**	**80**	**81**	**81**
Mossman	95	81	100	68	16	**72**	**68**	**56**	**63**	**63**	**55**
Barron	69	34	36	68	11	**44**	**46**	**47**	**45**	**47**	**43**
Mulgrave	80	43	100	78	33	**67**	**66**	**63**	**71**	**65**	**66**
Russell	91	41	100	79	33	**69**	**66**	**63**	**69**	**70**	**63**
Johnstone	96	24	98	74	25	**64**	**63**	**59**	**65**	**65**	**57**
Tully	100	71	57	72	17	**63**	**56**	**54**	**65**	**61**	**57**
Murray	78	19	100	75	19	**58**	**55**	**56**	**58**	**55**	**54**
Herbert	86	19	92	85	20	**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. 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 for the 2020-21 period are shown in Table 15. Confidence scores (1 – 3) for each criterion have been weighted according to the 2017 updated methods for assessing confidence (WTHWP 2017).

Table 15 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 2020-21.

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 16. 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 17. Further results of the fish assessment in Appendix E present the list of fish species caught in the Wet Tropics region (Table 85), the fish species caught at the sites within each basin (Table 86 to Table 93), the number of translocated and alien species caught within each basin (Table 94) and box plots showing the distribution of sites for each basins in relation to the POISE and PONI indicators (Figure 22).

Table 16 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 17 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 18). 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 18). 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 18 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 E Figure 22).

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 F 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 19. Confidence scores (1 – 3) for each criterion have been weighted according to the 2017 updated methods for assessing confidence (WTHWP 2017).

Table 19 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 overall scores and grades for basins for each reporting year are presented in Table 20. 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 20 Index scores and grades for 2020-21 and Overall basins scores and grades for 2020-21 and preceding years.

Basins	Water quality	Habitat and hydrology	Fish	20-21	19-20	18-19	17-18	16-17	15-16
Daintree	88	78	nd	83	85	82	81	81*	81*
Mossman	66	72	77	72¥	74¥	63	67	63*	55*
Barron	70	44	48	54¥	54¥	61	61	64	63
Mulgrave	73	67	84	74¥	73¥	68¥	71¥	64	64
Russell	75	69	92	79¥	75¥	75¥	75¥	70	68
Johnstone	75	64	72	70¥	71¥	67	67	68	68
Tully	71	63	90	75¥	72¥	61	64	64	61
Murray	49	58	80	63¥	61¥	57	59*	55*	54*
Herbert	66	60	85	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 location of the estuary reporting zones are shown in Figure 12. Monitoring and assessment of estuarine indicators was conducted in the vicinity of the reporting zone locations as described in the methods technical report (WTW 2022).

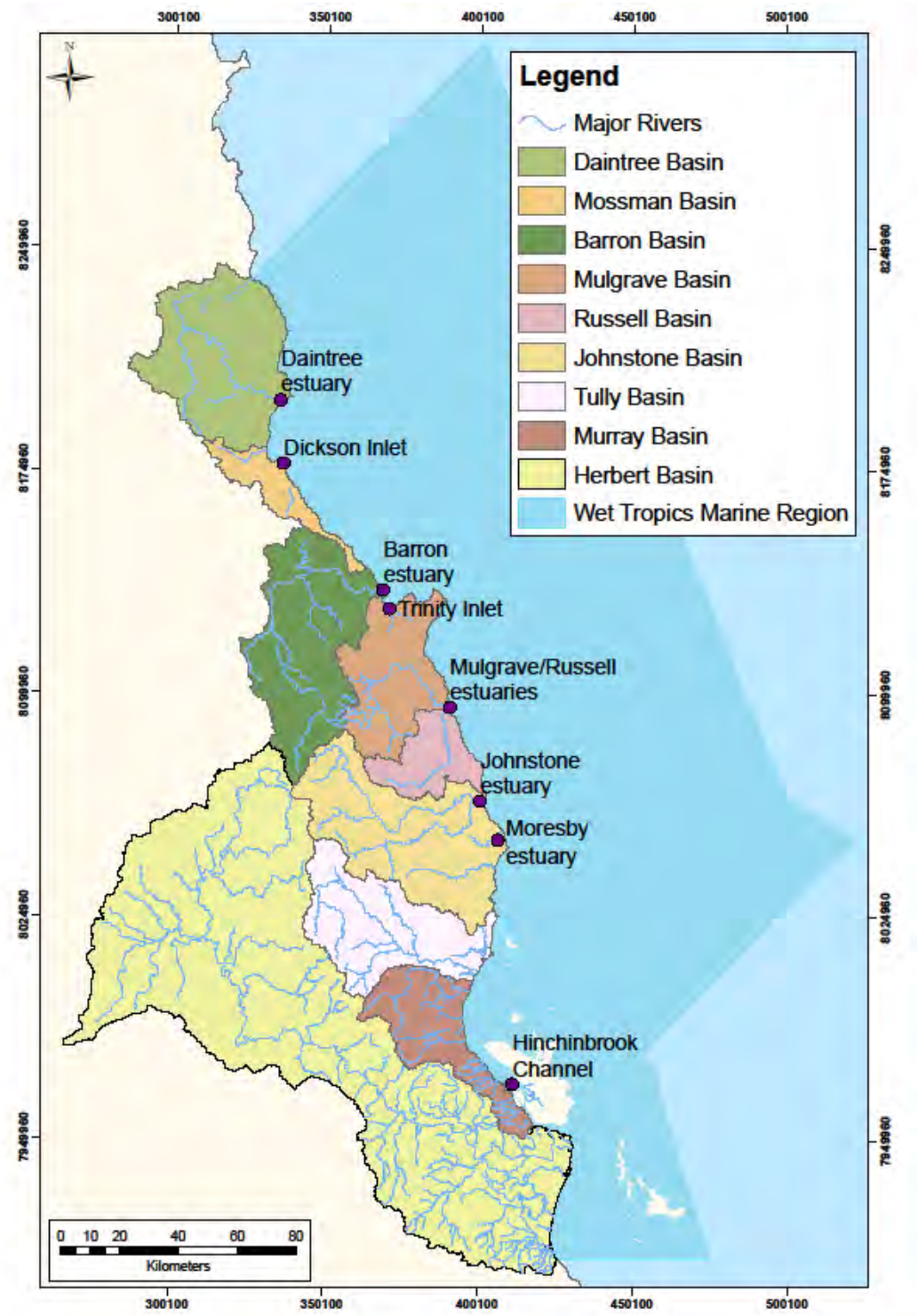


Figure 12 Location of estuary reporting zones.

5.1. Water Quality

Details of the monitoring frequency, indicators, and sample and site locations are provided in the methods technical report (WTW 2022).

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) for 2020-21 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 21 and the proportion of the three pesticide types that contribute to the pesticide risk metric is presented in Figure 13. Comparisons between the 2020-21 and previous years basin site results are presented for the full suite of pesticide types in Section 4.1 Figure 10 (note that results for Russell and Mulgrave are provided separately). The standardised scores for pesticides are presented in Table 22 for 2020-21 and in Table 107 to Table 111 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 21 The percentage of species protected for estuaries using the pesticide risk metric, based upon 22 pesticides for the 2020-21 reporting period.

	Pesticide risk metric (% species protected)
Estuary	**2020-21**
Daintree	> 99
Russell-Mulgrave	97.9
Johnstone (Coquette Point)	97.8

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). nd indicates no data or insufficient data available. Note that the most recent result for the Barron estuary was for 2018-19 with > 99% percentage of species protected.

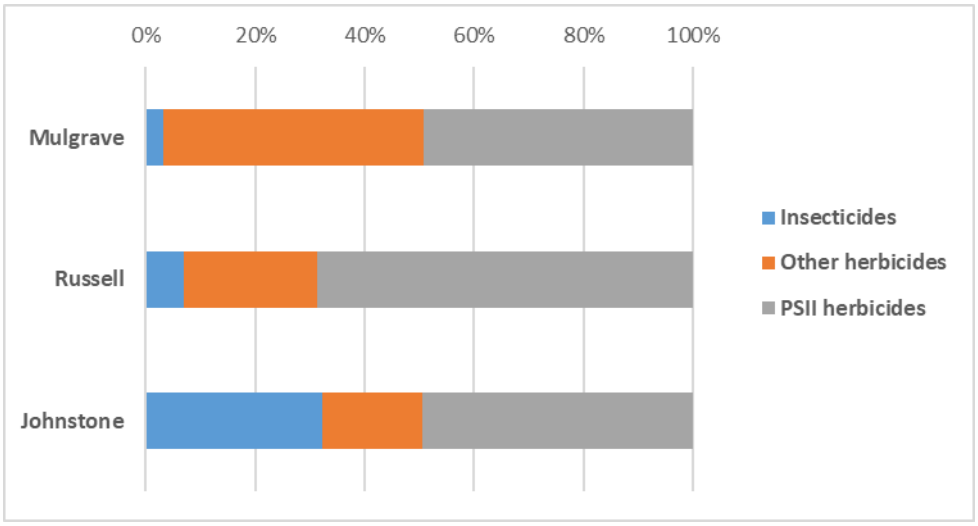


Figure 13 Percentage of pesticide categories contributing to the pesticide risk metric measure of percent species affected for estuaries.

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

For pesticides in 2020-21 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 2018-19, the pesticide scores declined from 98 to 94 in the Daintree, whilst the Russell-Mulgrave and Johnstone both scored 75 with very little change from the previous year (scoring 74 and 76 in 2019-20, respectively) (Table 22 and Table 108). The proportion of pesticide categories remained similar to the previous although there was some decline in the contribution of insecticides for the Russell.

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 2020-21 remained the same for all three monitored estuaries.
- Scores showed little change from the previous year.
- The proportion of insecticides decreased at the Russell monitoring site 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 pesticide monitoring data from these rivers can provide insight into pesticide types and risk of waters entering the channel (Figure 10) noting that dilution of river discharge occurs when mixing with the enclosed coastal waters of the channel.

Additional information is provided in Appendix F 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 water quality indicators, indicator categories and water quality index for 2020-21 and the water quality index for previous reporting years are presented in Table 22. The indicators, indicator categories and water quality indices for previous reporting years are presented in Appendix G Table 107 to Table 111. 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 64 to Table 71.

Table 22 Estuary water quality indicator and indicator category scores and grades for 2020-21 and water quality (WQ) index scores and grades for previous years.

	Chl *a*	Nutrients			Phys/Chem				Pest-icides	WQ	WQ				
Estuary	Chl *a*	DIN	FRP	Nut-rients	Turb-idity	DO Low	DO High	Phys/ Chem	Pest-icides	20-21	19-20	18-19	17-18	16-17	15-16
Daintree	**86**	81	90	**85**	90	81	90	**85**	**94**	**88**	**92**	**81**	**85**	**80**	**79**
Dickson Inlet	**84**	71	nd	**71**	90	90	90	**90**	**nd**	**82**	**81**	**83**	**80**	**64**	**nd**
Barron	**74**	46	73	**59**	90	65	90	**77**	**nd**	**70**	**60**	**61**	**66**	**64**	**50**
Trinity Inlet	**70**	90	90	**90**	90	31	90	**60**	**nd**	**73**	**70**	**58**	**65**	**78**	**83**
Russell-Mulgrave	**90**	52	90	**71**	90	69	90	**79**	**75**	**79**	**80**	**72**	**66**	**75**	**78**
Johnstone	**90**	37	70	**54**	nd	90	90	**90**	**75**	**77**	**76**	**76**	**67**	**72**	**63**
Moresby	**69**	70	90	**80**	90	68	90	**79**	**nd**	**76**	**83**	**80**	**79**	**81**	**78**
Hinchinbrook Channel	**64**	90	90	**90**	90	78	90	**84**	**nd**	**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. 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 2019-20, chlorophyll *a* declined from 'very good' to 'good' for the Moresby whilst the grade remained 'good' for Hinchinbrook but the score declined from 77 to 64. For the Barron chlorophyll *a* improved from 'moderate' to 'good' with the score increasing substantially from 46 to 74. Over previous years the Barron estuary consistently scored the poorest for chlorophyll *a* with grades varying between 'very poor' to 'moderate'. All other estuaries were graded either 'good' or 'very good' for chlorophyll *a* and their scores were similar to the previous year.

The DIN grade improved for the Barron from 'poor' to 'moderate' and declined in the Russell-Mulgrave from 'good' to 'moderate'. The grades for all other estuaries ranged from 'poor' to 'very good' and remained unchanged from the previous year.

FRP was graded 'very good' in all estuaries except for the Barron which was graded 'good' and declined from 80 in 2019-20 to 73, and the Johnstone which declined substantially from 'very good'

(scoring 90) in 2019-20 to 'good' (scoring 70). FRP data for Dickson Inlet was insufficient to provide a score and grade for 2020-21, noting in 2019-20 it was graded 'very good'.

Turbidity was graded 'very good' for all estuaries with grades unchanged from the previous year. Turbidity data for the Johnstone estuary was insufficient to provide a score and grade for 2020-21, as was the case for 2019-20.

Dissolved oxygen was graded 'good' or 'very good' for all estuaries except Trinity Inlet. Dissolved oxygen improved from 'good' to 'very good' for Dickson Inlet and declined from 'very good' to 'good' for Hinchinbrook Channel, since the previous year. The Johnstone estuary was graded 'very good' for 2020-21 (it had insufficient data for scoring and grading in 2019-20). Trinity inlet improved from 'very poor' to 'poor', and grades for all other estuaries remained unchanged since the previous year.

Although the Trinity Inlet dissolved oxygen score and grade improved for 2020-21, it is consistently the poorest scoring estuary for dissolved oxygen over the last five reporting years, and distinct from the other estuaries which are typically graded 'good' or 'very good'. 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 is presented in Appendix B p.104. 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 (Figure 20). 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.

- Chlorophyll *a* declined from 'very good' to 'good' for the Moresby. The grade remained 'good' for Hinchinbrook Channel but the score declined from 77 to 64.
- For the Barron chlorophyll *a* improved from 'moderate' to 'good' with the score increasing substantially from 46 to 74.
- The DIN grade improved for the Barron from 'poor' to 'moderate' and declined in the Russell-Mulgrave from 'good' to 'moderate'. The grades for all other estuaries ranged from 'poor' to 'very good' and remained unchanged from the previous year.

- FRP was graded 'very good' in all estuaries except for the Barron which was graded 'good', and the Johnstone which declined substantially from 'very good' (scoring 90) in 2019-20 to 'good' (scoring 70).
- Dissolved oxygen was graded 'good' or 'very good' for all estuaries except Trinity Inlet.
- Despite the dissolved oxygen score and grade improving for Trinity Inlet from 'very poor' in 2019-20 to 'poor', it has consistently been the poorest scoring estuary for dissolved oxygen over the last five years, and distinct from the substantially higher scores and grades of the other estuaries.
- Turbidity was graded 'very good' for all estuaries with grades from the previous year remaining unchanged.

Confidence

Confidence scores from the 2020-21 reporting period are presented in Table 23. 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 23 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). Riparian extent and mangrove and saltmarsh extent are long-term indicators and have not been updated for 2020-21. The results and discussion are repeated from the most recent update. Estuary fish barriers was updated for Hinchinbrook Channel for 2020-21 and updates for the Daintree, Dickson Inlet and Barron are planned for 2021-22. The indicator for shoreline mangrove habitat was introduced for 2020-21 and provides measures of condition to complement mangrove extent reporting. For 2020-21 mangrove habitat was reported for the Daintree, Dickson Inlet, Barron, Trinity Inlet and Russell-Mulgrave estuaries, with the remaining estuaries to be reported for 2021-22.

Mangrove and saltmarsh

Mangrove and saltmarsh habitat extent

The mangrove and saltmarsh habitat extent indicator was not updated for 2020-21. 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 2022).

The mangrove and saltmarsh extent loss from preclearing for 2017 and 2013, and the scores and grades for 2017 are shown in Table 24. 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. The has been no recent loss in extent of mangroves and saltmarsh in any of the estuaries with extent remaining unchanged between 2013 and 2017. The Daintree, Russell-Mulgrave and Hinchinbrook Channel were graded 'very good' whilst Dickson Inlet, Johnstone and Moresby were graded 'good'. The assessment of area remaining for mangroves and saltmarsh as separate vegetation types (Table 25) shows that historically' saltmarsh has lost more extent as a percentage of pre-clearing than mangroves across all estuaries.

Table 24 Mangrove and saltmarsh percent loss from pre-clearing for 2013 and 2017, change in extent between 2013 to 2017, and 2017 score and grade.

Estuary	Mangrove and saltmarsh extent loss from pre-clearing		Change	Score and grade
	2013 loss (%)	2017 loss (%)	2013-2017 (%)	2017
Daintree	1.7	1.7	0	93
Dickson Inlet	7.9	7.9	0	75
Barron	31.1	31.1	0	39
Trinity Inlet	20.6	20.6	0	53
Russell-Mulgrave	0.5	0.5	0	98
Johnstone	13.6	13.6	0	63
Moresby	5.9	5.9	0	79
Hinchinbrook Channel	4.2	4.2	0	84

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 25 Mangrove and saltmarsh pre-clearing, and 2017 area and extent remaining, presented as separate vegetation type.

	Mangroves			Saltmarsh		
Estuary	Area pre-clearing (km^2)	Area 2017 (km^2)	Extent remaining (%)	Area pre-clearing (km^2)	Area 2017 (km^2)	Extent remaining (%)
Daintree	22.7	22.3	98.4	0.1	0.0	41.5
Dickson Inlet	10.1	10.0	98.5	2.8	1.9	68.9
Barron	14.3	10.3	71.9	1.1	0.3	29.7
Trinity Inlet	38.8	32.3	83.3	4.7	2.2	46.8
Russell-Mulgrave	6.6	6.5	99.5	0.0	0.0	n/a
Johnstone	3.0	2.6	86.4	0.0	0.0	n/a
Moresby	32.9	31.1	94.4	0.7	0.5	78.0
Hinchinbrook Channel	181.9	175.4	96.4	14.6	12.9	88.6

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). For the estuaries that had shoreline mangrove assessments completed for the 2020-21 reporting period (Daintree, Dickson Inlet, Barron, Trinity Inlet and Russell-Mulgrave), results for the features, measures and indicator are presented as standardised scores in Table 26. A full description of the shoreline mangrove habitat indicator along with results including the scores prior to standardisation are available in McKenzie (2021).

Table 26 Shoreline mangrove habitat indicator results including scores for measures and features.

	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	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.

The shoreline mangrove habitat indicator score was lowest for Trinity Inlet (61), which was graded 'good' condition, and highest in the Daintree River (83) which was graded 'very good' condition and where there is minimal human impact. The other estuaries were graded 'good' with scores ranging from 64 to 74.

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). Canopy cover score was lowest 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. Trinity Inlet received a 'moderate' habitat impact grade and the lowest score (44) reflecting the relatively high levels of mangrove habitat damage and shoreline modification along shorelines, whilst in the Daintree estuary the least amount of habitat impact was recorded.

Key messages: mangrove habitat

- The shoreline mangrove habitat indicator score was lowest for Trinity Inlet (61), which was graded 'good' condition, and highest in the Daintree River (83) which was graded 'very good' where there is minimal human impact.

Habitat extent and condition

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 27), Trinity Inlet and Barron River estuaries were graded 'moderate', whereas Dickson Inlet was graded 'good' and the Daintree and Russell-Mulgrave systems were graded 'very good'. The other estuaries are represented only by the mangrove and saltmarsh extent indicator scores.

Table 27 Mangrove habitat and extent indicator category results.

	Shoreline mangrove habitat	Mangrove and saltmarsh extent	Habitat condition and extent
Daintree	83	93	88
Dickson	64	75	69
Barron	75	39	57
Trinity	61	53	57
Russell-Mulgrave	64	98	81
Johnstone	nd	63	63
Moresby	nd	79	79
Hinchinbrook Channel	nd	84	84

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 not updated for 2020-21. 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 2022).

The estuarine riparian vegetation extent scores and grades for 2017 are shown in Table 28 and report on the changes in extent and not the condition of the 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 2017 due to development including agricultural land use. The results show that since the first Queensland Herbarium assessments occurred in 1997, riparian extent in 2017 has increased slightly for the Daintree, Barron, Trinity Inlet and Moresby whilst no change in extent has occurred between 2013 to 2017.

Table 28 Estuarine riparian vegetation preclear area, percent loss from pre-clearing to 1997, 2013 and 2017, and change in area for 1997 to 2017 and 2013 - 2017.

	Riparian extent area	Percent riparian extent loss since pre-clearing and riparian extent area (km^2)*			Riparian extent change (% of pre-clearing area)		Score and grade
Estuary	**Pre-clearing (km^2)**	**1997**	**2013**	**2017**	**1997 - 2017**	**2013 - 2017**	**2017**
Daintree	3.6	45 (2.0)	42 (2.1)	42 (2.1)	+2.3	0	28
Dickson Inlet	0.6	25 (0.6)	25 (0.6)	25 (0.6)	0	0	47
Barron	2.0	48 (1.1)	48 (1.1)	48 (1.1)	+0.3	0	23
Trinity Inlet	8.8	18 9 (7.3)	16 (7.4)	16 (7.4)	+0.8	0	59
Russell-Mulgrave	5.7	47 (3.0)	47 (3.0)	47 (3.0)	0	0	24
Johnstone	4.5	77 (1.0)	77 (1.0)	77 (1.0)	0	0	9
Moresby	2.0	12 (1.8)	11 (1.8)	11 (1.8)	+0.7	0	68
Hinchinbrook Channel	10.7	22 (8.4)	22 (8.4)	22 (8.4)	0	0	51

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.

Note that for the 2020-21 reporting period the 2017 mangrove and saltmarsh extent data and estuary riparian extent data was obtained from the most recent Regional Ecosystem mapping (Version 5) as used for the Paddock to Reef Integrated Monitoring, Modelling and Reporting program (P2R). The habitat extent data for 2013 was based on version 4 of the Regional Ecosystem mapping. Slight differences of habitat extent between these data are evident, for example the Moresby estuary was previously scored 64, having a riparian extent loss of 13.2% based on version 4 of the Regional Ecosystem mapping. There has been no riparian loss recorded for the Moresby estuary since 2013 however the revised score is now 68 having a riparian extent loss of 11.1% based on the most recent Regional Ecosystem mapping (Version 5).

Fish barriers

The fish barrier indicator was updated in 2020-21 for the Hinchinbrook Channel, using data from the Fish Homes and Highways project (Terrain NRM). The Daintree, Dickson Inlet and Barron estuaries are due to be updated for 2021-22 using data from the Regional Lands Partnership fish barrier project (Terrain NRM). For the 2015-16 assessment the grades for estuary fish barriers ranged from 'good' to 'very good' (Table 29) and the high scores reflect the absence of low passability man-made barriers, such as dams and weirs, in the estuary reporting zones. The lowest score for barrier density was Moresby ('poor') and the lowest scores for percentage of stream to first barrier was the Barron 'poor'). Dickson Inlet had the highest score due to an absence of fish barriers.

Table 29 Results for fish barrier indicators in estuaries for 2015-16 reporting period. Assessments applied on Priority 3, 4 and 5 waterways as indicated.

Estuary	Barrier density (km per barrier on Priority 3, 4 and 5 waterways)	Stream (%) to the first barrier (km per barrier on Priority 3 and 4 waterways)	Stream (%) to the first low passability barrier (km per barrier on Priority 4 waterways)	Fish barriers (standardised score)
Daintree	6.5	76.2	no low pass barriers	61
Dickson Inlet	No barriers	No barriers	no low pass barriers	100
Barron	11.8	55.6	no low pass barriers	61
Trinity Inlet	5.8	74.1	no low pass barriers	61
Russell-Mulgrave	26.7	87.2	no low pass barriers	81
Johnstone	19.8	90.7	no low pass barriers	81
Moresby	2.6	82.1	no low pass barriers	61
Hinchinbrook Channel*	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. *The Hinchinbrook Channel is presented in grey text because it was updated for 2020-21 as per the table below.

The 2020-21 update of fish barriers for the Hinchinbrook Channel estuary added 15 verified fish barries 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 30. 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.

Table 30 Results of the fish barrier indicator for the Hinchinbrook Channel 2020-21 reporting period update. Assessments applied on Priority 3, 4 and 5 waterways as indicated.

Estuary	Barrier density (km per barrier on Priority 3, 4 and 5 waterways)	Stream (%) to the first barrier (km per barrier on Priority 3 and 4 waterways)	Stream (%) to the first low passability barrier (km per barrier on Priority 4 waterways)	Fish barriers (standardised score)
Hinchinbrook Channel	**15.7**	**11.9**	no low pass barriers	**60**

Refer to footnote in Table 29 for grading and scoring ranges.

Figure 14 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.

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)). 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 barriers

- The 2020-21 update of the fish barrier indicator for the Hinchinbrook Channel estuary added 15 verified fish barriers to the 18 fish barriers verified in the 2015-16 assessment, and the grade declined from 'good' to 'moderate'.
- The most significant fish barrier added for 2020-21 was a rock weir on the lower Herbert River which is drowned out during higher flows. This barrier has a total of 250 km of connected waterways upstream without fish barriers.

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 'very good', respectively, for flows during 2020-21, and the basins draining into the three estuaries were classified with an 'average' rainfall type for the Barron, Russell and Johnstone and 'wet' rainfall type for the Mulgrave (Table 31).

For the Barron estuary the grade declined from 'very good' to 'good' and the score decreased substantially from 93 in the previous year to 75. 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 declined from 95 in 2019-20 (WTW 2021) to 75 in 2020-21 (Appendix C Table 79) with slight decreases for measures of low, medium and high flows. In contrast the score for Freshwater Creek increased from 49 in the previous year to 80. Despite scoring poorly for high flow metrics, all the low and medium flow measures scored a maximum of five (Appendix C Table 79). Low flows during 2020-21 year were unusual for Freshwater Creek, which typically has at least one poor scoring low flow measure. Further description of the 2020-21 flow results for Freshwater Creek are provided in Section 4.2.

Flows for the Russell-Mulgrave improved from 'good' to 'very good' with almost all measures of flow across the three sites scoring highly. For the Johnstone the 'very good' grade for flows was unchanged from the previous year and all measures of flow scored highly.

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 79. 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 31 Rainfall type and number of flow assessment sites for 2020-21, and standardised estuary flow indicator score and grade for 2020-21 and the previous years.

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

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 2022). Both are available from the WTW website (wettropicswaterways.org.au).

Key messages: flow

- The Barron estuary was graded 'good' and the Russell-Mulgrave and Johnstone estuaries were graded 'very good', indicating flows to the estuaries were not substantially altered from reference condition.
- The scores increased for the Johnstone and Russell-Mulgrave from the previous year.
- The score for the Barron declined since the previous, however measures of low flows in Freshwater Creek, which drains into the Barron estuary, were unusually high scoring.

Seagrass

Seagrass condition scores and grades for 2020-21 and previous reporting years are presented in Table 32 . Indicator and condition scores for previous years are presented in Appendix G Table 112 to Table 116. The site scores and grades for the two reported estuaries are presented in Table 33. 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. Scores at the site level and each step of aggregation are presented in the detailed 2020-21 seagrass results (Appendix D).

Table 32 Estuary seagrass condition score and grade for 2020-21 and previous years.

Estuary	Condition score and grade	Condition score and grade				
		19-20	18-19	17-18	16-17	15-16
Daintree	-	-	-	-	-	-
Dickson Inlet	nd	nd	nd	nd	nd	nd
Barron	-	-	-	-	-	-
Trinity Inlet	42	54	46	31	30	21
Russell-Mulgrave	-	-	-	-	-	-
Johnstone	-	-	-	-	-	-
Moresby	18	25	8	0	7	13
Hinchinbrook Channel	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. The full results table is presented in Appendix D 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.

Table 33 Estuary seagrass site scores and grades for 2020-21.

Estuary	Site	Biomass	Area	Species composition	Site score and grade
Trinity Inlet	CN20	68	15	100	15
	CN19	86	89	0	43
	CN33	67	87	100	67
Moresby	MH1	0	0	0	0
	MH2	0	0	0	0
	MH3	56	14	0	7
	MH4	70	64	0	32
	MH5	53	58	100	53

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.

<u>Key messages: estuary seagrass</u>

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

- Seagrass meadows remained in moderate condition, but the overall zone score declined from 54 in 2019-2020 to 42 in 2020-2021.
- The reduced score was due to a significant decline in meadow area for intertidal meadow CN20, and the loss of the foundation species *Halophila ovalis* in subtidal meadow CN19.
- These small meadows consist of pioneering, ephemeral species and have been highly variable during the life of the monitoring program. Positive and negative change in condition scores between years is not unexpected.

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

- Overall seagrass condition in this zone declined from poor in 2019-2020 to very poor in 2020-2021.
- Seagrass was present in 3 of the 5 monitoring meadows in the Mourilyan Harbour. MH2 was not present during 2020-2021 monitoring. This is the fourth time that meadow has disappeared since 2014-2015.
- The average rainfall in September was double the long-term average. This may have reduced the light required for *Halophila* species to grow just prior to the survey.
- 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. In the formerly *Zostera muelleri* dominated meadows MH1 and MH2, no seagrass has returned to MH1. When present, meadow MH2 is comprised of less stable and low biomass *Halophila* species.
- 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. The meadows remaining consist of pioneering ephemeral species that can be highly variable over time.
- Assisted restoration is required in the Moresby estuary to return the foundation species *Zostera muelleri* to meadows MH1 and MH2 (see restoration update below).

Mourilyan Restoration Update:

In response to the loss of *Zostera muelleri* from Mourilyan Harbour Estuary for over a decade, JCU's TropWATER Seagrass Ecology Group in collaboration with OzFish unlimited and the Mandubarra Rangers have conducted two pilot trials (2020 & 2021) to test for viable restoration approaches for the Mourilyan meadows. These small scale trials have resulted in establishing a viable restoration approach with initial transplants surviving the wet season and surviving seagrass patches expanding 18 months after initial planting. New techniques with biodegradable planting frames were introduced in the latest trial established in July 2021. The team is now ready to scale up these approaches for full meadow restoration in Mourilyan and are seeking funding investment from a range of sources.

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 as it was recently identified as a diversity hotspot within the GBRWHA and adjacent estuaries as detailed in the spatial analysis of seagrass habitat and community diversity in the Great Barrier Reef World Heritage Area. (Carter *et al*. 2021).

Habitat and hydrology index

The scores and grades for estuary habitat and hydrology indicators, indicator categories and the index for 2020-21, and the indices for previous reporting years are presented in Table 34. The indicators, indicator categories and indices for previous reporting years are presented in Appendix G Table 117 to Table 121.

The habitat and hydrology index is comprised of three longer-term indicator categories that are updated every four years: mangrove and saltmarsh (extent updated for 2018-19 and condition introduced for 2020-21), riparian extent (updated for 2018-19) and fish barriers (Hinchinbrook updated for 2020-21, with more updates due for 2021-22). 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 have remained fairly consistent over reporting years with little change in grades (Table 34). For 2020-21 scores were similar to the previous year with no change in grades. The largest change in score was for Hinchinbrook Channel which declined from 71 to 65. This was due to the updated fish barrier indicator as detailed in the fish barriers section p. 49.

Table 34 Results for habitat and hydrology indicator categories and index for the 2020-21 and the habitat and hydrology index for previous years.

Estuary	Mangrove & saltmarsh	Riparian extent	Flow	Fish barriers	Sea-grass	20-21		19-20	18-19	17-18	16-17	15-16
Daintree	88^	28	nd	61	-~	59		60	60	60	60	60
Dickson Inlet	69^	47	nd	100	nd	72		74	74	74	74	74
Barron	57^	23	75	61	-	54		54	45	43	45	41
Trinity Inlet	57^	59	nd	61	42	54		57	55	50	50	48
Russell-Mulgrave	81^	24	84	81	-	67		69	65	75	69	67
Johnstone	63	9	98	81	-	63		62	54	63	58	51
Moresby	79	68	nd	61	18	56		58	54	51	53	54
Hinchinbrook Channel	84	51	nd	**60**	nd	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. ~ - 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.

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 2020-21, the indicator category and index scores without the shoreline mangrove habitat indicator are presented in Table 35. Comparing the index scores of Table 34 and Table 35 shows that the addition of the shoreline mangrove habitat indicator decreased scores for Daintree, Dickson Inlet and Russell-Mulgrave and increased the scores for Barron and Trinity inlet.

Table 35 Habitat and hydrology indicator category and index results excluding the new shoreline mangrove habitat indicator.

Estuary	Mangrove & saltmarsh extent	Riparian extent	Flow	Fish barriers	Sea-grass	20-21
Daintree	93	28	nd	61	-^	60
Dickson Inlet	75	47	nd	100	nd	74
Barron	39	23	75	61	-	49
Trinity Inlet	53	59	nd	61	42	53
Russell-Mulgrave	98	24	84	81	-	71

Confidence

Confidence scores for the 2020-21 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 36. Confidence in species composition is slightly lower due to the maturity of the methodology, which has been peer reviewed but not published.

Table 36 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 37. Note: riparian extent in estuarine zones is assessed using a different method to freshwater zones and scores differently for confidence.

Table 37 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 overall estuary scores and grades for each reporting year are presented in Table 38. For 2016-17 to 2020-21 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 in 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.

For 2020-21 all estuaries remained 'good' except for the Barron which improved from 'moderate' to 'good'. The increase in grade for the Barron was primarily due to the improved water quality index score.

Table 38 estuary index scores for 2020-21 and overall scores and grades for each reporting year.

Estuary	Water quality	Habitat and hydrology	20-21	19-20	18-19	17-18	16-17	15-16	14-15
Daintree	88	59	73	76	70	72	70	70	nd
Dickson Inlet	82	72	77	77	79	77	69	74*	nd
Barron	70	54	62	57	53	54	55	46	62
Trinity Inlet	73	54	64	63	56	57	64	66	59
Russell-Mulgrave	79	67	73	75	68	70	72	72	75
Johnstone	77	63	70	69	65	65	65	57	nd
Moresby	76	56	66	70	66	65	67	66	53*
Hinchinbrook Channel	79	65	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).

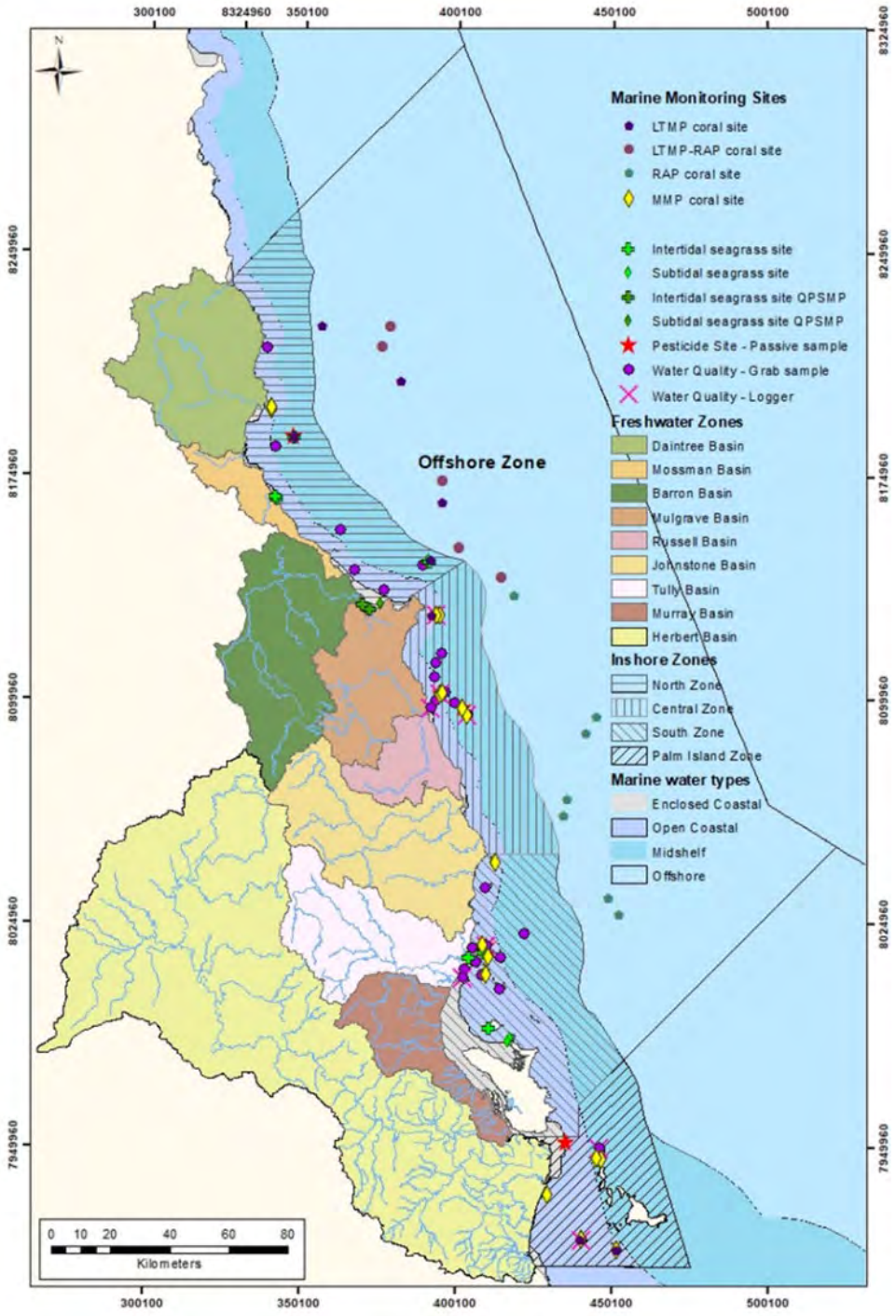


Figure 15 Reporting zones and monitoring sites for the inshore and offshore marine environments.

6.1. Water Quality

Inshore water quality indicator, indicator category and index scores for 2020-21 and index scores for previous years are presented in Table 39. Inshore water quality indicator, indicator category and index scores for previous years are presented in Appendix G Table 123 to Table 126. The 2020-21 water quality indicator annual means for all inshore water quality monitoring sites and the indicator scores before standardisation are presented in Appendix B (Table 75 and Table 76). All inshore water quality scores are calculated from *in-situ* data from the MMP. The pesticide monitoring reported for inshore zone, 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 2022). The methods for scoring inshore marine water quality are provided in the methods technical report (WTW 2022).

Table 39 Inshore marine water quality indicator, indicator category and index results for 2020-21 and water quality index (WQ) results for previous years.

	Water clarity			**Chl *a***	**Nutrients**				**Pest-icides**	**WQ**	**WQ**				
Zone	TSS	Tur-bidity	**Water clarity**	Chl *a*	NOx	PN	PP	**Nut-rients**	Risk metric	**20-21**	**19-20**	**18-19**	**17-18**	**16-17**	**15-16**
North	69	nd	69	86	57	65	57	60	nd	72	91	85	66	69	79
Central	81	59	75	69	22	26	62	37	nd	60	74	58	53	58	64
South	58	60	62	75	5	18	48	21	nd	52	72	44	47	47	60
Palm Island	76	67	71	64	44	44	61	50	nd	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. 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).

The water quality index score declined for all zones from the previous year with the most substantial declines occurring for the North (91 to 72) and the South (72 to 52). The grade declined from 'very good' to 'good' for the North zone and from 'good' to 'moderate' for the Central and South zones, whilst the Palm Island zone remained 'good'. Pesticide monitoring was discontinued in 2019-20 for the North and Palm Island zones and in 2020-21 in the Central and South zones. The effect of this on the water quality index has been to lower the index score since pesticides were high scoring and almost always graded 'very good' (Appendix G Table 123 to Table 126). The effect of this on the North and Palm Island zones for 2019-20 was masked by improvement in other water quality indicator scores but the effect on the Central and South zone for the 2020-21 water quality index scores is more apparent. For reference the water quality index scores and grades are provided for the most recent three years with the pesticide scores removed for 2019-20 (affecting Central and South zones) and for 2018-19 (affecting all four zones) (Table 40). Compared to Table 39, which includes the available pesticide scores, it is clear that during 2018-19 the pesticide scores had a substantial boost on the water quality index scores for the Central, South and Palm Island zones.

Table 40 Water quality index without pesticide scores for the most recent three years.

	Water Quality Index		
Zone	**20- 21**	**19-20**	**18-19**
North	72	91	81
Central	60	69	48
South	52	65	28
Palm Island	62	65	49

Water clarity scores decreased in all four zones after marked improvements in 2018-19 which continued into 2019-20. For 2020-21, all zones declined from 'very good' to 'good' with the most substantial decline occurring in the north zone (96 to 69). TSS grades varied from 'moderate' in the South zone to 'very good' in the Central zone, whilst turbidity was 'moderate' in the Central and South zones and 'good' in the Palm Island zone. Note that turbidity is monitored using loggers, which are present at 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 with the North zone remaining 'very good' and the other three zones remaining 'good'.

Nutrients had the poorest scores of the water quality indicator categories in all zones with grades of 'poor' for the Central and South zones, and moderate in the North and Palm Island zones. Of the three nutrient forms PP was the highest scoring, and NO_x was the lowest scoring, across all zones. The NO_x indicator continued to score lowest for the Central and South zones and was graded 'very poor' in the South zone. PN improved substantially in the Palm Island zone from 0 to 44 and the increase contributed to a higher score for nutrients compared to 2019-20 with the grade improving from 'poor' to 'moderate'. PP and NO_x scores declined substantially in the North zone with PP decreasing from 80 ('good') to 57 ('moderate') and NO_x decreasing from 100 ('very good') to 57 ('moderate').

During 2021-22 concentrations of NO_x exceeded guideline values in the North zone at five of the six sites. This was distinct from previous years with NO_x graded 'very good' every year since 2015-16 (Appendix G Table 122 to Table 126). There was no spatial or temporal pattern evident, with high concentrations of NO_x occurring during the wet and dry season and spread across sites from north to south.

In contrast to the North zone the Central and South zones displayed spatial trends in water quality. Highest concentrations of 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. This was most evident for nutrients and TSS. The South zone also had the highest concentrations of nutrients occurring during the wet season with spikes in nutrient concentrations coinciding with higher rainfall months. A seasonal pattern of nutrient concentration was less clear in the Central zone because the highest concentrations varied between sites, occurring either during wet season or early dry season months. Seasonal and spatial patterns of

water quality associated with river discharge were not apparent for the drier conditions of 2019-20 but were evident for the wetter conditions during 2018-19 (WTW 2020b).

The Palm Island sites are influenced by flood plumes from the south and it is the Burdekin, as well as the Haughton and Ross catchments that tend to directly affect water quality in the Palm Island inshore zone. 2020-21 and 2019-20 were lower discharge years from these 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 123) corresponded with these flood events. The Burdekin River typically has much higher PN loads during high discharge years (D. Moran pers. comm.). The substantial improvement in PN for the Palm Island in 2020-21 may be linked to the recent lower discharge years.

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.

Key messages: water quality

- Water quality index declined in all zones from the previous year with the most substantial declines in the North and South zones.
- Water clarity declined in all four zones following improvements and high scores in 2019-20.
- Nutrients had the poorest water quality scores in all zones with grades of ‘poor’ for the Central and South zones, and ‘moderate’ for the North and Palm Island zones.
- PN improved substantially in the Palm Island zone from 0 to 44 and the increase contributed to the grade for nutrients improving from ‘poor’ to ‘moderate’.
- The score for NOx declined substantially in North zone and was graded ‘moderate’ with all years previously graded ‘very good’.
- The Central and South zones displayed spatial trends in water quality with highest concentrations of nutrients, TSS and chlorophyl *a* occurring at sites closest to the river mouths and tending to decrease with distance of sites from the river mouths.
- The South zones had the highest concentrations of nutrients occurring during the wet season with spikes in nutrient concentrations coinciding with higher rainfall months.
- Pesticide monitoring and reporting in all inshore zones was suspended as from 2020-21. The final reporting year was 2019-20 for Central and South zones and 2018-19 for the North and Palm Island zones. The low pesticide risk and high scores for all zones had a positive effect on the water quality index scores for the years it was monitored and reported.

Confidence

Confidence for the inshore marine water quality results for all zones are shown in Table 41. 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 41 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)	Validation (x0.71)	Represent-ativeness (x2)	Directness (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

For 2020-21 coral index grades for the North and Palm Island zones remained 'moderate', whilst the Central and South zones remained 'good' and there was only marginal change in zone scores compared to the previous year (Table 42). The following assessment of inshore coral condition is based on findings from the Marine Monitoring Program report for inshore coral (Thompson *et al.* 2022) where more detailed assessment of the coral condition for sites in the Wet Tropics inshore zones is provided. The coral indicator and condition index scores for each site are provided in Appendix H (Table 146) for reference.

Table 42 Inshore marine coral indicators and index results for 2020-21 and coral index results for previous years.

Inshore Zone	Juvenile	Macro-algae	Cover	Change	Comp-osition	Coral 20-21		Coral 19-20	Coral 18-19	Coral 17-18	Coral 16-17	Coral 15-16
North	41	45	49	58	25	44		44	44	51	46	46
Central	36	74	70	68	65	63		61	60	61	57	60
South	72	34	49	68	81	61		62	62	55	60	55
Palm Island	44	45	45	48	63	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. Note: as from 2016-17 results for inshore coral are provided by MMP as whole numbers within the 0-100 scoring range. This ensures consistent reporting by the Wet Tropics 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.

There were no major disturbance events to inshore coral communities for 2020-21 in the Wet Tropics region. During January 2021, Tropical cyclone Kimi developed off the coast of Cairns at a category 1 intensity, and was within offshore waters as it tracked south and briefly intensified to a category 2. The system weakened to a tropical low and tracked back North before dissipating. Tropical cyclone Kimi did not cross the inshore reef and no clear evidence of damaging waves were

observed at coral monitoring sites. During 2020-21 sea temperatures remained below the 4 degree heating weeks level that represents a significant risk of thermal stress, and, unlike 2019-20, there were no warnings of coral bleaching released (Figure 5). Crown-of-thorns starfish were observed on Frankland Group East, Frankland Group West and High East, however the numbers were notably lower than for 2019-20. The Herbert River had considerably higher discharge than the long-term mean whilst all other major rivers had annual discharge closer to their long-term mean (Figure 4), which corresponded with the annual rainfall conditions for their basins (Table 2).

Whilst the inshore coral communities index scores have remained similar to the previous year in all four zones, some indicators have shown substantial change. The sections below describe the 2020-21 coral condition indicator results for the four inshore zones. The coral indicator and index scores for previous years are presented in Appendix G Table 127 to Table 131.

North zone

The condition of coral has remained 'moderate'. Coral cover across the zone continues to recover. While the rate of recovery (Change score) remains moderate it has declined since the Good score reported in 2020. Continuing to limit the coral scores in the zone are low scores for Composition as the relative proportion of fast growing, but sensitive to water quality and other pressures, corals of the genus Acropora remain below those observed in the baseline period (2005-2009) at most Snapper Island sites. The macroalgae score has improved at Snapper Island due to some decline in macroalgae cover at 5 m depth, but this contrasts with continued high cover of macroalgae at Snapper North 2 m. The juvenile coral score has improved at North Snapper and Low Isles reflecting slightly higher densities of juveniles at 5 m.

Central zone

The condition of coral has remained 'good' with a slight increase in score since 2020. Improvement in coral condition was due to higher rate of cover change, lower macroalgae cover and increased composition which offset marginal declines of coral cover and juvenile density. Impacts from crown-of-thorns-starfish predation on hard corals were observed at sites located at Fitzroy, Frankland, and High islands and contrasted with improved coral cover at sites without crown-of-thorns starfish impacts. The removal of crown-of-thorns starfish by the Crown-of-thorns Starfish Control Program is attributed with reducing the rate of coral cover loss, and this has been particularly evident for Fitzroy Island and the Frankland Group. Macroalgae cover from the brown macroalgae which is common on inshore reefs, has been consistently low across most sites, whilst the red macroalgae has been more variable with dense mats occurring at some sites, particularly Frankland West. Juvenile density remains the lowest scoring indicator and the grade declined to 'poor' in 2020-21.

South zone

The condition of coral has declined slightly since 2019-20 but the grade has remained good. For 2020-21 coral communities continued to recover from the severe impact of cyclone Yasi. However, the improvement in Cover and Composition scores were offset by lower juvenile coral density, increased macroalgae cover and a reduced rate of cover change. The juvenile coral indicator remains 'good' with the lower score reflecting corals that recruited following Tropical cyclone Yasi having out-grown the juvenile size class. The presence of macroalgae has the most impact on condition at the shallow (2 m depth) reefs of Bedarra, Dunk North and Dunk South. At these sites scores of zero for the macroalgae indicator reflect the high density of persistent brown macroalgae. The growth of

macroalgae on shallow reefs is indicative of high nutrient availability. Although the rate of coral change decreased, this indicator remains 'good' and has been high over preceding years.

Palm Island zone

The condition of coral remained moderate with the score declining from 53 in 2019-20 to 49. Coral cover remained similar or increased slightly compared to the previous year at most sites. Palms East was distinct, with strong growth and now over 45% cover at 2 m and 5 m reefs. Havannah North and South sites, were exposed to a high levels of thermal stress in early 2020 and the loss of coral cover through 2020 and 2021 was likely a result of severe coral bleaching in 2020. The disproportionate loss of branching *Acropora* cover at Havannah South also reduced the composition indicator. The macroalgae indicator remained 'moderate' although the score declined from 55 in 2019-20 to 45. The cover of macroalgae increased on reefs at Havannah and Lady Elliot. Although a substantial decline of macroalgae cover occurred on Pandora at 2 m depth, the remaining cover was still enough to score a zero for this indicator. Juvenile density declines occurred at most sites except for Palms West and Havannah North.

Key messages: inshore coral

- In the North zone the condition of coral has remained 'moderate'. Continuing improvement in coral cover is offset by the low density of juvenile corals at Snapper Island, the very high cover of macroalgae at Snapper North, and low composition scores.
- In the Central zone the condition of coral has remained 'good' with a slight increase in score since 2020. Improvement in coral condition was due to higher rate of cover change, lower macroalgae cover and increased composition scores which offset marginal declines of coral cover and juvenile density.
- In the South zone the condition of coral has declined slightly since 2019-20 but the grade has remained good. For 2020-21 limitations on the coral condition were predominantly due to lower juvenile coral density, increased macroalgae cover and a reduced rate of cover change.
- In the Palm Island zone the condition of coral remained 'moderate'. Limitations on coral condition for 2020-21 included decline of juvenile density and composition, and increased macroalgae cover at some sites.
- Crown-of-thorns starfish were observed at some sites in the Central zone, however the numbers were notably lower than for 2019-20.

Note that in the summer of 2021-22 extensive heat stress occurred across the Great Barrier Reef including the Wet Tropics Region. The high sea surface temperatures represent a risk to inshore coral reefs from bleaching events. The extent of impacts on inshore coral will only be known after the next round of monitoring surveys by AIMS. More information is provided in the Climate section (p. 9).

Confidence

Confidence in the inshore marine coral results are shown in Table 43. 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 43 Confidence scoring of coral indicators 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).

Coral indicators	Maturity of methodology (x0.36)	Validation (x0.71)	Represent-ativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final	Rank
Coral	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 2022). The inshore marine zone seagrass condition scores and grades for 20120-21 and previous years are presented in Table 44. The site scores and grades for the two reported inshore zones are presented in Table 45. 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. The condition score for an inshore zone is the average of the site scores. The complete results table for 2020-21 is presented in Appendix D . Indicator and condition scores for previous years are presented in Appendix G Table 133 to Table 136.

For 2020-21 the MMP for inshore seagrass updated their indicators of seagrass condition. This is explained below in the report card update which follows the inshore seagrass zone results. This is the third year that treating MMP transects as different sites has been discarded. For the MMP monitoring locations there are generally two transect blocks close to one another in the same meadow. It was decided in 2019 that these should not be counted as separate sites when being averaged within a zone and are now treated as replicates within a site.

Table 44 Inshore marine zone seagrass condition results for 2020-21 and previous years.

Inshore zone	20-21	19-20	18-19	17-18	16-17	15-16
North	57#	46	53	46	30	30
Central		nd	nd	nd	nd	nd
South	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.

Table 45 Seagrass site scores and grades calculated from indicators from QPSMP and MMP for 2020-21.

Inshore zone	Site code	QPSMP Biomass	QPSMP Area	QPSMP Species composition	MMP Percent cover	MMP Resil-ience	Site score and grade
North	CN13	80	91	94	nd	nd	80
	YP1 & YP2	nd	nd	nd	92	75	83
	CN34	66	74	85	nd	nd	66
	CN11	85	90	100	nd	nd	85
	GI1 & GI2	nd	nd	nd	50	69	60
	LI1	nd	nd	nd	0	6	3
	GI3	nd	nd	nd	63	87	75
	LI2	nd	nd	nd	13	0	6
South	LB1 & LB2	nd	nd	nd	0	23	11
	MS1 & MS2	nd	nd	nd	100	nd	100
	DI1 & DI2	nd	nd	nd	17	44	30
	GOI[#]	nd	nd	nd	nd	nd	nd
	DI3	nd	nd	nd	8	30	19

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 was in moderate condition in the North zone and poor in the South zones. North zone seagrass has been in this condition for the past 3 years although the score increased substantially from 46 in the previous year to 57. The South zone seagrass condition also improved from 35 in 2019-2020 to 40 which is just below the threshold for 'moderate' condition. The update to the MMP seagrass indicators, which introduced the resilience indicator for 2020-21, did not affect the direction of condition change (improvement or decline) for zones in 2020-21 compared to the previous year, since the overall seagrass scores for 2019-20 would have been 49 for the North zone and 30 for the South zone using the updated indicators. The effect of the 2020-21 changes to indicators on scores is assessed in the report card update section below.

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/.

Key messages: inshore seagrass

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).

- Overall seagrass condition remained in moderate condition for the third year.

- Seagrass condition in inshore QPSMP monitoring meadows (Cairns Harbour) have improved in recent years. In 2020-21 these large seagrass meadows were in the best condition since 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 2 years.
- 14 months after completion of the Cairns Shipping Development Project (CSDP) there were no signs of negative impacts on the monitoring meadows adjacent to the works.
- Overall condition scores improved at the Green Island MMP sites in the past year, with both intertidal and subtidal sites in good condition. Seagrass at the Low Isles sites remained very poor for the third 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 was poor but with some improvement since 2019-2020.
- This improvement was driven by an increase in seagrass % cover at Missionary Bay, with 100% cover recorded.
- Seagrass grades did not change in Lugger Bay or at the Dunk Island sites from 2019-2020. Seagrass condition remained very poor at Lugger Bay and Dunk Island subtidal site.
- Overall resilience was graded as poor.
- Goold Island has not been monitored for 5 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.

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. Hinchinbrook Channel
    c. Palm Island zone inshore waters.

Report card update

The Marine Monitoring Program updated the indicators for assessing seagrass condition for 2020-21 onwards. The seagrass indicators have changed with the removal of tissue nutrient status and the replacement of the reproductive effort with a more holistic resilience indicator. The resilience indicator uses a multivariate approach to measure the capacity of seagrass to cope with disturbances and accommodates differences in recovery strategies between species. The update is described in the methods technical report (WTW 2022) with full details provided in Collier *et al.* (2021). Back calculations are provided below to compare how the updated method scored previous years seagrass results.

When indicators for an index are changed it is likely to affect condition scores due to the changes in methodology in addition to any change in actual condition that has occurred. The removal of the

tissue nutrients indicator and replacement of reproductive effort with the resilience indicator for MMP sites (effective as of 2020-21) has been assessed by comparing results for 2018-19 and 2019-20 for the previous MMP indicators with the updated indicators. The previous MMP indicators were not calculated for 2020-21 but the resilience indicator was back-calculated for previous years to allow for comparison of results.

The comparison of the seagrass index zone scores includes all contributing indicators from both MMP and QPSMP (which is only applicable to the North zone). The effect of the change had varied effects (Table 46).

- North Zone – overall inshore water body score increased from 46 to 49 in 2019-2020, and decreased from 53 to 51 in 2018-2019 due to change in indicators.
- South Zone – overall inshore water body score decreased from 35 to 30 in 2019-2020 and 35 to 34 in 2018-2019 due to the change in indicators.

Table 46 Seagrass index zone scores for 2019-20 and 2018-19 using the previous MMP indicators and using updated MMP indicators back calculated.

	2019-20		2018-19	
Inshore zone	**Previous**	**Updated**	**Previous**	**Updated**
North	46	49	53	51
South	35	30	35	34

A comparison of the scores between the previous and updated MMP indicators for 2019-20 and 2018-19 is provided in Table 47. The percent cover indicator is common to both previous and updated methods. Apart from the South zone in 2019-20, the resilience indicator score is between the scores for the tissue nutrients and reproductive effort. The resilience score for the South zone in 2019-20 is below both tissue nutrient and reproductive effort scores. The resilience indicator is not consistently higher or lower than either the tissue nutrient or reproductive effort indicators. The change in methodology when applied for the 2019-20 and 2018-19 years has not had a substantial effect on seagrass condition scoring, although it is important to consider the changes in methodology when comparing scores before 2020-21, and those from 2020-21 onwards.

Table 47 Seagrass MMP indicator scores for 2019-20 and 2018-19 with the previous MMP indicators and with the updated MMP indicators back-calculated.

		Previous			Updated	
	Inshore zone	**Percent cover**	**Tissue nutrients**	**Reproductive effort**	**Percent cover**	**Resilience**
2019-20	North	36	38	20	36	36
	South	19	36	38	19	30
2018-19	North	43	37	63	43	46
	South	28	27	17	28	24

The full results table for the North and South zones with the updated MMP indicators back-calculated for 2019-20 and 2018-19 are provided in Appendix D , and for the previous MMP method they are provided in WTW (2021) for 2019-20 and WTW (2020b) for 2018-19.

Confidence

Confidence in the inshore seagrass results is shown in Table 48 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 48 Confidence scoring of seagrass indicators 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 2020-21 and the overall scores and grades for previous years are presented in Table 49. The grades for all inshore zones were unchanged however, the scores for all zones decreased from the previous year. The decline in scores was primarily due to decreases in scores for water quality, which occurred in all zones.

Table 49 Inshore index scores and grades for 2020-21 and overall inshore scores and grades for each previous reporting year.

Inshore zone	Water Quality	Coral	Sea-grass	Fish	20-21	19-20	18-19	17-18	16-17	15-16
North	72	44	57	nd	57	60	60	54	48	52
Central	60	63	nd	nd	61	67	59	57	57	62
South	52	61	40	nd	51	56	47	41	37	44
Palm Island	62	49	nd	nd	55	59	56	51	57	59

7. OFFSHORE MARINE

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

7.1. Water Quality

For 2020-21 there was no water quality monitoring program in place to allow for reporting on offshore water quality. For previous years 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 meets the water quality guideline value (Table 50). The scores were similar for all previous reporting years. The water quality indicators and index for previous years are presented in full in Appendix G Table 137 to Table 140.

Table 50 Results for the water quality indicators and index for 2020-21 and the water quality index for previous years

Water quality indicator categories		**Water quality**		**Water quality**	**Water quality**	**Water quality**	**Water quality**	**Water quality**
Chlorophyll-*a*	Water clarity (TSS)	20-21		19-20	18-19	17-18	16-17	15-16
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 has been 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 2021-22 reporting year.

7.2. Coral

The following information and key messages on results of the offshore coral for 2020-21 sourced information from online publications from the AIMS Long-Term Monitoring Program for surveys in the Wet Tropics region available on the website pages www.aims.gov.au/reef-monitoring/gbr-condition-summary-2020-2021#thenorthernregion, www.aims.gov.au/reef-monitoring/cairns-sector-2021 and www.aims.gov.au/reef-monitoring/innisfail-sector-2021. The offshore coral indicator and index scores (Table 51) were based upon the surveys of the Long-Term Monitoring Program (LTMP) between 2019-20 and 2020-21 and represented 15 separate reefs in the Wet Tropics region as specified in the methods technical report (WTW 2022). The coral indicator and condition index scores for 2020-21 are presented in Appendix H (Table 147). The indicators and index for previous years are presented in Appendix G Table 141 to Table 145.

Table 51 Results for coral indicators and index for 2020-21 and the coral index for previous years.

Coral indicators scores			Coral	Coral	Coral	Coral	Coral	Coral
Juveniles	Coral Cover	Coral Change	20-21	19-20	18-19	17-18	16-17	15-16
65	32	52*	50	42	48	51	67	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. * 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.

After a decade of cumulative disturbances, the Wet Tropics offshore zone experienced a low disturbance year for 2020-21. Disturbance from tropical cyclones was minimal with the major risk of impact occurring in January 2021 from Tropical cyclone Kimi which intensified to a category 2 in the offshore zone but rapidly dissipated. Sea surface temperatures for most of the offshore zone remained below the 4 degree heating weeks level that represents a significant risk of thermal stress, with values recorded slightly above this level in the north east corner of the offshore zone (Figure 5). There were no crowns-of-thorns starfish detected on the surveyed reefs.

Offshore coral condition declined since 2015-16 to a low of 42 in 2019-20 but has improved to 50 in 2020-21 (Table 51). Coral cover remained the lowest scoring indicator with an overall grade of 'poor', although the score increased marginally from 29 to 32. Of the 15 reefs surveyed (Appendix H, Table 147) four remained 'very poor', whilst five were 'poor' and six were 'moderate', with St. Crispin and Thetford reefs improving from 'poor' to 'moderate' since the previous year. The coral change indicator had the most substantial increase, improving from 'poor' (scoring 37) to 'moderate' (scoring 52) with seven reefs improving in grade, and one decreasing in grade. However, it must be noted that 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. Improvements in the grades for juvenile density occurred at three reefs which contributed to the slight increase in juvenile score across the offshore zone with the grade remaining 'good'.

Bleaching of hard corals was only observed at low levels across the survey sites, and this was restricted to scattered individual colonies. Thermal stress that occurred in 2020 resulting in bleaching events was spatially limited and only affected a few of the surveyed reefs. Recovery from recent bleaching events of in 2016, 2017 and 2020 was apparent at some sites including St. Crispin Reef where healthy coral assemblages were observed.

Key messages: offshore coral

- The Wet Tropics offshore zone experienced a low disturbance year for 2020-21, there were minimal impacts from tropical cyclones, heat stress and crown-of-thorns starfish.
- Coral condition improved after declining to its poorest condition in 2019-20 compared to previous years, however this result is confounded by disturbance categorisations that have improved coral change indicator scores.

- Coral cover remained the lowest scoring indicator with an overall grade of 'poor', although the score increased marginally from 29 to 32.
- There were no crowns-of-thorns starfish detected on the surveyed reefs.
- Bleaching of hard corals in 2020 only occurred at low levels across the survey sites, and was restricted to scattered individual colonies.
- Recovery from recent bleaching events of in 2016, 2017 and 2020 was apparent with strong coral growth occurring at some sites.

Note that in the summer of 2021-22 extensive heat stress occurred across the Great Barrier Reef including the Wet Tropics Region. The high sea surface temperatures represent a risk to offshore coral reefs from bleaching events. The extent of impacts on offshore coral will only be known after the next round of long-term monitoring surveys by AIMS. More information is provided in the Climate section (p. 9).

Confidence

Confidence in the offshore coral results is shown in Table 52.

Table 52 Confidence scoring of coral indicators for the offshore marine zone 2020-21. 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
Offshore coral	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 2020-21 there was insufficient data to provide an overall grade and score for the offshore zone (Table 53). 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 2021-22 reporting year and onwards, which will allow overall offshore marine scores and grades to be reported.

Table 53 Results of indices for 2020-21 and overall scores and grades for 2020-21 and previous years for the offshore marine zone.

Water quality	Coral	Fish	20-21	19-20	18-19	17-18	16-17	15-16
nd	50	nd	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.

8. REFERENCES

ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia www.waterquality.gov.au/anz-guidelines

BoM (Bureau of Meteorology) 2021. Monthly Weather Review Australia April 2021. Bureau of Meteorology. Melbourne http://www.bom.gov.au/climate/mwr/aus/mwr-aus-202104.pdf

Carter, A. Coles, R., Rasheed, M. and Collier, C. 2021. Seagrass communities of the Great Barrier Reef and their desired state: Applications for spatial planning and management. Report to the National Environmental Science Program. Reef and Rainforest Research Centre Limited, Cairns (80pp.).

Carter, A.B., Collier, C., Lawrence, E., Rasheed, M.A., Robson, B.J., and Coles, R. 2021 A spatial analysis of seagrass habitat and community diversity in the Great Barrier Reef World Heritage Area. Sci Rep 11, 22344 (2021). https://doi.org/10.1038/s41598-021-01471-4

Collier, C.J., Langlois, L., Waycott, M., McKenzie, L.J. 2021, Resilience in practice: development of a seagrass resilience metric for the Great Barrier Reef Marine Monitoring Program, Great Barrier Reef Marine Park Authority, Townsville, 61pp.

Burrows DW (2004) Translocated Fishes in Streams of the Wet Tropics Region, North Queensland: Distribution and Impact. Cooperative Research Centre for Tropical Rainforest Ecology and Management, Cairns pp. 83

DEHP (Department of Environment and Heritage Protection) 2009. Queensland Water Quality Guidelines, Version 3, ISBN 978-0-9806986-0-2.

DEHP (Department of Environment and Heritage Protection) 2014. Environmental Protection (Water) Policy 2009 Wet Tropics Basins Environmental Values and Water Quality Objectives. Environmental Policy and Planning Division, Department of Environment and Heritage Protection. https://www.ehp.qld.gov.au/water/policy/wet-tropics.html

DSITI (Department of Science, Information Technology and Innovation) 2017. Ground cover technical report 2015-16: Great Barrier Reef catchments, Queensland Department of Science, Information Technology and Innovation, Brisbane.

Emslie, M. 2019. Long-term Reef Monitoring Program - Annual Summary Report on coral reef condition for 2019. Australian Institute of Marine Science. Townsville.

Gallen, C., Devlin, M., Thompson, K., Paxman, C., & Mueller, J. 2014. Pesticide monitoring in inshore waters of the Great Barrier Reef using both time-integrated and event monitoring techniques (2013 - 2014). The University of Queensland, The National Research Centre for Environmental Toxicology (Entox).

GBRMPA (Great Barrier Reef Marine Park Authority) 2010. Water Quality Guidelines for the Great Barrier Reef Marine Park. Revised Edition 2010. Great Barrier Reef Marine Park Authority, Townsville. 100p.

Hateley, L.R., Ellis, R., Shaw, M., Waters, D., Carroll, C. 2014. Modelling reductions of pollutant loads due to improved management practices in the Great Barrier Reef catchments – Wet Tropics NRM region, Technical Report, Volume 3, Queensland Department of Natural Resources and Mines, Cairns, Queensland (ISBN: 978-0-7345-0441-8).

Heiner, I. J. and Grundy, M. J. 1994. Land resources of the Ravenshoe- Mt Garnet area north Queensland. Vol 1 - Land resource. Land Resources Bulletin Series QV94006. Department of Primary Industries, Brisbane.

Lenhart, C.F., Brooks, K.N., Heneley, D. and Magner, J.A. 2010. Spatial and temporal variation in suspended sediment, organic matter, and turbidity in a Minnesota prairie river: implications for TMDLs. Environmental Monitoring and Assessment. 165: 435–447.

Gruber, R., Waterhouse, J., Logan, M., Petus, C., Howley, C., Lewis, S., Tracey, D., Langlois, L., Tonin, H., Skuza, M., Costello, P., Davidson, J., Gunn, K., Lefevre, C., Moran, D., Robson, B., Shanahan, M., Zagorskis, I., Shellberg, J. and Neilen, A. 2020. Marine Monitoring Program: Annual Report for Inshore Water Quality Monitoring 2018-19. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville.

Marsh, N. 2004. RAP river analysis package: user guide, version 1.1. CRC for Catchment Hydrology, Australia, Jan 2004. www.toolkit.net.au/rap

Mackenzie, J. 2021. Development of an Estuarine Mangrove Habitat Indicator from MangroveWatch Citizen-Science Data for use in the Wet Tropics Healthy Waterways Report Cards. Earthwatch Institute, Melbourne.

McKenzie, L.J., Collier, C.J, Langlois, L.A., Yoshida, R.L., Uusitalo, J. and Waycott, M., 2021. Marine Monitoring Program: Annual Report for Inshore Seagrass Monitoring 2018–19. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville, 206pp.

Mitchell, A., Brodie, J., Lewis, S., Devlin, M., Bainbridge, Z., Bulsink, D-J., and Furnas, M., 2009. Water Quality Issues in the Barron WQIP Area. Australian Centre for Tropical Freshwater Research. ACTFR Report No. 08/06. James Cook University, Townsville.

Moore, M. 2016. HR2R – Freshwater & Estuary Fish Barrier Metrics Report – Final Report for Healthy Rivers to Reef Partnership.

Neldner, V.J., Butler, D.W. and G.P. Guymer (2019) Queensland's regional ecosystems: Building a maintaining a biodiversity inventory, planning framework and information system for Queensland, Version 2.0, Queensland Herbarium, Queensland Department of Environment and Science, Brisbane.

Queensland Government 2016. Water Plan (Wet Tropics) 2013. Water Act 2000. https://www.legislation.qld.gov.au/view/pdf/2016-12-06/sl-2013-0282

Queensland Government 2020. Policy for fish stocking in Queensland, Version 1.00, FIS/2020/5500.

Queensland Government Water Monitoring 2021. Personal communication by email. 20th April 2021.

Reason C. L., McKenna S.A. & Rasheed M. A .2020. Seagrass habitat of Cairns Harbour and Trinity Inlet: Cairns Shipping Development Program and Annual Monitoring Report 2019. JCU Publication, Centre for Tropical Water & Aquatic Ecosystem Research Publication 20/06, Cairns.

Schaffelke, B., Carleton, J., Skuza, M., Zagorskis, I., Furnas, M.J. 2012. Water quality in the inshore Great Barrier Reef lagoon: Implications for long-term monitoring and management. Marine Pollution Bulletin 65:249-260. DOI: 10.1016/j.marpolbul.2011.10.031

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.

Sweatman, H. 2018. Long-term Reef Monitoring Program Annual summary report on coral reef condition 2017/18. Australian Institute of Marine Science. Townsville.

Sydes, T. and Hunt, R. J. 2017. A method for assessing invasive weeds of waterways in the Wet Tropics for the Wet Tropics Healthy Waterways Report Card. Wet Tropics Health Waterways Partnership. Cairns.

Terrain NRM 2015. Wet Tropics Water Quality Improvement Plan 2015-2020. Terrain NRM, Innisfail.

Thompson, A., Davidson, J., Logan, M., Coleman, G. 2022, Marine Monitoring Program Annual Report for Inshore Coral Reef Monitoring: 2020–21. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville.151 pp.

Warne M.St.J., Neelamraju, C., Strauss, J., Smith, R.A., Turner, R.D.R., Mann, R.M. 2020. Development of a method for estimating the toxicity of pesticide mixtures and a Pesticide Risk Baseline for the Reef 2050 Water Quality Improvement Plan. Brisbane: Department of Environment and Science, Queensland Government.

Waterhouse, J., Brodie, J., Tracey, D., Lewis, S., Brinkman, R., Tonin, H., Furnas, M., Fabricius, K., Schaffelke, B., Wolff, N., Devlin, M., McKenzie, L. 2014. Assessment of the relative risk of water quality to ecosystems of the Wet Tropics Region, Great Barrier Reef. A report to Terrain NRM, Innisfail. TropWATER Report 14/27, Townsville, Australia.

WTHWP (Wet Tropics Healthy Waterways Partnership) 2017. Wet Tropics Report Card 2017 (reporting on data 2015-16). Waterway Environments: Methods. Wet Tropics Healthy Waterways Partnership and Terrain NRM, Cairns.

WTHWP (Wet Tropics Healthy Waterways Partnership) 2018. Wet Tropics Report Card Program Design: Five year plan 2018 - 2022. Wet Tropics Health Waterways Partnership and Terrain NRM, Cairns.

WTW (Wet Tropics Waterways) 2019b. Wet Tropics Report Card 2019 (reporting on data 2017-18). Waterway Environments: Results. Wet Tropics Waterways and Terrain NRM, Cairns.

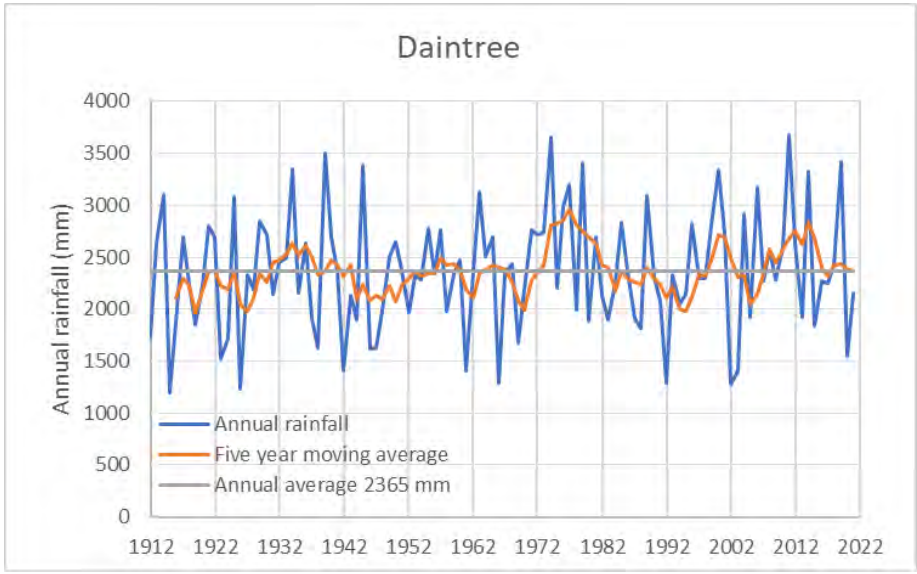
WTW (Wet Tropics Waterways) 2020a. Wet Tropics Report Card 2020 (reporting on data 2018-19). Waterway Environments: Methods. Wet Tropics Waterways and Terrain NRM, Cairns.

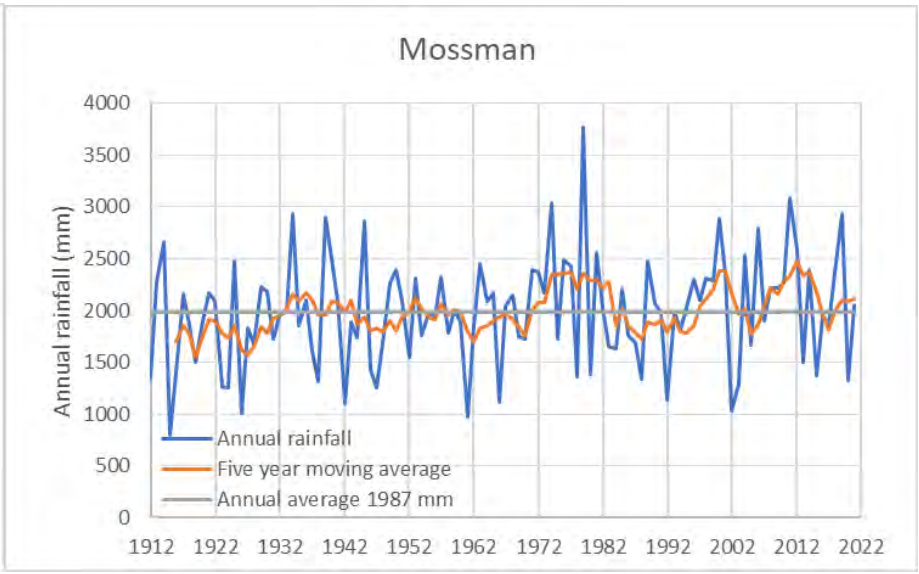
WTW (Wet Tropics Waterways) 2020b. Wet Tropics Report Card 2020 (reporting on data 2018-19). Waterway Environments: Results. Wet Tropics Waterways and Terrain NRM, Cairns.

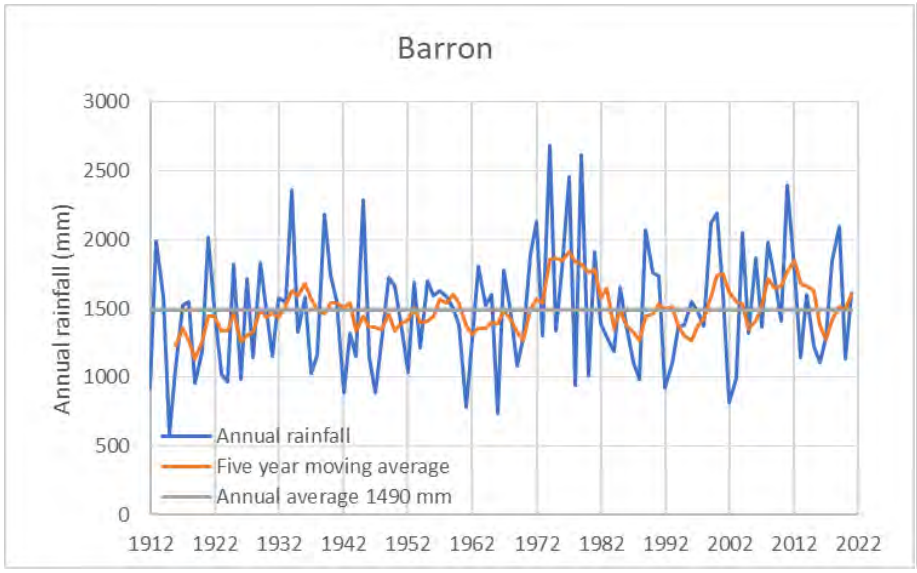
WTW (Wet Tropics Waterways) 2021. Wet Tropics Report Card 2020 (reporting on data 2019-20). Waterway Environments: Results. Wet Tropics Waterways and Terrain NRM, Cairns.

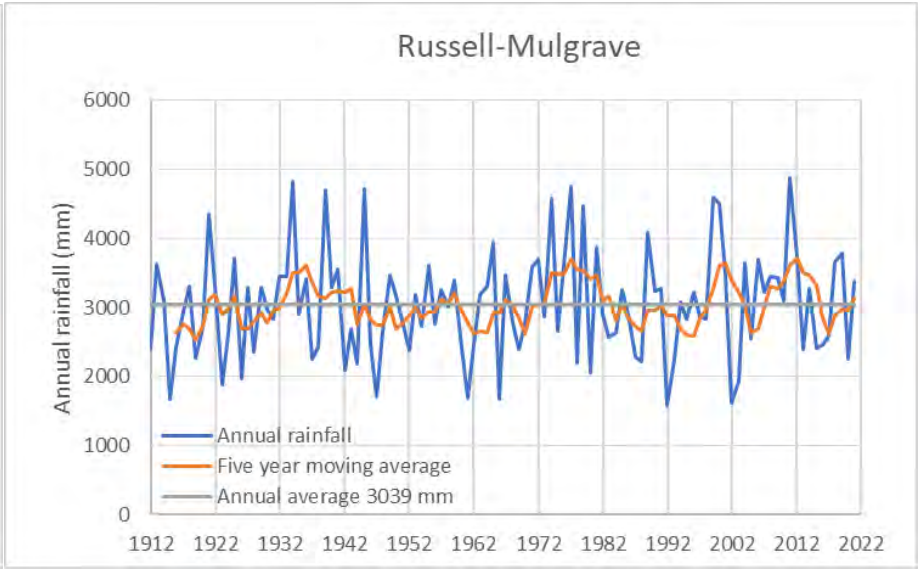
WTW (Wet Tropics Waterways) 2022. Wet Tropics Report Card 2022 (reporting on data 2020-21). Waterway Environments: Methods. Wet Tropics Waterways and Terrain NRM, Cairns.

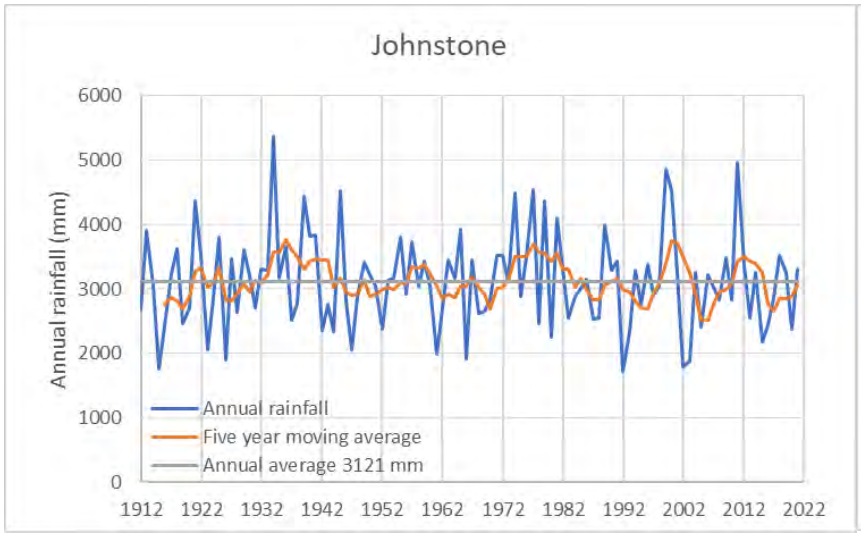
Appendix A. Long-term annual rainfall totals (1912 to 2021) for basin areas of the Wet Tropics

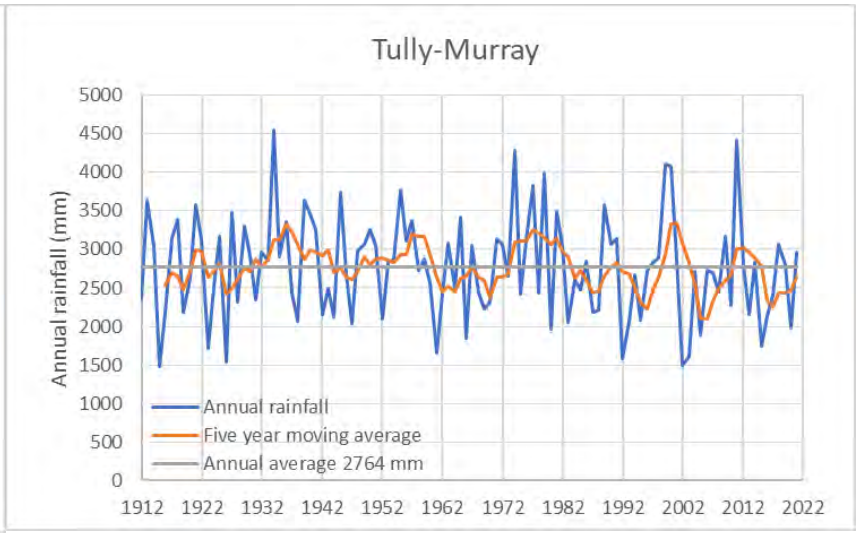












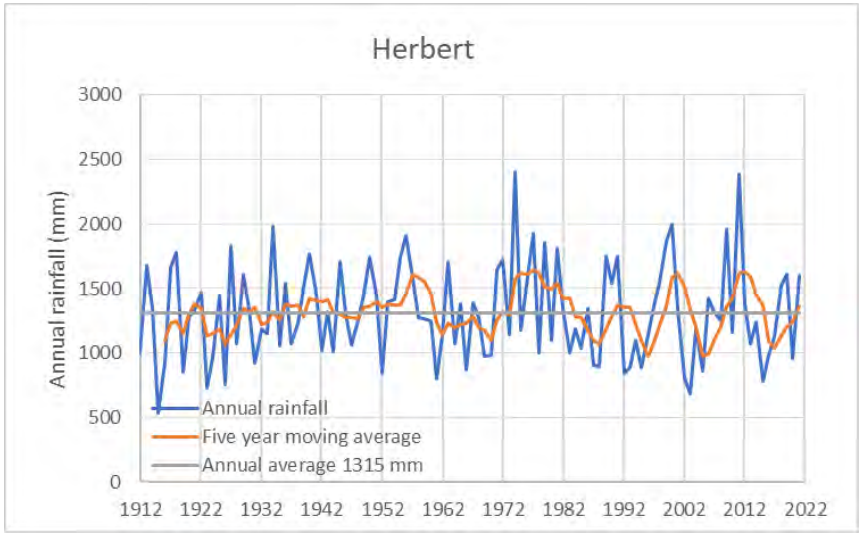


Figure 16. Annual rainfall totals, five year moving average of totals and long-term annual rainfall average (1912 to 2021) for basin areas of the Wet Tropics. Long-term annual rainfall data sourced from the Bureau of Meteorology.

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) 2009 for Wet Tropics basins (DEHP 2014) (Table 54 to Table 63). 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 54 to Table 63). The methods technical document provides full details of the method (WTW 2022). Box and whisker plots of water quality indicator concentrations for high flow and base-flow conditions are presented in Figure 17 to Figure 19 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 2009 for Wet Tropics Basins (DEHP 2014). 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 64 to Table 71 below.

The following scoring ranges and grading apply to freshwater basin and estuary water quality and are described in the methods technical report (WTW 2022).

- 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 54 Daintree Basin water quality monthly values and scores for 2020-21 reporting period.

High flows (>25 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jan	31	0.112	0.005	
	Feb	11	0.0745	0.005	
	Mar	14	0.09	0.004	
	Apr	32	0.095	0.005	
	May	8	0.047	0.004	
	Seasonal	14	0.090	0.005	172
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		31.2	0.098	0.005	
Condition score		90.0	90.0	55.8	
Grade		VG	VG	M	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	2	0.023	0.002	
	Aug	2	0.014	0.002	
	Sep	1	0.01	0.002	
	Oct	2	0.009	0.001	
	Nov	2	0.004	0.002	
	Dec	1	0.031	0.004	
	Jun	2	0.037	0.004	
	Seasonal	2	0.014	0.002	193
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		2	0.029	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	90.0	73.9	81.9
Grade		VG	VG	G	VG

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 55 Mossman Basin water quality monthly values and scores for 2020-21 reporting period.

Base-flows (Mossman US)	Monthly value (mg/L)	TSS	DIN	FRP
	Jul	1	0.060	0.005
	Sep	1	0.035	0.005
	Nov	1	0.080	0.010
	Jan	1	0.130	0.005
	Mar	2	0.145	0.010
	Jun	1	0.120	0.010
	Seasonal	1	0.100	0.008
GV (mg/L)		8	0.060	0.008
SF (mg/L)		74	0.261	0.013
80th %-tile (mg/L)		1	0.130	0.010
Condition score		90.0	48.8	65.0
Grade		VG	M	G

Base-flows (Mossman WWTP)	Monthly value (mg/L)	TSS	DIN	FRP
	Jul	1	0.060	0.010
	Sep	1	0.050	0.020
	Nov	2	0.140	0.040
	Jan	1	0.130	0.010
	Mar	2	0.150	0.010
	Jun	1	0.130	0.010
	Seasonal	1	0.130	0.010
GV (mg/L)		8	0.060	0.008
SF (mg/L)		74	0.261	0.013
80th %-tile (mg/L)		2	0.140	0.020
Condition score		90.0	39.7	36.5
Grade		VG	P	P

Base-flows (South Mossman)	Monthly value (mg/L)	TSS	DIN	FRP
	Jul	7	0.190	0.005
	Sep	5	0.190	0.005
	Nov	9	0.078	0.010
	Jan	8	0.260	0.010
	Mar	3	0.340	0.010
	Jun	2	0.210	0.010
	Seasonal	6	0.200	0.010
GV (mg/L)		8	0.060	0.008
SF (mg/L)		74	0.261	0.013
80th %-tile (mg/L)		8	0.260	0.010
Condition score		90.0	18.5	36.5
Grade		VG	VP	P

Base-flows (Mossman DS)	Monthly value (mg/L)	TSS	DIN	FRP
	Jul	1	0.070	0.005
	Sep	1	0.050	0.005
	Nov	4	0.090	0.010
	Jan	1	0.200	0.010
	Mar	2	0.210	0.010
	Jun	1	0.140	0.010
	Seasonal	1	0.115	0.010
GV (mg/L)		8	0.060	0.008
SF (mg/L)		74	0.261	0.013
80th %-tile (mg/L)		2	0.200	0.010
Condition score		90.0	44.2	36.5
Grade		VG	M	P

Annual (base-flows)	TSS	DIN	FRP	Nutrients
Score	90	34.9	51.8	43.3
Grade	VG	P	M	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 2022.

Table 56 Barron Basin water quality monthly values and scores for 2020-21 reporting period.

High flows (>8.2 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jan	128	0.130	0.023	
	Feb	68	0.104	0.010	
	Mar	82	0.088	0.008	
	Apr	159	0.111	0.007	
	May	7	0.114	0.005	
	Jun	10	0.160	0.012	
	Seasonal	75	0.113	0.0088	119
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		128	0.130	0.012	
Condition score		50.8	62.7	36.8	
Grade		M	G	P	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	4	0.059	0.003	
	Aug	5	0.046	0.004	
	Sep	9	0.003	0.002	
	Nov	8	0.006	0.003	
	Dec	7	0.012	0.002	
	Apr	9	0.033	0.001	
	Seasonal	7	0.023	0.003	246
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		9	0.046	0.003	
Condition score		69.5	90.0	90.0	
Grade		G	VG	VG	

Annual (high flow and base flow)	**TSS**	DIN	FRP	**Nutrients**
	63.4	81.1	72.7	76.9
	G	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 2022.

Table 57 Mulgrave Basin water quality monthly values and scores for 2020-21 reporting period.

High flows >30 m^3/s	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
High flow	July	11	0.070	0.006	
	Sep	8	0.078	0.006	
	Jan	22	0.191	0.013	
	Feb	9	0.199	0.013	
	Mar	34	0.082	0.010	
	Apr	31	0.064	0.013	
	May	6	0.288	0.006	
	Jun	37	0.155	0.010	
	Seasonal	17	0.119	0.010	127
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		33	0.196	0.013	
Condition score		90.0	59.5	30.5	
Grade		VG	M	P	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Aug	2	0.168	0.005	
	Oct	5	0.106	0.004	
	Nov	30	0.032	0.003	
	Dec	8	0.041	0.002	
	Mar	3	0.305	0.006	
	Apr	1	0.232	0.003	
	Jun	1	0.234	0.003	
	Seasonal	2.75	0.168	0.003	238
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile		7	0.234	0.005	
Condition score		90.0	28.3	90.0	
Grade		VG	P	VG	

Annual (high flow and base flow)	**TSS**	DIN	FRP	**Nutrients**
Score	90.0	39.2	69.3	54.2
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 terms and scoring method are provided in WTW 2022. The May TSS concentration for high flows coincided with rainfall very much above the average for May.

Table 58 Russell Basin water quality monthly values and scores for 2020-21 reporting period.

High flows (>39.5 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	20	0.116	0.003	
	Aug	5	0.078	0.002	
	Sep	15	0.092	0.004	
	Jan	17	0.211	0.006	
	Feb	13	0.147	0.008	
	Mar	15	0.110	0.004	
	Apr	13	0.068	0.007	
	May	11	0.084	0.003	
	June	73	0.087	0.006	
	Seasonal	15	0.092	0.004	168
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		18	0.128	0.006	
Condition score		90.0	73.0	61.0	
Grade		VG	G	G	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Aug	5	0.083	0.004	
	Oct	2	0.103	0.002	
	Nov	12	0.042	0.001	
	Dec	11	0.014	0.001	
	Apr	1	0.113	0.001	
	Jun	3	0.124	0.002	
	Seasonal	4	0.093	0.002	197
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		11	0.113	0.002	
Condition score		72.4	50.9	90.0	
Grade		G	M	VG	

Annual (high flow and base flow)	**TSS**	DIN	FRP	**Nutrients**
Score	80.5	61.1	76.7	68.9
Grade	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 2022. The May TSS concentration for high flows coincided with rainfall very much above the average for May.

Table 59 North Johnstone sub-basin water quality monthly values and scores for 2020-21 reporting period.

High flows (>31.6 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	27	0.117	0.007	
	Sep	16	0.076	0.006	
	Dec	32	0.039	0.008	
	Jan	25	0.168	0.008	
	Feb	114	0.125	0.011	
	Mar	34	0.134	0.006	
	April	24	0.149	0.007	
	Jun	4	0.090	0.003	
	Seasonal	26	0.121	0.007	220
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		33	0.143	0.008	
Condition score		90.0	58.7	45.7	
Grade		VG	M	M	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	1	0.069	0.002	
	Aug	1	0.059	0.003	
	Sep	1	0.032	0.002	
	Oct	1	0.028	0.003	
	Nov	1	0.023	0.003	
	Dec	6	0.083	0.010	
	Seasonal	1	0.046	0.003	145
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		1	0.069	0.003	
Condition score		90.0	73.3	90.0	
Grade		VG	G	VG	

Annual (high flow and base flow)	TSS	DIN	FRP	**Nutrients**
Score	90.0	64.5	63.3	63.9
Grade	VG	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 2022.

Table 60 South Johnstone sub-basin water quality monthly values and scores for 2020-21 reporting period.

High flows (>15.0 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
High flow	Jul	15	0.094	0.012	
	Sep	11	0.036	0.010	
	Dec	43	0.065	0.012	
	Jan	28	0.169	0.010	
	Feb	57	0.125	0.009	
	Mar	27	0.131	0.009	
	April	26	0.149	0.010	
	June	5	0.070	0.008	
	Seasonal	26	0.110	0.010	210
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		37	0.142	0.011	
Condition score		90.0	63.8	31.7	
Grade		VG	G	P	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	1	0.080	0.007	
	Aug	2	0.058	0.008	
	Sep	2	0.036	0.006	
	Oct	1	0.031	0.009	
	Nov	1	0.020	0.008	
	Dec	7	0.049	0.014	
	Seasonal	2	0.043	0.008	155
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		2	0.058	0.009	
Condition score		90.0	90.0	61.0	
Grade		VG	VG	G	

Annual (high flow and base flow)	**TSS**	DIN	FRP	**Nutrients**
Score	90.0	77.6	63.1	70.3
Grade	VG	G	G	G

Johnstone combined Annual (high flow and base-flow)	**TSS**	DIN	FRP	**Nutrients**
Score	90.0	74.9	44.2	59.5
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 2022.

Table 61 Tully Basin water quality monthly values and scores for 2020-21 reporting period.

High flows (>61.2 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
High flow	Jul	20	0.170	0.003	
	Sep	15	0.104	0.001	
	Jan	18	0.296	0.010	
	Feb	21	0.166	0.005	
	Mar	28	0.152	0.005	
	Apr	17	0.136	0.004	
	May	18	0.171	0.002	
	Jun	85	0.157	0.003	
	Seasonal	19	0.161	0.004	216
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		25	0.170	0.005	
Condition score		90.0	45.9	68.7	
Grade		VG	M	G	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	8	0.176	0.001	
	Aug	4	0.245	0.001	
	Oct	4	0.085	0.001	
	Nov	4	0.089	0.001	
	Dec	3	0.071	0.001	
	Seasonal	4	0.089	0.001	149
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		5	0.190	0.001	
Condition score		90.0	52.1	90.0	
Grade		VG	M	VG	

Annual (high flow and base-flow)	**TSS**	DIN	FRP	**Nutrients**
Score	90.0	48.4	77.4	62.9
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 the terms and scoring method are provided in WTW 2022.

Table 62 Murray Basin water quality monthly values and scores for 2020-21 reporting period.

High flows (>8.0 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
High flow	Jan	16	0.174	0.021	
	Feb	16	0.096	0.011	
	Mar	20	0.116	0.008	
	May	42	0.378	0.008	
	Jun	3	0.197	0.001	
	Seasonal	16	0.157	0.009	199
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		18	0.178	0.013	
Condition score		90.0	47.4	35.5	
Grade		VG	M	P	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	2	0.180	0.002	
	Aug	4	0.130	0.002	
	Sep	26	0.091	0.002	
	Oct	95	0.082	0.001	
	Nov	42	0.072	0.001	
	Dec	15	0.023	0.003	
	Seasonal	20	0.087	0.002	166
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		42	0.130	0.002	
Condition score		49.6	52.9	90.0	
Grade		M	M	VG	

Annual (high flow and base-flow)	**TSS**	DIN	FRP	**Nutrients**
Score	71.6	49.9	60.3	55.1
Grade	G	M	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 2022.

Table 63 Herbert Basin water quality monthly values and scores for 2020-21 reporting period.

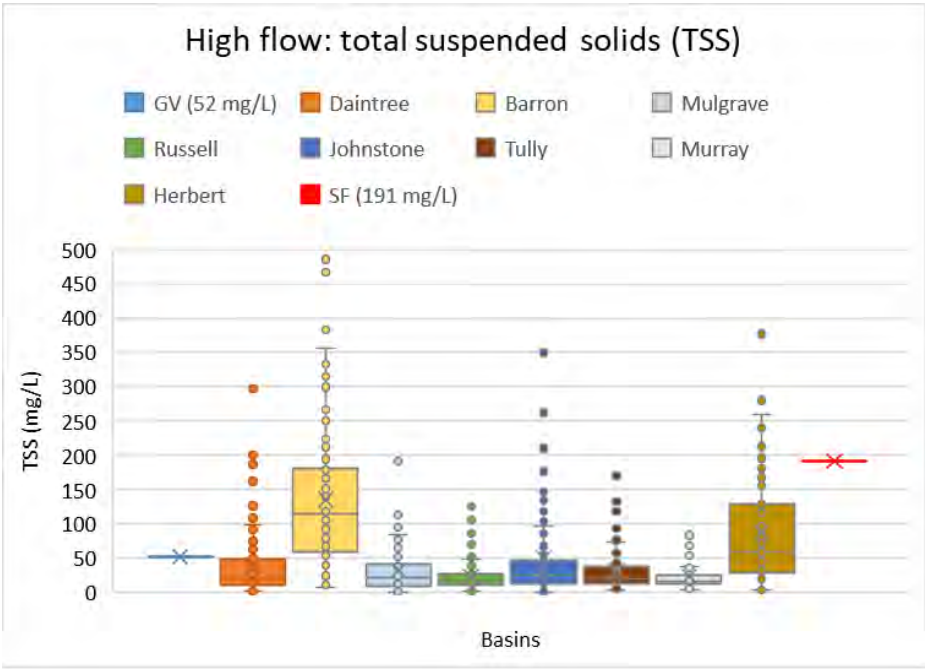
High flows (>44.2 m^3/s)	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Jul	3	0.109	0.002	
	Dec	124	0.085	0.004	
	Jan	121	0.138	0.012	
	Feb	83	0.074	0.008	
	Mar	41	0.137	0.006	
	Apr	28	0.114	0.006	
	May	7	0.193	0.003	
	Jun	4	0.181	0.001	
	Seasonal	34	0.125	0.005	176
GV (mg/L)		52	0.114	0.004	
SF (mg/L)		191	0.306	0.016	
80th %-tile (mg/L)		106	0.164	0.007	
Condition score		65.9	57.3	55.8	
Grade		G	M	M	

Base-flows	Monthly value (mg/L)	TSS	DIN	FRP	n (days)
	Aug	1	0.184	0.002	
	Sep	3	0.138	0.002	
	Oct	1	0.122	0.002	
	Nov	2	0.024	0.002	
	Dec	6	0.425	0.042	
	Apr	4	0.292	0.005	
	Seasonal	3	0.161	0.002	189
GV (mg/L)		8	0.060	0.008	
SF (mg/L)		74	0.261	0.013	
80th %-tile (mg/L)		4	0.292	0.005	
Condition score		90.0	30.3	90.0	
Grade		VG	P	VG	

Annual (high flow and base-flows)	**TSS**	DIN	FRP	**Nutrients**
Score	78.4	43.3	73.5	58.4
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 2022.

Figure 17 to Figure 19 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.



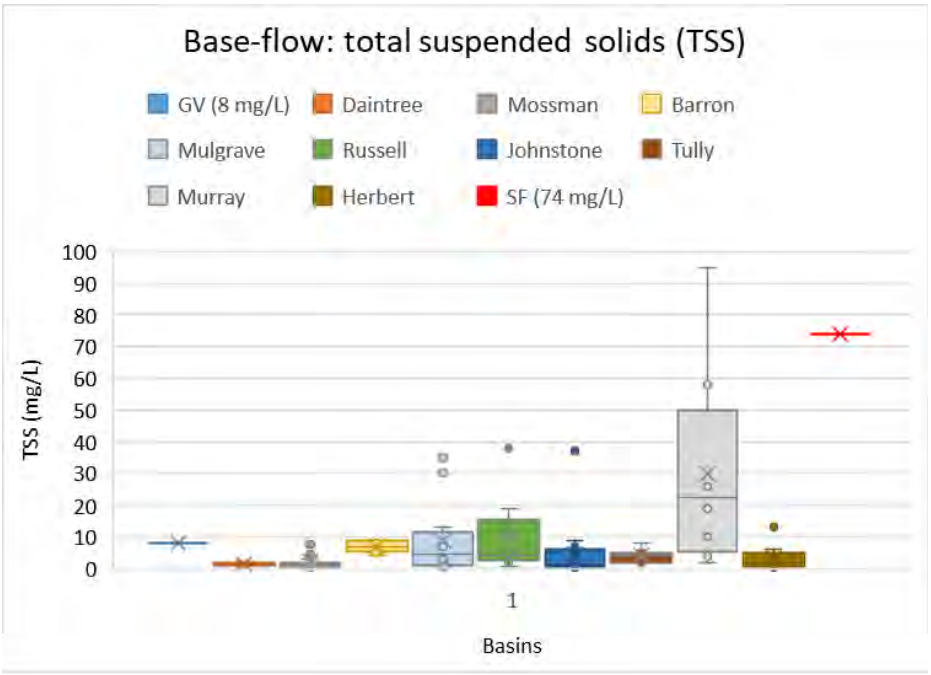
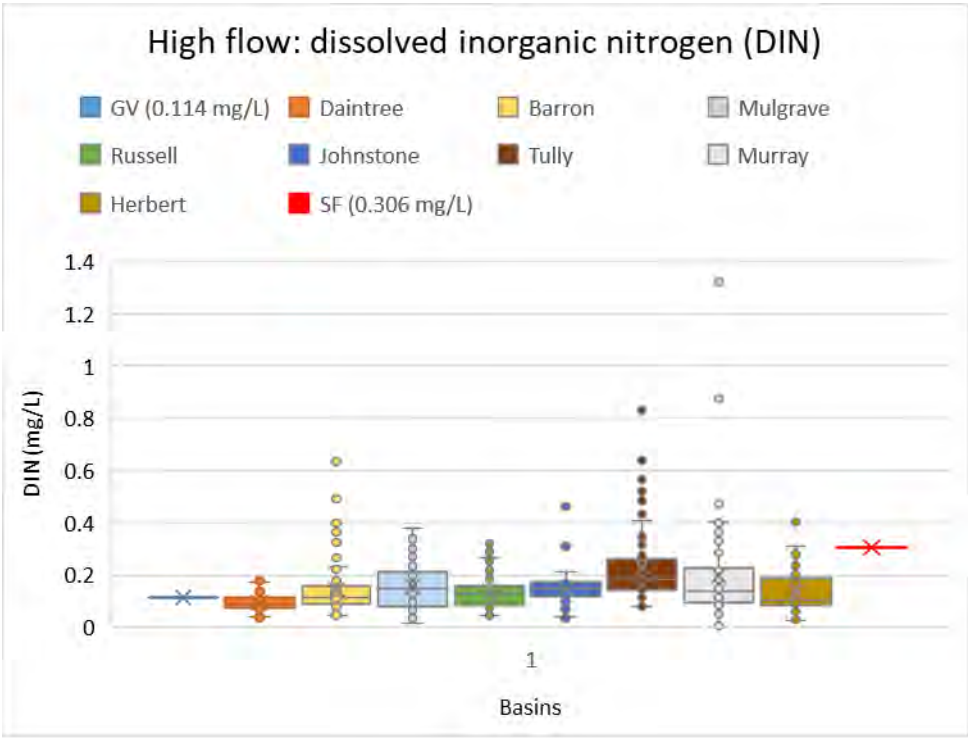


Figure 17 Box and whisker plots of total suspended solids (TSS) concentrations for base-flow and high flow conditions of basins. The mid-line is the median, the cross is the mean, the box depicts the upper and lower quartiles with 1.5 IQR (interquartile range) whiskers and outliers are above or below 1.5 IQR. The guideline value (GV) and scaling factor (SF) are presented.



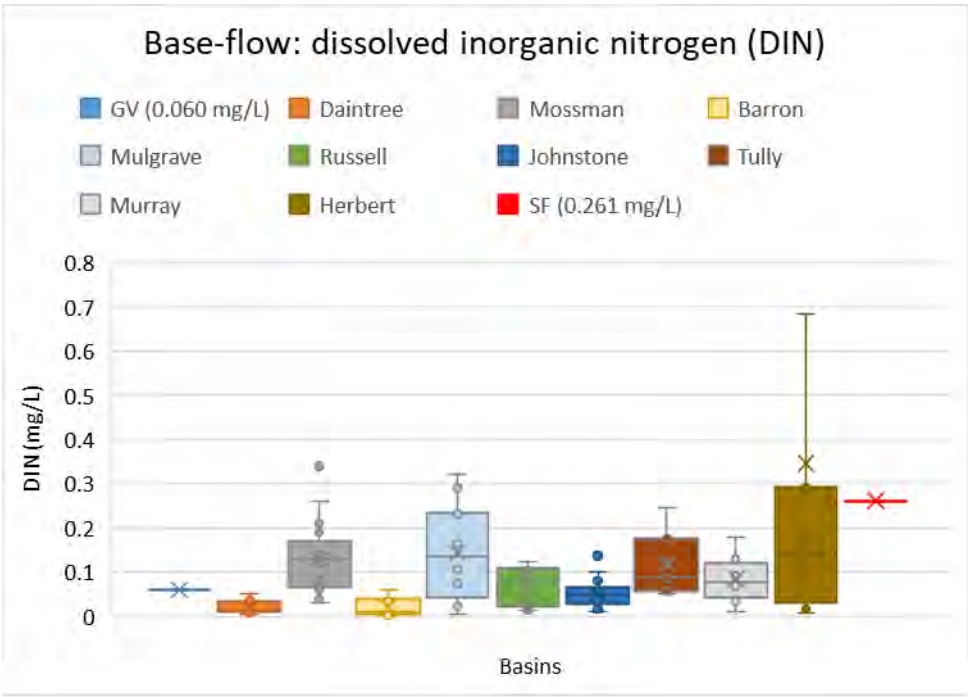


Figure 18 Box and whisker plots of dissolved inorganic nitrogen (DIN) concentrations for base-flow and high flow conditions of basins. The mid-line is the median, the cross is the mean, the box depicts the upper and lower quartiles with 1.5 IQR (interquartile range) whiskers and outliers are above or below 1.5 IQR. The guideline value (GV) and scaling factor (SF) are presented. The base-flow data included an outlier value of 2.04 mg/L DIN for the Herbert which is not shown in the plot.

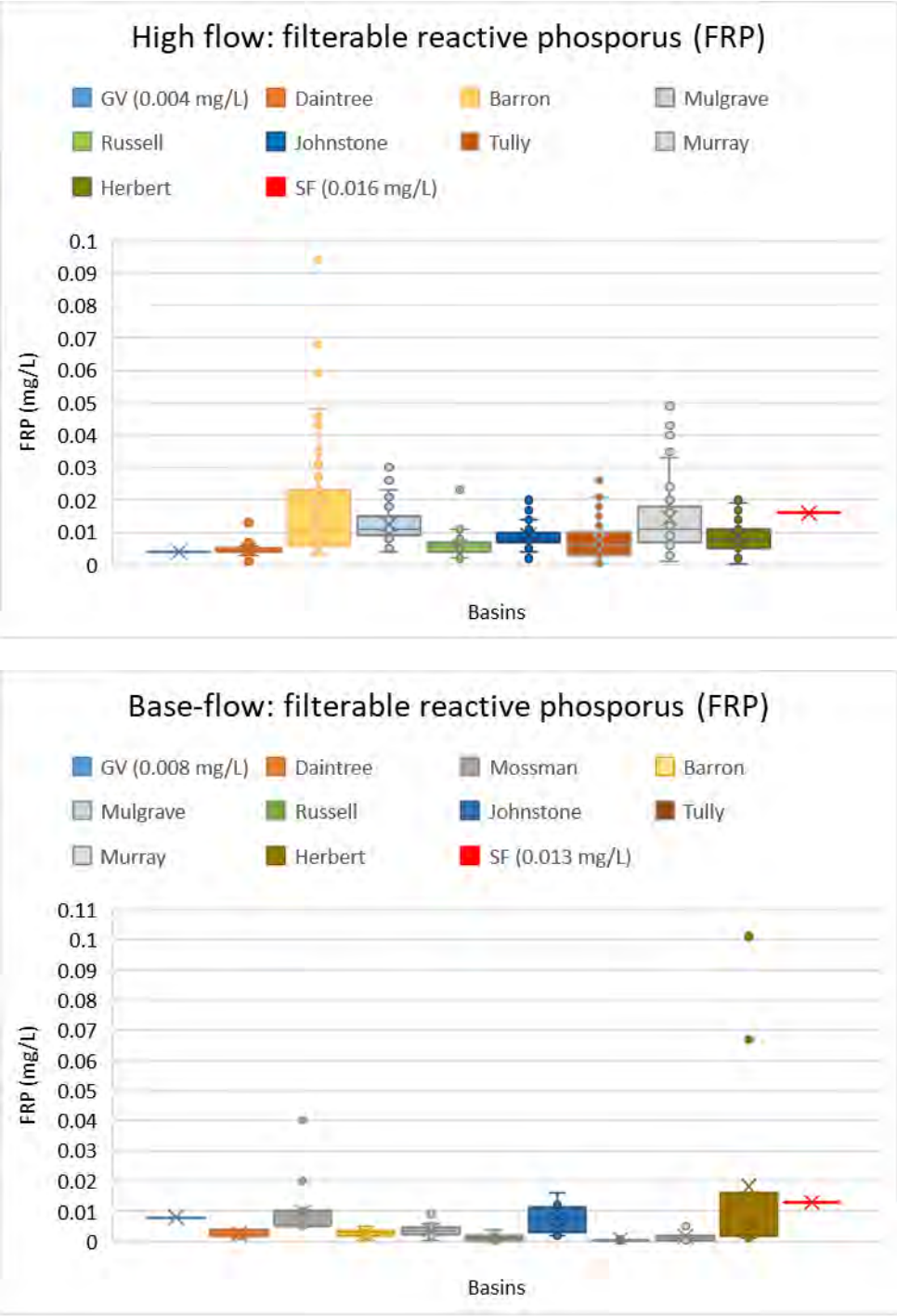


Figure 19 Box and whisker plots of filterable reactive phosphorus (FRP) concentrations for base-flow and high flow conditions of basins. The mid-line is the median, the cross is the mean, the box depicts the upper and lower quartiles with 1.5 IQR (interquartile range) whiskers and outliers are above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

Table 64 Daintree estuary 2020-21.

Mid-estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual Median	1.9	0.026	0.003	4.3	85.9	85.9
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	2.8	0.047	0.003	6.4	79.0	88.4
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	90.0	78.7	90.0	90.0	78.1	90.0
Grade	VG	G	VG	VG	G	VG
n	30	30	30	30	30	30

Enclosed coastal

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual Median	0.9	0.002	0.001	1.7	96.4	96.4
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	2.2	0.003	0.001	8.7	94.4	98.2
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	77.8	90.0	90.0	90.0	90.0	90.0
Grade	G	VG	VG	VG	VG	VG
n	10	10	10	10	10	10

Total estuary

	Chl *a*	DIN	FRP	**Nutrients**	Turbid-ity	DO Low	DO High	**Phys/ Chem**	**Pest-icides**	**WQ**
Score	87.0	81.5	90.0	85.8	90.0	81.1	90.0	85.5	94.0	88.1
Grade	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG

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 2022. 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 65 Dickson Inlet 2020-21.

Mid-estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	1.8	0.033	nd	2.8	85.5	85.5
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	2.7	0.048	n.d.	4.8	82.2	99.3
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	90.0	77.0	nd	90.0	90.0	90.0
Grade	VG	G		VG	VG	VG
n	18	18	-	18	18	18

Lower estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	0.9	0.023	nd	1.9	97.9	97.9
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	2.3	0.049	nd	2.5	92.5	102.7
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	76.9	62.9	nd	90.0	90.0	90.0
Grade	G	G		VG	VG	VG
n	12	12	-	12	12	12

Total estuary

	Chl *a*	DIN	FRP	**Nutrients**	Turbidity	DO Low	DO High	**Phys/ Chem**	**Pest-icides**	**WQ**
Score	84.8	71.4	nd	71.4	90.0	90.0	90.0	90.0	nd	82.1
Grade	VG	G		G	VG	VG	VG	VG		VG

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 2022. Condition scores weighted according to proportion of samples located in each water type: for nutrients, chlorophyll *a* and phys-chem mid-estuary = 0.6 and lower estuary = 0.4. nd indicates no data or insufficient data available.

Table 66 Barron estuary 2020-21.

Mid-estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	1.8	0.089	0.004	5.1	80.9	80.9
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	3.2	0.119	0.0064	7.0	76.7	87.3
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	78.2	43.6	69.3	90.0	65.1	90.0
Grade	G	M	G	VG	G	VG
n	22	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	2.1	0.037	0.002	6.5	87.5	87.5
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	2.9	0.078	0.002	10.0	81.7	93.3
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	59.9	56.7	90.0	90.0	69.6	90.0
Grade	M	M	VG	VG	G	VG
n	4	6	6	6	6	6

Total estuary

	Chl *a*	DIN	FRP	**Nutrients**	Turbidity	DO Low	DO High	**Phys/ Chem**	**Pest-icides**	**WQ**
Score	74.5	46.2	73.4	59.8	90.0	66.0	90.0	78.0	nd	70.8
Grade	G	M	G	M	VG	G	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 2022. 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 67 Trinity Inlet 2020-21.

Mid-estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	2.2	0.019	0.001	2.8	65.3	65.3
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	3.9	0.042	0.001	4.1	57.4	69.5
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	70.4	90.0	90.0	90.0	31.1	90.0
Grade	G	VG	VG	VG	P	VG
n	48	48	48	48	48	48

Total estuary

	Chl *a*	DIN	FRP	**Nutrients**	Turbidity	DO Low	DO High	**Phys/ Chem**	**Pest-icides**	**WQ**
Score	70.4	90.0	90.0	90.0	90.0	31.1	90.0	60.5	nd	73.6
Grade	G	VG	VG	VG	VG	P	VG	M		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 2022. nd indicates non data or insufficient data available.

Table 68 Russell-Mulgrave 2020-21.

Mid-estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual Median	0.5	0.057	0.002	2.0	85.9	85.9
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	1.3	0.091	0.003	3.0	82.1	87.9
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	90.0	56.2	90.0	90.0	90.0	90.0
Grade	VG	M	VG	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	0.5	0.053	0.002	2.6	83.9	83.9
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	1.1	0.126	0.003	4.2	82.6	91.5
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	90.0	51.2	90.0	90.0	58.9	90.0
Grade	VG	M	VG	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	90.0	52.8	90.0	71.4	90.0	69.3	90.0	79.6	75.6	79.2
Grade	VG	M	VG	G	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 2022. Condition scores weighted according to proportion of samples located in each water type: for mid-estuary, chlorophyll *a* = 0.3, nutrients and phys-chem = 0.33; for lower estuary chlorophyll *a* = 0.7, nutrients and phys-chem = 0.67.

Table 69 Johnstone estuary 2020-21.

Mid-estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	1.1	0.105	0.004	nd	88.2	88.2
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	1.4	0.163	0.0060	nd	82.0	100.0
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	90.0	37.3	71.0	nd	90.0	90.0
Grade	VG	P	G		VG	VG
n	11	38	38	-	14	14

Total estuary

	Chl *a*	DIN	FRP	**Nutrients**	Turbidity	DO Low	DO High	**Phys/ Chem**	**Pest-icides**	**WQ**
Score	90.0	37.3	71.0	54.1	nd	90.0	90.0	90.0	75.2	77.3
Grade	VG	P	G	M		VG	VG	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 2022. nd indicates no data or insufficient data available. nd indicates non data or insufficient data available.

Table 70 Moresby estuary 2020-21.

Mid-estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	2.4	0.008	0.001	1.9	84.0	84.0
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	0.106	0.0010	5.6	69.1	91.5
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	71.0	68.6	90.0	90.0	66.3	90.0
Grade	G	G	VG	VG	G	VG
n	49	48	48	45	50	50

Lower Estuary

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual median	2.1	0.003	0.001	1.1	94.9	94.9
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	2.8	0.004	0.001	5.8	93.4	97.6
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	58.6	90.0	90.0	90.0	90.0	90.0
Grade	M	VG	VG	VG	VG	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	69.7	70.9	90.0	80.5	90.0	68.9	90.0	79.4	nd	76.5
Grade	G	G	VG	G	VG	G	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 2022. nd indicates non data or insufficient data available.

Table 71 Hinchinbrook Channel 2020-21.

Enclosed coastal

	Chl *a* (µg/L)	DIN (mg/L)	FRP (mg/L)	Turbidity (NTU)	DO low (% sat.)	DO high (% sat.)
Annual Median	1.7	0.003	0.001	2.0	90.7	90.7
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	3.5	0.010	0.001	4.9	84.2	95.4
	Chl *a*	DIN	FRP	Turbidity	DO low	DO high
Condition score	64.2	90.0	90.0	90.0	78.5	90.0
Grade	G	VG	VG	VG	G	VG
n	31	31	31	31	31	31

Total estuary

	Chl *a*	DIN	FRP	**Nutrients**	Turbidity	DO Low	DO High	**Phys/ Chem**	**Pest-icides**	**WQ**
Score	64.2	90.0	90.0	90.0	90.0	78.5	90.0	84.2	nd	79.5
Grade	G	VG	VG	VG	VG	G	VG	G		VG

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 2022. nd indicates non data or insufficient data available.

Trinity Inlet: dissolved oxygen

The spatial variation of dissolved oxygen saturation in Trinity Inlet was assessed using data sets provided from long-term monitoring by Queensland Department of Environment and Science (DES) and from receiving environment monitoring (REMP) by Cairns Regional Council (CRC). Dissolved oxygen saturation was presented for the complete time series at each site with minimum (Min), maximum (Max), median and mean values, number of samples (n), and the years for which monitoring started and ended for the DES long-term monitoring (Table 72) and the CRC REMP (Table 73).

The median value of dissolved oxygen percent saturation at each site was categorised using colour coding to correspond with report card grades for the mid estuary water type of Trinity Inlet where a median that meets the guideline value of 80% is 'good' or 'very good', a median of 70% to less than 80% is 'moderate', and a median of 60% to less than 70% is 'poor' (Table 74).

Table 72 DES long-term monitoring sites and dissolved oxygen percent saturation summary data.

Site	n	Min	Max	Median	Mean	Start	End
Trinity Inlet 3.9km d/s from mouth grid reference 703323	84	74.8	105.3	94.6	93.5	18/07/1978	3/06/1980
Trinity Inlet 0.0km at mouth grid reference 704285	403	44.9	112.9	88.9	88.8	24/05/1973	28/05/1999
Trinity Inlet 3.2km from mouth grid ref 707257 (station 11)	462	44	113.5	84.0	83.7	15/09/1969	30/04/1999
Smiths Creek (Trinity Inlet) grid reference 696263 (station 4)	313	44.4	113.5	81.2	81.1	15/09/1969	31/05/1990
Smiths Creek (Trinity Inlet) grid reference 693249 (station 6)	438	36.8	137.8	77.4	78.0	15/09/1969	28/05/1999
Trinity Inlet 6.1km from mouth grid reference 711230	215	41.2	98.6	76.9	76.6	15/09/1969	31/05/1990
Trinity Inlet 7.7km from mouth grid reference 703218	170	42.5	102.3	73.2	72.9	15/09/1969	31/05/1990
Smiths Creek Grid Ref 688241 13.3km Station 8 (CRC Site 2)	347	19	151.5	72.8	72.6	15/09/1969	28/05/1999
Smiths Creek (Trinity Inlet) grid reference 691211 (station 9)	309	30.1	111.9	69.3	70.2	15/09/1969	28/05/1999
Smiths Creek (Trinity Inlet) grid reference 695228	195	28	109.5	68.1	70.0	15/09/1969	28/05/1999

Table 73 Cairns Regional Council REMP sites and dissolved oxygen percent saturation summary data.

Site	n	Min	Max	Median	Mean	Start	End
1	48	42	98.9	69.95	69.6	2014	2021
2	43	48.1	92.4	67.1	68.3	2014	2021
3	48	39.5	98.7	67.15	68.0	2014	2021
4	42	45.3	95.3	64.05	65.1	2014	2021
5	43	57.1	103	75.9	76.9	2014	2021
6	43	48.6	96.9	70.6	73.6	2014	2021
7	43	50.3	96.8	67.1	67.3	2014	2021
8	43	48.3	96	64.9	66.4	2014	2021

Table 74 Dissolved oxygen percent saturation ranges and grades.

Median DO % saturation	Grade
≥ 80	Good or very good
70 - <80	Moderate
60 - <70	Poor

The site locations colour coded according to the median dissolved oxygen percent saturation are presented in Figure 20 for the DES long-term monitoring and in Figure 21 for the Cairns Regional Council REMP.

Figure 20 DES long-term monitoring sites with colour coded grading for dissolve oxygen saturation percent.

Figure 21 Cairns Regional Council REMP sites with colour coded grading for dissolved oxygen saturation percent.

The spatial coverage from the DES long-term monitoring sites demonstrates a gradient of dissolved oxygen saturation which is highest downstream of the estuary mouth and which decreases with distance upstream from the estuary mouth with lowest values at the upstream sites on the western arm. The sites for the CRC REMP are grouped in the western arm and their median dissolved oxygen saturation corresponds with this gradient. The CRC REMP sites were selected to monitor the receiving environment of the Edmonton/Southern waste-water treatment plant and are all located in the area of Trinity Inlet which is at the lower end of the dissolved oxygen saturation gradient.

Inshore Marine

The annual means of inshore water quality indicators for sites within each reporting zones are presented in Table 75. The water quality scores for reach reporting zone before standardisation are presented in Table 76.

Table 75 Inshore marine water quality annual means and number of measurements taken by grab samples for each monitoring site for 2020-21.

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	1.46	16.93	2.45	1.14		0.26	4
	C011	1.89	10.18	1.58	0.46		0.15	4
	C04	5.56	16.35	2.80	1.46		0.28	4
	C05	2.78	19.07	2.80	1.53		0.28	4
	C06	2.79	30.29	5.02	3.65		0.43	4
	C08	0.98	24.17	4.09	2.85		0.29	4
Central	RM1	2.14	22.66	1.89	0.74	1.27*	0.33#	5
	RM10	19.68	46.01	5.92	3.29	4.67*	0.76#	10
	RM3	3.91	30.25	2.46	1.00		0.28	10
	RM7	2.16	26.59	2.02	0.71	1.02*	0.30#	10
	RM8	5.19	32.40	2.86	1.53	1.42*	0.42#	10
South	TUL10 (EC)	19.28	63.84	8.30	8.78	3.64*	0.82#	12
	TUL2	2.82	27.56	2.20	1.00		0.31	11
	TUL3	5.11	33.28	3.23	2.26	3.52*	0.52#	11
	TUL5	4.72	30.26	2.73	1.83		0.33	11
	TUL6	6.14	36.51	4.17	2.86		0.39	10
	TUL8	7.26	35.94	4.33	3.22		0.41	11
Palm Is	BUR1	2.75	23.35	2.14	1.15	0.95*	0.45#	10
	BUR2	2.13	25.30	3.61	2.03	1.87*	0.39#	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 76 Inshore marine water quality indicator scores for 2020-21 without standardisation.

	Water clarity		Chlorophyll *a*	Nutrients			Pesticides
Zone	TSS	Turbidity	CHL	NO_x (µg/L)	PN (µg/L)	PP (µg/L)	% species protected
North	0.21	nd	0.66	-0.07	0.12	-0.06	nd
Central	0.53	-0.03	0.21	-0.64	-0.58	0.04	nd
South	-0.05	0.00	0.35	-0.91	-0.70	-0.21	nd
Palm	0.38	0.17	0.11	-0.28	-0.28	0.01	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.

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 77. The 2020-21 rainfall types for each basin are presented in Table 78.

Table 77 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 78 Basin rainfall type for 2020-21.

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	3	Average	1	3
Tully	3	Average	-	4
Murray	4	Wet	-	3
Herbert	4	Wet	-	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 79 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 80.

Table 79 Flow measure scores and summary scores for each flow assessment site for 2020-21.

	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
Basin: Site																		
Mossman														106				95
Mossman River at Mossman	109001A	5	5	5	5	5	5	5	5	4	5	5.0	95	106		1.00	95.0	
Barron														2015				69
Barron River at Myola	110001D	5	5	3	5	5	4	5	5	4	5	4.7	75	1945	687	0.34	25.6	
Barron River at Mareeba	110002D	5	5	4	5	4	3	5	5	1	5	4.0	61	836	555	0.28	16.8	
Barron River at Picnic Crossing	110003A	5	5	4	5	4	5	4	5	5	5	4.7	75	228	101	0.05	3.8	
Mazlin Creek at Railway Bridge	110018A	5	5	4	5	1	5	5	1	5	5	4.7	75	53	53	0.03	2.0	
Barron River at Bilwon	110020A	5	5	4	5	5	4	5	5	1	4	4.0	61	1258	422	0.21	12.8	
Barron River at Goonara Creek	110021A	5	5	5	5	4	5	5	5	5	5	5.0	95	127	127	0.06	6.0	
Freshwater Creek at Redlynch Estate	110104A	5	5	5	5	5	5	5	5	1	1	5.0	80	70	70	0.03	2.8	
Mulgrave														520				80
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	5	5	5	5	1	5	5.0	80	520	163	0.31	25.1	
Russell														354				91
Russell River at Bucklands	111101D	5	5	5	5	5	5	4	4	5	5	5.0	95	315	315	0.89	84.5	
Babinda Creek at The Boulders	111105A	4	4	5	5	5	5	4	4	5	5	4.0	61	39	39	0.11	6.7	
Johnstone														1403				96
Fisher Creek at Nerada	112002A	4	4	5	5	5	5	5	5	4	5	4.7	75	15	15	0.01	0.8	
North Johnstone River at Glen Allyn	112003A	5	5	4	5	5	5	5	5	5	5	5.0	95	165	165	0.12	11.2	
North Johnstone River at Tung Oil	112004A	5	5	5	5	5	5	5	5	5	5	5.0	100	925	745	0.53	53.1	
South Johnstone River at Upstream Central Mill	112101B	5	5	5	5	5	5	5	5	4	5	5.0	95	400	400	0.29	27.1	

	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 (km^2)	Adjusted catchment (km^2)	Proportion	Satandardised score x proportion	Aggregated score
Liverpool Creek at Upper Japoonvale	112102A	5	5	5	5	5	5	5	5	4	2	5.0	85	78	78	0.06	4.7	
Tully														1450				100
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	5	5	5	5.0	100	1450	1355	0.93	93.4	
Murray														309				78
Murray River at Upper Murray	114001A	5	5	5	5	5	5	5	5	5	4	5.0	95	156	156	0.50	48.0	
Meunga Creek at Sing's	114002A	4	4	5	5	5	5	5	4	4	1	4.0	61	153	153	0.50	30.2	
Herbert														8581				86
Herbert River at Ingham	116001F	5	5	5	5	5	5	5	5	5	5	5.0	100	8581	970	0.11	11.3	
Herbert River at Glen Eagle	116004C	5	5	4	5	5	4	5	4	5	5	4.7	75	5236	3977	0.46	34.8	
Herbert River at Abergowrie	116006B	5	5	4	5	5	5	5	5	5	5	5.0	95	7454	1868	0.22	20.7	
Gowrie Creek at Abergowrie	116008B	5	5	5	5	5	5	5	5	5	2	5.0	85	124	124	0.01	1.2	
Blencoe Creek at Blencoe Falls	116010A	5	5	4	5	5	5	4	5	5	4	4.7	75	226	226	0.03	2.0	
Millstream at Ravenshoe	116011A	5	5	5	5	5	5	5	3	4	5	5.0	90	89	89	0.01	0.9	
Cameron Creek at 8.7km	116012A	5	5	5	5	5	5	5	5	5	5	5.0	100	360	360	0.04	4.2	
Millstream at Archer Creek	116013A	4	4	4	5	5	5	5	5	1	5	4.0	61	308	219	0.03	1.6	
Wild River at Silver Valley	116014A	4	5	5	5	5	5	5	4	5	5	5.0	95	591	591	0.07	6.5	
Blunder Creek at Wooroora	116015A	5	5	5	5	5	5	5	5	1	5	5.0	80	127	127	0.01	1.2	
Rudd Creek@Gunnawarra	116016A	5	4	5	2	5	1	5	5	5	5	4.7	75	127	127	0.01	1.1	
Stone River at Running Creek	116017A	4	4	5	4	5	4	5	5	5	5	4.0	61	157	157	0.02	1.1	

Estuary: Site

	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
Barron																		75
Barron River at Myola	110001D	5	5	3	5	5	4	5	5	4	5	4.7	75	1945	1945	0.97	72.4	
Freshwater Creek at Redlynch Estate	110104A	5	5	5	5	5	5	5	5	1	1	5.0	80	70	70	0.03	2.8	
Russell-Mulgrave																		84
Mulgrave River at Peets Bridge	111007A	5	5	5	5	5	5	5	5	1	5	5.0	80	520	520	0.59	47.6	
Russell River at Bucklands	111101D	5	5	5	5	5	5	4	4	5	5	5.0	95	315	315	0.36	34.2	
Babinda Creek at The Boulders	111105A	4	4	5	5	5	5	4	4	5	5	4.0	61	39	39	0.04	2.7	
Johnstone																		98
North Johnstone River at Tung Oil	112004A	5	5	5	5	5	5	5	5	5	5	5.0	100	925	925	0.70	69.8	
South Johnstone River at Upstream Central Mill	112101B	5	5	5	5	5	5	5	5	4	5	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 80 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. Seagrass detailed results for 2020-21

The detailed results for 2020-21 seagrass reporting are presented in Table 81 for estuary zones and Table 82 for inshore zones. The detailed results which include the new resilience indicator for inshore zones, back calculated for previous years are present in Table 83 for 2019-20 and in Table 84 for 2018-19.

Table 81 Estuary seagrass scoring tables for Trinity Inlet and Moresby River 2020-21 (Source: QPSMP).

Estuary	Depth	Meadow/ Site ID	Biomass	Area	Species Composition	% Cover	Tissue nutrients	Repro-ductive effort	Overall Meadow/ Site Score	Overall Water Body Score
Trinity Inlet	Intertidal	CN20	68	15	100	NA	NA	NA	15	42
	Subtidal	CN19	86	89	0	NA	NA	NA	43	
		CN33	67	87	100	NA	NA	NA	67	
	Aggregated indicator score		74	64	67	NA	NA	NA		
Moresby	Intertidal	MH1	0	0	0	NA	NA	NA	0	18
		MH2	0	0	0	NA	NA	NA	0	
		MH3	56	14	0	NA	NA	NA	7	
		MH4	70	64	0	NA	NA	NA	32	
	Subtidal	MH5	53	58	100	NA	NA	NA	53	
	Aggregated indicator score		36	27	20	NA	NA	NA		

NA = not applicable - indicator not measured by monitoring program

Table 82 Inshore seagrass scores for the 2020-21 reporting period (Source: QPSMP and MMP).

Inshore zone	Habitat	Depth	Meadow/ Site ID	Biomass	Area	Species Composition	% Cover	Resilience	Overall Meadow/ Site Score	Overall Water Body Score
North	Coast	Intertidal	CN13	80	91	94	NA	NA	80	57
			YP1 & YP2	NA	NA	NA	92	75	83	
			CN34	66	74	85	NA	NA	66	
		Subtidal	CN11	85	90	100	NA	NA	85	
	Reef	Intertidal	GI1 & GI2	NA	NA	NA	50	69	60	
			LI1	NA	NA	NA	0	6	3	
		Subtidal	GI3	NA	NA	NA	63	87	75	
			LI2	NA	NA	NA	13	0	6	
	Aggregated indicator score			77	85	93	43	47		
South	Coast	Intertidal	LB1 & LB2	NA	NA	NA	0	23	11	40
		Subtidal	MS1 & MS2*	NA	NA	NA	100	NA	100	
	Reef	Intertidal	DI1 & DI2	NA	NA	NA	17	44	30	
			GOI#	NA	NA	NA	S	S	S	
		Subtidal	DI3	NA	NA	NA	8	30	19	
	Aggregated indicator score			NA	NA	NA	31	32		

* QPWS Drop camera. # Seagrass watch. NS = not sampled this year. NA = not applicable - indicator not measured by monitoring program.

Table 83 Seagrass results with updated MMP indicator scores back dated to 2019-20

Inshore zone	Habitat	Depth	Meadow/ Site ID	Biomass	Area	Species Composition	% Cover	Resilience	Overall Meadow/ Site Score	Overall Water Body Score
North	Coast	Intertidal	CN13	69	87	87	NA	NA	69	49
			YP1 & YP2	NA	NA	NA	79	72	75	
			CN34	62	72	75	NA	NA	62	
		Subtidal	CN11	80	92	92	NA	NA	80	
	Reef	Intertidal	GI1 & GI2	NA	NA	NA	44	65	55	
			LI1	NA	NA	NA	17	7	12	
		Subtidal	GI3	NA	NA	NA	31	34	33	
			LI2	NA	NA	NA	8	5	7	
South	Coast	Intertidal	LB1 & LB2	NA	NA	NA	0	30	15	30
		Subtidal	MS1 & MS2*	NA	NA	NA	63	NA	63	
	Reef	Intertidal	DI1 & DI2	NA	NA	NA	13	44	28	
			GOI[#]	NA	NA	NA	S	S	S	
		Subtidal	DI3	NA	NA	NA	0	30	15	

Table 84 Seagrass results with updated MMP indicator scores back dated to 2018-19

Inshore zone	Habitat	Depth	Meadow/ Site ID	Biomass	Area	Species Composition	% Cover	Resilience	Overall Meadow/ Site Score	Overall Water Body Score
North	Coast	Intertidal	CN13	53	86	61	NA	NA	53	51
			YP1 & YP2	NA	NA	NA	91	99	95	
			CN34	59	90	63	NA	NA	59	
		Subtidal	CN11	75	100	88	NA	NA	75	
	Reef	Intertidal	GI1 & GI2	NA	NA	NA	67	70	68	
			LI1	NA	NA	NA	8	7	8	
		Subtidal	GI3	NA	NA	NA	31	47	39	
			LI2	NA	NA	NA	17	5	11	
South	Coast	Intertidal	LB1 & LB2	NA	NA	NA	0	15	8	34
		Subtidal	MS1 & MS2*	NA	NA	NA	88	NA	88	
	Reef	Intertidal	DI1 & DI2	NA	NA	NA	25	42	34	
			GOI#	NA	NA	NA	S	S	S	
		Subtidal	DI3	NA	NA	NA	0	13	7	

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

Table 85 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 86 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 87 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 88 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 89 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	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	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 90 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 91 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 92 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 93 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 94 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.

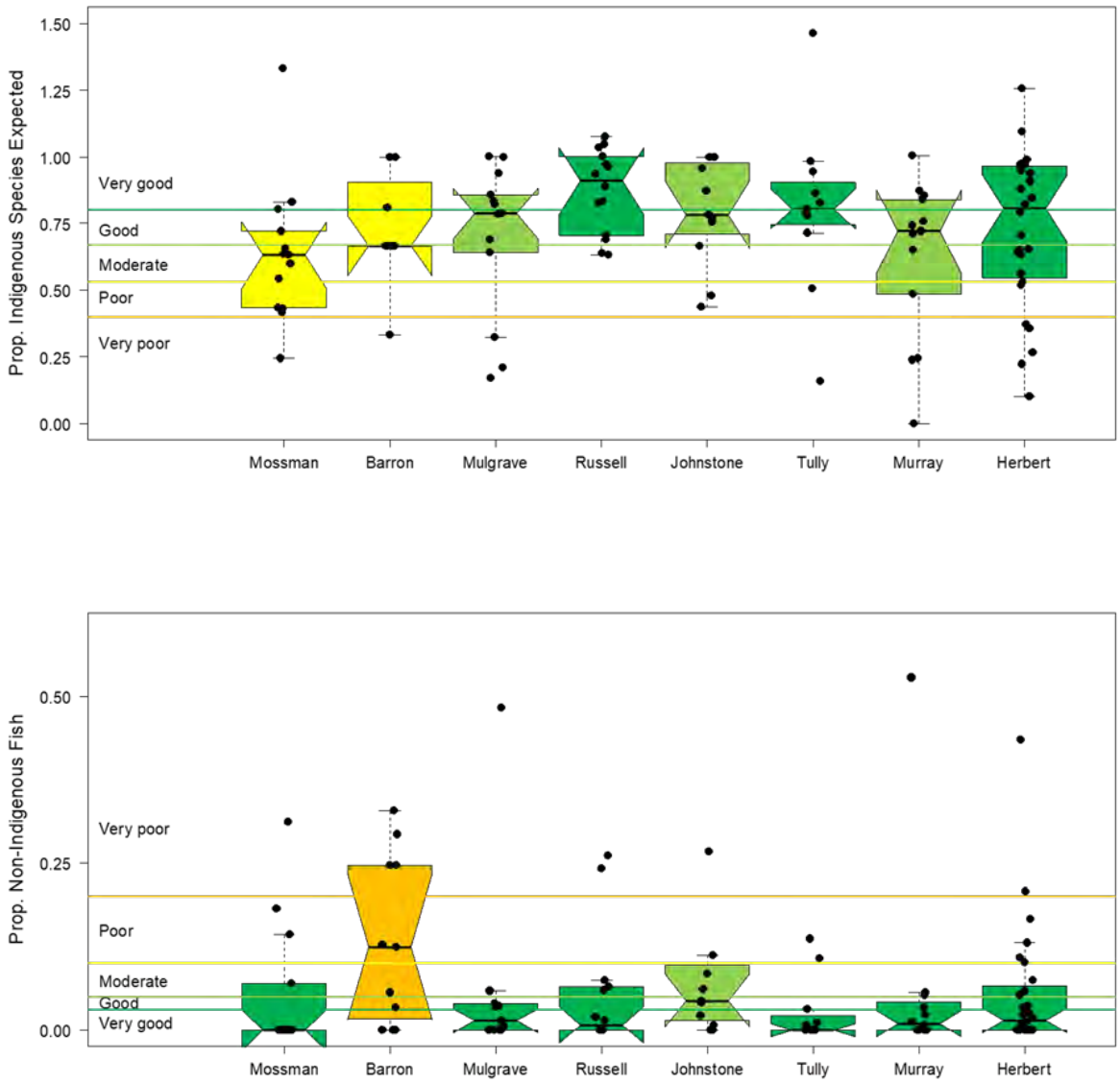


Figure 22 Box plots for sites within each basins in relation to the proportion of indigenous species expected indicator (top) and the proportion of non-indigenous fish indicator (bottom).

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 F. 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 95) 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 95.

Table 95 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	

References

ANZG, 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

Kroon, F., Hook, S.E., Jones, D., Metcalfe, S., Henderson, B., Smith, R., Warne, M.St.J., Turner, R.D., McKeown, A., Westcott, D.A. 2015, 'Altered transcription levels of endocrine associated genes in two fisheries species collected from the Great Barrier Reef catchment and lagoon', Ocean & Coastal Management, vol.104, pp. 51-61.

Warne, M. St. J., Neelamraju, C., Strauss, J., Smith, R. A., Turner, R. D., Mann, R. (in prep). Development of a Method of Determining the Toxicity of Pesticide Mixtures and a Pesticide Risk Baseline for the Reef 2050 Water Quality Improvement Plan.

WTW (Wet Tropics Waterways) 2020. Wet Tropics Report Card 2019 (reporting on data 2018-19). Waterway Environments: Methods. Wet Tropics Waterways and Terrain NRM, Cairns.

Wood, RJ, Mitrovic, SM, Lim, RP; Warne, MStJ; Dunlop, J; Kefford, BJ 2019, 'Benthic diatoms as indicators of herbicide toxicity in rivers - a new SPEcies At Risk (SPEARherbicides) index', Ecological Indicators, vol. 99, pp. 203-213.

Appendix G. Index, indicator category and indicator scores and grade tables for 2015-16 to 2018-19.

Basins

Water quality

Table 96 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. #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 97 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 98 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 99 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 100 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 101 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 102 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 103 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 104 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 105 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 106 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 107 Estuary water quality indicator, indicator category and index scores and grades for 2019-20

Estuary	Chl *a*	Nutrients			Phys/Chem				Pest-icides	WQ
	Chl *a*	DIN	FRP	**Nut-rients**	Turb-idity	DO Low	DO High	**Phys/ Chem**	Pest-icides	**19-20**
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**

Table 108 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 109 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 110 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 111 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.

Seagrass

Table 112 Results of estuary seagrass indicator for 2019-20.

Estuary	Biomass	Area	Species composition	Seagrass condition
Daintree	-^	-	-	-
Dickson Inlet	nd	nd	nd	nd
Barron	-	-	-	-
Trinity Inlet	64	68	93	54
Russell-Mulgrave	-	-	-	-
Johnstone	-	-	-	-
Moresby	38	55	41	25
Hinchinbrook Channel	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. ^ - indicates that it does not occur at the location. nd indicates no data available

Table 113 Results of estuary seagrass indicator for 2018-19.

Estuary	Biomass	Area	Species composition	Seagrass condition
Daintree	-^	-	-	-
Dickson Inlet	nd	nd	nd	nd
Barron	-	-	-	-
Trinity Inlet	86	68	67	46
Russell-Mulgrave	-	-	-	-
Johnstone	-	-	-	-
Moresby	15	43	60	8
Hinchinbrook Channel	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. ^ - indicates that it does not occur at the location. nd indicates no data available

Table 114 Results of estuary seagrass indicator for 2017-18.

Estuary	Biomass	Area	Species composition	Seagrass condition
Daintree	-^	-	-	-
Dickson Inlet	nd	nd	nd	nd
Barron	-	-	-	-
Trinity Inlet	39	36	98	31
Russell-Mulgrave	-	-	-	-
Johnstone	-	-	-	-
Moresby	0	0	0	0
Hinchinbrook Channel	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. ^ - indicates that it does not occur at the location. nd indicates no data available

Table 115 Results of estuary seagrass indicator for 2016-17.

Estuary	Biomass	Area	Species composition	Seagrass condition
Daintree	-^	-	-	-
Dickson Inlet	nd	nd	nd	nd
Barron	-	-		-
Trinity Inlet	57	30	100	30
Russell-Mulgrave	-	-	-	-
Johnstone	-	-	-	-
Moresby	13	10	50	7
Hinchinbrook Channel	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. ^ - indicates that it does not occur at the location. nd indicates no data available

Table 116 Results of estuary seagrass indicator for 2015-16.

Estuary	Biomass	Area	Species composition	Seagrass condition
Daintree	-^	-	-	-
Dickson Inlet	nd	nd	nd	nd
Barron	-	-		-
Trinity Inlet	67	31	70	21
Russell-Mulgrave	-	-	-	-
Johnstone	-	-	-	-
Moresby	13	13	20	13
Hinchinbrook Channel	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. ^ - indicates that it does not occur at the location. nd indicates no data available

Habitat and hydrology

Table 117 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	19-20
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.

Table 118 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.

Table 119 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.

Table 120 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

Table 121 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 122 Results for water quality indicators, indicator categories and index for inshore marine zones 2019-20.

Zone	Water clarity			Chl *a*	Nutrients				Pest-icides	WQ
	TSS	Tur-bidity	**Water clarity**	Chl *a*	NOx	PN	PP	**Nutrients**	Risk metric	**19-20**
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**

Table 123 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 124 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 125 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 126 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 127 Results for coral indicators and coral index for the inshore marine zones 2019-20

Inshore Zone	Juvenile	Macro-algae	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 128 Results for coral indicators and coral index for the inshore marine zones 2018-19

Inshore Zone	Juvenile	Macro-algae	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 129 Results for coral indicators and coral index for the inshore marine zones 2017-18.

Inshore Zone	Juvenile	Macro-algae	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 130 Results for coral indicators and coral index for the inshore marine zones 2016-17.

Inshore Zone	Juvenile	Macro-algae	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 131 Results for coral indicators and coral index for the inshore marine zones 2015-16.

Inshore Zone	Juvenile	Macro-algae	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 132 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

Table 133 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 134 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 135 Seagrass results for 2016-17.

Inshore zone	Biomass	Area	Species composit ion	Percent cover	Tissue nutrients	Repro-ductive 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 136 Seagrass results for the 2015-16.

Inshore zone	Biomass	Area	Species Composition	Abundance	Tissue nutrients	Repro-ductive 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 137 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 138 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 139 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 140 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 141 Results for coral indicators and coral index for the offshore marine environment 2019-20.

Coral indicators scores			Coral
Juveniles	Coral Cover	Coral Change	19-20
62	29	37	42

Table 142 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 143 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 144 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 145 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 H. Coral reef site indicator and index scores

Table 146 Inshore coral indicator and index scores (2020-21) for each site.

Zone	Reef	Depth	Comp-osition	Cover	Change	Juve-nile	Macro-algae	Coral condition
North	Snapper North	2	0	0.30	0.85	0.04	0.00	0.24
	Snapper North	5	0	0.49	0.62	0.36	0.83	0.46
	Snapper South	2	0	0.56	0.69	0.17	0.89	0.47
	Snapper South	5	0.5	0.87	0.68	0.08	0.00	0.43
	Low Isles	5	0.5	0.48	0.14	0.79	1.00	0.58
	Green	5	0.5	0.22	0.52	1.00	0.00	0.45
Central	Fitzroy East	2	0.5	0.50	0.60	0.28	1.00	0.58
	Fitzroy East	5	0	0.66	1.00	0.48	1.00	0.63
	Fitzroy West	2	1	1.00	0.87	0.51	0.91	0.86
	Fitzroy West	5	0.5	0.84	1.00	0.65	1.00	0.80
	Fitzroy West LTMP	5	1	0.77	0.82	0.68	1.00	0.85
	Franklands East	2	1	0.83	0.61	0.29	1.00	0.75
	Franklands East	5	1	0.39	0.45	0.41	0.81	0.61
	Franklands West	2	1	0.76	0.63	0.25	0.00	0.53
	Franklands West	5	1	0.77	0.38	0.25	0.00	0.48
	High East	2	0.5	0.69	0.49	0.16	0.00	0.37
	High East	5	0.5	0.69	1.00	0.20	0.94	0.67
	High West	2	0	0.79	0.30	0.23	0.91	0.45
	High West	5	0.5	0.42	0.63	0.32	1.00	0.57
South	Barnards	2	1	0.65	0.56	0.24	1.00	0.69
	Barnards	5	1	0.72	0.59	0.89	0.97	0.83
	Bedarra	2	1	0.20	0.36	0.47	0.00	0.41
	Bedarra	5	1	0.29	0.73	0.99	0.53	0.71
	Dunk North	2	0.5	0.64	0.84	1.00	0.00	0.60
	Dunk North	5	0.5	0.49	0.77	1.00	0.27	0.60
	Dunk South	2	1	0.44	0.79	0.41	0.00	0.53
	Dunk South	5	0.5	0.52	0.81	0.75	0.00	0.51
Palm Island	Havannah	2	0	0.33	0.00	0.19	0.00	0.10
	Havannah	5	1	0.53	0.71	0.33	0.00	0.51
	Havannah North	5	1	0.19	1.00	0.89	0.00	0.62
	Lady Elliot	2	1	0.30	0.22	0.27	0.00	0.36
	Lady Elliot	5	0.5	0.59	0.69	0.96	0.68	0.68
	Palms East	2	1	0.61	0.50	0.15	1.00	0.65
	Palms East	5	1	0.71	0.74	0.43	1.00	0.78
	Palms West	2	0	0.53	0.70	0.46	1.00	0.54
	Palms West	5	0	0.47	0.07	0.54	1.00	0.42
	Pandora	2	0.5	0.20	0.57	0.17	0.00	0.29
	Pandora	5	1	0.25	0.22	0.55	0.71	0.55
	Pandora North	5	0.5	0.75	0.38	0.33	0.00	0.39

Note that scores are multiplied by 100 to fit the standardised report card scoring range.

Table 147 Offshore coral indicator and index scores (2020-21) for each site.

Reef	Coral change	Coral cover	Juveniles	Coral condition
Agincourt Reef No.1	0.44	0.47	1.00	0.64
Arlington Reef	0.48	0.42	0.41	0.44
Farquarson Reef	0.43	0.14	0.60	0.39
Feather Reef	0.68	0.46	0.78	0.64
Hastings Reef	0.38	0.27	0.56	0.41
Hedley Reef	0.48	0.11	0.52	0.37
Mackay Reef	0.52	0.28	0.60	0.47
McCulloch Reef	0.06	0.27	0.66	0.33
Michaelmas Cay	0.97	0.39	0.68	0.68
Moore Reef	0.67	0.45	0.40	0.51
Opal Reef	0.55	0.14	0.37	0.35
Peart Reef	0.50	0.29	0.68	0.49
St. Crispin Reef	0.64	0.54	1.00	0.72
Taylor Reef	0.49	0.14	0.65	0.42
Thetford Reef	0.61	0.48	0.85	0.65

Note that scores are multiplied by 100 to fit the standardised report card scoring range.

Appendix I. Log of updated 2020-21

The table below lists section, page and caption number, and summary of updates for the 2020-21 results technical report to assist reviewers.

Section number and title	Page, paragraph, caption number	Summary of update
1. EXECUTIVE SUMMARY	p. iii-vii	2020-21score summary and selected key messages.
3. Climatic influences in the region	p. 9-13	Text, figures, tables and key messages.
	p.12	Sea surface heat stress updated for 2021-22
	Appendix A p. 79-80	Long-term rainfall figures.
4. Freshwater basins		
4.1.Water Quality	p. 16-22	Text, tables, figures and key messages.
	Fig.8, p.17	Murray basin land use
	Fig.10, p.20	Pesticide type detailed graph.
	Appendix B p. 81-95	Detailed results: text, tables and figures (box plots) for reference.
4.2.Habitat and Hydrology		
Invasive weeds	p.29-30	Update on frogbit
Flow	p. 30-32	Results text, tables and key messages.
	Appendix C p.108-114	Detailed results: figures and tables for reference.
Habitat and hydrology index	p. 31-32	Text, scoring and grading tables.
4.3. Fish	p. 34-36	Text, table: fish stocking and fish scoring.
4.4.Overall basin scores and grades	p.37-38	Text and table update.
5. ESTUARIES		
5.1.Water Quality	p.40-44	Text, tables, figures and key messaging.
	Appendix B p.96-103	Detailed results: tables for reference.
	Appendix B p.104-106	Trinity inlet DO assessment: text, tables, figures.
5.2.Habitat and Hydrology	p.45	Text
Shoreline mangrove habitat	p.46-47	Text, tables
Fish barriers	p.49-52	Hinchinbrook Channel update, text, table figure.
Flow	p.52-55	Results text, table and key messaging.
	Appendix C p.108-114	Detailed results: tables for reference.
Seagrass	P.53-55	Results text, table, key messaging and recommendations (messaging provided by Alex Carter).

Section number and title	Page, paragraph, caption number	Summary of update
	Appendix D p.115	Detailed results table for reference.
Habitat and hydrology index	p.56-59	Results text, and tables. Confidence update for mangrove habitat.
	Table 35, p.57	Effect of adding shoreline mangrove habitat indicator on index scores.
5.3.Overall estuary scores and grades	p.58-59	Text and table update.
6. INSHORE MARINE		
6.1.Water Quality	p.61-64	Results text, table, and key messaging
	Table 40, p.62	Effect of pesticide scores on water quality index scores.
	Appendix B p.107	Detailed results: tables for reference.
6.2.Coral	p.64-67	Results text, table and key messaging (messaging provided based on MMP report).
	Appendix H p.153	Inshore coral site list with indicator and condition index scores.
6.3.Seagrass	p.67-71	Results text, table, key messaging and recommendations (messaging provided by Alex Carter).
	Table 44 & 45, p.67-68	Report card updated with new resilience indicator, text and tables for back-calculations.
	Appendix D p.116-118	Detailed results table including back calculated years for reference.
6.4.Overall inshore marine scores and grades	p.71	Results text and table.
7 OFFSHORE MARINE		
7.1.Water Quality	p.72	No water quality reporting for 2020-21
7.2.Coral	p.72-74	Results text, tables and key messaging (messaging from LTMP monitoring results published online).
	Appendix H p.154	Offshore coral site list with indicator and condition index scores
7.3.Overall offshore marine score and grade	p.74	Results text and table.
Appendix G. Index, indicator category and indicator scores and grade tables for 2015-16 to 2019-20.	p.135-152	Results tables from all previous years.
Appendix H. Coral reef site indicator and index scores.	p. 153-154	List of inshore and offshore coral sites and their indicator and index scores.