Wet Tropics Waterways

WET TROPICS REPORT CARD 2026

WATERWAY ENVIRONMENT METHODS

REPORTING ON DATA: JULY 2024-JUNE 2025

wettropicswaterways.org.au

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

This report may be cited as: Wet Tropics Waterways 2026. Wet Tropics Report Card 2026 (reporting on data 2024-25). Waterway Environments: Methods. Wet Tropics Waterways and Terrain NRM, Cairns.

Report was compiled in March 2026.

EXECUTIVE SUMMARY

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 pilot report card with the current 'Report Card 2026' reporting on the 2024-25 year (1 July to 30 June).

The purpose of this document is to provide detailed information on the methods used to produce assessments of condition and state for the freshwater, estuarine, inshore marine and offshore marine environments. Specifically, this document describes the following.

- The data collection methods
- The scoring methods
- The confidence rating method

The indicators for basins (freshwaters) are grouped within the water quality, habitat and hydrology and fish indices. The water quality index includes sediment (total suspended solids), nutrients (dissolved inorganic nitrogen and filterable reactive phosphorus) and pesticides (22 pesticide types) as indicator categories. The habitat and hydrology index includes indicators relating to habitat modification (impoundment length and fish barriers), flow, riparian extent, wetland extent and invasive weeds. Of these indicators, fish barriers is still in development and is not reported in the Report Card 2026.

The indicators for estuaries are grouped within the water quality, habitat and hydrology and fish indices. Note that the fish index is aspirational and is not currently reported upon. The water quality index includes physical and chemical indicators (dissolved oxygen and turbidity), nutrient indicators (dissolved inorganic nitrogen and filterable reactive phosphorus) and pesticide indicators (as per basins). The habitat and hydrology index includes fish barriers, flow, riparian extent, mangrove and saltmarsh extent, shoreline mangrove habitat condition, and seagrass (above-ground biomass, meadow area and species composition) indicators. Seagrass condition is only reported for estuaries where it is known to be present.

The indicators for the inshore marine environment are grouped within the water quality, coral, seagrass and fish indices. Note that the fish index is aspirational and is not currently reported upon. The water quality index includes water clarity (total suspended solids and turbidity), nutrient (oxidised nitrogen, particulate nitrogen and particulate phosphorus) and pesticide (25 pesticide forms) indicators. The coral index includes coral cover, macroalgae cover, rate of coral cover increase, density of juvenile corals and community composition indicators. The seagrass index includes above-ground biomass, meadow area and species composition, and/or percentage cover and resilience indicators.

The indicators for the offshore marine environment are grouped within water quality (not available for 2024-25), coral, and fish indices. The coral index includes coral cover, rate of coral cover increase and density of juvenile corals indicators. Note that the fish index is aspirational and is not currently reported upon.

The locations of the Wet Tropics Report Card reporting zones for each of the four environments are presented in Figure i.

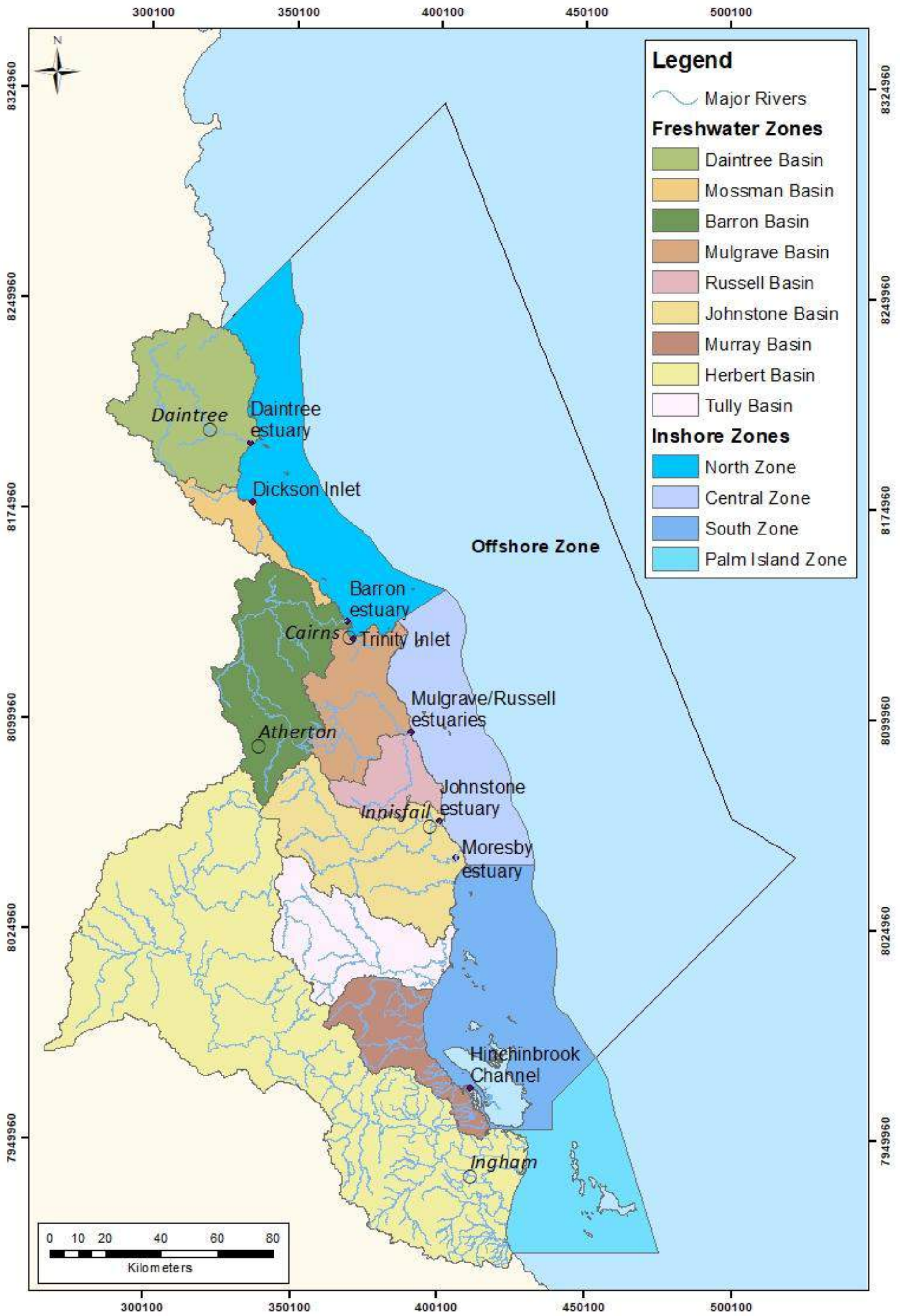


Figure ii. The location of the reporting zones for the four environments of the Wet Tropics Report Card.

The freshwater basin reporting was conducted for the nine freshwater reporting zones (Daintree, Mossman, Barron, Mulgrave, Russell, Johnstone, Tully, Murray and Herbert). Data for the water quality index was collected from Douglas Shire Council monitoring sites for the Mossman and Daintree Basin (base-flow) and by the Department of the Environment, Tourism, Science and Innovation (DETSI) Great Barrier Reef Catchment Loads Monitoring Program (GBR CLMP) sites for the Daintree, Barron, Mulgrave, Russell, Johnstone, Tully, Murray and Herbert basins. Data for the habitat and hydrology index (impoundment length, riparian extent, wetland extent and invasive weeds) was collected for all basins. Data for the habitat and hydrology flow indicator was collected for all basins except for the Daintree Basin. The fish index was reported for all basins except the Daintree.

The estuary reporting was conducted for the eight estuary reporting zones (Daintree, Dickson Inlet, Barron, Trinity Inlet, Russell-Mulgrave, Johnstone, Moresby and Hinchinbrook Channel). Data for the water quality index, excluding pesticides, was collected at DETSI monitoring sites (Daintree, Moresby and Hinchinbrook Channel), Douglas Shire Council monitoring sites (Dickson Inlet), Cairns Regional Council monitoring sites (Barron, Trinity Inlet and Russell-Mulgrave) and Cassowary Coast Regional Council monitoring sites (Johnstone). Data for pesticides was collected from the GBR CLMP site for the Daintree, Russell-Mulgrave and Johnstone estuaries. Data for the habitat and hydrology index (riparian extent, mangrove and saltmarsh extent and fish barriers) was collected for all eight estuary zones. Data for shoreline mangrove habitat condition assessments was collected from all estuary zones except for the Johnstone. Data for the flow indicator was collected for the Barron, Russell-Mulgrave and Johnstone estuaries. Data for estuarine seagrass was collected by the Queensland Ports Seagrass Monitoring Program (QPSMP) for Trinity Inlet and Moresby estuary.

The inshore marine reporting was conducted for the four inshore reporting zones (North, Central, South and Palm Island). Data for the water quality index, including pesticides, was collected from the Marine Monitoring Program (MMP) water quality monitoring sites for each zone. Data for coral was collected from the MMP and Long-term Monitoring Program (LTMP) coral monitoring sites for each zone. Data for seagrass was collected from the MMP seagrass monitoring sites (North and South zones) and QPSMP sites (North zone).

The offshore marine reporting was conducted for the single offshore reporting zone. Data for the water quality index was not available for 2024-25. Data for coral was collected from the LTMP using the sampling design updated as from 2021-22.

An overall condition grade was provided for each reporting zone within each environment (basin, estuary, inshore marine and offshore marine). Scores were averaged from the indicator level to generate indicator category scores. In some cases, for example estuary fish barriers and flow, multiple measures make up the indicator score. Where an indicator category is represented by a single indicator, the indicator category score is equal to the indicator score. Indicator categories were averaged to generate an index score, and indices were subsequently averaged to produce an overall score for an individual reporting zone in an environment. The levels of indicator aggregation and the terminology are presented in Figure i.

Scoring and aggregation were conducted by standardising all indicators into the Wet Tropics Report Card scoring range (0-100).

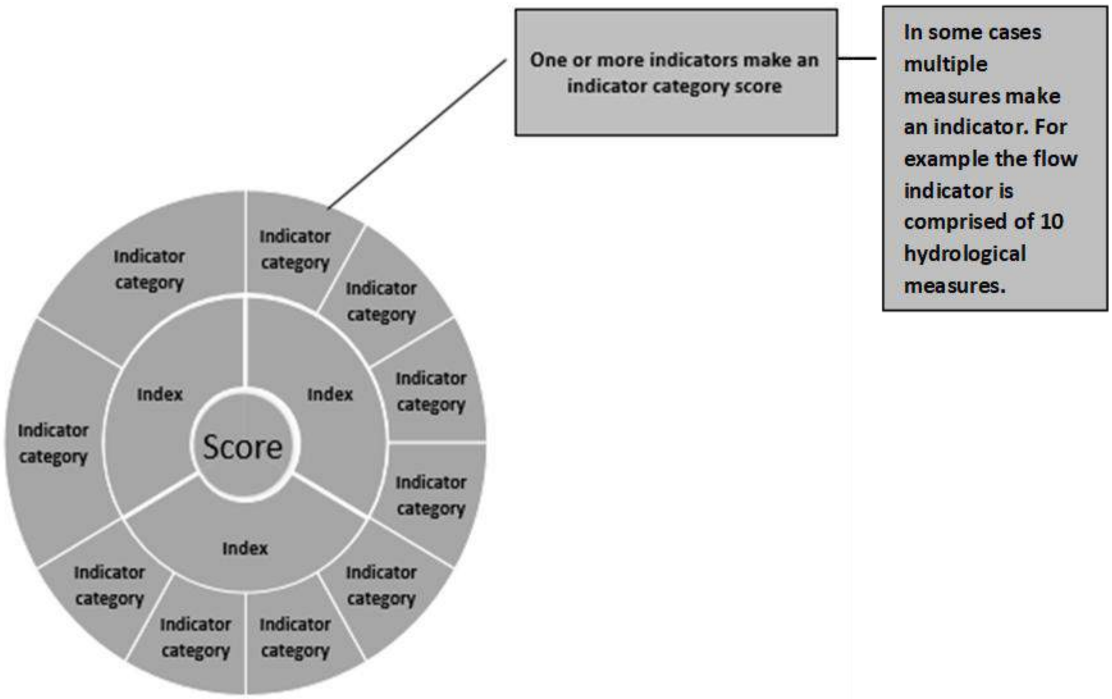


Figure ii. Terminology used for defining the level of aggregation of indicators.

The assessment results in the Report Card were rated in terms of the confidence surrounding the data used for indicators. The Wet Tropics Report Card uses the method developed for the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program for the Great Barrier Reef Report Card for estimating confidence of indicators based on five criteria (updated in 2017). The method is applied to the Wet Tropics report card indicators using revised weightings for each criteria. The confidence ratings of indicators are aggregated to provide ratings for each indicator category and index.

Contents

Terms and Acronyms xiii

1. Introduction 1

1.1. General 1

1.2. Purpose of this Document 1

1.3. Terminology 1

1.4. Indicators for waterway environments 2

2. Methods for Data Collection 4

2.1. Introduction 4

2.2. Freshwater Basins Data Collection 4

2.2.1. Water Quality 5

2.2.2. Habitat and Hydrology 8

2.2.3. Fish 13

2.3. Estuaries Data Collection 16

2.3.1. Water quality 16

2.3.2. Habitat and Hydrology Indicators 19

2.3.3. Fish 30

2.4. Inshore and Offshore Data Collection 31

2.4.1. Inshore Water Quality 32

2.4.2. Offshore Water Quality Data Collection 34

2.4.3. Inshore and Offshore Coral Data Collection 35

2.4.4. Inshore Seagrass Data Collection 37

2.4.5. Inshore and Offshore Fish Data 38

3. Condition and State Assessment Scoring Methods 39

3.1. General Scoring for Condition and State Assessments 39

3.2. Freshwater Basins and Estuaries 40

3.2.1. Water Quality – nutrient, sediment and physical-chemical indicators 40

3.2.2. Water quality - Pesticides 46

3.2.3. Habitat and Hydrology 47

3.2.4. Fish (Freshwater) 59

3.3. Inshore and Offshore Condition Assessment 60

3.3.1. Inshore Water Quality 60

3.3.2. Offshore Water Quality 62

3.3.3. Coral ... 62
3.3.4. Inshore Seagrass ... 65
3.3.5. Inshore and Offshore Fish ... 67
4. Confidence, limitations and recommendations ... 68
4.1. Confidence Associated with Results ... 68
4.1.1. Confidence Versus Uncertainty ... 68
4.1.2. Methods ... 69
4.1.3. Scoring ... 69
4.1.4. Assessment of representativeness for the flow indicator ... 71
5. References ... 73
APPENDIX A Estuarine Water Quality Monitoring Site Maps ... 78
APPENDIX B Estuarine Riparian Extent Assessment Area Maps ... 82
APPENDIX C Estuarine Mangrove and Salt Marsh Extent Maps ... 86
APPENDIX D Monitoring sites for inshore marine zones. ... 94
APPENDIX E Flow indicator ecological assets and flow measures. ... 99
APPENDIX F Basin fish assessment survey dates and sites. ... 102
APPENDIX G Log of updates for 2024-25. ... 122

FIGURES

Figure 1 Terminology used for defining the level of aggregation of indicators. 2
Figure 2 Freshwater basin reporting zones and water quality monitoring site locations for the Report Card. 4
Figure 3 Daintree water quality monitoring sites showing location of GBRCLMP site used for high flow monitoring and DSC (Douglas Shire Council) site used for base-flow monitoring. 6
Figure 4 Mossman Basin water quality monitoring sites. Sites were monitored by the Douglas Shire Council as part of their Environmental Impact Monitoring Program and additional water quality monitoring was also conducted by the Department of Environment and Science. GBR CLMP pesticide monitoring was conducted at MR5. 6
Figure 5 Location of estuary reporting zones. 16
Figure 6 Russell-Mulgrave estuary water quality monitoring sites and water type. 18
Figure 7 Estuary seagrass QPSMP monitoring meadows for Trinity Inlet (top) and Moresby estuary (bottom). 26
Figure 8 Fish barrier remediation work locations in the assessment area for the Hinchinbrook Channel estuary. 28
Figure 9 Diagram of the three fish barrier indicators and how they are calculated. 30
Figure 10 Reporting zones and monitoring sites for the inshore and offshore marine environments. 31
Figure 11. An example of how water quality grades are assigned. Where the middle point represents the annual median, the top whisker the 80th percentile and the bottom whisker the 20th percentile of the data. Only when the median meets or is better than the guideline (in this case below the guideline) can good or very good be scored. Scores for moderate, poor and very poor are equally scaled between the guideline and scaling factor. 41
Figure 12 Rainfall for the Barron Basin and flow records for Mareeba and Picnic Crossing for 2017-18. 53
Figure 13 DES estuary water quality monitoring sites and the DES GBR CLMP monitoring site for pesticides in the Daintree estuary. 78
Figure 14 Douglas Shire Council water quality monitoring sites in the Dickson Inlet estuary. 78
Figure 15 Cairns Regional Council water quality monitoring sites at the Barron estuary. 79
Figure 16 Cairns Regional Council water quality monitoring sites (sites 1 to 8 and DETSI sites EHP1, 2 and 3) at the Trinity Inlet estuary. 79
Figure 17 Cairns Regional Council water quality monitoring sites (Mul EHP1, Mulgrave Site 6, Russ EHP1 and Babinda Ck Site 7) and DES GBR CLMP monitoring sites for pesticides (Mulgrave River at Deeral and Russell River at East Russell)) at the Russell-Mulgrave estuary. 80
Figure 18. Cassowary Coast Regional Council water quality monitoring sites and the DES GBR CLMP Coquette Point site (CLMP) at the Johnstone estuary. 80
Figure 19 DES water quality monitoring sites in the Moresby estuary. 81
Figure 20 DES water quality monitoring sites in the Hinchinbrook Channel. 81
Figure 21 Daintree estuary riparian extent assessment area. 82
Figure 22 Dickson Inlet estuary riparian extent assessment area. 82
Figure 23 Barron estuary riparian extent assessment area. 83
Figure 24 Trinity Inlet estuary riparian extent assessment area. 83
Figure 25 Russell-Mulgrave estuary riparian extent assessment area. 84
Figure 26 Johnstone estuary riparian extent assessment area. 84
Figure 27 Moresby estuary riparian extent assessment area. 85
Figure 28 Hinchinbrook Channel estuary riparian extent assessment area. 85

Figure 29 Daintree estuary mangrove and salt marsh extent assessment area (shown by the orange line) and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom). 86
Figure 30 Dickson Inlet estuary mangrove and salt marsh extent assessment area (shown by the orange line) and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom). 87
Figure 31 Barron estuary mangrove and salt marsh extent assessment area (shown by the orange line) and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom). 88
Figure 32 Trinity Inlet estuary mangrove and salt marsh extent assessment area (shown by the orange line) and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom). 89
Figure 33 Russell-Mulgrave estuary mangrove and salt marsh extent assessment (shown by the orange line) area and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom). 90
Figure 34 Johnstone estuary mangrove and salt marsh extent assessment (shown by the orange line) area and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom). 91
Figure 35 Moresby estuary mangrove and salt marsh extent assessment area (shown by the orange line) and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom). 92
Figure 36 Hinchinbrook Channel estuary mangrove and salt marsh extent assessment (shown by the orange line) area and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom). 93
Figure 37 Pesticide monitoring locations of passive samplers. From north to south: Low Isles, High Island, Dunk Island and Lucinda. 94
Figure 38 Water quality, seagrass and coral monitoring sites for the inshore North zone. Water quality sites are labelled with site code. 95
Figure 39 Water quality and coral monitoring sites for the inshore Central zone. Water quality sites are labelled with site code. 96
Figure 40 Water quality, seagrass and coral monitoring sites for the inshore South zone. Water quality sites are labelled with site code. 97
Figure 41 Water quality and coral monitoring sites for the inshore Palm Island zone. Water quality sites are labelled with site code. 98
Figure 42 Daintree Basin fish assessment sites surveyed for the 2023-24 reporting period. 113
Figure 43 Mossman Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and the 2023-24 reporting period (bottom). 114
Figure 44 Barron Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and the 2023-24 reporting period (bottom). 115
Figure 45 Mulgrave Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and the 2023-24 reporting period (bottom). 116
Figure 46 Russell Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and the 2023-24 reporting period (bottom). 117
Figure 47 Johnstone Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and the 2023-24 reporting period (bottom). 118
Figure 48 Tully Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and the 2023-24 reporting period (bottom). 119

Figure 49 Murray Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and the 2023-24 reporting period (bottom). 120
Figure 50 Herbert Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and sites survey for the 2022-23 reporting period (bottom). 121

TABLES

Table 1 Indices, indicator categories and indicators used for scoring environmental state and condition of the four waterway environments (basins, estuaries, inshore marine and offshore marine). 2
Table 2 Water quality monitoring sites, the variables measured at each site that are used for Wet Tropics Report Card scoring and the percent (%) of basin upstream of the sites. 5
Table 3 Pesticides, their type and mode of action (MoA) that are included in pesticide mixture risk metric. Not all of the listed pesticides were necessarily detected in all collected water samples. 7
Table 4 Flow assessment sites with Queensland Government gauging station number (GS no.) used for the flow indicator within each basin. 9
Table 5 Rainfall data site details. 10
Table 6 The number of fish assessment sites used for calculating the indicator scores and the month and year of the fish surveys. 15
Table 7 Estuary monitoring programs with indicators, sample frequency, site numbers and water type for 2024-25. 17
Table 8 Months that water quality monitoring was conducted for each estuary during 2024-25. 18
Table 9 Electrical conductivity measurements for 2022-23 at the new Mulgrave River site (Mul EHP1) 19
Table 10 Shoreline mangrove habitat condition surveys and assessments for estuary reporting zones. 22
Table 11 Estuary zone and flow assessment sites with Queensland Government gauging station number (GS no.) used for the flow indicator within each estuary. 24
Table 12 QPSMP seagrass monitoring meadows by habitat and location for estuarine reporting zones. 25
Table 13 Basin, waterway, site name, barrier type, remediation works, and latitude and longitude for the fish barrier remediation work sites in the Hinchinbrook Channel estuary fish barrier assessment area. 29
Table 14 MMP water quality monitoring sites for the Wet Tropics showing data source, water type for application of guideline values (GVs): mid-shelf (MS), open coastal (OC), enclosed coastal (EC), reporting zones, site name and code, and sample type. 32
Table 15 Pesticide passive sampler site locations and deployment dates and duration. 33
Table 16 Pesticides analysed from inshore marine passive samplers 34
Table 17 Inshore coral annual survey sites. 35
Table 18 Reefs that are no longer included in the LTMP coral surveys. 36
Table 19 MMP seagrass monitoring locations sites and habitat for inshore zones. 37
Table 20 QPSMP seagrass monitoring meadows by water body, habitat and location for the inshore zones. 38
Table 21. Standardised scoring ranges and corresponding condition grades. 39
Table 22 Shared and similar scoring and assessment methods for indicators of the basin and estuarine environments. 40

Table 23 Rules, formula and scoring ranges and associated grades for nutrients, sediments and physico-chemical indicators in freshwater basins and estuaries of the Report Card, when to meet a guideline, values must be lower than the guideline. 42
Table 24 Rules, formula and scoring ranges and associated grades for nutrients, sediments and physico-chemical indicators in freshwater basins and estuaries, when to meet a guideline, values must be higher than the guideline (lower DO). 42
Table 25 Mean daily base-flow values for each GBR CLMP monitoring site. 43
Table 26 Scaling factors (SF) for calculating condition for basin water quality indicators. 44
Table 27 Scaling factors for calculating condition for estuary water quality indicators. 44
Table 28 Scheduled water quality guideline values for Wet Tropics basins. 45
Table 29 Water quality guideline values for Wet Tropics moderately disturbed estuarine waters. 45
Table 30 Mossman Basin monitoring sites adjusted catchment area and proportion of total upstream catchment area. 46
Table 31. Grading description for the pesticides risk assessments. 47
Table 32. Grading description for the impoundment length indicator for freshwater basins. 47
Table 33 Scoring range and subsequent score assigned for the barrier density indicator. 48
Table 34 Scoring ranges and score assigned for 'stream length to the first barrier as a proportion (%) of total stream length'. 48
Table 35 Scoring ranges and score assigned for 'stream length to the first low/no transparency/passability barrier as a proportion (%) of total stream length'. 48
Table 36 Overall fish barrier condition scoring range and fish barrier condition rating. 49
Table 37 The 10 flow measures used for the flow indicator, the season to which they apply and the hydrologic definition of the measure. 50
Table 38 The benchmark measures for all the flow measures expressed as standard deviations from the mean and approximate percentiles. 50
Table 39 Standardisation formula for 30th percentile scores of flow assessment sites. 51
Table 40 Scoring ranges, grades and aggregation formula for the riparian, wetland and mangrove/saltmarsh habitat extent indicators in freshwater basin and estuary assessments. 54
Table 41 Descriptions and scoring procedures for the shoreline mangrove habitat condition indicator. 55
Table 42. Grading description for invasive weeds in the freshwater basin assessments 2019-20. 58
Table 43 Rating scheme for the proportion of indigenous fish species (POISE) indicator for freshwater fish communities. 59
Table 44 Rating scheme for the proportion of non-indigenous fish species (PONI) indicator for freshwater fish communities. 59
Table 45 Water quality guidelines for inshore zone waters. 60
Table 46. Inshore water quality scoring ranges, grades and scaling for aggregation. 61
Table 47. Relationship of selected indices, indicator categories and indicators. 62
Table 48. GBRMPA guideline values to assess the offshore water quality indicators. 62
Table 49. Threshold values for the condition assessment of coral. 64
Table 50. Scoring ranges for aggregated coral results. 64
Table 51. Seagrass abundance (% cover) scoring thresholds in relation to condition grades (low = 10^{th} or 20^{th} percentile guideline). Source McKenzie *et al.* 2015. 65
Table 52. Seagrass sites grouped and graded according to resistance and reproductive qualities of resilience and the corresponding standardised scoring ranges and grades. Source Collier *et al*. 2021. 65
Table 53 Threshold levels for grading seagrass indicators for various meadow classes relative to the baseline. Upwards/ downwards arrows are included where a change in condition has occurred in any

of the three condition indicators (biomass, area, species composition) from the previous year (Source: Carter *et al.* 2016).......... 66
Table 54 Score range and grading colours used for QPSMP report cards.......... 67
Table 55 Scoring matrix for each criterion used to assess confidence.......... 70
Table 56 Confidence ranking. 71
Table 57 Number of gauging station (GS) sites in South East Queensland catchments based on catchment area. 71
Table 58 Terms used for determining representativeness for basins and estuaries.......... 72
Table 59 Summary of Ecological Assets and key flow events to meet flow requirements. 99
Table 60 Measure types for assessing hydrological measures relevant to ecological assets and key ecosystem components and processes. 100
Table 61 Selected flow measures used for the flow indicator.......... 101
Table 62 List of fish assessment sites for each basin with site code, site location and waterway, and year of survey.......... 102

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.
CCRC	Cassowary Coast Regional Council
Chl-*a*	Chlorophyll-*a*: a measure used to estimate phytoplankton biomass. It is widely considered a useful proxy for measuring nutrient availability and the productivity of a system.
CRC	Cairns Regional Council
DDL	Declared Downstream Limit
DEHP	Department of Environment and Heritage Protection, Queensland. Now part of DES.
DETSI	Department of the Environment, Tourism Science and Innovation, Queensland
Diadromous	Of fish: species with life cycles that require migration between freshwater and saltwater environments.
DIN	Dissolved Inorganic Nitrogen
DO	Dissolved Oxygen
Driver	An overarching cause of change in the environment
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.
EC	Enclosed coastal marine water body
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 evaluated, and included in the ecosystem health assessment (coasters). Inclusion in the Report Card will contribute to an understanding 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
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 'in-stream habitat modification' indicator for freshwater basins in the region. This index reports on the proportion (%) of the linear length of the main river channel when inundated at the Full Supply Level of an artificial in-stream structures such as dams and weirs
Index (for scoring)	Is generated by indicator categories (e.g. water quality made up of nutrients, water clarity, chlorophyll-*a* and pesticides)
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	The Integrated Water Quantity and Quality Model – used to model pre-development flow for the flow tool score calculations.
JCU	James Cook University
LAT	Lowest astronomical tide
LTMP	Australian Institute of Marine Science Long-term Monitoring Program
Macroalgae (cover)	An indicator used in part to assess coral health. Macroalgae is a collective term used for large fleshy seaweeds and other benthic (attached to the bottom) marine algae that are generally visible to the naked eye.
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 Great Barrier Reef monitoring program, led by GBRMPA, JCU and AIMS. This provides water quality, coral and seagrass data for the inshore zones of the report card.

MoA	The mode of action is used to classify pesticides according to how they exert their effect on the target organism. The mode of action will be defined by its biochemical effects.
MS	Mid-shelf marine water body
ms-PAF	Multiple substances-potentially affected fraction derived using a concentration addition model which estimates the cumulative toxicity for contaminants with different modes of action. Referred to as the Pesticide Risk Metric.
MWQ	Marine water quality (MWQ) dashboard and data – Bureau of Meteorology.
NATA	National Association of Testing Authorities, Australia.
NO_x	Oxidised nitrogen (nitrate and nitrite)
OC	Open coastal marine water body
Offshore 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 averaging of indices
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 Observed Indigenous Species compared to Expected
PONI	Proportion of non-indigenous fish
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

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).
RE	Regional Ecosystem
REMP	Receiving Environment Monitoring Plan
Resilience (MMP seagrass indicator)	Measure of the capacity of seagrass to cope with disturbances.
RIMReP	Reef 2050 Integrated Monitoring and Reporting Program
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
RPF	Relative potency factors
SF	Scaling factor. A value used to set scoring range limits for indicators.
SOP	Standard operating procedure
S-VAM	Shoreline-Video Assessment Method
TSS	Total Suspended Solids
UTL	Upper tidal limit
Waterway	All freshwater, estuarine and marine bodies of water, including storm drains, channels and other human-made structures in the Wet Tropics Region.
Water quality guideline	For purposes of waterway assessment, the term water quality guideline refers to values for condition assessment of water quality drawn from a range sources including water quality objectives scheduled under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (DES 2020), and water quality guideline values obtained from the Queensland Water Quality Guidelines (DEHP 2009), the GBRMPA Guidelines (GBRMPA 2010) and the ANZG (2018)
Water quality objective (WQO)	Water quality objective refers to values for condition assessment of water quality scheduled under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (DES 2020)
WWTP	Wastewater treatment plant

1. INTRODUCTION

1.1. General

Wet Tropics Waterways (WTW) 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 pilot report card with the current 'Report Card 2026' reporting on the 2024-25 year (1 July to 30 June).

The Report Card includes water quality and ecosystem condition and state assessments for freshwater, estuarine, inshore marine and offshore marine environments. For more detail on the Wet Tropics Report Card including reporting zones for the waterway environments refer to the Wet Tropics Report Card Program Design: Five-year plan 2018 - 2022 (WTHWP 2018).

1.2. Purpose of this Document

The purpose of this document is to provide detailed information on the methods used to produce condition and state assessments of the freshwater, estuarine, inshore marine and offshore marine environments. Specifically, this document describes the following.

- The data collection methods
- The scoring methods
- The confidence rating method.

A log of the updates applied to the 2024-25 methods technical report is presented in Appendix G.

1.3. Terminology

The Report Card assesses different indicators of waterway health to report on overall state and condition. Scores for indicators are aggregated together depending on the aspect of the environment 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 averaging 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 averaging indicator categories.
- Overall score is generated by the averaging of indices or by a single index score.

Overall scores and scores for indices are represented in the report card and website by a circle diagram (Figure 1). Presentation of the circle diagrams 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.

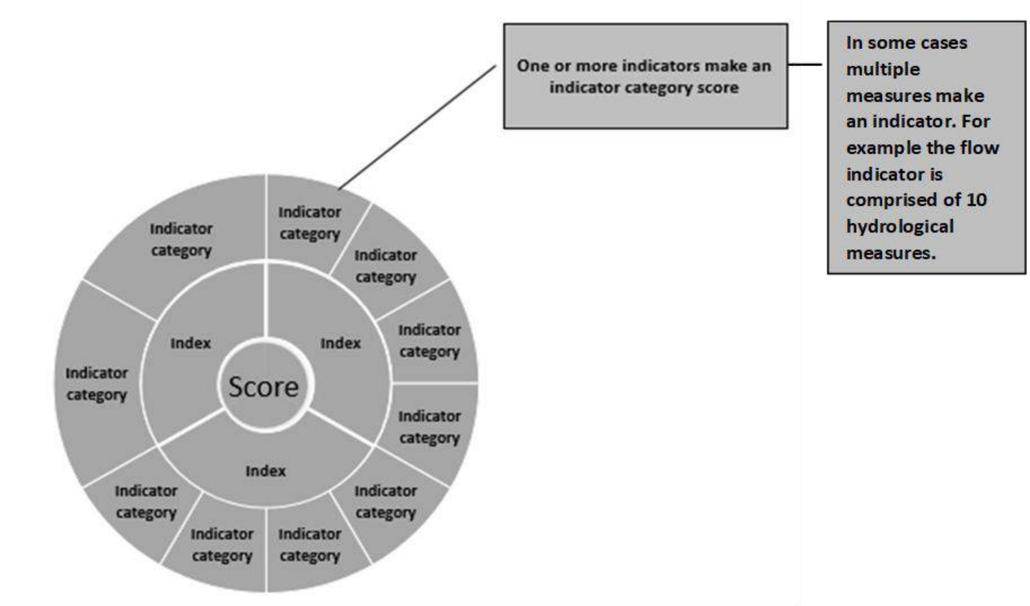


Figure 1 Terminology used for defining the level of aggregation of indicators.

1.4. Indicators for waterway environments

The Report Card provides scores for each reporting zone within each waterway environment. The indicators, indicator categories and indices selected for reporting state and condition are presented in Table 1 for each waterway environment. The table presents the nesting of indicators and indicator categories within indices. For the estuary, inshore marine and offshore marine environments, the fish index is aspirational and is not currently reported in the Report Card.

Table 1 Indices, indicator categories and indicators used for scoring environmental state and condition of the four waterway environments (basins, estuaries, inshore marine and offshore marine).

Environment	Index	Indicator category	Indicator
Basins	Water quality	Sediment	Total suspended solids
		Nutrients	Dissolved inorganic nitrogen
			Filterable reactive phosphorus
		Pesticides	Pesticide risk metric
	Habitat & hydrology	Habitat modification	Impoundment length*
			Fish barriers (in development)
		Flow	30th Percentile of 10 flow metrics
		Riparian vegetation	Extent*
		Wetlands	Extent*
		Invasive weeds	Extent, diversity and impact*
	Fish	Indigenous species*	Proportion of observed vs. expected species
		Non-indigenous species*	Proportion of translocated fish
			Proportion of non-Australian fish
Estuaries	Water quality	Physical-chemical	Turbidity
			Dissolved oxygen
		Nutrients	Dissolved inorganic nitrogen
			Filterable reactive phosphorus
		Chlorophyll *a*	Chlorophyll *a*
		Pesticides	Pesticide risk metric
	Habitat & hydrology	Mangroves and salt marsh#	Extent*
			Shoreline mangrove habitat condition

Environment	Index	Indicator category	Indicator
		Riparian vegetation	Extent*
		Fish barriers (between freshwater and marine environments) *	Barrier density
			Distance to first barrier
			Distance to first low passability barrier
		Flow	30th Percentile of 10 flow metrics
		Seagrass (Dickson Inlet, Trinity Inlet, Moresby, and Hinchinbrook Channel only)	Biomass
			Area
			Species composition
	Fish		
Inshore marine	Water quality	Water clarity	Total suspended solids
			Turbidity
		Nutrients	Oxidised nitrogen
			Particulate nitrogen
			Particulate phosphorus
		Pesticides	Pesticide risk metric
		Chlorophyll *a*	Chlorophyll *a*
	Coral	Change in coral cover	Change in coral cover
		Juvenile density	Juvenile density
		Macroalgae cover	Macroalgae cover
		Coral cover	Coral cover
		Composition	Composition
	Seagrass^	Biomass	Biomass
		Area	Area
		Species composition	Species composition
		% cover	% cover
		Resilience	Resilience
	Fish		
Offshore marine	Water quality		
	Coral	Change in coral cover	Change in coral cover
		Juvenile density	Juvenile density
		Coral cover	Coral cover
	Fish		

#The Mangroves and saltmarsh indicator category for estuaries has been updated to include shoreline mangrove habitat condition as from 2020-21. This update was recommended in the Five Year Program Design (WTHWP 2018) to address monitoring gaps for habitat condition. *Indicates reporting of long-term indicators that are updated approximately every four years. ^The Seagrass index for the inshore marine environment has been updated to remove tissue nutrient status and to replace reproductive effort with the resilience indicator. This update has been applied since 2020-21 and was discussed in WTW (2022). For the offshore zone, water quality reporting has not been available since 2020-21. For the estuary, inshore marine and offshore marine environments, the fish index is aspirational and is not currently reported upon.

Note that whilst the water clarity indicator category for inshore marine is aggregated from total suspended solids and turbidity, other measures such as Secchi depth and coloured dissolved organic matter are also effective indicators for water clarity and could be used for future reporting. The use of additional indicators for water clarity depend on availability of appropriate guideline values and monitoring data. The procedure for adding indicators for waterway reporting is presented in the Program Design (WTHWP 2018).

2. METHODS FOR DATA COLLECTION

2.1. Introduction

The sections below provide an overview of the data collection methods for the environmental indicator categories and indicators reported on in the Wet Tropics Report Card. The indicator selection procedure and descriptions of selected indicators is provided in the Program Design (WTHWP 2018). The methods used for data collection are provided in the sections below.

2.2. Freshwater Basins Data Collection

The freshwater basin reporting zones and the water quality monitoring site locations are shown in Figure 2. An additional site located in the upper catchment of the Tully Basin is shown which is used to reference the quality of water from undisturbed forest but not included in the Report Card condition assessment.

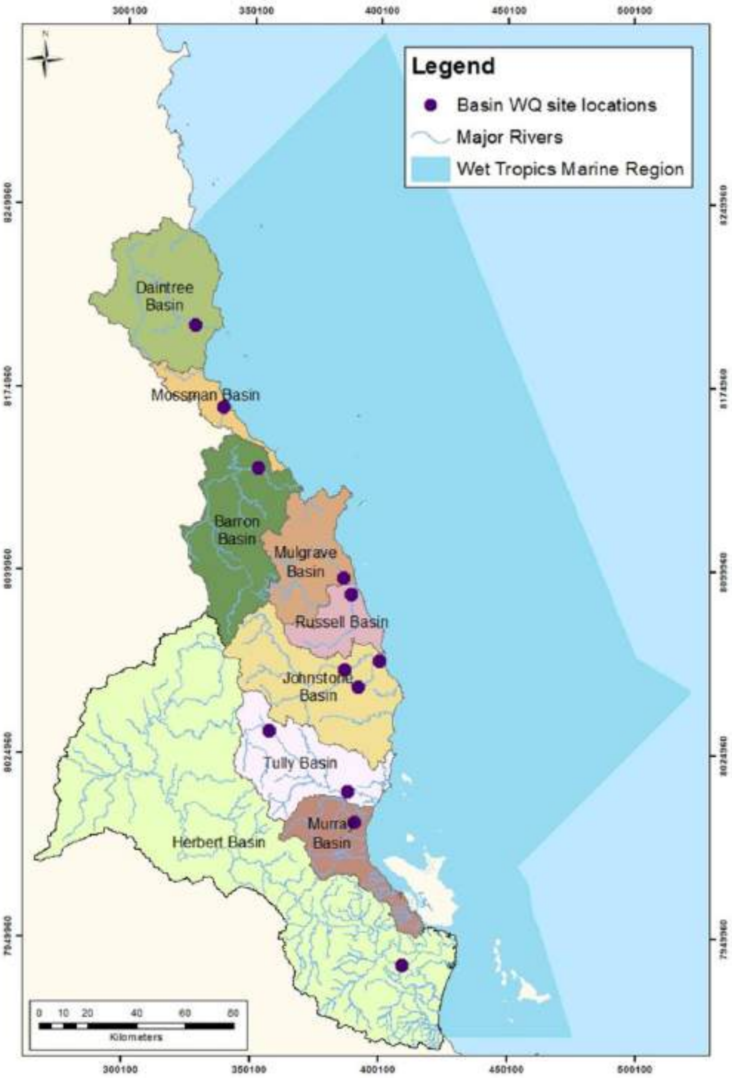


Figure 2 Freshwater basin reporting zones and water quality monitoring site locations for the Report Card.

2.2.1. Water Quality

The freshwater basin water quality data used in the Report Card were collected through the DES (Department of Environment and Science) GBR CLMP (Great Barrier Reef Catchment Loads Monitoring Program) and Queensland Government gauging station network and through Douglas Shire Council (DSC) for their Environmental Impact Monitoring Program (EIMP) with additional water quality monitoring conducted by the DES. Water sampling for determining concentration of the water quality indicators (total suspended solids (TSS), dissolved inorganic nitrogen (DIN), filterable reactive phosphorus (FRP)), was conducted at the GBR CLMP and DSC sites, whilst gauge measurement for determining river flow (discharge) was conducted at the GBR CLMP sites (Table 2). Sampling for pesticides was expanded to all basins in 2017-18 and 2018-19 in order to populate the Pesticide Risk Baseline, and from 2019-20 was dropped back to a more routine sampling regime at eight sites with the loss of monitoring for the Mossman Basin (previously monitored at Bonnie Doon) and for the Barron Basin (previously monitored at Rink's Close Jetty). Since 2021-22, pesticide monitoring was reinstated at the Mossman site MR5 (Bonnie Doon) (Table 2).

Table 2 Water quality monitoring sites, the variables measured at each site that are used for Wet Tropics Report Card scoring and the percent (%) of basin upstream of the sites.

Basin	Sites	TSS	DIN	FRP	Pesticides	Discharge	% of basin*
Daintree	Lower Daintree#, DSC$	•	•	•	•	•	93
Mossman	MR2, MR4, MR 4.1$	•	•	•			45
	SMR1$	•	•	•			41
	MR5$	•	•	•	•		86
Barron	Myola#	•	•	•		•	89
Mulgrave	Deeral#	•	•	•	•	•	60
Russell	East Russell#	•	•	•	•	•	78
Johnstone	Goondi# (N. Johnstone)	•	•	•	•	•	41
	Upstream Central Mill# (S. Johnstone)	•	•	•		•	17
	Coquette Point# (Johnstone)				•		70
Tully	Euramo#	•	•	•	•	•	86
Murray	Bilyana#	•	•	•	•	•	tbc
Herbert	Ingham#	•	•	•	•	•	87

#Great Barrier Reef Catchment Loads Monitoring Program (GBR CLMP) sites. $Douglas Shire Council (DSC) water quality monitoring sites and GBR CLMP pesticide monitoring site at MR5. *% of basin was sourced from Huggins *et al*. (2017) except for Mossman Basin sites which was sourced from drainage basin sub-area Queensland spatial mapping (DNRM 2009), and the Daintree Basin site which was sourced from the Queensland Department of Environment and Science.

The Daintree GBR CLMP site (Figure 3) was operational from 2017-18. This site is located in the mid-estuary water type in the main channel of the Daintree River. Analysis of daily electrical conductivity, water level and discharge data indicated that during base-flow the site was tidally influenced, whilst at higher discharge electrical conductivity was typical of freshwaters for the catchment. Consequently, data for freshwater basin condition assessment was restricted to high flows (> 25m^3/s) when event sampling occurred. Water quality monitoring during the dry season commenced in the latter half of 2019 at freshwater sites in the Daintree and provided data for reporting of water quality during base-flow periods.

Figure 3 Daintree water quality monitoring sites showing location of GBRCLMP site used for high flow monitoring and DSC (Douglas Shire Council) site used for base-flow monitoring.

The Mossman water quality monitoring was conducted at sites MR2, MR4 and MR4.1 which are located on the Mossman River upstream of the confluence with South Mossman River, site SMR1 which is located on the South Mossman River, and site MR5 is located on the Mossman River downstream of the confluence with the South Mossman River (Figure 4).

Figure 4 Mossman Basin water quality monitoring sites. Sites were monitored by the Douglas Shire Council as part of their Environmental Impact Monitoring Program and additional water quality monitoring was also conducted by the Department of Environment and Science. GBR CLMP pesticide monitoring was conducted at MR5.

All monitoring included in the Report Card was undertaken at these sites between 1 July 2024 and 30 June 2025. Sampling was conducted in accordance with the Environmental Protection (Water) Policy Monitoring and Sampling Manual (DES 2018).

At GBR CLMP sites, a combination of manual grab and automatic sampling was used. Daily river flows (mean m^3/s) from the Queensland Government were collected for each GBR CLMP site and used to separate water quality data into those associated with high flow and base-flow periods. Intensive sampling at GBR CLMP sites (up to hourly) occurred during high flow events and monthly sampling was undertaken during ambient (low or base-flow) conditions. Samples for TSS, nutrients and pesticide analysis were collected concurrently (Garzon-Garcia *et al.* 2015).

Samples from GBR CLMP sites were stored and transported in accordance with the Environmental Protection (Water) Policy Monitoring and Sampling Manual (DES 2018) and Wallace *et al.* (2015). Analyses for TSS and nutrients were undertaken by the Science Division Chemistry Centre (Dutton Park, Queensland), and the analyses for the PSII herbicides were conducted by Queensland Health Forensic and Scientific Services (Coopers Plains, Queensland) (Garzon-Garcia *et al.* 2015). Both laboratories are accredited by the National Association of Testing Authorities (NATA). Further information on the water quality data collection and analysis is provided in Garzon-Garcia *et al.* (2015).

At the Mossman Basin sites manual grab sampling was used. Samples were stored and transported in accordance with the Environmental Protection (Water) Policy Monitoring and Sampling Manual (DES 2018). Analyses of samples collected by Douglas Shire Council for TSS and Nutrients were undertaken by SGS Environmental Services, Portsmith, Qld, which is a NATA accredited laboratory. Analyses of samples collected by DES for TSS and Nutrients were undertaken at Queensland Health laboratories, Brisbane, Queensland. Where sampling at a given site was conducted by both Douglas Shire Council and DES on the same date, the DES sample was included in preference to the Douglas Shire Council sample because the Queensland Health laboratory provided higher accuracy of limit of reporting for the analyses.

Pesticide condition in freshwater catchments for 2024-24 was based on the monitored concentrations of up to 22 pesticides (Table 3). All pesticide concentration data and calculated pesticide risk metric data were provided by the Queensland Government's Great Barrier Reef Catchment Loads Monitoring Program.

Table 3 Pesticides, their type and mode of action (MoA) that are included in pesticide mixture risk metric. Not all of the listed pesticides were necessarily detected in all collected water samples.

Name of pesticide	Type	MoA
Chlorpyrifos	Insecticide	Acetylcholine esterase (AChE) inhibitor
Fipronil	Insecticide	Gamma-aminobutyric acid (GABA) gated chloride channel blocker
Imidacloprid	Insecticide	Nicotinic receptor agonist
Haloxyfop	Herbicide	Acetyl-coenzyme A carboxylase (ACCase) inhibitor
Imazapic	Herbicide	Group 1 Acetolactate synthase (ALS) inhibitor
Metsulfuron-methyl	Herbicide	Group 2 Acetolactate synthase (ALS) inhibitor
Pendimethalin	Herbicide	Microtubule synthesis inhibitor
Metolachlor	Herbicide	Inhib of VLCFA
2,4-D	Herbicide	Phenoxy-carboxylic acid auxin
MCPA	Herbicide	Phenoxy-carboxylic acid auxin
Fluroxypyr	Herbicide	Pyridine-carboxylic acid auxin

Name of pesticide	Type	MoA
Triclopyr	Herbicide	Pyridine-carboxylic acid auxin
Isoxaflutole	Herbicide	4-hydroxyphenylpyruvate dioxygenase (4-HPPD) inhibitor
Ametryn	Herbicide	PSII inhibitor
Atrazine	Herbicide	PSII inhibitor
Prometryn	Herbicide	PSII inhibitor
Terbuthylazine	Herbicide	PSII inhibitor
Tebuthiuron	Herbicide	PSII inhibitor
Simazine	Herbicide	PSII inhibitor
Diuron	Herbicide	PSII inhibitor
Hexazinone	Herbicide	PSII inhibitor
Metribuzin	Herbicide	PSII inhibitor

2.2.2. Habitat and Hydrology

Data collection methods for the habitat and hydrology index for the Report Card (habitat modification, flow, riparian extent, invasive weeds and wetland extent) are described below.

2.2.2.1. Habitat Modification

Impoundment Length

The impoundment length indicator reports on the proportion (%) of the linear length of non-tidal streams of order three or higher that are inundated at the full supply level of artificial in-stream structures, such as dams and weirs.

Impoundment locations and estimates of impounded lengths were derived from the Queensland Government 1:100,000 ordered drainage network, Google Earth imagery, Queensland Globe spatial layers (Dams, Weirs and Barrages, Referable Dams and Reservoirs) and local knowledge including Queensland Government regional hydrographic staff. The proportion of impoundment length was calculated as a percentage of the total linear length of the river channel as measured from Google Earth satellite imagery. All streams of order three or higher within the freshwater basin were included in the assessment. Impoundment length is updated every four years. Impoundment length data was updated for the 2022-23 period from a Queensland Government record search covering the last four years of works affecting existing impoundments or development for new impoundments on waterways of stream order 3 or greater in the Wet Tropics region. The impoundments were also visually assessed by Queensland Government staff from recent satellite imagery to verify their state. To assist in estimating impoundment length, mapping from the digital elevation model (25 metre Wet Tropics) data package (Queensland Government 2005) was used to identify the point upstream of the waterway which had an elevation equal to the height of the instream structure, where required. The 2022-23 update identified three impoundments in the region that were not included in the previous assessments, one was within the Tully Basin and two were in the Herbert Basin.

Fish Barriers

The indicators and measures for freshwater fish barriers are currently being developed for review.

2.2.2.2. Flow

The flow indicator follows a reference condition approach where a waterway with a highly modified flow regime, resulting in large deviations from an unregulated reference condition, will score poorly and a waterway with an unmodified flow regime, resulting in a similar flow regime to reference condition, will score well. The indicator was applied to all available flow assessment sites within each basin. A flow assessment site requires: i) an operational stream gauging station that provides daily stream flow data; and ii) time series modelled pre-development daily flows, which provide the reference condition. Observed daily flows (ML/day) were obtained from the Queensland Government water monitoring information portal (water-monitoring.information.qld.gov.au) and were all stream gauging stations managed by Queensland Government. Pre-development time series (100+ years, typically 1890 – 2008) of daily flows (ML/day) were obtained from Queensland Government hydrologic models (IQQM - Integrated Water Quantity and Quality Model), which were developed for Queensland basin Water Plans. The flow measures used to score the flow indicator assesses deviations of the observed flow data from the reference pre-development flow data. The flow assessment sites used for the flow indicator within each basin are presented in Table 4, along with the Queensland Government gauging station number. Note that as from 2024-25 the flow assessment site 'South Johnstone River at Upstream Central Mill, GS no. 112101B' for the Johnstone Basin was decommissioned and is no longer available for use in the flow indicator.

The hydrologic models for the Wet Tropics and Barron Water Plans, developed by Queensland Hydrology Unit, Science and Technology Division, Department of Environment and Science, have been externally reviewed. The pre-development flow data is based on those models, and the developers have a good level of confidence about the pre-development scenarios (A. Loy, Pers. Comm. Email 7/7/2021).

Table 4 Flow assessment sites with Queensland Government gauging station number (GS no.) used for the flow indicator within each basin.

Basin and flow assessment site	GS no.	Basin and flow assessment	GS no.
Mossman		**Tully**	
Mossman River at Mossman	109001A	Cochable Creek at Powerline	113004A
Barron		Tully River at Euramo	113006A
Barron River at Myola	110001D	**Murray**	
Barron River at Mareeba	110002A	Murray River at Upper Murray	114001A
Barron River at Picnic Crossing	110003A	Meunga Creek at Sing's	114002B
Mazlin Creek at Railway Bridge	110018A	**Herbert**	
Barron River at Bilwon	110020A	Herbert River at Ingham	116001F
Barron River at Goonara Creek	110021A	Herbert River at Glen Eagle	116004C
Freshwater Creek at Redlynch	110104A	Herbert River at Abergowrie	116006B
Mulgrave		Gowrie Creek at Abergowrie	116008B
Mulgrave River at The Fisheries	111005A	Blencoe Creek at Blencoe Falls	116010A
Mulgrave River at Peets Bridge	111007A	Millstream at Ravenshoe	116011A
Russell		Cameron Creek at 8.7km	116012A
Russell River at Bucklands	111101D	Millstream at Archer Creek	116013A
Babinda Creek at The Boulders	111105A	Wild River at Silver Valley	116014A
Johnstone		Blunder Creek at Wooroora	116015A
Fisher Creek at Nerada	112002A	Rudd Creek at Gunnawarra	116016A
North Johnstone River at Glen Allyn	112003A	Stone River at Running Creek	116017A
North Johnstone River at Tung Oil	112004A		
Liverpool Creek at Upper	112102A		

The annual flow pattern in any given river will vary naturally with the prevailing rainfall conditions. For example, in a free-flowing river, total annual discharge will naturally be lower in a drought year than a wet year. To account for differences of rainfall between years, historical daily rainfall data

(100+ years) was obtained from the Queensland Government SILO program for each catchment (https://www.longpaddock.qld.gov.au/silo/). The SILO rainfall record covers the entire hydrological modelling period (1890 – 2008) and continues to the present day. 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 5.

Table 5 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	-17.13	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	211
Mulgrave P5	Deeral	-17.2	145.9	131
Mulgrave P1	Behana Creek	-17.2	145.8	784
Mulgrave P2	Upper-mid Mulgrave	-17.2	145.75	252
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	430
Tully P2	Koombooloomba	-17.85	145.6	792
Tully P3	Kareeya	-17.75	145.6	469
Tully P4	Sugar Mill	-17.95	145.95	122
Tully 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	Meunga Creek at Sings	-18.2	145.9	199
Murray P3	US Murray and Meunga	-18.15	145.85	535

Note: Sites are either station (S) or point (P) locations on the SILO website (www.longpaddock.qld.gov.au/silo/).

Historical daily rainfall data was averaged from all rainfall sites within each basin and was used to define years within rainfall types using quartiles as follows.

- Drought: Annual rainfall ≤ 25th percentile year.
- Dry: 25th percentile year < Annual rainfall ≤ 50th percentile year.
- Average: 50th percentile year <Annual rainfall ≤ 75th percentile year.

- Wet: Annual rainfall>75th percentile year.

For a given basin, each year of the hydrological record was then ascribed a 'rainfall type'. As such, the flow measures used to produce the indicator scores each have reference distribution for each climatic type at each flow assessment site. The rainfall type for reporting year (2024-2) was determined by comparing the rainfall record to the historical rainfall data. Generation of rainfall types and determining rainfall type of the reporting year were conducted using the flow indicator tool developed for the Report Cards Flow Indicator Project (Stewart-Koster *et al*. 2018).

The methods used to generate flow indicator scores are presented in section 3.2.3.2, while the complete report for the Report Cards Flow Indicator Project (Stewart-Koster *et al*. 2018) is available on the WTW website here.

The Technical Working Group has recommended that the flow indicator is removed from the habitat and hydrology index for basins and estuaries, as part of the updated Program Design that will be implemented in 2027. Flow data will be provided in a contextual form as part of the climate section rather than as an indicator contributing to waterway condition scores and grades. Whilst the flow indicator has been useful for identifying differences between observed and modelled pre-development flows, the indicator framework has a limited capability to differentiate between anthropogenic and rainfall driven variability of flows, particularly for years with greater variation and extremes of rainfall, such as 2023-24. Presenting flow data in a contextual form will provide more detail of the flow conditions for the reporting year and allow for more nuanced assessment of conditions including the influences from rainfall events and anthropogenic impacts.

2.2.2.3. Riparian Extent

The assessment of riparian extent follows the same methodology used for the Reef Plan Great Barrier Reef Report Card (Queensland Government 2014). This methodology first defines riparian areas using topographic drainage data and riverine wetlands derived from the 2009 Queensland wetland areas data. The present extent of riparian forest is defined by those areas with a foliage projective cover of at least 11 % (Folkers *et al*., 2014) using the 2013 Landsat foliage projective cover data. This was then compared against the pre-clearing extent of riparian forest regional ecosystems (based on regional ecosystem mapping version 9) to estimate the amount of riparian forest remaining in the Daintree, Mossman, Barron, Mulgrave, Russell, Johnstone, Tully, Murray and Herbert basins. The method assumes that the pre-clearing riparian forest regional ecosystems were 100 % forested.

2.2.2.4. Wetland Extent

The assessment of wetland extent was updated for 2024-25 and used the most recent release of data from Queensland Wetland areas Version 7 (assessment as at 2021) mapping supplied through Queensland Herbarium (DETSI 2025) and is the same source of data used for the Reef Plan report card to report wetland extent. The Report Card wetland extent assessment only includes data for palustrine wetlands in the nine basins of the Wet Tropics (Daintree, Mossman, Barron, Mulgrave, Russell, Johnstone, Tully, Murray and Herbert basins). The most recent assessment of wetland extent was conducted through a comparison of 2021 extent against pre-clearing extent of vegetated freshwater swamp (palustrine) systems with more than 30 percent emergent vegetation cover. The updated wetland extent values of version 7 replace the previous values reported for 2019 (version 6).

2.2.2.5. Invasive Weeds

An established pest and weeds planning and prioritisation process operates throughout Far North Queensland and includes all of the basins within the Wet Tropics region (FNQROC 2015). The process involves the collation of information by an expert panel composed of officers and stakeholders from the Local Government's Pest Working/Advisory Groups (PWGs). The process was used for identification of the species included in the invasive weed indicator, mapping the distribution of aquatic weed species and defining impact scores for each aquatic weed species and was conducted for the 2019-20 reporting period.

Weed species that are distributed within Wet Tropics basins and which meet the following criteria were included in the invasive weeds indicator.

1. Priority species from Regional Pest Management Strategies or Local Government Biosecurity Plans.
2. Species with aquatic (in stream) habitat requirement and impact.
3. Able to be mapped (or are already mapped) at 1 kilometre grid resolution across the entire reporting region.
4. Management objectives, involving active management, in place across all jurisdictions.

Spatial analysis and assessments were conducted using ArcMap (10.0) and Community Viz (4.1.62.0). Spatial distribution data for each weed species is derived from a regional pest mapping project, which has been in development and use in the Wet Tropics region since 2005. The mapping project underpins Local Governments statutory Pest/Biosecurity Management Plans. The grid mapping is updated in each revision of the Local Plans and generated from a combination of management/survey data intersected with a 1 km^2 grid to create a presence/absence field for each species. Basin names and target species are captured in a single feature class and a short integer field (columns) is used to define presence [1] or absence [0] of each species in each grid cell (rows).

The distribution grid generated for each species is validated by local weed experts including members of the PWG from aerial imagery and local expert knowledge. Additional occurrences of weed species were added to the distribution grid as part of this process.

The weed distribution grid was intersected with the freshwater basin reporting zones to assign a basin name to each grid cell (partial grid cells were counted as whole grid cells if dissected by a basin boundary). The distribution grid for all species was then intersected with a single waterway habitat mapping layer compiled from merged polygons from Queensland Wetland Mapping representing lacustrine, palustrine, riparian and estuarine wetland types; and from Queensland Government 1:100,000 ordered drainage network Stream order ≥3. The polygons were then used to create a single feature representing waterway habitat.

Each weed species was scored from low (1) to high (5) according to its impact upon waterways based upon the impact scores developed by the PWGs. The score provided the impact rating for the species for use in the indicator.

The mapping procedure provided a record of the presence or absence of each weed species intersecting with the waterway habitat layer for all grid cells within each basin. The data was then exported from ArcMap into an Excel pivot table for processing into scores (see section 3.2.3.5).

For the 2019-20 a new species of invasive weed was added into the indicator due to an outbreak in the Barron Basin. The detection of the invasive weed Amazon frogbit (*Limnobium laevigatum*) has been accompanied by mapping of its distribution following implementation of the invasive weed indicator in 2015-16, and the mapping has revealed rapid spread of the species in the Barron Basin. The Amazon frogbit is now considered to be a priority species for management and control in the Wet Tropics.

A full description of the method including diagrams of key procedures is provided in Sydes and Hunt (2017). It is expected that the invasive weeds assessment for the Report Card will be conducted at least every four years.

2.2.3. Fish

All the field monitoring surveys, data collection and analysis, and fish indicator and index calculations were conducted by the Department of the Environment, Tourism, Science and Innovation (DETSI).
The fish index was updated for all basins expect the Herbert for 2023-24, the Herbert Basin only for 2022-23 and was reported for all basins except the Daintree for 2019-20. The initial reporting of the fish index was for 2017-18 and only included the Mulgrave and Russell basins. The fish index reports on the following indicators.

- The Proportion Observed Indigenous Species compared to Expected (POISE): the number of naturally-occurring native Australian fish species caught as a proportion of the number predicted to occur at the site (in a single sample, using a standardised method) by a quantitative statistical model.
- The proportion of non-indigenous fish (PONI): the number of non-Australian and translocated native Australian fish caught expressed as a proportion of the total fish catch at the site. The PONI indicator consisted of the following two measures summed for each site.
    - Proportion Alien Fish: the number of non-Australian fish caught expressed as a proportion of the total fish catch at the site and calculated as 'number alien fish caught / total number fish caught'.
    - Proportion Translocated Fish: the number of translocated native Australian fish caught expressed as a proportion of the total fish catch at the site and calculated as 'number translocated fish caught / total number fish caught'.

Values for all indicators and measures were calculated at the site level. For each indicator, the basin score was the median of the site indicator values.

A model was used to produce a Maximum Species Richness Line (MSRL) which predicts the 90th percentile of fish species richness across the landscape, based on catches at sites with varying degrees of disturbance. Data used for the model included multiple landscape-scale predictors (catchment area, elevation and stream bed slope) and fish species distribution data from 370 fish sampling events on 252 different stream segments across the Wet Tropics, Dry Tropics and Mackay-Whitsunday regions. The model was partitioned into 'species richness zones' to account for catchments with restricted fish movement due to natural barriers such as major waterfalls. The zones were the Upper Barron, being major streams on the escarpment forming Barron River Falls, the Upper Herbert, being major streams on the escarpment forming Herbert River Falls, the Upper Johnstone, and unrestricted coastal streams (coastal waterways without major natural barriers to fish movement) being all other major streams.

The landscape predictors were based upon a digital elevation model (DEM) derived by the Department of Environment and Science to produce hydrologically-correct 12.5 m cell-size based on the latest 1 second (≈30 m) SRTM-derived DEM-S elevation data (https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/72759) and State 1:25,000 waterway mapping (qldspatial.information.qld.gov.au).

The model applied for the non-indigenous fish indicator to derive scores and grades was developed for South East Queensland (EHMP 2008). This approach allows for direct comparison of Wet Tropics results with those from other regions of Queensland which also apply the model. Since the model is not limited to data from the Wet Tropics but includes regions that have higher numbers of alien fish species it is important to note that the scores are relative to other regions of Queensland.

Non-indigenous fish may affect aquatic plants and animals through direct competition for food and space, predation, driving habitat changes and the introduction of exotic diseases and parasites. For this reason, it is important to prevent the introduction of non-indigenous fish into local waterways and eradicate new incursions of alien fish wherever possible. Managing populations of existing alien fish such as Tilapia through management and eradication programs promotes the health of native fish communities and waterways.

Fish survey sites were randomly identified using Generalized Random-Tessellation Stratified (GRTS) selection. Site selection was determined according to sites that could actually be accessed for the survey operations. The number of sites used for calculating indicator scores and the months of the surveys for each basin are presented in Table 6. The survey site and year, and site locations for each basin are presented in APPENDIX F Table 62 and Figure 42 to Figure 50. Fish surveys were conducted using backpack and boat-mounted electrofishing. Backpack electrofishing was undertaken until the operator was confident that a site had been adequately sampled and at least 300 ‘power-on’ seconds had elapsed since capture of the last new species at the site. Boat electrofishing was undertaken until six 300 second ‘power-on’ time shots had been completed and no new species were captured during the last shot.

Table 6 The number of fish assessment sites used for calculating the indicator scores and the month and year of the fish surveys.

Reporting period	Basin	Number of sites	Month and year of survey
2019-20			
	Mossman	13	September 2019
	Barron	11	September 2019
	Mulgrave	13	July - August 2019
	Russell	14	July - August 2019
	Johnstone	11	September 2019
	Tully	11	August 2019
	Murray	13	August 2019
	Herbert	28	August 2020
2022-23			
	Herbert	16	June 2021 and September 2022
2023-24			
	Daintree	40	September 2024
	Mossman	12	September - October 2023
	Barron	11	September 2023
	Mulgrave	10	August – September 2023
	Russell	10	August 2023
	Johnstone	11	September 2023
	Tully	10	September 2023
	Murray	12	September 2023

The stocking of native Australian fish species 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 impoundments of Tinaroo Falls Dam (Barron River), Copperlode Dam (Freshwater Creek, Barron Basin) and Koombooloomba Dam (Tully River). Stocked fish can potentially be captured during fish surveys and contribute to measures of species richness and to the measure of translocated fish numbers when stocked in locations outside their natural distributions. Data of recent fish stocking activity including basin, location, date, fish species and number was sourced from the Queensland freshwater fish stocking records (https://www.data.qld.gov.au/dataset/queensland-freshwater-fish-stocking-records) and presented in the results of the freshwater fish assessments to inform on possible influence of fish stocking on survey results.

2.3. Estuaries Data Collection

The locations of the estuary reporting zones are shown in Figure 5. Monitoring and assessment of estuarine indicators is conducted at the reporting zone locations.

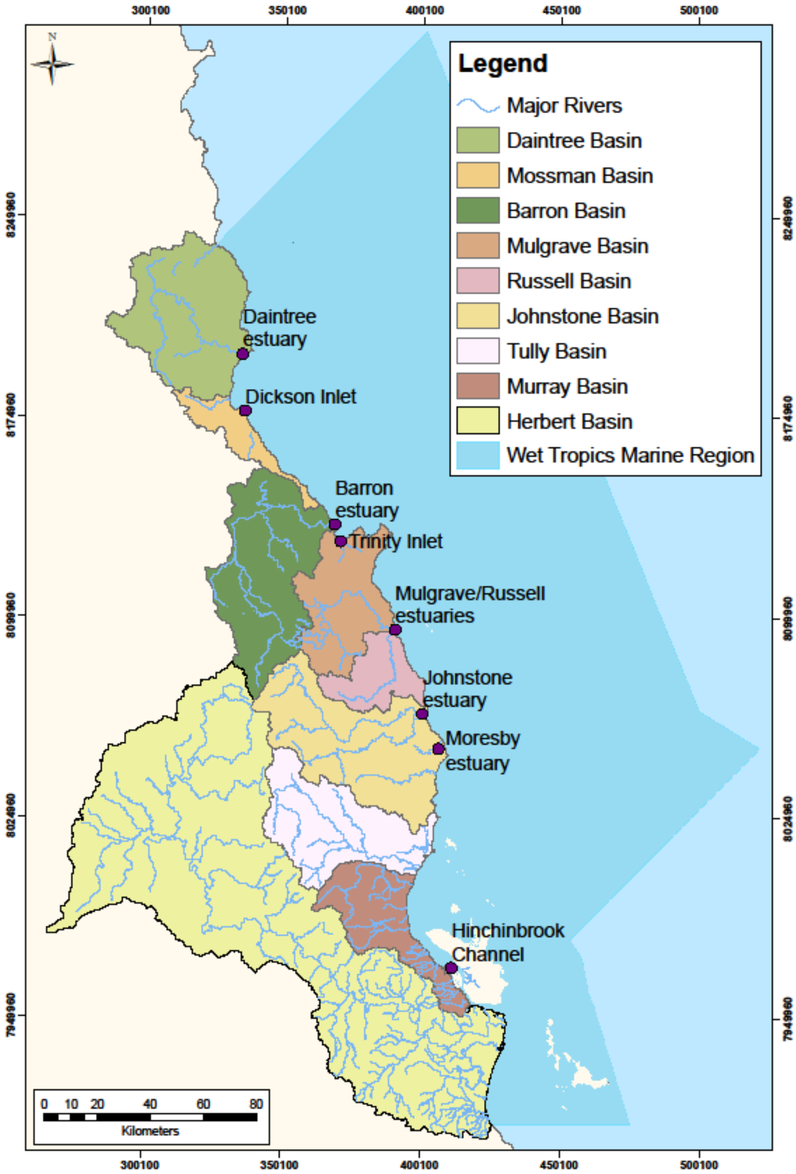


Figure 5 Location of estuary reporting zones.

2.3.1. Water quality

Water quality data for the Report Card was collected during the reporting period (1/7/24 to 30/6/25) by DETSI, Douglas Shire Council (DSC), Cairns Regional Council (CRC) and Cassowary Coast Regional Council (CCRC) monitoring programs at all of the eight estuary reporting zones (Table 7). The two sites from the Marine Monitoring Program for Inshore Water Quality located in the Russell-Mulgrave (RM11 and RM12) used for previous reporting years were discontinued in 2019. The estuary water quality monitoring site locations for each reporting zone are shown in APPENDIX A (Figure 13 to Figure 20). Additional monitoring of DIN and FRP for the Johnstone estuary was provided from the GBR CLMP site at Coquette Point (Figure 18). The months for which monitoring was conducted (excluding pesticides) for each estuary are presented in Table 8. Pesticides were not monitored as part of the estuary water quality monitoring programs. Pesticide monitoring conducted for the GBR CLMP which is used for the basins was also used for estuaries at the estuary reporting zones where the monitoring sites are located (Daintree (APPENDIX A, Figure 13), Russell-Mulgrave at Deeral and East Russell (APPENDIX A, Figure 17) and Johnstone at Coquette Point (APPENDIX A, Figure 18)). The GBR CLMP sites are located in the mid-estuary water type of the estuary zones.

Table 7 Estuary monitoring programs with indicators, sample frequency, site numbers and water type for 2024-25.

Reporting zone	Program	Turbidity	DO	DIN	FRP	Chl-*a*	*n*/ year	Number of sites and water type
Daintree	DES WTW estuary monitoring	•	•	•	•	•	12	3 mid-estuary, 1 enclosed coastal
Dickson Inlet	DSC Port Douglas WWTP – monitoring plan	•	•	•	•	•	4	3 mid-estuary (sites 1, 3 & 4), 1 lower estuary (sites 5).
Barron	CRC Northern WWTP plan	•	•	•	•	•	6	4 mid-estuary (sites 2 - 5) 1 lower estuary (site 6)
Trinity Inlet	CRC Edmonton/Southern WWTP - monitoring plan and additional DES monitoring.	•	•	•	•	•	6	10 mid-estuary (CRC sites 1 – 8, DES sites 2 & 3), 1 lower estuary site (DES site 1)
Russell-Mulgrave	CRC Gordonvale WWTP - monitoring plan.	•	•	•	•	•	3 (Russ EHP1, Site 7), 6 (Mul EHP1, Site 6)	3 mid-estuary (Mul EHP1, Russ EHP1, site 7), 1 lower estuary (site 6)
Johnstone	CCRC Ninds CK REMP, DES GBR CLMP	•	•	•	•	•	12(EHP1 - 3), 12 (CLMP)	4 mid-estuary (EHP1 – 3, CLMP#)
Moresby	DES WTW estuary monitoring	•	•	•	•	•	12	5 mid-estuary (sites 1-5), 1 lower estuary (site 6)
Hinchin-brook Channel	DES WTW estuary monitoring	•	•	•	•	•	11 (Site 1), 10 (Site 2), 9 (Site 3)	3 enclosed coastal

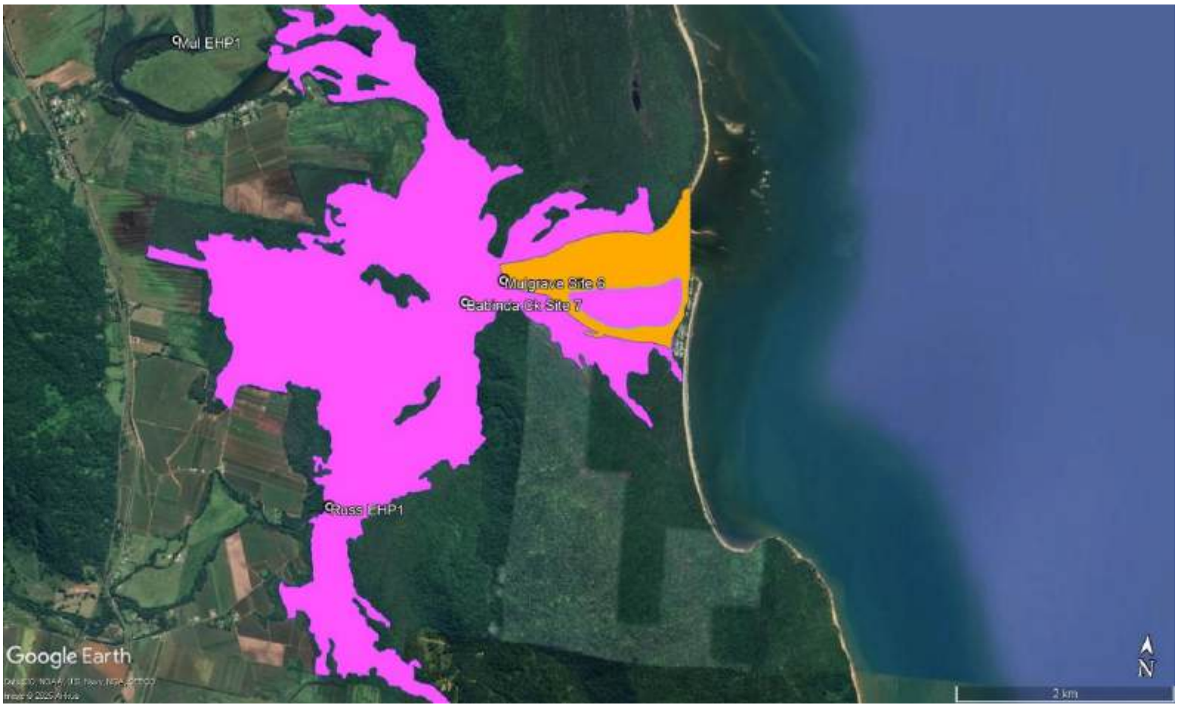
#GBR CLMP (GBR Catchment Loads Monitoring Program) site samples nutrients (DIN and FRP) only. Water type is defined by the Environmental Protection (Water and Wetland Biodiversity) Policy (EPP) 2019 Wet Tropics Map Series. Note: DES is Queensland Department of Environment and Science, DSC is Douglas Shire Council, CRC is Cairns Regional Council, CCRC is Cassowary Coast Regional Council, WTW is Wet Tropics Waterways, and WWTP is wastewater treatment plant.

Table 8 Months that water quality monitoring was conducted for each estuary during 2024-25.

Zone	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Daintree	•	•	•	•	•	•	•	•	•	•	•	•
Dickson Inlet	•		•				•				•	
Barron	•	•	•	•	•							•
Trinity Inlet	•		•		•			•		•		•
Russell-Mulgrave			•	•		•		•		•		•
Johnstone	•	•	•	•	•	•	•	•	•	•	•	•
Moresby	•	•	•	•	•	•	•	•	•	•	•	•
Hinchinbrook Channel	•	•	•	•	•	•	•	•	•		•	•

Monitoring for some zones did not occur at all sites for each month: Russell-Mulgrave Site 7 and Russ EHP1 were not monitored in December, February and April. For the Johnstone estuary the table shows monitoring at CCRC sites; monitoring at GBR CLMP site (Coquette point) for DIN and FRP occurred for all months. Pesticide monitoring is not included in the table.

Commencing in 2022-23 water quality data for the Russell-Mulgrave estuary from two additional sites monitored by Cairns Regional Council has been included. The sites are in the Mulgrave River (Mul EHP1) and Russell River (Russ EHP1) upstream from the existing sites (site 6 and site 7) used for all previous assessments of water quality (APPENDIX A, Figure 17). From mapping of water type as defined by the Environmental Protection (Water and Wetland Biodiversity) Policy (EPP) (2019 Wet Tropics Map Series) the new Russell River site (Russ EHP1) was located in mid-estuary water type, whilst the new Mulgrave River (Mul EHP1) site was located in lowland freshwater water type (Figure 6). Measurements of *in-situ* conductivity from Mul EHP1 showed the site location was tidally influenced (Table 9) and the site was included as an estuary water quality monitoring site and classified as mid-estuary for purposes of applying guideline values for scoring.



■ Mid-estuary waters | ■ Lower estuary waters | Water type mapping sourced from the Environmental Protection (Water and Wetland Biodiversity) Policy (EPP) 2019 Wet Tropics Map Series.

Figure 6 Russell-Mulgrave estuary water quality monitoring sites and water type.

Table 9 Electrical conductivity measurements for 2022-23 at the new Mulgrave River site (Mul EHP1)

Date	Time	Electrical conductivity (µS/cm)
24/08/2022	08:35	730
25/10/2022	09:25	15000
19/12/2022	09:45	290
07/02/2023	11:45	74
05/04/2023	09:10	390
19/06/2023	09:25	58

Sampling and analysis of the water quality indicators (DO, DIN, FRP and Chl-*a*) was conducted at all monitoring sites in accordance with the Environmental Protection (Water) Policy Monitoring and Sampling Manual (DES 2018). To address the influence of tides on water quality indicators, monitoring at sites was conducted on the ebbing (outgoing) tide as recommended (DES 2018). Whilst dissolved oxygen concentrations in estuarine waters typically vary with the time of day as a result of biological processes, the influence of tide can substantially exceed that of time of day on dissolved oxygen concentrations, for example see Fortune and Mauraud (2015). Laboratory analyses of water samples were conducted by various laboratories accredited by NATA. This monitoring is a collaboration between, DETSI, DSC, CRC, CCRC and the WTW.

Sampling and analysis of pesticides for the Daintree estuary, Russell-Mulgrave estuary at Deeral and East Russell, and Johnstone estuary at Coquette Point are as per freshwater basins and described in section 2.2.1.

2.3.2. Habitat and Hydrology Indicators

Data collection details and methods for the habitat and hydrology indicators (riparian extent, mangrove and saltmarsh extent, flow and fish barriers) for the Report Card are described below.

2.3.2.1. Estuarine riparian vegetation extent

The assessment of riparian vegetation extent in the estuarine environment was conducted on the most recent Regional Ecosystem data set (version 13.1: 2021 remnant and pre-clearing mapping) for each estuary zone assessment area (APPENDIX B) by reviewing the proportion of riparian area that has been cleared of natural vegetation. In the case of estuaries, riparian vegetation is assessed on waterway banks upstream to the tidal limit and also includes vegetation communities that extend from river mouths along coastal shorelines that face estuary waters within the estuary zone. Thus, the term estuarine riparian vegetation includes vegetation communities occurring on riverbanks and coastal shorelines.

The riparian area was defined using the “Watercourse Lines – North East Coast Drainage Division”, and the “Queensland Statewide Corridors” datasets available on QSpatial, with a 50m buffer area created either side of the watercourses. The upstream and downstream extent of estuarine waters was defined using the “Environmental Protection Policy 2019 - Water Types – Queensland” dataset, also available on QSpatial.

The following procedure was used to define the spatial extent of riparian area and estimate the extent of riparian vegetation remaining.

- Select all waterways in the “Watercourse Lines” and “Queensland Corridors” datasets.
- Filter the “Queensland Corridors” dataset for only riparian data.
- Filter the “Watercourse Lines” dataset for waterways with stream order >1.

- Filter for all waterways that pass within the eight Wet Tropics estuary zones as defined for the mangrove and saltmarsh areas.
- Create a buffer 50 m either side of all waterways.
- Select only buffered waterways that are within estuarine waters.
- Download all available years of remnant Regional Ecosystem data including the most recent version of pre-clearing data.
- Restrict data to the estuarine riparian areas as defined above.
- Group vegetation into the following categories:
    - Pre-clearing vegetation extent from the most recent version of Regional Ecosystems mapping.
    - Remnant (vegetation that is undisturbed) from the most recent version of Regional Ecosystems mapping and previous versions.
- Calculate the difference in area and the percentage change in area between the pre-clearing extent and the remnant vegetation extent for each mapping year to show any change from pre-clear to assessment year.
- Calculate the difference in area and the percentage change in area between the two most recent assessment years to show any recent change.
- Maps of riparian areas with remnant and non-remnant (cleared) vegetation were made of the most recent year of data for each estuary zone.

Maps of the riparian area for each estuary zone are provided in Figure 21 to Figure 28 (APPENDIX C).

Change in extent from pre-clearing to most recent assessment year is scored according to the standardized scoring procedures in Section 3.2.3.3.

2.3.2.2. Mangrove and Saltmarsh Extent

The assessment of mangrove and saltmarsh extent was conducted on the most recent Regional Ecosystem (RE) data set (version 13.1: 2021 remnant and pre-clearing mapping) available from QSpatial, with previous years available upon request to Queensland Herbarium. The data layers for 2021, 2019, 2013 and 1997, and the estimated pre-clearing areal extent of intertidal habitat categories (mangrove and saltmarsh) were compared and the proportion of extent loss since pre-clearing was determined.

Spatial estimation of the percentage loss from pre-clearing to 2021 and from 2019 to 2021 for important and dominant intertidal vegetation categories, including mangrove, samphire and melaleuca (categories 7.1.1, 7.1.2, 7.1.3, 7.1.4 and 7.1.5) selected from RE data were conducted as follows.

- Start with the defined area of each of the Wet Tropics Report Card estuary zones.
- Download all required years of regional ecosystem data.
- Restrict data to the defined estuary zone areas.
- Select all the dominant Regional Ecosystem data for the selected intertidal categories of vegetation including mangrove, samphire and melaleuca (7.1.1, 7.1.2, 7.1.3, 7.1.4 and 7.1.5).
- Extract and sum the areas for all the selected vegetation categories for each estuary zone for all required years: pre-clearing (from most recent Pre-clear RE version) and 2021, 2019, 2013 and 1997 Remnant RE assessment years.
- Calculate the difference in area and the percentage change in area between the pre-clearing extent and the remnant vegetation extent for each mapping year to show any change from pre-clear to assessment year.

- Calculate the difference in area and the percentage change in area between the two most recent assessment years to show any recent change.
- Maps of remnant mangrove and saltmarsh, and non-remnant vegetation were made of the most recent year of data for each estuary zone.

Maps of the area for each estuary zone for mangrove and saltmarsh extent and from the most recent mapping of remnant mangrove and saltmarsh, and non-remnant vegetation, are provided in Figure 29 to Figure 36 (APPENDIX C).

2.3.2.3. Shoreline mangrove habitat condition

The shoreline mangrove habitat condition indicator incorporates shoreline monitoring data of mangrove habitat structure, canopy cover and impacts which quantifies both physical and anthropogenic drivers of change at the estuary scale. The indicator has been developed to provide a repeatable and verifiable assessment of estuarine habitat that is sensitive to environmental change and human disturbance. The indicator adds to the assessment of habitat extent from the mangrove and saltmarsh indicator by providing measures of mangrove habitat quality.

The shoreline assessments underpinning the indicator are spatially restricted to the observable seaward fringe of the mangrove habitat. This section of the mangrove community informs on the habitat condition at the interface between land and water which is a key aspect of mangrove habitat health. Mangrove habitat extending from the coastline to the landward fringe is also an important aspect of condition which can inform upon pressures including land management and land use changes. The shoreline mangrove habitat condition indicator can be integrated with assessments that include more extensive habitat condition monitoring as and when they are developed.

Monitoring data for the shoreline mangrove habitat condition indicator is sourced from the Cairns and Far North Queensland MangroveWatch program coordinated by the Cairns and Far North Environment Centre (CAFNEC), which is a citizen science approach to mangrove habitat condition monitoring. The program has been conducting mangrove assessments at estuaries in the Wet Tropics region following the Shoreline-Video Assessment Method (S-VAM) protocol (Mackenzie *et al.* 2016). The S-VAM protocol is a standardised peer-review method that has been used for mangrove assessments across Queensland. The method of data collection and process is outlined below and the full description is available in Mackenzie (2021).

Shoreline surveys

Citizen scientists collected continuous video of estuary shorelines from a boat travelling between 6-10 kts speed, parallel to shoreline contours at a distance of up to 200 m from shore. The video camera was held at 90 degrees to the direction of boat travel at all times. A continuous 1-second GPS track was recorded. GPS waypoints and geotagged photos of special interest (for example wildlife, marine debris, dead mangroves, mangrove seedling banks, mangrove disturbance and places of local importance) were recorded. Voice recording while filming captured citizen science on-board observations to record local knowledge. Where possible, video data collection was captured on a low to mid tide during a neap tide period to ensure tidal waters were not obscuring shoreline features whilst maintaining safe navigation.

S-VAM surveys were undertaken to ensure whole-of-system capture of the main estuary channel shorelines from the mouth to upstream estuary limits or where practicably navigable. The S-VAM surveys provide a permanent visual record of estuary shoreline habitat that can be used to assess change over time.

To ensure data quality control, data was only accepted where at least one person on the S-VAM survey had participated in a MangroveWatch training event. Each survey team was provided with additional instruction sheets on the day to ensure video image data quality and time synchronisation between data streams.

For the 2024-25 reporting, data was collected between June to August 2025, and shoreline surveys were conducted for Barron, Johnstone, Moresby and Hinchinbrook Channel estuaries (Table 10).

Table 10 Shoreline mangrove habitat condition surveys and assessments for estuary reporting zones.

Reporting year	Estuary	Survey dates	Length of lower 40% of estuary shoreline surveyed (km)	Percentage of lower 40% of estuary surveyed (%)	Completed assessment for reporting year
2020-21					
	Daintree	May and September 2019	12.0	51%	✓
	Dickson Inlet	September 2019	3.9	58%	✓
	Barron	August to November 2019	9.4	52%	✓
	Trinity Inlet	May to July 2019	18.1	84%	✓
	Russell-Mulgrave	September 2019	11.3	46%	✓
	Johnstone	April 2021			×
	Hinchinbrook Channel	October 2021			×
2021-22					
	Daintree^[t]	September 2022	20.8	87%	✓
	Dickson Inlet	August 2022	4.3	65%	✓
	Barron^	July 2022	17.6	98%	✓
	Trinity Inlet	May to June 2022	17.3	80%	✓
	Russell-Mulgrave^[t]	May to July 2022	20.9	85%	✓
	Moresby	August 2022	16.1	78%	✓
	Hinchinbrook Channel*	March to May 2022	90.5	49%	✓
2023-24					
	Barron	June, August, November 2024	17.5	98%	✓
	Russell-Mulgrave	June to December 2024	16.8	79%	✓
	Johnstone	June 2024	12.3	67%	✓
	Moresby	June 2024	16.1	79%	✓
2024-25					
	Barron	July, August 2025	17.7	99%	✓
	Johnstone	June 2025	16.3	88%	✓
	Moresby	June 2025	15.7	76%	✓
	Hinchinbrook Channel	July 2025	32.0	18%	✓

^Estuaries where adjustments were made in 2021-22 to the extent of shoreline assessed to better represent mangrove extent for the purposes of improving inter-estuary comparisons. [t]Estuaries where point-intercept sampling frequency of habitat structure and canopy cover scores was increased in 2021-22 from every 100 m to every 50 m to better account for inter-estuary variability. *Hinchinbrook Channel includes the entirety of the channel and the lower Herbert and Seymour Rivers and lower Deluge Inlet. Only the lower 40% of estuaries was used for scoring. This was to provide standardisation of estuary habitat type for comparison between zones because the percentage of estuary assessed differed between estuaries.

The following describes method updates that were applied in 2021-22. The 2021-2022 shoreline mangrove dataset represents a more complete and relevant dataset compared to 2020-2021. Given that this dataset is more complete, it was recommended that the 2021-2022 surveys are used as the initial year of assessment, to which later surveys are compared, as they more accurately reflect the state and condition of shoreline mangrove habitats in Wet Tropics estuaries. Future assessments will closely align with the 2021-2022 data and this includes the 2023-24 and 2024-25 assessments. No further adjustments are envisioned.

Data in Table 10 for 2020-2021 has been amended from previous methods technical reports (e.g. WTW 2022) to reflect the following.

- The original data on estuary length and proportion of estuary assessed represented the total length and proportion of estuary surveyed rather than the lower 40% of the estuary used to quantify report scores.
- For 2020-2021 data, the shoreline representing the lower 40% of the estuary was calculated using the defined upper limits of estuarine wetlands identified by the Queensland Wetlands Mapping Program. The upper estuarine limits for the Wet Tropics estuaries have now been adjusted and extended to known upriver shoreline mangrove limits in the Daintree, Barron and Russell-Mulgrave estuaries. The resulting comparative lower 40% of the estuary used to calculate Report Card scores is now consistent across all estuaries assessed.
- The percentage of shoreline surveyed in 2020-2021 has been adjusted to reflect the proportion of estuary used to calculate report scores in 2020-2021 relative to adjusted and extended estuary shoreline length used to calculate scores in 2021-2022.

Other notable modifications that have resulted in some adjustments to shoreline mangrove assessments for 2021-22 include the following.

- Improved citizen science data collection capability increased the proportion of shoreline surveyed in the Daintree and Russell-Mulgrave estuaries.
- For the Daintree and Russell-Mulgrave estuaries, the point-intercept sampling frequency for shoreline mangrove density, maturity and condition was increased from every 100 meters to every 50 meters based on an assessment of intra-estuary variability (as per Section 3.2.3.4, p.54).

Post-survey Data Processing
The data streams collected from shoreline surveys were sent to MangroveWatch scientists for processing and assessment. Estuary video streams were converted to time stamped 1-second still image frames and shoreline shapefiles (.shp) were generated for each estuary in ArcMap 10.8 using existing estuary outlines from the Wetlands Mapping Program. A point-shapefile was generated for each estuary shoreline, with points representing 10-metre shoreline intervals creating a point-intercept transect line for each estuary shoreline. Analysis of data sets was conducted with R-studio to match video and still image video to 10 m shoreline points along the surveyed shoreline.

Estuary assessments
Seven estuaries (Daintree, Dickson Inlet, Barron, Trinity Inlet, Russell-Mulgrave, Moresby and Hinchinbrook Channel) have had surveys and data processing completed meaning that they have been fully assessed and have been scored and graded for the mangrove habitat condition indicator (Table 10). Only the lower 40% of estuaries was used for scoring. This was to provide standardisation of estuary habitat type for comparison between zones because the percentage of estuary assessed differed between estuaries. The methods used to generate mangrove habitat condition indicator scores are presented in Section 3.2.3.4,

2.3.2.4. Flow

Data collection for the estuary flow indicator follows that described for the basins (Section 2.2.2.2). The flow assessment sites used for the flow indicator for estuaries are presented in Table 11 along with the Queensland Government gauging station number. Flow assessment sites for estuaries only include the nearest upstream flow assessment sites on the waterways that discharge into the estuary. Note that as from 2024-25 the flow assessment site 'South Johnstone River at Upstream Central Mill, GS no. 112101B' for the Johnstone Basin was decommissioned and is no longer available for use in the flow indicator. This means the Johnstone estuary is assessed from the single flow assessment site 'North Johnstone River at Tung Oil GS no. 112004A'.

Table 11 Estuary zone and flow assessment sites with Queensland Government gauging station number (GS no.) used for the flow indicator within each estuary.

Estuary and flow assessment site	GS no.
Barron estuary	
Barron River at Myola	110001D
Freshwater Creek at Redlynch Estate	110104A
Russell-Mulgrave estuary	
Mulgrave River at Peets Bridge	111007A
Russell River at Bucklands	111101D
Babinda Creek at The Boulders	111105A
Johnstone estuary	
North Johnstone River at Tung Oil	112004A

For estuaries, the rainfall data from the basin at which the estuary is located is used to determine the rainfall type of the reporting year (as per methods for the freshwater zone described in section 2.2.2.2). Details of the sites used to produce the rainfall records for the basins where estuaries are located are presented in Table 5.

2.3.2.5. Seagrass

Seagrass is monitored at two estuary reporting zones in the Wet Tropics (Trinity Inlet and Moresby) by the Queensland Ports Seagrass Monitoring Program (QPSMP). Seagrass is also present at the Hinchinbrook Channel and Dickson Inlet estuary reporting zones but is not currently monitored there. The location and habitat of seagrass meadows monitored in the Wet Tropics estuary reporting zones that were assessed for the 2024-2 reporting period are listed in Table 12, and maps showing the location of the monitoring meadows are presented in Figure 7. The QPSMP monitoring methods for Trinity Inlet and Moresby are the same as used by the QPSMP for inshore marine zones and an outline of the methods is provided in the Inshore Marine section 2.4.4 (Seagrass Data Collection) with more details provided in QPSMP reports for Cairns (e.g. Reason *et al.* 2025) and Mourilyan (e.g. Shephard *et al.* 2025).

Table 12 QPSMP seagrass monitoring meadows by habitat and location for estuarine reporting zones.

Estuary zone	Habitat	Location	Meadow
Trinity Inlet	Estuary intertidal	Trinity Inlet	CN20
	Estuary subtidal	Trinity Inlet	CN19
			CN33
Moresby	Estuary intertidal	Mourilyan Harbour	MH1
			MH2
			MH3
			MH4
	Estuary subtidal	Mourilyan Harbour	MH5

Figure 7 Estuary seagrass QPSMP monitoring meadows for Trinity Inlet (top) and Moresby estuary (bottom).

2.3.2.6. Fish Barriers

Data for the fish barrier indicator category were collected in July 2017 by WTW for all eight estuary reporting zones. Data for the Hinchinbrook estuary zone was updated in 2021 from barrier mapping and field surveys conducted for the Fish Homes and Highways project managed by Terrain NRM in the Murray and Herbert basins (Moore *et al*. 2021). Data for the Daintree, Dickson Inlet and Barron estuaries was updated in 2022 from barrier mapping and field surveys conducted for the Regional Lands Partnership (RLP) fish barriers project managed by Terrain NRM (Moore *et al.* 2022). Works for the remediation of fish barriers were conducted in the Hinchinbrook Channel estuary in 2022-23 as part of the Fish Homes and Highways project. The fish barrier indicator for the Hinchinbrook Channel estuary was updated for 2022-23 to capture the changes to fish barriers as a consequence of these works (see section "2023 Fish Barrier Update (reporting for 2022-23)" below). The funding and delivery of projects that include mapping and surveying fish barriers in the Wet Tropics region have provided opportunities for the estuary fish barrier assessment to be updated in greater detail from these projects for these four estuary zones. Both projects have aligned reasonably well with the recommended four-year cycle for fish barrier reporting updates. The assessment of estuary fish barriers for the Wet Tropics was conducted based upon the method developed for Mackay-Whitsunday (Moore 2016) with modifications appropriate for the Wet Tropics region.

The assessment was conducted upon the waterway network connected to the estuary mouth for each estuary zone. Given that the focus of the indicator is assessing physical impacts upon the movement and migration of diadromous fish species the spatial extent of the waterway network was limited to the area in which the species would be naturally distributed in the absence of artificial barriers. The area excluded waterways at elevations above which natural species distributions of diadromous fish occur. To determine the spatial extent for the assessment, the location of upper tidal limits (UTL) was determined for each waterway network from the Coastal Management District and the Wet Tropics riparian extent spatial layers (DES). The average upper tidal limit was identified as 10 m above sea level based upon the elevation of upper tidal limit locations using Google Earth

Pro (accuracy of +/- 2.3 m standard deviations (Wang *et al*. 2017)). Expert opinion on the distribution of diadromous fish in relation to elevation was obtained for the Wet Tropics basins (Brendan Ebner JCU and CSIRO) and an elevation of 90 m above the upper tidal limit of 10m was identified. The elevation of 100 m above sea level is correlated with a separation between lowland fish communities and escarpment communities in the Wet Tropics region (Ebner pers. comm.). A boundary of 100 m elevation was mapped from the Queensland Government digital elevation model (25 metre Wet Tropics) data package (Queensland Government 2005) around the stream and estuary network layer (Queensland waterways for waterway barrier works, Queensland Fisheries 2013) for each estuary zone using Arc GIS to determine the spatial extent of the estuary assessment areas.

2017 Fish Barrier Assessment (reporting for 2015-16).

A desktop analysis was conducted on each assessment area by intersecting the Wet Tropics fish barrier spatial data layer developed by Lawson *et al*. (2010) and Kroon and Phillips (2015) with priority 3, 4 and 5 waterways of the stream and estuary network layer. Priority 3, 4 and 5 waterways only include waterways classified as 'estuarine' (priority 5), and waterways with 'major' (Strahler stream orders 4-7) and 'high' (Strahler stream orders 2-3 with low gradient; Strahler stream order 3 with medium gradient) risk categories. The analysis was performed on Google Earth Pro and used satellite imagery to identify precise locations of all potential barriers on priority 3, 4 and 5 waterways to produce a refined spatial layer of potential fish barriers for each estuary assessment area.

Field verification assessments were conducted on potential fish barriers for each estuary assessment area. Over 300 potential fish barriers were identified for field assessment and of these 83 were verified as fish barriers, whilst most of the remaining potential fish barriers were identified in the field as bridge structures. Of the 83 verified fish barriers, 62 were assessed directly in the field. For the remaining 23 barriers access was not possible and the assessment was conducted from Google Earth imagery and from local knowledge, including landholders and Terrain NRM staff who verified the presence of the fish barrier and the structural characteristics.

2021 Fish Barrier Update (reporting for 2020-21)

The fish barriers verified by the Fish Homes and Highways project (Moore *et al*. 2021) were selected for the fish barrier assessment if they occurred in the Hinchinbrook estuary zone and if they were located on priority 3, 4 and 5 waterways (Queensland waterways for waterway barrier works, Queensland Fisheries 2013). All selected barriers that had not previously been captured in the 2017 assessment were added into the 2020-21 update. The added barriers were all structures that existed in the 2015-16 assessment but were not identified during the assessment. A total of 15 additional barriers were added to the 18 fish barriers identified in 2017 for the Hinchinbrook estuary zone.

2022 Fish Barrier Update (reporting for 2021-22)

The fish barriers verified by the RLP fish barriers project (Moore *et al.* 2022) were selected for the fish barrier assessment if they occurred in the Daintree, Dickson Inlet or Barron estuary zones and if they were located on priority 3, 4 and 5 waterways. For this assessment, in addition to using the Queensland waterways for waterway barrier works, priority waterways were also identified using the Inland waters: watercourse layer in Queensland Globe. This additional mapping meant that more waterways were defined as priority 3 and 4 than in 2017. All selected barriers that had not previously been captured in the 2017 assessment were added into the 2021-22 update. For the Barron estuary 13 barriers were added, for Dickson Inlet one barrier was added and for the Daintree estuary five barriers were added to the fish barriers identified in 2017. The assessment also included field visits to previously inaccessible sites which were classed as barriers based on Google Earth satellite imagery. From the field visits three sites listed as barriers were removed for the Daintree and one for the Barron. One site listed as a barrier for the Barron was removed after confirmation it was not located on a priority waterway when using the Queensland Globe watercourse mapping.

2023 Fish Barrier Update (reporting for 2022-23)

The Fish Homes and Highways project included funding for remediation of prioritised fish barriers. Details of the completed fish barrier remediation works are provided in Terrain NRM (2024). Five of the fish barrier remediation works were conducted on barriers verified for the fish barrier indicator in the assessment area for the Hinchinbrook Channel estuary. The locations of the remediation sites are presented in Figure 8 whilst Table 13 provides the original barrier type, the remediation work conducted and location details (basin, waterway and latitude and longitude). The remediation works provided connectivity for fish movement upstream and downstream at the site which was previously impeded by the original fish barrier. Consequently, for the 2022-23 assessment of the fish barrier indicator for the Hinchinbrook Channel estuary, the five remediated sites were removed as verified fish barrier and the fish barrier analysis was repeated.

Figure 8 Fish barrier remediation work locations in the assessment area for the Hinchinbrook Channel estuary.

Table 13 Basin, waterway, site name, barrier type, remediation works, and latitude and longitude for the fish barrier remediation work sites in the Hinchinbrook Channel estuary fish barrier assessment area.

Basin	Waterway	Site name	Barrier	Remediation	Latitude	Longitude
Murray	Five Mile Creek	Five Mile	Rock weir with pipes	Rock fishway	-18.3259°	146.0576°
Herbert	Herbert River	Herbert	Rock weir	Rock fishway	-18.6346°	146.1439°
Herbert	Lannercost Creek	Lannercost upstream	Causeway/weir	Rock ramp fishway	-18.6141°	146.0125°
Herbert	Lannercost Creek	Lannercost	Causeway	Bed level crossing	-18.6188°	146.0239°
Herbert	Lagoon Creek	Lagoon	Rock weir with pipes	Rock ramp fishway	-18.6249°	146.2642°

Latitude and longitude provided in decimal degrees.

Fish Barrier Analysis

Verified fish barriers were assessed according to transparency/passability criteria to identify low transparency structures (Moore 2016). A spatial file of the locations of the verified fish barriers was created and for each estuary the following actions were performed on ArcGIS.

- The waterway layer was edited to show priority 3 and 4 waterways and estuaries (priority 5 waterways) whilst priority 1 and 2 waterways were removed. The waterways were intersected with the 100 m elevation boundary from a digital elevation model spatial file (Queensland Government 2005), removing waterways above 100 m elevation.
- The intersected waterway layer was selected, and lengths were determined using ArcGIS functions to calculate total stream length.
- The number of barriers was counted.
- Low transparency barriers were identified on the map. Only those that were located on waterways that could affect fish movement between freshwaters and estuarine waters were used for the low transparency measure. Those that were located on waterways that did not extend beyond estuary habitat and could not affect fish movement to freshwaters were not used for the measure.
- The first upstream barrier for each waterway branch was identified and the length of each waterway downstream of the barrier to the estuary mouth was calculated using ArcGIS functions.

From these procedures the following measures were calculated and used for scoring the estuary fish barrier indicator.

The **'barrier density**' indicator was assessed by calculating the total waterway length (km) of priority 3, 4 and 5 waterways in the estuary assessment area and dividing the total waterway length by the total number of barriers in the estuary assessment area (Figure 9).

The **'proportion of waterway length to the first barrier'** indicator was assessed by quantifying the distance (waterway length) downstream of the first barrier to the estuary mouth on all priority 3 and 4 waterways in the estuary assessment area (Figure 9). The total waterway length was divided by the overall connected waterway length to determine the proportion of waterway length of estuary waterways not impacted by barriers.

The **'proportion of waterway length to the first low/no transparency/passability barrier'** indicator was assessed by quantifying the distance (waterway length) upstream to the first low/no transparency/passability barrier for priority 4 waterways only (Figure 9). The total waterway length was divided by the overall connected waterway length in the estuary assessment area to determine the proportion of waterway length upstream of the estuary waterways not impacted by low/no transparency/passability barriers. A low transparency/passability barrier was defined as a barrier that never or rarely drowns out (<1 flow event per year), a dam or weir with >2 m head loss, a causeway >2m high with pipe/culvert configuration <10 % and/or bankfull stream width and head loss >1 m.

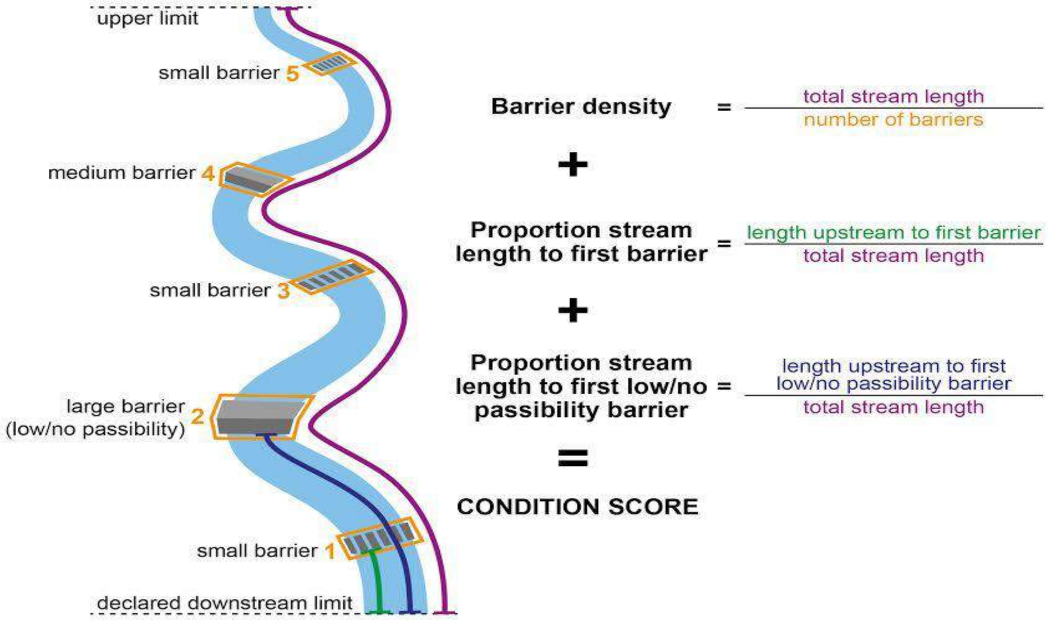


Figure 9 Diagram of the three fish barrier indicators and how they are calculated.

For purposes of the diagram the declared downstream limit is equivalent to the upper tidal limit. The fish barriers indicator category comprises of three indicators, barrier density, percent of stream length to the first barrier, and percent of stream length to the first impassable barrier. Each indicator is scored separately and then the scores for these three indicators are summed together to produce the overall score for the fish barriers index (Section 3.2.3.1).

2.3.3. Fish

Estuarine fish methodology is being developed and will be determined in collaboration with the Reef 2050 Integrated Monitoring, Modelling and Reporting Program (RIMReP) and other regional report card partnerships.

2.4. Inshore and Offshore Data Collection

The location of the inshore and offshore marine reporting zones, the inshore water quality, coral and seagrass monitoring sites, and the location of the offshore coral monitoring sites are shown in Figure 10. Locations of pesticide passive samplers and close up maps of inshore monitoring sites for each of the four inshore zones are in APPENDIX D Figure 37 to Figure 41.

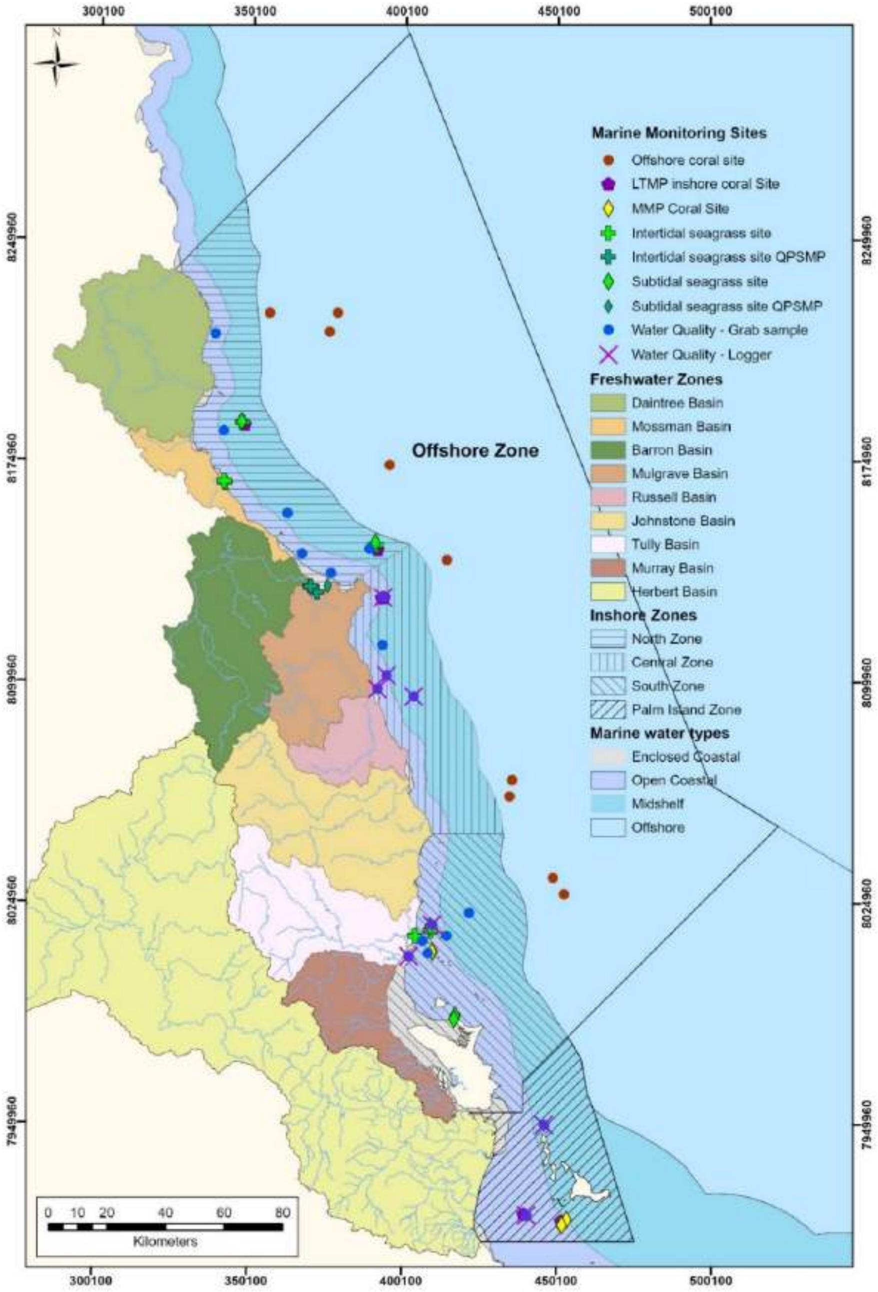


Figure 10 Reporting zones and monitoring sites for the inshore and offshore marine environments.

Note: Some monitoring sites are obscured, more detailed maps for each inshore zone are available in Figure 38 to Figure 41. LTMP is the Long Term Monitoring Program (inshore and offshore coral sites), MMP is the Marine Monitoring Program, QPSMP is the Queensland Ports Seagrass Monitoring Program.

The inshore reporting zone includes enclosed coastal, open coastal and mid-shelf marine water types (see section 2.4.1 for more details on marine water type definitions), extending east to the boundary with the offshore waters (Figure 10). The inclusion of enclosed coastal, open coastal and mid-shelf waters for the inshore zone is consistent with the inshore zoning used by the Great Barrier Reef Marine Monitoring Program (MMP) in the Wet Tropics region for their annual inshore monitoring reports (for example see Gruber *et al.* (2020)).

2.4.1. Inshore Water Quality

Inshore water quality data for the Wet Tropics Region was collected for the MMP by the Australian Institute for Marine Science (AIMS) and James Cook University (JCU) (Table 14) over the reporting period. All water quality data were collected in accordance with the methods outlined in Gruber *et al.* (2020). The water type at each monitoring location is defined by the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 Wet Tropics Map Series and by delineation of marine waterbodies (GBRMPA 2010). Guideline values are set for the different water types in the Queensland Water Quality guidelines (DEHP 2009), the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 Wet Tropics (DES 2020) and the Water Quality Guidelines for the Great Barrier Reef Marine Park (GBRMPA 2010). The guideline values for inshore marine waters (enclosed coastal (EC), open coastal (OC) and mid-shelf (MS)) are listed in Table 45.

Table 14 MMP water quality monitoring sites for the Wet Tropics showing data source, water type for application of guideline values (GVs): mid-shelf (MS), open coastal (OC), enclosed coastal (EC), reporting zones, site name and code, and sample type.

AIMS data	JCU data	Water Type GV	Inshore zones and water quality monitoring sites	Sample type
North Zone				
√		OC	Cape Tribulation (C1)	Grab
√		MS	Port Douglas (C4)	Grab
√		MS	Double Island (C5)	Grab
√		OC	Yorkey's Knob (C6)	Grab
√		OC	Fairlead Buoy (C8)	Grab
√		MS	Green Island (C11)	Grab
Central zone				
√		OC	Fitzroy Island West (RM1)	Grab and logger
√	√	MS	RM3	Grab
√	√	MS	Frankland Group West (RM7)	Grab and logger
√	√	OC	High Island West (RM8)	Grab and logger
√	√	OC	Russell-Mulgrave River mouth mooring (RM10)	Grab and logger
South zone				
√	√	MS	East Clump Point (TUL2)	Grab
√	√	OC	Dunk Island North (TUL3)	Grab and logger
√	√	OC	Dunk Island South East (TUL5)	Grab
√	√	OC	Between Tam O'Shanter and Timana (TUL6)	Grab
√	√	OC	Bedarra Island (TUL8)	Grab
√	√	EC	Tully River mouth mooring (TUL10)	Grab and logger
Palm Island Zone				
√	√	OC	Pelorus and Orpheus Island West (BUR1)	Grab and logger
√	√	OC	Pandora Reef (BUR2)	Grab and logger

The monitoring sites for 'grab' water samples (suspended solids, nutrients and chlorophyl *a*) and deployment of water quality loggers (chlorophyll *a* and turbidity) for the MMP routine water quality sampling, from which the report card sources water quality data for the inshore zone, are listed in Table 14 and their locations are shown on the inshore zone maps (Figure 38 to Figure 41). From 2020-21 a rationalisation of the MMP has reduced the number of sites monitored as part of routine water quality sampling. Five sites (RM2, RM4, RM5, RM6 and RM9) in the Central zone, and three sites (TUL4, TUL7 and TUL9) in the South zone were ceased for routine monitoring and now are monitored only during selected high rainfall events. The AIMS and JCU MMP water quality sampling and analysis were conducted as per the methods of Gruber *et al.* (2020). Particulate nitrogen (PN), particulate phosphorus (PP), nitrogen oxides (NO_x), chlorophyll-a (Chl-*a*), total suspended solids (TSS), and turbidity (NTU) were selected as indicators for the report card inshore water quality (WTHWP 2018).

The MMP monitoring of pesticides in inshore waters using passive samplers was resumed in 2022-23 after suspension of monitoring from 2020-21 to 2021-22. For 2024-25, results from passive samplers at the Palm Island zone Lucinda Jetty site were not available. Pesticides were sampled using passive samplers at sites within the inshore zone as listed in Table 15 for the specified deployment periods. The locations of the sites are presented in Figure 37. Results of pesticide concentrations from passive samplers were produced for the MMP by the Queensland Alliance for Environmental Health Sciences, University of Queensland. Laboratory analysis of pesticides was conducted on each passive sampler device to determine the concentrations for 25 pesticide types (Table 16).

Table 15 Pesticide passive sampler site locations and deployment dates and duration.

Inshore zone	Site location	Latitude	Longitude	Deployed dates	Retrieval dates	Days deployed
North	Low Isles	-16.38182	145.56213	06/11/2024	03/12/2024	27
				03/12/2024	07/01/2025	35
				07/01/2025	10/02/2025	34
				10/02/2025	13/03/2025	31
				10/02/2025	13/03/2025	31
				13/03/2025	14/04/2025	32
Central	High Island	-17.15843	146.0045	07/11/2024	02/12/2024	25
				07/11/2024	02/12/2024	25
				02/12/2024	08/01/2025	37
				08/01/2025	12/02/2025	35
				08/01/2025	12/02/2025	35
				12/02/2025	12/03/2025	28
South	Dunk Island	-17.94017	146.13177	06/11/2024	03/12/2024	27
				03/12/2024	07/01/2025	35
				07/01/2025	10/02/2025	34
				10/02/2025	13/03/2025	31
				10/02/2025	13/03/2025	31
				13/03/2025	14/04/2025	32
Palm Island	Lucinda jetty	-18.52083	146.38631	No data		

Latitude and longitude are presented in decimal degrees.

Table 16 Pesticides analysed from inshore marine passive samplers

Pesticides analysed from inshore marine passive sampler		
2,4-D	Fluometuron	Metsulfuron methyl
Ametryn	Fluroxypyr	Prometryn
Atrazine	Haloxyfop	Propazine
Atrazine desethyl	Hexazinone	Simazine
Atrazine desisopropyl	Imazapic	Tebuconazole
Bromacil	Imidacloprid	Tebuthiuron
Diuron	MCPA	Terbuthylazine
Fluazifop	Metolachlor (S+R)	Terbutryn
	Metribuzin	

Passive samplers allow for a longer term ‘average’ concentration to be identified, which suits annual condition reporting. While grab and automatic samples have the potential to identify acute, rapid, irregular peaks in pesticide concentration, this is only the case if taken at the opportune time. Details on sample sites, sampling methodology and laboratory analysis can be found in the relevant reports for the MMP inshore water quality monitoring programs.

2.4.2. Offshore Water Quality Data Collection

There is no data available for reporting offshore water quality for 2024-25.

Since the 2020-21 reporting year there has been no data available for scoring and grading water quality for the offshore zones of the regional report cards. Up until 2019-20, the data for the offshore assessment of water quality was extracted from the marine water quality (MWQ) Bureau of Meteorology dashboard based on remotely sensed analysis of reflectance. In early 2021 the Bureau of Meteorology advised that the MWQ dashboard and underlying data preparation workflow was to be discontinued. Since 2022, the Technical Working Group for regional report cards and the Independent Science panel recommended that services and products produced by CSIRO for eReefs are used for offshore water quality reporting and progress towards this has been made.

The Technical Working Group recommended in early 2025 that the reporting of offshore water quality is more effective using a contextual approach and should replace the scoring and grading approach. The rationale for this recommendation was based upon the following points.

- The offshore area for each report card is an extremely large water body in comparison to the other reporting zones.
- Offshore water quality under typical conditions is not affected by catchment influences.
- Applying a score and grade implies that the condition of offshore water quality can be affected by current management actions.
- Average conditions across an offshore zone are expected to consistently score and grade highly with very minimal change over time under current management arrangements.

Proposed information to be included for contextual reporting of offshore water quality include historical data of key indicators (e.g. chlorophyll *a* and total suspended solids or their surrogates) derived from eReefs, and mapping of flood plume extent for key indicators, which may include turbidity, total suspended solids, chlorophyll a and nutrients, derived from MMP inshore water quality reports and directly from remote sensing sources. Contextual reporting of offshore water quality will be developed and implemented as part of the 2027 Program Design update for regional report cards. Note that limitations on annual reporting of offshore water quality using eReefs data include the biennial timing of data releases which align with the Reef Report Card reporting cycle.

2.4.3. Inshore and Offshore Coral Data Collection

Coral monitoring for the Wet Tropics region is conducted by AIMS through the MMP and the LTMP. The monitoring plan and number of coral monitoring sites and depths at surveyed reefs are provided in Table 17 for each inshore zone and for the offshore zone. The inshore environment includes open coastal and mid-shelf waters, and coral monitoring for inshore zones, therefore, included MMP and some LTMP sites, whilst offshore coral monitoring included LTMP sites only (Figure 10, Table 17). The MMP coral surveys predominantly occurred between May to July 2025. The LTMP coral sampling occurred between August 2024 to May 2025. As from 2021-22 the LTMP coral monitoring program sampling design has been modified and now conducts annual surveys at a reduced number of reefs. Previously the LTMP sampling design surveyed a different set of reefs in alternating years. The six reefs no longer included in the LTMP are listed in Table 18. Prior to 2020-21, the MMP also sampled reefs in alternating years, with additional unscheduled coral surveys (even year scheduled reefs sampled in odd years and vice versa) undertaken to fill gaps when disturbances were suspected.

Table 17 Inshore coral annual survey sites.

Reporting Zone	Program	Reef	Number of sites	Number of depths
Inshore North	LTMP	Low Isles	3	1
	MMP	Snapper North	3	2
		Snapper South	3	2
Inshore central	LTMP	Fitzroy West LTMP	3	1
	MMP	Fitzroy East	2	2
		Fitzroy West	2	2
		Franklands East	2	2
		Franklands West	2	2
		High East	2	2
		High West	2	2
Inshore South	MMP	Barnards	2	2
		Bedarra	2	2
		Dunk North	2	2
		Dunk South	2	2
Palms	LTMP	Havannah North	3	1
		Pandora North	3	1
	MMP	Havannah	2	2
		Lady Elliot	2	5
		Palms East	2	2
		Palms West	2	2
		Pandora	1	2
Offshore	LTMP	Mackay	3	1
		Agincourt 1	3	1
		Hastings	3	1

Reporting Zone	Program	Reef	Number of sites	Number of depths
		St Crispin	3	1
		Thetford	3	1
		Feather	3	1
		Farquharson	3	1
		Peart	3	1
		Taylor	3	1

Table 18 Reefs that are no longer included in the LTMP coral surveys.

Reef
Arlington Reef
Hedley Reef
McCulloch Reef
Michaelmas Cay
Moore Reef
Opal Reef

Inshore coral data from the MMP and LTMP were collected from permanently marked sites within the Wet Tropics region by AIMS. The MMP consisted of five 20 m (each 5 m apart) transects along the 5 m or 2 m depth contour. Digital depth gauges and electronic tide charts (produced by the Australian Hydrographic Service) were used to determine the desired depths of 5 m and 2 m below lowest astronomical tide (LAT).

LTMP reefs are surveyed every year as from 2021-22. Details of the LTMP survey methods are provided online by AIMS in their Standard Operating Procedures (SOPs).

The data collection methods of the MMP and LTMP are largely comparable. The following Standard Operational Procedure from the AIMS Long-term Monitoring Program were used for both MMP and LTMP.

- #9: (sic.) Coral surveys using the manta tow and SCUBA search techniques.
- #10: Surveys of benthic reef communities using underwater digital photography and counts of juvenile corals.

The data collection methods for the density of juveniles (juveniles per square metre of unoccupied suitable space) differs slightly between monitoring programs. Juveniles up to 5 cm diameter are counted along the first 5 m of LTMP transects and the entire 20 m length of MMP transects. For both programs juvenile counts are converted to densities per area of substrate occupied by algae (considered potentially available for coral colonisation) as estimated from photo transects.

The MMP coral data for coral cover, macroalgal cover, rate of coral cover increase (change in coral), density of juvenile corals and community composition were sampled and analysed as per Thompson *et al.* (2016). For further detail on the MMP and LTMP methods, refer to Thompson *et al*. (2016) and Sweatman *et al.* (2007), respectively and to the AIMS Reef Monitoring website and SOPs.

2.4.4. Inshore Seagrass Data Collection

Marine Monitoring Program

The MMP seagrass sampling design was developed to detect change in inshore seagrass meadows in response to improvements in water quality parameters associated with specific catchments or regions and in context of disturbance events (McKenzie *et al*. 2015). The meadows monitored within the MMP were selected by the GBRMPA.

Mapping surveys were conducted to select representative meadows, which match the dominant community type, and average abundances (McKenzie *et al.* 2015). Sampled meadows were lower littoral (rarely exposed to air) and sub littoral (permanently covered with water) (McKenzie *et al.* 2015). Two sites were selected at each location to account for spatial heterogeneity (McKenzie *et al.* 2015). Additionally, minimum detectable difference (MDD) had to be no more than 20 % (McKenzie *et al.* 2015).

Monitoring timing was determined by GBRMPA for the MMP, with advice from experts. Monitoring for the reporting period occurred during the late dry (growing) season and late wet season, in order to obtain information on the seagrass communities' status pre- and post- wet. The MMP seagrass monitoring locations, sites and habitat type for the inshore zones are provided in Table 19.

Table 19 MMP seagrass monitoring locations sites and habitat for inshore zones.

Inshore zone	Habitat	Location	Site
North	Reef intertidal	Low Isles	LI1
		Green Is	GI1 & GI2
	Reef subtidal	Low Isles	LI2
		Green Is	GI3
	Coastal intertidal	Yule Pt	YP1 & YP2
South	Reef intertidal	Dunk Is	DI1 & DI2
	Reef subtidal	Dunk Is	DI3
	Coastal intertidal	Lugger Bay	LB1 & LB2
	Coastal subtidal	Missionary Bay	MS1 & MS2

For further information on site selection, methods and analysis, refer to the latest 'Marine Monitoring Program: Annual Report for inshore seagrass monitoring' available at https://elibrary.gbrmpa.gov.au/jspui/.

Queensland Ports Seagrass Monitoring Program

The objective of the QPSMP is to report on the condition of seagrass in the highest risk areas of Queensland and use this information to assist in the planning and management of anthropogenic activities. The QPSMP assesses seagrass condition at 50 individual meadows located within 7 port locations along the Great Barrier Reef (Carter *et al*. 2016). In contrast to the MMP which monitors smaller scale transect sites within individual meadows, the QPSMP monitors and reports on seagrass condition for entire individual meadows and sampling occurs annually during the peak of the seagrass growing season in late spring/early summer at the end of the dry season (Carter *et al.* 2023). Meadow selection is based on their representation of the range of meadow types found in each location (dominant species, intertidal/subtidal, meadow size and mean biomass). Condition indicators reported for each meadow are mean above-ground biomass, meadow area and species composition (Carter *et al*. 2023). The program and approach has had independent review on several occasions and results are regularly published in peer reviewed journals (Carter *et al.* 2023). For further information on site selection and methods in the Wet Tropics refer to previous QPSMP reports for Cairns (Reason *et al.* 2025). The location and habitat of seagrass meadows monitored in the Wet Tropics inshore marine zones for 2024-25 are listed in Table 20.

Table 20 QPSMP seagrass monitoring meadows by water body, habitat and location for the inshore zones.

Inshore zone	Habitat	Location	Meadow
North	coastal intertidal	Cairns Harbour	CN13
			CN34
	coastal subtidal	Cairns Harbour	CN11

The QPSMP report card approach was developed in consultation with the Gladstone Healthy Harbours Partnership (GHHP) to report on seagrass condition for the Gladstone region and was implemented across the QPSMP Ports in 2014. The methods for setting baseline conditions, score calculation and indicator assessment have received independent analysis and review through the GHHP Independent Science Panel (Carter *et al*. 2023).

2.4.5. Inshore and Offshore Fish Data

The development of marine (inshore and offshore) fish indicators and sampling methods is in progress with the view for inclusion in the Report Card once confirmed.

3. CONDITION AND STATE ASSESSMENT SCORING METHODS

3.1. General Scoring for Condition and State Assessments

The indicators are used to assess the different pressures on each of the environments in the region. The process of indicator selection, along with detail on the drivers and pressures in the Wet Tropics region, can be found in the Program Design (WTHWP 2018).

Ordinal categories are used to describe the scores for condition of indicators, indicator categories, indices and the overall grade. This follows a five-point grading system:

Very Good (A), Good (B), Moderate (C), Poor (D), Very Poor (E).

An overall condition grade was provided for separate reporting zones within each environment (freshwater basin, estuary, inshore marine and offshore marine). Scores were averaged from the indicator level to generate indicator category scores. Where an indicator category is represented by a single indicator the indicator category score is equal to the indicator score. Indicator categories were averaged to generate an index score, and indices were subsequently averaged to produce an overall score for an individual reporting zone in an environment.

Decision rules were developed for the minimum proportion of information required to generate the aggregated scores, as follows.

≥ 50 % of indicators to generate the indicator category score
≥ 60 % of indicator categories to generate the index score

Overall scores for reporting zones are presented in the Report Card, even if not all indicator categories and indices are available. However, the circle diagram presenting the data visually shows which indices contribute to the overall grade.

The common scoring range used for reporting is based on that used by the Great Barrier Reef Report Card, as shown in Table 21. Where required, indicator scores were standardised into the standardised scoring range by linear interpolation (scaling) within bandwidths. In the following sections, individual indicator scoring and associated formula for scaling are presented. Once standardised, relevant scores, calculated to at least one decimal place to allow for differentiation between grades, were averaged to aggregate into the higher category. For presentation in the results technical report the scores were then rounded down and presented as integers. The exception to this was the inshore and offshore coral standardised scores which were calculated to the nearest whole number using conventional rounding (values ≥ 0.5 are rounded up and values < 0.5 are rounded down). This was applied to maintain consistency with the MMP coral scoring method (Thompson et al. 2024).

Table 21. Standardised scoring ranges and corresponding condition grades.

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

Values for condition assessment of water quality are drawn from a range of sources including water quality objectives scheduled under the [Environmental Protection (Water and Wetland Biodiversity) Policy 2019](#) (DES 2020), and water quality guideline values obtained from the Queensland Water Quality Guidelines (DEHP 2009), the GBRMPA Guidelines (GBRMPA 2010) and the ANZG (2018). For the purposes of the waterway assessment and to simplify terminology, all values obtained from these sources will be referred to as water quality guideline values.

3.2. Freshwater Basins and Estuaries

Basin and estuary environments share several indicators, indicator categories and indices and also apply the same or similar methods for determining scores of state and condition. To minimise repetitions this section combines the assessment and scoring methods for basins and estuaries, describing similarities and differences where they occur. The results technical report provides all results separately for basin and estuaries. Table 22 shows the similarities between scoring and assessment methods for estuaries and basins.

Table 22 Shared and similar scoring and assessment methods for indicators of the basin and estuarine environments.

<table>
<tr><th>Index</th><th>Indicator category</th><th>Indicator</th><th>Basins</th><th>Estuaries</th><th>Shared scoring method</th><th>Similar scoring method</th></tr>
<tr><td rowspan="7">Water quality</td><td>Sediment</td><td>Total suspended solids</td><td>●</td><td></td><td rowspan="6"></td><td rowspan="6">●</td></tr>
<tr><td>Phys-chem</td><td>Turbidity</td><td></td><td>●</td></tr>
<tr><td></td><td>DO</td><td></td><td>●</td></tr>
<tr><td>Chlorophyll a</td><td>Chlorophyll a</td><td></td><td>●</td></tr>
<tr><td rowspan="2">Nutrients</td><td>Dissolved inorganic nitrogen</td><td>●</td><td>●</td></tr>
<tr><td>Filterable reactive phosphorus</td><td>●</td><td>●</td></tr>
<tr><td>Pesticides</td><td>Pesticide risk metric</td><td>●</td><td>●</td><td>●</td><td></td></tr>
<tr><td rowspan="8">Habitat & hydrology</td><td rowspan="2">Habitat modification</td><td>Impoundment length</td><td>●</td><td></td><td></td><td></td></tr>
<tr><td>Fish barriers</td><td></td><td>●</td><td></td><td></td></tr>
<tr><td>Flow</td><td>30^{th} Percentile of 10 flow metrics</td><td>●</td><td>●</td><td>●</td><td></td></tr>
<tr><td>Riparian</td><td>Extent</td><td>●</td><td>●</td><td rowspan="3"></td><td rowspan="3">●</td></tr>
<tr><td>Wetlands</td><td>Extent</td><td>●</td><td></td></tr>
<tr><td>Mangroves and salt marsh</td><td>Extent</td><td></td><td>●</td></tr>
<tr><td>Invasive weeds</td><td>Extent, diversity and impact</td><td>●</td><td></td><td></td><td></td></tr>
<tr><td>Seagrass</td><td>Biomass, cover, species composition</td><td></td><td>●</td><td></td><td></td></tr>
</table>

3.2.1. Water Quality – nutrient, sediment and physical-chemical indicators

The water quality condition assessments of basins and estuaries were conducted using monthly medians calculated for the reporting period (1/7/2022– 30/6/2023) for all water quality indicators excluding pesticides (TSS, DIN, FRP, Chl-*a*, turbidity and dissolved oxygen). Pesticides were assessed separately as outlined below. For data values recorded as below detection limit (BTL), a value of half the detection limit was applied.

To calculate a condition score (ranging from 0 – 100) for each water quality indicator, the medians from high flow periods and base-flow periods for freshwater basins and the annual medians for estuaries for sites within each estuary water type (all calculated from monthly values) are compared to scheduled guideline values. Only medians that meet or are better than the guideline value achieve a good or a very good score (Figure 11). This approach is very similar to the MMP system used in the marine zones, where the cut-off between "Good" and "Moderate" is where the indicator mean is equal to the guideline value.

Medians that do not meet the guidelines are scaled between the guideline and a scaling factor (SF). The approach to calculating a condition grade and translating this to the report card five-point grading is outlined in Table 23 and Table 24.

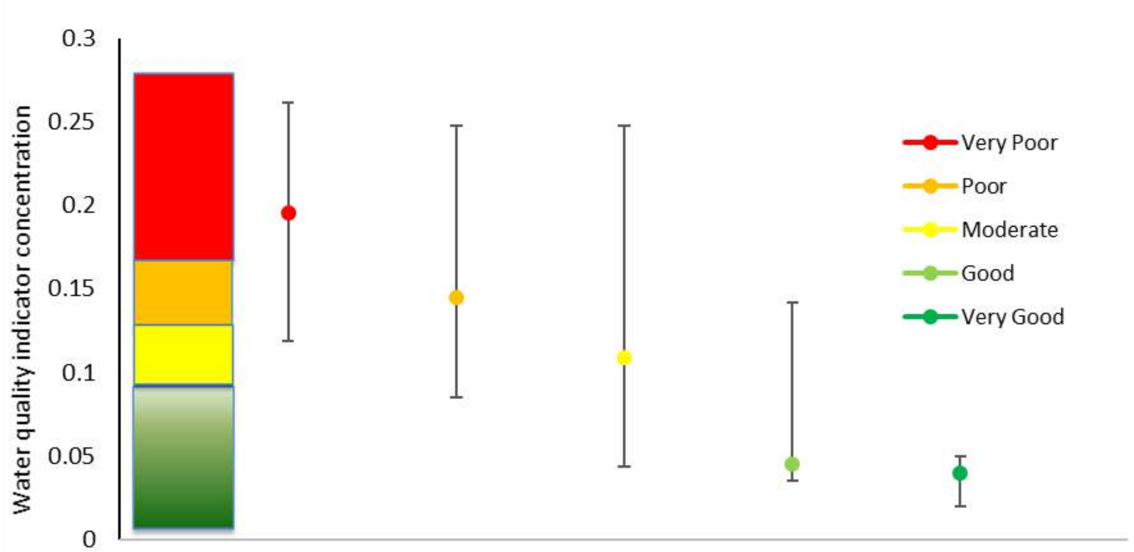


Figure 11. An example of how water quality grades are assigned. Where the middle point represents the annual median, the top whisker the 80th percentile and the bottom whisker the 20th percentile of the data. Only when the median meets or is better than the guideline (in this case below the guideline) can good or very good be scored. Scores for moderate, poor and very poor are equally scaled between the guideline and scaling factor.

The following steps are used to calculate condition scores for the water quality indicators.

- Derive DIN values from data where required (oxidised N + ammonia).
- For freshwater basins, excluding Mossman, separate the data according to high flow and base flow conditions.
- For the Mossman Basin separate the data to each of the five sites (data is all sampled during base-flows).
- For estuaries with more than one water type (enclosed coastal/lower estuary or mid-estuary), separate data according to water type (guideline values differ between water types).
- Determine monthly values for each site (for months with more than one data point monthly medians are calculated.
- For freshwater basins, excluding Mossman, calculate median for the high flow period and the base-flow period from monthly values.
- For the Mossman Basin calculate median for each of the five sites from their monthly values.
- For estuaries calculate annual median for each water type (enclosed coastal, lower estuary or mid-estuary) from monthly values.
- Compare median to guideline values.
- Calculate condition score (0 – 100) following rules and formula in Table 23 and Table 24.

Water quality guideline values for nutrients provided in the water quality objectives (WQOs) for the Wet Tropics Basins (DES 2020) do not include concentrations values for DIN. DIN is comprised of oxidised nitrogen (NO_x) and ammonia nitrogen (NH_3) forms, and water quality objectives for both are specified for freshwater and estuary water types for the Wet Tropics (DES 2020). To derive guideline values for DIN (DIN-N) the WQO concentration values for oxidised nitrogen (NO_x-N) and ammonia nitrogen (NH_3-N) were summed for each water type. Further information about this approach is presented in the Program Design (WTHWP 2018).

Table 23 Rules, formula and scoring ranges and associated grades for nutrients, sediments and physico-chemical indicators in freshwater basins and estuaries of the Report Card, when to meet a guideline, values must be lower than the guideline.

Rule	Formula	Scoring range	Grade
Median meets GV and 80th percentile of data meets GV	Assigned 90.0[1]	81 to 100	Very Good
Median meets GV, but 80th percentile data does not meet GV	80.9-(19.9*(ABS((80th-GV)/(80th-median))))	61 to <81	Good
Median does not meet GV	60.9-(60.9*(ABS((median-GV)/(SF-GV))))	41 to <61	Moderate
		21 to <41	Poor
		0 to <21	Very Poor

Note: 80th means 80th percentile of the data; GV means guideline value; median is the annual median of the data; ABS means the absolute value/positive value; SF means scaling factor based on 90th percentile of available data).

Table 24 Rules, formula and scoring ranges and associated grades for nutrients, sediments and physico-chemical indicators in freshwater basins and estuaries, when to meet a guideline, values must be higher than the guideline (lower DO).

Rule	Formula	Scoring range	Grade
Median meets GV and 20th percentile of data meets GV	Assigned 90.0[1]	81 to 100	Very Good
Median meets GV, but 20th percentile of data does not meet GV	80.9-(19.9*(ABS((20th-GV)/(20th-median))))	61 to <81	Good
Median does not meet GV	60.9-(60.9*(ABS((median -GV)/(SF-GV))))	41 to <61	Moderate
		21 to <41	Poor
		0 to <21	Very Poor

Note: 20th means 20th percentile of the data; GV means guideline value; median is the annual median of the data; ABS means the absolute value/positive value; SF means scaling factor based on 90th percentile of available data).

[1]QLD Water quality guidelines 2009 recommend protocols for testing against 20th, 50th (median) and 80th percentiles. There is no *a priori* knowledge or guidelines regarding the entire distribution of water quality parameters in our systems, so assumptions/decisions regarding the other 20% of the data (between 80-100%) and how it should be distributed around the GV cannot be made. The middle (i.e. 90) of the Very Good range (Table 23) is assigned to scores for Very Good. SF for DO is based on the 99th percentile of all values.

3.2.1.1. Separation of high flow and base-flow water quality data

For freshwater basins excluding Mossman Basin, the water quality data were separated into high flow and base-flow periods using mean daily discharge data (Queensland Government) at each monitoring site and applying the mean daily base-flow (MDBF) cut off value (Orr *et al.* 2014), or an estimated cut off value (Table 25). This procedure allowed the separate scheduled guideline values for high flows and base-flows (Table 28) to be applied for calculation of the water quality scores.

Base-flow is considered here to be flow that occurs in the absence of runoff due to rainfall events (Orr *et al*. 2014). For the MDBF cut off values, base-flow was calculated from the ratio of base-flow to total flow averaged across all years according to Grayson *et al*. (1996), using the River Analysis Package (eWater CRC 2012) as described by Orr *et al*. (2014). Base-flow was defined as all periods when mean daily discharge was less than or equal to the base-flow cut off value. Mean daily base-flow values have not been calculated for the Mulgrave and Russell CLMP sites, so base-flow cut off values were estimated and were set as the mean daily discharge, above which, high flow event sampling was initiated for DES loads monitoring. Monthly medians for basin water quality were calculated separately for high flow and base-flow conditions, and medians for high flow and base-flow periods were calculated from the monthly medians for each basin. For the purpose of calculating condition scores for the high flow and base-flow periods, the North Johnstone and the South Johnstone sub-basins were treated as separate basins. Note that the assessment of basin water quality will incorporate updated base-flow cut off values for separating high flow and base-flow conditions developed by Binns and Waters (2018) when scheduled. Examples of base-flow cut off values at sites for which data is currently available are presented in Table 25 and are lower than the values produced from the current method.

Table 25 Mean daily base-flow values for each GBR CLMP monitoring site.

Basin	GBR CLMP site	Base-flow cut off value (m^3/s)
Daintree	Lower Daintree	25*
Barron	Myola	8.2
Mulgrave	Deeral	30.0*
Russell	East Russell	39.5*
Johnstone	North Johnstone at Goondi	31.6
	South Johnstone at Central Mill	15.0 (12.1 – 13.7#)
Tully	Euramo	61.2 (51.1 – 53.4#)
Murray	Bilyana	8*
Herbert	Ingham	44.2

Mean daily base-flow sourced from Orr *et al*. (2014) or by estimation (*). # Shows the base-flow cut off values from the method developed by Binns and Waters (2018) and are yet to be scheduled.

3.2.1.2. Mossman Basin base-flow water quality data

The Mossman Basin water quality was conducted as part of their Environmental Impact Monitoring Program and did not include monitoring during high-flow conditions. Monthly values for DIN, FRP and TSS were determined for the pooled data from the three sites MR3, MR4 and MR4.1 located on the Mossman River upstream of the confluence with South Mossman River (MR-US), the South Mossman River site SMR1 (SMR), and the Mossman River site MR5 located downstream of the confluence with the South Mossman River (MR-DS).

3.2.1.3. Scaling factors

Scaling factors for the freshwater nutrient and sediment indicators (DIN, FRP and TSS) were derived as follows. The historical GBR CLMP data were pooled from all basins (seven sites). The data were separated into high-flow and base-flow periods using an approximation method, where any 'event-flow' data (indicated by consecutive samples within a single day or over consecutive days) represented samples taken above the event-flow threshold, and that conversely, any discrete 'ambient' samples (approximately monthly) were taken below the event-flow threshold (and therefore represented base-flow). The 90th percentile was set as the SF and was calculated for each data set (Table 26). The advantage of this approach was that the SFs were derived from the largest sample size available for high flow and base-flow conditions and the number of SF values across the Report Card were minimised and provided consistency between basins.

Table 26 Scaling factors (SF) for calculating condition for basin water quality indicators.

Indicator category	Sediment	Nutrients	
Indicator	**TSS (mg/L)**	**DIN (mg/L)**	**FRP (mg/L)**
High flow	191	0.306	0.016
Base-flow	74	0.261	0.013

For the estuarine indicators DO, turbidity, DIN, FRP and Chl-*a*, historical data were sourced for each estuary reporting zone from available data sets. Scaling factors were set by comparison of data sets with guideline values using expert knowledge, because there were too few historical data available to calculate sensible scaling factors from 90th percentiles. Guideline values for moderately disturbed waters are consistent across the estuary reporting zones for each water type (mid-estuary or lower estuary).

Table 27 Scaling factors for calculating condition for estuary water quality indicators.

Indicator category	Physico-chemical		Chlorophyll-*a*	Nutrients	
Indicator	**Turbidity (NTU)**	**DO (% saturation)**	**Chl *a* (µg/L)**	**DIN (mg/L)**	**FRP (mg/L)**
	20	50 – 111	5	0.200	0.010

3.2.1.4. Guideline values

For freshwater basins, the water quality indicator guideline values (GVs) for moderately disturbed (MD) freshwaters (50th percentile) for base-flow conditions (DES 2020 (Barron, Mulgrave and Johnstone Basins) and 80th percentile for high flow conditions (DES (2020) and Orr *et al*. (2014)) were applied and are provided in Table 28. All GVs are sourced from the EPP 2019 for Wet Tropics Basins (DES 2020). The scheduled high flow 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). Consequently, the FRP GVs are lower for high flows than for base-flows. 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.

Table 28 Scheduled water quality guideline values for Wet Tropics basins.

Guideline Values		TSS (mg/L)	DIN (µg/L)	FRP (µg/L)
Base-flows				
MD	All basins	8	60	8
High flows				
80th Percentile	All basins	52	114	4

Source DES (2020) EPP 2019 Wet Tropics Basins.

For estuaries, the guideline values for moderately disturbed mid estuary and moderately disturbed lower estuary/enclosed coastal waters (DES 2020, EPP 2019 Wet Tropics Basins) were applied. For estuary reporting zones where monitoring sites were located in both mid estuary and lower estuary water or enclosed coastal types (for example the Barron estuary, see Table 7) data were separated according to water type for the calculation of annual medians, and calculation of condition scores using the specified guideline values for each water type, as shown in Table 29 (DES 2020, EPP 2019 Wet Tropics Basins).

Table 29 Water quality guideline values for Wet Tropics moderately disturbed estuarine waters.

Guideline Values	Turbidity (NTU)	DO (% sat.)	Chl *a* (µg/L)	DIN (µg/L)	FRP (µg/L)
Mid estuary	10	80 – 105	3	45	5
Lower estuary/ enclosed coastal	10	85 - 105	2	25	5

The moderately disturbed guideline values for estuarine waters are the 80th percentiles of the reference data except for the lower DO values which are the 20th percentile of the reference data. Source DES (2020) EPP 2019 Wet Tropics Basins.

3.2.1.5. Calculation of annual condition scores for each indicator.

The following rules were applied to calculate the annual condition score for each indicator.

- For each basin, excluding the Mossman Basin, the condition scores for the high flow and base-flow period were multiplied by the proportion of days of the year they occurred and were then summed to provide the annual condition scores for each indicator.
- For the Johnstone Basin, the annual condition scores were averaged from the annual condition scores of the North Johnstone and South Johnstone sub-basins.
- For estuary reporting zones, the condition scores for each indicator were multiplied by the proportion of data values within each water type within the reporting zone (enclosed coastal/lower estuary or mid estuary) and then condition scores were summed.

For the Mossman Basin, the condition score was calculated as follows.

- The total catchment area upstream of the each monitoring site was determined using a 12.5 m cell-size hydrologically-correct digital elevation model (DEM) derived by the Department of Environment and Science based on the latest 1 second (≈30 m) SRTM-derived DEM-S elevation data (https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/72759) and State 1:25,000 waterway mapping (qldspatial.information.qld.gov.au).

- The adjusted upstream catchment area for each assessment site was determined, which is all the catchment area up until the next upstream monitoring site if present (applicable to sites MR4.1 and MR5).
- The proportion of total catchment for each monitoring site was determined and multiplied by the standardised score for the monitoring site.
- All scores were summed to provide the final basin score.

The upstream catchment area, adjusted catchment area and proportion of total upstream catchment area is presented in Table 30.

Table 30 Mossman Basin monitoring sites adjusted catchment area and proportion of total upstream catchment area.

Site	Upstream catchment area (km^2)	Adjusted catchment area (km^2)	Proportion of total upstream catchment
MR2/MR4	104/106	104	0.536
MR4.1	106	1	0.005
MR5	196	1	0.004
SMR1	89	89	0.456

Condition scores for indicators are aggregated into indicator categories (as presented in Table 26 and Table 27) and the water quality index by averaging the scores following decision rules for minimum information.

3.2.2. Water quality - Pesticides

In regional report cards prior to the 2017-18 reporting period, the Pesticide Risk Metric (PRM; previously referred to as the ms-PAF method) had been used to calculate the mixture toxicity for photosystem II (PSII) herbicides only. PSII herbicides share a common mode of action (MoA), and therefore, the ms-PAF could be calculated using the concentration addition model of joint action (Bliss 1939; Plackett and Hewlett 1952; Könemann 1981). From the 2017-18 Report Card, the ms-PAF approach was applied to pesticides with multiple MoAs (Table 3). The ms-PAF for pesticides with different modes of action was calculated using the independent action model of joint action (Plackett and Hewlett 1952). Further details on how the Pesticide Risk Metric calculations were made are provided in Warne *et al*. (2020). The pesticide mixture toxicity was calculated for all samples collected over the standardised 182-day wet season, commencing when a rise in river water level and an increase in aqueous pesticide concentrations occurs. Where there was more than one sample per day a daily mean concentration was calculated.

The mixture toxicity data (i.e. ms-PAF values) for all water samples collected over the wet season were then summarised as a single PRM value. In order to do this, it was necessary to estimate the daily average ms-PAF for days that weren't monitored during the wet season using a multiple imputation technique (Rubin 1996; Donders *et al*. 2006; Patrician 2002). This involved fitting a statistical distribution to the observed data for the wet season for the site. This distribution was then used to impute values to fill in the missing days in the 182-day period. The resultant 182 days of data were then divided by 182 to obtain the Pesticide Risk Metric, and ranked into five risk categories (Table 31). These categories are consistent with the ecological condition categories used in the Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters.

Table 31. Grading description for the pesticides risk assessments.

Risk categories (% species affected)	% species protected	Risk Level	Pesticides assessment	Standardisation of scores for aggregation (score = % species affected)
≤1.0%	≥99%	Very low risk	Very good	VG = 81+ ABS((19 - ((score-0) *(19/1))))
>1 – 5%	95 – <99%	Low risk	Good	G= 61+ ABS((19.9 - ((score -1.01) *(19.9/3.99))))
>5 – 10%	90 – <95%	Moderate risk	Moderate	M=41+ ABS((19.9 - ((score -5.01) *(19.9/4.99))))
>10 – 20%	80 – <90%	High risk	Poor	P= 21+ ABS((19.9 - ((score -10.01) * (19.9/9.99))))
>20.0%	<80%	Very high risk	Very poor	VP=0+ABS((20.9 - ((score-20.01) *(20.9/79.99))))

All values were rounded to the nearest whole number. For Russell-Mulgrave, the mean of the pesticide scores for each river basin is used for the estuary. Pesticide condition scores were aggregated into the water quality index following the procedure for the other water quality indicator categories.

3.2.3. Habitat and Hydrology

3.2.3.1. Habitat Modification (instream)

Impoundment Length (Freshwater Basins)

The suggested rating scheme (Table 32) was derived from earlier work on Murray-Darling Basin rivers, which involved benchmarking the ecological condition of multiple rivers in relation to several ecological indicators, one of which was the proportion of river impounded by dams and weirs. The ecological condition of streams was assessed during benchmarking based on existing studies and the expert opinion of a panel of experienced aquatic ecologists (see DNR 2000 and Sheldon *et al*. 2000).

There are likely to be differences in the degree of ecological impact resulting from impoundment of stream segments in differing areas of the stream network, but currently it is not possible to account for such complex differences in any robust way. The rationale for including impoundment length as an indicator was to highlight the loss of natural habitat and ecological processes in the region, many of which are related to natural channel wetting and drying – something that is lost as a result of impoundment. An assumption of status quo is implied in the scoring for impoundment length (rather than cause-and-effect with ecological function), with additional impoundments lowering subsequent Report Card scores.

Table 32. Grading description for the impoundment length indicator for freshwater basins.

% of waterway impounded	Condition grade	Scaling of scores for aggregation
< 1.0%	Very Good	VG= 81+ ABS((19 - ((score-0) *(19/0.99))))
1.0-3.99%	Good	G= 61+ ABS((19.9 - ((score -1) *(19.9/2.99))))
4.0-6.99%	Moderate	M=41+ ABS((19.9 - ((score -4) *(19.9/2.99))))
7.0-9.99%	Poor	P=21+ ABS((19.9 - ((score -7) * (19.9/2.99))))
≥ 10.0%	Very Poor	VP=0+ABS((20.9 - ((score-10) *(20.9/90))))

Fish Barriers (Freshwater Basins)

Methods of calculating condition scores for fish barriers will be presented following development and the review of the measures and indicators

Fish Barriers (Estuaries)

To assess the condition of fish barriers a scoring range and subsequent score was applied for each of the three indicators (Table 33 to Table 35) following the method developed by Moore (2016) used for the Mackay Whitsunday report cards. Each estuary was allocated a score for each indicator based on these scoring ranges. The final aggregated fish barriers indicator score for each estuary was derived by adding these three scores together (Table 36).

Table 33 Scoring range and subsequent score assigned for the barrier density indicator.

Scoring Range (km/barrier)	Score	Condition grade
≥16.1	5	Very Good
8.1 - 16	4	Good
4.1 - 8	3	Moderate
2.1 - 4	2	Poor
0 - 2	1	Very Poor

Table 34 Scoring ranges and score assigned for 'stream length to the first barrier as a proportion (%) of total stream length'.

Scoring Range (%)	Score	Condition grade
No Barriers	5	Very Good
80% - 99.9%	4	Good
60% - 79%	3	Moderate
40% - 59.9%	2	Poor
0% - 39.9%	1	Very Poor

Table 35 Scoring ranges and score assigned for 'stream length to the first low/no transparency/passability barrier as a proportion (%) of total stream length'.

Scoring Range (%)	Score	Condition grade
no low pass barriers (100%)	5	Very Good
90.1% – 99.9%	4	Good
80.1% - 90%	3	Moderate
60.1% - 80%	2	Poor
0% - 60%	1	Very Poor

Table 36 Overall fish barrier condition scoring range and fish barrier condition rating.

Scoring Range	Overall Fish Barrier Condition Rating	Scaling of scores for aggregation
14-15	Very Good	VG = 81+ ABS((19 + ((score-15) *(19/1))))
11-13	Good	G= 61+ ABS((19.9 + ((score -13) *(19.9/2))))
8-10	Moderate	M=41+ ABS((19.9 + ((score -10) *(19.9/2))))
5-7	Poor	P= 21+ ABS((19.9+ ((score -7) * (19.9/2))))
3-4	Very Poor	VP=ABS((20.9 + ((score-4) *(20.9/1))))

3.2.3.2. Flow (Freshwater Basins and Estuaries)

The flow indicator scores the daily flow record for the reporting year at a given flow assessment site. There are 10 flow measures that contribute to the flow indicator score (Table 37). Each measure assesses observed flow data against the reference distribution from the predevelopment modelled flow for the given flow assessment site. The reference distributions are selected for one of the four rainfall types (drought, dry, average or wet) to match the rainfall type of the reporting year. The 10 flow measures have been selected to represent key components of the natural flow regime that are required by a range of ecological assets with links to water resources that are sensitive to changed water allocation and management conditions. The key flow components and ecological assets are: cease to flow - amphibians, riffles and waterholes; low flows - low flow spawning fish species, reptiles, amphibians, riffles and waterholes; medium flows - riffles; and high flows - fisheries production in estuaries. Details of the flow requirements of the assets (including seasonal flow requirements), their links to the flow measures and a description of the flow measures are provided in Table 59 to Table 61 (APPENDIX E Flow indicator ecological assets and flow measures.) and also presented in the Report Card Flow Indicator Project report (Stewart-Koster *et al*. 2018) available from the WTW website.

Note that due to landscape changes resulting from human activities, including vegetation clearing, removal of wetlands, levelling, modification of channel morphology and removal or addition of waterway channels, the characteristics of flood waters including their duration, extent and frequency may have been affected. Consequently, whilst flow volumes during flood events may be similar to predevelopment levels the actual hydrological characteristics of the flood and inundation events, and hence their ecological functioning, may be altered.

Table 37 The 10 flow measures used for the flow indicator, the season to which they apply and the hydrologic definition of the measure.

Low flow Duration	July-Jan	Total duration of flows which remain equal to or below a lower threshold for the reporting period (annual).
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).
Low flow variability	July-Dec	Coefficient of variation (standard deviation/mean) of daily flow for dry season.
Driest six Months	July-Dec	Proportion of annual discharge contributed during the months July-December.
Cease to flow Duration	All year	Total duration of where flow ceases during the reporting period (annual).
Cease to flow Frequency	All year	Count of the number of occurrences during which flow ceases during the reporting period (annual).
Medium flow Duration	All year	Total duration of flows which remain equal to or above a threshold for the reporting period (annual)
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 threshold during the reporting period (annual).
High flow duration	All year	Total duration of flows which remain equal to or above a threshold for the reporting period (annual)
High flow Frequency	All year	Total count of flows which remain equal to or above a threshold for the reporting period (annual)

Source: Stewart-Koster *et al*. (2018).

The scoring for each flow measure is based upon the percentile range representative of standard deviations from the mean as presented in Table 38.

Table 38 The benchmark measures for all the flow measures expressed as standard deviations from the mean and approximate percentiles.

Score	Target standard deviations from mean	Rationale	Percentile range
5	1	within 68.27% observed range	15.87-84.13
4	2	within 95.45% observed range	2.28-15.87, 84.13-97.72
3	3	within 99.73% observed range	0.13-2.28, 97.72-99.87
2	4	within 99.99% observed range	0-0.13, 99.87-100
1	5	outside the observed range	<0, >100

The flow measures score the flow for the reporting year on a scale of 1 to 5. For each flow assessment site, the 30th percentile value of all 10 flow measures is used to provide a summary score. Several summary statistics were evaluated during the development of the flow indicator

(Stewart-Koster *et al*. 2018) and the 30th percentile value was selected as the most appropriate summary statistic for representing the range of the 10 flow measures. The other summary statistics evaluated were the mean, the mode and the minimum score. The procedures required for producing flow measure scores and summary scores were conducted using the flow indicator tool developed for the Report Card Flow Indicator Project (Stewart-Koster *et al*. 2018). The summary scores from the flow assessment sites were converted from the 1 to 5 scale to the standardised scale of 0 to 100 for aggregation with other report card indicators.

For each flow assessment site, the following steps were applied to provide a standardised score from 0 to 100 from the output score of the flow assessment tool (1 to 5).

1. Determine the 30th percentile value from the 10 flow measures (each scored 1-5) for each flow assessment site.

2. Apply the following formula for scores of <2: (20.9 + ((30th percentile - 1.9)*(23.2))).

3. Apply the following formula for scores of 2 to <5: ((30th percentile x 20) - 19).

4. Apply the following formula for scores of 5: 80 + ((M_{min} - 1) x 5) where M_{min} is the lowest scoring measure (1 to 5) for the flow assessment site.

The 30th percentile score, standardisation formula and standardised scoring range with grade colour code are presented in Table 39.

Table 39 Standardisation formula for 30th percentile scores of flow assessment sites.

30th percentile score	Formula applied for standardisation	Standardised range
5	80 +((minimum flow measure score - 1) x 5)	81-100
4 - <5	(score x 20) - 19	61-80.9
3 - <4	(score x 20) - 19	41-60.9
2 - <3	(score x 20) - 19	21-40.9
1 - <2	20.9 + ((score - 1.9) x (23.2*))	0-20.9

*23.2 is a scaling factor to convert the 30th percentile score to within the very poor standardised scoring range (0-20.9)

Note: Step 2 is to provide a value of 0 to 20.9 for scores of less than two and graded ‘very poor’. Step 3 is to provide a value of between 21 and 80 for scores between two and less than five and are graded ‘poor’, ‘moderate’ or ‘good’. Step 4 is to provide a value of between 80 to 100 for scores of five using the lowest contributing flow measure score as a scale and also prevents a flow assessment site for which a flow measure is scored 1 (outside of the observed distribution) from receiving a grade of "very good". For the Report Card, grades of very good are defined in the Program Design as: "Conditions frequently meeting guidelines or reference values and the majority of critical habitats are intact" (WTHWP 2018).

For basins or estuaries with more than one flow assessment site, the following steps were applied for aggregating scores.

- The total catchment area upstream of the gauged flow assessment sites was determined.
- The adjusted upstream catchment for each assessment site (stream gauge) was determined, which is all the catchment area up until the next upstream assessment site(s) if present.
- The proportion of total catchment for each assessment site was determined and multiplied by the standardised score for the assessment site.

- All contributing scores are summed to provide the final basin score.

Seasonal assessment approach

Review of the flow indicator for 2018-19 identified occasions where some flow metrics were scoring considerably lower than expected based on observations of river flows. It was concluded that the issue occurred due to marked differences of monthly rainfall for 2018-19 compared to long-term monthly averages (in particular the Mulgrave River). The period of July to November included months with rainfall well below their long-term monthly average whilst the period December to June included months with rainfall well above their long-term average. However, the flow indicator tool defines the rainfall type of a reporting year from its total rainfall, and compares observed flows to modelled pre-development flow from years of the same rainfall type. 2018-19 was defined as a 'wet' year and flow measures were calculated using 'wet' modelled pre-development flow data. The flow indicator tool was adjusted to assess the dry season months (July to November) and the months during and after the wet season (December to June) separately. Application of the adjusted flow season tool on the 2018-19 flow data resulted in the 'dry season' period classified as 'drought' (due to months with rainfall well below their long-term averages) and the 'wet season' classified as 'wet' (due to months with rainfall well above their long-term averages). The flow measure scores produced by the seasonally specific flow indicator tool were markedly more consistent with the observations of flow (based on results for the Mulgrave River). For reporting years which have high variation of monthly rainfall compared to long-term means the flow indicator may be applied seasonally to flow assessment sites on a case by case basis to correct for major differences of seasonal rainfall types.

Worked example of the flow indicator

The 2017 to 2018 rainfall for the Barron Basin and the annual flow records for Picnic Crossing and Mareeba flow assessment sites on the Barron River are presented in Figure 12. Picnic Crossing is upstream of Tinaroo Falls Dam and has a smaller catchment than Mareeba which is downstream of Tinaroo Falls Dam. Differences in the flow records between the sites include the effect of the impoundment on river flows. This example visually presents how assessment of flow records using the indicator differ between a site that has minimal alteration from predevelopment flows (Picnic Crossing) and one that has substantial alteration from predevelopment flows (Mareeba) for the 2017-18 reporting period.

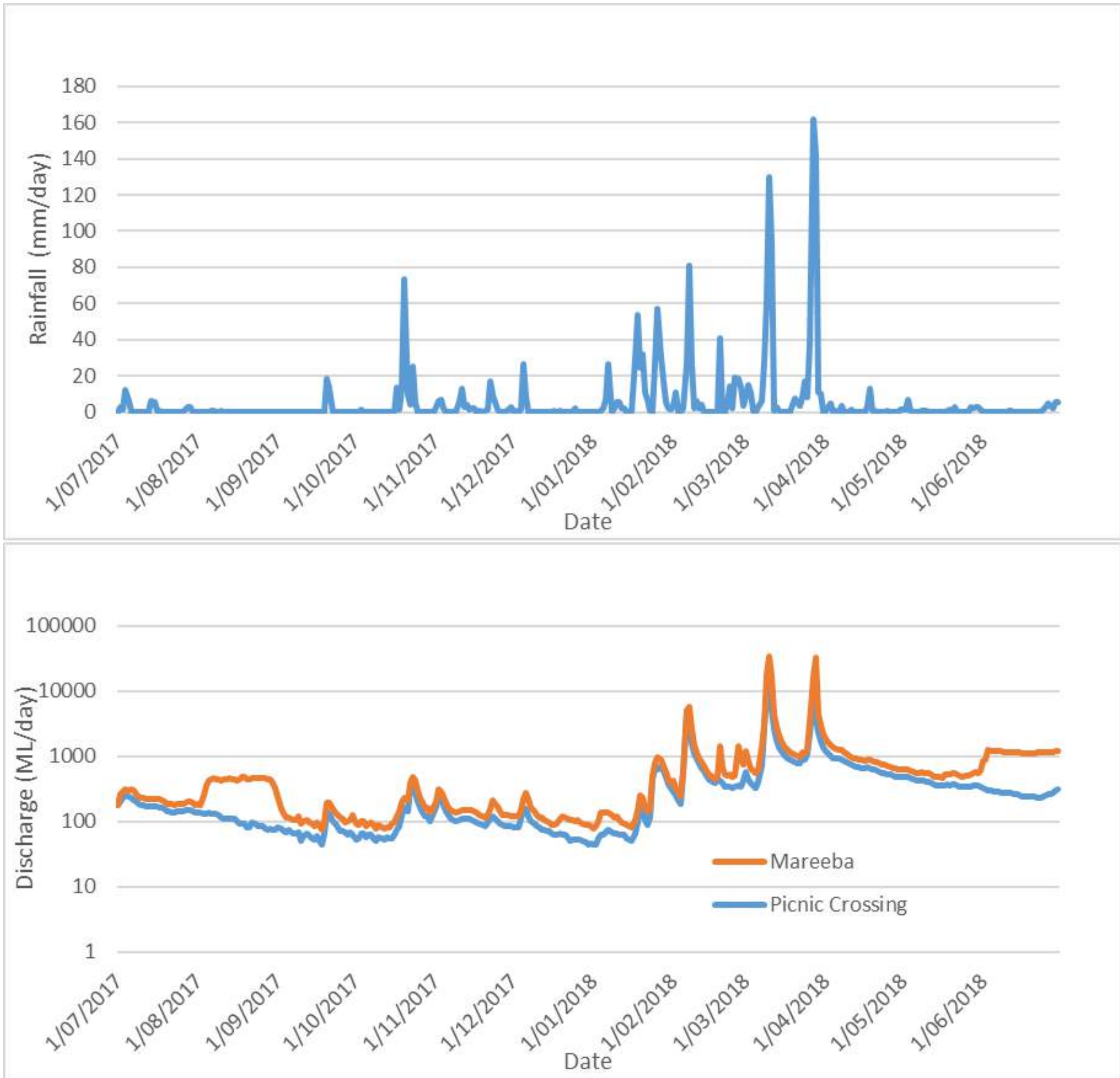


Figure 12 Rainfall for the Barron Basin and flow records for Mareeba and Picnic Crossing for 2017-18.

The flows at Picnic Crossing for 17-18 scored a maximum five for each of the 10 flow measures and flows were determined as being not substantially altered from pre-development flows. The flows at Mareeba were substantially altered from pre-development flows for the following four of the 10 flow measures: low flow duration (score = 1/5), low flow variability (score = 3/5), medium flow duration (1/5) and medium flow frequency (1/5). The flow record for Mareeba shows abrupt changes in flow during August 2017 and June 2018 as a results of flow regulation of Tinaroo Falls Dam. These changes in flow did not occur at Picnic Crossing and were not driven by rainfall. The flow measure scores for low and medium flows were affected by the alteration of flows at Mareeba. The overall flow indicator score for Mareeba was 2.4, as calculated as the 30th percentile of the 10 flow measure scores. The standardised value of this score was 29 (poor). The example demonstrates how the flow indicator assesses the degree of change from reference for different characteristics of the flow regime.

This example includes alterations to flow that are easy to visualise from an annual flow record. However, the 10 flow measures are able to assess and score aspects of the flow regime that may not be as clearly visualised from the flow record but may still be important to waterway health.

The potential impacts upon waterway health attributes linked to low flows include low flow spawning fish, critical hydraulic habitat, longitudinal connectivity and water quality, those linked to medium flows include riffle habitats and macrophyte beds, and those linked to high flows include fisheries production (Stewart-Koster *et al*. 2018). The results of the flow indicator for Mareeba identify that alteration of flows may be impacting on waterway health for the attributes linked to low flows and medium flows.

3.2.3.3. Riparian, Wetland and Mangrove/Saltmarsh Extent (Freshwater Basins and Estuaries)

For the habitat extent indicators riparian and wetland extent are applied to basins whilst riparian and mangrove/saltmarsh are applied to estuary environments. Note that mangrove and saltmarsh are separate habitats but have been grouped together as part of the mapping process. Data on the extent of saltmarsh and mangrove is presented separately for each zone in the results technical report.

The score for the extent of riparian vegetation was calculated as the percent loss of riparian vegetation since pre-development to current (2013) for each basin or estuary zone.

The score for wetland extent in freshwater basins was calculated as the percent loss of vegetated freshwater swamp (palustrine) systems with more than 30 per cent emergent vegetation cover. The score for the extent of mangroves and saltmarsh in estuaries was calculated as the per cent loss of mangroves and saltmarsh. For both habitat types, the current (2021) extent was calculated as a percentage of the pre-development extent for each zone, based on the most recent version of Queensland Regional Ecosystem.

For each zone (freshwater or estuarine) and applicable habitat type (riparian, wetland, or mangrove and saltmarsh), the percent loss of habitat extent score was assigned the appropriate grade and the corresponding standardisation formula was applied as per Table 40.

Table 40 Scoring ranges, grades and aggregation formula for the riparian, wetland and mangrove/saltmarsh habitat extent indicators in freshwater basin and estuary assessments.

Per cent loss of habitat extent score ranges	Grade	Standardisation 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))))

3.2.3.4. Shoreline mangrove habitat condition

Habitat features were identified and assessed from the processed post-survey data for each estuary. The features were scored using a criteria-based image analysis following Mackenzie et al. (2016). A description of the five features assessed, and the respective criteria used for assessments are detailed in Table 41. The scoring system for each feature was devised based on experience and knowledge of tropical shoreline estuary habitats. Scoring criteria used the most parsimonious approach that maintained relevance to spatial and temporal comparisons of features within and between estuaries. Image feature assessment was undertaken on images associated with 10-meter interval shoreline points. Mangrove presence and point features were scored every 10 m, whereas habitat features were scored every 50 m or 100 m depending on the estuary size and shoreline mangrove cover. The scoring interval was chosen after an initial assessment of shoreline mangrove percentage cover to ensure a minimum of 30 sampling points with mangroves present per estuary section. Estuaries were divided into 5 equal sections representing 20th percentiles of the distance from the estuary upstream limit to the estuary mouth along the main estuary channel.

Shoreline mangrove habitat condition features were grouped into three (3) measures: habitat structure, canopy cover and habitat impact. Each measure is designed to reflect ecosystem service provision potential and ecosystem resilience. The scores for the measures of shoreline mangrove habitat condition were calculated as the mean score of the features within each group. The shoreline mangrove habitat condition indicator score was calculated from the mean score of the three measures. Features were scored on a scale of 0 to 100 in accordance with the standardised scoring system of the report card (Table 41). For binary and discrete – nominal scores, the score was calculated relative to the proportional representation of classes within each feature. For features with a discrete-ordinal score, the score was based on the estuary mean score. A description of scoring and grading calculations is provided in Table 41 and further information on the method is provided in Mackenzie (2021).

Table 41 Descriptions and scoring procedures for the shoreline mangrove habitat condition indicator.

<table>
<tr><th colspan="7">Shoreline Mangrove Measure: Habitat Structure</th></tr>
<tr><td colspan="7">Shoreline Mangrove Habitat Structure Score =
((Mangrove Cover Score (%C) + Mangrove Density Score (MD) + Mangrove Maturity Score (MM)))/3</td></tr>
<tr><th>Feature</th><th>Interval</th><th>Feature Descriptor</th><th>Assessment Criteria (Point sampling)</th><th colspan="3">Score Metrics (Estuary sampling)</th></tr>
<tr><td rowspan="7">Fringe Mangrove Cover</td><td rowspan="7">10 m</td><td rowspan="7">The percent cover of mangroves along the estuary shoreline.</td><td rowspan="7">0) Mangroves not directly present along shoreline

1) Mangroves present along shoreline</td><td colspan="3">Base Metric: % Cover (%C)
Percentage cover of mangroves represented as the number of shoreline points assessed with mangroves present (1) as a proportion of total number of shoreline points assessed.</td></tr>
<tr><th>Range</th><th>Grade</th><th>Standardisation</th></tr>
<tr><td>> 90%</td><td>Very Good</td><td>= 81+((19+((%C-100)*(19/9.9))))</td></tr>
<tr><td>> 80-90%</td><td>Good</td><td>= 61+((19.9+((%C-90)*(19.9/9.9))))</td></tr>
<tr><td>> 70-80%</td><td>Moderate</td><td>= 41+((19.9+((%C-80)*(19.9/9.9))))</td></tr>
<tr><td>≥ 50-70%</td><td>Poor</td><td>= 21+((19.9+((%C-70)*(19.9/20))))</td></tr>
<tr><td>< 50%</td><td>Very Poor</td><td>= ((20.9+((%C-49.9)*(20.9/49.9))))</td></tr>
<tr><td rowspan="7">Shoreline Mangrove Stand Density</td><td rowspan="7">Small estuary
50 m

Large estuary
100m</td><td rowspan="7">The density of mangrove stands along the shoreline</td><td rowspan="7">1) Sparse
Individual mangrove plants but with other isolated individuals in close proximity not forming a contiguous mangrove stand.
2) Isolated Stand/Patch
Multiple individual plants present at assessment point not forming part of contiguous forest extending >20m along the shoreline as determined by mangrove absence or isolated individuals in adjacent frames.</td><td colspan="3">Mangrove Density Score (MD) – 1 to 4
Mean Mangrove Density Score along shoreline with mangroves present.</td></tr>
<tr><th>Range</th><th>Grade</th><th>Standardisation</th></tr>
<tr><td>> 3.75</td><td>Very Good</td><td>= 81+((19+((MD-4)*(19/0.24))))</td></tr>
<tr><td>> 3.25-3.75</td><td>Good</td><td>= 61+((19.9+((MD-3.75)*(19.9/0.49))</td></tr>
<tr><td>> 2.5-3.25</td><td>Moderate</td><td>= 41+ ((19.9+((MD-3.25)*(19.9/0.49))</td></tr>
<tr><td>≥ 2-2.5</td><td>Poor</td><td>= 21+ ((19.9+((MD-2.5)*(19.9/0.49))</td></tr>
<tr><td><2</td><td>Very Poor</td><td>= ((20.9+((MD-1.99)*(20.9/1.99))))</td></tr>
</table>

<table>
<tr><td></td><td></td><td></td><td>3) Open Continuous Forest
Mangrove visible at assessment point part of contiguous mangrove fringe (>20m along shoreline) but with large spaces between individuals and canopies not intermingling.
4) Closed Continuous Forest
Mangrove visible at assessment point part of contiguous mangrove fringe (>20m along shoreline) with no spaces between individuals and canopies intermingling.</td><td></td></tr>
<tr><td>Shoreline Mangrove Stand Maturity</td><td>Small estuary 50 m

Large estuary 100m</td><td>The estimated age class of mangroves along the shoreline as determined from expert visual assessment.</td><td>1) Seedlings
Only seedlings (< ~0.5m tall) present: <2 yrs old
2) Saplings
Only Immature plants <1.5m tall, 2-5 yrs old
3) Young Mature
Stand dominated young (~5-10 yrs) mature trees
4) Mature Established Trees
Stand dominated by established mature individuals >10 yrs old present.</td><td>Mangrove Maturity Score (MM) – 1 to 4
Mean mangrove maturity score along shoreline with mangroves present.
<table>
<tr><th>Range</th><th>Grade</th><th>Standardisation</th></tr>
<tr><td>> 3.75</td><td>Very Good</td><td>= 81+((19+((MM-4)*(19/0.24))))</td></tr>
<tr><td>> 3.25-3.75</td><td>Good</td><td>= 61+((19.9+((MM-3.75)*(19.9/0.49)))</td></tr>
<tr><td>> 2.5-3.25</td><td>Moderate</td><td>= 41+ ((19.9+((MM-3.25)*(19.9/0.49)))</td></tr>
<tr><td>≥ 2-2.5</td><td>Poor</td><td>= 21+ ((19.9+((MM-2.5)*(19.9/0.49)))</td></tr>
<tr><td><2</td><td>Very Poor</td><td>= ((20.9+((MM-1.99)*(20.9/1.99))))</td></tr>
</table></td></tr>
<tr><td colspan="5">Shoreline Mangrove Measure: Canopy Cover</td></tr>
<tr><td colspan="5">Shoreline Mangrove Canopy Cover Score = Mean Mangrove Condition Score</td></tr>
<tr><td>Shoreline Mangrove Condition</td><td>Small estuary 50 m

Large estuary 100m</td><td>The health of mangrove stands determined by canopy density related to leaf production, canopy retreat, exposed branches and twigs (dieback) and dead trees.</td><td>0) Dead or Almost Dead
<10% Canopy Cover
1) Very Poor Condition
10-30% Canopy Cover
2) Poor Condition
30-60% Canopy Cover
3) Moderate Condition
60-90% Canopy Cover
4) Healthy
>90% Canopy Cover</td><td>Mean Canopy Cover Score (CC) - 1 to 5
The mean canopy cover score along shoreline with mangroves present.
<table>
<tr><th>Range</th><th>Grade</th><th>Standardisation</th></tr>
<tr><td>> 3.5</td><td>Very Good</td><td>= 81+((19+((MC-4)*(19/0.49))))</td></tr>
<tr><td>> 3-3.5</td><td>Good</td><td>= 61+((19.9+((MC-3.5)*(19.9/0.49)))</td></tr>
<tr><td>> 2.5-3</td><td>Moderate</td><td>= 41+ ((19.9+((MC-3)*(19.9/0.49)))</td></tr>
<tr><td>≥ 2-2.5</td><td>Poor</td><td>= 21+ ((19.9+((MC-2.5)*(19.9/0.5)))</td></tr>
<tr><td><2</td><td>Very Poor</td><td>= ((20.9+((MC-1.99)*(20.9/1.99))))</td></tr>
</table></td></tr>
</table>

<table>
<tr><th colspan="5">Shoreline Mangrove Measure: Habitat Impact</th></tr>
<tr><td colspan="5">Shoreline Habitat Impact Score =
(Mangrove Damage Score (D) + Shoreline Modification Score (SM))/2</td></tr>
<tr>
<td>Shoreline Mangrove Habitat Damage</td>
<td>10m</td>
<td>The presence of active or recent (<1 year) human-related shoreline mangrove removal and damage where mangroves are present.</td>
<td>1) Physical Damage to mangroves causing loss of mangrove condition not causing tree death or habitat loss
Physical damage to mangrove plants including access tracks, boat landings/tie points, cattle grazing.

2) Physical Damage to mangroves causing minor (<10m shoreline) death or minor habitat loss
Physical damage to mangrove plants including trimming and cutting, removal of individual plants and small gap creation.

3) Physical Damage to mangroves causing extensive (>10m shoreline) tree death or habitat loss
Damage to multiple mangrove plants causing plant death or removal of mangrove stands.</td>
<td>Mangrove Damage Score (D)
The proportion of mangroves with modification evident, weighted for the level of damage where present

Damage Multipliers:
1 – x 1
2 – x 1.5
3 – x 2
<table>
<tr><th>Range</th><th>Grade</th><th>Standardisation</th></tr>
<tr><td>≤1</td><td>Very Good</td><td>= 81+ ((19 - (D*19))</td></tr>
<tr><td>> 1-3</td><td>Good</td><td>= 61+ ((19.9 - ((D-1.1) *(19.9/1.9)))</td></tr>
<tr><td>> 3-7</td><td>Moderate</td><td>= 41+ ((19.9 - ((D-3.1) *(19.9/3.9)))</td></tr>
<tr><td>> 7-15</td><td>Poor</td><td>= 21+ ((19.9 - ((D-7.1)*(19.9/7.9)))</td></tr>
<tr><td>>15</td><td>Very Poor</td><td>= ((20.9-((D-15.1)*(20.9/84.9))))</td></tr>
</table></td>
</tr>
<tr>
<td>Shoreline Modification</td>
<td>10m</td>
<td>The presence of human-related shoreline substrate modification (E.g. Rip-rap walls, concrete boat ramps, debris dumping).</td>
<td>0) Natural –
No substrate modification

1) Modified –
substrate modification with existing or potential for mangrove colonisation

2) Impervious –
substrate modification with no potential for mangrove colonisation</td>
<td>Shoreline Modification Score (SM)
The proportion of shoreline substrate modified weighted for the degree of modification.

Modification Multipliers:
1 – x 0.5
2 – x 1
<table>
<tr><th>Range</th><th>Grade</th><th>Standardisation</th></tr>
<tr><td>≤2</td><td>Very Good</td><td>= 81+ ((19 - ((SM *(19/1.9))))</td></tr>
<tr><td>> 2-6</td><td>Good</td><td>= 61+ ((19.9 - ((SM-2.1) *(19.9/3.9))</td></tr>
<tr><td>> 6-14</td><td>Moderate</td><td>= 41+ ((19.9 - ((SM-6.1) *(19.9/7.9))</td></tr>
<tr><td>> 14-30</td><td>Poor</td><td>= 21+ ((19.9 - ((SM-14.1)*(19.9/15.9)</td></tr>
<tr><td>>30</td><td>Very Poor</td><td>= ((20.9-((SM-30.1)*(20.9/69.9))))</td></tr>
</table></td>
</tr>
</table>

Shoreline Mangrove Habitat Condition Indicator Score =   **(Habitat Structure Score + Canopy Cover Score + Mangrove Habitat Impact Score)/3**

3.2.3.5. Invasive Weeds (Freshwater Basins)

The invasive weeds mapping procedure provided a record of the presence or absence of each weed species intersecting with the waterway habitat layer for all grid cells within each basin. The data was then exported from ArcMap into an Excel pivot table for processing. Grid cells with at least one species of weed present were defined as occupied cells. The basin impact score was the sum of impact scores of weed species from all occupied cells within each basin. To determine the potential impact scores, the assumption was made that all weeds identified in the prioritisation process would be able to potentially occupy each and every grid cell given their aquatic lifeform. The potential impact score for each basin was calculated as the sum of the impact scores for all weeds potentially present in all occupied grid cells (grid cells where at least one weed species occurred). In the pivot table the potential impact score (the sum of all mean impact scores) and the actual impact score were calculated as a percentage per basin, as follows.

Percent impact score = (actual impact score/potential impact score) x 100

The 10th, 25th, 50th and 75th percentiles of the percent impact scores from all basins were used to set the scoring ranges for each grade and formulae were applied to generate standardised scores for aggregation, as shown in Table 42.

Table 42. Grading description for invasive weeds in the freshwater basin assessments 2019-20.

Percentile range	Percent impact score	Grade	Standardisation formula for aggregation
0 - 0.10	0-11.5	Very good	Very good = INT(81+((19-(score-0)*(19/11.5)))
>0.10-0.25	>11.5-12.8	Good	Good = INT(61+ ((19 - ((score-11.5) * (19/1.3)))))
>0.25-0.50	>12.8-15.2	Moderate	Moderate = INT(41+ ((19 - ((score-12.8) * (19/2.5)))))
>0.50-0.75	>15.2-16.8	Poor	Poor = INT(21+ ((19 - ((score-15.2) * (19/1.6)))))
>0.75	>16.8	Very poor	Very poor = INT(20 - ((score-16.8) * (20/83.2)))

Assessment of invasive weeds was conducted for 2019-20 and was the second assessment of weed distribution and scoring of the nine Wet Tropics basins since the indicator was introduced for 2015-16. The indicator scoring framework applies scores that are relative between all the basins by using percentile ranges for assigning grades that are generated from the data set of all the basins for the assessment year. This means that the percentile ranges will change for different assessments and that direct comparison of scores and grades for a given basin for different assessments is not feasible. However, comparisons between basins for a given assessment are appropriate. These first two assessments have provided data sets that can be used for generating benchmarks for future assessments. An update of the indicator is planned before the next assessment due for 2023-24 and will mean invasive weed condition for individual basins can be assessed for change overtime in comparison to fixed benchmarks and targets.

3.2.3.6. Estuarine Seagrass (Estuaries)

Calculation of estuarine seagrass condition using the QPSMP method is described in inshore seagrass (section 2.4.4).

3.2.4. Fish (Freshwater)

The scoring methods for the freshwater fish community condition are outlined in Table 43 and Table 44. A qualitative rating scheme for the Proportion of Observed Indigenous Species compared to Expected (POISE), which scores and grades native species richness, was developed (Table 43), where the 'very good' category was based on available fish survey data and the 'poor' was based on the 90th percentile of the results for recent times as predicted by the modelled Maximum Species Richness Line. Anything less than the 90th percentile is considered 'very poor'. The rating scheme for the proportion of non-indigenous fish species (PONI) is presented in Table 44 and used a model for the pest fish indicator developed for South East Queensland (EHMP 2008).

Table 43 Rating scheme for the proportion of indigenous fish species (POISE) indicator for freshwater fish communities.

POISE	Grade	Scaling of scores for aggregation
0.80 to 1	Very Good	VG = 81+ ABS((19 + ((score-1) *(19/0.2)))
0.67 to <0.80	Good	G= 61+ ABS((19.9 + ((score -0.7999) *(19.9/0.1329))))
0.53 to <0.67	Moderate	M=41+ ABS((19.9 + ((score -0.6669) *(19.9/0.1339))))
0.40 to <0.53	Poor	P= 21+ ABS((19.9+ ((score -0.5329) * (19.9/0.1329))))
0 to <0.40	Very Poor	VP=ABS((20.9 + ((score-0.3999) *(20.9/0.3999))))

Table 44 Rating scheme for the proportion of non-indigenous fish species (PONI) indicator for freshwater fish communities.

PONI	Grade	Scaling of scores for aggregation
0 to 0.03	Very Good	VG = 81+ ABS((19 - ((score-0) *(19/0.025))))
>0.03 to 0.05	Good	G= 61+ ABS((19.9 - ((score -0.0251) *(19.9/0.0249))))
>0.05 to 0.1	Moderate	M=41+ ABS((19.9- ((score -0.051) *(19.9/0.049))))
>0.1 to 0.2	Poor	P= 21+ ABS((19.9- ((score -0.101) * (19.9/0.099))))
>0.20 to 1	Very Poor	VP=ABS((20.9 - ((score-0.201) *(20.9/0.799))))

3.3. Inshore and Offshore Condition Assessment

3.3.1. Inshore Water Quality

3.3.1.1. Water clarity, nutrients and chlorophyll *a*

Water quality indicator guideline values for the Great Barrier Reef enclosed coastal waters, open coastal and mid-shelf waters of the inshore zones are listed in Table 45. The guideline values are those used for the MMP 2016 water quality report (Lønborg *et al.* 2016), which were based upon the Water Quality Guidelines for the Great Barrier Reef Marine Park (GBRMPA 2010) and Queensland Water Quality Guidelines (DEHP 2009). For the North, Central and Palm Island reporting zones, all monitoring sites are located within open coastal and mid-shelf waters. The South reporting zone includes a site located in enclosed coastal waters (Table 14). Annual means were calculated for indicators at each site and condition scores were calculated using the relevant guideline value and the procedure below. Condition scores were aggregated for indicators and indicator categories (water clarity and nutrients) from all sites within each reporting zone.

Table 45 Water quality guidelines for inshore zone waters.

Indicator (unit)	**Inshore zone**		
	Enclosed coastal	**Open coastal**	**Mid-shelf**
TSS (mg/L)	nd	2.0	2.0
Turbidity (NTU)	10.0	1.5*	1.5*
Particulate nitrogen (µg/L)	nd	20.0	20.0
Particulate phosphorus (µg/L)	nd	2.8	2.8
NO_x (µg/L) ^{QLD}	10.0	2.0	2.0
Chlorophyll *a* (µg/L)	2.00	0.45	0.45

* The turbidity trigger value for opens coastal and mid-shelf water bodies (1.5 NTU) was derived for the MMP reporting by transforming the suspended solids trigger value in the Guidelines (2 mg/L) using an equation based on a comparison between direct water samples and instrumental turbidity readings (Lønborg *et al.* 2016). Note that the guideline values provided by Queensland Government, as indicated by 'QLD', are 80th percentile guidelines. nd: no (or insufficient) data.

The following steps were used for the calculation of the indicator condition scores.

1. For indicators where non-compliance is defined as values being *higher* than guideline values (for example Chl-*a*):

   Condition score = $\log_2$ (GV/AM)

   Where:

   AM means annual mean of measured values
   GV means guideline value or target

2. Ratios exceeding -1 or 1 were capped to bind the water quality indicator to the range from -1 to 1, such that all indicators were on the same scale.
3. The nutrients indicator category score was calculated by averaging indicator values for NO_x, PP and PN (where available); the water clarity indicator category score was calculated by averaging indicator values for TSS and Turbidity (where available).
4. The indicator scores and indicator category scores for nutrients, water clarity, Chl-*a* are translated to the Report Card five-point grading scale using the ranges and grades shown in Table 46.

This formula and method is described in full in Lønborg *et al*. (2016).

Table 46. Inshore water quality scoring ranges, grades and scaling for aggregation.

Condition grade and colour code	Score Range	Scaling of scores for aggregation
Very Good	>0.5 to 1	100- (19 - ((score-0.51) * (19/0.49)))
Good	>0 to 0.5	80.99 - (19.99 - ((score -0.01) *(19.99/0.49)))
Moderate	<0 to -0.33	60.99- (19.99 - ((score -(-0.33)) *(19.99/0.32)))
Poor	<-0.33 to -0.66	40.99- (19.99 - ((score -(-0.66)) * (19.99/0.32)))
Very Poor	<-0.66 to -1	20.99- (20.99 - ((score -(-1)) *(20.99/0.34)))

The water quality guidelines for coastal and marine waters in the Wet Tropics region have been reviewed by the Queensland Department of Environment and Science. Updates for environmental values (EVs) and water quality objectives (WQOs) of the Wet Tropics have been scheduled in the Environmental Protection (Water and Wetland Biodiversity) Policy 2019—the EPP (Water and Wetland Biodiversity) (DES 2020). These updates were introduced in 2020 and apply to coastal and marine waters in accordance with the Australian and New Zealand guidelines for fresh and marine water quality 2018(external link). The updates include revisions to oxidised nitrogen (NO_x) WQOs for enclosed coastal, open coastal and mid-shelf waters. Adopting the updated WQOs as guideline values for calculating inshore water quality condition for the Wet Tropics report card will substantially alter the scoring for the NO_x indicator, and this is presented in the Inshore Water Quality section of the WTW 2023 results technical report. To provide inshore marine water quality reporting that is consistent and comparable with all previous years the guideline values have remained unchanged for the purposes of scoring inshore marine waters. Inshore marine water quality guideline values used for scoring will be assessed in the upcoming program design review (2023-25) which will allow for application of the most appropriate guidelines and a consistent approach across regional report cards.

Note that on occasion indicators for water clarity, TSS and turbidity, can produce contrasting scores within a zone. This occurred for the South and Palm Island zones in 2017-18 (WTW 2019). Although TSS and turbidity are often correlated, they measure different properties of water and relationships between TSS and turbidity demonstrate considerable spatial and temporal variation. As well as temporal and spatial influences, the sampling frequency of TSS, which is manually sampled, and turbidity, which is sampled by continuous loggers, can influence data values averaged over the reporting year. The guideline values, which set the scoring ranges for water quality indicators, can also exacerbate contrasts between TSS and turbidity scores, especially when one of the indicators tends to slightly exceed guideline values whilst the other tends to meet guideline values. This issue is examined in more detail in section 5.1.1 of the 2017-18 results technical report (WTW 2019).

3.3.1.2. Pesticides

Pesticide monitoring for the MMP using passive samplers for inshore zones recommenced in 2022-23 following a suspension of monitoring from 2020-21 to 2021-22. The concentration of each pesticide type from each passive sampler device was used to produce a Pesticide Risk Metric value for each inshore zone. All concentration data was analysed using the Pesticide Risk Metric (PRM) Calculator developed by the DES and summarised in DES (2023). Output from the PRM Calculator produced a total PRM value for each passive sampler device over each deployment date. The highest total PRM value from each site was used to represent the total PRM value for each zone. The total

PRM value, which represents percent of species affected, was converted to a standardised score using the formulae presented in Table 31.

3.3.1.3. Water quality index.

The water quality indicators and indicator categories were equally weighted to generate the index score. Table 47 shows the relationship of indicators, indicator categories and indices, and the associated weightings.

Table 47. Relationship of selected indices, indicator categories and indicators.

<table>
<tr><th>Index</th><th>Indicator category</th><th>Indicator</th><th>Weighting of indicator within indicator</th></tr>
<tr><td rowspan="8">Water Quality</td><td rowspan="3">Nutrients</td><td>PN</td><td rowspan="3">Equally, therefore 33 % each</td></tr>
<tr><td>PP</td></tr>
<tr><td>NO_x</td></tr>
<tr><td>Chl-a</td><td>Chl-a</td><td>Entire score</td></tr>
<tr><td rowspan="2">Water clarity</td><td>TSS</td><td rowspan="2">Equally, therefore 50 % each</td></tr>
<tr><td>Turbidity</td></tr>
<tr><td>Pesticides</td><td>Risk assessment</td><td>Entire score</td></tr>
</table>

3.3.2. Offshore Water Quality

Reporting for offshore quality was suspended in 2020-21 due to decommissioning of the BoM Marine Water Quality dashboard. It proposed that reporting of offshore water quality is discontinued permanently. The following description is provided as reference for reporting years prior to 2020-21.

The offshore water quality condition assessment used the percentage of area in the offshore zone that exceeds the relevant water quality guideline value (Table 48). The water quality guideline values for offshore waters were not set solely using percentiles of reference data, they were set using additional environmental and water quality considerations as explained in GBRMPA (2010).

Table 48. GBRMPA guideline values to assess the offshore water quality indicators.

Indicator category	Indicator	Guideline value
Water clarity	TSS	0.7 mg/L
Chlorophyll-*a*	Chlorophyll-*a*	0.4 µg/L

Each indicator score (chlorophyll-*a* and TSS) was calculated by subtracting the percentage of the water body that exceeded the guideline value from 100 %, with the resulting value being that percentage of area that did not exceed the water quality guideline value, within the reporting period. The score (from 0 – 100) was then directly translated to the standardised Report Card score and grade (Table 21). The TSS and chlorophyll-*a* results were weighted equally, so were averaged to provide the water quality indicator category result for the offshore zone.

3.3.3. Coral

Condition assessment of the different coral indicators for inshore and offshore coral monitoring followed the method of the MMP (Thompson *et al*. 2016). The following coral indicators were scored for each site and averaged for each inshore reporting zone.

- **Coral cover (inshore and offshore):** This indicator simply scores reefs based on the level of coral cover. For each reef the proportional cover of all genera of hard (order Scleractinia) and soft (subclass Octocorallia) corals are combined into two groups, 'HC' and 'SC' respectively. The resulting value for coral cover is scaled linearly from zero (when cover is 0 %) through to 1 (when cover is at or above the threshold of 75 %).
- **Macroalgae cover (inshore only):** For the inshore environment macroalgae was measured as the percentage cover of macroalgae as a proportion of the total cover of all algal forms.
- **Density of juvenile hard corals (inshore and offshore):** Counts of juvenile hard corals (colonies up to 5 cm in diameter) were converted to density per m^2 of space available to settlement.
- **Change in coral cover (inshore and offshore)**: The change in coral cover indicator was derived from the comparison of the observed change in coral cover between two visits and predicted change in cover derived from multi-species forms of a Gompertz growth equation. Due to differences in growth rates, models were run separately for the fast growing corals of the family Acroporidae and the slower growing combined grouping of all other hard corals.
- **Community composition (inshore only):** The basis of the indicator is the scaling of cover for constituent genera (subset to life forms for the abundant genera *Acropora* and *Porites*) by genus weightings that correspond to the distribution of each genus along a gradient of turbidity and chlorophyll concentration (see Thompson *et al*. 2016 for more explanation).

Report card update

The MMP Inshore coral calculation method for scoring the composition indicator has been updated as from the 2024-25 reporting year. The composition indicator value is now set to zero for reefs at which there is zero cover of hard corals. This change has been applied to historical indicator and index scores and reduces the composition indicator and coral condition index for the Norh zone in 2024.

In the South zone no composition scores were estimated between 2015-16 and 2019-20 at Bedarra as the composition score requires comparison to a baseline of at least 5 prior observations. This lack of score for the composition indicator for those early years continued until 2024 despite the availability of a baseline. The omission of these scores was noted and back calculated in 2025.

The updated scores for inshore coral index and composition indicator are referenced in the inshore coral section of the results technical report (WTW 2026).

The condition of the inshore coral reefs is based upon data from MMP and LTMP sites and reports on all five coral indicators. The condition of offshore coral reefs is based on LTMP data, and the coral index for offshore reefs is based on coral cover, density of juvenile corals and the coral change index, but does not include the cover of macroalgae or the community composition indicators.

The indicators for both inshore and offshore regions were scored in a similar way. Methods for scoring condition of offshore reefs now include updates to align with the indices used by the Great Barrier Reef Report Card and with the coral index for inshore reporting zones. Observations for each indicator were scored on a continuous scale following Thompson *et al*. (2016) and can be seen in Table 49. The approach involves selecting bounding values for each indicator based on biology. These bounds become zero (very poor) and 1.0 (very good) on an approximately linear scale (see Section 6 of Thompson *et al*. 2016). This linear scale is then used to convert the value of each indicator from each reef to a value between zero and 1.0, and the values for the reefs in each reporting zone are averaged.

Note that different sets of reefs are surveyed in alternate years. For this reason, the indices for coral cover and the density of juveniles are based on the most recent surveys of each reef in the reporting zone. The most recent surveys for some of the reefs will have been made in the preceding year. The coral change index is based on estimates of rate of change over the interval between surveys, this is only possible during periods free from acute disturbances, such as cyclones or mass bleaching events. Estimates are averaged over valid observations over the four years, up to and including the reporting year.

All indicators are weighted equally, and the scores are then averaged to determine the overall coral index score for the reporting zone. The range between 0 and 1 is divided into five equal bands corresponding to ratings from very poor to very good (Table 50). The standardised scores are calculated to the nearest whole number using conventional rounding (values ≥ 0.5 are rounded up and values < 0.5 are rounded down). This is applied to maintain consistency with the MMP coral scoring method (Thompson *et al*. 2024).

Table 49. Threshold values for the condition assessment of coral.

Community attribute	Thresholds	Score
Combined hard and soft coral cover: **'Cover'**	1 at 75% cover or greater	Continuous between 0-1
	0 at zero cover	
Rate of increase in hard coral cover (preceding 4 years): **'Change'**	Change > 2x upper 95% CI of predicted change	1
	Change between upper 95% CI and 2x upper 95% CI	Continuous between 0.6 and 0.9
	Change within 95% CI of the predicted change	Continuous between 0.4 and 0.6
	Change between lower 95% CI and 2x lower 95% CI	Continuous between 0.1 and 0.4
	change < 2x lower 95% CI of predicted change	0
Proportion of algae cover classified as Macroalgae: **'Macroalgae' (inshore only)**	≤ reef specific lower bound and ≥ reef specific upper bound	Continuous between 0-1
Density of hard coral juveniles (<5 cm diameter): **'Juvenile'**	> 13 juveniles per m^2 of available substrate	1
	4.6 to 13 juveniles per m^2 of available substrate	Continuous between 0.4 and 1
	0 to 4.6 juveniles per m^2 of available substrate	Continuous between 0 and 0.4
Composition of hard coral community: **'Composition' (inshore only)**	Beyond 95% CI of baseline condition in the direction of improved water quality	1
	Within 95% Confidence intervals of baseline composition	0.5
	Beyond 95% CI of baseline condition in the direction of declined water quality	0

Table 50. Scoring ranges for aggregated coral results.

Condition grade and colour code	Score Range	Scaling of scores aggregation
Very Good	> 0.8	'score' x 100
Good	> 0.6 – 0.8	'score' x 100
Moderate	> 0.4 – 0.6	'score' x 100
Poor	> 0.2 – 0.4	'score' x 100
Very Poor	0 – 0.2	'score' x 100

3.3.4. Inshore Seagrass

3.3.4.1. Marine Monitoring Program

Through the MMP seagrass monitoring, a method has been developed and documented (refer to McKenzie *et al*. 2015) to aggregate seagrass data results into the Great Barrier Reef Report Card scoring range (Table 21). Each set of seagrass indicator results are analysed to provide a relevant score and grade. These scores are translated to fit the Great Barrier Reef Report Card scoring range. The scoring thresholds and their relation to the Great Barrier Reef Report Card scoring ranges are provided for seagrass abundance (% cover) in Table 51, and for seagrass resilience in Table 52. Note that the resilience indicator is a multivariate metric and sources data from a range of seagrass measures which are converted into the linear scoring system.

An overall seagrass index is calculated from standardised scores (0 - 100) by averaging each indicator score from replicate transects within each site, averaging the two seagrass indicator scores for each site, and averaging site scores within the reporting zone. Indicators are equally weighted. For further detail on the seagrass scoring methods, refer to latest 'Marine Monitoring Program: Annual Report for inshore seagrass monitoring' available at https://elibrary.gbrmpa.gov.au/jspui/.

Table 51. Seagrass abundance (% cover) scoring thresholds in relation to condition grades (low = 10th or 20th percentile guideline). Source McKenzie *et al.* 2015.

Category	Score	Standardised scoring range	Condition grade
75 – 100	100	81 – 100	Very Good
50 – 75	75	61 – 80	Good
Low – 50	50	41 – 60	Moderate
< Low	25	21 – 40	Poor
< Low by > 20 %	0	1 – 20	Very Poor

Table 52. Seagrass sites grouped and graded according to resistance and reproductive qualities of resilience and the corresponding standardised scoring ranges and grades. Source Collier *et al*. 2021.

<table>
<tr><th>Resilience group</th><th>Scoring range</th><th>Resilience group grade</th><th>Scoring range</th><th>Standardised scoring range</th><th>Condition grade</th></tr>
<tr><td rowspan="3">Reproductive high resistance</td><td rowspan="3">70-100</td><td>Persistent reproductive and high resistance</td><td>85-100</td><td rowspan="2">81 – 100</td><td rowspan="2">Very Good</td></tr>
<tr><td rowspan="2">Reproductive high resistance</td><td rowspan="2">70-100</td></tr>
<tr><td rowspan="2">61 – 80</td><td rowspan="2">Good</td></tr>
<tr><td rowspan="4">Non-reproductive high resistance</td><td rowspan="4">30-70</td><td rowspan="2">Reproductive history and high resistance</td><td rowspan="2">50-70</td></tr>
<tr><td rowspan="2">41 – 60</td><td rowspan="2">Moderate</td></tr>
<tr><td rowspan="2">Non-reproductive history and high resistance</td><td rowspan="2">30-50</td></tr>
<tr><td rowspan="2">21 – 40</td><td rowspan="2">Poor</td></tr>
<tr><td rowspan="3">Low resistance sites</td><td rowspan="3">0-30</td><td rowspan="2">Reproductive and low resistance</td><td rowspan="2">5-30</td></tr>
<tr><td rowspan="2">1 – 20</td><td rowspan="2">Very Poor</td></tr>
<tr><td>Non-reproductive, low resistance</td><td>0-15</td></tr>
</table>

For further detail on the seagrass scoring methods for seagrass abundance, refer to McKenzie *et al.* (2015) and for seagrass resilience refer to Collier et al. (2021).

3.3.4.2. Queensland Ports Seagrass Monitoring Program

The QPSMP uses a condition index developed for seagrass monitoring meadows based on changes in mean above-ground biomass, total meadow area and species composition relative to a baseline (10-year average). The index provides a means of assessing current meadow condition and likely resilience to impacts against the baseline. Seagrass condition for each indicator is scored from 0 to 1 and assigned one of five grades: A (very good), B (good), C (satisfactory), D (poor) and E (very poor) (Table 53). A meadow classification system defines threshold ranges for the three condition indicators (e.g. stable, variable) in recognition that, for some seagrass meadows, these measures are historically stable, while in other meadows they are relatively variable (Table 53). Baseline conditions for species composition were determined based on the annual percentage contribution of each species to mean meadow biomass of the baseline years. Meadows are classified as either single species-dominated (one species comprising ≥80 % of baseline species), or mixed species (all species comprise <80 % of baseline species composition). Where species composition was determined to be anything less than in ‘perfect’ condition (i.e. a score <1), a decision tree was used to determine whether equivalent and/or more persistent species were driving this grade/score (Carter *et al.* 2023).

Table 53 Threshold levels for grading seagrass indicators for various meadow classes relative to the baseline. Upwards/ downwards arrows are included where a change in condition has occurred in any of the three condition indicators (biomass, area, species composition) from the previous year (Source: Carter *et al.* 2016).

Seagrass condition indicators/ Meadow class		**Seagrass grade**				
		A Very good	**B Good**	**C Satisfactory**	**D Poor**	**E Very Poor**
Biomass	Stable	>20 % above	20 % above - 20 % below	20-50 % below	50-80 % below	>80 % below
	Variable	>40 % above	40 % above - 40 % below	40-70 % below	70-90 % below	>90 % below
Area	Highly stable	>5 % above	5 % above - 10 % below	10-20 % below	20-40 % below	>40 % below
	Stable	>10 % above	10 % above - 10 % below	10-30 % below	30-50 % below	>50 % below
	Variable	>20 % above	20 % above - 20 % below	20-50 % below	50-80 %	>80 % below
	Highly variable	> 40 % above	40 % above - 40 % below	40-70 % below	70-90 % below	>90 % below
Species	Stable and variable; Single species dominated	>0 % above	0-20 % below	20-50 % below	50-80 % below	>80 % below
	Stable; Mixed species	>20 % above	20 % above - 20 % below	20-50 % below	50-80 % below	>80 % below
	Variable; Mixed species	>20 % above	20 % above- 40 % below	40-70 % below	70-90 % below	>90 % below

Increase above threshold from previous year — BIOMASS

Decrease below threshold from previous year — BIOMASS

Each overall meadow grade/score is defined as the lowest grade/score of the three condition indicators within that meadow, unless species composition is the lowest, in which case it is the average of species composition and the next lowest scoring indicator. The score range and grading colours used for QPSMP report cards are provided in Table 54. For further details on the scoring methods see Carter *et al.* (2023).

Table 54 Score range and grading colours used for QPSMP report cards.

Grade	Description	Score Range	
		Lower bound	Upper bound
A	Very good	≥0.85	1.00
B	Good	≥0.65	<0.85
C	Satisfactory	≥0.50	<0.65
D	Poor	≥0.25	<0.50
E	Very poor	0.00	<0.25

3.3.4.3. Combined Display Approach for MMP and QPSMP Seagrass Indicators.

The combined display approach for seagrass indicators maintains the score calculation methods from each program. This ensures that the scores given in the regional report cards for a particular meadow/site remain consistent with MMP and QPSMP reporting. There is no overlap between the QPSMP and MMP locations in the Wet Tropics NRM regions.

Scores for each monitoring site that are generated (either by averaging across indicators for MMP sites, or using the lowest grade for QPSMP sites) are averaged to generate an overall score for a defined reporting zone. The combined display method adopts the Great Barrier Reef Report Card scaling, and the MMP terminology and score ranges. For this, the QPSMP scores were multiplied by 100 so both programs are reported on the 0-100 scale and the scores are graded based on the Great Barrier Reef Report Card scoring ranges (Table 21). For a full description and worked example of the combined display approach refer to Carter *et al*. (2016).

3.3.5. Inshore and Offshore Fish

As mentioned above, the development of marine fish indicators and methods is still in progress and therefore the fish indices are not included in the Report Card.

4. CONFIDENCE, LIMITATIONS AND RECOMMENDATIONS

4.1. Confidence Associated with Results

The Regional Report Cards use the 2015 Great Barrier Reef Water Quality Protection Plan Report Card method for communicating confidence (Australian Government and Queensland Government, 2015) developed through the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program. This is based on a multi-criteria analysis approach to qualitatively score the confidence for each key indicator used in the report card. The approach enables the use of expert opinion and measured data.

The multi-criteria analysis identifies the key components that contribute to confidence. These are known as criteria. Each criterion is then scored using a defined set of scoring attributes. The attributes are ranked from those that contribute weakly to the criteria to those that have a strong influence. If the criteria are seen to have different levels of importance for the problem being addressed, they can be weighted accordingly. The strengths of this approach are that it is repeatable, transparent and can include contributions from a range of sources. The weaknesses are that it can be subjective and open to manipulation.

The method was updated for the 2015-16 reporting period. The update involved revising the weighting of confidence for each criterion as described below.

4.1.1. Confidence Versus Uncertainty

Uncertainty and confidence are closely related; high uncertainty around a theme would lead to low confidence that the given theme is contributing to program outcomes. However, confidence does not eliminate the presence of uncertainty.

Each time an observation is made, or a score calculated, there is the potential that error may be introduced. Even if this potential error is miniscule, it can add up and be compounded by further calculations, extrapolation of results, changes in scale and many other processes. It is important to measure and report this potential error. This is done through the measurement of uncertainty.

In this instance, **uncertainty** relates to the state of knowledge (epistemic) relating to a theme and the potential for error in that knowledge. It is very rare (if not impossible) to know absolutely everything about a theme without any potential for error, and so there will always be some degree of uncertainty. Having a strong understanding of the knowledge gaps (uncertainty) for a theme is critically important for program theme leaders. An understanding of uncertainty allows for continuous improvement of program themes, filling knowledge gaps and reducing uncertainty. Uncertainty (by itself) is less useful at a whole of program level as it fails to convey the confidence managers have that the various themes are contributing to the program goals.

Confidence as reported by the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program is the state of mind (psychological) of managers relating to the contribution of the program theme output to the overarching program goals. Confidence incorporates the state of knowledge (uncertainty), but also considers other factors, such as the logic frameworks (conceptual models), scale of observation and the use of scientifically robust methods. The five key criteria used in reporting confidence for the Paddock to Reef Integrated Monitoring, Modelling and reporting program are outlined in the Methods section below.

4.1.2. Methods

The determination of confidence for the Report Card 2018 used five criteria.

- Maturity of methodology
- Validation
- Representativeness
- Directness
- Measured error

Maturity of methodology
The purpose of this criterion is to show the confidence that the method/s being used are tested and accepted broadly by the scientific community. Methods must be repeatable and well documented. Maturity of methodology is not a representation of the age of the method, but the stage of development. It is expected that all methods used would be robust, repeatable and defendable. This score is weighted 0.36 for this criterion, so as not to outweigh the importance of the other criteria.

Validation
The purpose of this criterion is to show the proximity of the indicator being measured to the indicators reported. The use of proxies is scored lower than direct measures. The reason for this criterion is to minimise compounded error. This score is weighted 0.71 for this criterion, so as not to outweigh the importance of the representativeness criteria.

Representativeness
The purpose of this criterion is to show the confidence in the representativeness of monitoring/data to adequately report against relevant targets. This criterion takes into consideration the spatial and temporal resolution of the data, as well as the sample size. This criterion is considered most important when considering confidence for regional report cards, so the score for this criterion is weighted 2.

Directness
This criterion is similar to "validation", but instead of looking at the proximity of the indicator, the criterion looks at the confidence in the relationship between the monitoring and the indicators being reported against. This score is weighted 0.71 for this criterion, so as not to outweigh the importance of the representativeness criteria.

Measured error
The purpose of this criterion is to incorporate uncertainty (as defined above) into the measure and use any quantitative data where it exists. This score is weighted 0.71 for this criterion, so as not to outweigh the importance of the representativeness criteria.

4.1.3. Scoring

For all indicators where a condition score was reported, each criterion is scored 1 (lowest) to 3 (highest) as defined in Table 55. The score of each criterion is weighted accordingly and the total confidence score is calculated by adding all weighted scores of the five criteria. The final score is assessed against a 1 to 5 qualitative confidence ranking (Table 56). When scoring confidence for indicators in the Wet Tropics region, confidence of an indicator was considered separately for the different reporting zones (i.e. for each of the nine freshwater basins, eight estuaries, four inshore marine zone and the one offshore marine zone). This was because, for some indicators, there were different sample sizes and programs contributing to the condition scores of an indicator depending on the reporting zone.

The representativeness criteria were considered at a spatial and temporal scale. Where confidence was lower at one scale, the conservative (lowest) score was applied to this criterion for that indicator. For example, if spatial representativeness was moderate (i.e. 2), but at the temporal scale representativeness was low (i.e. 1), the score used for representativeness was low (i.e. 1).

Table 55 Scoring matrix for each criterion used to assess confidence.

Maturity of methodology (weighting 0.36)	**Validation** (weighting 0.71)	**Representat-iveness** (weighting 2)	**Directness** (weighting 0.71)	**Measured error** (weighting 0.71)
Score = 1 **New** or experimental methodology	**Score = 1** **Limited** Remote sensed data with no or limited ground truthing or Modelling with no ground truthing or Survey with no ground truthing	**Score = 1** **Low** 1:1,000,000 or Less than 10% of population survey data	**Score = 1** **Conceptual** Measurement of data that have conceptual relationship to reported indicator	**Score = 1** Greater than 25% error or limited to no measurement of error or error not able to be quantified
Score = 2 **Developed** Peer reviewed method	**Score = 2** **Not comprehensive** Remote sensed data with regular ground truthing (not comprehensive) or Modelling with documented validation (not comprehensive) or Survey with ground-truthing (not comprehensive)	**Score = 2** **Moderate** 1:100,000 or 10%-30% of population survey data	**Score = 2** **Indirect** Measurement of data that have a quantifiable relationship to reported indicators	**Score = 2** Less than 25% error or some components do not have error quantified
Score = 3 **Established** methodology in published paper	**Score = 3** **Comprehensive** Remote sensed data with comprehensive validation program supporting (statistical error measured) or Modelling with comprehensive validation and supporting documentation or Survey with extensive on ground validation or directly measured data	**Score = 3** **High** 1:10,000 or 30-50% of population	**Score = 3** **Direct** Direct measurement of reported indicator with error	**Score = 3** 10% error and all components have errors quantified

Table 56 Confidence ranking.

Final confidence score range	Ranking	Display in report card
>11.7 to 13.5	Five	High ●●●●●
>9.9 to 11.7	Four	●●●●○
>8.1 to 9.9	Three	●●●○○
>6.3 to 8.1	Two	●●○○○
4.5 to 6.3	One	Low ●○○○○

4.1.4. Assessment of representativeness for the flow indicator

For the flow indicator, representativeness was assessed from the proportion of catchment monitored by gauging stations and, for basins only, the number of gauging stations (flow assessment sites) per unit area of catchment. The number of flow assessment sites within a basin was not considered relevant to estuaries since estuaries are downstream of all assessment sites and only assessed from the most downstream assessment site(s).

To assess the number of flow assessment sites per unit area, a fixed area of 100 km^2 was applied. This was selected to represent an optimal number of assessment sites for larger catchments (>500 km^2) based on catchments in South East Queensland (Table 57). River networks will differ between the optimal number of flow assessment sites per unit area, for example, the siting of gauging stations downstream of all major confluences will vary between systems. Queensland Government has commissioned a surface water network review, part of which will inform on optimal network monitoring, based on catchment area, rainfall and climate zone.

Table 57 Number of gauging station (GS) sites in South East Queensland catchments based on catchment area.

Catchment	Area (km^2)	Number of GS	GS sites/100km^2
Brisbane River	10170	28	0.3
Logan	2416	10	0.4
Mary	6845	15	0.2
Albert	544	4	0.7
Maroochy	307	6	2.0

For basins, representativeness values were generated from relating the proportion of monitored catchment to coverage by multiplying both terms, whilst for estuaries representativeness values were generated just from the proportion of monitored catchment (Table 58). The standard criteria for representativeness used for determining a score of 1 to 3 was then applied to these values where 0 < 10% = 1, 10 – 30% = 2 and > 30% = 3 (Table 55).

Table 58 Terms used for determining representativeness for basins and estuaries.

Basin/ estuary	Catchment area (km^2)	Gauged catchment area (km^2)	Proportion of catchment area monitored	Number of assessment sites	Coverage (sites per 100km^2)	Coverage x proportion	Represent-ativeness
Basin							
Mossman	472.4	106	0.22	1	0.21	0.05	1
Barron	2188.8	2015	0.92	7	0.32	0.29	2
Mulgrave	1315	520	0.40	2	0.15	0.06	1
Russell	669	354	0.53	2	0.30	0.16	2
Johnstone	2323.9	1221	0.53	6	0.26	0.14	2
Tully	1683.5	1450	0.86	2	0.06	0.05	1
Murray	1108.4	309	0.28	2	0.18	0.05	1
Herbert	9845.9	8581	0.87	11	0.11	0.10	2
Estuary							
Barron	2188.8	2015	0.92	na	na	na	3
Russell-Mulgrave	1648	874	0.53	na	na	na	3
Johnstone	2246	1325	0.59	na	na	na	3

Note: The number of assessment sites is not applicable to estuaries since estuaries are downstream of all assessment sites and only assessed from the most downstream assessment site(s). The catchment area for the Russell-Mulgrave estuary excludes the Trinity Inlet sub-catchment which drains to the north, and the catchment area for the Johnstone estuary excludes Liverpool Creek sub-catchment which drains to the south. na is not applicable.

5. REFERENCES

ANZG 2018 the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. http://www.waterquality.gov.au/anz-guidelines/

Australian Government and Queensland Government. 2015. Scoring system, Great Barrier Reef Report Card 2014. Available to download from: http://www.reefplan.qld.gov.au/measuring-success/report-cards/2014/assets/gbrscoring-system-2014.pdf

Binns, P. and Waters, D. 2018. Baseflow separation. Refinement of the Lyne & Hollick baseflow separation methodology using historical water quality data from Great Barrier Reef catchments. Resource Assessment & Information, Queensland Department of Natural Resources, Mines and Energy. Brisbane. https://trove.nla.gov.au/work/234290652?

Bliss CI. 1939. The toxicity of poisons applied jointly. Ann Appl Biol 26:585–615.

Carter, A., Rasheed, M., McKenzie, L., & Coles, R. 2016. An interim approach to integrate seagrass monitoring results for NRM regional report cards. A case study using the Wet Tropics NRM region. Seagrass Ecology Group- James Cook University. Centre for Tropical Water & Aquatic Ecosystem Research, Cairns.

Carter, A.B., Coles, R., Jarvis, J.C. *et al*. (2023) A report card approach to describe temporal and spatial trends in parameters for coastal seagrass habitats. Sci Rep 13, 2295 (2023). https://doi.org/10.1038/s41598-023-29147-1

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.

DEHP (Department of Environment and Heritage Protection) 2009. Queensland Water Quality Guidelines, Version 3, ISBN 978-0-9806986-0-2. Available at https://environment.des.qld.gov.au/__data/assets/pdf_file/0020/95150/water-quality-guidelines.pdf

DES (Department of Environment and Science) 2018. Monitoring and Sampling Manual: Environmental Protection (Water) Policy. Brisbane: Department of Environment and Science Government.

DES (Department of Environment and Science) 2020. Environmental Protection (Water and Wetland Biodiversity) Policy 2019. Wet Tropics Basins Environmental Values and Water Quality Objectives. Environmental Policy and Planning Division, Department of Environment and Science.

DES (Department of Environment and Science) 2023. Pesticide Risk Metric (PRM) Calculator User Guide. Water Quality and Investigations, Water Ecosystem Science. Brisbane.

DETSI (Department of Environment, Tourism, Science and Innovation) 2025. Wetland areas version 7 Queensland. Queensland Spatial Catalogue (QSpatial). http://qldspatial.information.qld.gov.au/catalogue/

DNR (Department of Natural Resources) 2000. Condamine-Balonne WAMP: environmental flows technical report. Water Resource Allocation and Management, Department of Natural Resources, Brisbane. 163 pp.

DNRM (Department of Natural Resources and Mines) 2009. Drainage basin sub-area Queensland. [Drainage basin sub areas - Queensland - Dataset - Open Data Portal | Queensland Government]

Donders AR, van der Heijden GJ, Stijnen T, Moons KG. 2006. Review: a gentle introduction to imputation of missing values. J Clin Epidemiol. 59(10):1087-91. doi: 10.1016/j.jclinepi.2006.01.014. Epub 2006 Jul 11. PMID: 16980149.

EHMP 2008. Ecosystem Health Monitoring Program 2006–07 Annual Technical Report. Moreton Bay Waterways and Catchments Partnership, Brisbane.

eWater CRC 2012. Water Quality Analyser. eWater Limited Canberra, Australia, https://ewater.org.au/ewater-solutions/tools/toolkit/ Accessed March 2014.

FNQROC (Far North Queensland Regional Organisation of Councils) 2015. Pest Management Planning - Local Government Pest assessment, prioritisation and planning framework. Appendix to the Far North Queensland Local Government Regional Pest Management Strategy 2010-15. Version 1.6. Cape York edition (July 2015).

Folkers, A., Rohde, K., Delaney, K., & Flett, I. (2014). Water Quality Improvement Plan 2014-2021 Mackay, Whitsunday, Isaac.

Fortune, J and Mauraud, N.(2015). Effect of tide on water quality of Jones Creek, Darwin Harbour. Report No. 02/2015D. Department of Land Resource Management, Aquatic Health Unit. Palmerston, NT.

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).

Garzon-Garcia, A., Wallace, R., Huggins, R., Smith, R. A., Turner, R. D. R., Warne, M. St. J. 2015. Total suspended solids, nutrient and pesticide loads (2013–2014) for rivers that discharge to the Great Barrier Reef – Great Barrier Reef Catchment Loads Monitoring Program. Department of Science, Information Technology and Innovation. Brisbane

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

Grayson, R.B., Argent, R.M., Nathan, R.J., McMahon, T.A., Mein, R. 1996. Hydrological Recipes: Estimation Techniques in Australian Hydrology. Cooperative Research Centre for Catchment Hydrology, Clayton, Victoria, Australia.

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.

Huggins, R., Wallace, R., Orr, D. N., Thomson, B., Smith, R. A., Taylor, C. King, O., Gardiner, R., Wallace, S., Ferguson, B., Preston, S., Simpson, S., Shanks, J., Warne, M. St. J., Turner, R. D. R., Mann, R. M. 2017. Total suspended solids, nutrient and pesticide loads (2015–2016) for rivers that discharge to the Great Barrier Reef – Great Barrier Reef Catchment Loads Monitoring Program. Department of Science, Information Technology and Innovation. Brisbane.

Könemann H. 1981. Fish toxicity tests with mixtures of more than two chemicals: A proposal for a quantitative approach and experimental results. Toxicology 19:229–238.

Kroon, F. J. and Phillips, S. 2015 Identification of human-made physical barriers to fish passage in the Wet Tropics region, Australia. Marine and Freshwater Research http://dx.doi.org/10.1071/MF14397.

Lawson, T., Kroon, F., Russell, J., Thuesen, P., and Fakes, A. 2010. Audit and prioritisation of physical barriers to fish passage in the Wet Tropics region. Milestone report, MTSRF project 2.6.2. (CSIRO Ecosystem Sciences: Atherton, Qld, Australia.).

Lønborg C, Devlin M, Waterhouse J, Brinkman R, Costello P, da Silva E, Davidson J, Gunn K, Logan M, Petus C, Schaffelke B, Skuza M, Tonin H, Tracey D, Wright M and Zagorskis I (2016). Marine Monitoring Program: Annual Report for inshore water quality monitoring: 2014 to 2015. Report for the Great Barrier Reef Marine Park Authority. Australian Institute of Marine Science and JCU TropWATER, Townsville 229pp.

Mackenzie, J.R. 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.

Mackenzie, J. R., Duke, N. C., & Wood, A. L. 2016. The Shoreline Video Assessment Method (S-VAM): Using dynamic hyperlapse image acquisition to evaluate shoreline mangrove forest structure, values, degradation and threats. Marine pollution bulletin, 109(2), 751-763.

McKenzie, L. J., Collier, C. and Waycott, M. 2015. Reef Rescue Marine Monitoring Program - Inshore Seagrass, Annual Report for the sampling period 1st June 2012 – 31st May 2013. TropWATER, James Cook University, Cairns. 173pp.

Moore, M. 2015. Mackay Whitsunday WQIP barriers to fish migration health metrics. Catchments solutions.

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

Moore, M., Fries, J. and Power, T. 2021. Fish Barrier Prioritisation – Murray and Lower Herbert Rivers. Final Report. Catchment Solutions – Fisheries and Aquatic Ecosystems. Mackay, Queensland.

Moore, M., Power, T. and Fries, J. 2022. Fish Barrier Prioritisation – Daintree, Mossman, & Lower-Barron Catchments Final Report. Catchment Solutions – Fisheries and Aquatic Ecosystems. Mackay, Queensland.

Orr, D., Turner, R.D.R., Huggins, R., Vardy, S., Warne, M. St. J. 2014. Wet Tropics water quality statistics for high and base flow conditions. Great Barrier Reef Catchment Loads Monitoring Program, Department of Science, Information Technology, Innovation and the Arts, Brisbane.

Plackett RL, Hewlett PS. 1952. Quantal responses to mixtures of poisons. J Roy Stat Soc B 14:141.

Patrician PA. 2002. Multiple imputation for missing data. Res Nurs Health. 25(1):76-84. doi: 10.1002/nur.10015. PMID: 11807922.

Queensland Government 2005. Digital elevation model - 25metre - Wet Tropics - data package QSpatial, Department of Resources, Brisbane.

Queensland Government 2014. Riparian methods. Great Barrier Reef Report Card 2014. http://www.reefplan.qld.gov.au/about/assets/gbr-report-card-2014-riparian-methods.pdf

Reason C.L., Rasheed M., Concannon T., Forte Valiente L., and McKenna S. 2025. Seagrass habitat of Cairns Harbour and Trinity Inlet: Annual Monitoring Report 2024, Centre for Tropical Water & Aquatic Ecosystem Research, Publication Number 25/07, James Cook University, Cairns, 43 pp.

Rubin, D.B. 1996. Multiple Imputation after 18+ Years. Journal of the American Statistical Association, 91, 473-489. https://doi.org/10.1080/01621459.1996.10476908.

Sheldon, F., Thoms, M., Berry, O., and Puckridge, J. 2000. Using disaster to prevent catastrophe: Referencing the impacts of flow changes in large dryland rivers. Regulated Rivers: Research and Management 16: 403-420.

Shepherd LJ, York PH & Rasheed MA (2025). Seagrass habitat of Mourilyan Harbour: Annual Monitoring Report – 2024. Centre for Tropical Water & Aquatic Ecosystem Research, JCU, Cairns. Publication 25/25 pp.36

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, Thompson A, Delean S, Davidson J, Neale S. 2007. Status of inshore reefs of the Great Barrier Reef 2004. 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 Healthy Waterways Partnership.

Terrain NRM 2024. Fish barrier remediation works in the Herbert and Murray Catchments Reef. Trust VII Fish Homes and Highways 2021-2023 Summary Report. Terrain NRM, Innisfail, Queensland.

Thompson A, Costello P, Davidson J, Logan M, Gunn K, Schaffelke B. 2016. Marine Monitoring Program. Annual Report for inshore coral reef monitoring: 2014 to 2015. Report for the Great Barrier Reef Marine Park Authority. Australian Institute of Marine Science, Townsville.133 pp.

Thompson, A., Davidson, J., Logan, M., Thompson, C. 2024. Marine Monitoring Program Annual Report for Inshore Coral Reef Monitoring: 2022–23. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville.151 pp.

Wallace, R., Huggins, R., Smith, R. A., Turner, R. D. R., Garzon-Garcia, A and Warne, M. St. J. 2015. Total suspended solids, nutrient and pesticide loads (2012–2013) for rivers that discharge to the Great Barrier Reef – Great Barrier Reef Catchment Loads Monitoring Program 2012–2013. Department of Science, Information Technology and Innovation. Brisbane.

Wang, Y., Zou, Y., Henrickson, K., Wang, Y. Tang, J., and Park, B-J. 2017 Google Earth elevation data extraction and accuracy assessment for transportation applications. PLoS ONE 12(4): e0175756. https://doi.org/10.1371/journal.pone.0175756

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.

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) 2019. Wet Tropics Report Card 2019 (reporting on data 2017-18). 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.

WTW (Wet Tropics Waterways) 2023. Wet Tropics Report Card 2023 (reporting on data 2021-22). Waterway Environments: Results. Wet Tropics Waterways and Terrain NRM, Cairns.

WTW (Wet Tropics Waterways) 2026. Wet Tropics Report Card 2026 (reporting on data 2024-25). Waterway Environments: Results. Wet Tropics Waterways and Terrain NRM, Cairns.

APPENDIX A Estuarine Water Quality Monitoring Site Maps

Figure 13 DES estuary water quality monitoring sites and the DES GBR CLMP monitoring site for pesticides in the Daintree estuary.

Figure 14 Douglas Shire Council water quality monitoring sites in the Dickson Inlet estuary.

Figure 15 Cairns Regional Council water quality monitoring sites at the Barron estuary.

Figure 16 Cairns Regional Council water quality monitoring sites (sites 1 to 8 and DETSI sites EHP1, 2 and 3) at the Trinity Inlet estuary.

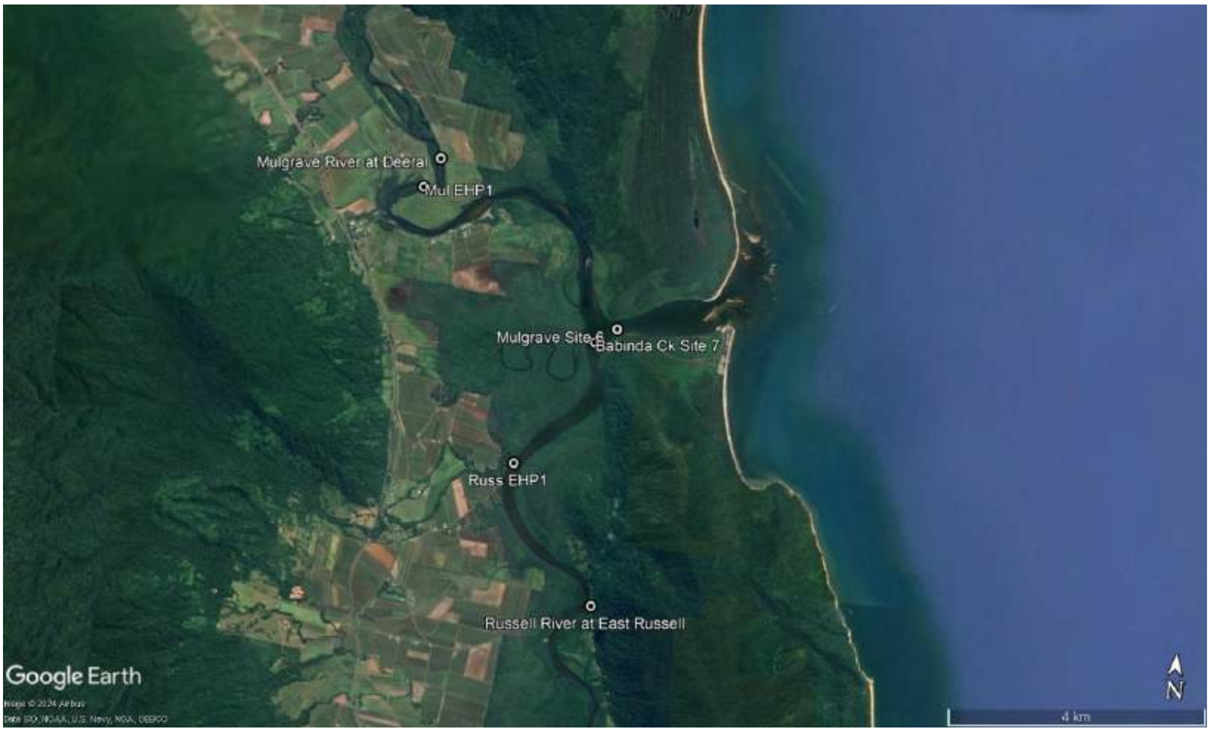


Figure 17 Cairns Regional Council water quality monitoring sites (Mul EHP1, Mulgrave Site 6, Russ EHP1 and Babinda Ck Site 7) and DES GBR CLMP monitoring sites for pesticides (Mulgrave River at Deeral and Russell River at East Russell)) at the Russell-Mulgrave estuary.

Figure 18. Cassowary Coast Regional Council water quality monitoring sites and the DES GBR CLMP Coquette Point site (CLMP) at the Johnstone estuary.

Figure 19 DES water quality monitoring sites in the Moresby estuary.

Figure 20 DES water quality monitoring sites in the Hinchinbrook Channel.

APPENDIX B Estuarine Riparian Extent Assessment Area Maps

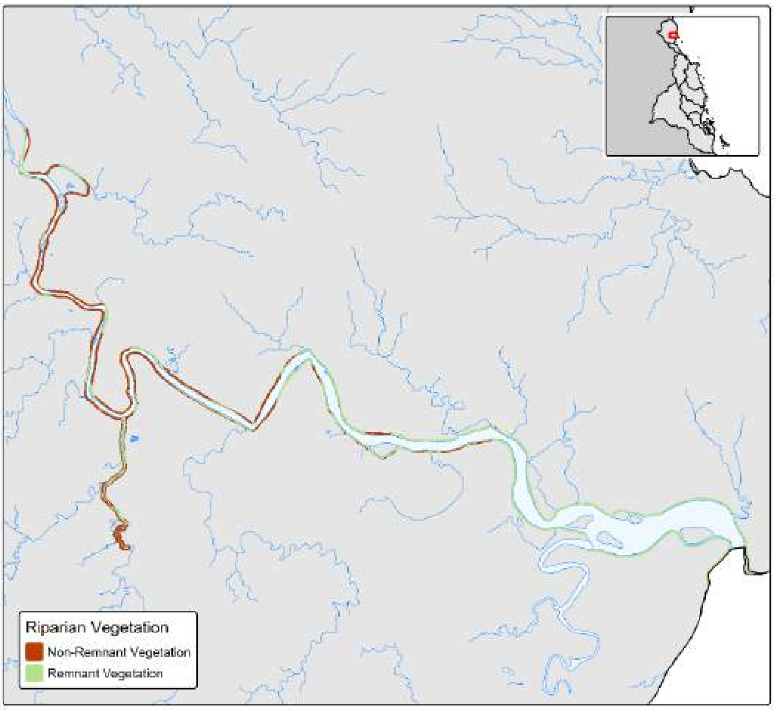


Figure 21 Daintree estuary riparian extent assessment area.

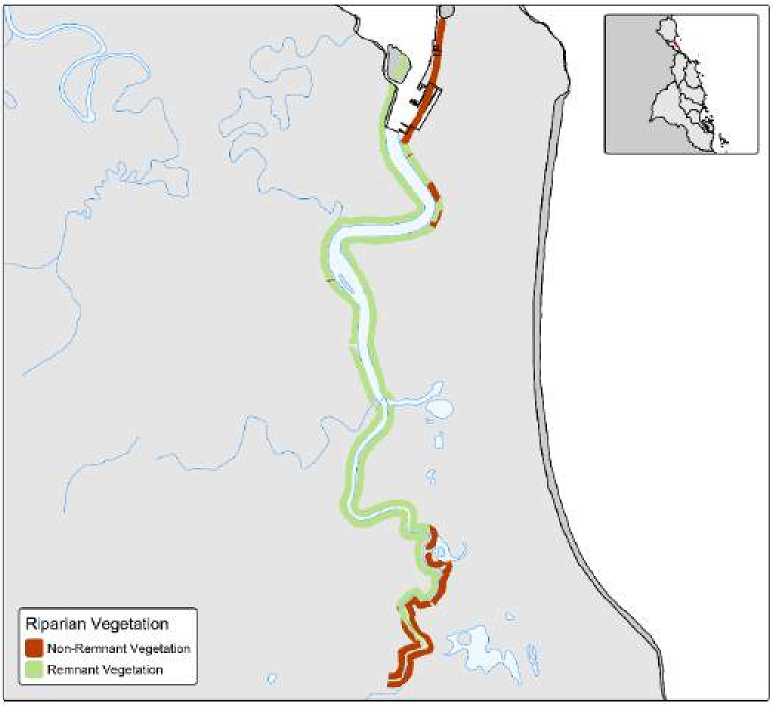


Figure 22 Dickson Inlet estuary riparian extent assessment area.

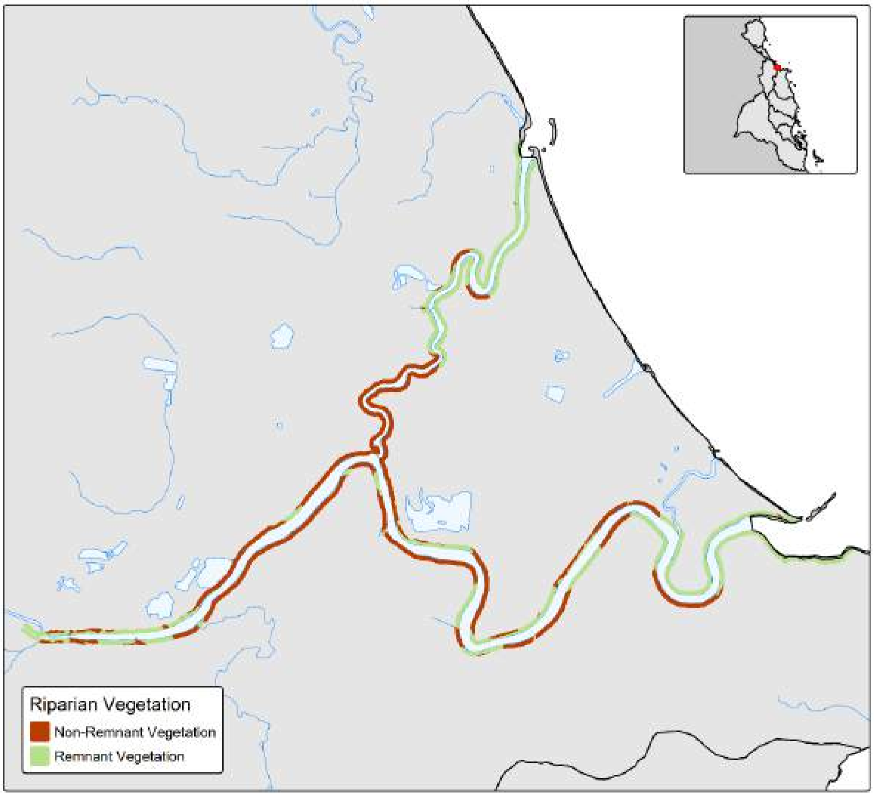


Figure 23 Barron estuary riparian extent assessment area.

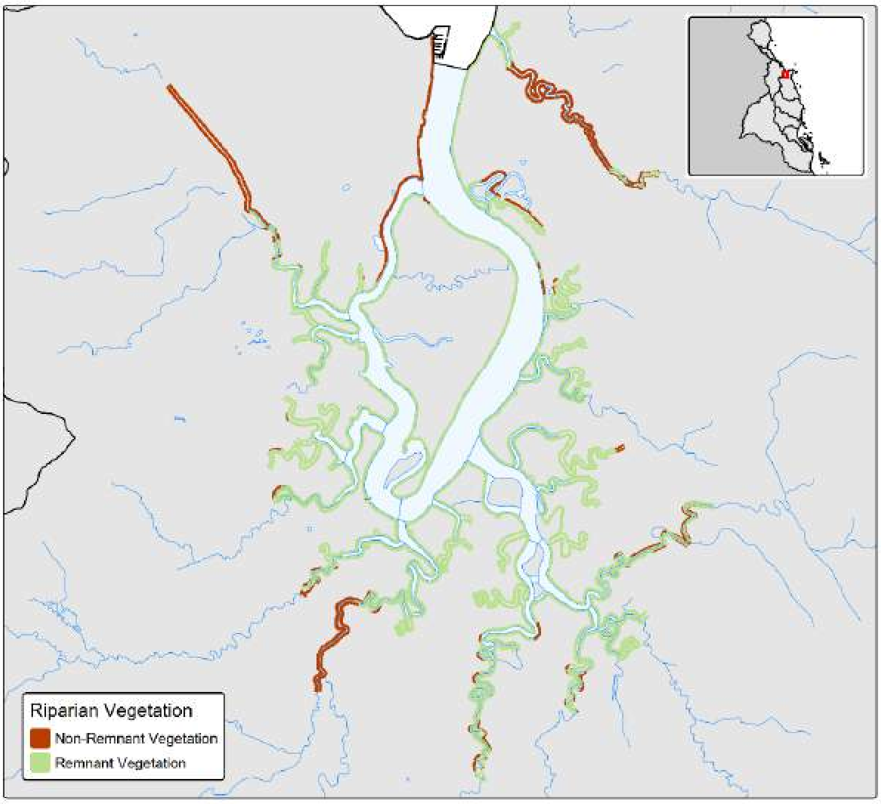


Figure 24 Trinity Inlet estuary riparian extent assessment area.

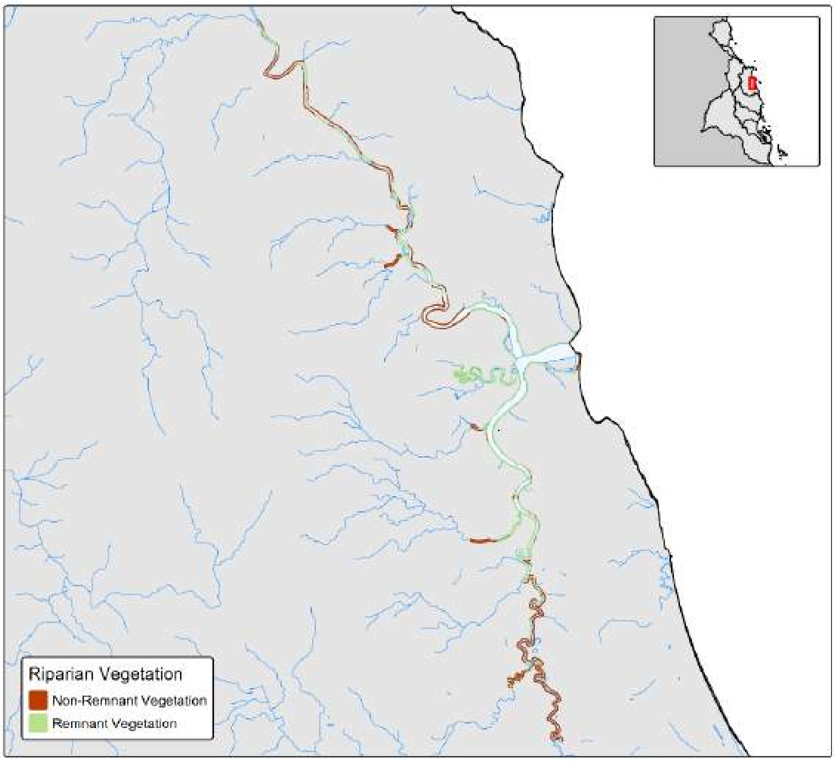


Figure 25 Russell-Mulgrave estuary riparian extent assessment area.

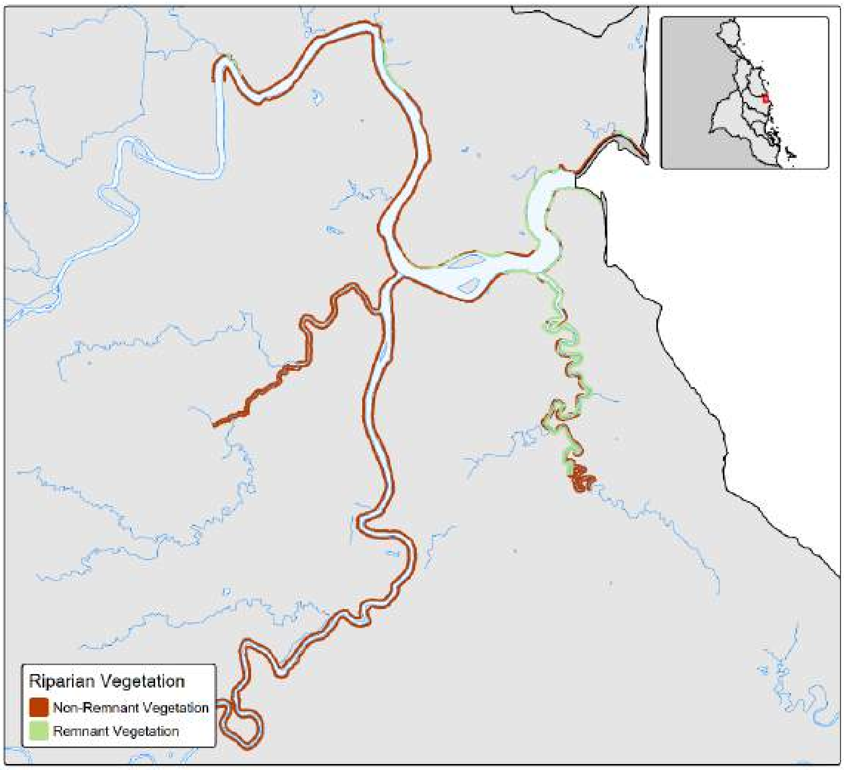


Figure 26 Johnstone estuary riparian extent assessment area.

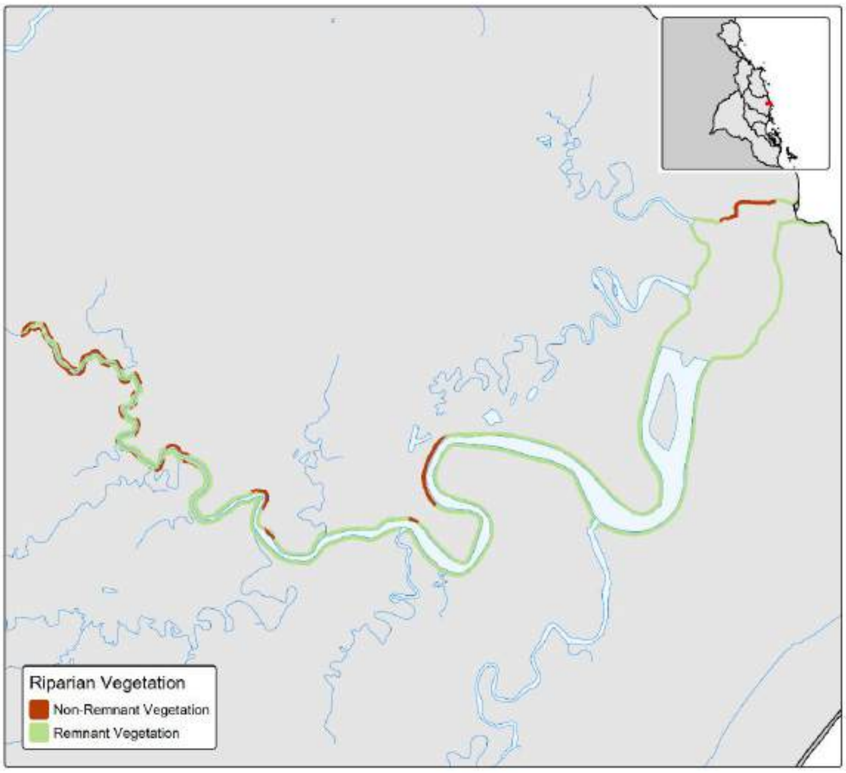


Figure 27 Moresby estuary riparian extent assessment area.

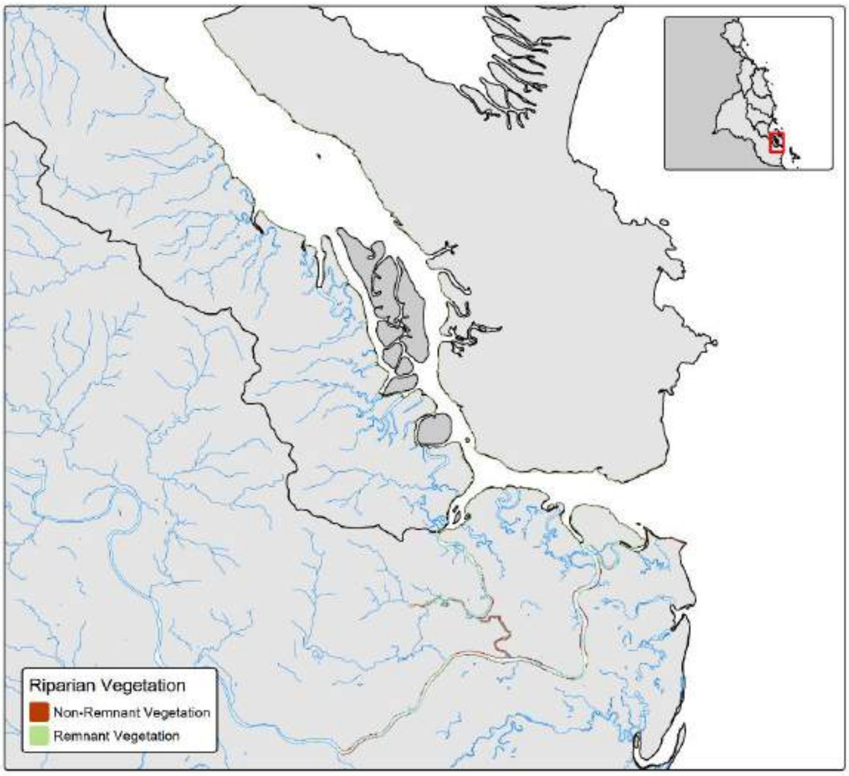


Figure 28 Hinchinbrook Channel estuary riparian extent assessment area.

APPENDIX C Estuarine Mangrove and Salt Marsh Extent Maps

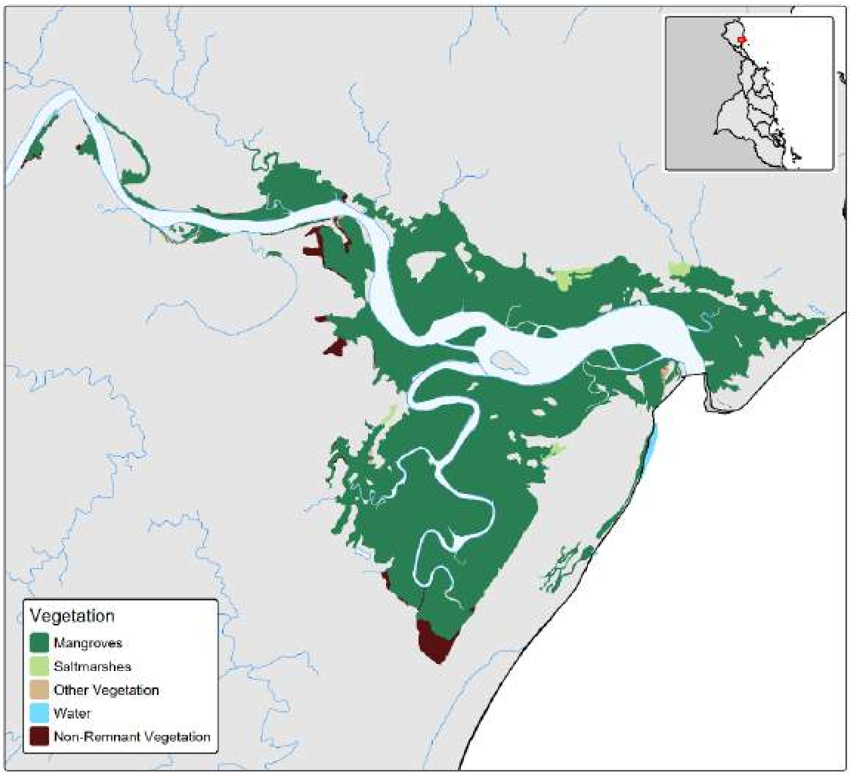


Figure 29 Daintree estuary mangrove and salt marsh extent assessment area (shown by the orange line) and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom).

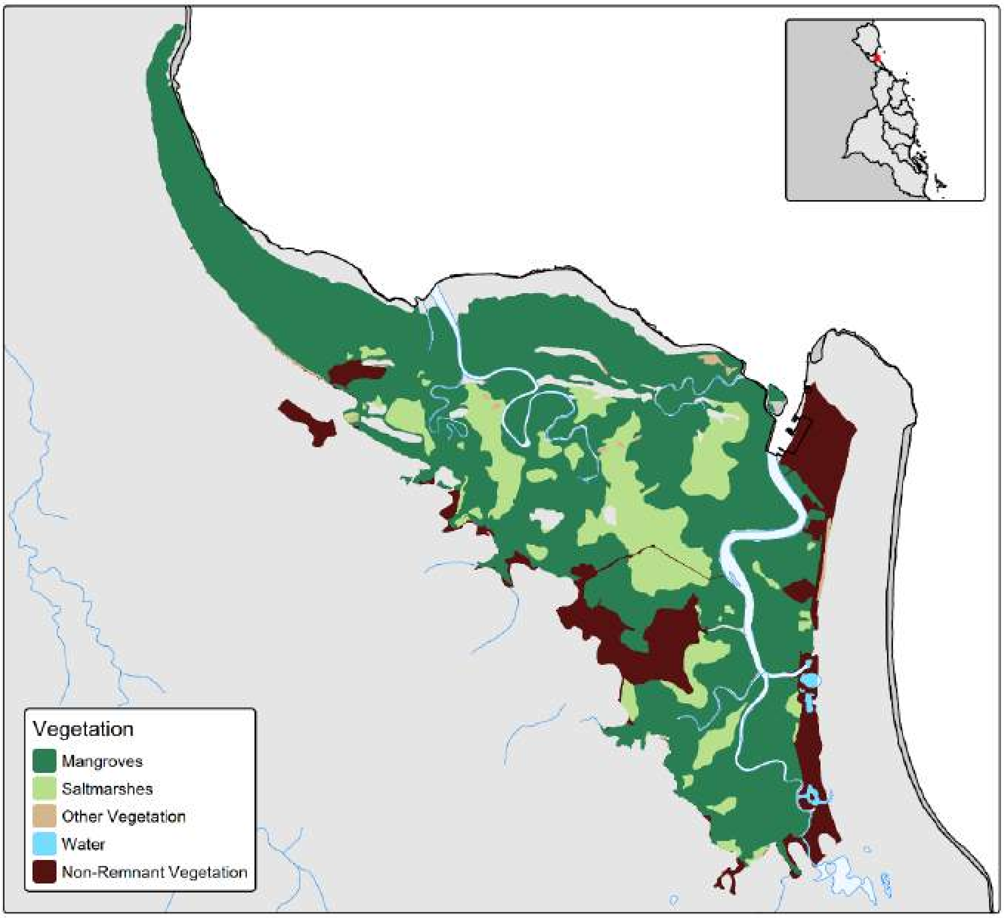
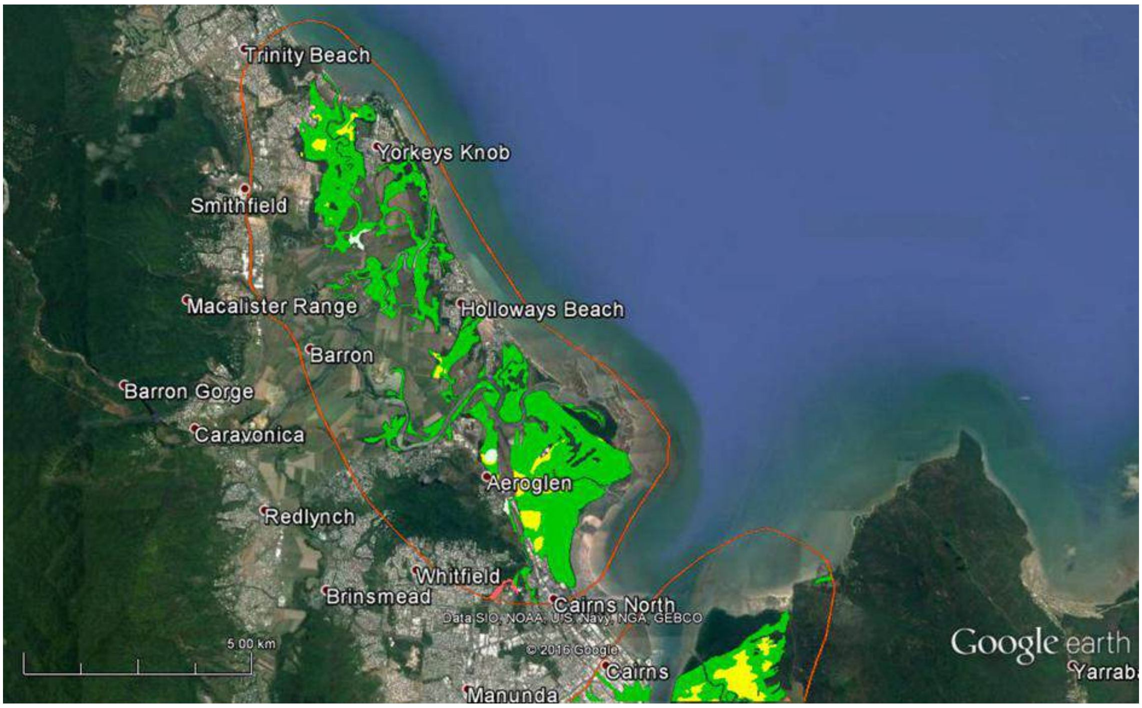


Figure 30 Dickson Inlet estuary mangrove and salt marsh extent assessment area (shown by the orange line) and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom).



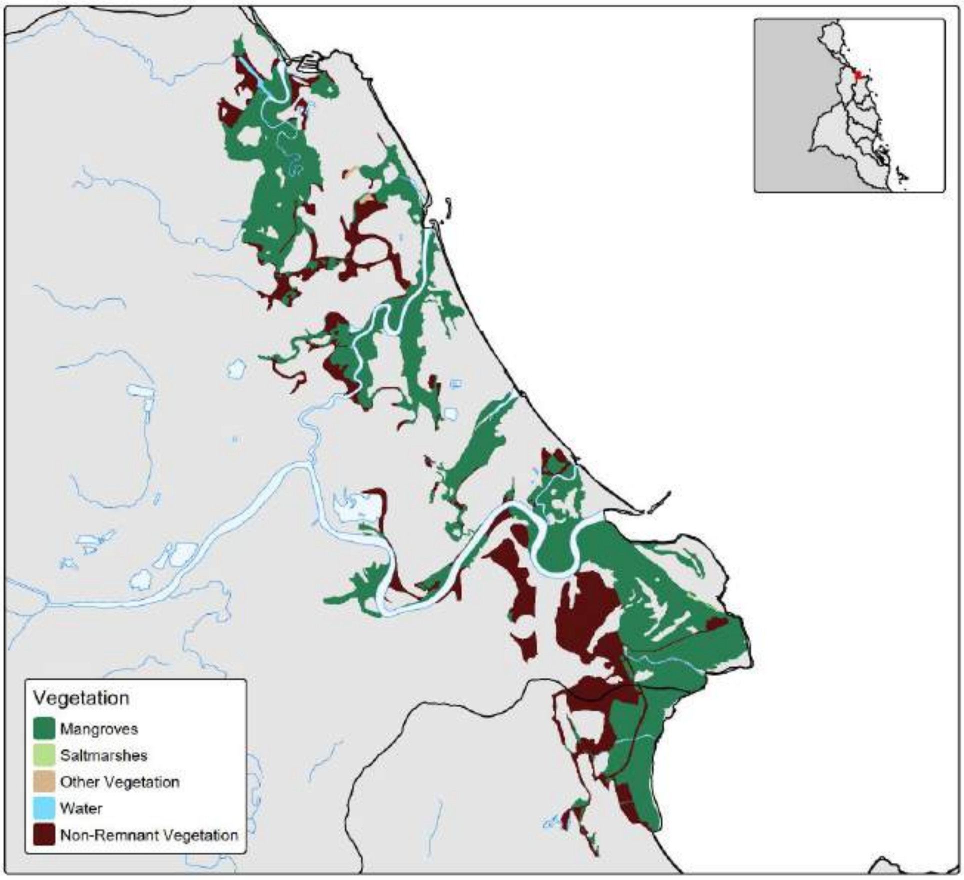


Figure 31 Barron estuary mangrove and salt marsh extent assessment area (shown by the orange line) and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom).

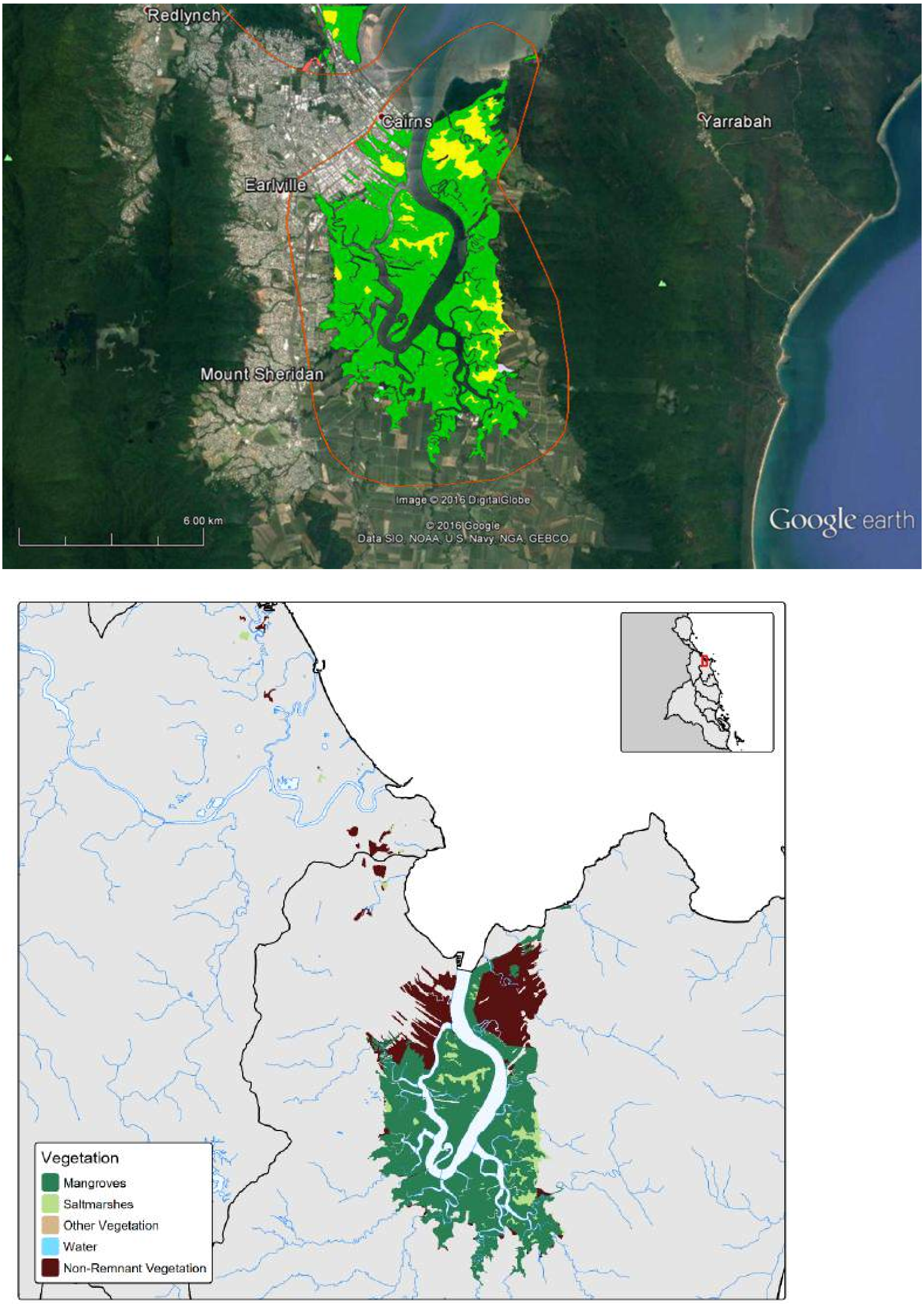
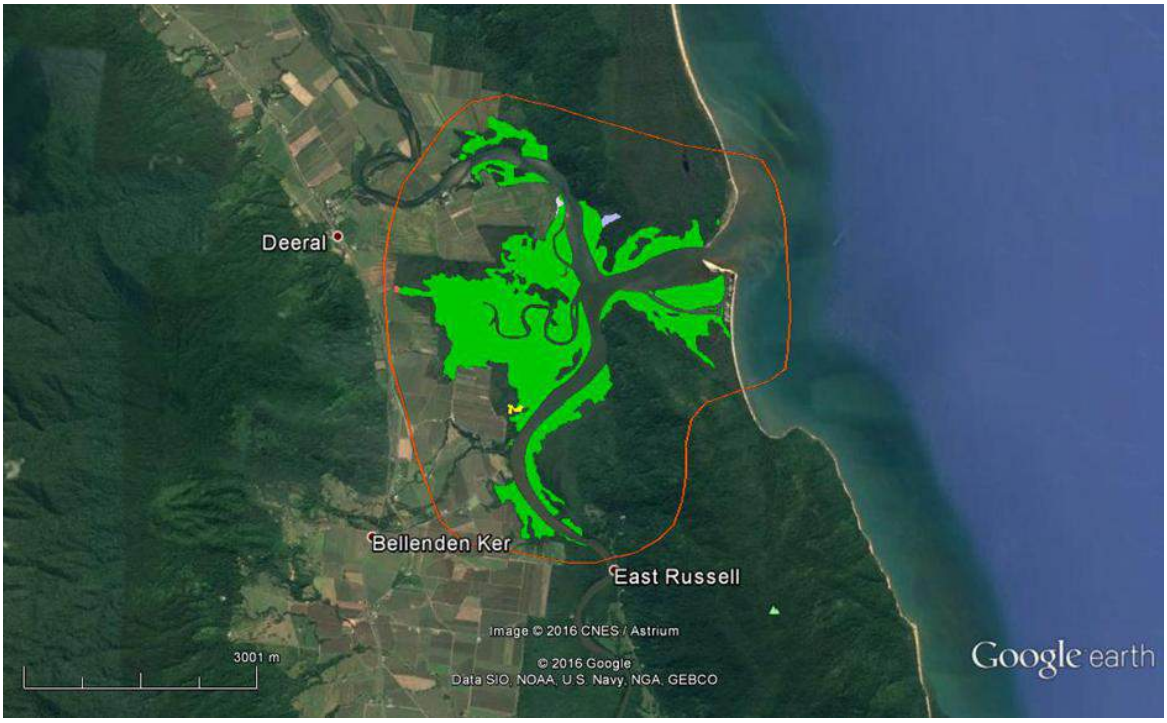


Figure 32 Trinity Inlet estuary mangrove and salt marsh extent assessment area (shown by the orange line) and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom).



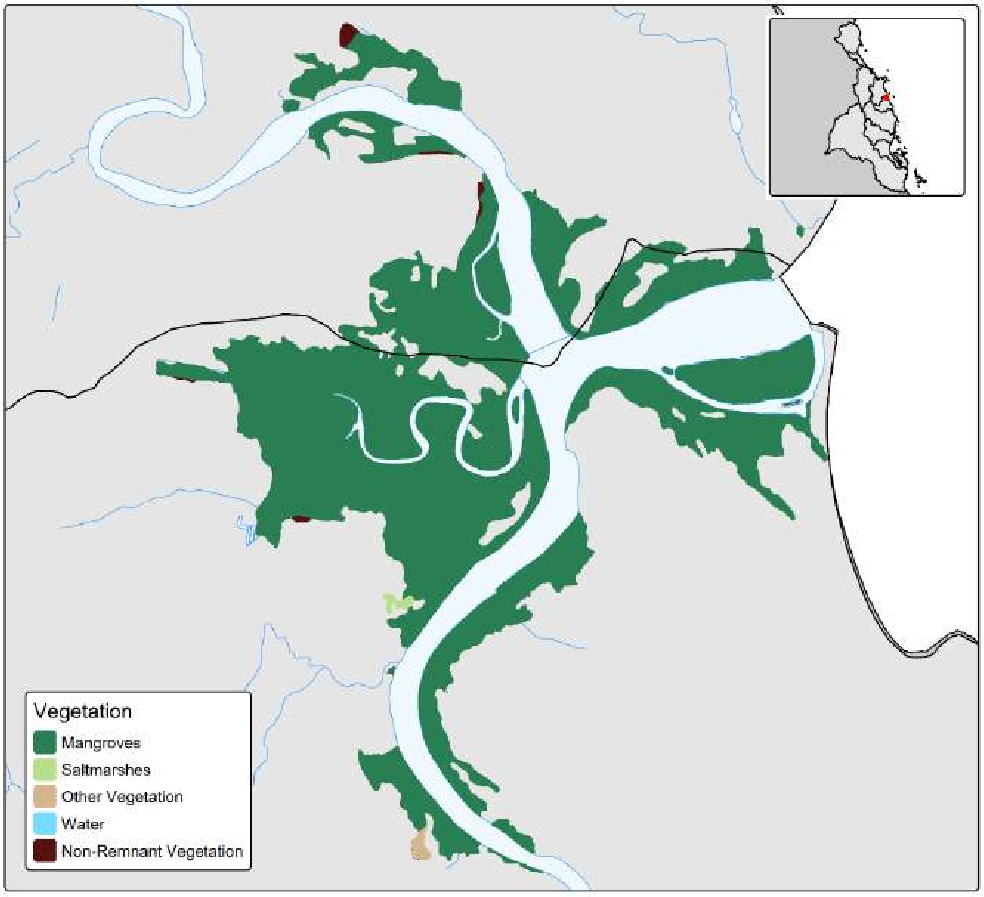


Figure 33 Russell-Mulgrave estuary mangrove and salt marsh extent assessment (shown by the orange line) area and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom).

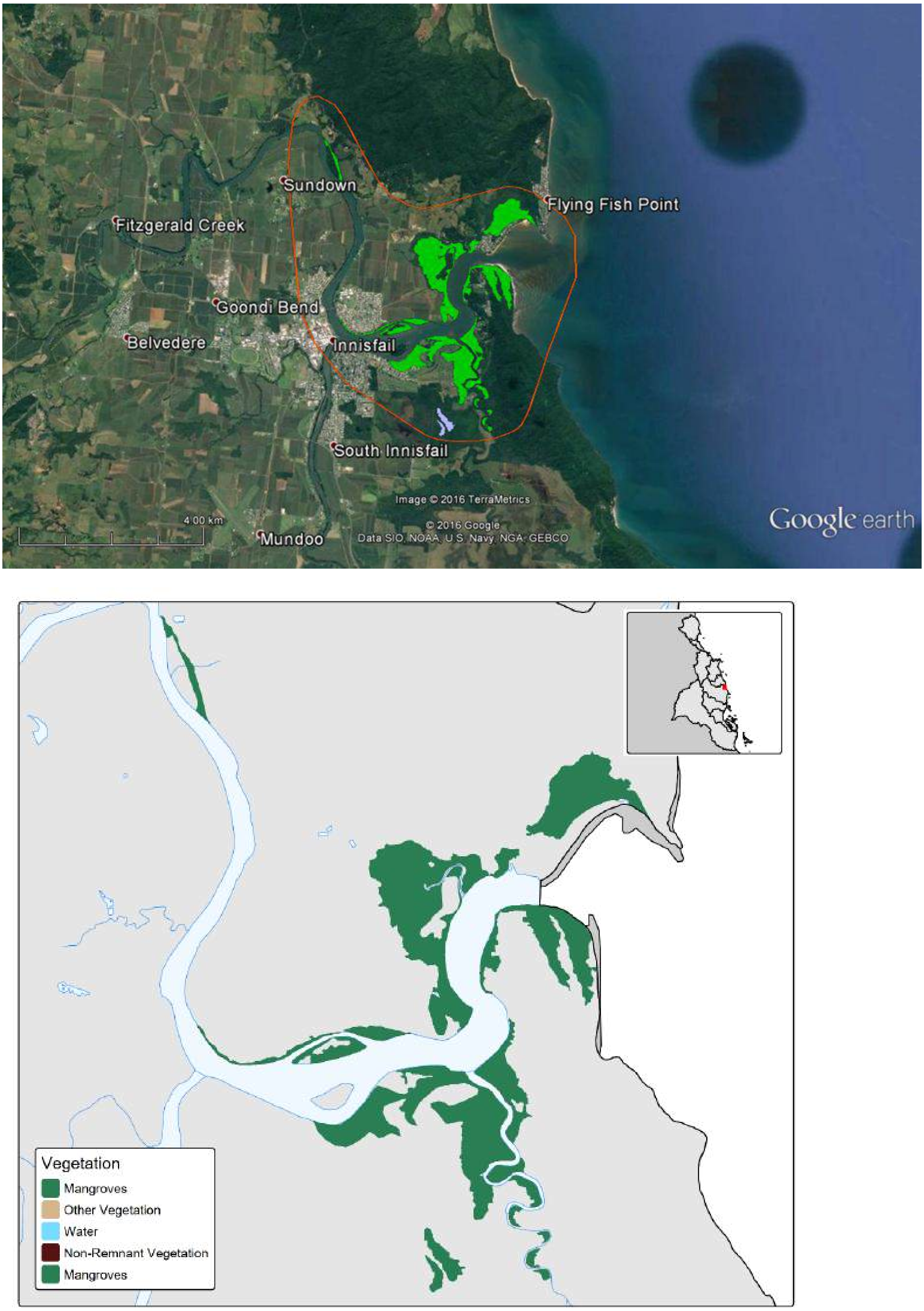
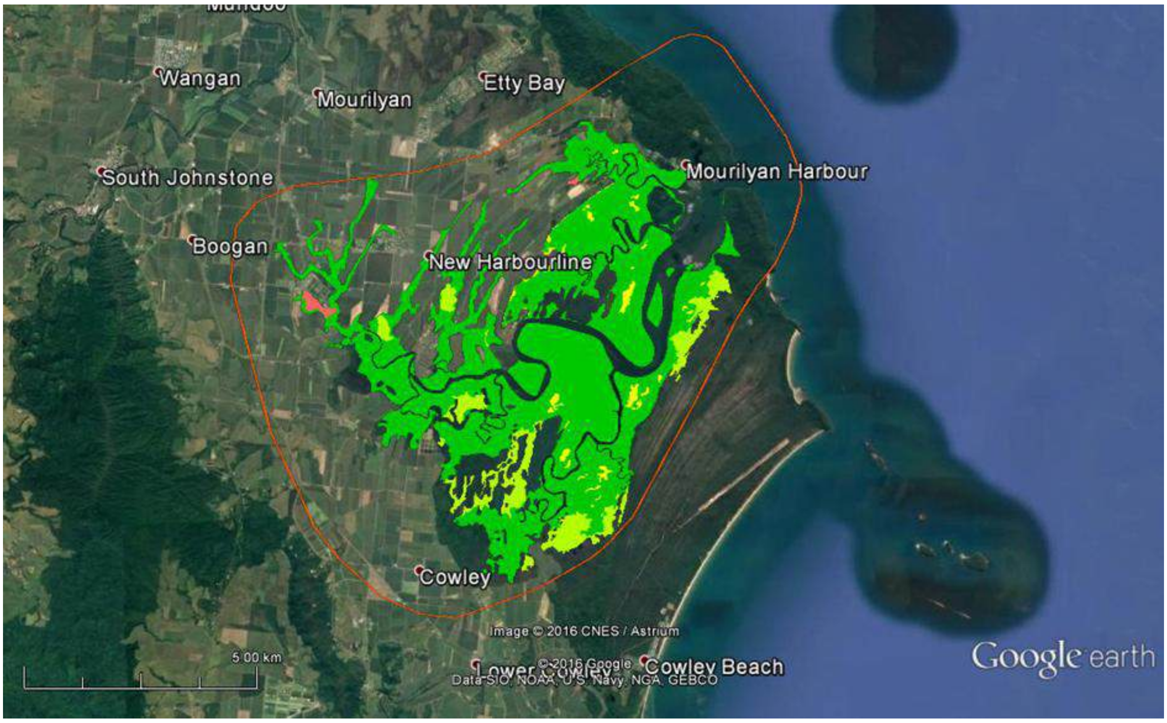


Figure 34 Johnstone estuary mangrove and salt marsh extent assessment (shown by the orange line) area and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom).



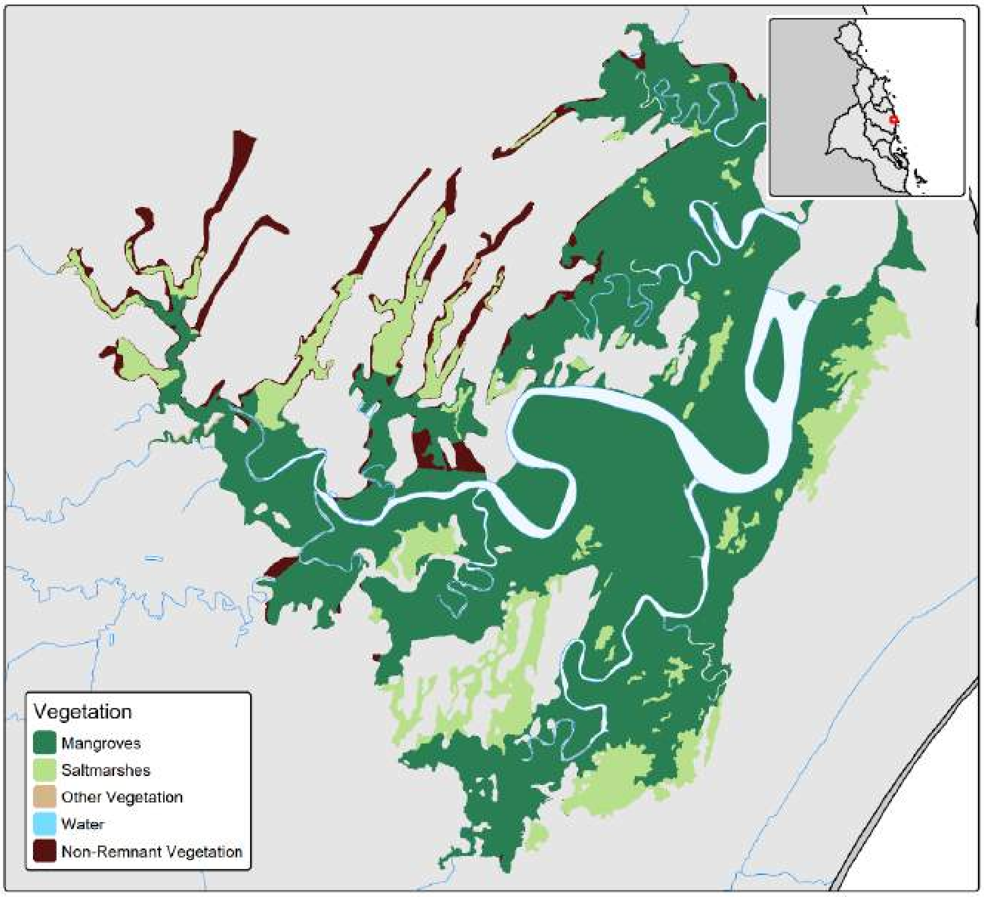


Figure 35 Moresby estuary mangrove and salt marsh extent assessment area (shown by the orange line) and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom).

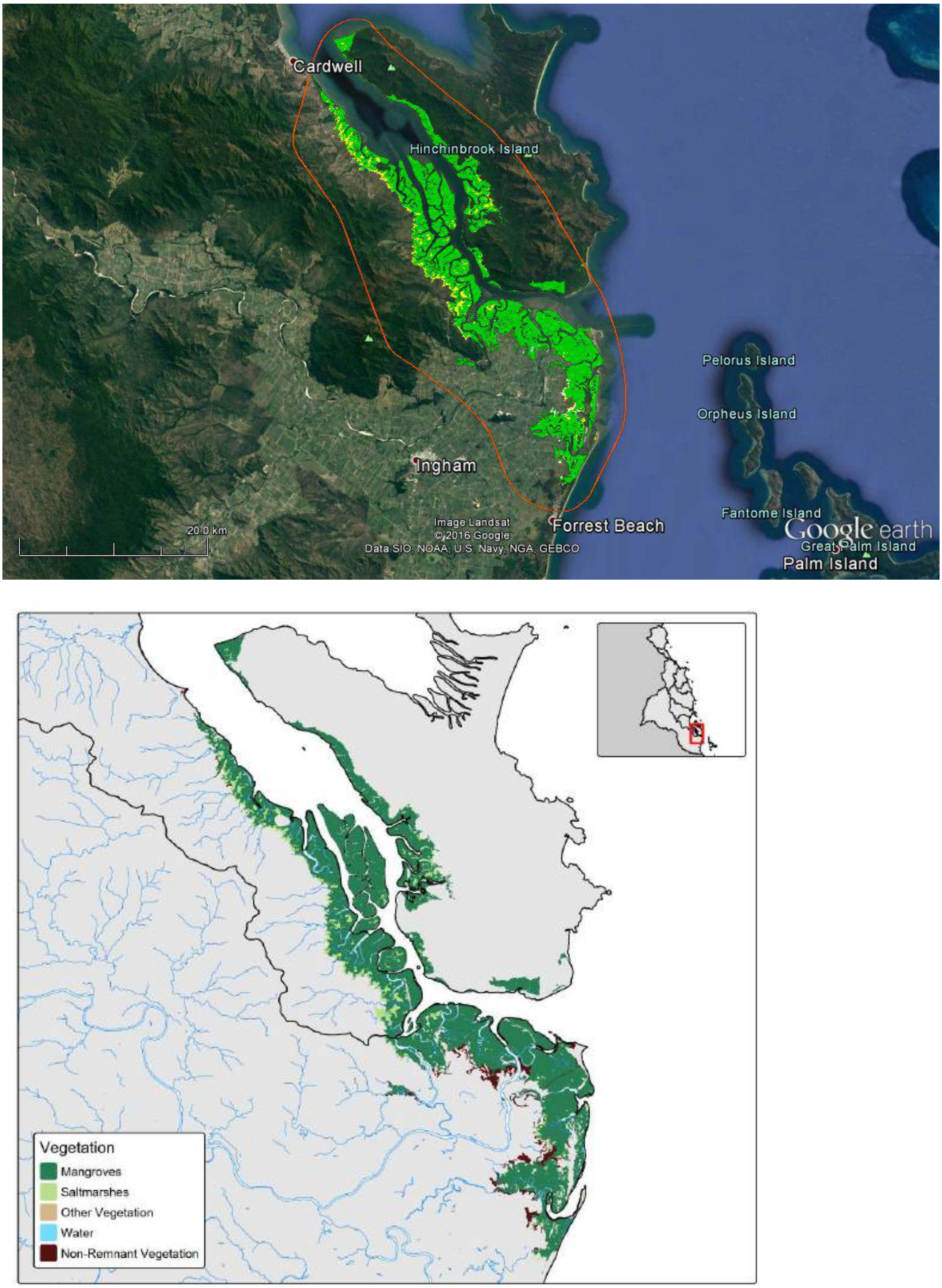


Figure 36 Hinchinbrook Channel estuary mangrove and salt marsh extent assessment (shown by the orange line) area and pre-cleared remnant ecosystem vegetation layer (Top); remnant mangrove and saltmarsh and non-remnant vegetation extent for the latest (2021) assessment (Bottom).

APPENDIX D Monitoring sites for inshore marine zones.

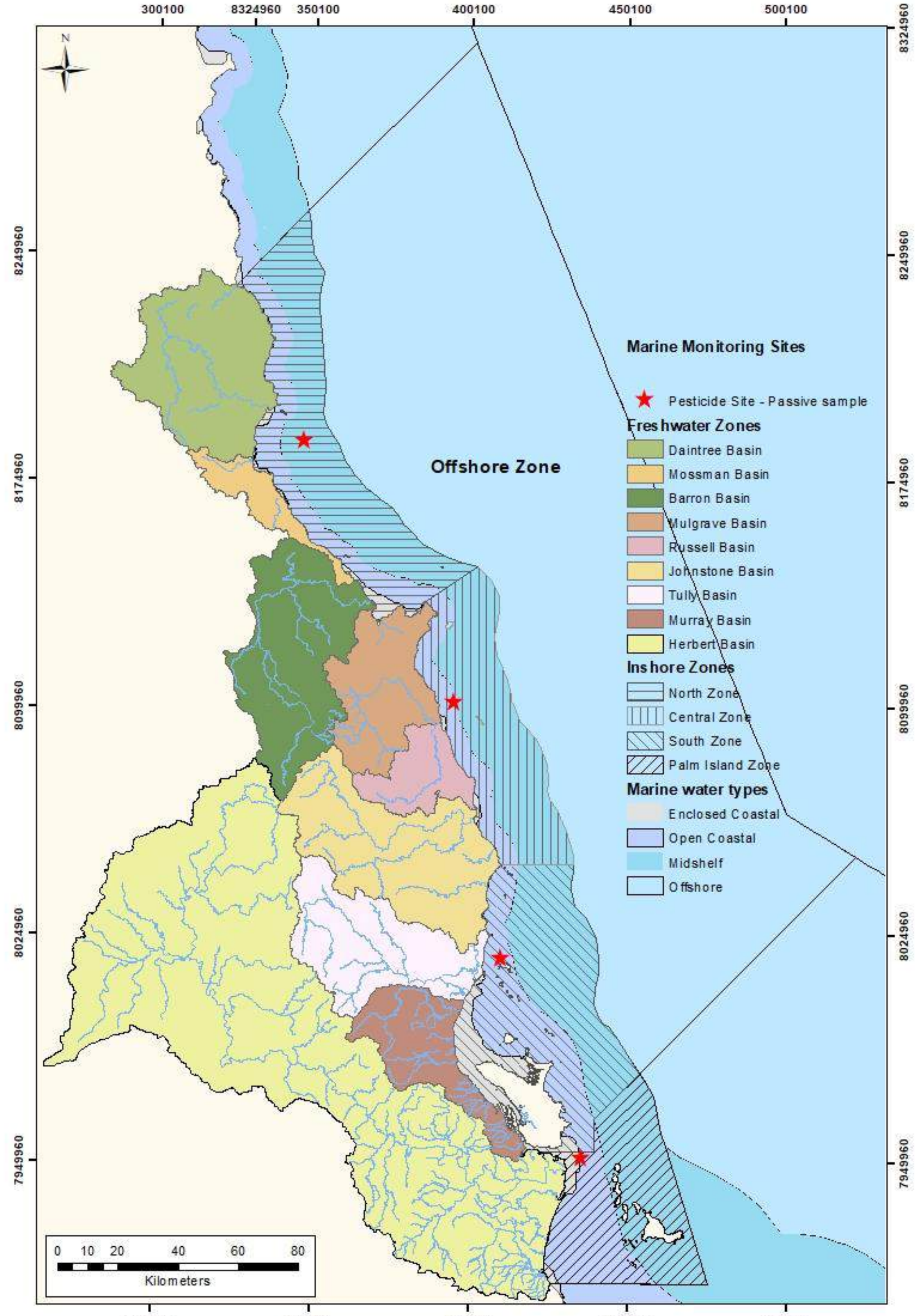


Figure 37 Pesticide monitoring locations of passive samplers. From north to south: Low Isles, High Island, Dunk Island and Lucinda.

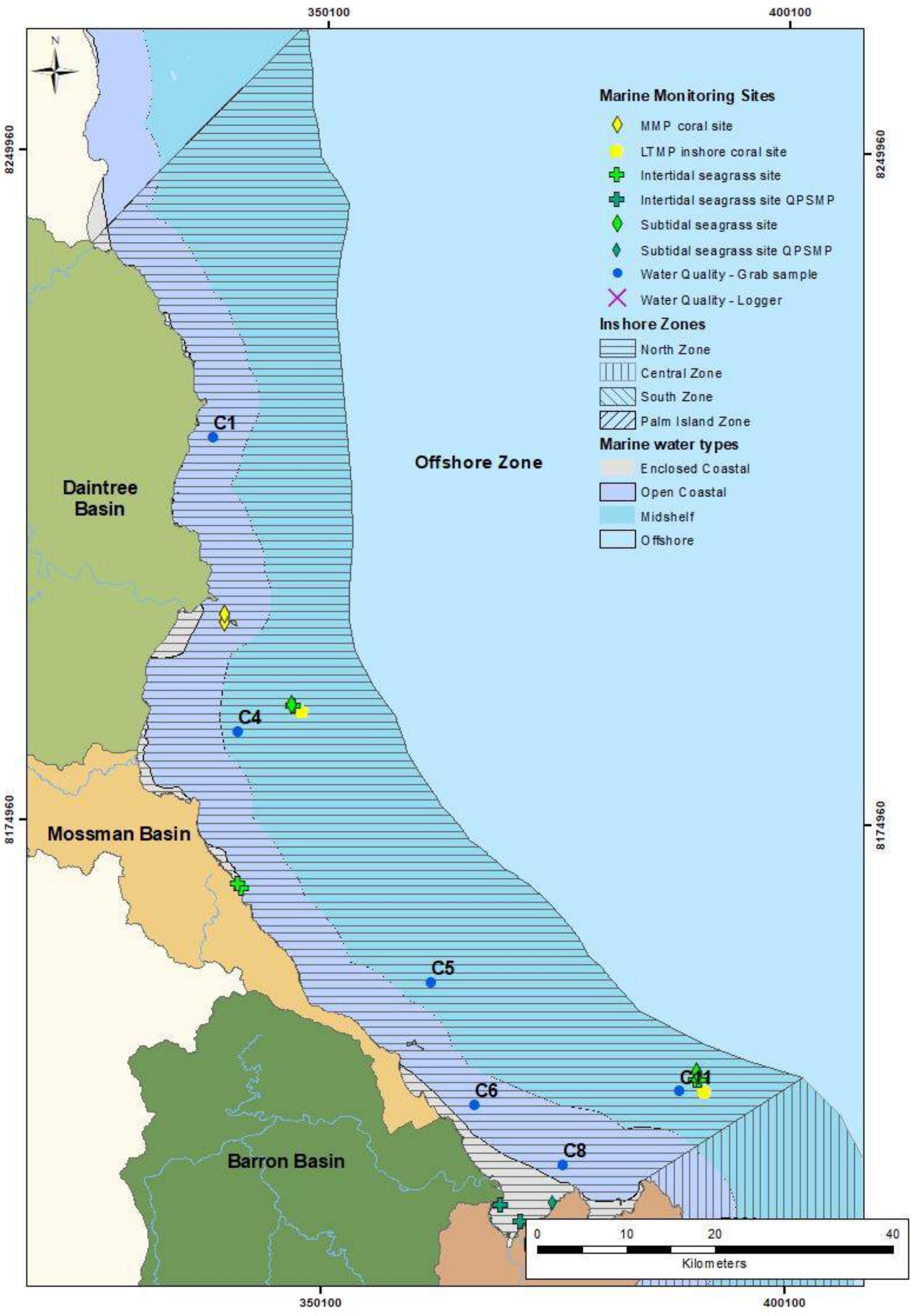


Figure 38 Water quality, seagrass and coral monitoring sites for the inshore North zone. Water quality sites are labelled with site code.

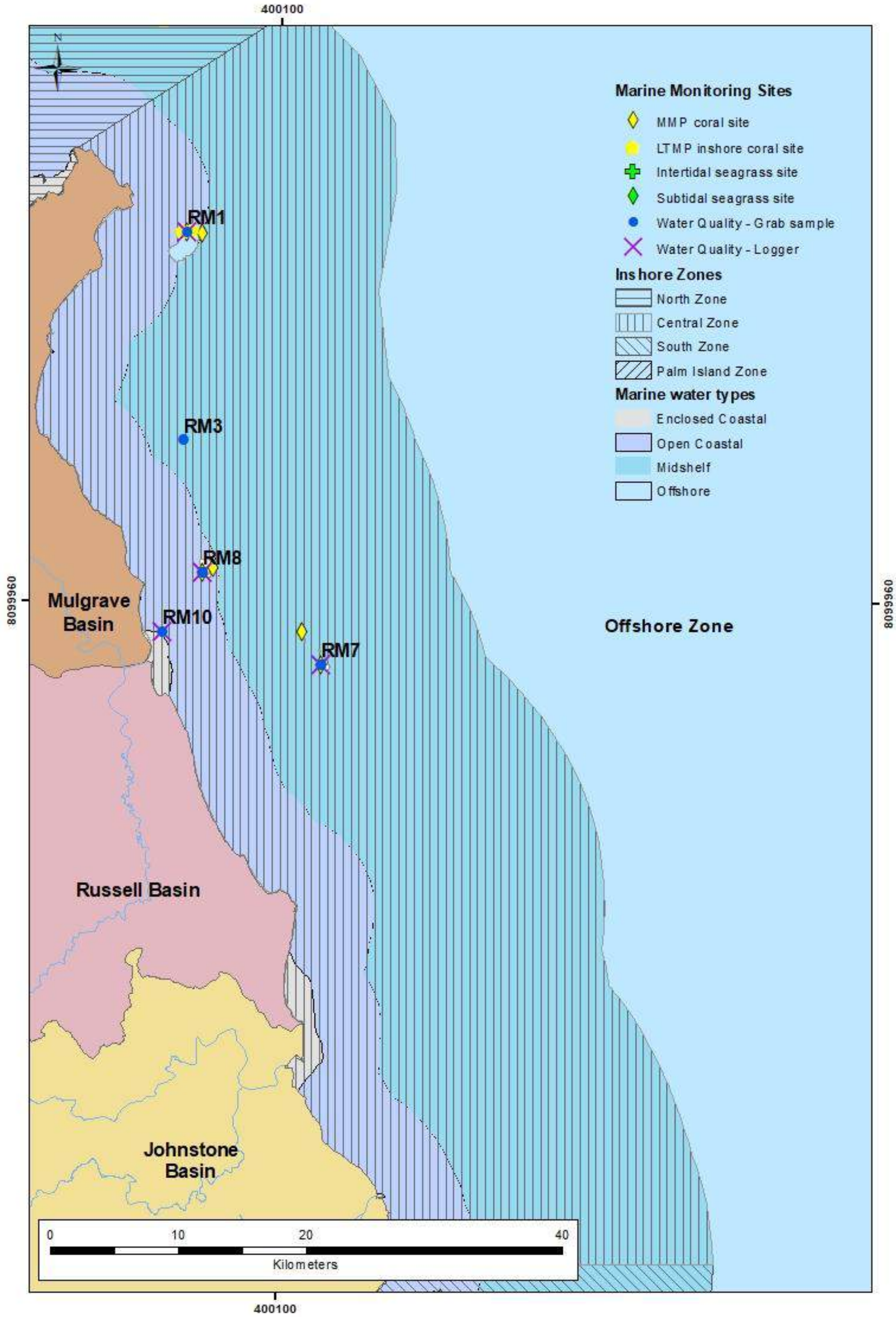


Figure 39 Water quality and coral monitoring sites for the inshore Central zone. Water quality sites are labelled with site code.

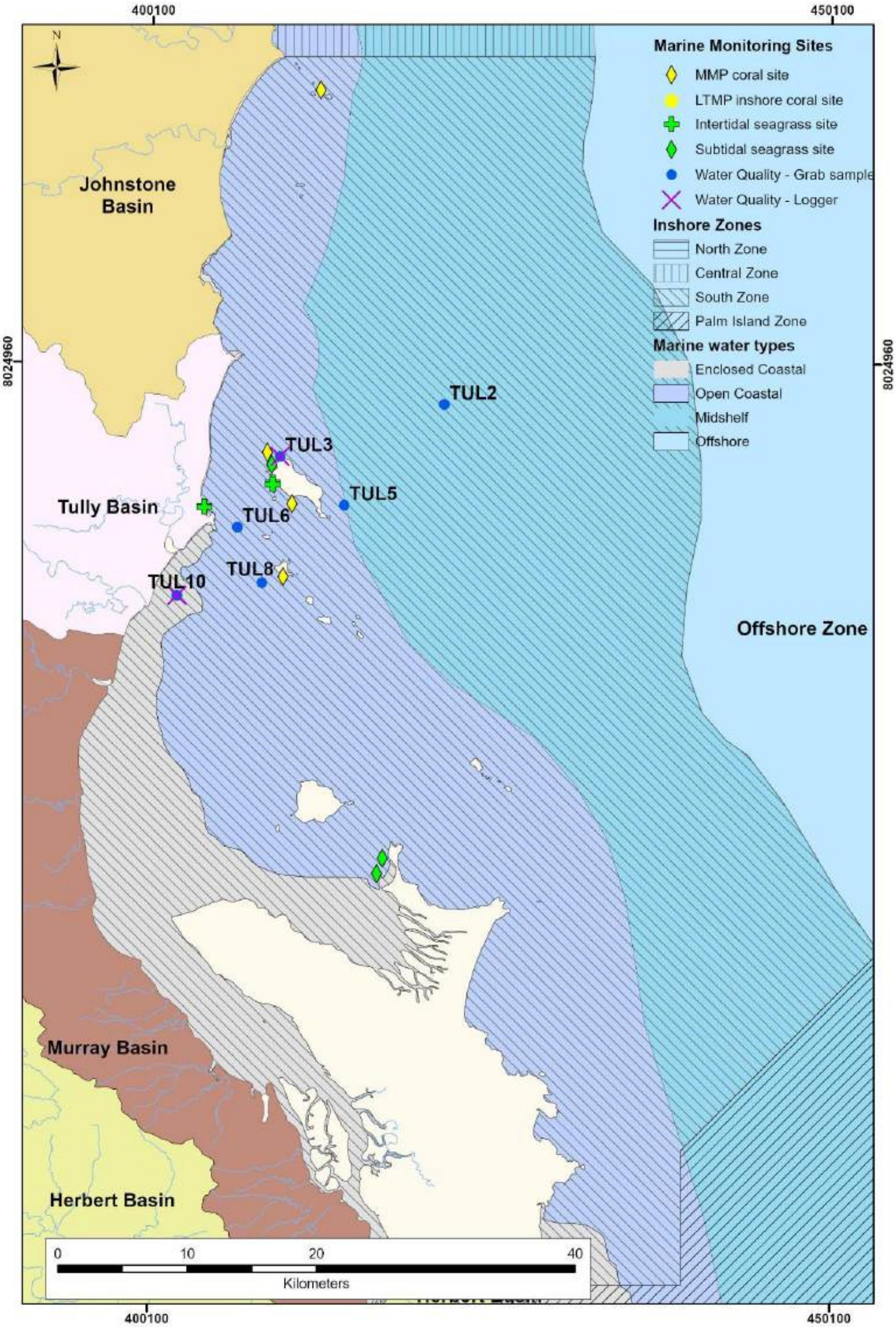


Figure 40 Water quality, seagrass and coral monitoring sites for the inshore South zone. Water quality sites are labelled with site code.

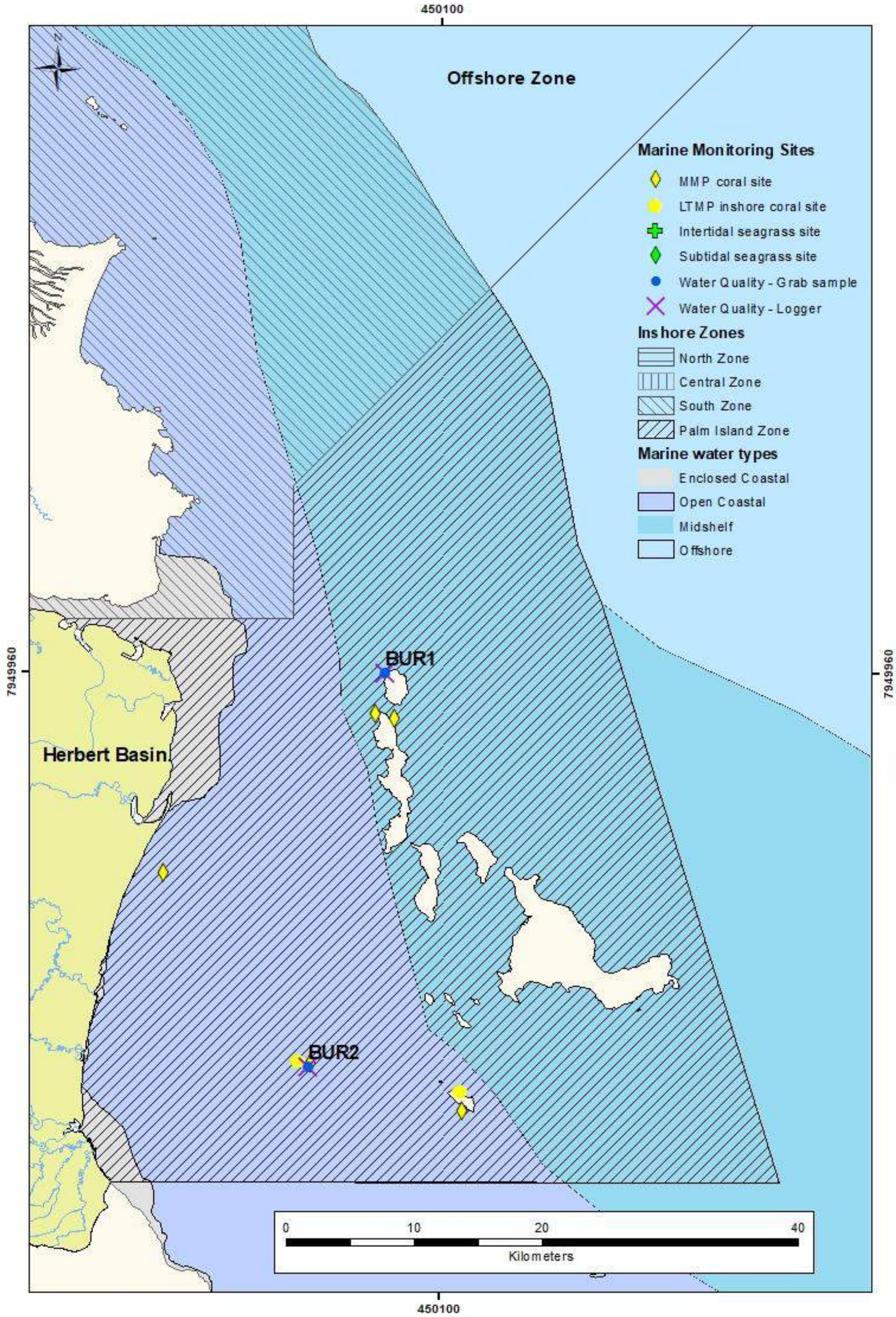


Figure 41 Water quality and coral monitoring sites for the inshore Palm Island zone. Water quality sites are labelled with site code.

APPENDIX E Flow indicator ecological assets and flow measures.

The tables below provide details of the flow requirements of the ecological assets (Table 59), measure types for assessing hydrological measures and key ecological assets (Table 60), and selected flow measures used for the flow indicator (Table 61)

Table 59 Summary of Ecological Assets and key flow events to meet flow requirements.

ASSET	Mog	Mel	Amb	Cai	Tan	Pse	Ljung	Lwil	Bara	Praw	Riff	Wat
Locations present	WT (all)	WT (all)	WT (mos, bar, mul, joh, tul, her, mur)	WT (mul, joh, tul)	WT (dai, mos, bar, mul, joh, tul, mur)	WT (all)	WT (joh, tul, mur, her)	WT (joh)	estuaries	estuaries	WT (all)	WT (all)
Low stable flows and timing of these	Aug-Nov	Aug-Nov	Aug-Nov	Sep - Oct	Oct - Jan	July - Oct						
Continuous baseflow to provide refugial waterholes > 2m deep												All year
Stable low and medium flows							Nov - Mar	Nov-Mar			All year	
High flows at end of system									Dec-Feb	Dec-Feb		

Note: codes: Mog (*Mogurnda* sp.), Mel (*Melanotaenia splendida splendida*), Amb (*Ambassis agassizii*), Cai (*Cairnsichthys rhombosomoides*), Tan (*Tandanus tandanus*), Pse (*Pseudomugil signifer*), Ljung (*Littoria jungguy*), Lwil (*Littoria wilcoxii*). Bara (Barramundi fishery), praw (banana prawn fishery, riff (riffle habitat) wat (waterholes). Catchments: Wet Tropics (WT): – dain (Daintree), mos (Mossman), bar (Barron), mul (Mulgrave Russell), Joh (Johnstone), tul (Tully), her (Herbert), mur (Murray).

Table 60 Measure types for assessing hydrological measures relevant to ecological assets and key ecosystem components and processes.

Flow category	Key Asset	Additional assets	Types of measures	Timing of flow event (season)	Duration of flow
Low flows	Low flow spawning fish	Maintain critical aquatic habitat (e.g aquatic macrophytes) and water quality for aquatic biota. Maintain river longitudinal connectivity	Duration of low flow events Frequency of low flow events Timing of low flow event Magnitude of flow events Variability of baseflow	July – Jan (Mostly dry)	Maximum change in depth of 5cm over whole stable period (min of 25 d to meet needs of all species)
Cease to flow	Amphibians	Macro-invertebrates Maintenance of refugial waterholes and provision of critical habitat for dependant taxa	Duration of low flow events Timing of low flow event	Aug – Dec (dry)	Short duration of zero flow
Low to Medium flows	Creation or maintenance of riffle habitat and associated biota	Maintain macrophyte habitat	Duration of low to medium event Frequency of low-medium medium flows	Year round (all)	Long duration of low to medium events High frequency of these events
High flows	High production of prawns and barramundi fisheries Downstream sediment delivery	Scouring of riparian zones ensures no vegetation encroachment	Magnitude of high flow events Duration of high flow events	Dec- Mar (wet)	High magnitude and duration of high flow events

Table 61 Selected flow measures used for the flow indicator.

Flow measure	Season	Flow threshold	Hydrologic Measure definition
Low flow Duration	July-Jan	Test three thresholds: 25th, 10th, 5th percentiles*	Total duration of flows which remain equal to or below a lower threshold for the reporting period (annual).
Low flow Frequency	July-Jan	Test three thresholds: 25th, 10th, 5th percentiles*	Count of the number of occurrences during which the magnitude of flow falls to or below the threshold during the reporting period (annual).
Low flow variability	July-Dec		Coefficient of variation (stdev/mean) of daily flow for dry season.
Driest six Months	July-Dec		Proportion of annual discharge contributed during the months July-December.
Cease to flow Duration	All year	0	Total duration of where flow ceases during the reporting period (annual).
Cease to flow Frequency	All year	0	Count of the number of occurrences during which flow ceases during the reporting period (annual).
Medium flow Duration	All year	Median (50th percentile)	Total duration of flows which remain equal to or above a threshold for the reporting period (annual)
Medium flow Frequency	All year	Median (50th percentile)	Count of the number of occurrences during which the magnitude of flow passes from below to equal or above the threshold during the reporting period (annual).
High flow duration	All year	Test three thresholds: 75th, 90th, 95th percentiles*	Total duration of flows which remain equal to or above a threshold for the reporting period (annual)
High flow Frequency	All year	Test three thresholds: 75th, 90th, 95th percentiles*	Total count of flows which remain equal to or above a threshold for the reporting period (annual)

*percentile – the percentage of the flow record below this value (low percentile = low flow). This is often confused with the often used hydrological nomenclature of Q10, Q90 – where Q10 is the flow that is exceeded 10% of the time.

APPENDIX F Basin fish assessment survey dates and sites.

Table 62 List of fish assessment sites for each basin with site code, site location and waterway, and year of survey.

Basin	Site code	Waterway	Location	Latitude	Longitude	2018	2019	2020	2021	2022	2023	2024
Barron	110-0001	Severin Creek	Binnie Road, Danbulla	-17.2033	145.6656		✓				✓	
Barron	110-0002	Davies Creek	Kennedy Highway, Koah	-16.9658	145.5374		✓				✓	
Barron	110-0003	Oaky Creek	Hodzic Road, Biboohra	-16.8302	145.4527		✓				✓	
Barron	110-0004	Wright Creek	Gillies Range Road, Lake Eacham	-17.2719	145.6124		✓				✓	
Barron	110-0007	Atherton Creek	Jenninga Road, Mareeba	-17.0273	145.3948		✓				✓	
Barron	110-0008	Tinaroo Creek	Danbulla National Park, Mareeba	-17.1315	145.5266		✓					
Barron	110-0009	Varch Creek	Dinden National Park, Mareeba	-17.0269	145.5910		✓				✓	
Barron	110-0011	Poona Creek	Herberton Range Conservation Park, Upper Barron	-17.3943	145.4814		✓				✓	
Barron	110-0013	Barron River	Off Parklands Circuit, Mareeba	-17.0076	145.4473		✓				✓	
Barron	110-0021	Freshwater Creek	Ryan Weare Park, Freshwater	-16.8843	145.7042		✓				✓	
Barron	110-0045	Tinaroo Creek	Henry Hannam Drive, Mareeba	-17.0601	145.4743						✓	
Barron	110-0083	Clohesy River	Koah Road, Koah	-16.8422	145.5266		✓				✓	
Barron	110-9997	Stony Creek	Douglas Track Road, Kamerunga	-16.8738	145.6710				✓			
Barron	110-9998	Freshwater Creek	Mary Parker Drive, Redlynch	-16.9421	145.6959				✓			
Barron	110-9999	Barron River	Hartley Street North Park, Kamerunga	-16.8731	145.6936				✓			
Daintree	108-0017	Saltwater Creek	Off O'Donoghue Road, Daintree National Park, Miallo	-16.4321	145.3377		✓					
Daintree	108-0023	Whyanbeel Creek	Off Whyanbeel Road, Whyanbeel	-16.3823	145.3343		✓					✓
Daintree	108-0033	Saltwater Creek	Poletti Road, Miallo	-16.4082	145.3554		✓					✓
Daintree	108-0670	Tributary of Forest Creek	Forest Creek Road, Forest Creek	-16.2402	145.3669				✓			
Daintree	108-9957	Roaring Meg Creek	Upper Daintree Road, Wujal Wujal	-15.9954	145.2939							✓
Daintree	108-9958	Whyanbeel Creek	Whyanbeel Road, Whyanbeel	-16.3713	145.3293							✓
Daintree	108-9959	Tributary of Saltwater Creek	Corner of Syndicate and White roads, Miallo	-16.4171	145.3539							✓

Basin	Site code	Waterway	Location	Latitude	Longitude	2018	2019	2020	2021	2022	2023	2024
Daintree	108-9960	Tachalbadga Creek	Cape Tribulation Bloomfield Road, Cape Tribulation	-16.0270	145.4460							✓
Daintree	108-9961	Owen Creek	Upper Daintree Road, Wujal Wujal	-15.9776	145.3168							✓
Daintree	108-9962	Tributary of Myall Creek	Cape Tribulation Road, Cape Tribulation	-16.0993	145.4585							✓
Daintree	108-9963	Mission Creek	CREB Track, Wujal Wujal	-15.9497	145.2970							✓
Daintree	108-9964	Cooper Creek	Cape Tribulation Road, Thornton Beach	-16.1742	145.4196							✓
Daintree	108-9965	Tributary of Cooper Creek	Turpentine Road, Diwan	-16.1696	145.4135							✓
Daintree	108-9966	Baird Creek	CREB Track, China Camp	-16.0284	145.2813							✓
Daintree	108-9967	Meelele Creek	Cape Tribulation Bloomfield Road, Bloomfield	-15.9712	145.3974							✓
Daintree	108-9968	Tributary of Keating Creek	CREB Track, China Camp	-16.0080	145.2620							✓
Daintree	108-9969	Watermelon Creek	CREB Track, Wujal Wujal	-15.9484	145.2839							✓
Daintree	108-9970	Keating Creek	CREB Track, China Camp	-16.0187	145.2665							✓
Daintree	108-9971	Tributary of Keating Creek	Ten Mile Creek Road, "Dawnvale"	-15.9845	145.2570							✓
Daintree	108-9972	Baird Creek	Upper Daintree Road, Noah	-16.0546	145.3054							✓
Daintree	108-9973	Tributary of Baird Creek	China Camp Road, Monkhouse	-16.0454	145.2968							✓
Daintree	108-9974	Baird Creek	CREB Track, Monkhouse	-16.0394	145.2972							✓
Daintree	108-9975	Tributary of High Falls Creek	High Falls Road, Whyanbeel	-16.3967	145.3382							✓
Daintree	108-9976	Saltwater Creek	O Donoghue Road, Miallo	-16.4276	145.3496							✓
Daintree	108-9977	Saltwater Creek	Syndicate Road, Miallo	-16.4227	145.3576							✓
Daintree	108-9978	Tributary of Chinaman Creek	Kahana Road, Whyanbeel	-16.3650	145.3528							✓
Daintree	108-9979	Bamboo Creek	Bamboo Creek Road, Bamboo	-16.3472	145.3896							✓
Daintree	108-9980	Douglas Creek	Douglas Creek Road, Stewart Creek Valley	-16.2810	145.2924							✓
Daintree	108-9981	Orsova Creek	Stewart Creek Road, Stewart Creek Valley	-16.3177	145.3235							✓
Daintree	108-9982	Intake Creek	Cassowary Falls, Upper Daintree Road, Upper Daintree	-16.2504	145.2932							✓
Daintree	108-9983	Martins Creek	Cassowary Falls, Upper Daintree Road, Upper Daintree	-16.2433	145.2984							✓
Daintree	108-9984	Niau Creek	Upper Daintree Road, Upper Daintree	-16.1984	145.2903							✓
Daintree	108-9985	Emmagen Creek	Cape Tribulation Bloomfield Road, Cape Tribulation	-16.0407	145.4568							✓

Basin	Site code	Waterway	Location	Latitude	Longitude	2018	2019	2020	2021	2022	2023	2024
Daintree	108-9986	Olufson Creek	Rossville Bloomfield Road, Wujal Wujal	-15.9349	145.3311							✓
Daintree	108-9987	Woobadda River	Cape Tribulation Bloomfield Road, Wujal Wujal	-15.9596	145.3535							✓
Daintree	108-9988	Woobadda River	Cape Tribulation Bloomfield Road, Wujal Wujal	-15.9668	145.3746							✓
Daintree	108-9989	Granite Creek	Rossville Bloomfield Road, Wujal Wujal	-15.9331	145.3261							✓
Daintree	108-9990	Saltwater Creek	Miallo Road, Miallo	-16.3883	145.3755				✓			
Daintree	108-9991	Brown Creek	Cape Tribulation Road, Kimberley	-16.2554	145.4182				✓			✓
Daintree	108-9992	McLean Creek	Buchanan Creek Road, Diwan	-16.2258	145.4227				✓			✓
Daintree	108-9993	Tributary of Hutchinson Creek	Pandanus Road, Diwan	-16.2202	145.4215				✓			
Daintree	108-9994	Tributary of Forest Creek	Forest Creek Road, Forest Creek	-16.2462	145.3930				✓			✓
Daintree	108-9995	Cassowary Creek	Crystal Brook Road, Stewart Creek Valley	-16.2970	145.3115				✓			✓
Daintree	108-9996	Tributary of Forest Creek	Forest Creek Road, Forest Creek	-16.2376	145.3772				✓			✓
Daintree	108-9998	Hutchinson Creek	Cape Tribulation Road, Diwan	-16.2166	145.4225				✓			✓
Daintree	108-9999	Oliver Creek	Cape Tribulation Road, Thornton Beach	-16.1378	145.4411				✓			✓
Herbert	116-0005	Trebonne Creek[C]	Orient Road, Orient	-18.7392	146.1993			✓		✓		
Herbert	116-0006	Tributary of Herbert River[C]	Craven Road, Abergowrie	-18.4487	145.8370			✓		✓		
Herbert	116-0007	Blunder Creek	Waggon Road, Koombooloomba National Park	-17.7788	145.5135			✓		✓		
Herbert	116-0009	Breakaway Creek[C]	Lannercost Main North, Lannercost State Forest	-18.5918	145.9461			✓		✓		
Herbert	116-0013	Ashton Creek[C]	Lannercost Main North, Lannercost State Forest	-18.6093	145.9150			✓		✓		
Herbert	116-0014	White Adder Creek	Garrawalt Road, Girringun National Park	-18.5041	145.7518			✓*		✓		
Herbert	116-0016	Tributary of Jacky Jacky Ck[C]	Kirrama Range Road, Kirrama National Park, Kirrama	-18.1899	145.7471			✓*				
Herbert	116-0018	Hawkins Creek[C]	Off Hawkins Creek Road, Hawkins Creek	-18.5818	146.0772			✓*		✓		
Herbert	116-0019	Mill Creek	Off Johnston Road, Evelyn	-17.4966	145.4488			✓				
Herbert	116-0026	Wild River	Atherton Herberton Road, Herberton Range State Forest,	-17.3678	145.3916			✓				
Herbert	116-0029	Stone River	Stone River Road, Lannercost	-18.6424	146.0344			✓		✓		
Herbert	116-0033	Spring Creek (North Branch)[C]	Milton Road, Helens Hill	-18.8248	146.0605			✓				

Basin	Site code	Waterway	Location	Latitude	Longitude	2018	2019	2020	2021	2022	2023	2024
Herbert	116-0035	Robinson Creek	Robinson Creek Road, Tumoulin Forest Reserve, Ravenshoe	-17.5840	145.4812			✓				
Herbert	116-0038	Wigwam Creek	Broadwater Forest Road, Abergowrie State Forest	-18.4357	145.9951			✓				
Herbert	116-0039	Blunder Creek	Wooroora Road, Koombooloomba	-17.7322	145.4308			✓		✓		
Herbert	116-0048	Anabranch of Rudd Creek	Gunnawarra Road, Innot Hot Springs	-17.9117	145.1578			✓				
Herbert	116-0048	Rudd Creek	Gunnawarra Road, Innot Hot Springs	-17.9117	145.1578					✓		
Herbert	116-0054	Gowrie Creek	Gowrie, off Kokoda Road, Abergowrie	-18.3905	145.8470			✓				
Herbert	116-0059	Wild River	Woodleigh Road, Innot Hot Springs	-17.6722	145.2645			✓				
Herbert	116-0061	Arnot Creek[C]	Bruce Highway, Bemerside	-18.5592	146.1846			✓				
Herbert	116-0090	Wild River	Off Adams Road, Kalunga	-17.4285	145.3846			✓				
Herbert	116-0099	Vine Creek	Off Mount Ronald Road, Ravenshoe Forest Reserve I,	-17.6660	145.4647			✓				
Herbert	116-0220	Herbert River	Above Herbert River Falls, Girringun National Park	-18.2304	145.3541			✓		✓		
Herbert	116-0274	Palm Creek	Hawkins Street, Ingham	-18.6463	146.1533			✓				
Herbert	116-0303	Blencoe Creek	Cashmere Kirrama Road, Girringun National Park	-18.2154	145.5419			✓				
Herbert	116-0652	Herbert River	Cashmere Kirrama Road, Glen Ruth	-18.1370	145.3390			✓		✓		
Herbert	116-0871	Break-O-Day Creek	Wooroora Road, Millstream	-17.6772	145.4328			✓				
Herbert	116-0998	Tin Creek	Gowrie, off Kokoda Road, Abergowrie	-18.3815	145.8557			✓				
Herbert	116-1018	Black Adder Creek	Garrawalt Road, Girringun National Park	-18.5123	145.7485			✓				
Herbert	116-1029	Garrawalt Creek	Garrawalt Road, Girringun National Park	-18.5200	145.7614			✓				
Herbert	116-1120	Tributary of Kirrama Creek	Kirrama, Kirrama Range Road, Kirrama	-18.1592	145.6554			✓				
Herbert	116-1336	Yuccabine Creek	Kirrama Range Road, Kirrama National Park, Kirrama	-18.2056	145.7648			✓*				
Herbert	116-1475	Gowrie Creek[C]	Abergowrie Road, Abergowrie	-18.4475	145.8478			✓				
Herbert	116-9995	Herbert River~[C]	Upstream of Atkinsons Pocket Road, Garrawalt	-18.5114	145.8671				✓			
Herbert	116-9996	Waterview Creek	Jourama Road, Yuruga	-18.8520	146.1250				✓			
Herbert	116-9997	Herbert Rive~[C]	Upstream of Farrell Drive, Halifax	-18.5854	146.2825				✓			
Herbert	116-9998	Herbert River~[C]	Upstream of Gairloch Road, Gairloch	-18.6187	146.1767				✓			
Herbert	116-9999	Herbert River~[C]	Downstream of Atkinsons Pocket Road, Garrawalt	-18.5056	145.8785				✓			

Basin	Site code	Waterway	Location	Latitude	Longitude	2018	2019	2020	2021	2022	2023	2024
Johnstone	112-0001	Tributary of Malanda Creek	Odyssey Close, Lake Eacham	-17.3009	145.6367		✓				✓	
Johnstone	112-0006	Malanda Creek	Chappell Close, North Johnstone	-17.3369	145.6439		✓				✓	
Johnstone	112-0007	Cowley Creek	Adair Road, Warrubullen	-17.6893	146.0158		✓				✓	
Johnstone	112-0009	North Beatrice River	Riversong Retreat, Mullins Road, Beatrice	-17.5387	145.6342		✓				✓	
Johnstone	112-0010	South Maria Creek	Granadilla Road, Granadilla	-17.8629	146.0254		✓				✓	
Johnstone	112-0015	Eel Creek	Lawrence Road, Bamboo Creek	-17.5473	145.9981		✓					
Johnstone	112-0016	Tributary of Mena Creek	Palms, Seres Road, Mena Creek	-17.6714	145.9101		✓				✓	
Johnstone	112-0017	Muston Creek	Whiting Road, Beatrice	-17.5589	145.6016		✓				✓	
Johnstone	112-0028	Utchee Creek	Utchee Creek Road, Utchee Creek	-17.6391	145.9395		✓				✓	
Johnstone	112-0030	Liverpool Creek	Kroger Road, Japoonvale	-17.7190	145.9228		✓				✓	
Johnstone	112-0031	Scheu Creek	Friel Road, Currajah	-17.5857	145.9847						✓	
Johnstone	112-0036	Fitzgerald Creek	Pernase Road, Fitzgerald Creek	-17.4933	145.9884		✓					
Johnstone	112-0041	Middle Brook	Middlebrook Road, Middlebrook	-17.5651	145.6433						✓	
Johnstone	112-9975	Big Maria Creek	Taggart Road, Maadi	-17.8241	145.9841				✓			
Johnstone	112-9976	Lacey Creek	El Arish Mission Beach Road, Djiru National Park, Djiru	-17.8510	146.0640				✓			
Johnstone	112-9977	Tributary of Sanderson Creek	Bruce Highway, Silkwood	-17.7750	146.0287				✓			
Johnstone	112-9978	Nyleta Creek	Nyleta Creek Road, Japoon National Park, Gulngai	-17.7910	145.9552				✓			
Johnstone	112-9979	Cane drain	Cassar Road, Silkwood	-17.7408	146.0239				✓			
Johnstone	112-9980	Bombeeta Creek	Innisfail Japoon Road, Bombeeta	-17.7043	145.9447				✓			
Johnstone	112-9981	Llansolas Creek	Garradunga Road, Garradunga	-17.4661	145.9957				✓			
Johnstone	112-9982	Bora Creek	Pullom Road, Nerada	-17.5515	145.8418				✓			
Johnstone	112-9983	Tributary of Fitzgerald Creek	Erbacher Road, Fitzgerald Creek	-17.4934	145.9805				✓			
Johnstone	112-9984	Tributary of Victory Creek	Bruce Highway, Vasa Views	-17.4732	145.9692				✓			
Johnstone	112-9985	Tributary of Polly Creek	Jubilee Road, Jubilee Heights	-17.4825	146.0325				✓			
Johnstone	112-9986	Cane drain	Ehlerth Road, Granadilla	-17.8362	146.0292				✓			
Johnstone	112-9987	Polly Creek	Jubilee Road, Jubilee Heights	-17.4786	146.0300				✓			

Basin	Site code	Waterway	Location	Latitude	Longitude	2018	2019	2020	2021	2022	2023	2024
Johnstone	112-9988	Kenning Creek	Thornhill Road, Granadilla	-17.8243	146.0227				✓			
Johnstone	112-9989	Ninds Creek West Branch	Mourilyan Harbour Road, Mourilyan	-17.5836	146.0405				✓			
Johnstone	112-9990	Cane drain	Innisfail Japoon Road, Bombetta	-17.6711	145.9658				✓			
Johnstone	112-9991	Tributary of Boundary Creek	Gullota Road, Walter Lever Estate	-17.7258	145.9724				✓			
Johnstone	112-9992	Fisher Creek	Gregory Falls Road, East Palmerston	-17.5922	145.8724				✓			
Johnstone	112-9993	Tributary of Mourilyan Creek	Hill End Road, Lower Cowley	-17.6880	146.0656				✓			
Johnstone	112-9994	Cane drain	Rinaudo Road, McCutcheon	-17.7098	146.0813				✓			
Johnstone	112-9995	Cowley Creek (South Branch)	Warrubullen Road, Cowley Creek	-17.7025	146.0140				✓			
Johnstone	112-9996	Meuribah Creek	Warrakin Road, Japoonvale	-17.7163	145.8874				✓			
Johnstone	112-9997	South Johnstone River	Near Gracey Creek, Comoon Loop	-17.5650	146.0284				✓			
Johnstone	112-9998	North Johnstone River	Old Ferry Road, Goondi	-17.4926	146.0133				✓			
Johnstone	112-9999	Liverpool Creek	Stephenson Road, Lower Cowley	-17.6996	146.0752				✓			
Mossman	109-0002	Parker Creek	Alchera Drive, Mossman	-16.4693	145.3728		✓					
Mossman	109-0007	South Mossman River	Ponzo Road, Shannonvale	-16.5026	145.3679		✓				✓	
Mossman	109-0010	Spring Creek	Spring Creek Road, Mowbray	-16.5827	145.4852		✓				✓	
Mossman	109-0011	Tributary of Ball Creek	Borzi Road, Shannonvale	-16.5044	145.3731		✓				✓	
Mossman	109-0014	Spring Creek	Trezise Road, Mowbray	-16.5689	145.4779		✓				✓	
Mossman	109-0020	Flin Creek	Pinnacle Road, Julatten	-16.5742	145.4076		✓				✓	
Mossman	109-0024	Cassowary Creek	Wilkinson Road, Cassowary	-16.5151	145.4126		✓				✓	
Mossman	109-0027	Ball Creek	Borzi Road, Shannonvale	-16.5086	145.3755		✓				✓	
Mossman	109-0040	Cassowary Creek	Cassowary Road, Cassowary Creek	-16.5204	145.4191						✓	
Mossman	109-0043	South Mossman River	Captain Cook Highway, Shannonvale	-16.4855	145.3838		✓				✓	
Mossman	109-0061	Mossman River	Finlayvale Road, Mossman Gorge	-16.4507	145.3610		✓				✓	
Mossman	109-0064	Mossman River	Mossman Gorge Road, Daintree National Park	-16.4715	145.3317		✓					
Mossman	109-0074	Mossman River	Finlayvale Road, Mossman Gorge	-16.4575	145.3581		✓				✓	
Mossman	109-0083	Mossman River	Cassowary Road, Cassowary Creek	-16.4657	145.3521						✓	

Basin	Site code	Waterway	Location	Latitude	Longitude	2018	2019	2020	2021	2022	2023	2024
Mossman	109-9998	Mowbray River	Mowbray River Road, Mowbray	-16.5633	145.4644				✓			
Mossman	109-9999	Cane drain	McCracken Road, Bonnie Doon	-16.4654	145.4019				✓			
Mulgrave	111-0009	Wright Creek	Page Road, Wrights Creek	-17.0177	145.7636	✓	✓					
Mulgrave	111-0025	Little Mulgrave River	Little Mulgrave Road, Little Mulgrave	-17.1288	145.7035	✓	✓				✓	
Mulgrave	111-0053	Mulgrave River	Water Treatment Plant, Gordonvale	-17.0913	145.7985	✓	✓					
Mulgrave	111-0073	Gray Creek	Mount Peter Road, Mount Peter	-17.0615	145.7407		✓					
Mulgrave	111-0077	Falls Creek	East Trinity Cocoa, East Trinity	-16.9826	145.8208	✓						
Mulgrave	111-0086	Mulgrave River	Goldsborough Valley Road, Goldsborough	-17.2012	145.7422	✓	✓					
Mulgrave	111-0117	Campbell Creek	Dalton Road, Aloomba	-17.1117	145.8635	✓						
Mulgrave	111-0137	Little Mulgrave River	Nielsen Road, Little Mulgrave	-17.1222	145.6975	✓	✓				✓	
Mulgrave	111-0146	Fishery Creek	Bruce Highway, Fishery Creek	-17.1844	145.8870	✓	✓				✓	
Mulgrave	111-0150	Tributary of Mulgrave River	Goldsborough Valley Road, Goldsborough	-17.2056	145.7465	✓	✓				✓	
Mulgrave	111-0153	Middle Creek	Nebbia Access, Green Hill	-17.0201	145.8207	✓	✓					
Mulgrave	111-0162	McDonnell Creek	McDonnell Creek State School, Fishery Falls	-17.1975	145.8960	✓	✓					
Mulgrave	111-0181	Tributary of Behana Creek	Behana Gorge Road, Aloomba	-17.1322	145.8218	✓	✓				✓	
Mulgrave	111-0201	Mulgrave River	Peets Bridge, Downing Road, Goldborough	-17.1411	145.7600	✓	✓					
Mulgrave	111-0229	Hobson Creek	Bruce Highway, Aloomba	-17.1476	145.8523	✓					✓	
Mulgrave	111-0230	Mulgrave River	Mulgrave River Forestry Road, Wooroonooran NP	-17.2954	145.8003	✓						
Mulgrave	111-0390	East Mulgrave River	Goldfield Track causeway, Wooroonooran NP	-17.2999	145.8029	✓						
Mulgrave	111-0437	Tributary of Behana Creek	Off Behana Gorge Road, Aloomba	-17.1447	145.8155	✓	✓				✓	
Mulgrave	111-0585	Wright Creek	Bruce Highway, Wrights Creek	-17.0400	145.7635	✓					✓	
Mulgrave	111-0677	Behana Creek	Moller Road, Aloomba	-17.1257	145.8382	✓					✓	
Mulgrave	111-1013	Stony Creek	Petersen Road, Wrights Creek	-17.0320	145.7510						✓	
Mulgrave	111-1077	Tree Creek	A Road, Gadgarra National Park, Gadgarra	-17.2791	145.6842	✓						
Mulgrave	111-2519	Middle Creek	Brown Road, Green Hill	-17.0335	145.8271				✓			
Mulgrave	111-9966	Fig Tree Creek	Bruce Highway, Deeral	-17.2057	145.9051				✓			

Basin	Site code	Waterway	Location	Latitude	Longitude	2018	2019	2020	2021	2022	2023	2024
Mulgrave	111-9967	Rocky Creek	Richardson Road, Green Hill	-17.0748	145.8375				✓			
Mulgrave	111-9968	Pilba Creek	Brays Road, Little Mulgrave	-17.1147	145.7036				✓			
Mulgrave	111-9969	Oleary Creek	Dexter Road, Gordonvale	-17.0735	145.7842				✓			
Mulgrave	111-9973	Camp Creek	Cowton Road, Aloomba	-17.1389	145.8468				✓			
Mulgrave	111-9977	Blackfellows Creek	Resolution Drive, Bentley Park	-17.0137	145.7318				✓			
Mulgrave	111-9979	Rusty Creek	Bruce Highway, Fishery Falls	-17.1645	145.8768				✓			
Mulgrave	111-9980	Kristy Creek	Whereat Road, Bentley Park	-17.0188	145.7124				✓			
Mulgrave	111-9983	Gordon Creek	Mulgrave Road, Woree	-16.9533	145.7467				✓			
Mulgrave	111-9984	Mulgrave River	Downstream of Figtree Creek, Deeral	-17.2053	145.9239				✓			
Mulgrave	111-9986	Hills Creek	Hamilton Road, Glen Boughton	-16.9428	145.8219				✓			
Mulgrave	111-9997	Unnamed creek (South)	Ella Bay Road, Ella Bay National Park, Wanjuru	-17.4774	146.0729	✓						
Mulgrave	111-9998	Unnamed creek (North)	Ella Bay Road, Ella Bay National Park, Wanjuru	-17.4746	146.0693	✓						
Mulgrave	111-9999	Tree Creek	Sewell Road, Lake Eacham	-17.2882	145.6631	✓						
Murray	114-0001	Stony Creek	Esplanade Road, Cardwell	-18.2935	146.0379		✓				✓	
Murray	114-0003	Cane drain	Blackman Road, Warrami	-18.0586	145.8093		✓		✓		✓	
Murray	114-0005	Scrubby Creek	Cardwell Spa Pool, Cardwell State Forest, Cardwell	-18.2635	145.9695		✓				✓	
Murray	114-0006	Tributary of Kennedy Creek	Kirrama Range Road, Girramay National Park, Lumholtz	-18.1960	145.8693		✓				✓	
Murray	114-0007	Tributary of Woodfield Creek	Off Murray Falls Road, Girramay National Park	-18.1192	145.7923		✓				✓	
Murray	114-0011	Cane drain	Off Blackman Road, Warrami	-18.0208	145.7901		✓				✓	
Murray	114-0014	Dallachy Creek	Nash Road, Bilyana	-18.1577	145.9578		✓					
Murray	114-0016	Cane drain	Leichardt Road, Munro Plains	-18.0097	145.8522		✓				✓	
Murray	114-0018	Tributary of Meunga Creek	Sullivan Road, Carruchan	-18.2494	145.9131						✓	
Murray	114-0023	Murray River	Ronlund Road, Murray Upper	-18.1177	145.8057						✓	
Murray	114-0031	Murray River	Yabullum Nature Refuge, Murray Upper	-18.0658	145.8490		✓				✓	
Murray	114-0046	Murray River	Middle Murray Road, Murray Upper	-18.1078	145.8036		✓				✓	
Murray	114-0079	Murray River	Dore Road, Murray Upper	-18.0624	145.8489		✓				✓	

Basin	Site code	Waterway	Location	Latitude	Longitude	2018	2019	2020	2021	2022	2023	2024
Murray	114-0081	Meunga Creek	Cardwell Intake Road, Ellerbeck	-18.2354	145.9823		✓					
Murray	114-9977	Unnamed Creek	Henry Road, Euramo	-18.0075	145.8943				✓			
Murray	114-9978	Meunga Creek	Ellerbeck Road, Carruchan	-18.2334	145.9397				✓			
Murray	114-9979	Clarkson Creek	Bruce Highway, Damper Creek	-18.3567	146.0669				✓			
Murray	114-9980	Whitfield Creek	Off Kennedy Creek Road, Cardwell State Forest	-18.2076	145.9417				✓			
Murray	114-9981	Camp Creek	Ellerbeck Road, Ellerbeck	-18.2463	145.9602				✓			
Murray	114-9982	Scrubby Creek	Bruce Highway, Damper Creek	-18.4448	146.1406				✓			
Murray	114-9991	Unnamed Creek	Blackman Road, Warrami	-18.0529	145.7893				✓			
Murray	114-9992	Corduroy Creek	Bilyana Road, Murray River Upper	-18.0888	145.8640				✓			
Murray	114-9997	Woodfield Creek	North Murray Road, Murray Upper	-18.1111	145.7982				✓			
Murray	114-9998	Tributary of Kennedy Creek	Kirrama Range Road, Girramay National Park, Lumholtz	-18.1955	145.8697		✓					
Russell	111-0045	Cane drain	Triple H Farm, Buttigieg Road, East Russell	-17.3368	145.9724	✓	✓				✓	
Russell	111-0050	Harvey Creek	Bruce Highway, Bellenden Ker	-17.2599	145.9218	✓	✓				✓	
Russell	111-0058	Allison Creek	Joyce Road, Woopen Creek	-17.4589	145.8571		✓					
Russell	111-0061	Pugh Creek	Upham Road, Mirriwinni	-17.3983	145.8955	✓	✓				✓	
Russell	111-0066	Pugh Creek	Bruce Highway, Mirriwinni	-17.4088	145.9110	✓	✓				✓	
Russell	111-0074	Babinda Creek	Stager Road, Babinda	-17.3477	145.8747		✓					
Russell	111-0074	Babinda Creek	The Boulders, Babinda	-17.3477	145.8747	✓					✓	
Russell	111-0106	Menzies Creek	Menzies Road, Bartle Frere	-17.4536	145.8799	✓	✓					
Russell	111-0109	Tributary of Babinda Creek	The Boulders Road, Babinda	-17.3470	145.9065	✓	✓				✓	
Russell	111-0122	Woopen Creek	Woopen Creek Bananas, Woopen Creek Road	-17.4819	145.8620	✓	✓				✓	
Russell	111-0125	Cane drain	Ti Tree Road, Mirriwinni	-17.3866	145.9242	✓	✓				✓	
Russell	111-0173	Russell River	Alice River junction, Mirriwinni	-17.3925	145.9655	✓	✓					
Russell	111-0221	Russell River	Cristiano Access, East Russell	-17.3503	145.9626	✓	✓					
Russell	111-0362	Russell River	Joyce Road, Bartle Frere	-17.4517	145.8659	✓	✓					
Russell	111-0365	Babinda Creek	Off Stager Road, Mirriwinni	-17.3565	145.8981	✓					✓	

Basin	Site code	Waterway	Location	Latitude	Longitude	2018	2019	2020	2021	2022	2023	2024
Russell	111-0618	Chooky Chooky Creek	Woopen Creek Road, Woopen Creek	-17.4699	145.8782	✓	✓				✓	
Russell	111-0733	Russell River	Kruckow Road, Babinda	-17.3260	145.9538	✓						
Russell	111-2238	Tributary of Russell River	Welsh Road, Bellenden Ker	-17.2785	145.9348				✓			
Russell	111-2820	Cane drain	Clyde Road, Babinda	-17.3327	145.9426				✓			
Russell	111-9964	Tributary of Russell River	Kruckow Access, East Russell	-17.3123	145.9621				✓			
Russell	111-9965	Tributary of OMalleys Creek	Dinner Creek Road, Garradunga	-17.4472	145.9973				✓			
Russell	111-9970	Tributary of Middle Creek	Dinner Creek Road, Eubenangee	-17.4062	145.9975				✓			
Russell	111-9971	Dinner Creek	Dinner Creek Road, Eubenangee	-17.4173	146.0006				✓			
Russell	111-9972	Meringulah Creek	Kruckow Access, East Russell	-17.2956	145.9642				✓			
Russell	111-9974	Cod Fish Creek	Bruce Highway, Bellenden Ker	-17.2996	145.9279				✓			
Russell	111-9975	Tributary of Babinda	Bruce Highway, Babinda	-17.3357	145.9283				✓			
Russell	111-9981	Tributary of Josephine Creek	Rogers Road, Bartle Frere	-17.4284	145.8902				✓			
Russell	111-9985	Tributary of Babinda Creek	Howard Kennedy Drive, Babinda	-17.3482	145.9253				✓			
Russell	111-9987	Frenchman Creek	Bruce Highway, Babinda	-17.3094	145.9261				✓			
Russell	111-9988	Cane drain	Bucklands Road, Mirriwinni	-17.4065	145.9248				✓			
Russell	111-9989	Coninaughtons Creek	Connaughton Road, Bartle Frere	-17.4241	145.8922				✓			
Russell	111-9990	Niringa Creek	Musumeci Road, Mirriwinni	-17.3854	145.9141				✓			
Tully	113-0002	Cane drain	Sandy Creek Road, Jarra Creek	-17.9716	145.9015		✓					
Tully	113-0006	Davidson Creek	Off North Davidson Road, Munro Plains	-17.9600	145.7993		✓				✓	
Tully	113-0010	Tributary of Davidson Creek	Ranch Road, Munro Plains	-17.9904	145.7152						✓	
Tully	113-0012	Marquette Creek	Tea Plantation Road, Jarra Creek	-17.8933	145.8532		✓				✓	
Tully	113-0016	Banyan Creek	Skardon Road, Merryburn	-17.9070	145.9668		✓					
Tully	113-0022	Cane drain	Adams Road, Munro Plains	-17.9730	145.8085		✓		✓		✓	
Tully	113-0023	Tributary of Python Creek	Tully Gorge Road, Cardstone	-17.7670	145.5887		✓				✓	
Tully	113-0025	Hull River	Collins Road, Lower Tully	-17.9779	146.0017		✓					
Tully	113-0026	Tributary of Davidson Creek	Ranch Road, Munro Plains	-17.9689	145.7222		✓				✓	

Basin	Site code	Waterway	Location	Latitude	Longitude	2018	2019	2020	2021	2022	2023	2024
Tully	113-0041	Banyan Creek	Dean Road, Tully	-17.9481	145.9315		✓					
Tully	113-0062	Tributary of Tully River	Tully Gorge Road, Cardstone	-17.7992	145.6855		✓				✓	
Tully	113-0079	Stony Creek	North Davidson Road, Cardstone	-17.8671	145.7236						✓	
Tully	113-0240	Bulgun Creek	Bulgun Road, Bulgun	-17.8871	145.9315						✓	
Tully	113-0274	Banyan Creek	Cavs Marine and Outdoor, Tully	-17.9274	145.9374						✓	
Tully	113-0580	Wongaling Creek	El Arish Mission Beach Road, Mission Beach	-17.8713	146.0946		✓					
Tully	113-6131	Tributary of Wongaling Creek	Boyett Road, Mission Beach	-17.8602	146.0946				✓			
Tully	113-9983	Cane drain	North Davidson Road, Munro Plains	-17.9454	145.7874				✓			
Tully	113-9984	Unnamed Creek	Tully Gorge Road, Jarra Creek	-17.9397	145.8912				✓			
Tully	113-9985	Silky Oak Creek	Silky Oak Creek Road, Silky Oak	-17.9677	145.9439				✓			
Tully	113-9986	Carmoo Creek	Tully Mission Beach Road, Mount Mackay	-17.9264	146.0182				✓			
Tully	113-9987	Barbed Wire Creek	North Davidson Road, Kooroomool	-17.8860	145.7426				✓			
Tully	113-9988	Stony Creek	Tully Mission Beach Road, Djiru National Park,	-17.9197	146.0686				✓			
Tully	113-9990	Meerang Creek	Old Tully Road, Feluga	-17.8797	145.9565				✓			
Tully	113-9991	Moongera Creek	Djarawong East Road, Djarawong	-17.8702	145.9796				✓			
Tully	113-9992	Bronzewing Creek	Murray Street, Tully	-17.9262	145.9287				✓			
Tully	113-9993	Tributary of Bronzewing Ck	Murray Street, Tully	-17.9239	145.9294				✓			
Tully	113-9994	Boundary Creek	Davidson Road, Munro Plains	-17.9883	145.8551				✓			
Tully	113-9995	Tully River	Upstream of Talisman Creek, Lower Tully	-18.0098	146.0187				✓			
Tully	113-9996	Tully River	Upstream of rail bridge, Euramo	-17.9884	145.8989				✓			
Tully	113-9997	Tully River	Downstream of Santolin Road, Rockingham	-18.0044	145.9850				✓			
Tully	113-9998	Tully River	Upstream of Banyan Creek, Euramo	-17.9964	145.9208				✓			

* indicates site surveys that were used for developing the modelled maximum species richness baseline but were not included in the calculations of the basin scores due to uncertainty of model. Note that all four of these sites were during 2020 in the Upper Herbert. ~ Additional sites surveyed using boat electrofishing for the 2022-23 reporting period located on the lower Herbert River. [C] indicates sites located in the coastal zone of the Herbert Basin, the remaining sites in the Herbert catchment are classified as upper Herbert Basin sites.

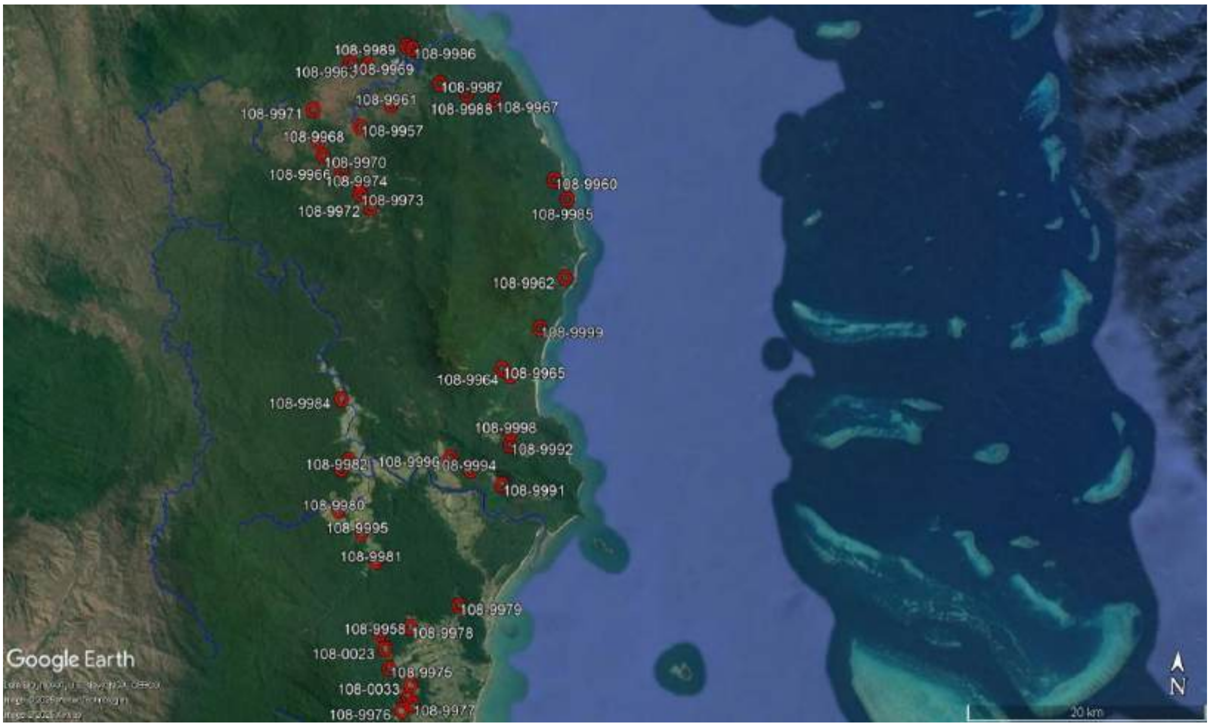
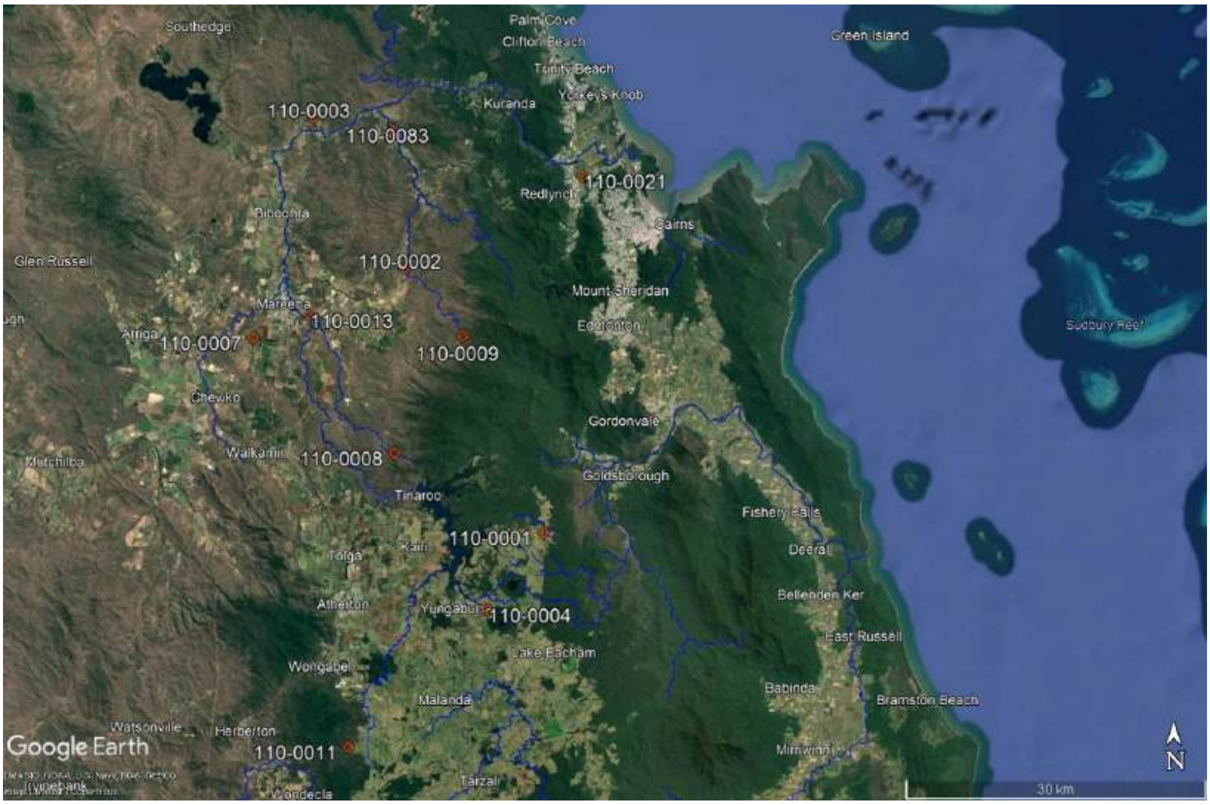


Figure 42 Daintree Basin fish assessment sites surveyed for the 2023-24 reporting period.

Figure 43 Mossman Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and the 2023-24 reporting period (bottom).



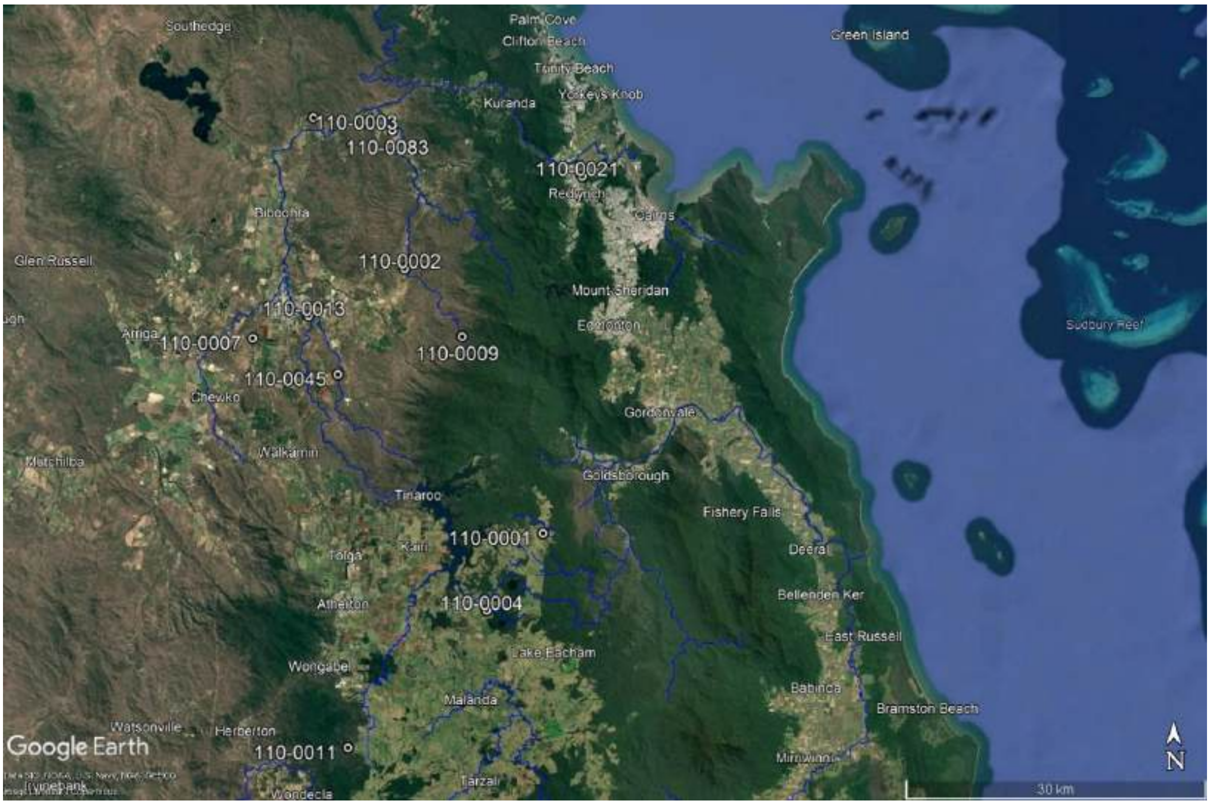


Figure 44 Barron Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and the 2023-24 reporting period (bottom).

Figure 45 Mulgrave Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and the 2023-24 reporting period (bottom).

Figure 46 Russell Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and the 2023-24 reporting period (bottom).

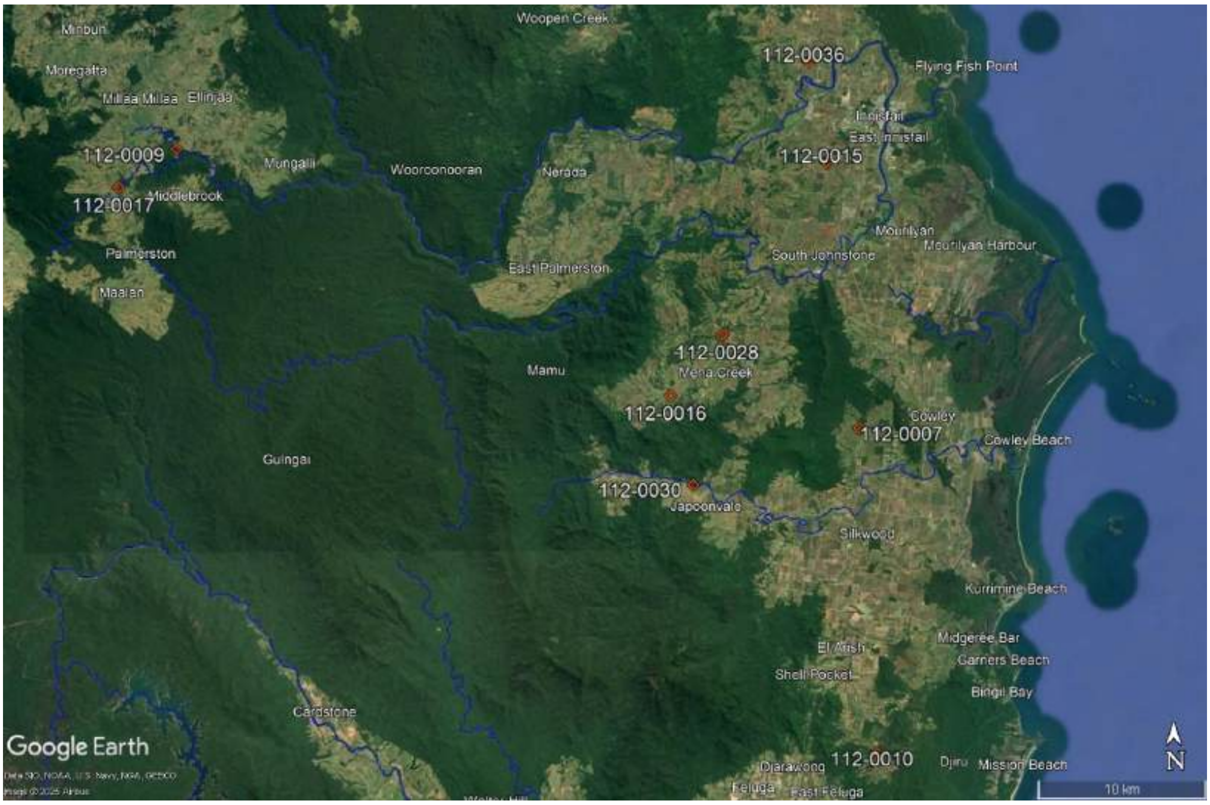
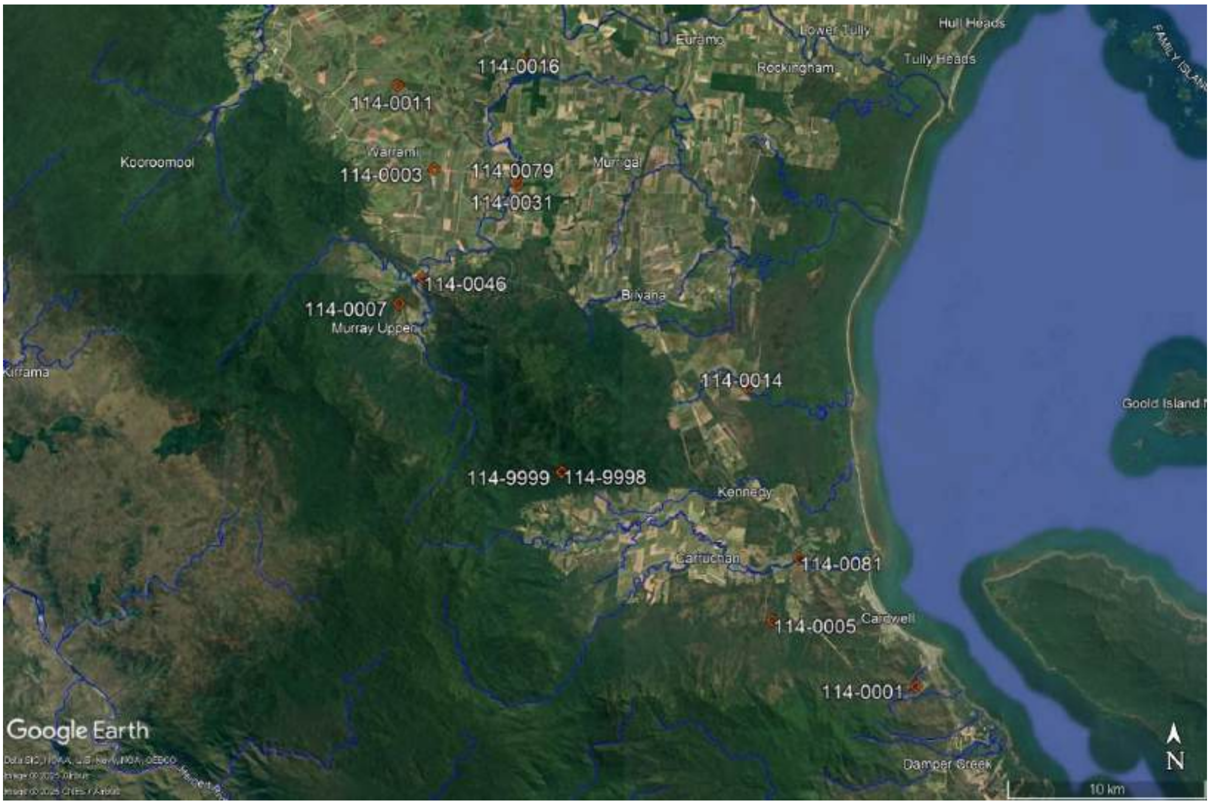


Figure 47 Johnstone Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and the 2023-24 reporting period (bottom).

Figure 48 Tully Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and the 2023-24 reporting period (bottom).



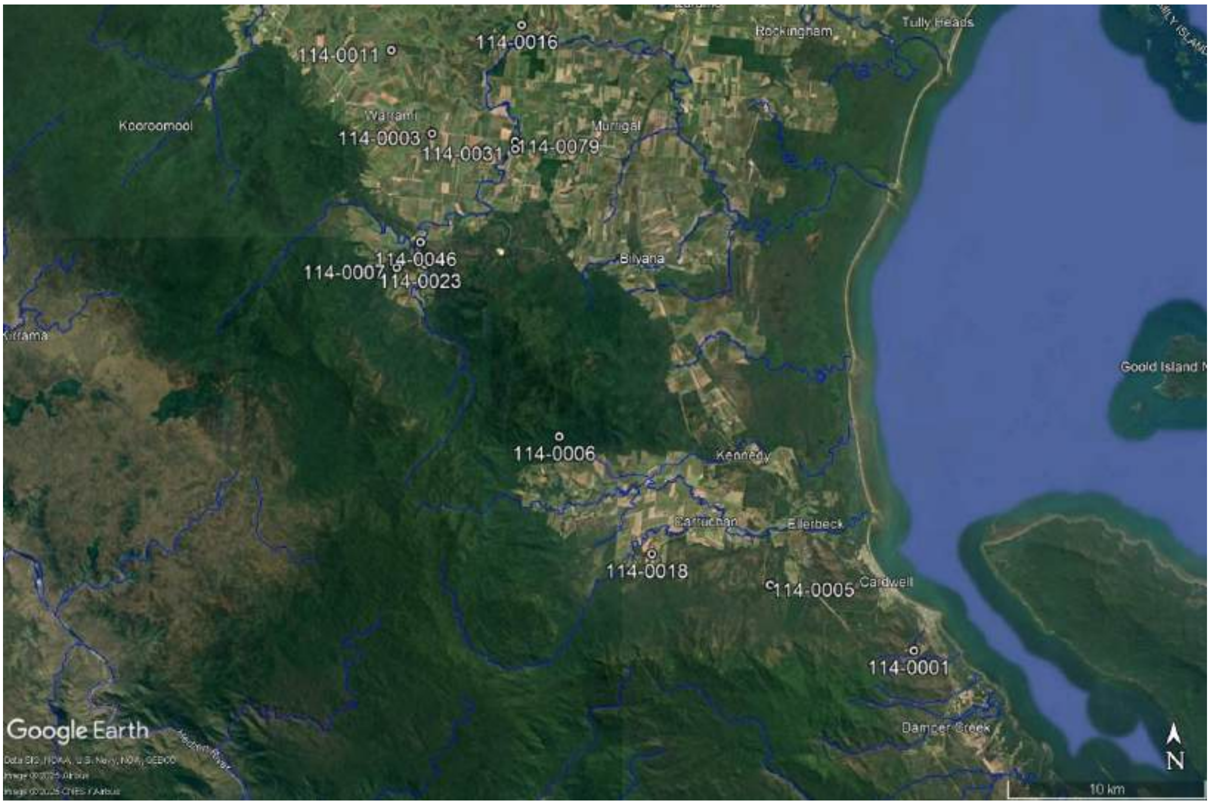


Figure 49 Murray Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and the 2023-24 reporting period (bottom).

Figure 50 Herbert Basin fish assessment sites surveyed for the 2019-20 reporting period (top) and sites survey for the 2022-23 reporting period (bottom).

APPENDIX G Log of updates for 2024-25.

The table below lists section number, page and caption number, and summary of updates for the 2024-25 methods technical report to assist reviewers.

Section number and title	Page/caption number	Details
Title pages	p. i - ii	Dates
Executive Summary	p. iii - iv	Report card dates.
1. INTRODUCTION		
1.1 General	p. 1	Dates updated.
2. METHODS FOR DATA COLLECTION		
2.2. Freshwater Basins Data Collection		
2.2.2.2 Flow	p.9, Table 4	As from 2024-25 the flow assessment site 'South Johnstone River at Upstream Central Mill, GS no. 112101B' for the Johnstone Basin was decommissioned and is no longer available for use in the flow indicator.
2.2.2.4 Wetland Extent	p. 11	Updated with most recent Qld Wetland Mapping version.
2.3. Estuaries Data Collection		
2.3.1. Water quality Estuary monitoring programs	Table 7, p. 17; Table 8, p. 18	Updates for estuary monitoring programs: Indicators and n/year estuaries, monitoring months.
2.3.2.1 Estuary riparian extent	p. 19	Updated data selection procedures (coded by Adam Shand, Dry Tropics report card). Updated with most recent Qld Regional Ecosystem Mapping version.
	Appendix B p. 82-85	Updated riparian assessment area maps.
2.3.2.2 Mangrove and saltmarsh extent	p. 20	Updated data selection procedures (coded by Adam Shand, Dry Tropics report card). Updated with most recent Qld Regional Ecosystem Mapping version.
	Appendix C p. 86-93	Updated mangrove and saltmarsh assessment area (remnant and non-remnant vegetation extent) maps.
2.3.2.3 Shoreline mangrove habitat condition	p. 21	Updated survey dates and details
2.3.2.4 Flow	p. 24, Table 11	As from 2024-25 the flow assessment site 'South Johnstone River at Upstream Central Mill, GS no. 112101B' for the Johnstone Basin was decommissioned and is no longer available for use in the flow indicator.

2.4. Inshore and Offshore Data Collection		
2.4.1 Inshore Water Quality	p. 33, Table 15	Pesticide passive sample deployment details.
2.4.3. Inshore and Offshore Coral Data Collection	p. 35, Table 17	Coral survey dates.
3. CONDITION AND STATE ASSESSMENT SCORING METHODS		
3.3 Inshore and Offshore Condition Assessment		
3.3.3 Coral	p 63	Updated method for scoring Coral Composition indicator.
4 CONFIDENCE, LIMITATIONS AND RECOMMENDATIONS		
5. References	p. 73	Reference list updated.