EASTERN CAPE YORK

# WATER QUALITY IMPROVEMENT PLAN

Cape York Natural Resource Management

Cape York Natural Resource Management | 2016

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Eastern Cape York **Water Quality Improvement Plan**

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### Note to the reader

The Eastern Cape York Water Quality Improvement Plan has been structured to enable you to easily access the key findings in the first two chapters. Chapter 1 presents a summary of information that was used to develop the implementation plan and Chapter 2 presents the implementation plan. The subsequent chapters and appendices present more detailed information on the Water Quality Improvement Planning process that was used to develop the first two chapters.

For more information (i.e. higher resolution maps) please email admin@capeyorknrm.com.au

### Referencing this document

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### General disclaimer



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# EXECUTIVE SUMMARY

## Eastern Cape York and the Water Quality Improvement Plan

The Eastern Cape York Water Quality Improvement Plan (WQIP) was developed in consultation with scientists, Traditional Owners and the wider community to identify water quality issues and actions to maintain and improve the rivers, wetlands and reefs of eastern Cape York. The Plan has been designed to support the Reef 2050 Long-Term Sustainability Plan (Commonwealth of Australia, 2015), which sets targets to reduce sediment and nutrient pollution to the Great Barrier Reef (GBR). The planning region for the WQIP includes all the catchments that drain to the northern Great Barrier Reef, from Jacky Jacky Creek in the north to the Annan River in the south (Figure 1).

Eastern Cape York Peninsula and the far north region of the Great Barrier Reef are globally significant ecosystems. Native vegetation dominates the landscape and freshwater wetlands and floodplains are still hydrologically and ecologically connected to estuarine and marine ecosystems. The northern GBR marine environment is in much better condition than the rest of the GBR, and needs to be protected as a future refugium. While most eastern Cape York rivers are not pristine, many are in good to excellent condition. In the more developed catchments, current and historic land use—including grazing, agriculture, mining, roads, urban development, changing fire patterns and the introduction of weeds and feral animals—have caused some degree of degradation. Most catchments are experiencing increasing development pressure that could further degrade river water quality and impact the health of the reefs.

To improve existing river water quality in the more degraded areas of Cape York Peninsula, the current land use impacts on water quality will need to be addressed through improved management practices, active land, river and wetland restoration, planning and regulation, and innovative thinking. However, preventing further disturbance of catchments from new developments is also critical if we wish to maintain the relatively good river water quality and ensure that the northern GBR does not become degraded like the central and southern GBR.

## Environmental Values and Aquatic Ecosystem Condition

Environmental Values (EVs) define the uses of water by humans or aquatic ecosystems and help to prioritise management goals for specific rivers and uses. The human-use EVs for eastern Cape York include drinking water (low to medium use), stock water (low to medium use in the north and medium to high in the central and southern regions), irrigation (Laura, Endeavour, McIvor catchments), cultural and spiritual connections to water (high use across all regions), aquaculture (low use), recreation and fishing (medium to high use across all regions), and visual appreciation (medium to high use across all regions).

Many river catchments and most marine waters in eastern Cape York were identified as being of high ecological value (HEV). The management goal for HEV aquatic ecosystems is to ensure that there is no detectable decline in condition. However, rivers such as the upper Normanby and Laura Rivers, Endeavour River and Oakey Creek (Annan River) have been identified as slightly/moderately disturbed. The marine receiving waters in Princess Charlotte Bay (Normanby and Stewart Basins) and southeastern Cape York (Endeavour Basin) are also identified as slightly disturbed.

## Land Use, Disturbances and Pollutant Sources

Nature and cultural conservation, including National Park and Traditional Owner land, is the dominant land use in eastern Cape York (60%). Cattle grazing covers 34% of the region and is an important part of its history, lifestyle and economy. Grazing has also been identified as a trigger for accelerated soil and gully erosion in Cape York. Gully erosion is a major source of sediment pollution in the Normanby Basin and other catchments. Agriculture occurs over a small (<1%) but expanding area in the Normanby, Jeannie (McIvor) and Endeavour Basins. Fertiliser and soil run-off is currently a source of sediment and nutrient pollution in the Laura River (Normanby Basin) and is likely to occur in other basins, to a lesser extent. Recent and proposed land clearing, increased dam building and water extraction, and additional fertiliser and pesticide use associated with agricultural developments, will place new pressures on the Laura, Normanby and McIvor Rivers. Innovative management will be required to address these challenges to maintain or improve water quality.

Urban and rural residential land use represents less than 1% of the total planning area, but has important water quality implications in these regions due to the intensity of land use. The Lockhart township in the Claudie River catchment (Lockhart Basin), the Laura and Lakeland townships within the Laura River catchment (Normanby Basin), and Cooktown, Hope Vale and several peri-urban precincts within the Annan and Endeavour River catchments (Endeavour Basin) are concentrated sources of urban water quality pollution (sediment, nutrients, petroleum, metals and gross pollutants).

Forestry, mining and other land uses also account for a small percentage of the total area (<1%) in the Central and Southern sections of Cape York; but can be significant sediment sources when they occur within or near river and creek corridors.

Wetlands cover at least 2% of eastern Cape York. The important role wetlands play in maintaining natural hydrological processes, trapping sediment and processing nutrients has been reduced by late season wildfire, weed infestation and feral animal activity.

Roads, fence lines, fire, gully erosion, feral animals and weeds are human disturbances that occur across all land uses (including conservation). Roads, tracks and fence lines have been identified as the largest direct human land use disturbance across Cape York. It is estimated that there are around 20,000 km of these 'linear disturbances', and all of these disturbances deliver excess sediment and nutrients to the stream network. Inappropriate fire regimes, which burn large areas of Cape York, reduce vegetation ground cover and can also significantly increase sediment and nutrient pollution in rivers. Feral animals (cattle, horses and pigs) directly disturb soil and wetlands, while weeds replace or destroy riparian and aquatic vegetation, all of which contribute to sediment pollution and loss of aquatic habitat.

The available Disturbance Index data (Appendix 1) suggests that the management of accelerated gully erosion is one of the highest priorities for maintaining and improving water quality in the northern GBR; however, linear disturbances (roads, tracks and fences), agricultural development, and urban/peri-urban expansion represent the main potential sources of future declines in water quality.

Commercial shipping is another source of sediment pollution delivered directly to reefs across all the eastern Cape York GBR region. Large ships stir up sediments over large areas, impacting adjacent reefs.

## Marine Risk Assessment

The relative risk of degraded water quality among the basins in the Cape York region was determined by combining information on the estimated (modelled) loads of sediment and nutrients from human land use discharged to the marine environment from each river basin, and the area of coral reefs and seagrass meadows that may be exposed to these pollutants. The Normanby Basin had much more supporting data than the other basins, and this limited the capacity to produce a consistent assessment of risk across all basins.

With these limitations, the assessment concluded that the greatest risk posed to coral reefs and seagrass from degraded water quality in the Cape York region is from the Normanby, Hann and Stewart Rivers, due to the relatively high level of disturbance and area of impact, making them a priority for improved management. However, land disturbances, pollutant loads, and flood plume behavior from other catchments remain poorly quantified to properly assess their risks of impacting adjacent reefs.

Catchments in the Southern section, such as the Endeavor, Annan, McIvor and Starke, have intensive land uses (urban, rural residential, mining, grazing, agriculture, forestry and roads) that have a cumulative impact on fresh water and marine water quality. Intensification of land use in the Southern section is increasing and the resulting water quality impacts are not well documented. New agricultural and urban developments may impact previously less disturbed rivers. Southern Cape York rivers, such as the McIvor, Endeavour and Annan, are directly connected to fringing, inshore, and mid-shelf reefs, as well as extensive coastal seagrass meadows. River floodwater plumes regularly reach these local reefs, which are of high cultural, recreational and commercial value to local communities and Traditional Owners. These reefs are vulnerable to increased levels of sediment and nutrient pollution. Rivers in the Endeavour and Jeannie Basins also discharge directly into the known crown-of-thorns starfish initiation area for the whole GBR.

## Water Quality Guidelines and Targets

Water Quality Guidelines have been established for eastern Cape York rivers and estuaries based on an assessment of existing water quality data. The derivation of guidelines based on local data represents an improved level of detail to the standard Australian (ANZECC) and Queensland water quality guidelines. Short-term Targets (2022) and Long-term Objectives (2050) for reductions in pollutant loads have also been established.

For the Northern section (Jacky Jacky, Olive, Pascoe and Lockhart Basins) the target is to maintain current water quality so that there are no increases in sediment or nutrient loads.

For the Central and Southern sections, the targets to improve water quality have been set to reduce total suspended sediment loads by 25% in the most disturbed sub-catchments (the upper Normanby, Laura, Annan and Endeavor Rivers), to achieve a 10% reduction in sediment loads discharged to the GBR. A reduction target of 25% of total nutrient loads has also been set for the Laura River (Normanby Basin).

Long term water quality objectives aim for a 30% reduction in total sediment loads discharged to the GBR from the most disturbed catchments. For many rivers, particularly in the Northern section, limited data was available and additional sampling is recommended to improve guideline certainty in these areas.

## Implementation

This Water Quality Improvement Plan (WQIP) will require widespread community acceptance and involvement in its implementation if it is to be effective in maintaining and improving water quality. Implementation of the WQIP involves a range of management interventions for each section of eastern Cape York. A staged approach is recommended, with an initial focus on the Normanby Basin sediment reduction targets (gully rehabilitation, improved grazing and agricultural land management), plus actions to manage road erosion, fire, pests and wetland health in all disturbed catchments. In the Southern section, there will be a strong focus on improved management of urban and rural residential land development, as well as intensive agricultural land use.

An Integrated Monitoring Strategy has been developed that will build on and improve existing Cape York monitoring efforts and partnerships. The monitoring strategy combines nested paddock, property, sub-catchment, and catchment scale monitoring with marine monitoring activities to provide information on the effect of land use and improved land management on water quality and ecosystem health. The integrated monitoring program will provide more accurate measurements of land use disturbances and pollutant loads delivered to the GBR over the long-term by using new technology and established Super Gauge techniques. The lessons learned from monitoring will be continuously incorporated into on-ground management activities to ensure that WQIP implementation is effective in delivering water quality and ecosystem health targets.

The establishment of a Cape York Catchments to Coral Partnership is recommended to provide strategic direction and coordination of implementation and monitoring activities. The Catchments to Coral Partnership will also inform the Queensland and Australian Governments of issues that are relevant to the whole of the GBR and/or the protection of the northern Great Barrier Reef.

## Cost Assessment

Costings have been presented for the additional resources that are required to implement management actions to protect and maintain water quality and ecosystem health in major land uses and disturbances across the region and to reduce suspended sediment and nutrients to meet the Reef 2050 Plan water quality targets. The total cost of the additional resources, including in kind support and monitoring, to implement the first stage from 2016-2022 and achieve the short-term targets is estimated at $171 million.

A more detailed cost-effectiveness analysis for achieving long-term sediment reduction targets through passive and active gully remediation in priority sub-catchments within the Normanby Basin is presented. This is an example of the detailed cost effectiveness analysis that will need to be undertaken for roads, wetlands, agriculture, fire and urban management, using the results of the integrated monitoring program across all basins. Continuous improvement of prioritisation is recommended through an annual synthesis of the spatial pattern of disturbance, water quality and ecological datasets and on-ground implementation costs.

The land managers of eastern Cape York are resilient and if provided with additional resources, they are willing to adopt a range of improved management practices that will maintain and improve the water quality and ecosystem health of eastern Cape York for future generations.



# CHAPTER 1: SUMMARY

## Introduction

Cape York Peninsula is a diverse and iconic tropical landscape. Its eastern Great Barrier Reef catchments are a mosaic of contrasting ecosystems supporting exceptional biodiversity: savanna, tropical rainforests, dune fields, sandstone escarpments, wetlands and heathlands. Compared to southern Great Barrier Reef regions, eastern Cape York remains relatively undisturbed by modern industrialisation and development, and the good condition of the northern Great Barrier Reef reflects this.

The rivers and wetlands of eastern Cape York are also in good condition compared to many other Australian and international systems. There are almost no man-made barriers to fish movement, low levels of most pollutants, largely intact native vegetation and a high level of interconnectedness between freshwater and marine ecosystems. These characteristics ensure that the water quality of Eastern Cape York's aquatic ecosystems remains good.

Water Quality Improvement Plans aim to improve or maintain the water quality of waterways through whole catchments to the ocean. This is achieved by developing land management strategies that reduce inputs of sediment, nutrient and other pollutants to rivers and wetlands, and encourage ecosystem repair and health. While the waterways of eastern Cape York are currently relatively healthy, there are some areas where water quality has been impacted by human land use, introduced plants and animals and fire. The Eastern Cape York Water Quality Improvement Plan has been developed to highlight what actions our community can take to protect the region's rivers, wetlands and reefs for future generations.

High Ecological Value waters at Ussher Point (Photo: Kerry Trapnell)

## Purpose of the Eastern Cape York Water Quality Improvement Plan

The Eastern Cape York Water Quality Improvement Plan has been funded by the Australian Government to inform implementation and investment priorities to achieve the overarching vision, water quality outcomes and water quality targets of the Reef 2050 Long-Term Sustainability Plan (Commonwealth of Australia, 2015). The Reef 2050 Long-Term Sustainability Plan is referred to as the Reef 2050 Plan throughout this document. The Reef 2050 Plan is the overarching framework for protecting and managing the Great Barrier Reef from 2015 to 2050. The Reef 2050 Plan is a key component of the Queensland and Australian Government's response to the recommendations of the UNESCO World Heritage Committee.

At the core of the Reef 2050 Plan is an outcomes and targets framework that will drive progress towards an overarching vision:

> *"To ensure the Great Barrier Reef continues to improve on its Outstanding Universal Value every decade between now and 2050 to be a natural wonder for each successive generation to come."*

The Reef 2050 Plan Outcomes Framework has seven overarching themes—ecosystem health, biodiversity, heritage, water quality, community benefits, economic benefits and governance. These themes reflect the priority areas for action identified by governments and partners. Together they will address the key risks to the Reef and will ensure ecologically sustainable use can continue.

Under each theme, there are the following components:

- **Actions** - identified components of work to be undertaken to meet the targets
- **Targets** - the results being aimed for by **2020**, a five-year time horizon; to facilitate delivery they are Specific, Measurable, Achievable, Realistic and Time-bound (SMART)
- **Objectives** - linking targets to outcomes, expected to be achieved by **2035**, the medium term
- **an Outcome** - which must be achieved by **2050** to deliver the vision.

The Eastern Cape York Water Quality Improvement Plan specifically addresses the actions, targets, objectives and outcome of the water quality theme (Table 1). The specific Reef 2050 Plan actions and targets that are addressed are highlighted throughout this document.

The Eastern Cape York Water Quality Improvement Plan has been developed by Cape York Natural Resource Management and South Cape York Catchments through funding provided by the Australian Government to deliver on the following Reef 2050 Plan water quality action:

- **WQA7** - Finalise and implement plans (e.g. Water Quality Improvement Plans and Healthy Waters Management Plans) for Reef catchments and key coastal areas, identifying implementation priorities for protection of the Reef

**Table 1:** Reef 2050 Plan Water Quality Theme Actions, Targets, Objectives and Outcome

| 2015 - 2020 ACTIONS | |
|---|---|
| **Improving broadcare land management** | |
| WQA1 | By 2018, review and update the Reef Water Quality Protection Plan and its targets. |
| WQA2 | Continue improvement in water quality from broadscale land use through implementation of *Reef Water Quality Protection Plan 2013* actions. |
| WQA3 | Pending the outcome of the review of regulation and market-based mechanisms to improve water quality, require farmers to be accredited to best management practice guidelines or to operate under an Environmental Risk Management Plan |
| **Improving water quality from all sectors** | |
| WQA4 | Implement innovative management approaches through the Reef Trust for improving water quality. |
| WQA5 | Increase use of cost-effective measures to improve water quality from broadscale land use, urban, industrial and port activities. |
| WQA6 | Establish an agreed performance-based voluntary reporting framework across agriculture, urban, ports and industry to measure management efforts to achieve best management practices and to inform regional report cards |
| WQA7 | Finalise and implement plans (e.g. Water Quality Improvement Plans and Healthy Water Management Plans) for Reef catchments and key coastal areas, identifying implementation priorities for protection of the Reef. |
| WQA8 | Increase industry participation in regional water quality improvement initiatives and partnerships aimed at managing, monitoring and reporting of water quality. These should build on existing initiatives such as:<br>• Fitzroy Partnership for River Health<br>• Gladstone Healthy Harbour Partnership<br>• Mackay Whitsunday Healthy Rivers to Reef Partnership. |
| WQA9 | Review and update water quality objectives and Great Barrier Reef Marine Park Authority Water Quality Guidelines at Reef-wide and regionally relevant scales based on scientifically verified monitoring and research. |
| **Improving urban and industrial water quality** | |
| WQA10 | Review and set regionally relevant standards for urban and point-source discharges into the World Heritage Area and ensure licenses meet these standards. |
| WQA11 | Increase adoption of leading practice in the management and release of point-source water affecting the Reef. |
| WQA12 | Implement best practice stormwater management (e.g. erosion and sediment control, water sensitive urban design and capture of gross pollutants) for new development in coastal catchments. |
| WQA13 | Build capacity for local government and industry to improve water quality management in urban areas. |
| **Reducing the impact of ports and dredging** | |
| WQA14 | Restrict capital dredging for the development of new or expansion of existing port facilities to within the regulated port limits of Gladstone, Hay Point/Mackay, Abbot Point and Townsville. |
| WQA15 | Develop and implement a dredging management strategy that includes:<br>• an examination, and, where appropriate, a potential pilot program to evaluate different treatment and re-use options for management dredge material<br>• measures to address dredging-related impacts on Reef water quality and ecosystem health<br>• a 'code of practice' for port-related dredging activities. |
| WQA16 | Develop a State-wide coordinated maintenance dredging strategy which:<br>• identifies each port's historical dredging volumes and likely future requirements and limits<br>• identifies appropriate environmental windows to avoid coral spawning, seagrass recruitment, turtle breeding and weather events<br>• examines opportunities for the beneficial reuse of dredge material or on-land disposal from maintenance activities<br>• establishes requirements for risk-based monitoring programs. |
| WQA17 | Understand the port sediment characteristics and risks at the four major ports and how they interact and contribute to broader catchment contributions within the World Heritage Area. |
| WQA18 | In 2015 legislate to ban sea-based disposal of capital dredge material in the Great Barrier Reef Marine Park and in the balance of the Great Barrier Reef World Heritage Area from port-related capital dredging. |
| WQA19 | Mandate the beneficial reuse of port-related capital dredge spoil, such as land reclamation in port development areas, or disposal on land where it is environmentally safe to do so. |
| WQA20 | The Queensland Government will require all proponents of new dredging works to demonstrate their project is commercially viable prior to commencement. |
| WQA21 | The Queensland Government will not support trans-shipping operations that adversely affect the Great Barrier Reef Marine Park. |
| WQA22 | Support on-land disposal or land reclamation for capital dredge material at Abbot Point. |
| **Monitoring and reporting** | |
| WQA23 | Expand 'nested' integrated water quality monitoring and report card programs at major ports and activity centres (e.g. Gladstone), in priority catchments (e.g. Mackay Whitsundays) and Reef-wide, to guide local adaptive management frameworks and actions. |
| WQA24 | Identify and action opportunities for Traditional Owners, industry and community engagement in on-ground water quality improvement and monitoring programs. |

| 2020 TARGETS | 2035 OBJECTIVES | 2050 OUTCOME |
|---|---|---|
| **WQT1**<br>By 2018:<br>• at least a 50 per cent reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas, on the way to achieving up to an 80 per cent reduction in nitrogen by 2025<br>• at least a 20 per cent reduction in anthropogenic end-of-catchment loads of sediment in priority areas, on the way to achieving up to a 50 per cent reduction by 2025<br>• at least a 20 per cent reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas<br>• at least a 60 per cent reduction in end-of-catchment pesticide loads in priority areas.<br>[From *Reef Water Quality Protection Plan 2013* targets, based on a comparison with a 2009 baseline] | **WQO1**<br>Over successive decades the quality of water entering the Reef from broadscale land use has no detrimental impact on the health and resilience of the Great Barrier Reef. | **Reef water quality sustains the Outstanding Universal Value, builds resilience and improves ecosystem health over each successive decade.** |
| **WQT2**<br>By 2018:<br>• 90 per cent of sugarcane, horticulture, cropping and grazing lands are managed using best management practice systems (soil, nutrient and pesticides) in priority areas<br>• Minimum 70 per cent late dry season groundcover on grazing lands<br>• The extent of riparian vegetation is increased<br>• There is no net loss of the extent, and an improvement in the ecological processes and environmental values, of natural wetlands.<br>[From *Reef Water Quality Protection Plan 2013*] | **WQO2**<br>Over successive decades the quality of water in or entering the Reef from all sources including industrial, aquaculture, port (including dredging), urban waste and storm-water sources has no detrimental impact on the health and resilience of the Great Barrier Reef. | |
| **WQT3**<br>By 2020, Reef-wide and locally relevant water quality targets are in place for urban, industrial, aquaculture and port activities and monitoring shows a stable or improving trend. | | |
| **WQT4**<br>Water quality in the Great Barrier Reef has a stable positive trend. | | |
| **WQT5**<br>Traditional Owners, industry and community are engaged in on-ground water quality improvement and monitoring. | | |

## Key principles of the Eastern Cape York Water Quality Improvement Plan

The key principles that supported the development of the Eastern Cape York Water Quality Improvement Plan are:

- The planning process engages the people of eastern Cape York in the development of the Plan and in water quality management for the region
- The Plan makes best use of available science though synthesis of data and expertise, and identifies critical knowledge gaps and future monitoring priorities
- The Plan localises Australian Government and Queensland Government Reef 2050 Plan commitments and informs future implementation priorities
- The Plan provides an implementation plan for priority management actions that is endorsed and ready to be resourced and implemented

At its core a Water Quality Improvement Plan is about people:

- People who are responsible for the laws that govern the area;
- People who value water for the benefits it provides to them;
- People who manage land and water for conservation, residential and economic uses;
- People who conduct scientific research to improve the understanding of water quality, aquatic ecosystem health and water management; and
- People who implement programs to protect and improve the values that water provides.
- The Eastern Cape York Water Quality Improvement Planning process was designed to engage as many of these people as possible in the process of developing a practical implementation plan that is endorsed by them and can be resourced and implemented with them in the future.

## The planning region

The planning region for the Eastern Cape York Water Quality Improvement Plan includes all the catchments that drain to the northern Great Barrier Reef (GBR), from Jacky Jacky Creek in the north to the Annan River in the south (Figure 1).

As part of planning process, the northern GBR has been broken into three sections; Northern, Central and Southern, based on logical marine receiving waters, and the catchments that drain to them (Figure 1). These logical marine receiving waters were defined by assessing the coastal landform, hydrographic processes and potential zone of influence of the catchments that discharge into the marine receiving waters. It is important to note that the Normanby, Hann and Stewart Rivers' combined influence in very large widespread flooding may extend from the Central section well into the Northern section.

The marine receiving waters within the Northern, Central and Southern section have been broken up based on cross-shelf boundary lines that define Marine Water Bodies (enclosed coastal, open coastal, midshelf, offshore) within the Great Barrier Reef Marine Park Authority (GBRMPA) water quality guidelines (Figure 2) (GBRMPA, 2010 and Appendix 5, GBRMPA, 2016).

The catchments within the Northern, Central and Southern sections have typically been grouped up into drainage basins; however, several of the planning processes involved detailed assessments at sub-catchment and reach scale. For example, the Walking the Landscape and Environmental Values assessment for the whole planning region, the gully prioritisation for Normanby and Hann Basins and the water quality guidelines for the Normanby Basin were completed at sub-catchment and reach scale. The Walking the Landscape analysis of characteristics such as



topography, groundwater, land use and geology was used to define the appropriate sub-catchment scale to present.

Table 2 shows the drainage basins, catchments and sub-catchments that are within each section of the Region.

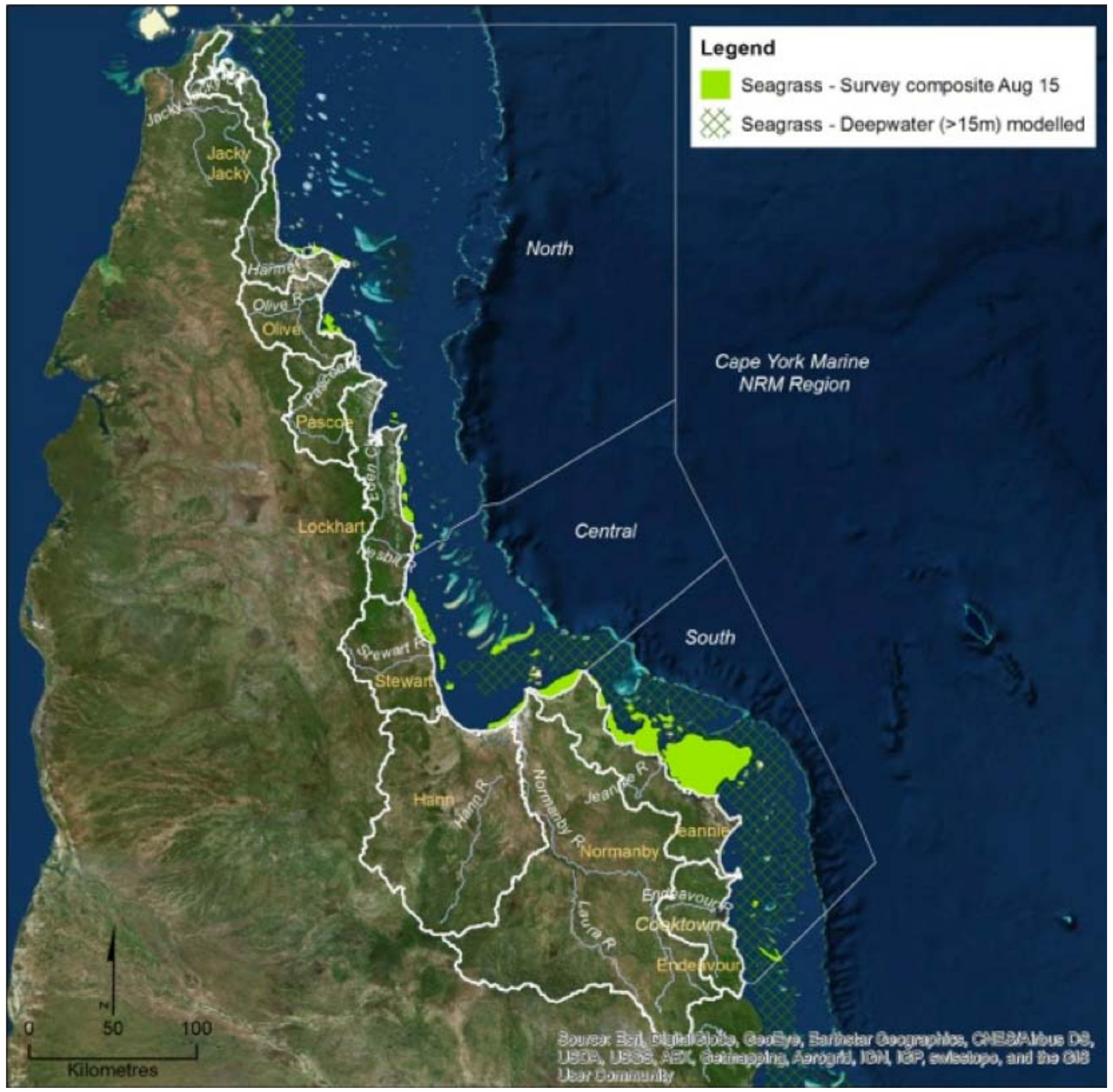



**Figure 1:** Drainage Basin Boundaries and Marine Receiving Waters (North, Central and South) Cape York WQIP. (Source: Waterhouse et al., Marine Risk Assessment, 2015)

Please note that in the map above and throughout this document, the Normanby Basin has been split into the Normanby Sub-Basin and the Hann Sub-Basin and the Olive Pascoe Basin has been split into the Olive Sub-Basin and the Pascoe Sub-Basin.

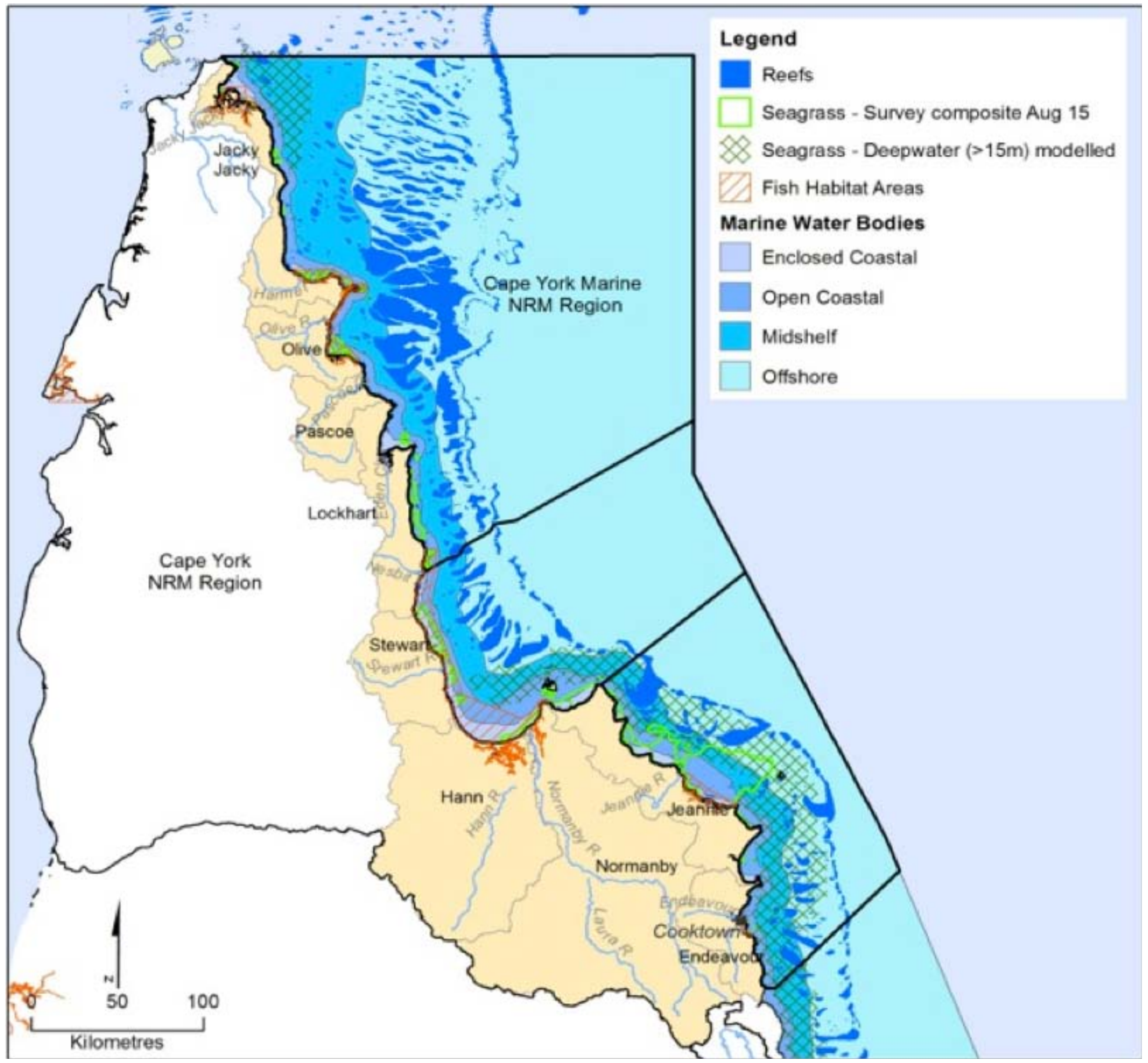



**Figure 2:** Marine Water Bodies (enclosed coastal, open coastal, midshelf and offshore) used in the Eastern Cape York WQIP (Source: Waterhouse et al., Marine Risk Assessment, 2015)

The catchment boundary for the Northern section starts at the boundary between Stewart and Lockhart drainage basins while the marine receiving water boundary for the Northern section starts at the mouth of the Nesbit River. This is to account for the level of suspended sediment in flood plumes coming from the Stewart, Hann and Normanby Basins and to align with the Slightly Disturbed marine zone (Figure 11).

From a freshwater aquatic ecosystem standpoint, Massey Creek (between the Stewart River and Nesbit River) is the beginning of the undisturbed High Ecological Value (HEV) ecosystem zone that extends almost uninterrupted from the northern bank of Massey Creek to the tip of Cape York.



**Table 2:** Drainage basin, catchments and sub-catchments within the Northern, Central and Southern sections of the planning region

| Section | Drainage Basin | Catchment | Sub-catchment |
|---|---|---|---|
| Northern | Jacky Jacky | Jacky Jacky Creek | Jacky Jacky Creek |
| Northern | Jacky Jacky | Escape River | Escape River |
| Northern | Jacky Jacky | Harmer Creek | Harmer Creek |
| Northern | Olive | Olive River | Glennie Creek |
| Northern | Olive | Olive River | Kangaroo River |
| Northern | Olive | Olive River | Olive River |
| Northern | Pascoe | Pascoe River | Garraway Creek |
| Northern | Pascoe | Pascoe River | Yam Creek |
| Northern | Pascoe | Pascoe River | Hann Creek |
| Northern | Pascoe | Pascoe River | Pascoe River |
| Northern | Lockhart | Claudie River | Wilson Creek |
| Northern | Lockhart | Claudie River | Claudie River |
| Northern | Lockhart | Claudie River | Scrubby Creek |
| Northern | Lockhart | Lockhart River | Lockhart River |
| Northern | Lockhart | Nesbit River | Nesbit River |
| Northern | Lockhart | Chester River | Chester River |
| Central | Stewart | Massey Creek | Massey Creek |
| Central | Stewart | Breakfast Creek | Breakfast Creek |
| Central | Stewart | Stewart River | Station Creek |
| Central | Stewart | Stewart River | Stewart River |
| Central | Stewart | Balclutha Creek | Balclutha Creek |
| Central | Stewart | Running Creek | Running Creek |
| Central | Hann | Hann River | Annie River |
| Central | Hann | Hann River | Hann River |
| Central | Hann | Hann River | North Kennedy River |
| Central | Normanby | Normanby River | Bizant River |
| Central | Normanby | Normanby River | Kennedy River |
| Central | Normanby | Normanby River | Mosman River |
| Central | Normanby | Normanby River | Deighton River |
| Central | Normanby | Normanby River | Laura River |
| Central | Normanby | Normanby River | Normanby River |
| Southern | Jeannie | Muck River | Muck River |
| Southern | Jeannie | Howick River | Howick River |
| Southern | Jeannie | Jeannie River | Jeannie River |
| Southern | Jeannie | Starke River | Starke River |
| Southern | Jeannie | McIvor River | McIvor River |
| Southern | Endeavour | Endeavour River | Isabella Creek |
| Southern | Endeavour | Endeavour River | Endeavour North Branch |
| Southern | Endeavour | Endeavour River | Endeavour South Branch |
| Southern | Endeavour | Endeavour River | Endeavour Right Arm |
| Southern | Endeavour | Endeavour River | Endeavour River |
| Southern | Endeavour | Annan River | Oakey Creek |
| Southern | Endeavour | Annan River | Trevethan Creek |
| Southern | Endeavour | Annan River | Annan River |

## Characteristics of eastern Cape York

Cape York Peninsula, as part of the physical bridge between Australia and Papua New Guinea, represents an outstanding, evolving, geological landscape. Cape York Peninsula holds the key to connections between the ancient, stable shield of Australia and the much younger, evolving landmass of New Guinea (Valentine, 2006).

The eastern Cape York catchments are representative of the biodiversity and ecosystems of the whole of Cape York. The fully functioning savannah ecosystems represent a biome now largely transformed elsewhere in the world (Valentine, 2006) and the eastern dune fields are of global significance as evidence of geo-evolution under the influence of climate change (sea level change) (Mackey et. al., 2001).

The eastern Cape York marine environment (northern GBR) is considered to be in good condition compared to other parts of the GBR or other global coral reef ecosystems (Fabricius et al., 2005, Halpern et al., 2008). In addition to healthy coral reefs this region has high-value seagrass meadows, high fisheries values and harbors significant populations of rare or threatened marine turtles, dugongs and dolphins. This is attributed to a combination of factors, including good water quality resulting from lower levels of development within the eastern Cape York catchments, and less pressure from recreational and commercial fishers, tourism and other boats. However, threats and impacts to the eastern Cape York marine environment are generally poorly documented and quantified, with the exception of recent research efforts in the Normanby River and past water quality monitoring in the Endeavour and Annan rivers.

While sharing iconic features such as the interconnected savannah, rainforest, dune lakes and mangrove forests, the three sections of eastern Cape York have unique characteristics.

Southern
- Extension of the wet tropics into Annan River
- Granite ranges at Black Mountain and Cape Melville

Central
- Extensive flood plain wetland of Rinyirru National Park
- Sandstone escarpments
- Princess Charlotte Bay

Northern
- Largest area of lowland rainforest in Australia
- Heathlands between Escape River and Shelbourne Bay

Termite mounds of Cape York savannah (Photo: Lyndal Scobell)

From a human perspective eastern Cape York presents significant climatic challenges that add to the social and economic challenges of isolation. Flooding during the strong monsoon wet season can cut people off for months at a time and the widespread extended dry season increases the impact and extent of wildfires.

The current population density of eastern Cape York is very low. The majority of the population lives in the Southern section of the region within an hour's drive of Cooktown. There are small communities spread throughout the region and the cost of living increases further north.

Cattle were introduced to Cape York around 1865, and the majority of the region was developed for extensive grazing on pastoral leases. Stocking rates are low compared to other savannah regions and the grazing systems have low profitability. Profitability declines further north due to increasing transport costs; however, future live export opportunities from Weipa may improve cattle profitability.

In the last 20 years there has been large-scale land-tenure change from pastoral lease to nature conservation and Traditional Owner land tenures. The historic displacement of Traditional Owners has impacted on connection to Country. This will require extra resources to overcome particularly in sparsely populated areas.

The annual economic value of the eastern Cape York coastal and marine environment is estimated to be AU $160 million per year (Appendix 12, Thomas and Brodie, 2015). However, the higher cost of living, low socio-economic status, and the scale of the land being managed, creates challenges with adoption of improved management practices. Anything other than the bare necessity of land management is unaffordable and not considered practical. The people of eastern Cape York require significant technical and financial resources to enable them to improve grazing, agriculture, urban, wetland and nature and culture conservation management practices in priority areas.

The people of eastern Cape York are resilient. If they are provided with the resources they require, they are willing to implement region-wide adoption of improved management to meet Reef 2050 Plan water quality targets and objectives.

High Ecological Value wetland, Alligator Lagoon, on Lama Lama country (Photo: Jessie Price)

## Historical land use and disturbance

The focus of this plan is current land use and disturbance, current threats to water quality and the priority management actions that can be implemented to maintain and improve water quality in eastern Cape York. However, historic land uses have shaped the current landscape and in some areas this legacy may continue to impact water quality.

Cattle were introduced to Cape York around 1865 and cattle numbers increased greatly during the Palmer River gold rush. Over 150 years of grazing on Cape York has altered the landscape and left a legacy of gully erosion in fragile dispersive soil types that continues to increase sediment loads from some catchments.

There are a range of other historical disturbances that are likely to have impacted fresh water quality and marine water quality. It is likely that gold and tin mining and clearing for agriculture in the late 19th century and early 20th century and clearing for military purposes during World War 2 will have significantly increased erosion and sediment loads to the marine environment during flood events in the following areas:

- Endeavour River – Cooktown population explosion and railway construction to Laura during Palmer River gold rush in the 19th century
- Upper Stewart River, Station Creek – gold mining in early 20th century
- Annan River- tin mining and clearing for sugar cane production in late 19th and early 20th century
- Starke River – gold mining in early 20th century
- Claudie River – clearing for military purposes, including airfields and bomb test sites during World War 2 near Lockhart

The historic port at Port Stewart, once a major port for supplying the cattle stations and gold fields of the Coen region (Batavia mine, Great Northern mine), is now too shallow for all but small vessels to enter from mid to high tide. Accelerated erosion from mining, roads and grazing is believed to have caused the sedimentation of this once busy port.

Evidence of these historic disturbances is still present. However, the water quality today in the upper Stewart River and Claudie River is likely to be better than it was in the early to mid 20th century when mining and military activities were most active.

For more information refer to Steve Lewis' report on historical land use (Appendix 3) and the historical disturbance section of the report on the Annan River by Shellberg et al. (2016) (Appendix 4).

Rainforest in the Station Creek headwaters (top) and in the Claudie River (bottom) has naturally regenerated early 20th century mine sites and World War 2 gun placements. (Photo: Jessie Price)



## Community consultation and science synthesis

During the Eastern Cape York Water Quality Improvement Plan development process, many public meetings and one-on-one consultations were held with the communities, Traditional Owners, farmers, graziers and local government representatives of eastern Cape York. Meeting processes and surveys for each major stakeholder group were developed to capture the critical information required to define the Environmental Values and develop recommended management actions and implementation strategies presented in the Eastern Cape York Water Quality Improvement Plan. Table 3 presents a summary of the community consultation and science synthesis activities. For more information on community consultation and science synthesis see Chapter 6.

**Table 3:** Summary of community and science consultation activities

| Stakeholder | Activity Description | Purpose | Number |
|---|---|---|---|
| Agriculture - farmers | Agriculture Round Table meeting | Introduce the Water Quality Improvement Plan process to agricultural community.<br>Gauge willingness to adopt improved management practices. | 1 |
| | Horticulture network meetings | Introduce the Water Quality Improvement Plan process to horticultural community.<br>Gauge willingness to adopt improved management practices. | 2 |
| | Individual consultations – property visits or phone calls | Property scale assessment of management practices- Stewardship and Improvement Plans.<br>Collect information for Environmental Values. | 13 |
| Graziers | Grazing Round Table meeting | To gauge willingness to adopt improved management practices. | 1 |
| | Presentations with AgForce | Introduce the Water Quality Improvement Plan process to grazing community. | 3 |
| | Individual consultations – property visits or phone calls | Property scale assessment of management practices- Stewardship and Improvement Plans.<br>Collect information for Environmental Values. | 18 |
| Traditional Owners | Field trips on Country | Introduce Water Quality Improvement Plan process.<br>Collect information on water assets, threats and pressures, management actions and Environmental Values. | 10 |
| | Individual consultations | Opportunity for editing and comment on content by Traditional Owners and collection of additional information. | 8 |
| Local Government | Individual consultations | Introduce Water Quality Improvement Plan process<br>Collect information on current management practices, and gauge interest in improved management practices.<br>Collect information for Environmental Values. | 3 |
| Walking the Landscape | Walking the Landscape workshops | Describe and document hydrological processes, natural terrain and ecological attributes, landscape modifications and threats to water quality. Collect information for Environmental Values. | 2 |
| | Follow-up meetings and teleconferences | Quality assurance – editing and comment. | 3 |
| Science Advisory Panel | Workshops | Synthesise science and expert opinion to create knowledge. | 2 |
| | Teleconferences | Provide scientific and technical input to the planning process.<br>Review supporting studies and planning products. | 8 |
| Community | Public meetings | Introduce Water Quality Improvement Plan process.<br>Collect information on water assets, threats and pressures, and Environmental Values. | 6 |
| | Individual consultations | Introduce Water Quality Improvement Plan process.<br>Collect information on water assets, threats and pressures, management actions and Environmental Values.<br>Opportunity for editing and comment on content. | 13 |

## Environmental Values

Environmental Values are the qualities that make water suitable for supporting aquatic ecosystems and human use (Table 4 and Figure 3). During the Eastern Cape York Water Quality Improvement Plan development process, many meetings were held with community members, grazing and agriculture land managers, Traditional Owners and ranger groups to ask what people are using water for. The information gathered was analysed to determine human use and aquatic ecosystem Environmental Values in the catchments and waterways of eastern Cape York. Freshwater and estuarine Environmental Values for the major sub-catchments of eastern Cape York are presented in Figures 4 to 10. Environmental Values for coastal waters were assessed by Great Barrier Reef Marine Park Authority and are presented in Figure 11. For more information on Environmental Values refer to Chapter 5.

**Table 4:** Definitions of Environmental Values used in the consultation process.

| Environmental Values and definitions | | | |
|---|---|---|---|
| **Aquatic Ecosystem** | Water for freshwater ecosystem protection | **Primary Recreation** | Recreation with direct contact with water ie: swimming, snorkeling |
| **Irrigation** | Irrigating crops such as bananas, legumes etc. | **Secondary Recreation** | Recreation with indirect contact with water such as boating, canoeing etc. |
| **Stock Water** | Water for stock consumption | **Visual Appreciation** | Activities with no contact with water ie: sightseeing |
| **Farm Use** | Water for farm use other than drinking water, such as in fruit packing | **Drinking Water** | Drinking water supplies for human consumption |
| **Aquaculture** | Water for aquaculture farming | **Industrial** | Water for uses such as power generation, manufacturing plants |
| **Human Consumption** | Human consumption of wild or stocked fish, crustaceans or shellfish | **Cultural and Spiritual** | Cultural and spiritual values including those of Traditional Owners |

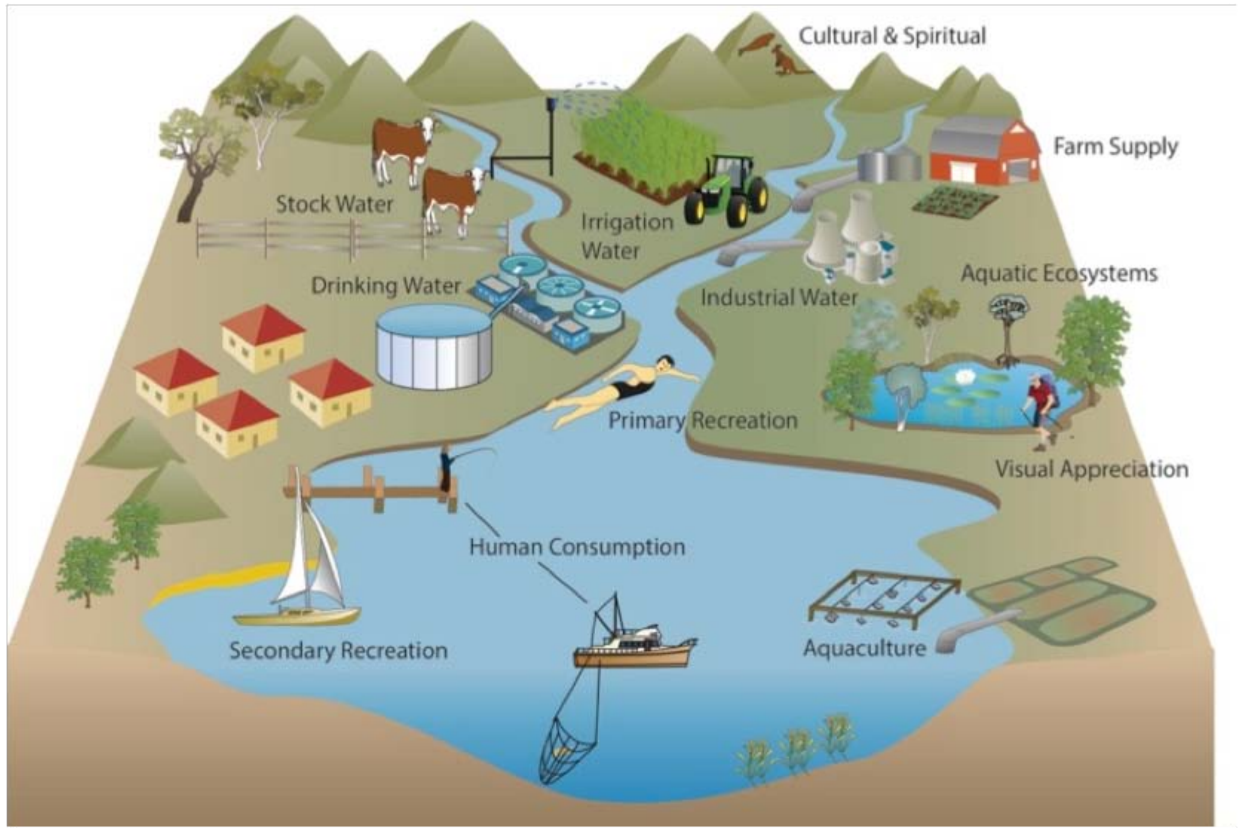



**Figure 3:** A conceptual model presenting the Environmental Values that were assessed through the Eastern Cape York Water Quality Improvement Plan (swimming in the estuaries of eastern Cape York is not recommended).

Coral reefs provide a range of human use environmental values including primary recreation, secondary recreation, visual appreciation, human consumption and cultural and spiritual values (Photo: Kerry Trapnell)

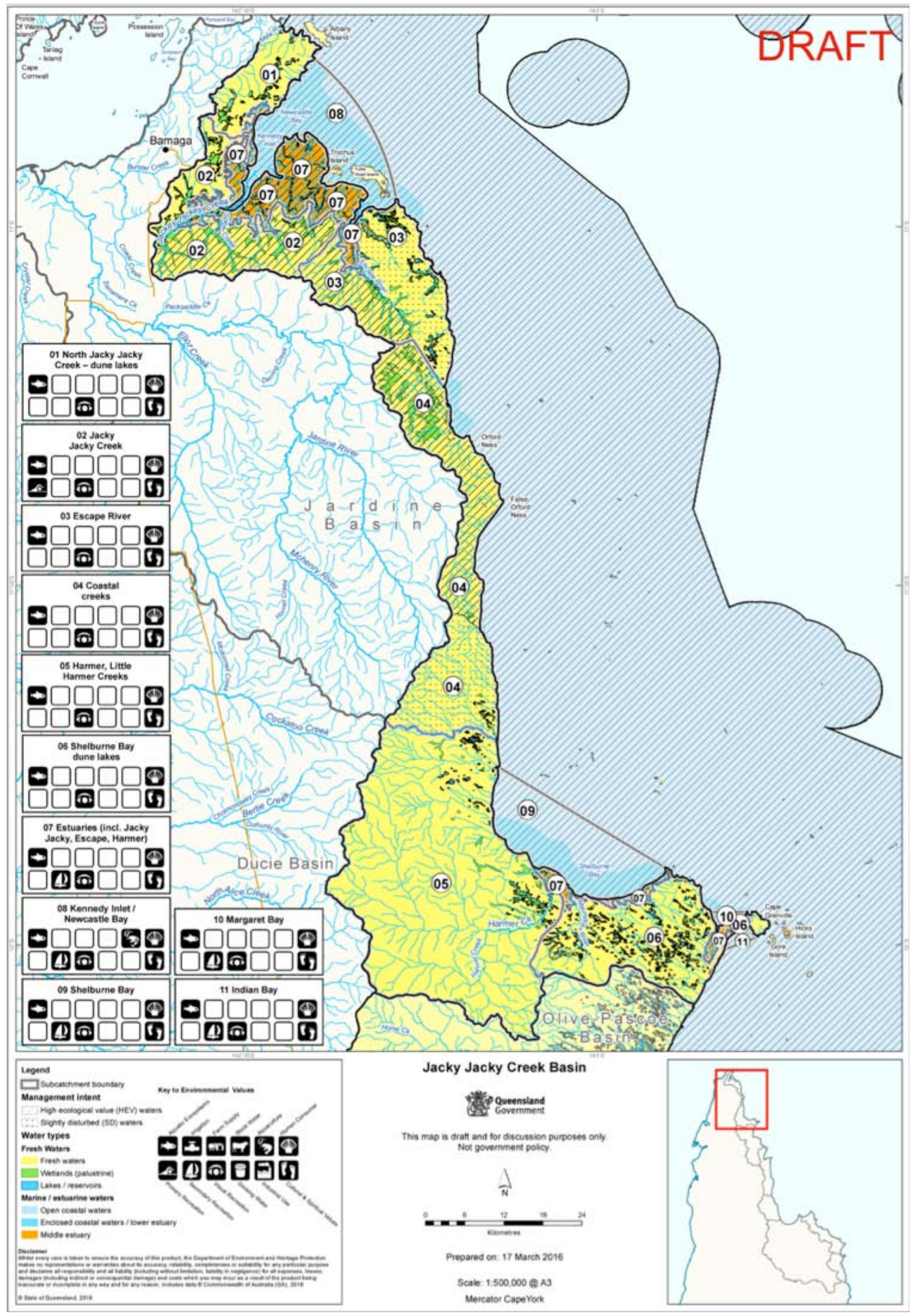



Figure 4: Environmental Values for freshwaters and estuaries of Jacky Jacky Basin (Source: EHP)

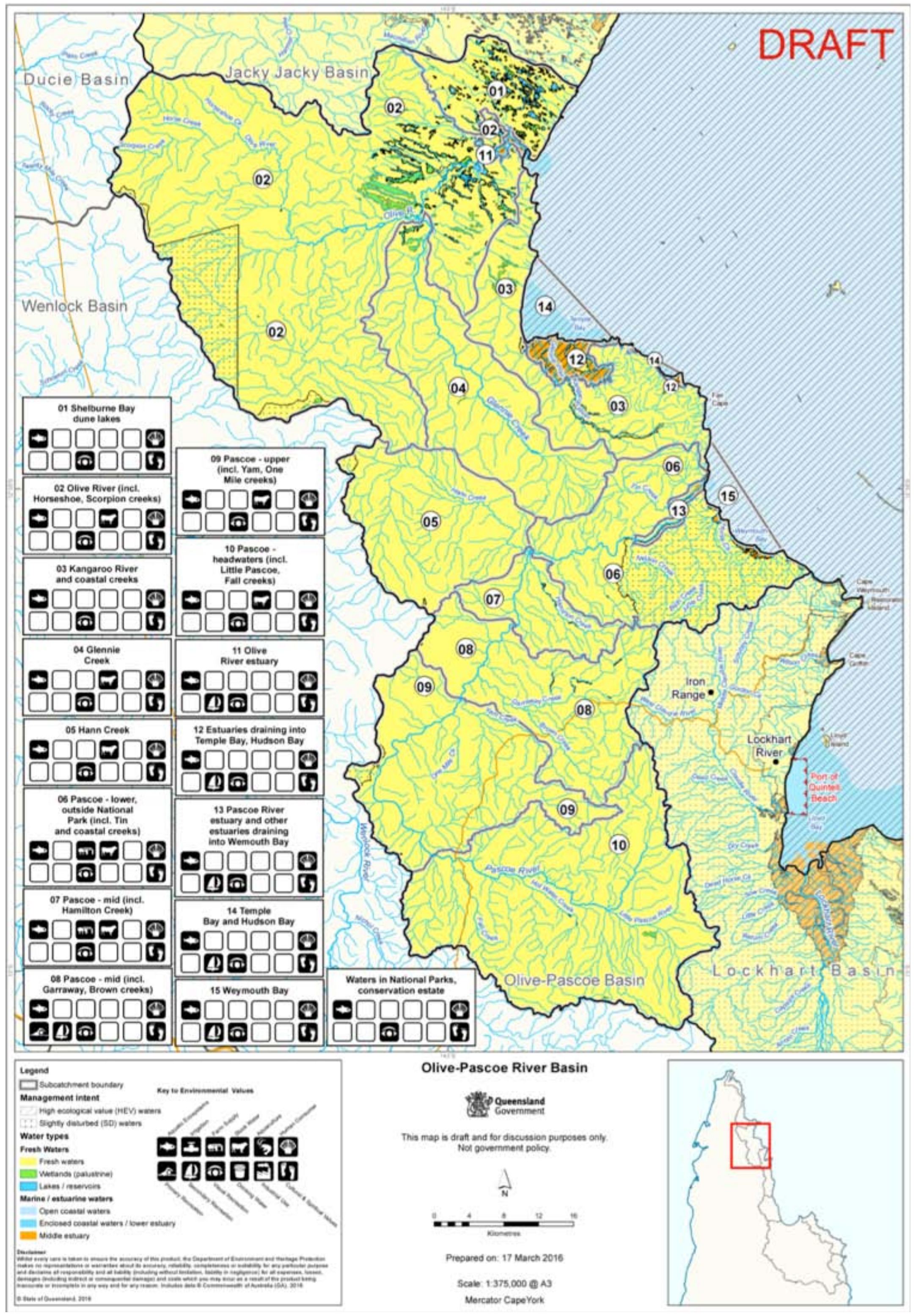



Figure 5: Environmental Values for freshwaters and estuaries of Olive-Pascoe Basin (Source: EHP)

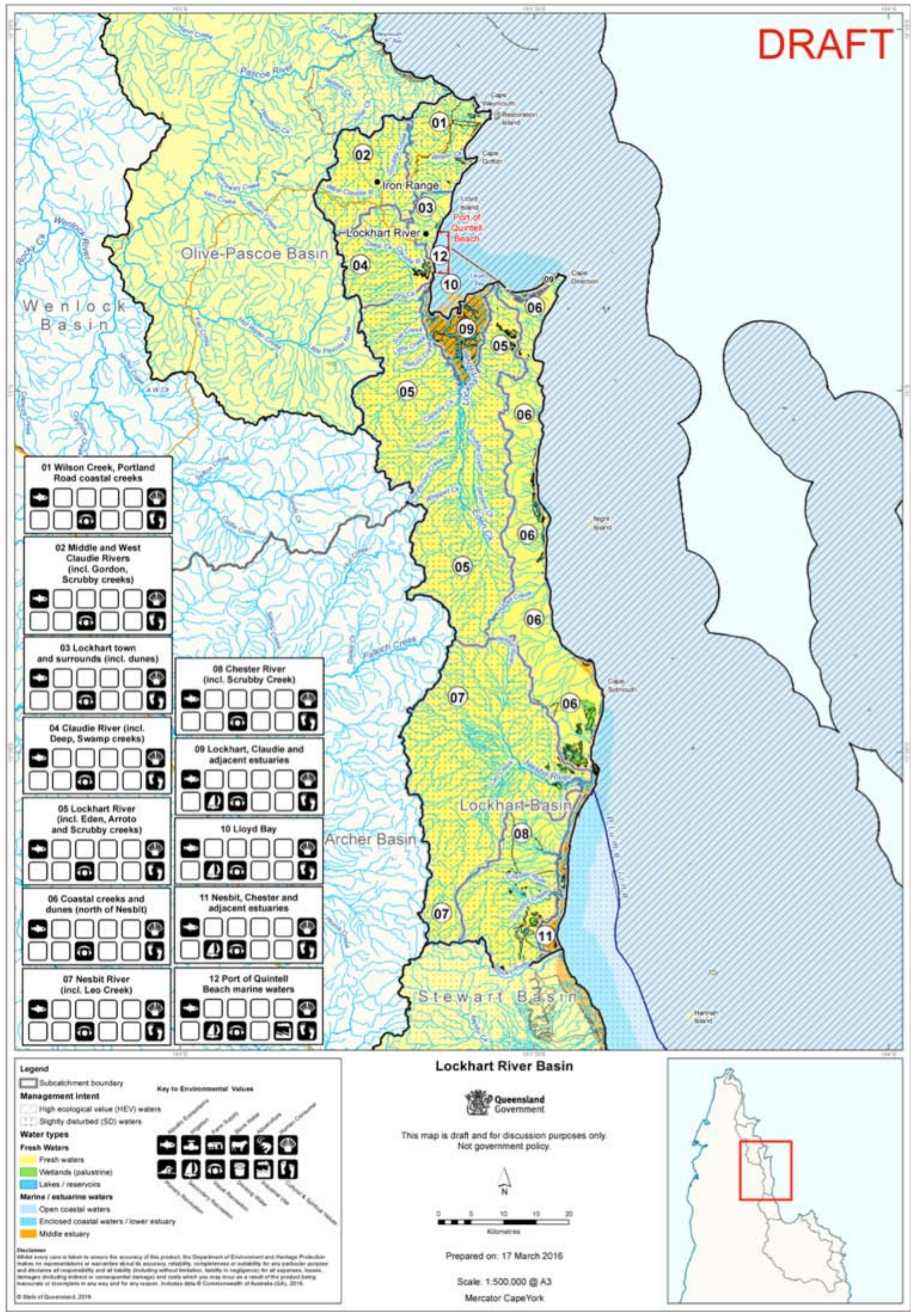



**Figure 6:** Environmental Values for freshwaters and estuaries of Lockhart Basin (Source: EHP)

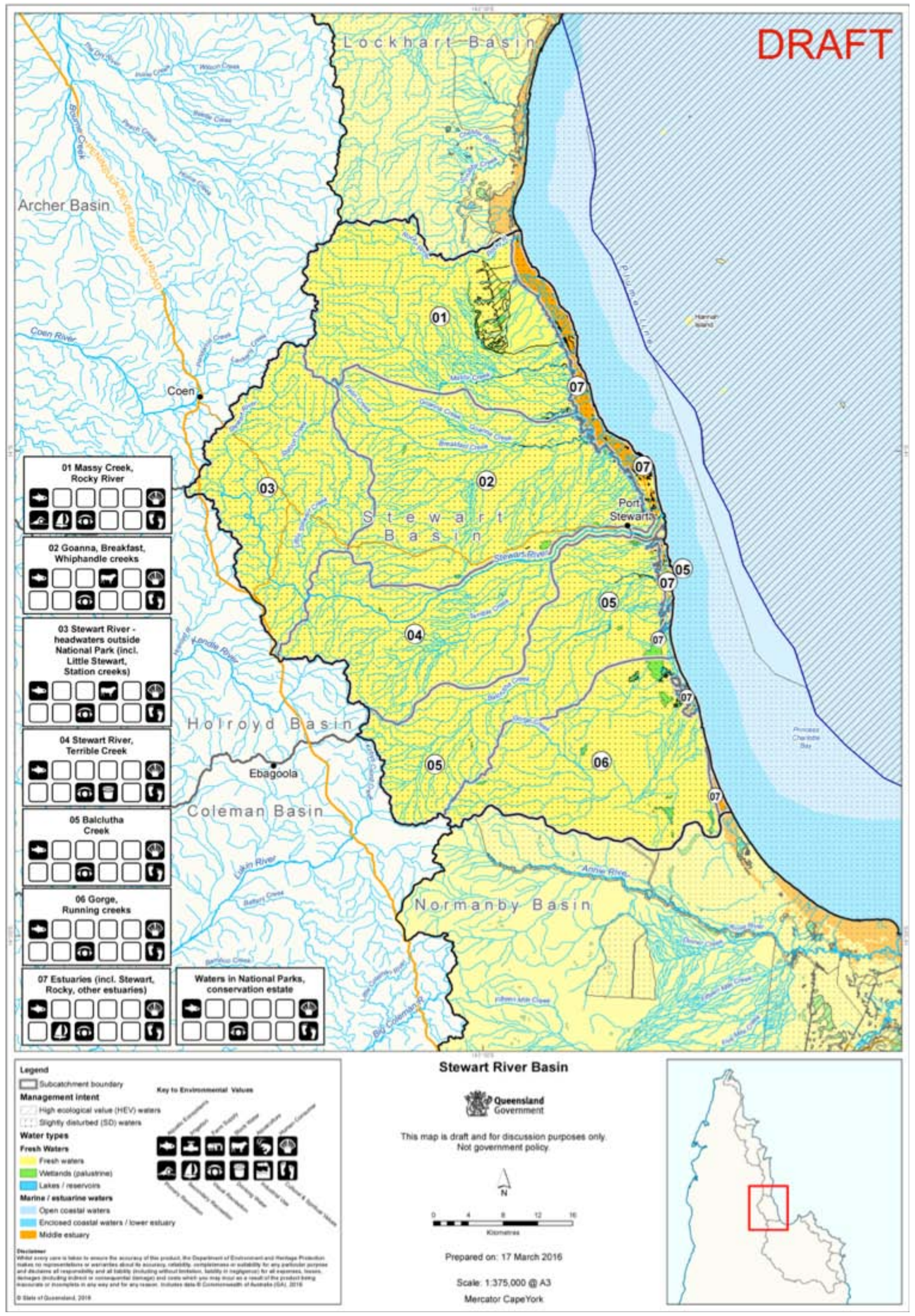



Figure 7: Environmental Values for freshwaters and estuaries of Stewart Basin (Source: EHP)

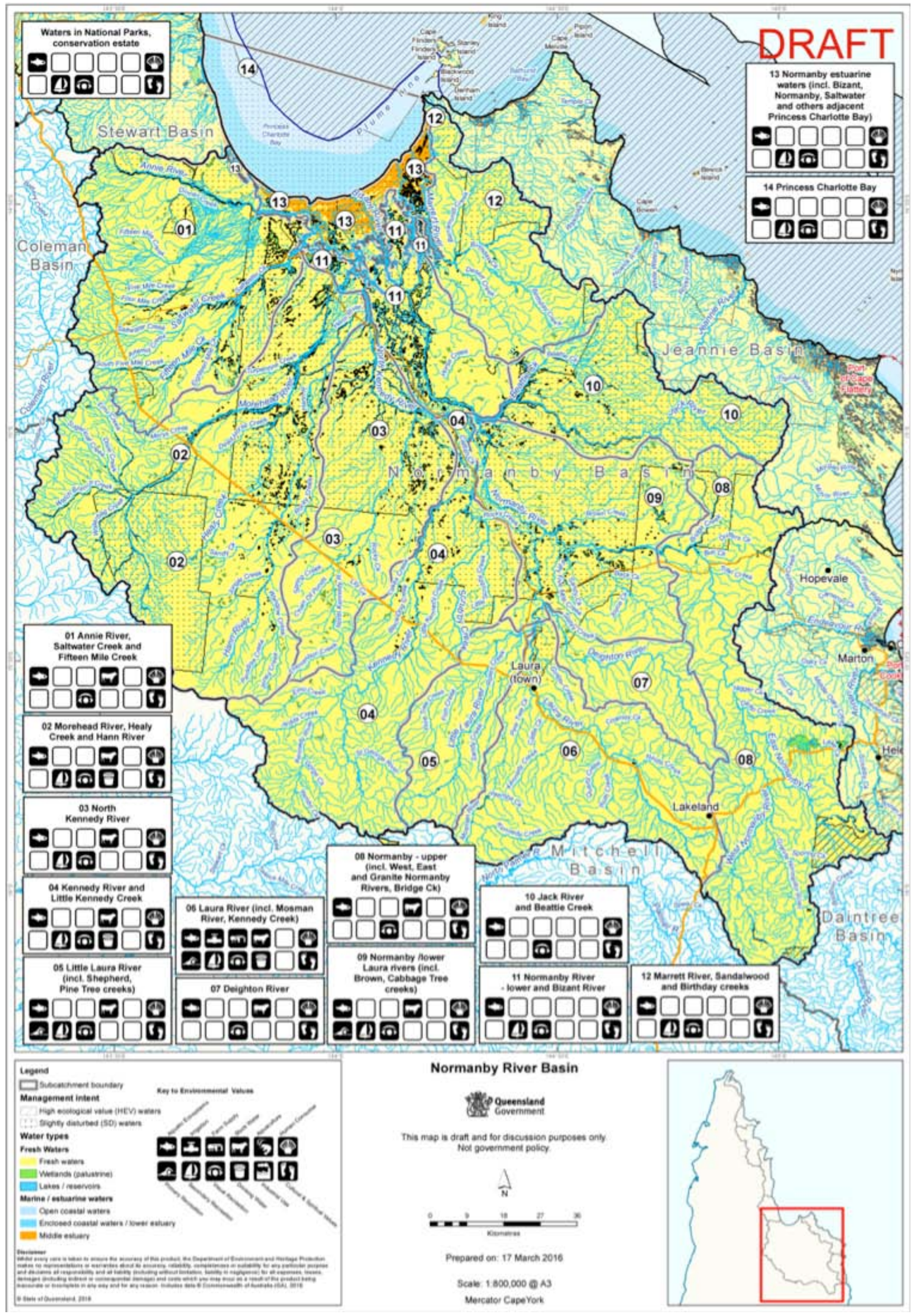



**Figure 8:** Environmental Values for freshwaters and estuaries of Normanby Basin (Source: EHP)

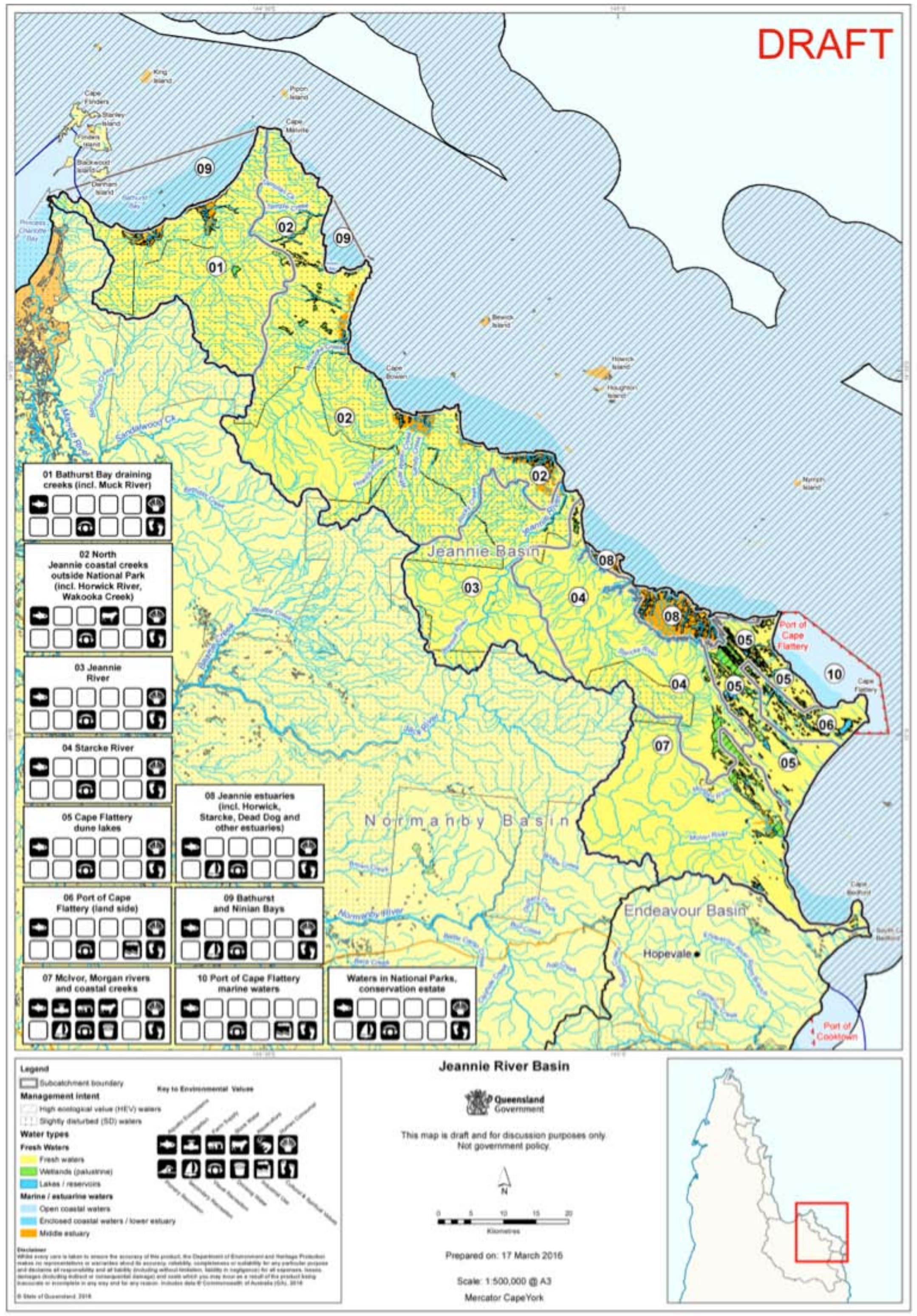



**Figure 9:** Environmental Values for freshwaters and estuaries of Jeanie Basin (Source: EHP)

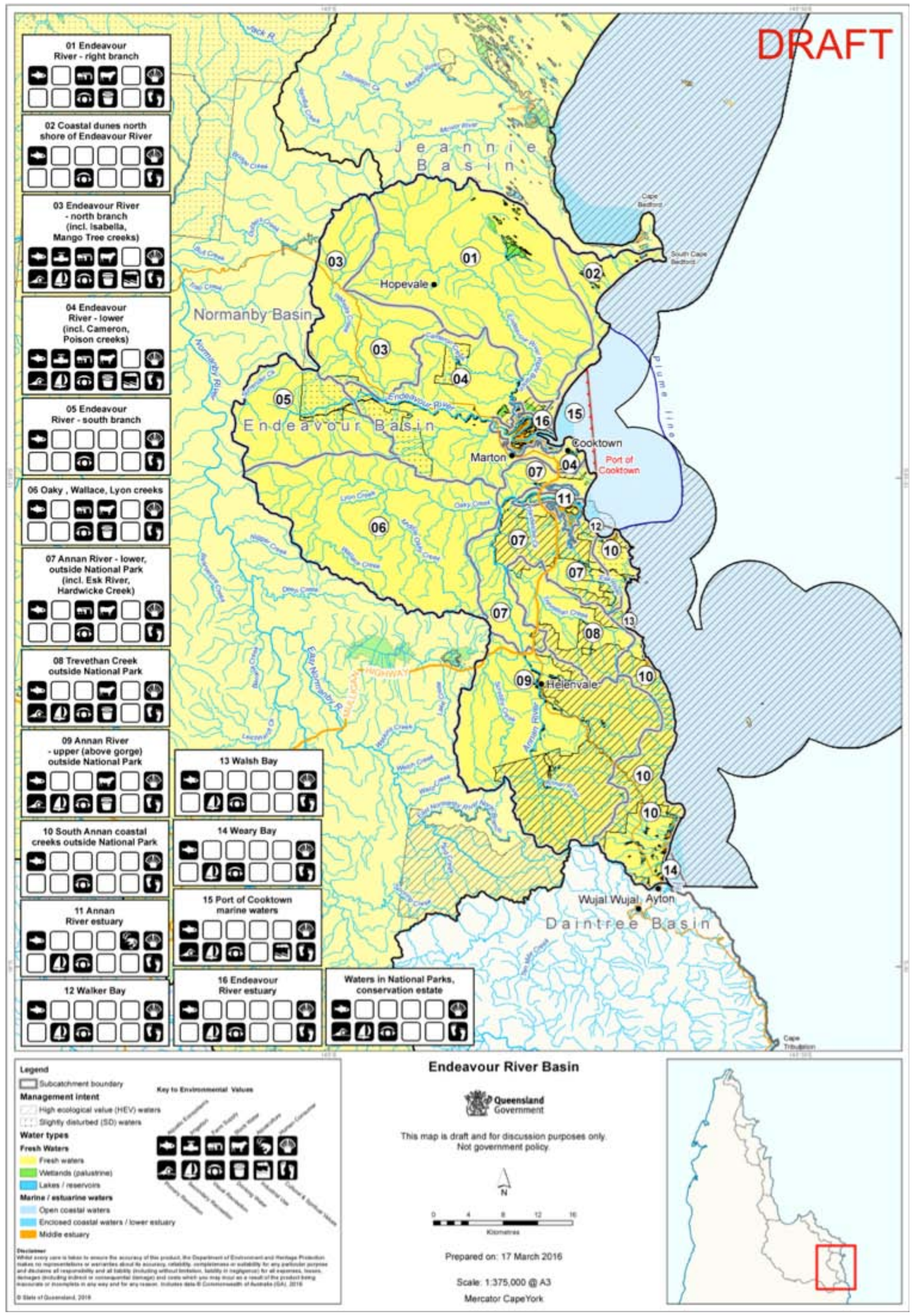



**Figure 10:** Environmental Values for freshwaters and estuaries of Endeavour Basin (Source: EHP)

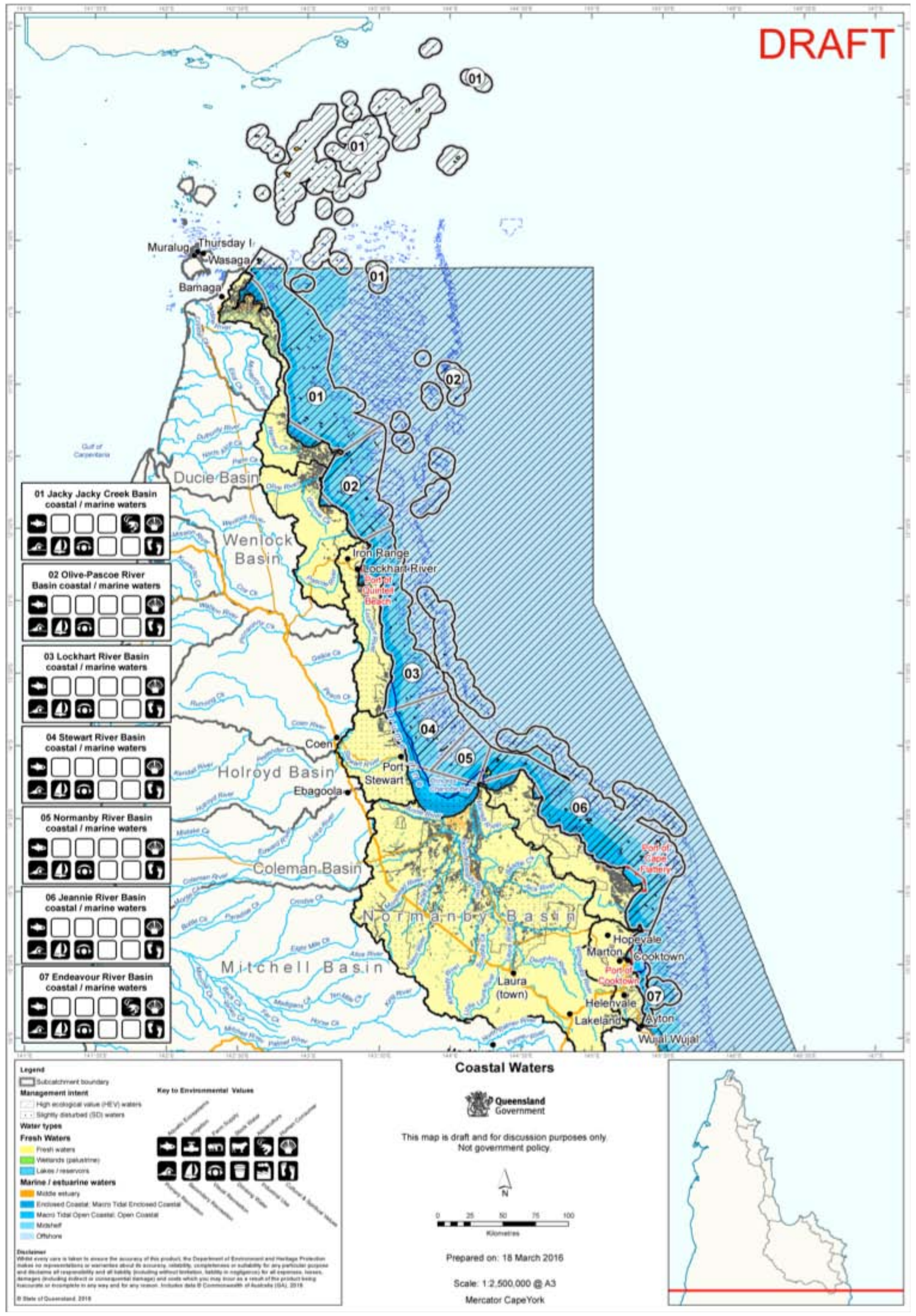



**Figure 11:** Environmental Values for coastal waters of eastern Cape York (Source: EHP)

## Current condition of water quality

### Freshwater and estuary water quality

Eastern Cape York is a large region with a diversity of landforms, river types, and land use intensity. While extensive freshwater and/or estuary water quality datasets exist from some eastern Cape York rivers, such as the Annan, Endeavour and Normanby Rivers, there is a paucity of data from many other river systems, particularly those in the Northern section of the region. However, it is generally accepted that water quality in the Northern section is relatively good and is considered to have High Ecological Value (HEV) status.

In the Central section (Stewart Basin, Hann Sub Basin and Normanby Sub-Basin), accelerated erosion from land use has increased sediment concentrations in waterways, particularly during the wet season and flood events (Brooks et al., 2013). A large fraction of these sediments (up to 80%) settle out in the main river channels, wetlands and floodplains, potentially reducing habitat condition in these areas. Highly turbid conditions in the estuary (>500 NTU at times) may be associated with this deposition of sediments from the upper catchment. The remaining fine suspended sediment and associated nutrients are discharged to the GBR lagoon during flood events. During ambient conditions (base flow), the Normanby Basin is considered to be in generally good condition compared to more intensively developed catchments. There are very low concentrations of pollutants (hydrocarbons, pesticides, metals) and nutrients in the rivers, except for the upper Laura River, where high levels of nutrients and algae are associated with agricultural land use. During periods of very low or no flow, poor conditions have been recorded in the Normanby due to lack of freshwater flushing, cattle accessing the remaining waterholes and the concentration of nutrients, algae and bacteria (Howley, 2010).

In the Southern section, water quality condition is also dependent on season and flow. Ambient water quality in the Annan and Endeavour rivers are generally considered good, with low contaminant levels (suspended sediments, nutrients, hydrocarbons, metals and herbicides) in the areas that have been sampled (Howley et al., 2012). During flood events, high concentrations of suspended sediments (up to 800mg/L) from accelerated erosion, particularly in the Scrubby and Oakey Creek sub-catchments, enter the Annan and Endeavour rivers to be discharged to the marine receiving waters (Eyre and Davies, 1996, Shellberg et al., 2016). Elevated metals have been detected in the upper Annan River associated with releases from a mine tailings dam; however, water quality remains within the acceptable range for the Protection of Aquatic Ecosystems (ANZECC, 2000) for the majority of the year. Although little monitoring has been done, rivers such as the McIvor, Jeannie, and Starcke are also assumed to be in generally good condition, but with some anthropogenic impact from erosion, grazing, mining and agriculture.

Wetland condition, as with the river condition, is extremely variable. During the wet season, most eastern Cape York wetlands appear to be in excellent condition, with good water quality, high aquatic and riparian vegetation cover and diversity. However, across all sections of the region, many wetlands are highly degraded during the dry season, when cattle and feral pigs are concentrated around the wetlands and water quality and vegetation condition is poor (Doupe et al., 2009, Howley et al., 2009, Stephan and Howley, 2009).

### Freshwater and estuary water quality guidelines and targets

Water Quality Guidelines have been established for eastern Cape York rivers and estuaries based on an assessment of all available water quality data. Figures 12 and 13 show the water quality monitoring locations for eastern Cape York. The Guidelines report (Moss and Howley, 2016) presents the acceptable range of concentrations for each river for a range of water quality parameters including dissolved oxygen, pH, turbidity, electrical conductivity, nutrients (total, dissolved and particulate nitrogen and phosphorus) and suspended sediments.

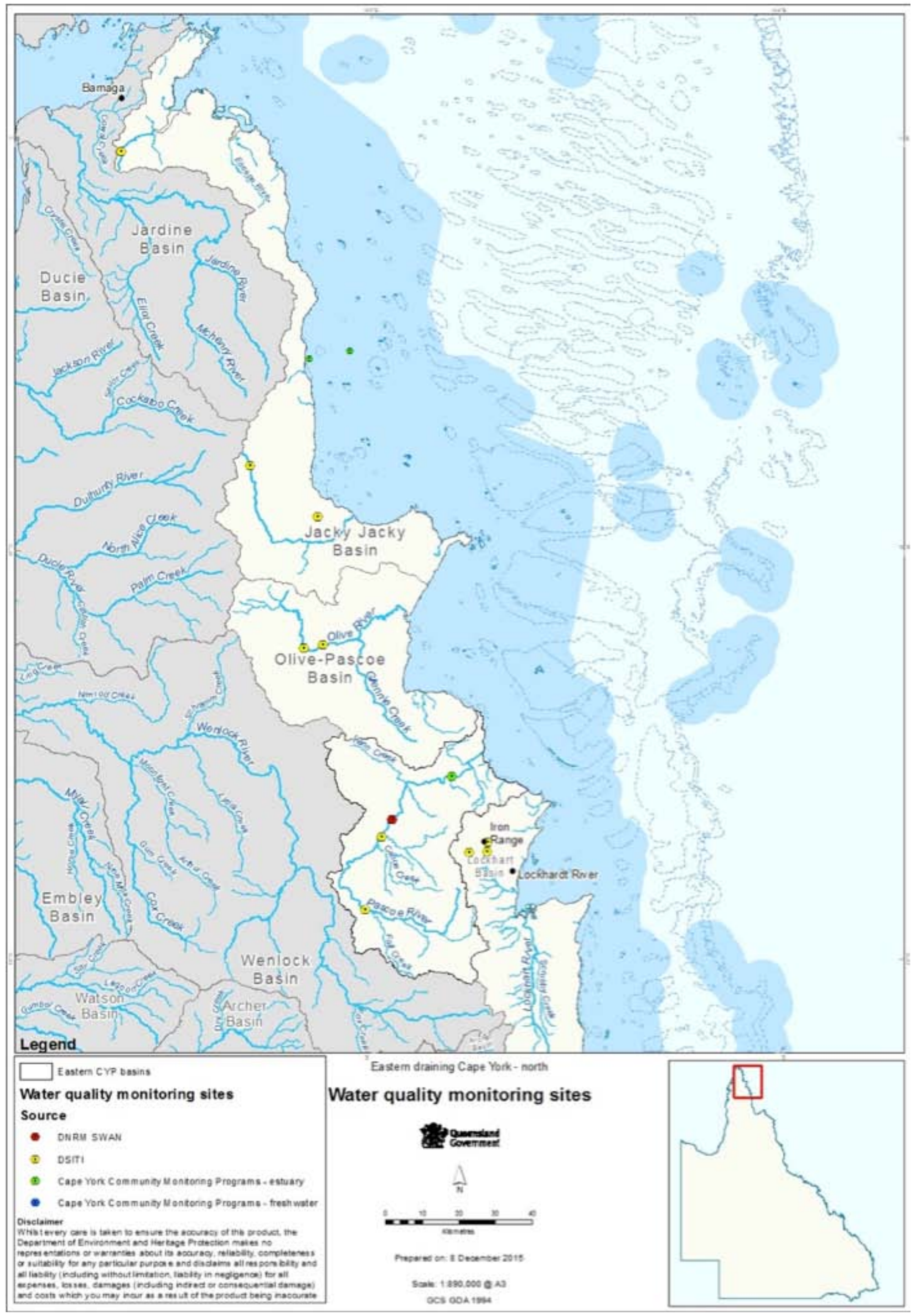



**Figure 12:** Water Quality sample locations for Northern section of eastern Cape York (Source: Appendix 9, Moss and Howley, 2016)

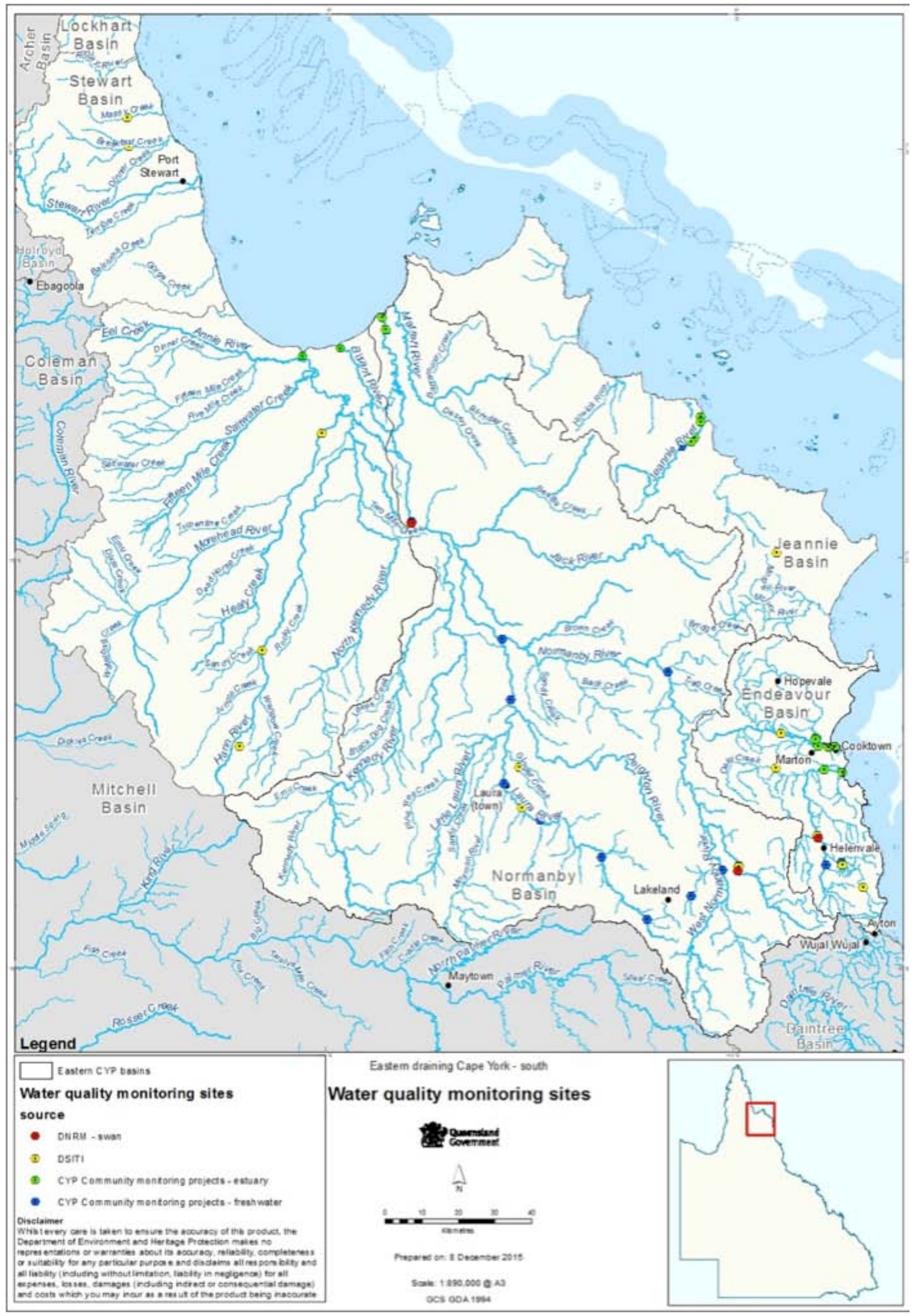



**Figure 13:** Water Quality Sample locations for Central and Southern sections of eastern Cape York (Source: Appendix 9, Moss and Howley, 2016)



The water quality guidelines apply only to ambient (baseflow) conditions for most river systems; however, the Normanby guidelines specify water quality ranges for wet season, dry season and event flow. For many river systems or sub-catchments (all basins in the Northern section, the Stewart Basin and Hann Sub Basin in the Central section, and most of the Jeannie Basin in the Southern section), there was only a limited dataset available and additional monitoring is recommended to improve guideline certainty. Additional monitoring of event flow conditions to detect accelerated erosion impacts is a high priority. Estuary water quality data was also limited for all but the Normanby, Annan, Endeavour and Jeannie rivers. Further sampling is recommended to establish estuarine guidelines for the remaining estuaries.

Many of the Eastern Cape York freshwaters are considered to be high ecological value (HEV). For these waters, the guidelines state that there should be no detectable change in water quality. For rivers that are slightly or moderately disturbed such as the upper Normanby river tributaries, targets have been set for reductions in suspended sediment concentrations and particulate nutrients. The targets are for a 10th percentile reduction in suspended sediments and particulate nutrients during the wet season and a 25% reduction of flood event concentrations. At the lower Normanby (end-of-catchment) targets are set for a short-term (7 year) 10% reduction in event sediment and particulate nutrient concentrations. The end-of-catchment targets are lower due to the large fraction of sediment that settles out within the catchment. Targets have also been set to reduce nutrient concentrations in the Laura River across all seasons.

The proposed water quality guideline sources to protect human-use EVs (those EVs other than the aquatic ecosystem, e.g. recreation, stock watering, aquaculture and crop irrigation) are presented in Table 5. Unless otherwise stated, these are based on relevant national water quality guidelines, and reference to those national guidelines or codes (as updated) is essential to obtain comprehensive listings of all indicators and corresponding guideline values. Table 5 presents a summary only. The human use water quality guideline source documents include:

- *Australian Drinking Water Guidelines* (NHMRC, 2011, updated Feb 2016)
- *Australia New Zealand Food Standards Code* (Australian Government).
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ, 2000).
- *Guidelines for Managing Risks in Recreational Water* (NHMRC, 2008).

For more information on the water quality guidelines for all rivers refer to Appendix 9: Water Quality Guidelines for fresh and estuarine waters of Eastern Cape York (Moss and Howley, 2016).

**Table 5:** Water quality guidelines to protect human use Environmental Values

| Environmental value | Water type/area | Water quality guidelines to protect Human Use Environmental Values (refer to specified codes and guidelines for full details) |
|---|---|---|
| Suitability for drinking water supply | All fresh waters including groundwaters | Note: For water quality after treatment or at point of use refer to the following guidelines and legislation (as updated):<br>• Australian Drinking Water Guidelines (ADWG, 2011, updated Feb 2016)Public Health Act 2005 and Regulations<br>• Water Supply (Safety and Reliability) Act 2008, including any approved drinking water quality management plan under the Act<br>• Water Fluoridation Act 2008<br>Quality of raw water (prior to treatment) to meet requirements of water supply operators. |
| Protection of the human consumer (including oystering) | Fresh waters, estuarine and coastal waters | AWQG and Australia New Zealand Food Standards Code, Food Standards Australia New Zealand, 2007 and updates. |
| Protection of cultural and spiritual values | Fresh waters (including groundwaters), estuarine and coastal waters | Protect or restore indigenous and non-indigenous cultural heritage consistent with relevant government policies and plans. |
| Suitability for industrial use | Fresh waters, estuarine and coastal waters | Water quality requirements for industry vary within and between industries. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality do not provide guidelines to protect industries, and indicate that industrial water quality requirements need to be considered on a case-by-case basis. This EV is usually protected by other values, such as the aquatic ecosystem EV. |
| Suitability for aquaculture | Fresh waters, estuarine and coastal waters | AWQG and Australia New Zealand Food Standards Code, Food Standards Australia New Zealand, 2007 and updates. |
| Suitability for irrigation | All fresh waters including groundwaters | Australian and New Zealand Guidelines for Fresh and Marine Water Quality (including pathogens, metals, salinity, sodicity, herbicides and other indicators) |
| Suitability for stock watering | All fresh waters including groundwaters | Australian and New Zealand Guidelines for Fresh and Marine Water Quality (including faecal coliforms, total dissolved solids, metals, cyanobacteria and pathogens) |
| Suitability for farm supply/use | All fresh waters including groundwaters | Australian and New Zealand Guidelines for Fresh and Marine Water Quality |
| Suitability for primary contact recreation | Fresh waters, estuarine and coastal waters | NHMRC (2008) Guidelines for Managing Risks in Recreational Water (including faecal contamination, physical hazards, toxic/irritating chemicals, venomous/dangerous aquatic organisms, cyanobacteria) |
| Suitability for secondary contact recreation | Fresh waters, estuarine and coastal waters | NHMRC (2008) Guidelines for Managing Risks in Recreational Water |
| Suitability for visual recreation | Fresh, estuarine and coastal waters | Objectives as per NHMRC (2008) Guidelines for Managing Risks in Recreational Water |



### Annual loads of suspended sediments and nutrients

Estimates of sediment or nutrient loads (the amount of a substance that passes a section of a river over a specific amount of time) are used to compare quantities of these substances delivered to the GBR lagoon by different river systems and the contributions of different tributaries to total catchment loads, and to measure change over time in response to management actions or land use changes. "Empirical" loads can only be accurately calculated at locations where there is frequent monitoring of both pollutant concentrations and river flow, particularly during flood events. For areas where insufficient monitoring data is available, pollutant loads are often estimated using models such as the 'Source Catchments' model; however, these models have been shown to be highly inaccurate for Cape York catchments (Brooks et al., 2013).

For the WQIP, empirical estimates of annual suspended sediment and nutrient loads have been calculated for gauge sites on the Annan, Normanby and Pascoe rivers—the only eastern Cape York rivers with any intensive flood event monitoring data. For the Annan and Pascoe Rivers, loads have been calculated for the 2014-2015 water year (July-June), while long-term monitoring at some Normanby catchment gauges have allowed for the calculation of annual loads for up to 7 years. The annual loads calculated are presented as the current best estimates of pollutant loads discharged from eastern Cape York rivers to the GBR; however, there are uncertainties associated even with these empirical calculations. To greatly improve empirical load calculations on Cape York Peninsula, it is recommended that a 'Super Gauge' approach, as per Shellberg et al., 2016, (see summary below and Appendix 4) is developed at key sites, based on international standards for measurements of river pollutants and using continuous water quality dataloggers. The nutrient and sediment empirical load estimates are presented in Table 6. Average suspended sediment loads for each site are presented in Figure 14, however, it should be noted that annual loads are highly variable, and for some sites there was only one year of data.

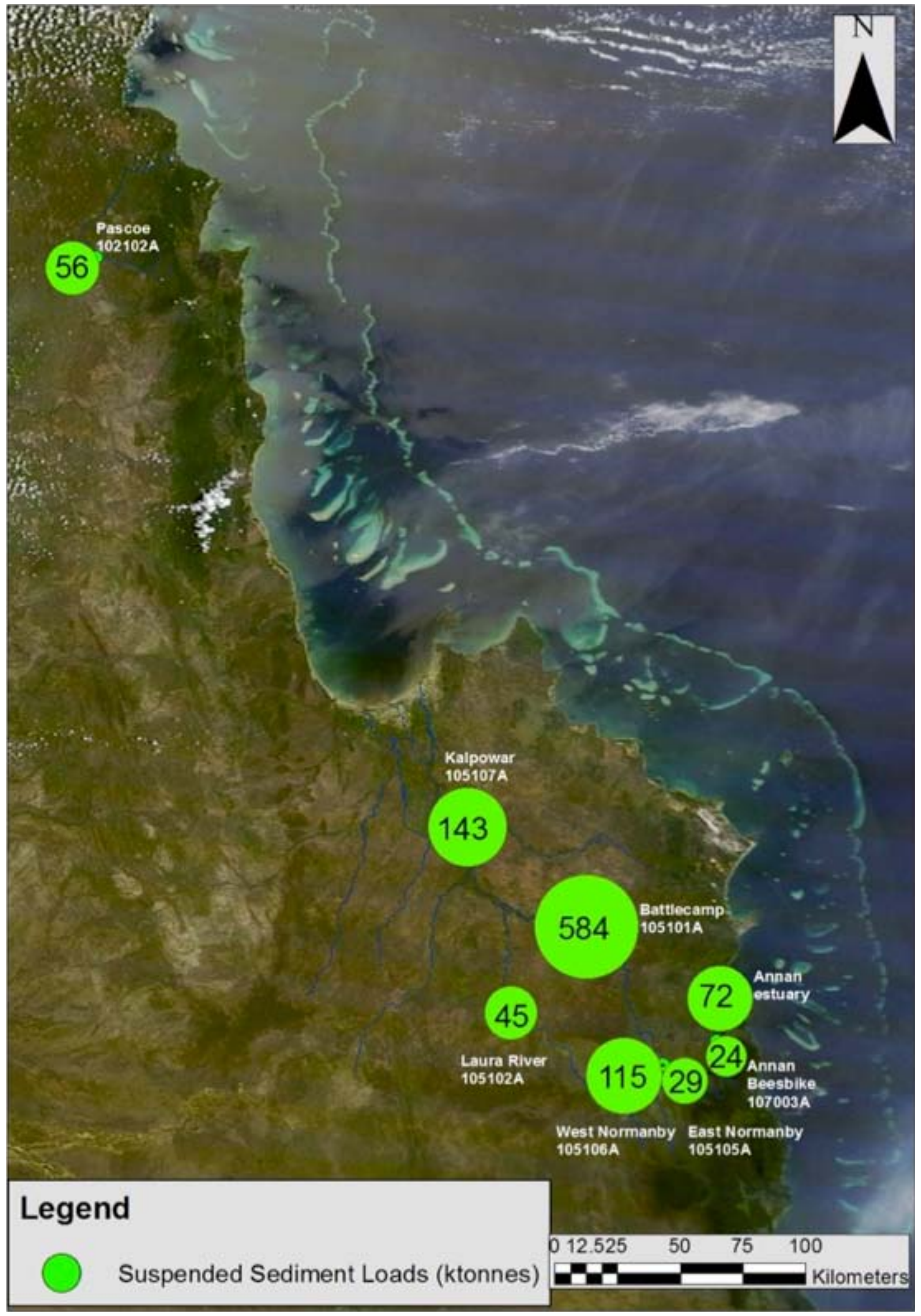



**Figure 14:** Average estimated annual suspended sediment load over the periods of intensive sampling for Pascoe, Normanby and Annan River gauge sites. The periods of sampling varied 1 to 7 years. The averages are presented only as a rough comparison of loads from different sub-catchments. Annual loads vary greatly depending on discharge and catchment conditions (Source: Appendix 8, Howley et al., 2016)



**Table 6:** Suspended Sediment and Nutrient Load Estimates for Pascoe, Normanby and Annan River gauge sites (Source: Appendix 8, Howley et al., 2016)

| Site Code | Water Year | Discharge | SS | TN | PN | DON | $NH_3$ | NOx | TP | PP | DOP | $PO_4$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | GL/year | ktonnes | tonnes | | | | | | | | |
| Pascoe River 102102A | 2014-15 | 1,315 | 56 | 527 | 142 | 254 | 12 | 69 | 21 | 17 | 13 | 1 |
| Normanby River at Kalpowar 105107A | 2006-07 | 1,766 | 58 | 723 | 170 | 499 | 22 | 36 | 87 | 20 | 49 | 23 |
| | 2007-08 | 3,649 | 206 | 1841 | 595 | 1143 | 53 | 43 | 167 | 30 | 70 | 78 |
| | 2008-09 | 2,350 | 101 | 1098 | 266 | 753 | 30 | 58 | 98 | 18 | 72 | 25 |
| | 2009-10 | 2,927 | 173 | 1326 | 65 | 1229 | 46 | 59 | 159 | 30 | 126 | 14 |
| | 2010-11 | 5,960 | 268 | 5605 | 481 | 839 | 68 | 74 | 318 | 31 | 159 | 141 |
| | 2011-12 | 1,162 | 46 | 494 | 139 | 338 | 9 | 13 | 87 | 3 | 65 | 28 |
| | 2012-13 | 1,828 | 142 | | | | | | | | | |
| | 2013-14 | 2,663 | 150 | 2069 | 623 | 1200 | 64 | 53 | 258 | 182 | 52 | 11 |
| Battlecamp 105101A | 2013-14 | 953 | 584 | 1589 | 1256 | 273 | 9 | 55 | 530 | 503 | 13 | 15 |
| Laura River 105102A | 2013-14 | 396 | 90 | 316 | 173 | 89 | 4 | 20 | 48 | 34 | 4 | 3 |
| | 2014-15 | 22 | 1 | 12 | 4 | 5 | 0 | 0 | 1 | 1 | 0 | 0 |
| East Normanby 105105A | 2013-14 | 166 | 38 | 135 | 71 | 32 | 1 | 26 | 16 | 14 | 2 | 1 |
| | 2014-15 | 94 | 19 | 83 | 40 | 21 | 1 | 11 | 10 | 8 | 1 | 0 |
| West Normanby 105106A | 2012-13 | 332 | 100 | 338 | 230 | | | | 68 | 50 | | 6 |
| | 2013-14 | 300 | 138 | 360 | 279 | | | | 79 | 64 | | 6 |
| | 2014-15 | 34 | 8 | 31 | 20 | | | | 6 | 4 | | 1 |
| Annan River Beesbike 107003A | 2014-15 | 303 | 24 | 142 | 67 | 44 | 2 | 37 | 21 | 19 | 3 | 1 |
| Annan River estuary | 2014-15 | 600 | 71 | 271 | 132 | | | | 38 | 32 | | |

The Reef 2050 Plan goal is to reduce end-of-river anthropogenic loads of suspended sediment and particulate nutrients by at least 20% by 2018. The Cape York WQIP Science Advisory Panel has determined that the 20% end-of-catchment anthropogenic load reductions for sediment and particulate nutrients are appropriate short-term (by year 2022) goals for disturbed catchments that are identified as priorities in eastern Cape York. End-of-catchment sediment loads in the most disturbed catchments are estimated to have at least doubled due to human disturbance (anthropogenic); this equates to a 10% total load reduction of end-of-catchment sites. However, in order to achieve this end-of-catchment reduction, a greater reduction is needed at the most disturbed upstream sub-catchments. A 50% anthropogenic sediment and particulate nutrient load reduction target (equating to 25% of total loads) was determined by the Science Advisory Panel to be a reasonable goal for these disturbed sub-catchment gauge sites, to achieve a 20% reduction of anthropogenic loads (10% of total loads) at end-of-river sites. These 25% (disturbed sub-catchment) and 10% end-of-catchment total load reductions for suspended sediments and particulate nutrients correlate to the flood event concentration reduction targets established in the Eastern Cape York Water Quality Guidelines Report (Appendix 9, Moss and Howley, 2016). For the less disturbed (HEV) catchments such as the Pascoe, the target is to maintain current water quality through management that ensures there is no increase in pollutant loads.

Applying reduction targets directly to annual loads values is problematic since these values vary depending on rainfall and other catchment factors. It is recommended that a percentage load reduction target is applied to individual flood events based on accurate (continuous) measurements of concentration and discharge, which can be used to evaluate ratings curves and to calculate event mean concentration (EMC) for each flood event.

Loads calculation methods, sampling frequencies, ratings curves, estimated loads tables and recommendations for future loads calculations are presented in the Eastern Cape York Sediment and Nutrient Loads Report (Appendix 8, Howley et al., 2016).

### Marine water quality

Several studies over the past 20 years have shown that ambient marine water quality in eastern Cape York is in good condition, and is generally in better condition than other GBR regions. Fabricius et al. (2005) found that water around inshore reefs in northern Princess Charlotte Bay (PCB) had lower nutrient, sediment and chlorophyll-a concentrations than reefs in the Wet Tropics, correlating to higher live coral cover, coral species richness and fish abundance in PCB. The Long-Term Chlorophyll-a Monitoring Programme (Brodie et al., 2007) found that inner-shelf waters adjacent to Cape York Peninsula had mean chlorophyll-a concentrations (0.21 μg/L) less than half that of inshore waters of the central and southern GBR (0.54 μg/L).

In contrast to ambient water quality, flood event and flood plume monitoring from the Annan, Endeavour and Normanby rivers (Southern and Central sections) have shown that high concentrations of suspended sediments are discharged from these rivers to the marine environment, where they regularly inundate inshore reefs and coastal seagrass meadows. Davies (1995) measured suspended sediment concentrations between 15-55 mg/L in an Annan River flood plume. In a comparison of Annan River and Daintree River flood events, Davies and Eyre (2005) found that the estimated sediment load discharged from the Annan River was significantly higher than the load from a larger magnitude flood event in the Daintree River. Nutrient yields from the Annan were also higher than those from the Daintree River for the events studied. Amongst GBR flood plume studies, plume samples from Princess Charlotte Bay (Normanby Basin event discharge) had the third highest mean suspended sediment concentration (21.3 mg/l) next to the Burdekin and Fitzroy River plumes (Howley et al., in prep; Devlin 2012). High dissolved nitrogen concentrations were also detected in Princess Charlotte Bay plumes. With the exception of the Normanby research and one small Annan River plume, few Cape York flood plumes have been sampled.

An assessment of all the available marine water quality data for the Northern, Central and Southern sections of eastern Cape York indicated that ambient water quality remains in relatively good condition for the open coastal, mid-shelf and offshore zones, however, there were some exceedances of the GBR marine water quality guidelines (Appendix 5). Mean particulate nitrogen and particulate phosphorus concentrations exceeded the GBR guidelines in both the dry season and wet season at a range of zones across all sections. Mean suspended sediment concentrations in the Central section for all zones and Northern open coastal zone also exceeded the guidelines. There were significant variations between the Northern, Central (Princess Charlotte Bay) and Southern sections, however it was difficult to draw conclusions about these findings due to the lack of consistent sampling regimes across each of the sections—for example, flood event data was only available from the Normanby Basin (Central section). The most notable difference was the elevated chlorophyll-a concentrations detected in the Southern enclosed coastal zone (Endeavour and Jeannie Basin receiving waters) during both the dry and wet seasons (Figure 15). Elevated Chlorophyll-a is an indicator of elevated nutrients in marine waters and there is a potential link between elevated Chlorophyll-a and crown-of-thorns starfish outbreaks in the Southern section of the region. Mean suspended sediment concentrations for the coastal and midshelf zones were slightly higher in the Central section during the dry season and were similar to the Southern section during the wet season (Figure 15). This may indicate that the fine suspended sediment from flood events in the Normanby, Annan and Endeavour Rivers, which is estimated to have increased by 50% from human land use, is being re-suspended during non-flood periods to impact water quality in the inshore marine environment of the Central and Southern sections of eastern Cape York.

For more information on marine water quality refer to the synthesis of marine water quality (Appendix 6, Howley, 2015) and the marine water quality guidelines (Appendix 5, GBRMPA, 2016)

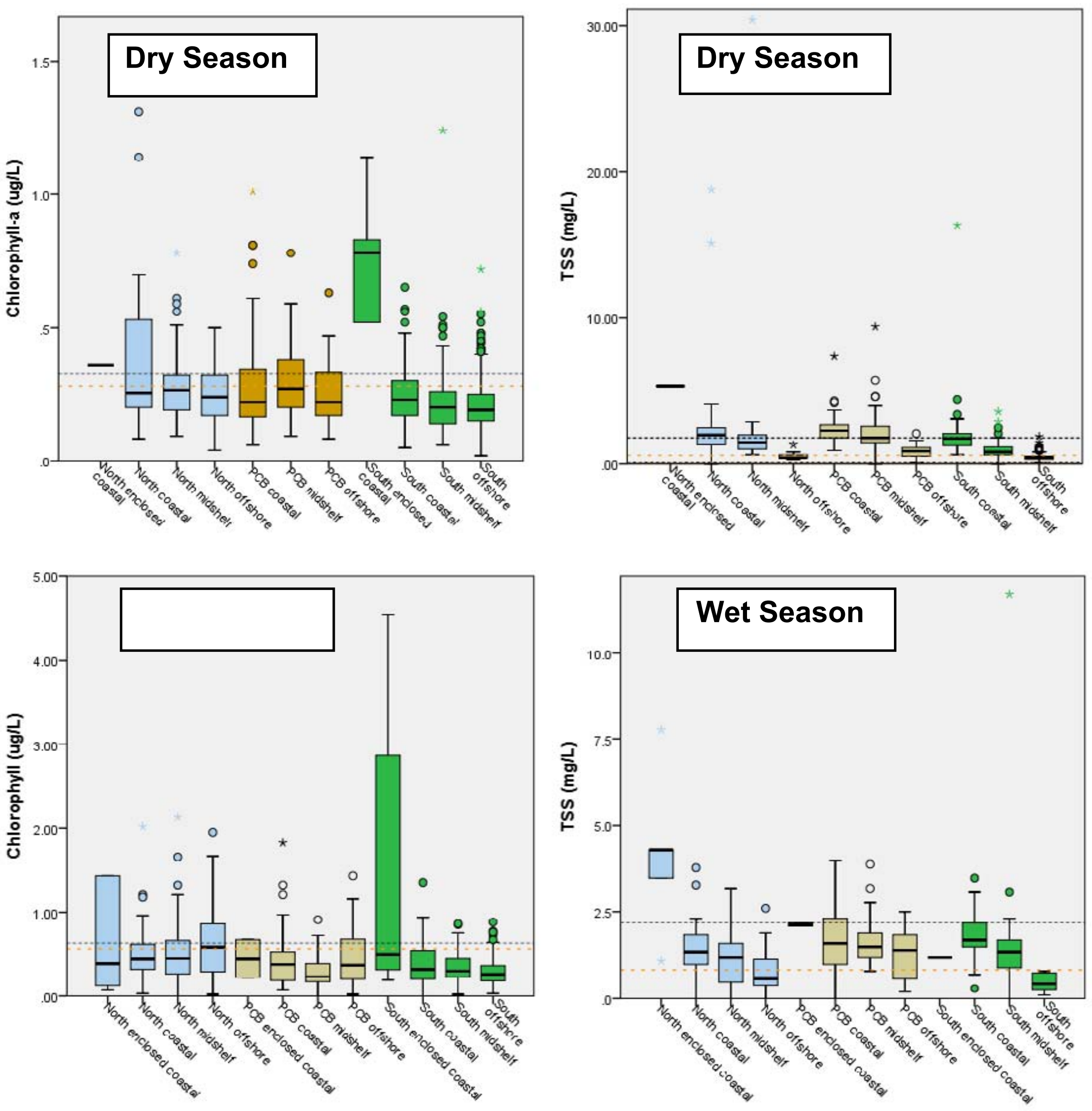



**Figure 15:** Wet and dry season marine water quality sampling results for chlorophyll and total suspended solids (TSS) for Northern, Central (PCB) and Southern sections of eastern Cape York.



## Current condition of ecosystem health

### Estuarine systems

The eastern Cape York region contains approximately 40,000 km2 of estuarine systems (mangroves, saltmarsh/salt flats and intertidal flats) and of the 49 estuaries surveyed in this region 47 (95.8%) were assessed as near pristine and two (4.2%) estuaries were assessed as largely unmodified (Australian Government, 2015). The catchment modifying factors were altered catchment hydrology (extractive industry and a weir) in the Annan River estuary and estuary use (port/port works) and land use (urban) in the Endeavour River estuary.

### Coastal wetlands

Coastal wetlands in the eastern Cape York region are primarily unmodified, and most catchments have retained almost all of the natural coastal wetland extent (Queensland WetlandInfo, 2015). Wetland extent is reported as part of the Paddock to Reef Program every four years. In the period between 2009 and 2013, no net loss of wetlands was reported in the Cape York Region (Queensland Government, 2015).

### Coral reefs

The total area of coral reef in the GBR World Heritage Area is estimated around 24,000 km2 (GBRMPA, 2014). The total area of coral reefs calculated in the eastern Cape York marine NRM region for this assessment is 10,354 km2 (Coppo et al., 2016) (derived from GBRMPA coral reef mapping). A large proportion of reefs are located in the Northern section.

The AIMS Long Term Monitoring Program has conducted coral reef surveys in the region, at 70 sites for broad scale surveys and 8 sites for intensive surveys (AIMS, 2015). At inner, middle and outer shelf reefs in the Northern section coral cover was very variable between reefs; 20-50%, 10-70% and 20-45% respectively. Hard coral cover in the Central section was 10-50%, 5-30% and 5-50% at inner, middle and outer shelf reefs. All reefs in the Southern section exhibited variable hard coral cover of between 10-50%. Average coral cover in the Northern section is higher than the Central and Southern sections of the region (Figure 16). Coral reefs in the Northern section are considered to be in very good condition while the reefs in the Central and Southern Sections are considered to be good. While the condition of most reefs in the Southern section is good, a decline in condition has been observed at some fringing and in-shore reefs in the Southern section over the past 20 years (Howley et al., 2007).

The generally high coral cover and very good condition of reefs in the Northern section of eastern Cape York mirrors similarly high levels on the contiguous reefs of the Torres Strait section of the GBR (Sweatman et al., 2015). It should be noted that the differences in coral condition may reflect natural variations in ambient conditions as well as variations arising from land use and water quality impacts. The most significant threats to the viability of reefs in eastern Cape York are reduced water quality and increased storm damage and coral bleaching due to climate change (Coppo et al., 2016).

At the time of finalising this plan (early 2016), the northern GBR experienced a significant mass coral bleaching event that is likely to result in high levels of coral mortality along all the reefs adjacent to eastern Cape York. This coral bleaching event can be attributed to climate change, however, in the short term the practical mechanism for improving the recovery and resilience of the affected coral reefs is to take action to improve water quality in eastern Cape York catchments.

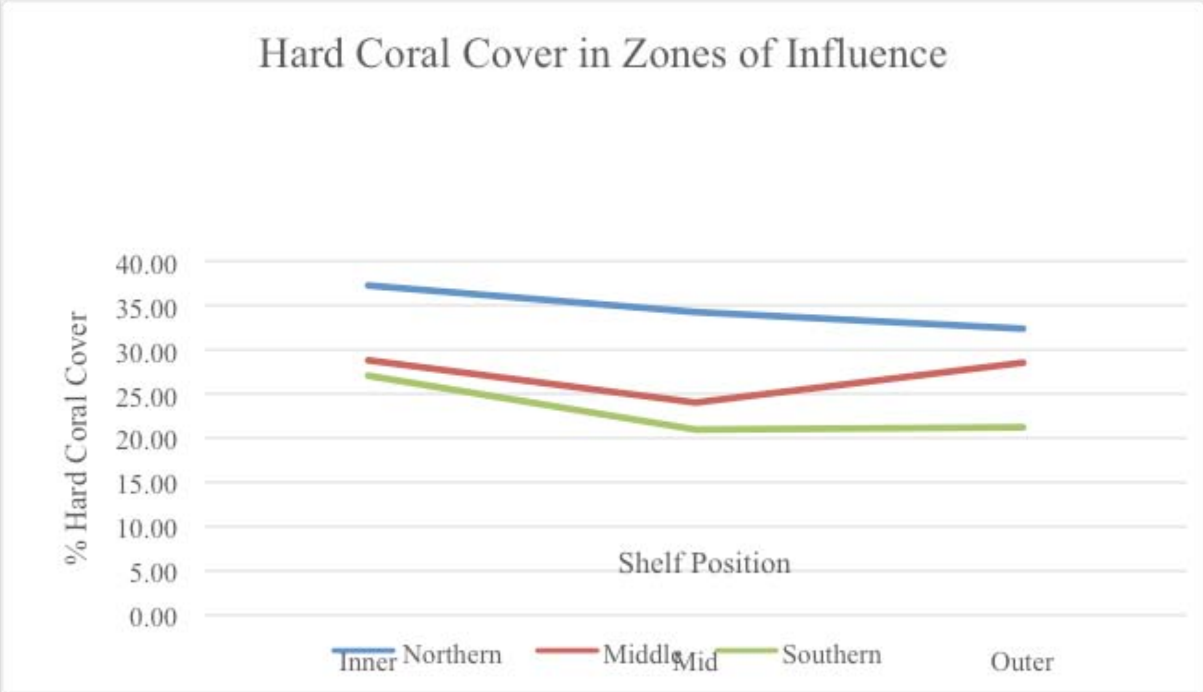



**Figure 16:** Average hard coral cover of inner, mid and outer shelf reefs within the Northern, Central and Southern Sections of eastern Cape York (Source: Appendix 7, Coppo et al., 2016)

## Potential Biodiversity Impact Matrix

Will Higham (Cape York NRM) and Jessie Price (South Cape York Catchments)

Little is currently known about the marine water quality thresholds for a wide range of individual coral species; however, there are some species of coral that are more sensitive to water quality degradation. As marine water quality declines, the more sensitive species of a coral reef ecosystem are lost and the less sensitive species dominate, resulting in a loss of biodiversity and decline in reef condition. The marine water quality threshold that would degrade a coral reef in Very Good condition down to Good condition is not currently defined.

The Marine Risk Assessment process that informs this plan provides a visual representation of the relative risk of degraded water quality to the marine environment and has been used by many others to prioritise investment at both GBR-wide and regional scales. A major limitation to interpretation of the marine risk assessment in the northern GBR is that the current condition of a reef ecosystem is not factored when calculating relative risk of water quality. For example, a coral reef ecosystem defined as Very Good condition in a relative risk area has a much greater potential for biodiversity impact (i.e. species loss), than a Moderate condition reef in the same relative risk area.

A Potential Biodiversity Impact Matrix has been developed to overcome these limitations and support interpretation of the relative risk assessment mapping and decision-making in the Eastern Cape York Water Quality Improvement Plan.

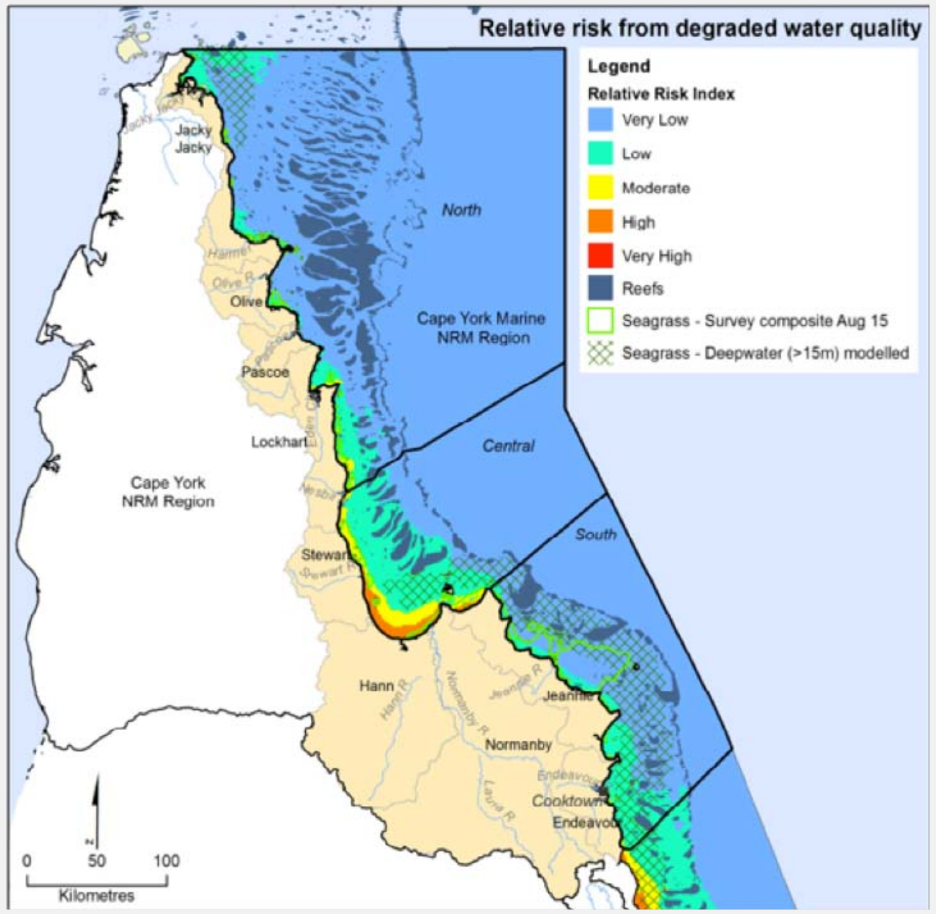
The Potential Biodiversity Impact Matrix shows that as current reef condition increases from poor to very good, and the relative risk of degraded water quality increases from very low to very high, the potential biodiversity impact increases from very low to catastrophic. When applying this matrix to the Marine Risk Assessment for eastern Cape York, the Southern and Central sections are considered to be in good condition, and the Northern section is considered to be in very good condition.

To interpret the Marine Risk Assessment for eastern Cape York we used this Potential Biodiversity Impact Matrix to modify the map of relative risk to water quality to an indicator of potential biodiversity impact from degraded water quality.

| Potential Biodiversity Impact Matrix | | | | |
|---|---|---|---|---|
| Relative Risk of degraded water quality | Current Reef Condition | | | |
| | Poor | Moderate | Good | Very Good |
| Very Low | Very Low | Very Low | Low | Low - Medium |
| Low | Very Low | Low | Medium | High |
| Moderate | Low | Medium | High | Very High |
| High | Medium | High | Very High | Catastrophic |
| Very High | High | Very High | Catastrophic | Catastrophic |

When applying this matrix to the Marine Risk Assessment for eastern Cape York:

- The Northern section is considered to be Very Good condition
- The Southern and Central sections are considered to be Good condition



## Seagrass

Approximately 35,000 km2 of potential seagrass habitat has been mapped in the coastal waters around Queensland and Torres Strait since the mid-1980s (McKenzie et al., 2010). These surveys, plus statistical modelling of seagrass in deeper offshore waters, show that 37,454 km2 of the sea floor within the Great Barrier Reef World Heritage Area and Torres Strait has some seagrass present making Queensland's seagrass resources globally significant (Coles et al., 2011). The total area of potential seagrass habitat (surveyed) in the marine NRM region for Cape York is 2,668km2 (TropWATER, 2013) and the modelled deep water (>15m) seagrass estimate is 5,668km2 (Coles et al., 2009). The combined total of 12,218km2 accounts for ~35% of the total area reported for the GBR. A large proportion of surveyed seagrass and deep water modelled seagrass are in the Southern section.

Regular seagrass monitoring through the Marine Monitoring Program indicates that the status of seagrass condition in the eastern Cape York region is poor. Coastal intertidal seagrass abundance was very good in the Central section, poor in the Northern section and not monitored in the Southern section. Intertidal reef seagrass abundance is moderate, very poor and poor in the Northern, Central and Southern sections respectively. A higher proportion of colonising species and declining and very poor reproductive effort may suggest weaker ecosystem resistance to perturbations and a more vulnerable state for seagrass meadows in this region.

The largest, and potentially least disturbed, coastal seagrass meadows (primarily sub-tidal) in eastern Cape York (those of the Southern section between Cape Flattery and Cape Melville) have not been monitored and their condition is not reflected in this assessment. Extensive seagrass meadows have been mapped in the Southern section in areas such as Walker Bay (Annan catchment), Elim Beach and near the mouth of the Starcke River (Howley, unpublished). The results of these surveys indicate that there are large areas of coastal seagrass meadows (intertidal and sub-tidal) in the Southern section that are in good condition.

## Dugongs

Dugong populations along the Eastern Cape York regional coastline, as well as around large reefs in Princess Charlotte Bay, had high to very high (>0.5 dugongs/km2) relative dugong density and modelling of survey results indicate an almost continuous distribution of dugong along the Eastern Cape York regional coastline. The very high dugong population densities in Cape York waters are similar to those found in the contiguous Torres Strait section of the GBR to the north of Cape York.

Climate change, coastal development and increases in terrestrial pollutants (sediment, nutrients and pesticides) are all considered potential threats to the coastal and marine assets of the eastern Cape York region, particularly in the Central and Southern sections where anthropogenic effects are more likely.

Dugong (Photo: Unknown)



## Sediment and Cape York

Jon Brodie, James Cook University

The fine sediment, clay minerals and associated nutrients are the components of river discharge which have short time lags in delivery to the GBR (Brodie et al. 2012b; Lewis et al. 2015a, b) and are associated with effects that directly impact the biology of reef species and ecosystems such as increasing turbidity in coastal waters and loss of light for benthic species (Fabricius et al. 2014, 2016), coral disease (Haapkyla et al. 2011), COTS outbreaks (Wooldridge and Brodie 2015), seagrass loss also associated with increased turbidity and reduced light (Petus et al. 2014; McKenzie et al. 2015) and the connected decline in dugong populations (Devlin et al. 2012 ICRS; Coppo et al. 2014, 2015).

The suspended sediment of most risk to the GBR is the fine fraction sometimes defined as that smaller than 15.7 μm, i.e. below the fine silt boundary and containing the clay and fine silt particle size fractions (Bainbridge et al., 2012, 2014, 2016; Bartley et al., 2014; Douglas et al. 2008) or of even more risk, just the clay mineral fraction <4 μm (Bainbridge et al. 2016) as this is the material which contains most of the nitrogen and phosphorus content (and other contaminants); is transported furthest in flood plumes (as organic rich flocs – Bainbridge et al. 2012 – Figure 1), rather than all depositing near the river mouth (Lewis et al., 2014, 2015a, b; Delandmeter et al. 2015); stays in suspension longest and is most effective at attenuating light when in suspension (Storlazzi et al. 2015) and results in the greatest degree of resuspension throughout the months following the river discharge event as seen in the marine waters of Cape York (Fabricius et al. 2016 - Figure 2).

The increased fine sediment supply from rivers (Kroon et al. 2012; Waters et al. 2014) and the resultant potential increased turbidity and sedimentation can have severe impacts on GBR organisms such as reef fish (e.g. Wenger et al. 2011, 2012, 2013, 2014; Hess et al. 2015; Gordon et al. 2015) through effects on juvenile recruitment and feeding; corals through sedimentation (e.g. Weber et al., 2006, 2012; Flores et al., 2012; Pollock et al. 2014); decreased light (Fabricius et al. 2013, 2014, 2016); and increasing the competitive advantage of macro-algae and turf algae over corals (Gowan et al. 2014; Goatley and Bellwood 2012, 2013); and seagrass (Collier et al., 2012, Petus et al., 2014). Suspended sediment also interacts with other stressors to increase the overall impact of multiple stressors on coral reefs (Ban et al. 2014; Risk 2014; Graham et al. 2015). Resuspension of sediment in windy conditions or strong tidal currents in shallow waters (<15 m) leads to conditions where suspended sediment concentrations are above the GBR water quality guidelines (De'ath and Fabricius, 2008; Great Barrier Reef Marine Park Authority, 2010), and this threatens coral reefs and seagrass meadows through reduced light for photosynthesis (Bartley et al. 2014).

Figure 1 shows flocs comprised of fine sediment particles bound by transparent exopolymer particles (e.g. mucus) forming large mud flocs, with floc size increasing with depth. Samples captured along Plume Transect (bottom section) show an increase in biological production, i.e. presence of diatoms and cellulose/gelatinous plankton castings often aggregated with small mud flocs.

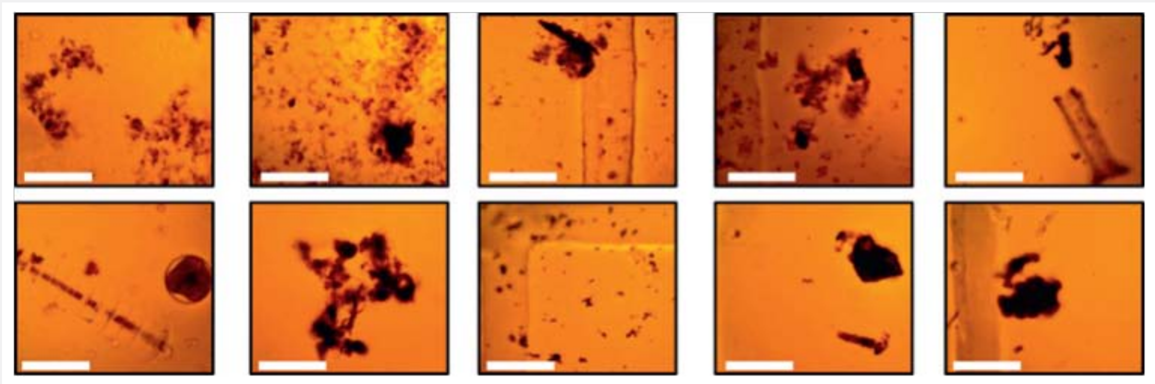


**Figure 1:** Organic rich flocs containing a mixture of fine sediment, mucus and plankton in the Burdekin River flood plume (from Bainbridge et al. 2012).

In Figure 2 it can be seen that photic depth, in the inshore area of Cape York marine waters, starts to decline from average values of 7 metres before the period of heavy rainfall (December) to 4 metres by May. This decline is driven briefly by the presence of flood plumes themselves but over the next four months by resuspension of the fine sediment-associated flocs deposited from the flood plumes into waters less than about 15 metres deep. Following May photic depth gradually improves as the fine sediments are winnowed away and redeposited into mangroves or deeper waters out of reach of further resuspension.

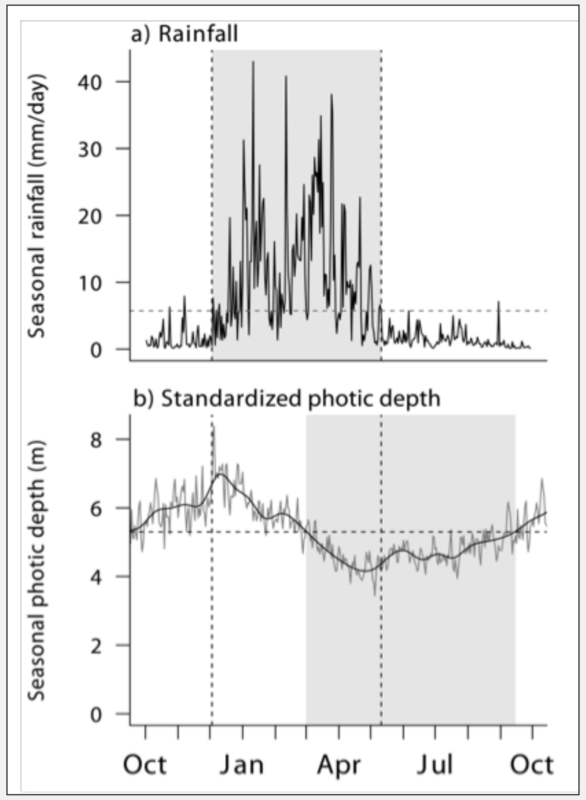



**Figure 2:** Seasonal cycles of river discharges and photic depth following decomposition of the seasonal components of the time series. Shown here the 'Inshore' zones within the Cape York, all years combined (Cape York example drawn from Fabricius et al. 2016).



## Relative risk of water quality

A spatial assessment of the relative risk of water quality to key coastal and marine assets in the eastern Cape York region was conducted to inform the Eastern Cape York Water Quality Improvement Plan, using consistent methods with those used in other GBR regions (Appendix 10, Waterhouse et al. 2016). The assessment takes into account a suite of water quality variables that represent the pollutants of greatest concern to the GBR with regards to land-sourced pollutants and potential impacts on coral reef and seagrass ecosystems. These include exceedance of ecologically-relevant thresholds for concentrations of total suspended sediments (TSS) from remote sensing data, chlorophyll a (Chl-a) obtained from long term in-situ monitoring data, and the distribution of key pollutants including TSS, dissolved inorganic nitrogen (DIN), particulate nitrogen (PN) and photosystem II-inhibiting herbicides (PSII herbicides) in the marine environment during flood conditions (based on end-of-catchment loads and plume loading estimates). A factor that represents the direct influence of crown-of-thorns starfish (COTS) on coral reefs in the COTS Initiation Zone was included in previous GBR-wide assessments but was revised for the eastern Cape York situation and accounted for in the discussion.

In the combined assessment of the relative risk of marine water quality variables, it is notable that there are no areas in the Very High relative risk assessment class in the region (Figure 17a), in contrast to other NRM regions where large proportions of the inshore areas are in the highest risk classes (Figure 17b). A majority of the region is within in Very Low assessment class (87% of the area) which extends out to the Marine Park boundary, containing 84% of the coral reefs, 51% of the surveyed seagrass and 70% of the deep water modelled seagrass in the region. The Low relative risk class extends to the offshore waterbodies in the central part of the region and contains 15% of the coral reefs and ~30% of the surveyed and deep water modelled seagrass. The greatest area of influence from degraded water quality is in Princess Charlotte Bay where High relative risk assessment classes extend to the midshelf waterbodies of the Bay. The total area of the High relative risk class (717km2; <1% of the region's area) contains ~6% of the region's surveyed seagrass and <1% of coral reefs and deep water modelled seagrass. The Moderate relative risk class extends to the outer parts of Princess Charlotte Bay and in some coastal areas northward to the Lockhart River mouth. It contains approximately 14% of the region's surveyed seagrass.

The Normanby Basin (Central section) had much more supporting data than the other catchments, and this limited the capacity to produce a true assessment of risk in other sections. There are no accurate end-of-catchment load estimates for most Cape York rivers, and the modelled load data used in the risk assessment has been shown to underestimate sediment loads from the Annan river (Southern section) by as much as 1/7th of the actual load (Howley et al., 2016). There is also little plume monitoring other than the Normanby River, and cloud cover masks satellite images of flood plumes on wetter coasts. The magnitude and frequency of flood plumes from many coastal rivers, and the concentrations of pollutants in the marine environment during flood conditions is unknown. As a result, the risks to reefs and seagrass meadows outside of the Central section remain poorly quantified. Although this was not reflected in the risk assessment, the monitored sediment and nutrient loads from the Annan River (Shellberg et al. 2016, Howley et al. 2016), and high TSS and chlorophyll-a concentrations (Davies and Hughes 1983, Davies and Eyre 2005; Howley 2015) provide substantial evidence that there is a moderate to high risk to inner-shelf reefs and seagrass meadows in the Southern section from the Annan and Endeavour catchments.

The consequences of increased stressors to reefs and other ecosystems which are currently in good condition are more severe than if the ecosystems are already in poor condition. This risk differential is shown in the Potential Biodiversity Impact Matrix in the coral reef section above and in the Marine Risk Assessment report (Waterhouse et al. 2016). The use of the Potential Biodiversity Impact Matrix approach in a conservation management framework would modify the rankings in the Risk Assessment and hence the management priority approach.

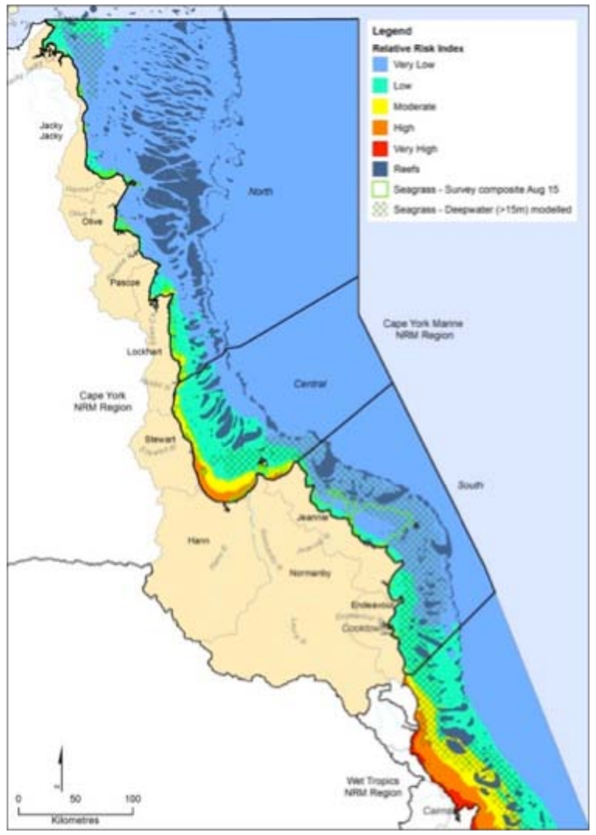



**Figure 17 (a):** Results of the combined assessment of the relative risk of water quality variables in the Cape York region. Note that much of this influence is driven by sediment variables.

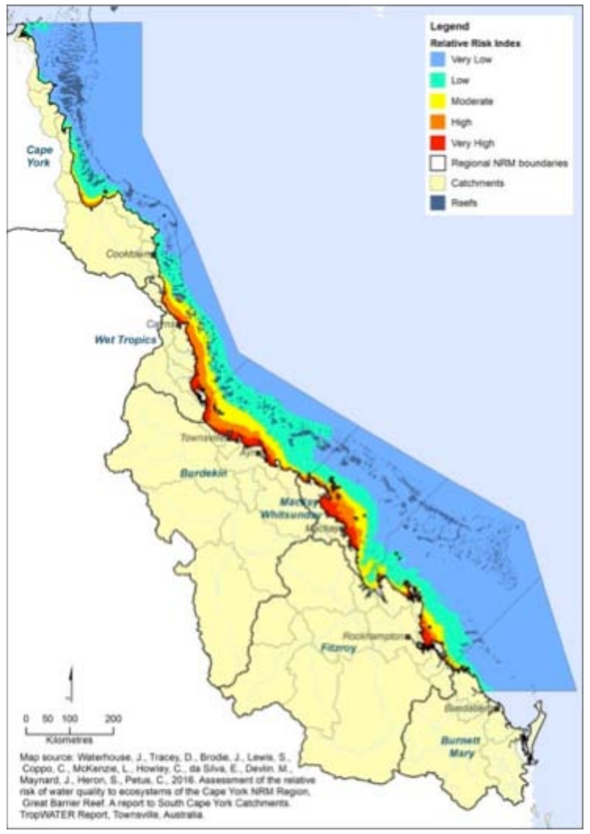



**Figure 17 (b):** Results of the combined assessment of the relative risk of water quality variables in the GBR. (Source: Waterhouse et al. Marine Risk Assessment, 2016)



## Zones of influence of river flood plumes

Modelling of river plumes in the region between 2009 and 2013, and definition of 'zones of influence' for river plume waters in the wet season indicates that the Normanby River dominates the water quality influence in the region (Waterhouse et al. 2016). The zone of influence extended as far north as Cape Grenville during the 2010-11 wet season, although the southern extent of the estimated zones of influence were still within Cape Melville, reflecting the northward movement of the plumes and the role of Cape Melville in steering water inside Princess Charlotte Bay. Additional studies have also shown that while the plumes typically move in a northerly direction driven by south easterly winds, there are conditions when the plumes are deflected outwards in an easterly direction, as shown in Figure 18 (Petus and da Silva unpublished, Howley et al. unpublished). There is a possibility that the nutrients delivered to reefs in these plumes could increase crown-of-thorns starfish (COTS) larvae survival and contribute to secondary outbreaks of CoTs in Princess Charlotte Bay. Further analysis of future flood plumes and COTS populations are required to clarify the relationship between river discharges and COTS populations in the northern GBR.

The estimated zones of influence from the Stewart, Hann and Normanby River all overlap to some extent in Princess Charlotte Bay which contains notable areas of surveyed potential seagrass habitat and deep water modelled seagrass. It should be noted that the modelled zones of influence for the Endeavour River typically extend north to Cape Flattery and as far south as the southern NRM boundary (zones of Influence for rivers of the Jeannie Basin have not been estimated). This area contains the largest area of surveyed potential seagrass habitat and deep water modelled seagrass than any other river zone of influence.

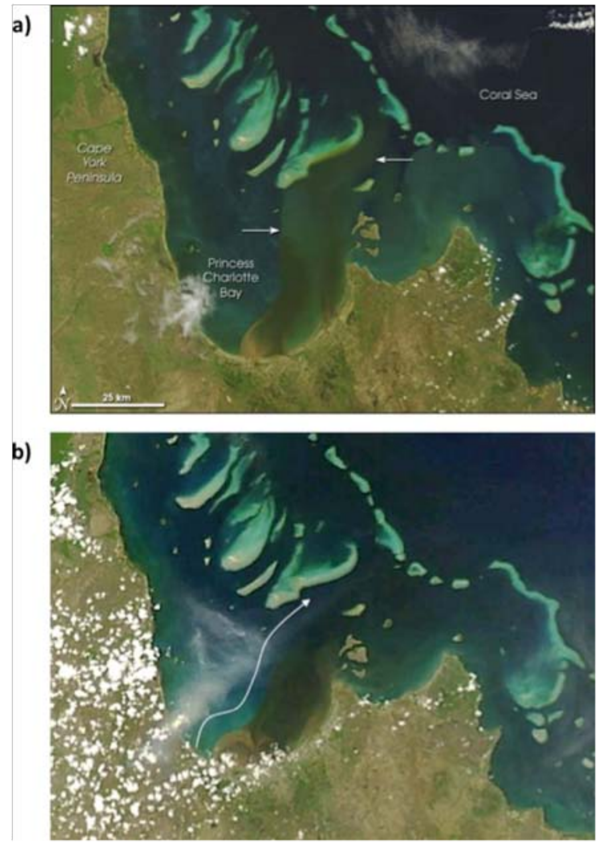



**Figure 18:** MODIS true colour images of the 9th of February 2007 and 31th of January 2013 showing Princess Charlotte Bay river plumes deflected to the right and reaching coral reefs. (Source: Petus and da Silva, unpublished).

## Relative risk of water quality to important habitat features

Results of the relative risk assessment for important habitat features in the eastern Cape York region are summarised in Table 7. This highlights that many of the ecosystems in the region are still considered to be in good condition and are at relatively low risk from water quality influence. Importantly, in the northern rivers where there is limited development in the catchments, the water quality conditions are driven by natural conditions such as ocean upwelling of nutrients in the Southern section of the region (associated with Halimeda banks), and natural turbidity in shallow coastal waters. As a way of linking these results to catchment water quality influences, modelled end-of-catchment pollutant loads (generated from the Source Catchments model framework for the Paddock to Reef Program) were obtained for each basin for key pollutants (TSS, DIN, PSII herbicides, PN, Dissolved Inorganic Phosphorus and Particulate Phosphorus), and only the anthropogenic portions of regional total pollutant loads were considered in relating the relative risk to the basins. The anthropogenic load is calculated as the difference between the long term average annual load, and the estimated pre-European annual load. In addition, the input variables represent longer term time series, and in most cases, represent average conditions. While they provide a rough indication of anthropogenic load, the end-of-catchment models are considered to be very low reliability for eastern Cape York rivers (Brooks et al. 2013, Howley et al. 2016) due to the lack of monitoring data to inform model development.



**Table 7.** Results of the relative risk assessment for important habitat features in the East Cape York Region. (Source: Waterhouse et al. (2016).

| Section | Habitat Feature | Description | Potential Biodiversity Impact | Relative risk of water quality | Likely rivers of influence |
|---|---|---|---|---|---|
| **Northern** | *Escape River and Kennedy Inlet System* | *FHA; WNI; the most extensive stand of medium–tall mangroves in QLD.* | *Moderate/ High* | *Very Low/Low* | *Limited* |
| | *Margaret Bay, Lloyd Bay and Cape Grenville Area* | *FHA; WNI; outstanding seagrass beds (size and diversity); important dugong habitat; significant wetlands for wading birds.* | *Moderate/ High* | *Very Low/Low* | *Limited* |
| | *Raine Island* | *Largest known green turtle rookery; most significant seabird rookery in the GBRWHA; NP.* | *Low/ Moderate* | *Very Low* | *Limited* |
| | *Temple Bay* | *FHA; WNI.* | *Moderate/ High* | *Very Low/Low* | *Olive Pascoe* |
| | *Weymouth Bay* | *High seagrass diversity.* | *Moderate/ High* | *Very Low/Low* | *Olive Pascoe* |
| | *Olive River* | *WNI.* | *Moderate/ High* | *Very Low/Low* | *Olive* |
| | *Cape Direction* | *High seagrass diversity* | *High* | *Low* | *Lockhart* |
| **Central** | *Silver Plains* | *FHA; important hawksbill turtle habitat.* | *Moderate* | *Low* | *Stewart* |
| | *Princess Charlotte Bay* | *FHA; WNI; one of the largest tidal wetland areas in Australia; high seagrass diversity; important green turtle foraging grounds and dugong habitat.* | *High/Very High* | *Moderate/ High* | *Normanby, Hann, Stewart* |
| | *Marina Plains—Lakefield Aggregation* | *WHI; >100 permanent riverine lagoons.* | *High/Very High* | *Moderate/ High* | *Normanby* |
| | *Clack Reef Complex* | *WHI; small continental island with fringing reef and seagrass.* | *Moderate* | *Low* | *Normanby* |
| | *Flinders Island Group* | *Inner shelf high continental islands with fringing reef and seagrass.* | *Moderate/ High* | *Low/ Moderate* | *Normanby* |
| **Southern** | *Bay Creek, Cape Melville—Bathurst Bay* | *WNI; Amongst best representative mangroves on CY.* | *Low/ Moderate* | *Very Low/ Low* | *Limited* |
| | *Lizard Island* | *Unique granitic high continental islands with fringing reef and a lagoonal system.* | *Low* | *Very Low* | *Limited* |
| | *Starcke River* | *FHA; one of the most varied Cape York coastlines.* | *Low/ Moderate* | *Very Low/ Low* | *Limited* |
| | *Howick Island Group* | *Important turtle nesting area.* | *Low* | *Very Low* | *Limited* |
| | *Cape Flattery Dune Lakes wetland* | *WNI; In largest dune field (international significance) on the east coast, north of Fraser Is.* | *Low/ Moderate* | *Very Low/ Low* | *Endeavour* |
| | *Barrow Point—Cedar Bay* | *High seagrass diversity.* | *Moderate* | *Low* | *Endeavour, Annan* |
| | *Annan River* | *FHA.* | *Moderate* | *Low* | *Endeavour, Annan* |

**FHA** - Fish Habitat Area;
**WNI** - Wetland of National Importance

The assessment based on modelled loads data indicated that the Normanby catchment dominates the contributions to the regional anthropogenic loads for all parameters. It also assumes that much of the dissolved nutrients in the marine assessment are not likely to be derived from human-induced sources, although a potentially significant portion of dissolved inorganic nutrients is derived from the accelerated erosion of fine clays. In contrast, it is estimated that about half of the regional TSS load, and up to half of the particulate nutrient loads are from human-induced (anthropogenic) sources (McCloskey et al. in review). Taking these influences into account, Waterhouse et al. (2016) estimated that the relative risk of degraded water quality in the eastern Cape York region is greatest from the Normanby Sub Basin, followed by the Hann Sub Basin and the Stewart Basin, indicating a need to significantly improve management practices to reduce priority sediment sources in the Central section of the region. Further analysis of the sediment related parameters shows that almost 15 percent of the seagrass in the region is in the Moderate relative risk class, including large areas of deep water modelled seagrass in Princess Charlotte Bay and around the Cooktown coastal areas, although these southern areas are also likely to be influenced by the northern movement of the Wet Tropics river plumes.

While the risk assessment clearly highlights the Normanby Basin as a priority for land management to improve water quality, the potential risk the other sections pose to reefs or seagrass meadows remains poorly quantified. Catchments such as the Endeavor, Annan, McIvor and Starke, have experienced intensive land use (urban, rural residential, mining, grazing, agriculture, forestry and roads) and have an increasing level of disturbance. New agricultural and urban developments may impact previously less disturbed rivers. Southern Cape York rivers are directly connected to fringing, inshore, and mid-shelf reefs, as well as extensive coastal seagrass meadows, which are vulnerable to increased levels of sediment and nutrient pollution. Rivers in the Endeavour and Jeannie Basins also discharge directly into the crown of thorns starfish initiation area for the whole Great Barrier Reef.

The potential biodiversity impact and relative risk of water quality to important habitat features presented in Table 7 indicate that there is likely to be increasing threats for some marine and coastal ecosystems due to the cumulative pressures of potentially declining water quality in the Central and Southern sections, secondary crown of thorns starfish outbreaks, extreme cyclone and flooding events and climate change. Addressing chronic stressors, such as declining water quality, are important for maintaining and improving ecosystem condition in order to maintain ecological resilience and decrease the sensitivity of coral reefs and seagrass meadows to episodic disturbances, the frequency of which is likely to increase with the impact of climate change.

For more information on marine ecosystem health refer to the status of coastal and marine assets (Appendix 7, Coppo et al., 2016) and the marine risk assessment (Appendix 10, Waterhouse et al., 2016).



## Water Quality Objectives, Water Quality Targets and Management Action Targets

Water Quality Objectives, Water Quality Targets and Management Action Targets are based on an integrated understanding of current condition of freshwater quality, marine water quality and marine ecosystem health, land use and disturbance, management actions, and practical implementation strategies. Table 8 presents the general rules used to define Water Quality Objectives for end-of-catchment load reductions to be achieved by the year 2050, Table 9 presents Current Condition in the year 2015 and Water Quality Targets set for the year 2022 and Table 10 presents Management Action Targets set for the year 2022 for priority sub-catchment load reductions along with scale of management action to achieve Management Action Targets.

Current Condition 2015 for End-of-Catchment anthropogenic load (human induced load) has been estimated through detailed analysis of wet season event water quality monitoring results for the Normanby, Pascoe and Annan Rivers the spatial pattern and intensity of catchment land use and disturbances for all catchments and through Science Advisory Panel consensus.

Water Quality Objectives 2050 for End-of-Catchment load reductions have been defined based on the best estimates of Current Condition 2015 End-of Catchment anthropogenic loads and the load reductions that could be achieved if all recommended management actions were widely adopted for all catchment land uses and disturbances. See Table 8 for general rules to define Water Quality Objectives.

**Table 8:** General rules applied to define the Water Quality Objectives 2050 for End-of-Catchment load reductions

| Current Condition 2015 for End-of-Catchment anthropogenic load as % of total load | General rules to define the Water Quality Objectives to be achieved by the year 2050 for End-of-Catchment load reductions |
|---|---|
| 10% FSS (Fine Suspended Sediment) | Maintain Current Condition and undertake priority management actions to offset and minimise the impact of both existing and new development within the sub-catchment |
| 30% FSS (Fine Suspended Sediment) | Undertake priority management actions to reduce total fine suspended sediment load by 20%. |
| 50% FSS (Fine Suspended Sediment) | Undertake priority management actions to reduce total fine suspended sediment load by 30%. |
| 50% DIN (Dissolved Inorganic Nitrogen) | Undertake priority management actions to reduce dissolved inorganic nitrogen load by 25% |

Water Quality Targets set for the year 2022 for End-of-Catchment load reductions have been defined based on the Reef 2050 Plan targets of 20% reduction in anthropogenic fine suspended sediment load and 50% reduction in anthropogenic dissolved inorganic nitrogen loads within priority sub-catchments by the year 2018. These water quality targets set for eastern Cape York are considered to be achievable by 2022 if the implementation strategy is resourced appropriately to enable the priority management actions within each section, basin, and sub-catchment to be implemented in priority sub-catchments. However, the improvements in water quality from investments in improved land management have the potential to be negated by new intensive land use developments.

Water Quality Targets set for the year 2022 for End-of-Catchment load reductions have been presented as percent reduction in total load. Due to the degree of uncertainty in the anthropogenic load estimation, it is more practical to develop monitoring protocols to measure improvement in total load as a result of adoption of recommended management actions. Improvements in water-quality monitoring practices in Cape York will allow for more accurate total load estimates and monitoring of load reductions into the future.

Management Action Targets set by the Scientific Advisory Panel for the year 2022 for Priority Sub-catchment load reductions presented as a percent reduction in total load, have been developed based on review of all available sub-catchment water quality data, and consideration of catchment sediment deposition processes and time lags associated with achieving End-of-Catchment water quality.

For fine suspended sediment, to achieve an End-of-Catchment load reduction target, a 2.5x sediment reduction target would need to be achieved within the priority sub-catchments for anthropogenic sediment sources.

For dissolved inorganic nitrogen, as long as all high priority sub-catchments for agricultural and urban nitrogen sources are targeted for improvement, the sub-catchment reduction target and the end-of-catchment dissolved inorganic nitrogen reduction target are the same.

For more information on water quality datasets and the spatial pattern and intensity of catchment land use and disturbance refer to the loads report (Appendix 8, Howley, 2016) the water quality guidelines report (Appendix 9, Howley and Moss, 2016) and the disturbance index report (Appendix 1, Spencer et al., 2016).

### Target summary

Basins within the northern Great Barrier Reef catchment can be generally classified into the following two water quality goals:

**1. Improvement to meet Reef 2050 Plan targets** - Improving water quality from current condition to achieve a 15% to 25% reduction in fine suspended sediment load in priority sediment sources at sub-catchment scale by the year 2022.

**2. Maintenance and prevention** - Maintaining current condition of water quality and preventing new developments or increasing disturbance from increasing sediment load in the sub-catchment. For some of these less developed systems, further characterisation of land disturbances and water quality impacts are necessary to quantify current condition.

The drainage basins within the planning area have been allocated the following water quality goals:

Jacky Jacky - Maintenance and prevention
Olive - Maintenance and prevention
Pascoe - Maintenance and prevention
Lockhart - Maintenance and prevention
Stewart - Improvement to meet targets
Hann - Improvement to meet targets
Normanby - Improvement to meet targets
Jeannie - Improvement to meet targets
Endeavour - Improvement to meet targets



**Table 9:** Current Condition (2015), Water Quality and Management Action Targets (2022)

| **Basin** | **Sub-catchment** | **Aquatic EV Status** | **Current Condition 2015**<br><br>**End-of-Catchment anthropogenic load as % of total load**<br><br>**Bold** = load monitoring site | **Water Quality Target 2022**<br><br>**End-of-Catchment load reduction target as % of total load** | **Management Action Target 2022**<br><br>**Priority Sub-Catchment load reduction target as % of total load** |
|---|---|---|---|---|---|
| **Jacky Jacky** | Jacky Jacky Creek | HEV | 10% FSS | MCL | MCL |
| | Escape River | HEV | 10% FSS | MCL | MCL |
| | Harmer Creek | HEV | 10% FSS | MCL | MCL |
| **Olive** | Glennie Creek | HEV | 10% FSS | MCL | MCL |
| | Kangaroo River | HEV | 10% FSS | MCL | MCL |
| | Olive River | HEV | 10% FSS | MCL | MCL |
| **Pascoe** | Garraway Creek | HEV | 10% FSS | MCL | MCL |
| | Yam Creek | HEV | 10% FSS | MCL | MCL |
| | Hann Creek | HEV | 10% FSS | MCL | MCL |
| | **Pascoe River** | HEV | **10% FSS** | MCL | MCL |
| **Lockhart** | Wilson Creek | HEV | 10% FSS | MCL | MCL |
| | Claudie River | HEV | 30% FSS | 6% FSS | 15% FSS |
| | Scrubby Creek | HEV | 10% FSS | MCL | MCL |
| | Lockhart River | HEV | 10% FSS | MCL | MCL |
| | Nesbit River | HEV | 10% FSS | MCL | MCL |
| | Chester River | HEV | 10% FSS | MCL | MCL |
| **Stewart** | Massey Creek | SD | 10% FSS | MCL | MCL |
| | Breakfast Creek | SD | 30% FSS | 6% FSS | 15% FSS |
| | Station Creek | HEV | 30% FSS | 6% FSS | 15% FSS |
| | Stewart River | SD | 30% FSS | 6% FSS | 15% FSS |
| | Balclutha Creek | HEV | 30% FSS | 6% FSS | 15% FSS |
| | Running Creek | HEV | 30% FSS | 6% FSS | 15% FSS |
| **Hann** | Annie River | SD | 30% FSS | 6% FSS | 15% FSS |
| | Hann River | HEV | 30% FSS | 6% FSS | 15% FSS |
| | North Kennedy River | HEV | 30% FSS | 6% FSS | 15% FSS |
| **Normanby** | Bizant River | HEV | 30% FSS | 6% FSS | 15% FSS |
| | Kennedy River | HEV | 30% FSS | 6% FSS | 15% FSS |
| | Mosman River | HEV | 30% FSS | 6% FSS | 15% FSS |
| | Deighton River | HEV | 30% FSS | 6% FSS | 15% FSS |
| | **Laura River** | SMD | **50% FSS, 50% DIN** | 10% FSS, 25% DIN 50SSS55050% | 25% FSS, 25% DIN 50SSS55050% |
| | **Normanby River** | SMD | **50% FSS** | 10% FSS | 25% FSS |
| **Jeannie** | Muck River | HEV | 10% FSS | MCL | MCL |
| | Howick River | HEV | 10% FSS | MCL | MCL |
| | Jeannie River | HEV | 30% FSS | 6% FSS | 15% FSS |
| | Starke River | SD | 30% FSS | 6% FSS | 15% FSS |
| | McIvor River | SD | 30% FSS | 10% FSS | 15% FSS |
| **Endeavour** | Isabella Creek | SD | 30% FSS | 6% FSS | 15% FSS |
| | Endeavour North Branch | SD | 50% FSS | 10% FSS | 25% FSS |
| | Endeavour South Branch | HEV | 30% FSS | 6% FSS | 15% FSS |
| | Endeavour Right Arm | HEV | 30% FSS | 6% FSS | 15% FSS |
| | Endeavour River | SMD | 50% FSS | 10% FSS | 25% FSS |
| | Oakey Creek | SMD | 50% FSS | 10% FSS | 25% FSS |
| | Trevethan Creek | HEV | 30% FSS | 6% FSS | 25% FSS |
| | **Annan River** | SD | **50% FSS** | 10% FSS | 25% FSS |

*FSS = fine suspended sediment DIN = Dissolved Inorganic Nitrate MCL = Maintain Current Load*
*HEV = High Ecological Value SD = Slightly Disturbed SMD = Slightly to Moderately Disturbed*

**Table 10:** Priority Management Action Targets (2022) by sub-catchment

| Basin | Sub-catchment | Aquatic EV Status | Management Action Target 2022<br>Priority Sub-Catchment load reduction target as % of total load | Grazing | Agriculture | Urban, Rural, Residential | Nature Culture Conservation | Mining | Forestry | Ports and Shipping | Wetlands | Gullies | Roads, Tracks, Fence lines | Fire | Feral animals | Weeds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Jacky Jacky** | Jacky Jacky Creek | HEV | MCL | L | | | H | | | | H | L | H | L | M | M |
| | Escape River | HEV | MCL | L | | | H | | | | L | L | M | L | M | L |
| | Harmer Creek | HEV | MCL | L | | | H | | | | L | L | M | M | M | L |
| **Olive** | Glennie Creek | HEV | MCL | L | | | H | | | | L | L | L | L | M | L |
| | Kangaroo River | HEV | MCL | L | | | H | | | | L | L | L | L | M | L |
| | Olive River | HEV | MCL | L | | | H | | | | L | L | L | H | M | L |
| **Pascoe** | Garraway Creek | HEV | MCL | L | | | H | | | | L | L | L | H | M | M |
| | Yam Creek | HEV | MCL | L | | | H | | | | L | L | L | H | M | L |
| | Hann Creek | HEV | MCL | L | | | H | | | | L | L | L | H | M | L |
| | **Pascoe River** | HEV | MCL | L | | | H | | | | L | L | L | M | M | L |
| **Lockhart** | Wilson Creek | HEV | MCL | L | | | H | | | | H | L | M | L | M | H |
| | Claudie River | HEV | 15% FSS | M | L | H | H | | | L | H | L | H | M | M | H |
| | Scrubby Creek | HEV | MCL | L | | | H | | | | H | L | M | L | M | L |
| | Lockhart River | HEV | MCL | L | | | H | | | | L | L | L | L | M | L |
| | Nesbit River | HEV | MCL | L | | | H | | | | L | L | L | L | M | L |
| | Chester River | HEV | MCL | L | | | H | | | | L | L | L | L | M | L |
| **Stewart** | Massey Creek | SD | MCL | M | | | H | | | | M | L | L | M | H | H |
| | Breakfast Creek | SD | 15% FSS | H | | | H | | | | H | L | M | H | H | H |
| | Station Creek | HEV | 15% FSS | H | | | H | L | | | H | L | M | H | H | H |
| | Stewart River | SD | 15% FSS | H | | L | H | | | | H | H | M | H | H | H |
| | Balclutha Creek | HEV | 15% FSS | M | | | H | | | | M | M | M | H | H | H |
| | Running Creek | HEV | 15% FSS | M | | | H | | | | M | L | M | H | H | H |
| **Hann** | Annie River | SD | 15% FSS | M | | | H | | | | H | H | M | H | H | H |
| | Hann River | HEV | 15% FSS | H | | | H | | | | H | H | M | H | H | H |
| | North Kennedy River | HEV | 15% FSS | H | | | H | | | | H | H | M | H | H | H |
| **Normanby** | Bizant River | HEV | 15% FSS | H | | | H | | | | H | L | L | H | H | L |
| | Kennedy River | HEV | 15% FSS | H | M | | H | | | | H | H | M | H | H | H |
| | Mosman River | HEV | 15% FSS | H | | | H | | | | H | H | M | M | M | H |
| | Deighton River | HEV | 15% FSS | H | | | H | | | | H | H | M | H | M | M |
| | **Laura River** | SMD | 25% FSS 25% DIN DDIDIN 50SSS55050% | H | H | M | H | | | | M | H | H | M | M | H |
| | **Normanby River** | SMD | 25% FSS | H | | | H | M | L | | M | H | H | H | M | H |
| **Jeannie** | Muck River | HEV | MCL | L | | | H | | | | M | L | L | H | H | L |
| | Howick River | HEV | MCL | L | | | H | | | | L | L | L | H | H | L |
| | Jeannie River | HEV | 15% FSS | L | | | H | | | | M | M | M | H | H | L |
| | Starke River | SD | 15% FSS | L | | L | H | M | | M | M | M | M | H | H | M |
| | McIvor River | SD | 15% FSS | M | H | L | H | M | | | M | M | M | M | H | M |
| **Endeavour** | Isabella Creek | SD | 15% FSS | M | | L | H | | | | M | L | L | M | M | M |
| | Endeavour North Branch | SD | 15% FSS | M | H | H d | H | | L | | L | L | M | M | M | M |
| | Endeavour South Branch | HEV | 15% FSS | L | | L | H | | | | L | L | L | H | M | L |
| | Endeavour Right Arm | HEV | 25% FSS | M | | H | H | | L | | H | L | H | H | M | M |
| | Endeavour River | SMD | 25% FSS | M | H | H | H | | | M | M | L | H | M | M | M |
| | Oakey Creek | SMD | 25% FSS | M | | H | H | | | | L | M | H | H | M | M |
| | Trevethan Creek | HEV | 25% FSS | L | | H | H | | | | L | L | M | M | L | M |
| | **Annan River** | SD | 25% FSS | L | M od | H | H | M | | | M | L | M | H | L | M |

*FSS = Fine suspended sediment DIN = Dissolved Inorganic Nitrate MCL = Maintain Current Load*
*HEV = High Ecological Value SD = Slightly Disturbed SMD = Slightly to Moderately Disturbed*
*Scale of Management Action to achieve Management Action Targets = H = High, M = Moderate, L = Low*



## Localising Reef 2050 Plan and Reef Plan 2013 targets to the Normanby Sub Basin

**Reef Plan 2013 Water Quality Targets**

The Reef Plan 2013 set targets designed to achieve the overarching goal of ensuring that by *2020 the quality of water entering the lagoon from broadscale land use has no detrimental impact on the health and resilience on the GBR*. The Reef Plan 2013 targets to be achieved by 2018 include:

- At least a 50 per cent reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas.
- **At least a 20 per cent reduction in anthropogenic end-of-catchment loads of sediment and particulate nutrients in priority areas.**
- At least a 60 per cent reduction in end-of-catchment pesticide loads in priority areas. The pesticides referred to are the PSII herbicides considered are hexazinone, ametryn, atrazine, diuron and tebuthiuron.

In addition to water quality targets the Reef Plan also includes land and catchment management targets which address improved agricultural practices as well as the protection of natural wetlands. These land based targets recognise the important role of land management practices in reducing the end-of-catchment pollutant load reduction targets and are based on the conceptual understanding of the link between management practice standards and water quality outcomes. The land and catchment management targets to be achieved by 2018 are:

- 90% of sugarcane, horticulture, cropping and grazing lands are managed using best management practice systems (soil, nutrient and pesticides) in priority areas.
- Minimum 70% late dry season groundcover on grazing lands.
- The extent of riparian vegetation is increased.
- There is no net loss of the extent, and an improvement in the ecological processes and environmental values, of natural wetlands.

**Reef 2050 Plan Targets**

The Reef 2050 Long Term Sustainability Plan (Reef 2050 Plan; Commonwealth of Australia 2015) is a joint initiative between the Australian and Queensland Governments and provides an overarching strategy for management of the GBR, and contains objectives, targets and actions across several themes including: biodiversity, ecosystem health, heritage, water quality, community benefits and governance. The Reef 2050 Plan builds on the Reef Plan 2013 targets.

- At least a 50 per cent reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas, on the way to achieving up to an 80 per cent reduction in dissolved inorganic nitrogen in priority areas by 2025;
- **At least a 20 per cent reduction in anthropogenic end-of-catchment loads of sediment in priority areas, on the way to achieving up to a 50 per cent reduction in priority areas by 2025;**
- At least a 20 per cent reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas; and
- At least a 60 per cent reduction in end-of-catchment pesticide loads in priority areas.

**Example of localising Reef Plan 2013 and Reef 2050 Plan targets to the Normanby Sub Basin**

Short-term (year 2022), medium-term (year 2030) and long-term (year 2037) fine suspended sediment reduction targets have been developed for Normanby Sub Basin and the Hann Sub Basin. The Normanby Sub Basin targets are presented below as an example of how the localised targets represent both Reef Plan and Reef 2050 Plan targets.

In localising the Reef 2050 Plan targets to the Normanby Sub Basin, the only major modification has been to extend the timeline for target achievement. This has been done to reflect the practical capacity building required to achieve cost-effective adoption of management actions to measurably reduce fine suspended sediment loads.

The relationship between management action target timelines and monitoring timelines has also been considered. A seven-year time delay for End-of-Catchment monitoring (EoC) and a three-year delay for Sub-Catchment monitoring (SuC) is considered practical. In doing this the practical management action timeline is separated from the practical monitoring timeline. The Sub-Catchment monitoring (SuC) sites will need to be installed close to the priority sediment sources that are being managed to detect change in sediment load from management within three years. The End-of-Catchment monitoring (EoC) sites will need to be monitored continuously from 2016 using a Super Gauge approach for the monitoring timelines to be met.

The specific fine sediment fraction that applies to End-of-Catchment (EoC) and Sub-Catchment (SuC) targets has also been considered. For End-of-Catchment targets the fine sediment fraction has been defined as <15.7um which represents the clay and fine silt fractions that are typically transported by flood plumes greater distances into the marine environment. For Sub-Catchment targets the fine sediment fraction has been defined as <63um which represents the clay and total silt fractions that potentially impact on both freshwater and marine ecosystems.

**Normanby Sub Basin End-of-Catchment reduction targets:** fine suspended sediment (<15.7um) load reduction presented as a percentage of total load.

**Short-term (7.5 years, by 2022):** 10% total fine suspended sediment (<15.7um) load reduction, with a monitoring time lag of seven years, this will begin to be confirmed by EoC Monitoring in 2030.

*This target is equivalent to 20% anthropogenic load reduction and consistent with the Reef 2050 Plan reduction target for 20% reduction in anthropogenic end-of-catchment loads of sediment in priority areas by 2018 but with the timeline extended to 2022.*

**Mid-term (15 years by 2030):** 20% total fine suspended sediment (<15.7um) load reduction, with a monitoring time lag of seven years, this will begin to be confirmed by EoC Monitoring in 2037.

*This target is equivalent to 40% anthropogenic load reduction and consistent with the Reef 2050 Plan reduction target for up to 50% reduction in anthropogenic end-of-catchment loads of sediment in priority areas by 2025 but with the timeline extended to 2030.*

**Long-term (22.5 years by 2037):** 30% total fine suspended sediment (<15.7um) load reduction, with a monitoring time lag of seven years, this will begin to be confirmed by EoC Monitoring in 2044.

*This target is equivalent to 60% anthropogenic load reduction and consistent with the Reef Plan 2013 goal that 'the quality of water entering the lagoon from broadscale land use has no detrimental impact on the health and resilience on the GBR' but with the timeline extended from 2020 to 2037.*

**Normanby Sub Basin Priority Sub-catchment reduction targets:** fine suspended sediment (<63um) load reduction presented as a percentage of total load. This reduction target is applied to the most disturbed sub-catchments within the Normanby sub-basin that will be the focus for management action, such as the East and West Normanby Rivers and the upper Laura River.



**Short-term (7.5 years, by 2022):** 25% total fine suspended sediment (<63um) load reduction in priority sub-catchments, with a monitoring time lag of three years, this will begin to be confirmed by SuC Monitoring in 2025.

*This target is equivalent to 20% anthropogenic end-of-catchment load reduction and consistent with the Reef 2050 Plan reduction target for 20% reduction in anthropogenic end-of-catchment loads of sediment in priority areas by 2018 but with the implementation timeline extended from 2018 to 2022.*

**Mid-term (15 years by 2030):** 50% total fine suspended sediment (<63um) load reduction in priority sub-catchments, with a monitoring time lag of three years, this will begin to be confirmed by SuC Monitoring in 2033.

*This target is equivalent to 40% anthropogenic end-of-catchment load reduction and consistent with the Reef 2050 Plan reduction target for up to 50% reduction in anthropogenic end-of-catchment loads of sediment in priority areas by 2025 but with the timeline extended to 2030.*

**Long-term (22.5 years by 2037):** 75% total fine suspended sediment (<63um) load reduction in priority sub-catchments, with a monitoring time lag of three years, this will begin to be confirmed by SuC Monitoring in 2040.

*This target is equivalent to 60% anthropogenic end-of-catchment load reduction and consistent with the Reef Plan 2013 goal that 'the quality of water entering the lagoon from broadscale land use has no detrimental impact on the health and resilience on the GBR' but with the timeline extended from 2020 to 2037.*

The End-of-Catchment and Priority Sub-catchment water quality targets and management action targets have been developed to localise the following Reef 2050 Plan water quality targets:

**WQT1 – By 2018**

- At least a 50% reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas on the way to achieving up to an 80% reduction in nitrogen by 2025
- At least a 20% reduction in anthropogenic end-of-catchment loads of sediment in priority areas, on the way to achieving up to a 50% reduction by 2025
- At least a 20% reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas

**WQT2 – By 2018:**

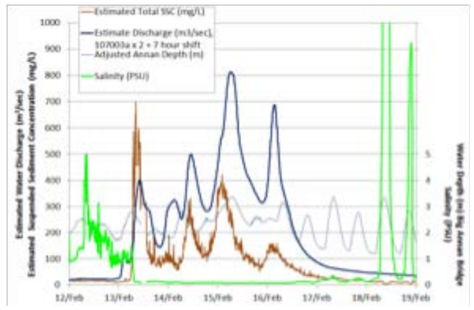
- 90% of sugarcane, horticulture cropping and grazing lands are managed using best management practice systems (soil, nutrient and pesticides) in priority areas
- Minimum 70% late dry season groundcover on grazing lands
- The extent of riparian vegetation is increased
- There is no net loss of the extent and an improvement in the ecological processes and environmental values, of natural wetlands

Super Gauge technology to accurately measure pollutant loads delivered to the Great Barrier Reef

Dr. Jeffrey Shellberg, Christina Howley
and Jason Carroll

- A Super gauge combines international field standards for fluvial river monitoring and continuous water quality surrogate technology, which are used together to measure pollutant concentrations, water discharge, and loads instantaneously through time.
- River gauging at end-of-river sites draining to the Great Barrier Reef (GBR) can be dramatically improved using the super gauge approach, which represents an innovative practice to accurately measure GBR pollutant load reductions through 2050 and beyond.
- Super gauge technology greatly reduces measurement and stochastic uncertainty associated with load calculations by using accurate field and laboratory protocols and measuring water quality surrogates at frequent intervals (10 minutes), such as turbidity or nitrate analysers.
- Continuous surrogate data are correlated to periodic field samples of suspended sediment concentration (SSC), nutrients or other pollutants at a point in a cross-section, in order to predict continuous pollutant concentrations over time.
- Correlation of pollutant concentrations to continuous surrogate data significantly reduces the error introduced by using water discharge (or stage) as a pollution correlate, whose relationships are hindered by hysteresis issues on the rising and falling limbs of flood events.
- Point samples of sediment and nutrient concentrations can be collected using the assistance of refrigerated pump samplers triggered by turbidity thresholds during flood.
- Field samples of cross-section average sediment and nutrient concentrations need to be collected using isokinetic width and depth sampling equipment following international standards.
- Measurements of isokinetic cross-section average concentrations can be compared to point concentrations to correct these data to average cross-section conditions (box coefficient).
- Water discharge in bidirectional tidal estuaries can be accurately measured using acoustic doppler velocity meters (ADVMs) to measure 'velocity index' areas that can be correlated to standard water discharge measurements needed for load calculations.
- Analysis of high-accuracy event-scale load data and shifts in continuous 'time and discharge weighted' event mean concentrations (EMC) and loads for individual types of storm events can be used to assess changes in loads over both the short-term (5-10 years) and long-term (50-100 years).
- Annual running costs of a super gauge are estimated at $47,000/year for both field and laboratory analysis. 10 super gauges on Cape York and 26 total across the GBR are proposed.






Shellberg, J., Howley, C., Carroll, J., 2016. The Need for a 'Super Gauge' Approach Using Surrogate Technologies and Improved Field and Laboratory Techniques to Accurately Monitor Suspended Sediment and Nutrient Loads Delivered to the Great Barrier Reef: A Case Study from the Annan River Catchment on the Cape York Peninsula. Report by South Cape York Catchments with support from the CSIRO, the Queensland Government, and the Australian Government's Cape York Water Quality Improvement Plan program. 86pp.

## Catchment land use, disturbances and pollution sources

The water quality within a catchment is influenced by the scale and intensity of land uses and other disturbances within the catchment. Within the Eastern Cape York Water Quality Improvement Plan process a catchment land use and disturbance analysis has been used to inform decision making in the following areas:

- Providing evidence for the conceptual understanding of human disturbance on fresh water quality, flood water quality, estuary and marine water quality
- Exploring the cumulative impact that human disturbances have on water quality within a catchment
- Exploring the different level of human disturbance and likely impact on water quality in different catchments
- Providing information to support interpretation of ambient and event monitoring results
- Providing information to support the design of future monitoring and modelling programs

To support the development of management actions and implementation strategies, catchment land use mapping undertaken by Queensland Government (QLUMP 2013) has been grouped into the following five broad classes:

- Grazing
- Agriculture (horticulture and cropping)
- Urban, Rural Residential areas and roads
- Nature and Cultural Conservation
- Wetlands

Wetlands have been classified as a land use because of the relatively large spatial extent of wetlands within the planning region. Wetlands in a healthy condition play an important role in water quality within catchments by maintaining natural hydrological processes, sediment trapping and nutrient processing. Wetlands in poor condition can have reduced hydrological function and can become an active sediment and nutrient source.

The following disturbances have also been analysed in developing the recommended management actions and implementation strategies:

- Gullies
- Roads, tracks, fence lines and firebreaks
- Fire
- Feral animals
- Weeds

These disturbances are present across the whole region, are found in all five land use classes and if poorly managed or ignored have negative impacts on water quality and ecosystem health.

For more information on each land use and disturbance refer to The Normanby Water Quality Management Plan (Howley et al., 2014), the disturbance index report (Appendix 1, Spencer et al., 2016), the gully prioritization report (Appendix 2, Brooks et al., 2016) and the fire report (Appendix 13, Standley, 2016).

### Catchment land use

Land use characteristics of the Eastern Cape York region are shown in Table 11. This information is derived from QLUMP 2013 data. This land use data has been combined to present the major land uses classes (grazing, nature and cultural conservation, agriculture, etc.) in Figure 19, and small-scale land uses (mining, native forestry, aquaculture etc.) in Figure 20.

Land use within each basin can be summarised as follows:

- **Jacky Jacky Basin:** Nature and cultural conservation (82%) and grazing (9%) are the dominant land uses. Urban and other intensive land uses represent less than 1% (65 ha) and water represents 9% of the basin area.
- **Olive Basin:** Nature and cultural conservation (73%) and grazing (26%) are the dominant land uses.
- **Pascoe Basin:** Nature and cultural conservation (84%) and grazing (16%) are the dominant land uses.
- **Lockhart Basin:** Nature and cultural conservation (92%) is the dominant land use. Grazing represents 3%, Urban and other intensive land uses represent less than 1% (174 ha) and water represents 5% of the basin area.
- **Stewart Basin:** Nature and cultural conservation (92%) is the dominant land use. Grazing represents 2% and water represents 4% of the basin area.
- **Hann Basin:** Grazing (56%) and nature and cultural conservation (43%) are the dominant land uses. Urban and other intensive land uses represent less than 1% (192 ha) of the basin area.
- **Normanby Basin:** Grazing (52%) and nature and cultural conservation (46%) are the dominant land uses. Cropping (5,718 ha), horticulture (461 ha) and urban and other intensive land uses (672 ha) represent less than 1% of the basin area.
- **Jeannie Basin:** Nature and cultural conservation (81%) and grazing (11%) are the dominant land uses. Forestry (2,050 ha), horticulture (44 ha), cropping (52 ha), and urban and other intensive land uses (495 ha) represent less than 1% and water represents 7% of the basin area.
- **Endeavour Basin:** Nature and cultural conservation (52%) and grazing (44%) are the dominant land uses. Urban and other intensive land uses (3326 ha) represent 2% and forestry represents 1 %. While horticulture (173 ha) and cropping (267 ha) represent less than 1% and water represents 1% of the basin area.

### Grazing and nature and cultural conservation

National Parks, nature refuges and Traditional Owner land tenures represent a relatively high proportion of the region (60%), with nature and cultural conservation being the predominate use of this land. In the last 20 years there has been a significant shift in land tenure from Pastoral Lease to National Park, nature refuge and Traditional Owner land tenure that has implications for productive grazing management on Traditional Owner land. Issues such as low herd quality and rundown infrastructure will need to be overcome by the Traditional Owners who have aspirations for a cattle business on their land. Grazing land use now represents only 34% of eastern Cape York but remains an important part of the history, lifestyle and economy of this region. While the current area of grazing land use on pastoral lease is relatively low, feral cattle and horses remain at grazing land use densities within a large proportion of the area designated as nature and cultural conservation land use (see feral animal section below). Trampling by feral cattle and horses have degraded wetlands, permanent springs and riparian vegetation in all sections and across land uses. Grazing has also been identified as a trigger for accelerated erosion and a major source of sediments to rivers in the Normanby Basin and other catchments.

### Agriculture

Agriculture occurs over a small (<1%) but expanding area in the Normanby, Jeannie (McIvor River) and Endeavour Basins. Bananas and irrigated and dryland cropping in Lakeland are the current major intensive agricultural land uses. Fertiliser and soil run-off is a source of sediment and nutrient pollution in the Laura River (Normanby Basin) and likely in the other basins to a lesser extent. There is a high level of concern amongst the downstream community of Laura about the impact of agriculture on their social and cultural uses of the Laura river. Recent and proposed land clearing, increased dam building and water extraction, and additional fertiliser and pesticide use associated with agricultural developments will place new pressures on the Laura, Normanby and McIvor Rivers. Innovative management will be required to address these challenges to maintain or improve water quality.

## Urban

Urban (including rural residential) and other intensive land uses represent less than 1% of the total planning area, but have significant local water quality implications in these locations:

- Lockhart township in the Claudie River catchment (Lockhart Basin)
- Laura and Lakeland townships within the Laura River catchment (Normanby Basin)
- Cooktown, Hope Vale townships and several peri urban precincts within the Endeavour River catchment (Endeavour Basin)
- Rossville township and several peri urban precincts within the Annan River catchment (Endeavor Basin)

These urban and rural residential centres are all located adjacent to major river systems, and with the exceptions of Laura and Lakeland are also in close proximity to the coast and GBR. Storm-water run-off, sewerage treatment plants and septic systems, rubbish and hazardous waste (oils, paints, biomedical supplies, etc.) disposal, weed spread, and sediment erosion from building developments and roads can all impact on water quality in adjacent rivers. Of these, sediment run-off from building sites with inadequate erosion control measures and poorly designed roads are the two most evident and significant sources of pollution to the GBR from urban or rural residential areas.

## Mining

Mining land use represents less than 0.001% of the total planning area, but can have significant local water quality implications due to erosion from disturbed areas and access roads, and pollutants from mine tailings. The main mines in the planning area are:

- Cape Flattery silica mine and port within the Jeanie Basin
- Collingwood tin mine in the Annan River catchment
- Small alluvial mining leases in the Normanby River catchment

Historic mining covered a much larger area and drastically altered waterways and water quality. For example, hydraulic tin mining in the upper Annan river catchment in the late 1800s had a devastating impact on the rivers. Large areas of forest were cleared, creeks were re-routed in dams and sluices, and "the water was made muddy for much of the time" (Anderson, 1983). Recent tin mining in the upper Annan catchment also increased sediment and metal concentrations in the Annan River while it was in operation (Howley, 2012) and a tailings dam remains a potential source of metals. Small scale alluvial mining leases still exist in the upper Normanby. These mines are a substantial local sediment source due to the fragile dispersive soils and the direct connectivity of the mine locations with the stream network. Further development of alluvial mining on fragile dispersible soils within eastern Cape York should be actively discouraged because the resulting sediment loss will counteract current and future efforts to reduce sediment loss from gully erosion, grazing and roads in these landscapes.

## Native forestry

Forestry land use represents about 0.001% of the total planning area (1% in the Endeavour Basin) but has significant local water quality implications due to erosion from the disturbed area and access roads. Historic forestry activities on pastoral leases with fragile dispersible soils in the Normanby River have contributed to the large areas of gully erosion on these properties. Further development of forestry on fragile dispersible soils within eastern Cape York should be actively discouraged because the resulting sediment loss will counteract current and future efforts to reduce sediment loss from gully erosion, grazing and roads in these landscapes.



## Ports and shipping

Ports and shipping represent less than 0.001% of the total planning area, but have significant local water quality implications due to dredging and spoil dumping, waste management and disposal (sewage, anti-fouling and other chemicals, fuel and oil spillage) and sediment resuspension from shipping wakes. The main ports in the planning area are:

- Community port with barge facility at Quintell Beach, Lockhart River Community
- Port at Cape Flattery silica mine
- Harbour and port at Endeavour River mouth, Cooktown

The shipping channel within the northern GBR is a major route for commercial ships going to bulk ports on the Queensland coast. These ships stir up sediment in shallow areas, muddying the water over large areas. Sediment plumes up to 20 km long have been observed in the wake of ships in the section between Cape Melville and Cape Tribulation. There is anecdotal evidence that this has had a detrimental impact on reefs that are close to the shipping channel, but there have been no formal studies of this impact. Ship numbers along the whole of the GBR are estimated to greatly increase over the next 10 years.

## Disturbances

Eastern Cape York has large areas of fragile sodic or dispersive soils. Development for grazing, roads, alluvial mining, forestry and agriculture on these soils has resulted in the formation of severely eroded landscapes ("gullies" or "breakaways") that represent the largest human source of sediment being delivered to the northern GBR lagoon.

Gully erosion is present across the whole planning region and can be found in all land uses, but is most prevalent in the Normanby Basin, where scientists from Griffith University have conducted detailed mapping of gullies and research on how to reduce gully erosion (Shellberg et al. 2013, Appendix 2, Brooks et al., 2016). Once gullies have been initiated by soil disturbances, it is extremely difficult to slow or stop the erosion process. These sensitive, erosion prone soils are therefore considered to be unsuitable for any land use other than nature and culture conservation.

## Roads

Roads, tracks, borrow pits and fence lines also occur across all land uses and catchments and represent the largest area of intensive human disturbance across eastern Cape York (Appendix 1, Spencer et al., 2016). Erosion from roads, tracks, fence lines and firebreaks has been identified as a significant sediment source within the Central and Southern sections of eastern Cape York, and may also be one of the largest sediment sources within much of the Northern section of the region due to the low level of other disturbances.

Despite being a major source of sediment draining to the Great Barrier Reef, roads and other linear disturbances have been largely ignored in the past as a priority for programs aimed at reducing sediment runoff. Federal- and State-funded road development programs that create sediment and nutrient pollution are in conflict with funded water quality improvement programs aimed at reducing this pollution and improving reef health.

## Fire

The timing and frequency of fire across the landscape can have a major impact on water quality. Fires at the end of the dry season reduce ground cover leading into the wet season, which increases erosion and sediment and nutrient levels in rivers. Inappropriate fire regimes occur across all land uses and most of the planning region (with the exception of wet rainforest areas). This has been identified as a contributing factor to sediment erosion within all sections of eastern Cape York. The spatial extent of late season wildfire within the planning region over the last 15 years has been analysed by Cape York NRM based on a Northern Australian Fire Information (NAFI) MODIS imagery analysis. This information has been used to determine priority areas for fire management.

## Feral animals

Feral cattle, horses and pigs are present across the whole planning region and can be found in all land uses. Overgrazing and trampling by feral cattle and horses, and vegetation destruction by feral pigs, results in low ground cover and exposed soil (particularly around wetlands, permanent springs and riparian areas). This has been identified as a contributing factor to sediment erosion in addition to the destruction of aquatic habitat. Improving feral animal management improves overall ecosystem health (particularly wetland functionality) and reduces sediment and associated nutrient loss to downstream freshwater and marine ecosystems.

## Weeds

Sicklepod, hymenachne, rubber vine, pond apple, gamba grass and salvinia are six invasive weeds of wetlands and waterways that are present in eastern Cape York and have the potential to impact widely on the ecological health of waterways, wetlands and floodplains. Sicklepod and rubbervine have already taken over large areas of riparian vegetation in the southern and central regions of Cape York, reducing the ability of native trees and grasses to grow and maintain healthy river banks. Hymenachne and salvinia are aquatic weeds that can take over wetlands and rivers, reducing water flow, destroying habitat and changing water quality. Hymenachne has been detected in the southern and central zones. Pond apple is present in all sections of the region where it can dominate estuary riparian vegetation and change the ecological function of these habitats.

Improving weed management improves overall ecosystem health (particularly wetland and floodplain functionality) and can help to reduce sediment and associated nutrient loss to downstream freshwater and marine ecosystems.



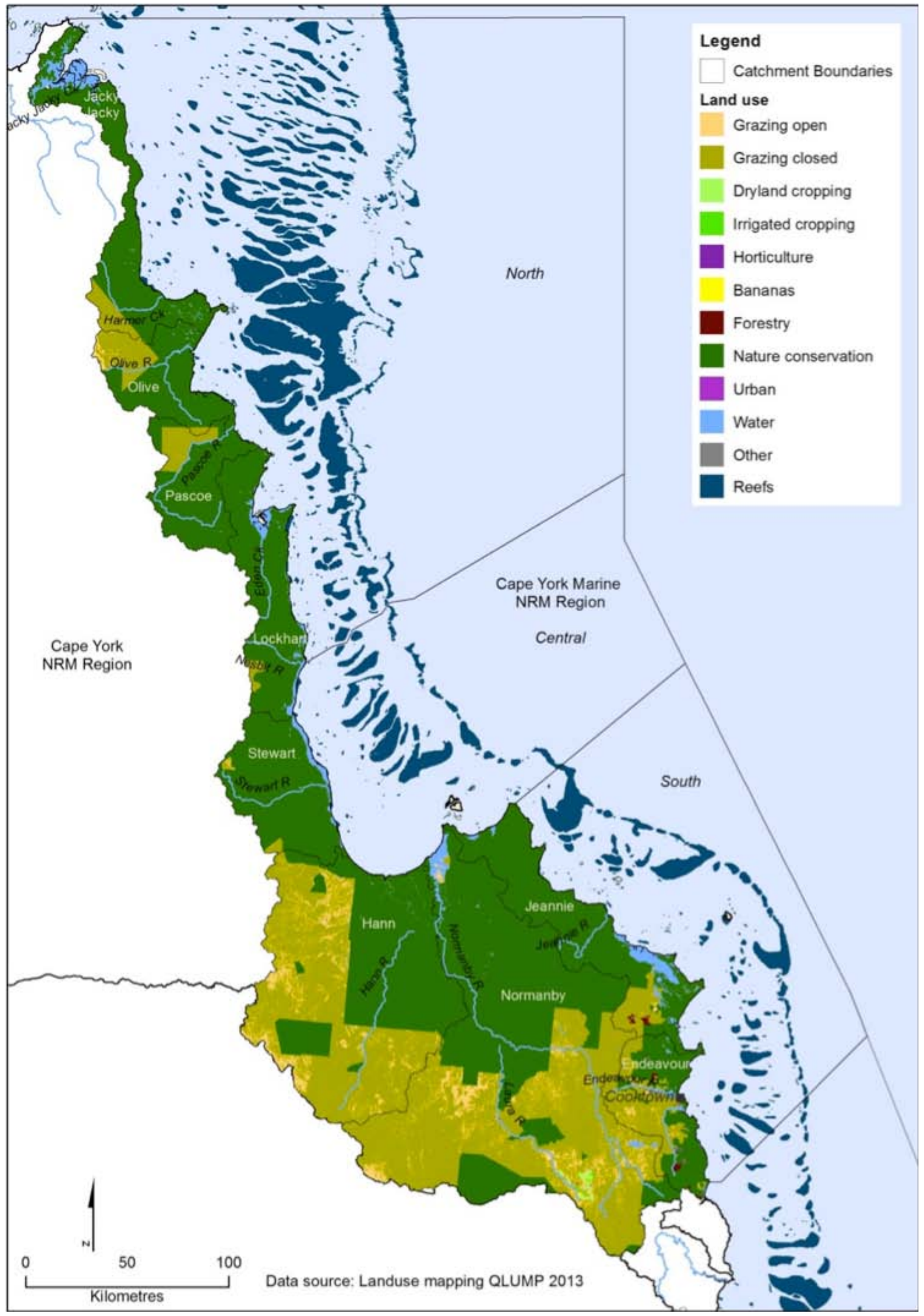



**Figure 19:** Land use map of the eastern Cape York region, QLUMP 2013 (Source: Appendix 10, Waterhouse et al., 2016)

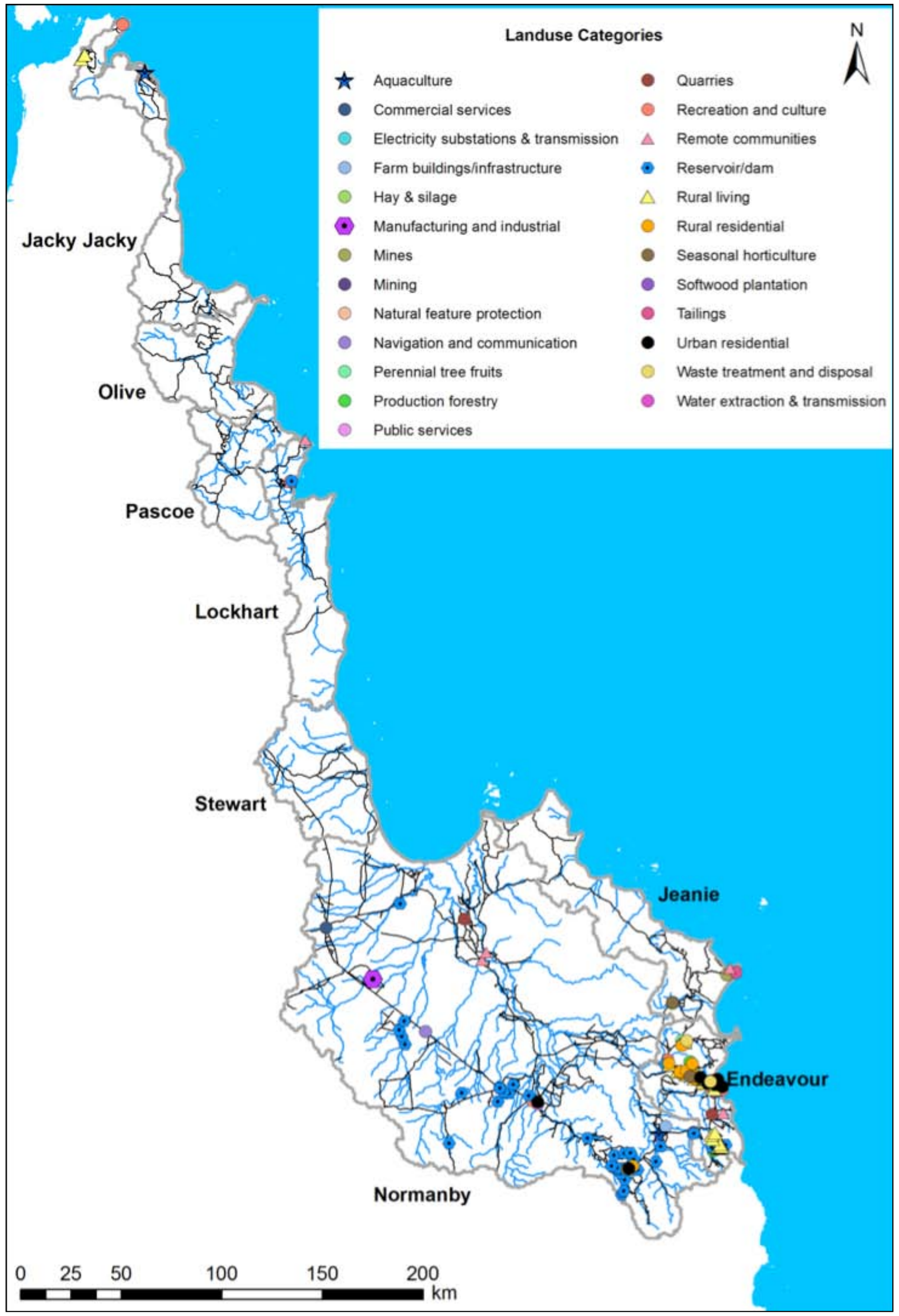



**Figure 20:** Location of land use categories (QLUMP 2013) covering relatively small areas. Shown here to complement Figure 19 where the small areas are not visible (Source: Appendix 1, Spencer et al., 2016)



**Table 11.** Estimated land use by area (ha) in the Cape York region (based on QLUMP 2013 data used in Source Catchments modelling)

| Basin or Catchment | Grazing | Dryland & Irrigated Cropping | Forestry | Horticulture | Urban | Nature and Culture Conservation | Water | Other | Total |
|---|---|---|---|---|---|---|---|---|---|
| **Jacky Jacky Basin** | 26,065 | | | | 9 | 243,725 | 29,180 | 56 | 299,036 |
| **Olive Sub Basin** | 54,511 | | | | | 152,755 | 1,142 | | 208,408 |
| **Pascoe Sub Basin** | 32,463 | | | | | 176,035 | 327 | 12 | 208,837 |
| **Lockhart Basin** | 7,434 | | | | 60 | 262,996 | 16,659 | 114 | 287,263 |
| **Stewart Basin** | 6.469 | | 3 | | | 260,500 | 10,011 | | 276,983 |
| **Hann Sub Basin** | 547,100 | | | | 22 | 422,671 | 5644 | 170 | 975,607 |
| **Normanby Sub Basin** | 762,713 | 5,718 | 186 | 461 | 144 | 675,849 | 16,848 | 528 | 1,462,447 |
| **Jeannie Basin** | 39,013 | 52 | 2,050 | 44 | 15 | 296,575 | 25,492 | 480 | 363,721 |
| **Endeavour Basin** | 95,579 | 267 | 2,529 | 173 | 2,617 | 113,814 | 2,927 | 709 | 218,616 |
| Total | 1,469,572 | 6,037 | 4,768 | 678 | 2,867 | 2,604,920 | 108,230 | 2,069 | 4,300,918 |

## Management actions to improve water quality

Management actions to improve water quality have been grouped based on the following land use classes:

- Grazing
- Agriculture (horticulture, cropping and plantation forestry)
- Native Forestry
- Urban, Rural Residential areas and roads
- Mining
- Ports and Shipping
- Nature and Cultural Conservation
- Wetlands

Table 12 presents a summary of the priority focus for management actions within the Northern, Central and Southern sections of the region.

Following the recommended management actions for each land use there are specific management actions to address the following disturbances that are present across the whole region:

- Gullies
- Roads, tracks, fence lines and firebreaks
- Fire
- Feral animals
- Weeds

**Table 12:** Priority focus for management actions within the Northern, Central and Southern sections of the region

| Section | Northern | Central | Southern |
|---|---|---|---|
| **Key Feature** | Most undisturbed section of whole Great Barrier Reef | Eastern Cape York's agriculture and grazing hub | Eastern Cape York's residential, tourism and social services centre |
| **Management Action Priority Focus** | • Nature and cultural conservation and monitoring<br>• Wetland management<br>• Grazing management<br>• Ports and Shipping Management | • Grazing management<br>• Agriculture management<br>• Nature and cultural conservation<br>• Wetland Management<br>• Native Forestry Management<br>• Mining Management | • Urban, rural residential and road management<br>• Agriculture management<br>• Grazing management<br>• Nature and cultural conservation<br>• Wetland Management<br>• Native Forestry Management<br>• Mining Management<br>• Ports and Shipping Management |

Different land uses and disturbances have different impacts on water quality. Table 13 presents a summary of the water quality parameters that will be improved if the recommended management actions are implemented.

**Table 13:** Water quality parameters that will be improved if the recommended management actions are implemented

| | Sediment & particulate nutrients | Dissolved nutrients | Residual herbicides | Urban & Industrial pollutants | Ecosystem Health |
|---|---|---|---|---|---|
| **Grazing** | yes | | | | yes |
| **Agriculture** | yes | yes | yes | | yes |
| **Urban Rural Residential and Roads** | yes | yes | yes | yes | yes |
| **Mining** | yes | yes | | yes | yes |
| **Ports and shipping** | yes | yes | | yes | yes |
| **Native forestry** | yes | | | | yes |
| **Nature and cultural conservation** | yes | | | | yes |
| **Wetlands** | yes | yes | yes | yes | yes |
| **Gullies** | yes | | | | yes |
| **Roads, tracks, fence lines and firebreaks** | yes | | | | yes |
| **Fire** | yes | yes | | | yes |
| **Feral animals** | yes | | | | yes |
| **Weeds** | yes | | | | yes |

### Grazing

Improving grazing management improves herd and pasture quality and the ability to finish cattle to market specifications as well as reducing sediment and associated nutrients.

Maintain Healthy Pastures by:
- Monitoring pastures and stocking rates to promote perennial grass cover and prevent over grazing
- Restoring pastures to a more productive state by wet season spelling

Repair eroding gullies by:
- Excluding cattle, sowing grass seeds and managing fire
- Destocking cattle from large areas of highly erodible soils along rivers
- Engineering structures to stabilise highly active gully head cuts

Manage fire to improve ground cover by:
- Developing and implementing a fire plan
- Following an appropriate fire regime for each land type e.g. early, mosaic and storm burning and rotational burning
- Working with neighbours to coordinate burning activities

Reduce erosion along roads, fence lines and firebreaks by:
- Minimising construction of new roads, fence lines and firebreaks
- Maintaining roads, fence lines and firebreaks to a high standard
- Relocating roads and fence lines on sensitive soils to more stable land types
- Diverting water by using erosion control structures eg. 'Woah Boys' and spoon drains

Improve Wetland health by;
- Controlling feral animals and weeds
- Controlling stock access e.g. low stocking rates, periodic grazing or complete exclusion

Controlling Weeds by:
- Holding new cattle and ensuring feed is clean
- Using vehicle wash down facilities to reduce spread and introduction of new weeds
- Controlling weeds that impact on waterways such as hymenachne and sicklepod

**Resources required to improve grazing management:**
- Grazing Technical Extension Officers to work one on one with grazing landholders and deliver a voluntary incentive program to encourage adoption of grazing best management practices (including incentives to destock cattle from highly erosive lands and improve within property road, firebreak and fence line erosion control)
- Field days, workshops and communication materials
- Soil mapping and soil tests for grazing management plans
- Road erosion expert technical support

The Grazing Technical Extension officers will connect the participating graziers to other resources that are recommended for pest, fire, wetland and gully management.

For more information on prioritisation of grazing management refer to the grazing implementation strategy (Appendix 15), the disturbance index report (Appendix 1, Spencer et al., 2016), the gully prioritisation report (Appendix 2, Brooks et al. 2016) and the Cape York fire report (Appendix 13, Standley, 2016).



Breeding bulls a Silver Plains Station (Photo: Jessie Price)

The grazing management actions are designed to localise the following Reef 2050 plan actions to meet Reef 2050 targets:
- **CBA11** - Strengthen programs to understand and promote threats to the values of the Reef and what people can do to address them
- **CBT3** - Community participation in stewardship actions to improve Reef health and resilience continues to grow
- **WQA2** - Continue improvement in water quality from broadscale land use through implementation of Reef Plan actions
- **WQT1** - By 2018:
  - At least a 20% reduction in anthropogenic end-of-catchment loads of sediment in priority areas, on the way to achieving up to a 50% reduction by 2025
  - At least a 20% reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas
- **WQT2** - By 2018:
  - 90% of sugarcane, horticulture cropping and grazing lands are managed using best management practice systems (soil, nutrient and pesticides) in priority areas
  - Minimum 70% late dry season groundcover on grazing lands
  - The extent of riparian vegetation is increased
  - There is no net loss of the extent and an improvement in the ecological processes and environmental values, of natural wetlands

## Nature and cultural conservation

Improving nature and cultural conservation management improves visitor experience and ecosystem health and resilience and as well as reducing sediment and associated nutrient loss.

Keep waterways pest free by:

- Controlling weeds and feral animals along waterways
- Controlling weeds such as sicklepod, hymenachne, rubbervine, pond apple and gamba grass
- Looking out for and controlling new pest species as they arrive
- Utilising vehicle wash down facilities
- Destocking unmanaged cattle

Manage fire to improve ground cover by:

- Developing and implementing a fire plan
- Following an appropriate fire regime for each land type e.g. early, mosaic and storm burning and rotational burning
- Working with neighbours to coordinate burning activities

Reduce erosion along roads, fence lines and firebreaks by:

- Minimising construction of new roads, fence lines and firebreaks
- Maintaining roads, fence lines and firebreaks to a high standard
- Relocating roads and fence lines on sensitive soils to more stable land types
- Diverting water by using erosion control structures e.g. 'Woah Boys' and spoon drains

Repair eroding gullies by:

- Excluding cattle, sowing grass seeds and managing fire
- Engineering structures to stabilise highly active gully head cuts

Create aware visitors by:

- Installing interpretive signage and running awareness campaigns
- Promoting weed wash down activities
- Regular patrol and maintenance of existing 4X4 tracks to discourage use of side tracks
- Maintaining walkways, campsites, toilets and rubbish disposal

Cultural Management to improve ground cover by:

- Undertaking Traditional burning that promotes ground cover

**Resources required to improve nature and cultural conservation management:**

- Grazing Technical Extension Officers to work one on one with Traditional Owners and deliver a voluntary incentive program to encourage adoption of best management practices (including incentives to destock cattle from highly erosive lands, improve pest management and improve within property road, firebreak and fence line erosion control) on Traditional Owner lands
- Field day, workshops and communications materials
- Soil mapping and soil tests for grazing management plans
- Road erosion expert technical support

The Grazing Technical Extension Officers will connect the participating Traditional Owners to other resources that are recommended for pest, fire, wetland and gully management.

For more information on prioritisation of nature and culture conservation management refer to the grazing implementation strategy (Appendix 15), the disturbance index report (Appendix 1, Spencer et al., 2016), the gully prioritisation report (Appendix 2, Brooks et al. 2016) and the Cape York fire report (Appendix 13, Standley, 2016).



- **HA1** - Build capacity for the involvement of TOs and community members in
- coperative management, planning and impact assessment.
- **HT1** - New and effective cooperative management practices are developed for protection and conservation of GBR Indigenous and non-Indigenous heritage.
- **CBA8** - Industry, community and governments work together to implement policies and programs that address tourism and recreational use of the GBR Marine Park: … provide adequate and well-maintained visitor infrastructure such as public moorings, interpretive signs, etc.
- **CBA11** - Strengthen programs to understand and promote threats to the values of the Reef and what people can do to address them.
- **CBT3** - Community participation in stewardship actions to improve Reef health
- and resilience continues to grow.
- **WQT1** - By 2018:
  - At least a 20% reduction in anthropogenic end-of-catchment loads of sediment in priority areas, on the way to achieving up to a 50% reduction by 2025
  - At least a 20% reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas.
- **WQT2** - By 2018:
  - Minimum 70% late dry season groundcover on grazing lands
  - The extent of riparian vegetation is increased
  - There is no net loss of the extent and an improvement in the ecological processes, and environmental values, of natural wetlands.

An Indigenous Ranger watches an early-season burn die in the late afternoon (Photo: Jessie Price)

Agriculture (horticulture, cropping and plantation forestry)

Improving agriculture management improves the efficiency and profitability of crop production as well as reducing sediment, nutrient and pesticide loss.

Improve soil health by:

- Minimising soil disturbance, maintaining ground cover and crop residue to increase organic matter and minimise soil loss
- Mapping soils to understand soil variability and impacts on crop yield
- Avoiding agriculture on nutrient poor erodible soils near especially near rivers

Reducing nutrients runoff by:

- Applying fertilisers at rates based on crop type, growth stage, soil testing and yield mapping
- Timing fertiliser application with respect to irrigation and rainfall to maximise uptake by the crop and minimise nutrient loss
- Precise placement of fertilser, in a band onto the bed using subsurface application or liquid products (avoiding broadcast application)

Reducing pesticide runoff by:

- Applying pesticides at correct rates and based on pest pressure mapping, crop phase and seasonal conditions
- Timing pesticide application with respect to irrigation and rainfall to maximise efficiency of pest control and minimise pesticide loss

Maximise irrigation efficiency by:

- Matching irrigation applications to soil type, crop phase and plant available water status to reduce loss to deep drainage
- Designing efficient irrigation systems that minimise energy consumption and water loss



Maintain downstream environmental flows by:

- Quantifying available water resources and allocating water based on availability
- Investigating innovative water saving measures
- Farm drainage is well planned (e.g. managing water logging in cropping areas and avoiding directing flows directly into waterways and onto areas with dispersive soils)

Reduce farm waste by:

- Choosing packing products that can be recycled or composted
- Designing packing plants and processes that minimise waste

Minimise soil compaction by:

- Improving heavy vehicle traffic controls to reduce soil compaction and improve infiltration and reduce runoff

**Resources required to improve agriculture management:**

- Precision Agriculture Technical Extension Officer to work one on one with farmers and to deliver a voluntary incentive program to encourage adoption of innovative agriculture management practices (including incentives for innovative soil, nutrient and pesticide management) within agriculture land uses
- Field days, workshops and communication materials
- EM soil mapping and soil tests for nutrient management plans

The Precision Agriculture Technical Extension officers will connect the participating farmers to other resources that are recommended for pest, fire, wetland and gully management.

For more information on prioritisation of agriculture management refer to the agriculture implementation strategy (Appendix 16).

The agriculture management actions are designed to localise the following Reef 2050 plan actions to meet Reef 2050 targets:

- **CBA11** - Strengthen programs to understand and promote threats to the values of the Reef and what people can do to address them.
- **CBT3** - Community participation in stewardship actions to improve Reef health and resilience continues to grow.
- **WQA2** - Continue improvement in water quality from broadscale land use through implementation of Reef Plan actions.
- **WQT1** - By 2018:
  - At least a 50% reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas on the way to achieving up to an 80% reduction in nitrogen by 2025
  - At least a 20% reduction in anthropogenic end-of-catchment loads of sediment in priority areas, on the way to achieving up to a 50% reduction by 2025
  - At least a 20% reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas
- **WQT2** - By 2018:
  - 90% of sugarcane, horticulture cropping and grazing lands are managed using best management practice systems (soil, nutrient and pesticides) in priority areas
  - There is no net loss of the extent and an improvement in the ecological processes and environmental values, of natural wetlands

Newly planted bananas on Collins Farm, Lakeland (Photo: Michael Goddard)

### Native forestry

Improving native forestry management improves future timber production as well as reducing sediment and associated nutrient loss.

Implement sustainable forestry practices by:

- Producing a sustainable timber production plan that outlines timber harvest over time across the native forestry production area
- Define habitat and waterway protection areas within the native forestry production area that will be left in a natural state
- Avoid all forestry activities on sensitive soils or in areas where there is evidence of gully erosion
- Selective logging – retaining 30 - 50% of large trees with good form and timber properties to provide seed source for next generation of trees (in rainforest, retain 60 - 70% canopy cover after harvest)
- Thinning regrowth in stages to encourage good form and achieve optimum stem density

Reduce erosion from loading ramps and along roads, fence lines and firebreaks by:

- Strategically placing loading ramps to minimise ground disturbance during harvest
- Minimising construction of new roads, fence lines and firebreaks
- Maintaining roads, fence lines and firebreaks to a high standard
- Relocating roads and fence lines on sensitive soils to more stable land types
- Diverting water by using erosion control structures e.g. 'Woah Boys' and spoon drains

Keep waterways pest free by:

- Controlling weeds and feral animals along waterways
- Controlling weeds such as sicklepod, hymenachne, rubbervine, pond apple and gamba grass
- Looking out for and controlling new pest species as they arrive
- Utilising vehicle wash down facilities
- Destocking unmanaged cattle



Manage fire to improve ground cover by:

- Developing and implementing a fire plan
- Following an appropriate fire regime for each land type e.g. early, mosaic and storm burning and rotational burning
- Working with neighbours to coordinate burning activities

Repair eroding gullies by:

- Excluding cattle, sowing grass seeds and managing fire
- Engineering structures to stabilise highly active gully head cuts

**Resources required to improve native forestry management:**
Extra resources are not described for native forestry management as native forestry typically occurs on grazing lands. The Grazing Technical Extension officers will connect the participating graziers and Traditional Owners to other resources that are recommended for pest, fire, wetland and gully management.

### Urban, rural residential and roads

Improving urban management reduces long-term maintenance costs and improves social wellbeing as well as reducing sediment, nutrient and other pollutant loss.

Keep waterways pest free by:

- Controlling weeds and feral animals along waterways
- Looking out for and controlling new pest species as they arrive

Create low impact Urban and Rural Residential blocks by:

- Implementing best practice erosion control measures to reduce off-site sediment impacts during initial development phase
- Keeping stocking rates low to prevent over grazing
- Controlling weeds and feral animals along waterways
- Encouraging native vegetation along waterways
- Limiting clearing to minimise disturbance
- Zoning to reduce development impacts on sensitive areas
- Ensuring water, sewage and waste don't impact waterways by:
- Installing world-class water and waste infrastructure
- Incorporating water sensitive design into new development and existing urban areas

Reducing road development and maintenance impact by:

- Ensuring road upgrades are designed and implemented to world class standard
- Timing road works to minimise soil loss
- Stabilising existing stream crossings
- Minimising clearing of road reserves
- Creating weed management programs, focused on vehicle hygiene and slashing over spraying road sides
- Creating an aware community by:
- Educating our community about choices that promote healthy waterways

**Resources required to improve urban management:**

- Urban Technical Extension Officers to build technical capacity in urban water management within local government and coordinate demonstration sites and education and awareness
- Materials for best practice urban erosion and sediment control and storm water demonstration sites
- Training, workshop and communications materials

For more information on prioritisation of urban management refer to the implementation plan (Chapter 3) and the disturbance index report (Appendix 1, Spencer et al., 2016).

The urban, rural residential and roads management actions are designed to localise the following Reef 2050 plan actions to meet Reef 2050 targets:

- **EHA24** - Work with local councils to build their capacity to effectively implement coastal planning laws and policies to protect the Reef
- **CBA11** - Strengthen programs to understand and promote threats to the values of the Reef and what people can do to address them
- **CBT3** - Community participation in stewardship actions to improve Reef health and resilience continues to grow
- **WQA11** - Increase adoption of leading practice in the management and release of point-source water affecting the Reef
- **WQA12** - Implement best practice stormwater management (e.g. erosion and sediment control, water sensitive urban design and capture of gross pollutants) for new development in coastal catchments
- **WQA13** - Build capacity for local government and industry to improve water quality management in urban areas
- **WQT1** - By 2018:
  - At least a 50% reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas on the way to achieving up to an 80% reduction in nitrogen by 2025
  - At least a 20% reduction in anthropogenic end-of-catchment loads of sediment in priority areas, on the way to achieving up to a 50% reduction by 2025
  - At least a 20% reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas
- **WQT2** - By 2018:
  - The extent of riparian vegetation is increased
  - There is no net loss of the extent and an improvement in the ecological processes and environmental values, of natural wetlands

Dune lake of eastern Cape York (Photo: Kerry Trapnell)



### Mining

Improving mining management reduces the long-term impacts on natural environment as well as reducing sediment, nutrient and other pollutant loss.

Reduce erosion from active mining areas by;

- Implementing world-class erosion control measures to reduce off-site sediment impacts

Reduce erosion from roads, fence lines and firebreaks by;

- Ensuring access road upgrades are designed and implemented to world class standard
- Timing road works to minimise soil loss
- Stabilising existing stream crossings
- Minimising construction of new roads, fence lines and firebreaks
- Maintaining roads, fence lines and firebreaks to a high standard
- Relocating roads and fence lines on sensitive soils to more stable land types
- Diverting water by using erosion control structures eg. ‘Woah Boys’ and spoon drains

Ensure mine storm water, wastewater and sewage doesn’t impact on waterways by;

- Constructing bund walls so all rainfall is captured in sediment detention basins and evaporated or treated
- Ensuring water used in wash plants and mineral processing is stored in tailings dams and treated before release
- Ensuring that sediment detention basins, bund walls and tailings dams have adequate capacity to deal with monsoon wet season conditions
- Installing tertiary sewage treatment infrastructure

Reduce the long-term impacts of mines by;

- Ensuring mine rehabilitation plans, including rehabilitation bonds, are at a high standard to reflect the natural value of Cape York
- Rehabilitating abandoned mines and quarries in the Normanby, Mosman, Annan, Starke and Stewart catchments

Keep waterways pest free by;

- Controlling weeds and feral animals along waterways
- Looking out for and controlling new pest species as they arrive
- Creating weed management programs, focused on vehicle hygiene and slashing over spraying roadsides

**Resources required to improve mining management:**
Extra resources required for improving mining management are not described as this is a regulated activity.

### Ports and shipping

Improving ports and shipping management reduces the long-term impacts on natural environment as well as reducing sediment, nutrient and other pollutant loss.

Ensure port storm water, sewage and waste doesn’t impact on marine environment by;

- Constructing bund walls and storm water storage so all rainfall from port industrial areas (fuel tank farms, fueling docks, anti-foulant slipways) is captured and treated
- Ensuring waste disposal (including waste oil) and sewage pump-out facilities are available and maintained to a high standard
- Implementing a regular water quality monitoring program for early detection of pollutants in port waters

Reduce impacts of dredging by;

- Minimising dredging of ports and shipping channels
- Ensuring dredging operations are implemented to world-class standards

- Undertaking land-based disposal of dredge materials

Reduce sediment impacts of shipping by;
- Regularly mapping the deepest shipping channel in the northern GBR
- Defining and monitoring shallow sections of the northern GBR that present highest risk of sediment impacts
- Considering speed and tide restrictions for largest ships in these shallow sections
- Implementing regular monitoring of shipping plumes, water quality and reef condition in shallow sections

Reduce other pollutant impacts of shipping by;
- Education and enforcement to exclude routine discharges of oils, chemicals, sewage and waste within northern GBR
- Education and enforcement to exclude exchange of ballast water within the northern GBR

Reduce the frequency of shipping incidents (groundings and collisions) by;
- Requiring compulsory pilotage through the northern GBR
- Regularly reviewing and improving vessel monitoring and reporting

Improve the response to shipping incidents by;
- Implementing the highest possible incident response (equipment and training) at Cooktown, Cape Flattery and Lockhart River
- Adopting world class management practices in all current port operations

Creating an aware community by;
- Educating our community about port waste, water and sewage facilities
-

**Resources required to improve ports and shipping management:**
Extra resources required for improving ports and shipping management are not described as this is a regulated activity.

## Wetlands

Improving wetland management improves wetland and floodplain health and improves the sediment trapping and nutrient processing function of wetlands and floodplains.

Minimise the impacts of managed and feral animals by:
- Controlling feral animals along waterways
- Looking out for and controlling new pest species as they arrive
- Controlling stock access eg low stocking rates, periodic grazing or complete exclusion

Monitor the health of wetlands by;
- Undertaking a Wetland Condition Assessment at least twice a year (ideally end of wet and end of dry). Assessments will track the health of a wetland and allow development of a management plan

Manage fire to improve wetland health by;
- Developing and implementing a fire plan
- Following an appropriate fire regime for the wetland system e.g. early, mosaic and storm burning and rotational burning
- Working with neighbours to coordinate burning activities
- Keeping fire out of wetland riparian edges permanently

Keep wetlands from silting up by;
- Identifying and repairing upstream sediment sources such as gullies, roads and firebreaks



Maintain natural water levels by;
- Minimising water extraction particularly in the dry season
- Limiting vegetation clearing for tracks at vehicle access points on wetland edges

Keep wetlands weed free by;
- Controlling weeds such as sicklepod, hymenachne, pond apple and para grass in wetlands and along edges
- Looking out for and controlling new pest species as they arrive
- Utilising vehicle wash down facilities

**Resources required to improve wetland management:**
- Wetland Coordination Officer to deliver a voluntary incentive program to encourage adoption of wetland best management practices within grazing and nature and culture conservation land uses
- Training, workshop and communications materials
- Wetland monitoring expert technical advice to support wetland management project design and wetland condition monitoring

For more information on prioritisation of wetland management on grazing and nature and culture conservation land uses refer to the grazing implementation strategy (Appendix 15), the gully prioritisation report (Appendix 2, Brooks et al. 2016) and the Cape York fire report (Appendix 13, Standley, 2016).

The wetland management actions are designed to localise the following Reef 2050 plan actions to meet Reef 2050 targets:
- **CBA11** - Strengthen programs to understand and promote threats to the values of the Reef and what people can do to address them.
- **CBT3** - Community participation in stewardship actions to improve Reef health and resilience continues to grow.
- **WQT1** - By 2018:
  - at least a 50% reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas on the way to achieving up to an 80% reduction in nitrogen by 2025
  - at least a 20% reduction in anthropogenic end-of-catchment loads of sediment in priority areas, on the way to achieving up to a 50% reduction by 2025
  - at least a 20% reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas
- **WQT2** - By 2018:
  - The extent of riparian vegetation is increased
  - There is no net loss of the extent and an improvement in the ecological processes and environmental values, of natural wetlands

## Gullies

Gullies are present across the whole planning region and can be found in all land uses. Widespread gully erosion has been identified as the largest sources of anthropogenic (human caused) sediment within the Normanby Basin (Central Section). Gullies are also a significant localised sediment source within the Northern and Southern sections of the region.

Improving gully management reduces sediment and associated nutrient loss and improves the ecosystem health of downstream freshwater and marine ecosystems.

The spatial extent of gullies within the Normanby and Stewart basins has been mapped by Griffith University (Appendix 1 and Appendix 2). A spatial prioritization, identifying the top 100 sub-catchments for gully erosion in the Normanby has also been completed by Griffith University (Figure 21 and Appendix 2). This information has been used to inform the implementation strategies and prioritisation of investment to reduce sediment loss.

Recommendations for implementation within each section:

**North**

- Gully mapping to identify priority gully remediation sites that will improve nature and cultural conservation and wetland management outcomes.
- Implement high priority gully remediation demonstration sites.

**Central**

- Implement catchment wide gully management within grazing and nature conservation land uses.
- Utilise grazing implementation strategy (Appendix 15) and gully prioritization (Appendix 2) to strategically invest in active gully remediation to stabilise the most active gullies to achieve the sediment reduction target.

**South**

- Gully mapping to identify priority gully remediation sites that will improve urban, rural residential and road management, grazing management, nature and cultural conservation and wetland management outcomes.
- Implement high priority gully remediation demonstration sites.

**Resources required to improve gully management:**

- Gully Erosion Technical Officers coordinate a strategic active gully remediation program to achieve cost effective erosion reduction within grazing and nature and culture conservation land uses
- Training, workshop and communications materials
- Gully erosion expert technical advice to support project design

For more information on prioritisation of gully management refer to the grazing implementation strategy (Appendix 15), the disturbance index report (Appendix 1, Spencer et al., 2016), the gully prioritisation report (Appendix 2, Brooks et al., 2016) and the alluvial gully management technical report (Shelberg and Brooks, 2013).



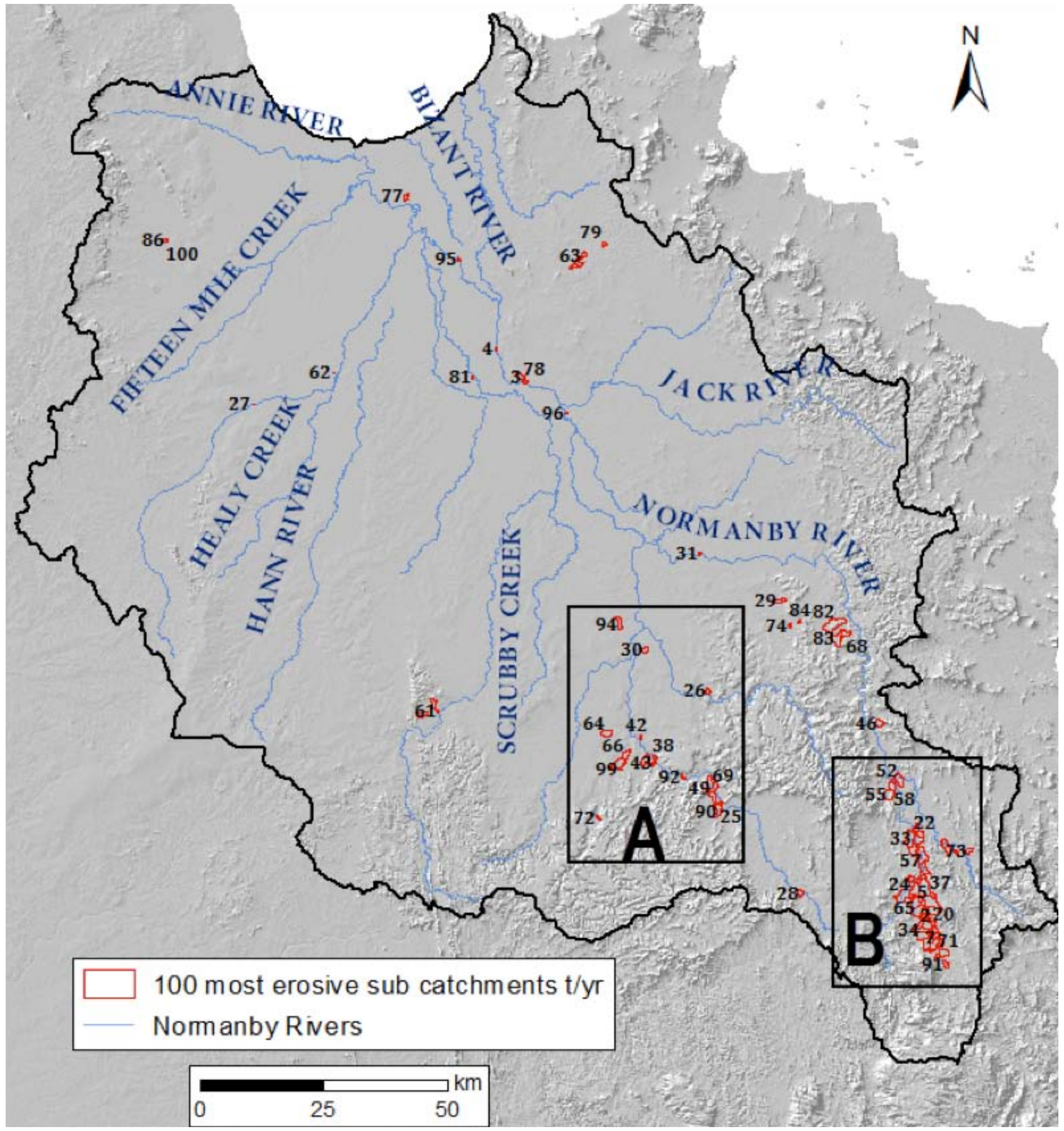



**Figure 21:** Top 100 gully erosion sub-catchments in the Normanby Basin. Erosion from alluvial and colluvial sources (i.e. total gully output) were ranked by TOTAL gully output. (Source: Appendix 2, Brooks et al., 2016)

## Roads, tracks, fence lines and firebreaks

Roads, tracks, fence lines and firebreaks are present across the whole planning region and can be found in all land uses. Widespread erosion from roads, tracks, fence lines and firebreaks has been identified as a significant sediment source within the Central and Southern sections of the region. Roads, tracks, fence lines and firebreaks may be one of the largest sediment sources within much of the Northern section of the region due to the low level of other disturbances.

Improving road, track, fence line and firebreak management reduces sediment and associated nutrient loss and improves the ecosystem health of downstream freshwater and marine ecosystems.

The spatial extent of roads, tracks, fence lines and firebreaks within the Central section has been mapped at high resolution by Griffith University (Appendix 1). A lower resolution mapping and analysis of roads and tracks within the Northern and Southern sections has also been completed by Griffith University (Figure 22 and Appendix 1). This information has been used to inform the implementation strategies.

Recommendations for implementation within each section:

**North**

- High resolution road, track, fence line and firebreak mapping to identify priority road management sites that will improve nature and cultural conservation and wetland management outcomes.
- Work with Main Roads and local governments to identify and implement road construction and maintenance practices to reduce erosion.
- Implement high priority road management demonstration sites.

**Central**

- Implement catchment wide road, track, fence line and firebreak management within grazing and nature conservation land uses. Focus on actively eroding roads, fence lines and fire breaks that are directly connected to the stream network. Utilise the grazing implementation strategy (Appendix 15), the high resolution road mapping within the disturbance index report (Appendix 1) and the top 100 gully sub-catchments within the gully prioritisation report (Appendix 2) to strategically invest in active road, track, fence line and firebreak remediation to stabilise the most active within property road erosion sites to achieve the sediment reduction target.
- Work with Main Roads and local governments to identify and implement road construction and maintenance practices to reduce erosion and implement high priority road management demonstration sites.

**South**

- High resolution road, track, fence line and firebreak mapping to identify priority road management sites that will improve Urban, rural residential and road management, grazing management, nature and cultural conservation and wetland management outcomes.
- Work with Main Roads and local governments to identify and implement road construction and maintenance practices to reduce erosion
- Implement high priority road management demonstration sites.

**Resources required to improve road management:**

- Road Technical Extension Officer to build road management technical capacity within local government and coordinate best practice road management demonstration sites
- Engineering design and material expenses for best practice road management demonstration sites
- Training, workshop and communications materials
- Within property roads, tracks, fence lines and firebreaks are addressed through the grazing technical extension and voluntary incentive program.

For more information on prioritisation of road management within grazing and nature and culture conservation land uses refer to the grazing implementation strategy (Appendix 15), the disturbance index report (Appendix 1, Spencer et al., 2016) and the gully prioritisation report (Appendix 2, Brooks et al. 2016).

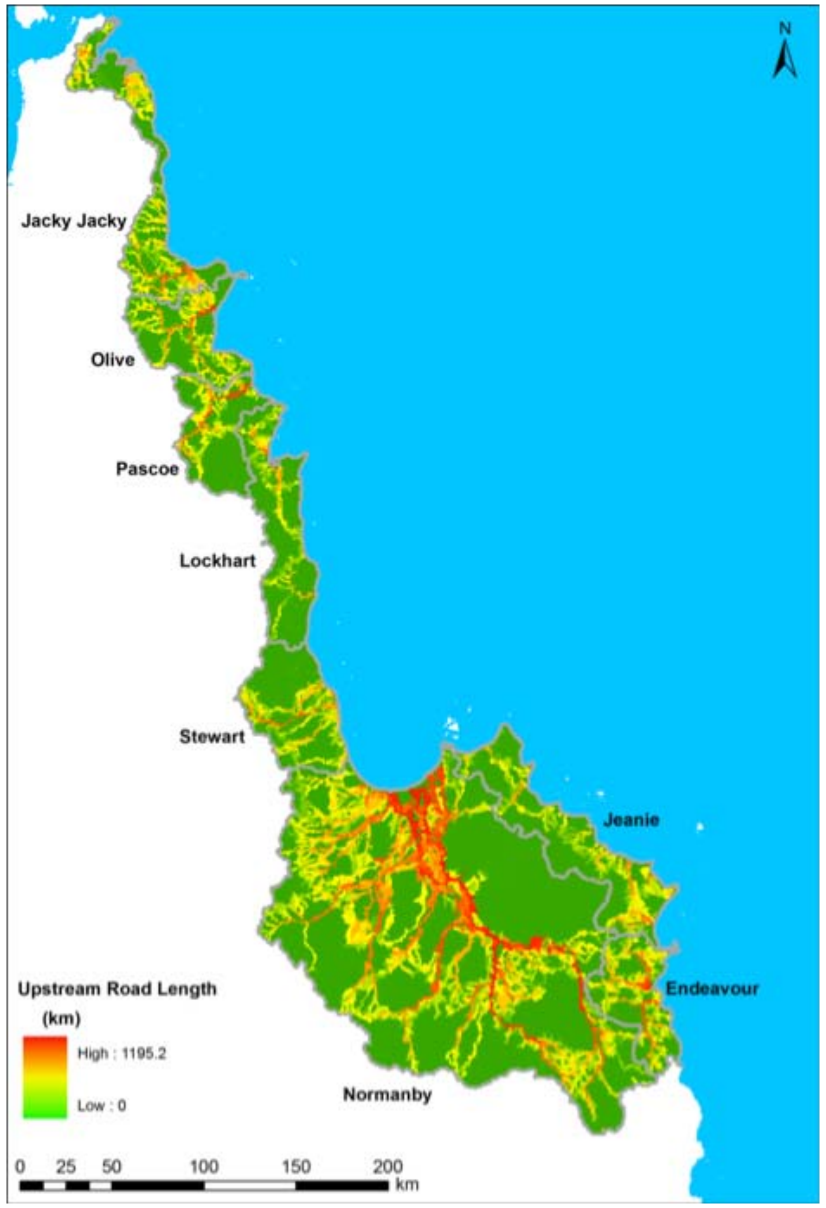
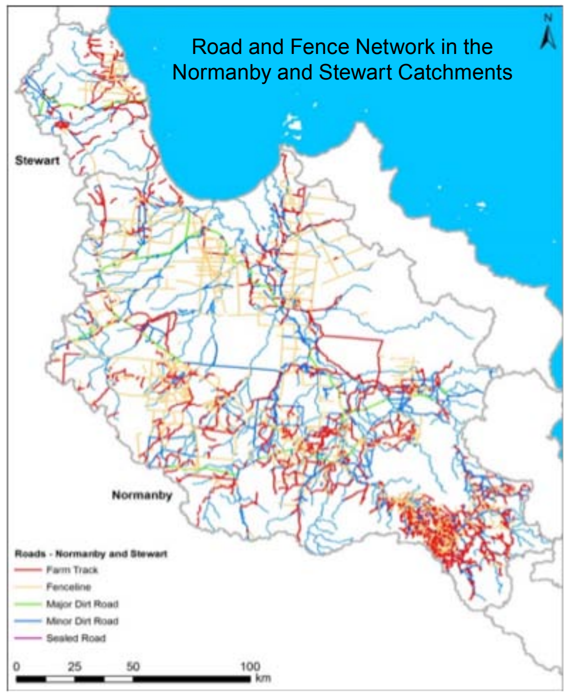



**Figure 22:** Spatial representation of potential road disturbances on the stream network of eastern Cape York. These data represent the absolute minimum extent of the linear disturbance network given that they are derived from the existing Geodata3 road network. Detailed mapping in the Normanby and Stewart catchments shows that this existing data represents only about 26% of the total linear disturbance network (Source: Appendix 1, Spencer et al, 2016)

## Impact of main and council roads on water quality on Cape York Peninsula and the Great Barrier Reef

Dr. Jeffrey Shellberg and Dr. Andrew Brooks (Griffith University)

- Roads, borrow pits, tracks, fence lines and other linear disturbances are a major sediment source draining to the Great Barrier Reef (Gleeson et al. 2012; Brooks et al. 2013; Shellberg and Brooks 2013) and have been poorly quantified in the past to prioritize sediment reduction to the GBR.
- In the Normanby-Stewart catchment of Cape York Peninsula, there are >10,800 km of linear road disturbance covering 7988 ha, which represents the largest direct human land use disturbance across Cape York compared to all other intensive land uses (Spencer et al. 2016).
- Road development represents THE major human disturbance vector for developing catchments on Cape York and the GBR, similar to other remote regions of the globe (e.g., Amazon basin; Laurance et al. 2001; 2014). Roads pollute sediment and nutrients, and carry people, animals, weeds, and development into remote intact ecosystems.
- Annual road maintenance, new road construction, and legacy road problems pollute 100s of thousands of tonnes of sediment to Cape York rivers and the GBR each year. On Cape York, road maintenance crews replace >25 mm of road surface lost to erosion each year, which represents > 500 tonnes/km/year not including associated road gully erosion.
- Both Shire Council and Queensland State road crews are publically funded many hundreds of millions of dollars each year to maintain and develop roads for public use.
- Federal and State funded 'road development programs' that pollute sediment and nutrients are in direct conflict with funded 'reef rescue programs' aimed at reducing this pollution.
- Addressing these program conflicts of interest represents the lowest hanging fruit for sediment pollution abatement by government programs in the northern GBR, by reducing sediment disturbance and mobilisation through improved Best Management Practices (BMPs).
- Shire Councils rely on annual and emergency State and Federal road funds to maintain their road development work forces and intricate networks of contactors and machine operators.
- Historically and recently, there has been little incentive by road engineers, Councils and contractors to 1) minimize their sediment and erosion disturbance volumes and areas along roads and borrow pits, 2) engineer and construct roads that will last with minimal ongoing maintenance, or 3) implement rigorous BMPs to reduce erosion following international standards. Many recent examples have been documented of road crews poorly addressing erosion problems year after year, and accelerating erosion to the GBR.
- Road construction and maintenance practices that would never be allowed in southeast Queensland are prevalent on Cape York Peninsula. Most road projects do not include effective sediment reduction BMPs such as minimizing disturbance, active revegetation of slopes and borrow pits, frequent effective grade control structures, or avoiding cutting drains that feed into gullies, creeks and the GBR.
- The major funding investments to pave (bitumen) the Peninsula Development Road (PDR) on Cape York will eventually reduce sediment pollution in the long-term (>20 years). However, in the short term (1–10 years), these construction works will likely contribute tens if not hundreds of thousands of tonnes of sediment through major earthwork disturbance and lack of rigorous BMPs. Many examples have been documented of major pollution from recent construction and poor road management along the PDR.
- Best Management Practices (BMPs) to reduce sediment pollution and erosion along Shire Council and Queensland State roads are in desperate need of review and improvement to bring the standards up to International best practice to reduce GBR pollution impacts.
- BMP requirements and standards must be increased for Federal and State funded road projects, with greater than >20% of project funds directly invested to avoid or reduce sediment pollution.
- Cooperation is needed between Federal, State and Council funded 'road development programs' and 'reef rescue programs' to ensure that these programs are not antagonistic and both produce outcomes for the public good and public trust (GBR).
- Cooperative education, training, and monitoring programs are needed for sediment reduction and avoidance during road projects, through the interaction of geomorphology scientists, engineers, road practitioners, and contractors. Independent monitoring and auditing of BMP implementation measures and pollution outcomes is essential for improved management and oversight.





Brooks, A., Spencer, J., Olley, J., Pietsch, T., Borombovits, D., Curwen, G., Shellberg, J., Howley, C., Gleeson, A., Simon, A., Bankhead, N., Klimetz, D., Eslami-Endargoli, L., Bourgeault, A., 2013. An Empirically-Based Sediment Budget for the Normanby Basin: Sediment Sources, Sinks, and Drivers on the Cape York Savannah, Griffith University, Australian Rivers Institute, Final Report for the Australian Government Caring for Our Country - Reef Rescue Program, April 2013, 506pp. http://www.capeyorkwaterquality.info/references/cywq-229.

Gleeson, A., 2012. Cape York's Unsealed Road Network and Its Impact on the Surrounding Aquatic Ecosystem. Honours thesis, Griffith School of Environment, Griffith University, Nathan, QLD.

Laurance, W.F., Cochrane, M.A., Bergen, S., Fearnside, P.M., Delamônica, P., Barber, C., D'Angelo, S., Fernandes, T., 2001. The Future of the Brazilian Amazon. Science, 291(5503), 438-439.

Laurance, W.F., Clements, G.R., Sloan, S., O'Connell, C.S., Mueller, N.D., Goosem, M., Venter, O., Edwards, D.P., Phalan, B., Balmford, A., Van Der Ree, R., Arrea, I.B., 2014. A global strategy for road building. Nature, 513(7517), 229-232.

Shellberg, J.G., Brooks, A.P., 2013. Alluvial Gully Prevention and Rehabilitation Options for Reducing Sediment Loads in the Normanby Catchment and Northern Australia. Griffith University, Australian Rivers Institute, Final Report for the Australian Government's Caring for our Country - Reef Rescue Initiative, 312pp. http://www.capeyorkwaterquality.info/references/cywq-223.

Spencer, J., Brooks, A., Curwen, G., Tews, K., 2016. A Disturbance Index Approach for Assessing Water Quality Threats in Eastern Cape York. A report to South Cape York Catchments and Cape York NRM for the Cape York Water Quality Improvement Plan, by the Australian Rivers Institute, Griffith University, 42 pp


## Fire

Inappropriate fire regimes such as late-season wildfires have been present across the whole planning region (with the exception of wet rainforest areas) in the last 15 years and can be found in all land uses. Late-season wildfire that results in low ground cover leading into the wet season has been identified as a contributing factor to sediment erosion within all sections of the region.

Improving fire management improves overall ecosystem health (particularly wetland functionality) and reduces sediment and associated nutrient loss to downstream freshwater and marine ecosystems.

The spatial extent of late-season wildfire within the planning region over the last 15 years has been analysed by Cape York NRM based on a Northern Australian Fire Information (NAFI) modus imagery analysis (Figure 23). The areas identified as 'No Burn Recorded' generally aligns with the wet rainforest and coastal vegetation types however there are many examples of fire scars not being picked up by the NAFI analysis due to a range of technical issues. This information has been used to inform the implementation strategies.

Recommendations for implementation within each section:

**North**

- Formation of fire management cluster groups to develop fire management strategies to improve nature and cultural conservation and wetland management outcomes.
- Implement fire management strategies.

**Central**

- Formation of fire management cluster groups to develop fire management strategies to improve grazing, nature and cultural conservation and wetland management outcomes.
- Implement fire management strategies.

**South**

- Formation of fire management cluster groups to develop fire management strategies to improve urban and rural residential, grazing, nature and cultural conservation and wetland management outcomes
- Implement fire management strategies.

**Resources required to improve fire management:**

- Fire Coordination Officers and on ground Fire Managers working across 18 fire cluster groups to coordinate broad scale early season aerial burning and provide technical support to encourage adoption of appropriate burning regimes.
- Material and operating expenses for broad scale early season aerial burning program (plane and helicopter time and fuel, aerial incendiaries, etc.)
- Cluster group meetings and communications materials
- GIS and mapping support for fire management plans

For more information on prioritisation of fire management within grazing and nature and culture conservation land uses refer to the Cape York fire report (Appendix 13, Standley, 2016) and the grazing implementation strategy (Appendix 15).



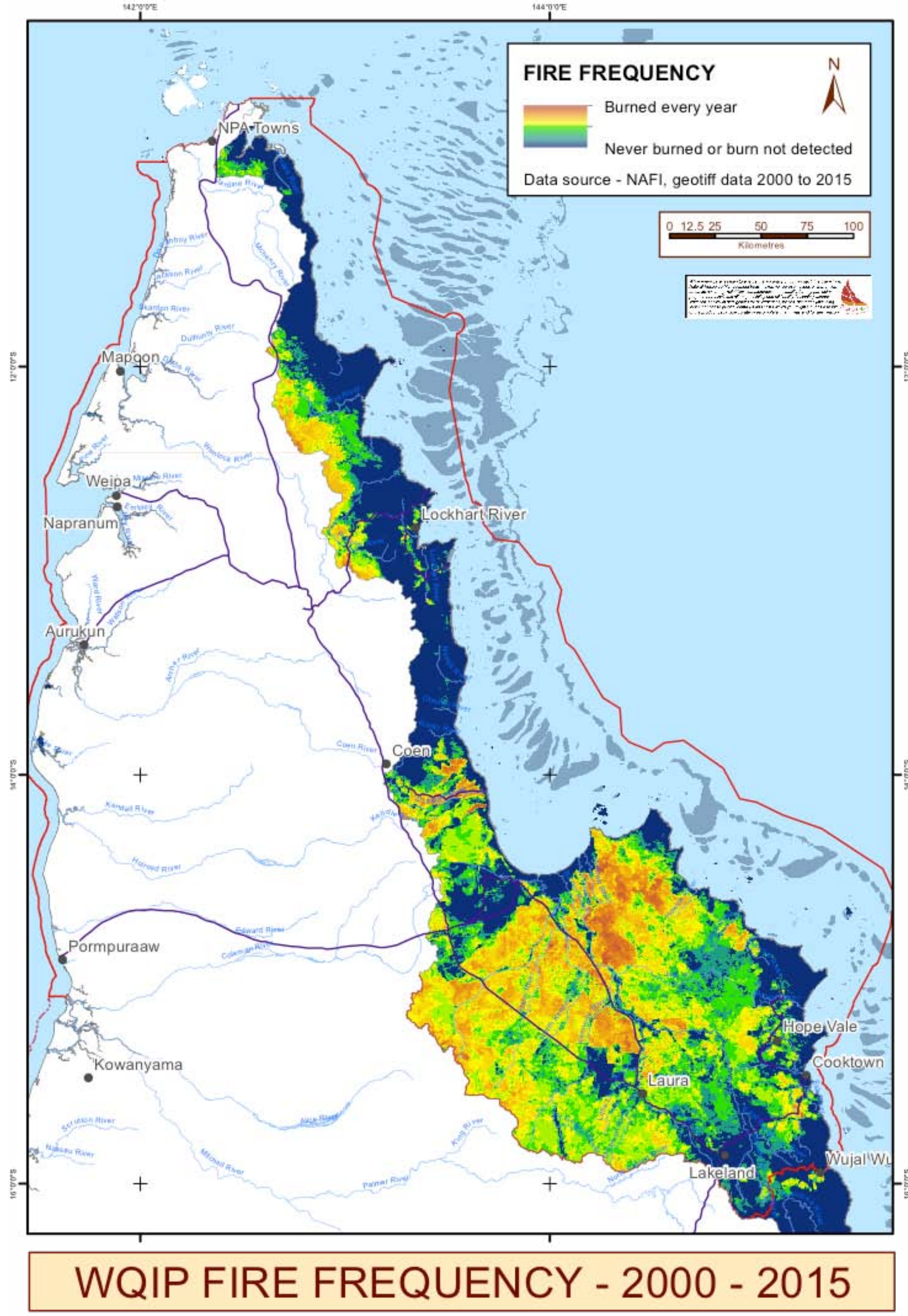



**Figure 23:** Fire Frequency of eastern Cape York (Source: Appendix 13, Standley 2016).

### Feral animals – cattle, horses and pigs

Feral cattle, horses and pigs are present across the whole planning region and can be found in all land uses. Overgrazing and trampling by feral cattle and horses and vegetation destruction and cultivation by feral pigs results in low ground cover and exposed soil (particularly around wetlands, permanent springs and riparian areas) leading into the wet season has been identified as a contributing factor to sediment erosion within all sections of the region.

Improving feral animal management improves overall ecosystem health (particularly wetland functionality) and reduces sediment and associated nutrient loss to downstream freshwater and marine ecosystems.

The spatial extent of feral animals within the planning region has been assessed through one on one consultation with local technical experts, land managers and wetland condition survey records. A spatial analysis of typical grazing vegetation types within nature and cultural conservation land use was undertaken to estimate the potential area that is impacted by the feral cattle and horses (Figure 24). This information has been used to inform the implementation strategies.

Recommendations for implementation within each section:

**North**

- Support National Park and Traditional Owner Ranger programs and other land managers to develop and implement a strategic feral animal control program to greatly reduce the impact of feral cattle, horses and pigs on high priority wetland and nature and cultural conservation areas.
- Implement and monitor high-priority feral animal control demonstration sites.

**Central**

- Identify opportunities to facilitate grazing, agriculture and other land manager and community partnerships to implement coordinated feral animal control programs.
- Coordinate the establishment of feral animal control demonstration sites to protect high-priority wetland and nature and cultural conservation areas.

**South**

- Identify opportunities to facilitate urban and rural residential, agriculture, grazing and other land manager and community partnerships to implement coordinated feral animal control programs.
- Coordinate the establishment of feral animal control demonstration sites to protect high priority wetland and nature and cultural conservation areas.

**Resources required to improve feral animal management:**

- Voluntary Incentive program coordinated by local government to encourage sound pest management
- Pest forum and field day, training and communications materials
- Strategic pest mapping for pest management plans

For more information on the prioritisation of feral animal management within grazing and nature and culture conservation land uses refer to the grazing implementation strategy (Appendix 15). Cook Shire Council, Cape York Weeds and Feral Animals, and Cape York NRM also have a range of publications and information on the control of feral animals.

Feral pig in Jack Lake (Photo: Dr. Jim Mitchell)

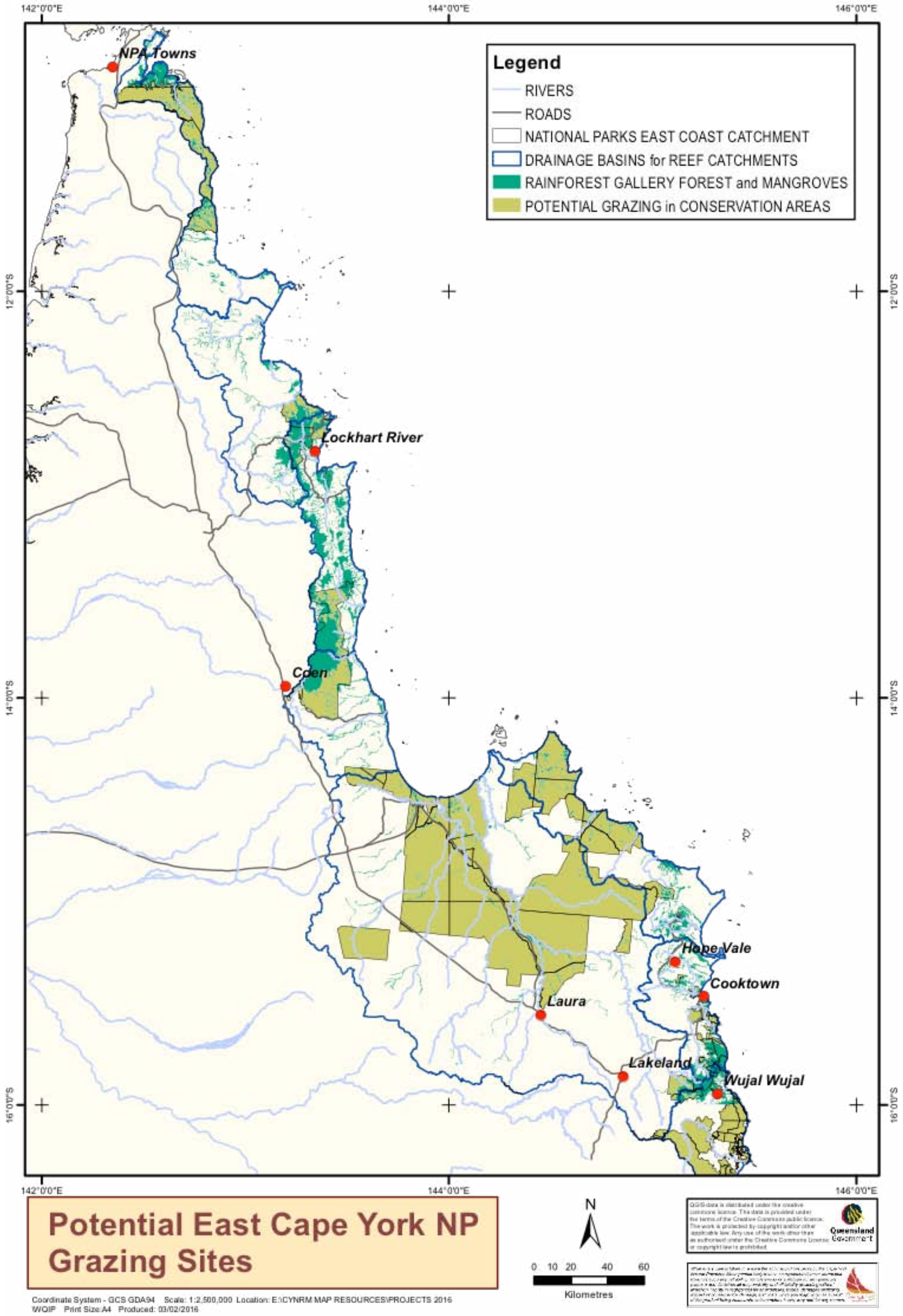



**Figure 24:** Area that is potentially impacted by feral cattle and horses within National Parks.

## Weeds

Sicklepod, hymenachne, rubber vine, pond apple, and salvinia are six invasive weeds of wetlands and waterways that are present in Eastern Cape York. If unmanaged these weeds have the potential to spread and impact widely on the ecological health of waterways, wetlands and floodplains. The impact of these weeds can be summarised as follows:

**Sicklepod** - an annual broadleaf legume that displaces native grasses around rivers, wetlands and floodplains. It is unpalatable so is particularly invasive when combined with heavy grazing pressure. Has spread rapidly throughout the Normanby Basin and is also a major threat to river health in other catchments. Nitrogen fixation may increase nitrogen in the soil surface and contribute to nitrogen in soil water and runoff water. Early identification and control of outbreaks (such as upper Pascoe River) will be required to prevent establishment within the Northern section of the region.

**Hymenachne** - a perennial grass that displaces aquatic plants in waterways and wetlands. A very invasive species with well-established populations in the Central and Southern sections of the region. Early identification and control of outbreaks will be required to prevent establishment within the Northern section of the region.

**Rubber vine** - a perennial vine that displaces and smothers native vegetation in riparian zones. A very invasive species well established populations in the Central section of the region. A current containment line is being maintained just south of Coen at Yarraden Station. Early identification and control of outbreaks will be required to prevent establishment within the Northern section of the region.

**Pond apple** - a tree that displaces mangroves and other riparian species in estuarine and coastal freshwater wetlands. A very invasive species that is the focus of ongoing containment at specific outbreaks in Temple Bay, South Bedford and south of Archer Point. Early identification and control of new outbreaks will be required to prevent establishment throughout the region.

**Salvinia** - an aquatic weed that displaces other aquatic vegetation by forming floating mats that reduce light availability in water. A very invasive species that is the focus for eradication at specific locations in Lakeland and Mount Poverty. Early identification and control of new outbreaks will be required to prevent establishment throughout the region.

**Gamba grass** - a perennial grass that displaces native grasses. Has been shown to increase the intensity of fire regimes and reduce canopy cover and groundcover when burnt. A very invasive species that is the focus for containment and eradication at Kalinga Station on Hann River and Silver Plains Station on Breakfast Creek. Early identification and control of new outbreaks will be required to prevent establishment throughout the region.

Improving weed management improves overall ecosystem health (particularly wetland and floodplain functionality) and when coupled with improved grazing management can help to reduce sediment and associated nutrient loss to downstream freshwater and marine ecosystems.

The spatial extent of weeds within the planning region has been assessed through one-on-one consultation with local technical experts, land managers and wetland condition survey records. Weed outbreak and control mapping by Cape York Weeds and Feral Animals Program and Cook Shire Council has been used to produce maps of known outbreaks to inform the implementation strategies.

Recommendations for implementation within each section:

**North**

- Support National Park and Traditional Owner Ranger programs to develop and implement a strategic weed control program to greatly reduce the impact of the six priority weeds on high-priority wetland and nature and cultural conservation areas.
- Surveillance and control of new outbreaks. Regular surveillance along roads including quarries, and water access points used for road maintenance should be a priority.
- Establish and maintain a containment line including wash-down facilities at Coen, Port Stewart and Lockhart to minimise the northward spread of all weeds.

**Central**

- Identify opportunities to facilitate grazing, agriculture and other land manager and community partnerships to implement strategic weed control programs.
- Implement high priority weed control demonstration sites.
- Establish and maintain a containment line including a wash-down facility at Lakeland to minimise the northward spread of all weeds.

**South**

- Identify opportunities to facilitate urban and rural residential, agriculture, grazing and other land manager and community partnerships to implement strategic weed control programs.
- Implement high priority weed control demonstration sites.
- Establish and maintain a containment line including a wash-down facility at Rossville to minimise the northward spread of all weeds.
- Resources required to improve weed management:
- Voluntary Incentive program coordinated by local government to encourage sound pest management
- Construction of community wash down facilities
- Pest forum and field day, training and communications materials
- Strategic pest mapping for pest management plans

For more information on the prioritisation of weed management within grazing and nature and culture conservation land uses, refer to the grazing implementation strategy (Appendix 15). Cook Shire Council, Cape York Weeds and Feral Animals, and Cape York NRM have a range of publications and information on the identification and management a wide range of weeds.

Spraying sicklepod at Helenvale in the Endeavour basin (Photo: Trevor Meldrum)

# CHAPTER 2: IMPLEMENTATION PLAN

## Priority focus for implementation

The planning region for the northern Great Barrier Reef has been broken into three sections based on marine receiving waters, Northern, Central and Southern and the catchments that drain to them. The priority focus for each section reflects human use and associated level of risk to water quality and ecosystems and Reef 2050 Plan targets. A staged approach to implementation is recommended to ensure that measurable progress is made towards achieving water quality targets.

The priority focus for each section is:

- Northern section - nature and cultural conservation and monitoring
- Central section - grazing (gully), agriculture and road management
- Southern section - urban, rural residential and road and intensive agriculture management

More detail on these priorities is presented below.

The establishment of a Cape York Catchments to Coral Partnership is recommended to provide strategic direction and coordination of implementation activities. The Cape York Catchments to Coral Partnership will also raise awareness within Queensland and Australian Government of Great Barrier Reef-wide and global issues that influence implementation of the Eastern Cape York Water Quality Improvement Plan.

### Northern section (Jacky Jacky, Olive Pascoe and Lockhart)

This is where the most undisturbed ecosystems are.

**Priority focus**
Wetland, floodplain, estuary and reef ecosystem management, protection and monitoring. Fire management, pest management, visitor management and road management as well as wetland condition monitoring, water quality monitoring and baseline marine species diversity and condition monitoring.

**Critical issue**
To document the current condition, threats and species diversity within the Northern section and undertake management to minimise threats from fire, pests, visitors and roads. Traditional Owner Ranger Programs and QPW Rangers must be central to the implementation strategy.

**Do nothing?**
If we don't act now, there is a risk that climate change impacts and other threats will result in a loss of species diversity and/or species range. We will miss the opportunity to define the extent of species diversity that is present in the northern Great Barrier Reef.

**Monitoring questions?**
What impact has human disturbance in the Great Barrier Reef catchment had on species diversity and ecosystem health? Utilise Disturbance index, ecosystem health and water quality monitoring to compare relatively undisturbed ecosystems in the Northern section to:

- Grazing impact on wetland and marine ecosystems at Port Stewart/ Silver Plains (Breakfast Creek) in the Central section
- Expansion and intensification of urban, rural residential, road and agricultural impacts on wetland and marine ecosystems at Cooktown, McIvor River and Annan River in the Southern section.
- Impact of widespread intensive agricultural and urban development on wetland and marine ecosystems in the Wet Tropics region.

### Central section (Stewart, Hann and Normanby)

This is where most of the grazing and agriculture is.

**Priority focus**
Improving grazing, agriculture and road management to minimise the impacts of current and future development on downstream freshwater and marine environments. For grazing, focus on catchment wide adoption of cattle exclusion from gully prone land and ground cover improvement through stocking rates and fire management. Undertake active gully remediation in highest priority areas in Normanby River and Hann River first then Stewart River (Terrible Creek). For agriculture focus on fostering an innovation network supported by small grants and one on one technical support. For roads, work with Main Roads and Cook Shire Council to implement measures to improve road construction and maintenance.

**Critical issue**
Take immediate action to reduce sediment loads and associated nutrient loads from grazing land (gullies), agriculture and roads to minimise the current impact on the marine environment.

**Do nothing?**
If we don't act now there is clear evidence that marine water quality and ecosystem health will decline in both the Central and Northern sections. In large flood events the Normanby and Hann rivers produce flood plumes that extend well into the Northern section.

**Monitoring questions?**
What is a sustainable allocation of water resources to irrigated agriculture and environmental flows in the Lakeland area?

What are the best long-term solutions to reduce and avoid gully and road erosion?

How are current rates of accelerated erosion impacting on downstream environments? What is the impact on water hole and wetland infilling as well as sediment and nutrients discharged to Princess Charlotte Bay?

What proportion of the coastal erosion process in Princess Charlotte Bay is attributable to human activity? How will climate change (sea level rise) affect erosion rates?

### Southern section (Jeanie and Endeavour)

This is where most of the people live.

**Priority focus**
Improving current and future urban and rural residential land development, road construction and intensive agricultural land use to minimise the cumulative impacts on downstream freshwater and marine environments.

**Critical issue**
Foster community action to improve urban, peri-urban and intensive agriculture management. Use practical demonstration sites, small grants and technical training in road, gully, storm water, agriculture, riparian and wetland management to increase community awareness and capacity. Encourage the adoption of world-class standards for all new urban and road developments and agricultural intensification.

**Do nothing?**
If we don't act now there is a significant risk that both current and future urban development and intensification of agricultural land use will impact on seagrass meadows and inshore fringing reefs. There is also potential to increase crown of thorns starfish outbreaks. The coral reefs in the Southern section are easily accessible for tourism and may represent the future of Australia's Reef tourism industry.

**Monitoring questions?**
What role do the Jeannie, Starcke, McIvor, Endeavour and Annan River flood plumes have on crown of thorns starfish outbreaks?

Can we quantify the current cumulative impacts of agricultural and urban land use on seagrass meadows and inshore fringing reefs to establish a baseline for measuring future impacts on the marine environment of potential intensification of land use in Jeannie and Endeavour Basin?

## Strategic and staged approach to implementation

To make best use of local capacity and resources there is a need to use a strategic and staged approach to implementation. The first three to five years should focus on the highest priority activities within the Northern, Central and Southern sections of the planning region. The Cape York Catchments to Coral Partnership will work to exchange information on implementation success and failures and opportunities for expanding the successful activities. Once there is clearly demonstrated progress and further resources are secured, then expansion of priority implementation activities across the region can occur. For example:

- Grazing and gully erosion implementation will move into Oaky Creek (Annan River) and Jeanie River once methods applied in the Central section have been established
- Nature and culture conservation programs will move south through Stewart basin and Hann Basin once methods applied in the Northern section have been established
- Urban and peri urban management programs will move into Lockhart, Lakeland and Laura once methods applied in Southern section have been established

It is important to note that local people will invest their own resources to implement recommended management actions if they are provided with technical support, and encouragement. The cross regional working groups can help to identify where extra technical support is required to encourage local action that is additional and complementary to the priority focus areas.

## Climate change defines our timeline for implementation

The Great Barrier Reef Marine Park Authorities' Outlook Report (2014) defines climate change impacts as the single largest threat to the Great Barrier Reef ecosystem. Improved water quality improves the resilience of the Great Barrier Reef ecosystem to recover following cyclone damage and crown of thorn starfish outbreaks and improves the ability to cope with the impacts of increased temperature and ocean acidification. For example, temperature increases by 2018 are expected to result in coral bleaching events twice per decade and 2035 has been used as a critical climate change timeline within the Wet Tropics Water Quality Improvement Plan (Terrain NRM, 2015).

To provide the marine ecosystems within the northern Great Barrier Reef with resilience to climate change impacts, the water quality improvement targets need to be achieved within the marine environment before the impacts of climate change are expressed. A seven - year timeline (2016 – 2022) for widespread land management action has been used within the implementation plan to maximise the opportunity for marine water quality to begin improving by 2030 (this takes into account the long time lags associated with sediment reduction at whole of catchment scale).

The impact of climate change on the marine ecosystems within the Central section may be even more extreme, due to increased sediment loads associated with the lowland floodplain/coastal plain erosion process in Princess Charlotte Bay. It is unclear whether climate change induced sea level rise will accelerate this erosion process. While this lowland floodplain/coastal plain erosion process presents a critical knowledge gap, it also reinforces the need for significant effort to improve land management to reduce the other sediment sources in the Normanby and Hann Basins.



## GBR-wide and global issues that influence implementation

There are a range of GBR-wide or global issues that influence WQIP implementation that should be addressed by Queensland and the Australian Government to support WQIP implementation in the northern GBR.

The required actions include:

- GBR-wide pest management strategies for surveillance and quarantine. For example, to utilise best practice pest management to create a quarantine / containment boundary north from Stewart River – ie at Coen/Port Stewart Road and north from Lakeland and Rossville
- GBR-wide mining/road/infrastructure development implemented at world class environmental standards supported by legislative policies
- GBR-wide land use intensification for agriculture and urban implemented at world class environmental standards supported by legislative policies
- GBR-wide integrated voluntary and regulatory approaches to encourage adoption where regulation focuses on reinforcing significant financial investment to land management change
- Global climate change impacts create a 15–20-year timeline for achieving significant water quality improvement. Between 2030 and 2035, the health of the whole Great Barrier Reef and its catchment will be influenced by climate change
- Global economic development paradigm is encouraging increased human development pressure and there is a need for greater emphasis on environmental accounting across the whole GBR. The northern GBR is one of the last relatively undisturbed marine ecosystems on Earth and we need to apply an economic value that reflects its rarity and irreplaceability

## Cape York Catchments to Coral Partnership

Successful implementation of the Eastern Cape York Water Quality Improvement Plan requires a coordinated strategic approach that engages many individuals with technical expertise and experience in the ongoing design and review of practical implementation strategies. A Cape York Catchments to Coral Partnership with a structured approach involving the formation a management committee and five working groups with coordination and facilitation by appropriate, regionally-based natural resource management organisations is recommended.

### Cape York Catchments to Coral management committee

The Cape York Catchments to Coral management committee will have overall responsibility for implementing the Eastern Cape York Water Quality Improvement Plan. The five working groups would report to the Cape York Catchments to Coral management committee. Proposed makeup of the committee is presented in Table 14.

**Table 14:** Potential members of Cape York Catchment to Coral management committee

| Stakeholder | Potential Organisations (presented as examples not fait accompli') |
|---|---|
| Local NRM coordination | Cape York NRM and/or SCYC representatives |
| Queensland Government | Office of the Great Barrier Reef and/or EHP representatives |
| Australian Government | GBRMPA and/or DoE representatives |
| Local Government | Cook Shire Council, NPA Council, Hope Vale Council and Lockhart River Council representatives |
| Agriculture Sector | QFF and/or AgForce representatives |
| Conservation Sector | WWF and/or Wilderness Society and/or South Endeavour Trust representatives |
| Traditional Owner Sector | Cape York Land Council and/or Balkanu representatives |

The Cape York Catchments to Coral management committee would provide strategic direction to the working groups and major implementation programs as well as the following suggested activities:

- Foster community action with a long term focus on positive outcomes
- Annual process to synthesise science and monitoring results which could include production of an annual implementation report card
- Annual community celebration of success, which could include awareness raising events such as field days and a community awards process
- Develop strategies that encourage Queensland and Australian Government to address the GBR-wide and global issues that influence implementation

The governance arrangements recommended to guide and support implementation of the Eastern Cape York Water Quality Improvement plan have been developed with reference to the following Reef 2050 Plan water quality action:

- **WQA8** - Increase industry participation in regional water quality improvement initiatives and partnerships aimed at managing, monitoring and reporting of water quality.

  These should be based on existing initiatives such as:
  - Fitzroy Partnership for River Health
  - Gladstone Healthy Harbour Partnership
  - Mackay Whitsunday Healthy Rivers to Reef Partnership



## Cape York Catchments to Coral working groups

The Cape York Catchments to Coral Partnership will include five working groups:

- **Urban** - including rural residential, roads, ports and shipping. All three sections but typically meet in Cooktown (sometimes in Lockhart)
- **Roads** - including development and maintenance of all public roads. All three sections but typically meet in Cooktown
- **Grazing** - including gullies, farm roads and fence lines. All three sections but typically meet in Laura or Coen
- **Agriculture** - including both intensive and extensive agriculture. Central and Southern sections and typically meet in Lakeland or Cooktown
- **Nature and Cultural Conservation** - including biodiversity research, species protection plans, and wetland, floodplain, riverine, estuary and marine monitoring. All three sections but typically meet at Silver Plains, Lockhart or Bamaga.

All of these working groups require overarching facilitation, coordination and consistent expert technical support for fire management, pest management, road management, gully management, economic analysis (cost benefit) and disturbance, water quality and ecosystem monitoring (Table 15). The aim of these roles is to encourage consistent implementation methodologies across the region. This will also enable region wide reporting of successful implementation.

**Table 15:** Working group support roles

| Role | Potential Organisation | Urban | Roads | Grazing | Agriculture | Nature and cultural conservation |
|---|---|---|---|---|---|---|
| Coordination | Cape York NRM and/or SCYC | All meetings | All meetings | All meetings | All meetings | All meetings |
| Fire technical support | QPWS, Cape York NRM or consultant | As required | As required | All meetings | As required | All meetings |
| Pest technical support | CYWAFAI, DAF or consultant | All meetings | As required | As required | As required | All meetings |
| Road technical support | CSC, Main Roads or consultant | All meetings | All meetings | All meetings | As required | All meetings |
| Gully technical support | SCYC, Griffith Uni or consultant | As required | All meetings | All meetings | As required | All meetings |
| Economic analysis technical support | DAF, CQU or consultant | Once per year | Once per year | Once per year | Once per year | Once per year |
| Disturbance, water quality and ecosystem monitoring technical support | SCYC and DSITI or consultant | All meetings | All meetings | All meetings | All meetings | All meetings |

### Working group processes

The five working groups that support the Cape York Catchments to Coral Partnership will be facilitated and coordinated by appropriate, regionally-based Natural Resource Management organisations to ensure that there is resilience in delivery processes. These organisations will ensure that the working groups are supported to undertake the following:

- Cross regional exchange of technical information to support adaptive implementation (share successes and failures and plans for future implementation)
- Water quality and ecosystem health monitoring designs reviewed and results discussed (before public release if practical)
- Investment priorities and methodologies for prioritising on ground implementation reviewed and results discussed (before public release if practical)
- Support development of technical training and action learning to increase implementation capability
- Support development of integrated region wide funding applications
- Support development of communication processes, including communication materials (such as case studies) and communication events (such as demonstration days or field tours)

An example of membership and actions that will be undertaken by the Urban Working Group follows:

Urban Working Group membership:

Cook Shire Council, Hope Vale Council, Lockhart Council, Northern Peninsula Area Council, roads technical support, fire technical support, gully technical support, monitoring technical support, pest technical support.

Urban Working Group actions:

- Develop urban management framework that is specific to northern GBR. Review other urban frameworks used in GBR (particularly Cairns and Townsville)
- Undertake a review of current urban management practices for all urban centers in the northern GBR catchment
- Identify opportunities for improved management that integrates with council implementation priorities
- Foster an information exchange between councils within the region and consider technical information exchange with neighbouring regions through the regional organisation of councils (NQRoC and Indigenous Council RoC)
- Identify technical training opportunities for roads management, fire management, gully management, stormwater management
- Identify funding opportunities for urban implementation that the partnership can support.
- Develop urban and peri urban communication and awareness program that includes pest management, fire management, road and track management, gully management, vegetation management
- Identify and support implementation of demonstration sites that will support community awareness activities
- Integrate monitoring into demonstration sites to quantify improvement.
- Report on implementation success and failures

## Implementation costings

For most management actions a simple costing method was used to determine a reasonable cost required to provide the resources to achieve the sub-catchment management action targets. For gully management sufficient sediment load reduction data was available to enable a cost effectiveness analysis to be undertaken for sediment reduction in the Normanby Basin. The Quantified Cost Effective Reduction Targets for the Normanby Basin is presented after the costing summary table as an example of quantified cost effectiveness analysis that can be undertaken during implementation for other significant sediment sources (such as roads and agriculture) as data becomes available.

The cost of the Integrated Monitoring Program is presented in detail in Chapter 3 and in summary in Table 16. The total cost of the Integrated Monitoring Program from 2016 – 2022 is $17.05M, which represents 10% of the total cost of implementation of $171M for the first seven-year implementation period (2016 to 2022).

### Gully management

A strategic active gully remediation program to achieve cost-effective erosion reduction within grazing and nature and culture conservation land uses. The following costings summarises costs from the Quantified Cost Effective Reduction Target analysis presented in the section below. These costs are estimated for the seven years between 2016 and 2022; all other costs presented are annual.

- Grazing exclusion of top 200 high priority gully erosion sub-catchments; 4000kms fencing, @$7000 per km = $28M
- Grazing exclusion and destocking of Springvale = $2.25M
- High priority active gully remediation projects 1700ha @ $30,000/ha = $51.6M
- 6 x Gully Technical Design and Coordination Officers = $6.3M
- LiDar and site monitoring to quantify erosion reduction = $1.85M

These costs will be spread across the seven years with the first two years scaling up as capacity builds ($8M year one, $12M year two and $14M per year for years three to seven). Individual projects and sites may vary from year to year depending on the scale of the proposed projects and the priority of the proposed management practices in line with the Grazing Implementation Strategy (Appendix 15) and the Gully Prioritisation Report (Appendix 2).

Total Cost = $90M per 7 years

Funding required = $90M per 7 years

Landholder contribution = mustering and fence maintenance support.

### Grazing management

Voluntary Incentive program to encourage adoption of grazing best management practices (including within property road, firebreak and fence line erosion control) within grazing and nature and culture conservation land uses.

- 40 Projects at $30K per project on 20 properties per year = $1.2M per year
- 3 x Grazing Technical Extension Officers = $450K per year
- Field day, workshop and communications materials = $100K per year
- Soil mapping and soil tests for grazing management plans = $50K per year
- Road erosion expert technical support = $50K per year
- Landholder in kind or cash contribution to projects $15K per project = $600K per year

The number of individual projects and landholders may vary from year to year depending on the scale of the proposed projects and the priority of the proposed management practices in line with the Grazing Implementation Strategy (Appendix 15).

Total Cost = $2.45M per year

Funding required = $1.85M per year

Landholder contribution = $600K per year

### Agriculture management

Voluntary Incentive program to encourage adoption of innovative agriculture management practices within agriculture land uses.

- 10 Projects at $15K per project on 6 properties per year = $150K per year
- Precision Agriculture Technical Extension Officer = $150K per year
- Field day, workshop and communications materials = $20K per year
- EM soil mapping and soil tests for nutrient management plans = $50K per year
- Landholder in kind or cash contribution to projects $30k per project = $300K per year

The number of individual projects and landholders may vary from year to year depending on the scale of the proposed projects and the priority proposed management practices in line with the Agriculture Implementation Strategy (Appendix 16).

Total Cost = $670K per year

Funding required = $370K per year

Landholder contribution = $300k per year

### Wetland management

Voluntary Incentive program to encourage adoption of wetland best management practices within grazing and nature and culture conservation land uses.

- 30 projects at $30K per project on 20 properties per year = $900K per year
- Wetland Coordination Officer = $150K per year
- Training, workshop and communications materials = $50K per year
- Wetland monitoring expert technical advice to support project design and wetland condition monitoring = $200K per year
- Landholder in kind or cash contribution to projects $15K per project = $300K per year

The number of individual projects and landholders may vary from year to year depending on the scale of the proposed projects and the priority of the proposed projects for improving water quality and ecosystem health.

Total Cost = $1.6M per year

Funding required = $1.3M per year

Landholder contribution = $300K per year

### Local government road management

Road management technical capacity building program within local government

- 1 x Road Technical Extension Officer = $150K per year
- Engineering design and material expenses for three best practice road management demonstration sites per year = $150K per year
- Training, workshop and communications materials = $50K per year
- Council contribution to best practice road management demonstration sites = $150K per year

The resources allocated to individual demonstration sites may vary from year to year depending on the resources required for the specific road management activity and the priority of the proposed activity for improving water quality.

Total Cost = $500K per year

Funding required = $350K per year

Council contribution = $150K per year



### Urban management

Urban water management technical capacity building program within local government

- 2 x Urban Technical Extension Officers = $300K per year
- Material expenses for 10 best practice urban erosion and sediment control and storm water demonstration sites per year = $200K per year
- Training, workshop and communications materials = $50K per year
- Council contribution to best practice urban water management demonstration sites = $200K per year

The resources allocated to individual demonstration sites may vary from year to year depending on the resources required for the specific urban water quality management activity and the priority of the proposed activity for improving urban water quality.

Total Cost = $750K per year

Funding required = $550K per year

Council contribution = $200K per year

### Fire management

Coordinated broad scale early-season aerial burning and technical support for Fire Cluster Group program to encourage adoption of appropriate burning regimes.

- 2 x full time Fire Coordination Officers to coordinate aerial burning and on-ground activities through 4 x half time fire managers working across 18 fire cluster groups = $600K per year
- Material and operating expenses for broad-scale early-season aerial burning program (plane and helicopter time and fuel, aerial incendiaries, etc) = $400K per year
- Cluster group meetings and communications materials = $90K per year
- GIS and mapping support for fire management plans = $90K per year
- Landholder contribution to property scale fire management (firebreaks, storm burns etc) $80K per group = $540K per year

The resources allocated to each fire cluster group/fire warden district may vary from year to year depending on the resources required to implement the priority activities within each property's fire management plan for that year.

Total Cost = $1.72M per year

Funding required = $1.18M per year

Landholder contribution = $540K per year

### Pest management

Voluntary Incentive program to encourage adoption of best management practices.

- 30 Projects at $15K per project on 20 properties per year = $450K per year
- Construction of 1 community wash down facility per year = $100K per year
- Pest forum and field day, training and communications materials = $50K per year
- Strategic pest mapping for pest management plans = $50K per year
- Landholder in kind or cash contribution to projects $15K per project = $300K per year
- Local Government in kind or cash contribution to maintenance of community wash down facility per year = $50K per year
- Local Government in kind or cash contribution to 3 x Pest Technical Extension Officers = $450K per year

The number of individual projects and landholders may vary from year to year depending on the scale of the proposed projects and the priority of the proposed projects for improving water quality and ecosystem health.

Total Cost = $1.45M per year

Funding required = $650K per year

Landholder + Local Government contribution = $800K per year

## Adaptive management

The integrated monitoring framework described in Chapter 3 will allow for adaptive management to be applied to the implementation of the WQIP. Effective improvement or maintenance of water quality in the northern GBR requires adaptive management to account for changing knowledge, biophysical condition, funding, legislation and public sentiment. Monitoring for the WQIP implementation should undertake several functions:

- Quantify the adoption of improved management practices;
- Determine and validate relationships between improved management practices, water quality and load output, as well as ecosystem health;
- Accurately measure pollutant loads delivered to the sub-catchments, end-of-catchment gauges, and the GBR to empirically track changes over long periods of time (next century); and
- Investigate water quality issues of concern to the community as part of ongoing community-driven activities in the region.

The results of this monitoring program will feed a growing body of knowledge regarding the most effective land management practices to reduce pollutant loads across the Cape York landscape. These data can also be applied at a cross-regional, reef-wide level. The on-going incorporation of the lessons learned through adaptive management will ensure that WQIP implementation remains relevant in delivering water quality and ecosystem health improvements.

## Reasonable assurance

This Water Quality Improvement Plan has been produced using the best available information (with consideration of time and resourcing constraints) by experienced water quality improvement planners. Where limitations to data exist they have been identified throughout the plan. Several of the data sets, such as the linear disturbance analysis for Normanby and Stewart Basins (Appendix 1, Spencer et al., 2016), gully prioritisation (Appendix 2, Brooks et al., 2016) and the water quality data set for Normanby Sub Basin presented in the loads report (Appendix 8, Howley et al., 2016) and fresh water quality guidelines (Appendix 9, Howley and Moss, 2016) are considered to be of high reliability and represent some of the most detailed datasets of their kind for the Great Barrier Reef catchment. Many of the other data sets utilised are considered to be of moderate to low reliability and have typically been used for basin scale or marine receiving waters scale analysis. The Science Advisory Panel process has considered the limitations to the data sets in the context of the recommended approach presented in the implementation plan (Chapter 2).

The information contained in this Water Quality Improvement Plan has been compiled in good faith by Cape York NRM and South Cape York Catchments from sources believed to be reliable. However, Cape York NRM and South Cape York Catchments, their officers, board members, employees and consultants do not invite reliance upon, nor accept responsibility for, or guarantee the accuracy or completeness of the information. Before relying on any information in this report, the reader should make their own enquiries and seek independent professional, scientific and technical advice. The reliance upon and/or use of any information contained in this report shall be at the reader's own risk and no liability will be accepted for any consequences which may arise directly or indirectly as a result.



**Table 16:** Estimated cost to implement the recommended management actions ($)

| Theme | Funding breakdown | 2016/2017 | 2017/2018 | 2018/2019 | 2019/2020 | 2020/2021 | 2021/2022 | 2022/2023 | Total Cost 7 yrs |
|---|---|---|---|---|---|---|---|---|---|
| Gully Management | Funding Required | $8,000,000 | $12,000,000 | $14,000,000 | $14,000,000 | $14,000,000 | $14,000,000 | $14,000,000 | $90,000,000 |
| | In Kind Contribution | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| | **Total Cost** | **$8,000,000** | **$12,000,000** | **$14,000,000** | **$14,000,000** | **$14,000,000** | **$14,000,000** | **$14,000,000** | **$90,000,000** |
| Grazing Management | Funding Required | $1,850,000 | $1,850,000 | $1,850,000 | $1,850,000 | $1,850,000 | $1,850,000 | $1,850,000 | $12,950,000 |
| | In Kind Contribution | $600,000 | $600,000 | $600,000 | $600,000 | $600,000 | $600,000 | $600,000 | $4,200,000 |
| | **Total Cost** | **$2,450,000** | **$2,450,000** | **$2,450,000** | **$2,450,000** | **$2,450,000** | **$2,450,000** | **$2,450,000** | **$17,150,000** |
| Agriculture Management | Funding Required | $370,000 | $370,000 | $370,000 | $370,000 | $370,000 | $370,000 | $370,000 | $2,590,000 |
| | In Kind Contribution | $300,000 | $300,000 | $300,000 | $300,000 | $300,000 | $300,000 | $300,000 | $2,100,000 |
| | **Total Cost** | **$670,000** | **$670,000** | **$670,000** | **$670,000** | **$670,000** | **$670,000** | **$670,000** | **$4,690,000** |
| Wetland Management | Funding Required | $1,300,000 | $1,300,000 | $1,300,000 | $1,300,000 | $1,300,000 | $1,300,000 | $1,300,000 | $9,100,000 |
| | In Kind Contribution | $300,000 | $300,000 | $300,000 | $300,000 | $300,000 | $300,000 | $300,000 | $2,100,000 |
| | **Total Cost** | **$1,600,000** | **$1,600,000** | **$1,600,000** | **$1,600,000** | **$1,600,000** | **$1,600,000** | **$1,600,000** | **$11,200,000** |
| Local Government Road Management | Funding Required | $350,000 | $350,000 | $350,000 | $350,000 | $350,000 | $350,000 | $350,000 | $2,450,000 |
| | In Kind Contribution | $150,000 | $150,000 | $150,000 | $150,000 | $150,000 | $150,000 | $150,000 | $1,050,000 |
| | **Total Cost** | **$500,000** | **$500,000** | **$500,000** | **$500,000** | **$500,000** | **$500,000** | **$500,000** | **$3,500,000** |
| Urban Management | Funding Required | $550,000 | $550,000 | $550,000 | $550,000 | $550,000 | $550,000 | $550,000 | $3,850,000 |
| | In Kind Contribution | $200,000 | $200,000 | $200,000 | $200,000 | $200,000 | $200,000 | $200,000 | $1,400,000 |
| | **Total Cost** | **$750,000** | **$750,000** | **$750,000** | **$750,000** | **$750,000** | **$750,000** | **$750,000** | **$5,250,000** |
| Fire Management | Funding Required | $1,180,000 | $1,180,000 | $1,180,000 | $1,180,000 | $1,180,000 | $1,180,000 | $1,180,000 | $8,260,000 |
| | In Kind Contribution | $540,000 | $540,000 | $540,000 | $540,000 | $540,000 | $540,000 | $540,000 | $3,780,000 |
| | **Total Cost** | **$1,720,000** | **$1,720,000** | **$1,720,000** | **$1,720,000** | **$1,720,000** | **$1,720,000** | **$1,720,000** | **$12,040,000** |
| Pest Management | Funding Required | $650,000 | $650,000 | $650,000 | $650,000 | $650,000 | $650,000 | $650,000 | $4,550,000 |
| | In Kind Contribution | $800,000 | $800,000 | $800,000 | $800,000 | $800,000 | $800,000 | $800,000 | $5,600,000 |
| | **Total Cost** | **$1,450,000** | **$1,450,000** | **$1,450,000** | **$1,450,000** | **$1,450,000** | **$1,450,000** | **$1,450,000** | **$10,150,000** |
| **Total Project Funding Required per year** | | **$14,250,000** | **$18,250,000** | **$20,250,000** | **$20,250,000** | **$20,250,000** | **$20,250,000** | **$20,250,000** | **$133,750,000** |
| **Total Project In Kind Contribution per year** | | **$2,890,000** | **$2,890,000** | **$2,890,000** | **$2,890,000** | **$2,890,000** | **$2,890,000** | **$2,890,000** | **$20,230,000** |
| **Total Project costs per year** | | **$17,140,000** | **$21,140,000** | **$23,140,000** | **$23,140,000** | **$23,140,000** | **$23,140,000** | **$23,140,000** | **$153,980,000** |
| **Integrated Monitoring Program** | | **$2,050,000** | **$2,500,000** | **$2,500,000** | **$2,500,000** | **$2,500,000** | **$2,500,000** | **$2,500,000** | **$17,050,000** |

## Quantified cost effective reduction targets for the Normanby Basin

Fine suspended sediment loads from the Normanby and Hann Sub Basins present the greatest water quality risk to the northern GBR. To develop practical and measureable targets, the percentage of end-of-catchment anthropogenic load has been converted to a quantity of total load that is required to be reduced at both end-of-catchment and in priority sub-catchments.

The following ten steps were used to develop quantified cost-effective fine suspended sediment reduction targets for Normanby Basin:

1. Analysis of load monitoring data sets and the extent and intensity of catchment disturbance for the Hann and Normanby sub basins to estimate percentage of anthropogenic fine suspended sediment loads at the end-of-catchment in 2015 (50% anthropogenic for Normanby sub basin and 30% anthropogenic for Hann sub basin).
2. Utilise Normanby Empirical Sediment Budget and Source Catchments total load estimates to convert percentage of anthropogenic load to a quantity of total fine suspended sediment load (<15.7um) at the end-of-catchment (Tables 17, 18 and 19).
3. Use a 2.5x multiplier to convert the quantity of end-of-catchment fine suspended sediment (<15.7um) load reduction to a quantity of priority sub-catchment fine suspended sediment (<63um) load reduction. This multiplier represents the sediment deposition processes that take place between the priority sub-catchment and the end-of-catchment.
4. Analyse all available data on the magnitude of anthropogenic sediment sources in priority catchments to determine which sediment sources could be practically reduced to achieve the quantity of sediment reduction required to meet targets (Gully erosion presents as the only major anthropogenic sediment source that has a reasonable local data set to support a calculation of scale and cost of management action required to meet sediment reduction targets).
5. Analyse all available gully erosion data in priority sub-catchments within the Normanby basin to estimate the quantity of sediment that could be reduced in priority sub-catchments through practical management actions (such as cattle exclusion and active gully remediation).
6. Estimate the cost of implementing practical management actions (such as cattle exclusion and active gully remediation) to achieve the quantity of sediment reduction that is required to meet priority sub-catchment load reductions (that in turn result in end-of-catchment load reduction targets being met. This can inform an analysis of cost effectiveness of management actions in different locations or properties.
7. Estimate the time lags between the adoption of management actions (cattle exclusion and active gully remediation) and resulting improvement in priority sub-catchment and end-of-catchment water quality. Active gully remediation has shorter time lags (within three years), whereas grazing exclusion has longer time lags (up to 22 years) to achieve significant measurable sediment reductions.
8. Estimate the time lags for water quality monitoring to detect and confirm changes at priority sub-catchment scale and end-of-catchment scale. Approximately three years lag at sub-catchment scale and at least seven years lag at end-of-catchment scale, after management is implemented (and assuming we begin collecting Super Gauge water quality data at sub-catchment and end-of-catchment scale from 2016).
9. Do the calculations as a straw man to estimate the scale and cost of practical management actions (grazing exclusion and active gully remediation) that could achieve the quantity of sediment reduction at priority sub-catchment scale that is required to meet end-of-catchment targets. Check the result for practicality of the scale of implementation required to meet targets and cost effectiveness between different locations (Table 20).
10. Refine and repeat calculation until cost effective sub-catchment management action targets with practical implementation timelines are defined. (This process was repeated multiple times to produce the third estimate presented in Table 20 below).

Results of the above process being undertaken to produce a third estimate of the scale and costs of gully erosion control management actions required to meet fine suspended sediment reduction targets in the Normanby Basin (the first two estimates were reviewed by the Science Advisory Panel). This cost and load reduction analysis is based on the best available information on sediment load reductions from priority gully erosion sites identified by Brooks et al., 2016 (Appendix 2).

The following conclusions are based on the estimate presented in Table 20, of the scale and cost of gully erosion control management actions required to meet targets in the Normanby Basin:

- A focused investment of $90M into gully erosion control activities from 2016 to 2022 will lay the foundation for achieving a 60% reduction in anthropogenic end-of-catchment fine suspended sediment loads by 2037
- It is likely that the actual load reductions from active gully remediation at sub-catchment scale will be higher due to a complementary reduction in bank and channel erosion
- It is likely that the actual implementation costs of active gully remediation required to achieve the reductions will improve as experience and capacity improve through on ground implementation - enabling more to be achieved with the same investment
- A complementary investment of $43M into the other recommended management activities such as grazing, agriculture, fire, wetland and road management from 2016 to 2022 will ensure that the 60% reduction in anthropogenic end-of-catchment fine suspended sediment loads can be achieved by 2037
- The complementary investment in grazing technical extension officers and fire coordination officers and fire managers will ensure that grazing exclusion and appropriate fire regimes are maintained in the long term
- A further investment of $126M into gully erosion control activities and $86M into other activities from 2022 to 2037 will ensure that the 2037 load reduction target is met and can be confirmed by sub-catchment and end-of-catchment monitoring between 2040 and 2050
- An absolute minimum of $1.85M would be required between 2016 and 2022 for LiDAR and strategic site monitoring to confirm soil loss improvements at small sub-catchment scale and end-of-catchment scale
- An absolute minimum of $3.25M would be required between 2022 and 2037 for lidar and strategic site monitoring to confirm soil loss improvements at small sub-catchment scale and end-of-catchment scale
- These investments are required to ensure that the northern GBR has the marine water quality that is required to maximise the resilience and adaptation of the northern GBR to future climate change impacts

Important notes to the conclusions above:

- There are approximately 1500 ha of alluvial and colluvial gullies mapped using google earth in the Normanby Basin (Appendix 2, Brooks et al., 2016). However, LiDAR analysis has revealed that this represents less than 15% of the actual gullied area, indicating that the total active gully area is likely to be at least 10,000 ha's in the Normanby Basin

- The Top 100 gully erosion sub-catchments are on approximately 12 properties within the Normanby Basin. With Springvale and Crocodile Stations having the greatest number of the Top 100 gullies (Appendix 2, Brooks et al., 2016). However, once the next 100 gully erosion sub-catchments are identified (ie 101 to 200), it is estimated that these will be on at least 20 properties in the Normanby Basin. When other basins (ie. Stewart and Endeavour) are mapped it is likely that there will be gullies from these basins within the top 200 gullies.
- There was insufficient data to enable a cost effectiveness analysis of road erosion remediation works to be undertaken. However, it is likely that there will be a range of cost-effective road erosion remediation sites where actively eroding roads intersect with the stream network within the top 200 gully erosion sub-catchments

**Table 17:** Estimation of the quantity of fine suspended sediment (t/y) required to meet anthropogenic load reduction targets for the Normanby Basin (Normanby plus Hann Sub-Basins).

| Model | 2015 Current Condition End of Catchment Anthropogenic fine suspended sediment (<15.7um) t/y | 2022 Target End of Catchment Fine suspended sediment reduction (<15.7um) t/y | 2022 Target Sub Catchment Fine suspended sediment reduction (<63um) t/y | 2030 Target End of Catchment Fine suspended sediment reduction (<15.7um) t/y | 2030 Target Sub Catchment Fine suspended sediment reduction (<63um) t/y | 2037 Target End of Catchment Fine suspended sediment reduction (<15.7um) t/y | 2037 Target Sub Catchment Fine suspended sediment reduction (<63um) t/y |
|---|---|---|---|---|---|---|---|
| **Normanby Empirical Sediment Budget** | **232,000** | 46,000 | **116,000** | 93,000 | **232,000** | 139,000 | **349,000** |
| **Source Catchments 2015** | **160,000** | 32,000 | **80,000** | 64,000 | **160,000** | 96,000 | **240,000** |

**Table 18:** Calculation of Anthropogenic fine suspended sediment load and quantification of total load reduction based on Normanby Empirical Sediment Budget

| Normanby Basin Sediment Budget | | tonnes per year | |
|---|---|---|---|
| Total FSS (<63um) | | 777,000 | based on Normanby Empirical Sediment Budget |
| Normanby Sub Basin Total FSS (<63um) | | 622,000 | based on Normanby Empirical Sediment Budget |
| Hann Sub Basin Total FSS (<63um) | | 155,000 | based on Normanby Empirical Sediment Budget |
| Normanby Sub Basin Anthrop FSS (<63um) | 50% | 311,000 | 50% based on Science Advisory Panel |
| Hann Sub Basin Anthrop FSS (<63um) | 30% | 46,000 | 30% based on Science Advisory Panel |
| Total Anthropogenic FSS (<63um) | 46% | 357,000 | 46% based on Science Advisory Panel |
| **Total Anthropogenic FSS (<15.7um)** | 65% | **232,000** | 65% based on Kalpowar monitoring |
| 20% of anthropogenic by 2022 | 20% | 46,000 | 7.5 year End of Catchment reduction target |
| **20% of anthropogenic by 2022** | 2.5x EoC | **116,000** | **7.5 year Sub Catchment reduction target** |
| 40% of anthropogenic by 2030 | 40% | 93,000 | 15 year End of Catchment reduction target |
| **40% of anthropogenic by 2030** | 2.5x EoC | **232,000** | **15 year Sub Catchment reduction target** |
| 60% of anthropogenic by 2037 | 60% | 139,000 | 22.5 year End of Catchment reduction target |
| **60% of anthropogenic by 2037** | 2.5x EoC | **349,000** | **22.5 year Sub Catchment reduction target** |

*Please note in Table 18, the Normanby basin sediment budget total sediment load output (<63um) has been converted to <15.7um using a 65% factor based on estimates made from Kalpowar monitoring data.*

**Table 19:** Calculation of Anthropogenic fine suspended sediment load and quantification of total load reduction based on Source Catchments 2015

| Source Catchments (2015) | | tonnes per year | |
|---|---|---|---|
| Total FSS (<15.7um) | | 226,000 | based on Source Catchments |
| Normanby Sub Basin Total FSS (<15.7um) | | 181,000 | based on Source Catchments |
| Hann Sub Basin Total FSS (<15.7um) | | 45,000 | based on Source Catchments |
| Normanby Sub Basin Anthrop FSS (<15.7um) | | 131,000 | based on Source Catchments |
| Hann Sun Basin Anthrop FSS (<15.7um) | | 29,000 | based on Source Catchments |
| **Total Anthropogenic FSS (<15.7um)** | | **160,000** | based on Source Catchments |
| 20% of anthropogenic by 2022 | 20% | 32,000 | 7.5 year End of Catchment reduction target |
| **20% of anthropogenic by 2022** | 2.5x EoC | **80,000** | **7.5 year Sub Catchment reduction target** |
| 40% of anthropogenic by 2030 | 40% | 64,000 | 15 year End of Catchment reduction target |
| **40% of anthropogenic by 2030** | 2.5x EoC | **160,000** | **15 year Sub Catchment reduction target** |
| 60% of anthropogenic by 2037 | 60% | 96,000 | 22.5 year End of Catchment reduction target |
| **60% of anthropogenic by 2037** | 2.5x EoC | **240,000** | **22.5 year Sub Catchment reduction target** |

*Please note in Table 19, Source Catchments predicts <20um which is considered the same as <15.7um given the uncertainty/error associated with the catchment modelling outputs. As a result a conversion factor was not considered necessary to convert Source Catchments outputs to <15.7um.*

**Incorporating within property roads tracks, fence lines and firebreaks into the quantified cost effective reduction target analysis.**

During the early stages of gully erosion implementation, it is recommended to collect the information required to undertake a quantified cost effective reduction target analysis that includes both active gully erosion and active road erosion remediation. Quantification of the cost and water quality benefits of actively remediating within property roads, tracks, fence lines and firebreaks is required. A focus on the roads, tracks, fence lines and firebreaks within the highest priority gully erosion sub-catchments is recommended due to the complementary erosion reduction benefits from these high priority locations for anthropogenic sediment sources.

As implementation progresses the allocation of resources to gully remediation vs within property road remediation should be reviewed periodically to ensure that the most cost effective erosion control actions and locations are being addressed.

Public road management and improvement is the responsibility of local, state and federal government, whereas within property roads are the responsibility of the individual property owner. A voluntary incentive program for active remediation of within property roads should be considered, however, the private benefit of within property roads, tracks, fence lines and firebreaks should be a key factor in determining the level of incentive provided for these activities.

**Table 20:** Estimate of scale and cost of management action to achieve sediment reduction targets in the Normanby Basin (Sediment reduction figures are cumulative).

| Gully erosion control activity | Cost to implement 2016 to 2022 ($) | Fine suspended sediment (<63um) reduction by 2022 (t/y) | Cost to implement 2022 to 2030 ($) | Fine suspended sediment (<63um) reduction by 2030 (t/y) | Cost to implement 2030 to 2037 ($) | Fine suspended sediment (<63um) reduction by 2037 (t/y) | Notes: |
|---|---|---|---|---|---|---|---|
| Top 100 high priority sub-catchments grazing exclusion | 14,000,000 | 19,000 | 2,800,000 | 58,000 | 2,800,000 | 97,000 | Grazing exclusion fencing is done ASAP to enable 2037 target to be met |
| 101-200 high priority sub-catchments grazing exclusion | 14,000,000 | 6,000 | 2,800,000 | 18,000 | 2,800,000 | 30,000 | Grazing exclusion fencing is done ASAP to enable 2037 target to be met |
| High priority active gully remediation (1700ha per stage) | 51,600,000 | 26,000 | 51,600,000 | 53,000 | 51,600,000 | 79,000 | Three stages of active gully remediation |
| Springvale grazing exclusion and destocking | 2,250,000 | 14,000 | 750,000 | 41,000 | 750,000 | 68,000 | Grazing exclusion fencing is done ASAP to enable 2037 target to be met |
| Technical Design and Coordination | 6,300,000 | | 3,375,000 | | 3,375,000 | | Technical design and coordination supports all other activities |
| Lidar and site monitoring | 1,850,000 | | 1,675,000 | | 1,675,000 | | Lidar and site monitoring to confirm erosion reductions |
| Total | **90,000,000** | **65,000** | **63,000,000** | **170,000** | **63,000,000** | **274,000** | |
| % of Target based on Source Catchments (2015) | | 81% | | 106% | | 114% | |
| % of Target based on Normanby Empirical Sediment Budget | | 56% | | 73% | | 79% | |



# CHAPTER 3: INTEGRATED MONITORING PROGRAM

The aim of this chapter is to define a strategy and the resource requirements for the development of an Integrated Monitoring Program to support the implementation of the Eastern Cape York Water Quality Improvement Plan (WQIP) and the Reef 2050 Plan. This monitoring program will build on and dramatically improve existing Cape York monitoring efforts and partnerships, to collect data that can support Reef wide reporting on the outcomes of WQIP implementation. This is a monitoring and evaluation tool that is required to implement the WQIP and Reef 2050 Plan. A key aspect of a catchment monitoring program associated with a Great Barrier Reef (GBR) WQIP is to accurately measure pollutant loads delivered to the GBR, and to track changes over time in relation to WQIP implementation, land use development, and climate variability. This proposed program will also significantly improve monitoring of outcomes from investments in land management change and the long-term effectiveness of these investments. This monitoring framework can be implemented immediately with current knowledge (before future phases of Reef Trust and other Reef 2050 Plan investments begin) and can be expanded as the resources become available and on-ground implementation progresses.

## Background

The far north region of the Great Barrier Reef (northern GBR) and its eastern Cape York catchments are globally significant. This is a region where native vegetation dominates the landscape and freshwater wetlands and floodplains are still hydrologically and ecologically connected to estuarine and marine ecosystems. On a global index of human disturbance, the northern GBR has been identified as one of the least disturbed marine environments on earth (Halpern et al. 2008). Surveys of water quality, seagrass meadows and coral reef ecosystems show that the Cape York marine environment is in better condition than much of the rest of the GBR (Brodie et al., 2007; Fabricius et al., 2005). At the same time, many of the eastern Cape York catchments are experiencing continued and accelerated development pressure that could degrade river water quality and impact the health of the relatively intact reefs of the northern GBR.

Despite the importance of the far northern region to the whole of the Great Barrier Reef, the majority of monitoring and research effort to date has been invested in the highly disturbed central and southern sections of the GBR. This monitoring and research effort has shown that widespread development of the central and southern GBR catchment for grazing and intensive agriculture has had a negative impact on the ecological health of the downstream seagrass and nearshore coral reef ecosystems (Schaffelke et al., 2013, Thompson et al., 2013, McKenzie et al., 2013). There has also been a recognition that modification of the hydrological and ecological function of freshwater wetlands, floodplains and coastal ecosystems in the central and southern GBR catchments has reduced the overall health of the GBR ecosystem (GBRMPA, 2014). These cumulative and widespread (catchment wide) disturbances have modified the natural landscape processes and caused significant negative ecological consequences for the central and southern GBR (such as the decline in seagrass condition and a 50% decline in live coral cover over a 27-year timeframe).

The eastern Cape York catchments have a relatively smaller scale of human disturbance than the central and southern GBR, but human disturbance is still significant with real impacts on water quality. European settlement and disturbance on Cape York started with the mining boom in the 1870's at the Palmer River via Cooktown, followed by other mining booms and areas (Annan, Normanby, Starke, Stewart, Pascoe catchments) (e.g., Lewis, 2015; Shellberg et al., 2016). Mining lead the way toward other land use impacts and disturbances such as cattle grazing, forest logging, agricultural development, weed and pest invasion and urban development.

Cattle grazing, associated disturbances (clearing, roads and fences, fire changes, weed invasion), and accelerated gully erosion all impact on the majority of the eastern Cape York catchments. The conversion of many historic pastoral leases to nature conservation and traditional owner land uses has not necessarily reduced the impact of grazing on the landscape. Unmanaged cattle remain on the land, typically at maximum dry season carrying capacity. The eastern Cape York catchments have large areas of sodic and dispersive soils that became unstable when grazing was introduced to the peninsula in the late 19th century. As a result, large areas of gully erosion have developed over time to become a major source of sediment to the downstream freshwater and marine environments, particularly in the Normanby Basin (Brooks et al., 2013) but also others.

Linear disturbances such as dirt roads, fence line and fire break clearings, which are largely ignored in the central and southern GBR, are relatively more important in the eastern Cape York catchments because they are the primary vectors of on-going land use development and disturbance. Road, track and fence development divides the landscape into smaller units for more intensive development and impacts. Roads and fences disturb erodible tropical soils (e.g., sodic soils on floodplains) and act as point sources of sediment where they intersect with the stream network (Brooks et al., 2013; Shellberg and Brooks, 2013). Currently, there are tens of thousands of hectares of exposed soils along road, track and fence networks in the eastern Cape York catchments, which are effective point sources of sediment and nutrients, and cumulatively as significant a source as cleared agricultural land.

The majority of the eastern Cape York catchments have soils that are unsuitable for intensive agricultural development. The most suitable intensive agricultural soils, the red and brown basalt soils (Biggs and Phillip, 1995) in Lakeland, Shiptons Flat, Endeavour Valley and McIvor Valley were cleared and partially developed for cropping, horticulture and plantation forestry in the last century. The major current intensive agricultural land use is based around bananas and irrigated cropping at Lakeland, and the Endeavour catchment. Clearing for new large scale agricultural development for dryland and irrigated cropping has commenced in recent years in the Normanby basin. These new developments are occurring on soils that are considered by some to be marginally suitable for dryland and irrigated crops, but which are of lower quality than the basalt soils and more prone to erosion and sediment pollution. The expansion of agriculture is accompanied by an increase in water extraction and surface water impoundments in an area where groundwater is already deemed to be over-allocated and groundwater dependent ecosystems (GDE's) are threatened.

The direct impacts of inappropriate fire regimes, feral animals (cattle, pigs and horses) and weeds (sicklepod, grader grass, hymenachne etc.) are also significant disturbances in the Cape York region. Numerous wetland surveys have demonstrated widespread degradation of water quality and aquatic habitat in eastern Cape York catchments as a result of feral animal activity (Dupre et al., 2009; Stephan and Howley, 2009). Late dry-season fires, which are frequent in eastern Cape York, have been shown to increase sediment loads in north Australian rivers (Townsend and Douglas 2000, 2004).

Fire, weeds, cattle grazing, feral animals and sedimentation from gullies and linear disturbances, currently present the biggest threats to the ecological health of the freshwater ecosystems and wetlands, which are hydrologically and ecologically connected to the estuarine and marine ecosystems of the northern GBR. Although these aquatic ecosystems remain functional and in relatively decent ecological condition, the impacts from current and historic land uses on freshwater ecosystems have been well documented (e.g., Stephan and Howley, 2009; Doupe et al., 2009; Howley, 2010; Brooks et al., 2013). The loss of fringing coral reefs has also been observed over the past 25



years (Ian McCollum, Cape York Marine Advisory Group, personal communication).

Urban, rural residential (peri-urban) and agricultural development continue to intensify as more people move into the Cape York region, especially in the more populated areas of the Endeavour, McIvor, and Annan catchments. This mixed land use development poses an ongoing threat to water quality, seagrass beds, and fringing and in-shore reefs (Carroll et al., 2007; Howley et al., 2012). Compared to the rest of the northern GBR, the fringing and in-shore reefs off the combined Endeavour, McIvor, and Annan catchments are particularly close and connected to sources of pollution from land use development.

General land use development, clearing for new roads, agriculture, urban and rural residential (peri-urban) land uses, as well as intensification of land use (such as cleared pasture to irrigated cropping), will result in increases in the sediment and nutrient loads entering downstream freshwater and marine environments. An integrated monitoring program is required for the northern GBR that is specifically designed to monitor water quality and pollutant loads, ecosystem health, and management practice indicators that are sensitive enough to detect the changes in ecosystem condition as a result of the type, scale and intensity of human disturbances present in the eastern Cape York catchments.

In addition to land use pressures, coral reefs and associated marine ecosystems are under pressure from climate change, including ocean acidification, coral bleaching and crown of thorns starfish. Reducing anthropogenic pollution to the reef by improved land management practices and remediation activities may avoid or postpone a tipping point for the Reef.

**Accurate monitoring of the Cape York region of the GBR should be a high priority to ensure that this region does not follow the downward trend in ecosystem health observed in most other GBR catchments, and to ensure that the appropriate management actions are implemented to maintain or improve the current condition of this region.**

## Adaptive management

The integrated monitoring framework will allow for adaptive management to be applied to the implementation of the WQIP. Effective improvement or maintenance of water quality in the northern GBR requires adaptive management to account for changing knowledge, biophysical condition, funding, legislation and public sentiment.

Monitoring for the WQIP implementation should undertake several functions:

- Quantify the adoption of improved management practices;
- Determine and validate relationships between improved management practices, water quality and load output, as well as ecosystem health;
- Accurately measure pollutant loads delivered to the sub-catchments, end-of-catchment gauges, and the GBR to empirically track changes over long periods of time (next century); and
- Investigate water quality issues of concern to the community as part of ongoing community-driven activities in the region.

The results of this monitoring program will feed a growing body of knowledge regarding the most effective land management practices to reduce pollutant loads across the Cape York landscape. These data can also be applied at a cross-regional, reef-wide level. The on-going incorporation of the lessons learned through adaptive management will ensure that WQIP implementation remains relevant in delivering water quality and ecosystem health improvements.

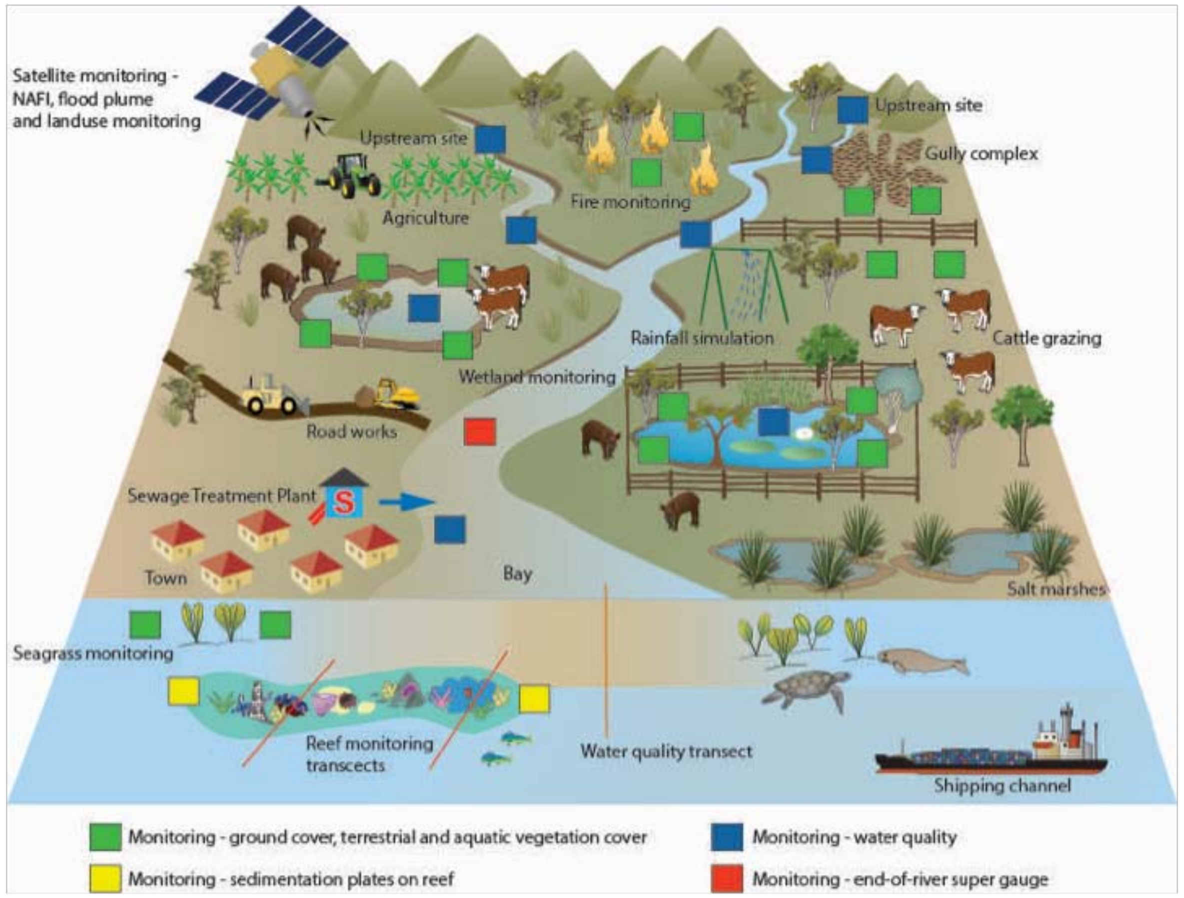
## Framework for integrating monitoring

The following framework is proposed to integrate paddock-scale, sub-catchment, catchment (end-of river), and marine monitoring activities. This framework should provide information to resource managers on the effectiveness of management practices in improving water quality and ecosystem health throughout the eastern Cape York region. A conceptual diagram of future monitoring is shown in Figure 25 (which is still in draft form).

During the initial WQIP implementation phase, changes in water quality and aquatic ecosystem health are most likely to be detected at the paddock, property or small sub-catchment scale. Time lags through large catchments and biophysical systems, time for widespread adoption of management practices to occur, and improvements needed to the current methods of measuring change at the end-of-catchment scale mean that monitoring at paddock to small sub-catchment scale is more likely to detect water quality changes over short time frames. However, paddock or small sub-catchment monitoring cannot confirm the benefits to the downstream river and GBR marine environment, or provide accurate long-term reporting on Reef targets. For this reason, the integrated monitoring plan will incorporate both:

1. Short-term paddock and sub-catchment monitoring, and
2. Long-term, rigorous, empirical monitoring at end-of-catchment and marine monitoring locations.

**Figure 25.** (Draft) Conceptual diagram of future monitoring at different scales in eastern Cape York catchments






To determine change in management practices over time, monitoring adoption of management practices by grazing, cropping, horticultural and urban land managers should be carried out in the region. In addition to the adoption of management practices, monitoring of changes in land condition and aquatic ecosystems should be conducted to determine the relationship between management practice and water quality. Management practice monitoring locations should be selected for both paddock and sub-catchment scale trials to be conducted by independent auditors working with landholders, agricultural industry organisations (AgForce and Growcom), local government and other catchment stakeholders.

To determine the relationship between water quality and ecosystem health, water quality and ecosystem health monitoring locations should be selected for sub-catchment, end-of catchment and marine receiving waters. The sub-catchment, end-of-catchment and marine monitoring locations should be designed and maintained to provide accurate evidence of long-term changes in water quality and aquatic ecosystem health.

These different hierarchical levels of monitoring (adoption of management change; monitoring of the effects of management practices on the paddock, sub-catchment and catchment scale; and water quality and ecosystem health at the end-of-catchment and marine receiving waters) are described in the following sections and summarised in Table 21.

## Monitoring adoption of management practices

Monitoring adoption of management practices should be conducted across the drainage basins of eastern Cape York for different land uses including: nature conservation, Indigenous land management, cattle grazing, cropping and horticulture, mining, forestry, peri-urban and urban development, and road development. Cape York NRM and South Cape York Catchments are building on and expanding earlier outreach programs (Reef Rescue, Cape York Sustainable Futures (CYSF), Landcare, QDPI, Griffith University) with the grazing, cropping and horticulture industries to collect baseline data and develop industry-specific property-scale management practices and improvement processes that build from industry and international Best Management Practice (BMP) guidelines. Field validation of land use management and land condition is essential to assessing BMP adoption and associated water quality improvements through time. These data will need to be collected at a range of spatial scales from plots to paddocks to properties and sub-catchments.

For grazing, the key management indicators of BMP uptake include stock numbers, grazing intensity in different land types, animal health, pasture condition and cover, rotational grazing, supplemental feeding, riparian management in frontage country, gully management, stock water management, fire management, weed management, and road and fence management. A combination of empirical field data and land manager survey data can be used to assess the level of BMP uptake. Remote sensing (satellite data) analysis to support grazing management is also being explored through a partnership with the Rangelands Alliance. These spatial analysis tools may assist with collecting and interpreting the effectiveness of grazing management strategies at both a property scale and catchment scale. Evaluation of the aggregated information should also be useful for planning delivery of incentives and extension.

For horticulture and cropping land managers, Precision Agriculture and automated collection of data should be promoted through GPS-tracked harvesting and application of nutrients and pesticides (such as residual herbicides). Automated data collection is a priority because it removes the limitations of paper-based and manual record keeping. Land managers should be encouraged to maintain real-time spatial records of tillage, harvesting, fertiliser and pesticide applications, and water use through adoption of GPS technology, extension and incentive delivery. To achieve this, significant education and extension resources will be required during implementation to generate enough land management data for a meaningful baseline to be established. This extension effort should initially focus on management areas that contain paddock, sub-catchment and end-of-catchment monitoring sites in the Normanby and Endeavour Basins that contain agriculture.

## Validating management practice – water quality relationships

Monitoring of the relationship between management practices and water quality is necessary to confirm whether management practices identified in the WQIP will achieve the water quality improvements required to meet targets and objectives. Some work has already been done in this area. Significant research effort has been undertaken by Griffith University in the last 10 years to create an empirical sediment budget with local data for the Normanby catchment (Brooks et al., 2013), which can be improved and updated with additional field data to assess relative risks to water quality. Research on gully best management practices has shown the influence of different gully management practices on sediment yield from treated and untreated gullies, road networks, and fence lines (Shellberg and Brooks, 2013). The use of rainfall simulation (Rhode, 2015) can also help assess the relative ratios of pollutants in run-off from different land uses (horticulture, grazing and roads). However, the relative concentrations of pollutants generated by a specific land use should be used along with measurements of aerial coverage, as unit yield is not as important as yield by land use or source type calculated within nutrient and sediment budgets (Brooks et al., 2013).

Plot, paddock and sub-catchment scale research into relationships between management practice and water quality should be increased throughout the WQIP implementation phase. The management practice monitoring should include economic productivity and social analysis to help refine implementation of management practice change. Management practice monitoring data also can be used to calibrate and validate existing models such as "How Leaky" to help extrapolate the results of management practice implementation to large properties and sub-catchments. Model extrapolation can be used as a scenario and education tool, but should not replace a network of empirical monitoring sites across a range of land uses and different catchment conditions.

## Paddock and property scale monitoring

At the paddock or property scale, monitoring should be designed to measure relevant changes in land, water and aquatic ecosystem condition related to the implementation of management actions associated with various land uses and land types. In addition to environmental indicators, financial viability of the associated business (where relevant) should also be considered as an important indicator of successful management change and long-term sustainability.

### Grazing management

The priorities for monitoring grazing management practice are in the Normanby, Stewart, Endeavour, Jeannie and Pascoe river basins. Performance and condition indicators that should be monitored at a paddock and property scale include: ground cover (% and type of vegetation cover); stock numbers; grazing intensity in different land types; access to riparian areas; cattle pad density; depth and use; stock water management; wetland and/or riparian condition; rainfall run-off response (via flumes and natural rainfall, or rainfall simulation); and financial viability. Wetland and riparian condition indicators include the number of cattle pads, hoofprints/m2 and aquatic and riparian vegetation condition. Appropriate methods for monitoring ground cover, wetland and riparian areas include plot scale surveys (Rolfe et al., 2004; Karfs et al., 2009; Shellberg and Brooks, 2013), remotely sensed Natural Difference Vegetation Index (NDVI), Tropical Rapid Appraisal of Riparian Condition (TRARC), and the Cape York Wetland Condition Assessment Methods (Howley and Stephan, 2009). Where possible, these indicators should be monitored using a before/after, control/impact (BACI) study design.

### Fire management

Fire management is an important aspect of land management for most land types and land uses in the Cape York region. Wildfires can increase sediment and nutrient run-off when inappropriate fire regimes are followed (Townsend and Douglas, 2000; 2004). The Northern Australian Fire Information (NAFI) satellite tracking website (http://www.firenorth.org.au/nafi3/) provides a useful tool for monitoring fire areas burnt, fire frequency, and timing. However, small fires of low intensity are often not detected. Additional on-ground monitoring indexes include fire intensity, scar height, riparian area burn frequency, ground cover and water quality. Existing fire management and monitoring programs within Cape York Peninsula are numerous, and are rapidly evolving with emerging carbon markets. Numerous pastoral lease and Indigenous land managers are monitoring fire and its impacts on biodiversity and land productivity. Several Aboriginal fire programs have established methods for monitoring fire impacts, such as the Chuulangun IPA Fire Research Program and the Kuku Thaypan Fire Management Research Project (Standley, 2011).

### Main roads (council and state)

Erosion along unpaved main roads needs to be monitored through an adaptive management program both during the construction and maintenance phases of road use, and changes over time. A range of metrics related to erosion should be used such as the road surface condition, road and disturbance width, frequency and volume of inputs of material to the road prism, traffic volume, implementation of road BMPs, the frequency of drains (V and table drains), the connectivity of drains to creeks and waterways, the extent of gully erosion along drains and road batters, the erosion condition of battered slopes, grass and rock cover along battered slopes, and condition and extent of borrow pits related to erosion and sediment pollution. Erosion along roads, battered slopes and drains should be monitored using on-ground plots, permanent photo points, terrestrial LIDAR of erosion volume, suspended sediment concentrations of water runoff, and especially upstream-downstream comparison of suspended sediment concentrations at creek road crossings.

### Secondary roads, tracks and fence lines on properties

The construction and maintenance of fences, roads and tracks on station and private properties should be monitored for sediment production and the use of BMPs through an adaptive management program. A representative range of roads, fences and tracks should be monitored for erosion via on-ground plots, permanent photo points, terrestrial LIDAR, and, where appropriate, rainfall simulation. A range of metrics should be used, such as the length of road or fence of certain types, ground surface condition, soil type, the width of road or fence clearing, slope of road, frequency of drainage structures such as whoa boys, surface erosion on the road or fence line, gully and rill erosion along the road or fence line and associated drainage outlets, frequency of fire along fence lines, and appropriate BMPs.

### Horticulture management

Horticulture management practices and effects should be monitored in the Normanby, Endeavour and Jeannie Basins. Horticultural monitoring should include: area under cultivation, inner-row cover, water use, rate of fertilizer and pesticide application, crop yield, frequency of soil disturbance and soil compaction.

Nutrient and sediment run-off at the paddock scale can be monitored via the use of run-off flumes to collect water samples as well as rainfall simulation tests. This paddock monitoring will be complimented by efforts at the sub-catchment scale addressed below.

### Gullies

A full range of gully types needs to be monitored, including colluvial (hillslope) gullies, alluvial (floodplain) gullies, gullies along paddocks and agricultural areas, road and fence line gullies, and gullies associated with mines and road borrow pits. Gully area and the rate of increase can be measured by detailed GPS surveys, erosion plots, aerial photos from airplanes or drones, and airborne or terrestrial LIDAR. Changes in sediment yield over time from gully complexes (e.g., Shellberg et al., 2013) can be used to document improvements from implemented control measures and BMPs (Shellberg and Brooks, 2013). Other important indicators to be measured include grass-cover and cattle-pad density inside and around gullies. These indices should be measured inside and outside of fenced cattle exclusion areas and other types of BMPs to better understand before-after control-impact conditions.

### Feral animals

Feral animals have a significant impact on water quality and aquatic habitat in wetlands and rivers. The use of motion detecting cameras is recommended at key wetland and river riparian sites to monitor the number of pigs, cattle and horses. Monitoring of pugging, hooves, riparian and aquatic vegetation and water quality (turbidity and nutrients, plus pH and metals where acid sulphate soils are suspected) has been conducted at numerous south-eastern Cape York wetlands and should be continued at these sites and instigated at additional target management areas (Howley and Stephan, 2009).

### Urban and peri-urban (rural residential)

Pollution from both urban and peri-urban (rural residential) sites should be monitored over time at the site and property scale. Water quality monitoring (sediment, nutrients, hydrocarbons, metals, etc) and disturbance condition assessments are needed at construction sites, cleared areas, borrow pits, stormwater drains, industrial sites, rubbish tips, sewerage treatment plant outfalls or septic tanks, boat docks and other disturbances. Data at the site or property scale should be correlated to sub-catchment and catchment monitoring at adjacent river sites, especially for peri-urban development and rural residential agriculture. Previous community-based monitoring (2002-2010) by CYMAG Env. (Howley, 2010; Howley, 2012) included monitoring of impacts from STP outfalls, rubbish tips, and boat slipways in the Endeavour, Annan and Normanby rivers.

### Forest logging

Selective forest logging is becoming more common as an enterprise in targeted areas on eastern Cape York on private and Aboriginal land. Historic logging was also more widespread. The cumulative impacts from logging on water quality mainly come from machinery ground disturbance and soil compaction along roads and skid tracks. This disturbance can accelerate water runoff and soil erosion. Monitoring water quality impacts at the site, property, and sub-catchment scale of forestry activities is needed. These data could be used within an adaptive management framework to help implement best management practices to reduce erosion in logging areas.

## Sub-catchment scale monitoring

Sub-catchment monitoring entails monitoring the effects of land use management actions at key downstream locations, such as long-term gauge sites on creeks and rivers.



### Nested paddock to sub-catchment case studies (BACI or paired catchment studies)

Case studies at the sub-catchment scale are recommended to improved knowledge of management actions on both the paddock and sub-catchment scale. These studies should be implemented using the BACI design, utilizing either upstream and downstream sites or paired sub-catchment sites. These case studies will incorporate the paddock and sub-catchment monitoring indicators listed above, nested with downstream measurement of pollutant loads and water discharge at BACI sites.

At least one focused case study should be implemented for each of the following land uses / land management areas:

- Gully erosion (upper Normanby catchment)
- Agriculture (Lakeland)
- Urban / peri-urban development (Endeavour Basin)
- Fire (water quality impacts from various fire regimes)
- Grazing

### Sub-catchment water quality monitoring

The Queensland Department of Natural Resources (QDNR) has conducted freshwater ambient monitoring as part of the State Wide Ambient Network at sub-catchment gauging stations in Cape York, but the data are fairly limited. While some physical and chemical parameters are well represented, nutrient and suspended sediment sampling and flood event monitoring has been very limited in these historic data sets (Moss and Howley, 2015). These limitations have been addressed to some extent for the Normanby, Endeavour and Annan Rivers through the efforts of CYMAG Environmental, South Cape York Catchments (SCYC) and the Laura Rangers, with both ambient and event-based monitoring samples being collected at a range of sites between 2002 and 2015. This includes reoccupying the historic QDNR gauge at the West Normanby, one of the highest sub-catchment sediment contributors per unit area on eastern Cape York. More recently, monitoring has been undertaken on the Pascoe River by SCYC and local scientists with assistance from CSIRO.

Water monitoring programs for the WQIP should build on these existing community based monitoring programs, which have been implemented in partnership with the Qld government (DSITI) and CSIRO. Monitoring at gauge sites should be expanded to include additional eastern Cape York rivers and sub-catchment gauges. Improvements in field methods are needed by installing continuous turbidity dataloggers and automatic pump samplers designed to provide continuous surrogate data and improve sampling across flood events (Shellberg et al. 2016). Improving flood event data collection at existing water gauge sites in sub-catchments should be seen as an immediate priority.

The existing gauge and water quality monitoring network should be expanded to include key sub-catchment sites that have been identified as priorities for improved monitoring and land management, including the following sites and others that may be identified during WQIP implementation:

- Normanby Basin (West Normanby, Little Laura and Hann River)
- Annan River (Oakey Creek)
- Endeavour River (Right Branch/ Hopevale)
- McIvor River
- Claudie River

The available eastern Cape York water quality data has been used to set freshwater and estuarine ambient and event-based Water Quality Objectives (WQOs) for eastern Cape York rivers (Moss and Howley, 2015). This process identified data gaps where insufficient data were available for setting accurate water quality guidelines for some sub-catchments or catchments.

During implementation of the WQIP, ambient and event-based monitoring sites should be increased to improve the accuracy of water quality guidelines for each drainage basin. Specific data gaps identified in the Guidelines Report include:

- Ambient water quality from north-eastern Cape York rivers (Olive-Pascoe, Lockhart, Stewart)
- Flood event data from all Basin and sub-catchments with the exception of the Laura-Normanby sub-basin
- Estuarine water quality for systems other than the Annan, Endeavour and Normanby

### Monitoring of agricultural water extraction and retention impacts

The expansion of horticulture and cropping is occurring in the Lakeland region, as well as the Endeavour and Jeannie Basins. The recent increase in the number of dams in the Lakeland region, along with groundwater extraction, has the potential to reduce downstream water flows in the Laura River and other tributaries, potentially effecting aquatic habitat and groundwater dependent ecosystems. Water discharge from rivers, creeks and springs and groundwater levels in the Lakeland area are currently being monitored by community groups and the Qld government to assess any potential impacts from water extraction and retention. These monitoring projects should be continued and expanded upon to document the effects of water extraction and dams on downstream water quantity and quality, and to ensure that minimum water flows for the maintenance of aquatic habitats are maintained.

### Urban / peri-urban / harbours

Urban and peri-urban areas such as Cooktown, Endeavour Valley, Hope Vale, Lakeland, Laura, Rossville, and Lockhart River are associated with both point source and diffuse water quality impacts. As the on-going population growth and development of rural residential and urban areas is predicted, these areas should be carefully monitored to assess their cumulative impacts on water quality at the sub-catchment scale. The area of new clearing and exposed soil, use of BMPs in development, impervious cover area, and road/track density should be documented for correlations with changes in downstream water quality at the sub-catchment scale.

### Mining

The downstream impacts from cumulative mining related activities need to be monitored over time, including the initial forest clearing, road or track developments, tailings dams, sediment and metal pollution during floods, water extraction and discharge, sewerage and waste oil disposal. The rehabilitation of old and abandoned mines also needs to be monitored for water quality impacts and benefits downstream (e.g. the current dewatering and decommissioning the Collingwood Mine on the Annan River). Priority mining areas to be monitored at the sub-catchment scale include existing mines at the West Normanby and upper Annan catchments, and historic mining areas in the Starke, Stewart, and Annan catchments.

### Visitor impacts

Tourism and visitor impacts on water quality need to be monitored and assessed at both the site-scale and sub-catchment scale. Road and track use and traffic is a key metric of tourism use and potential impacts in a given sub-catchment. Existing and new weed incursions into visitor areas and remote destinations needs to be monitored and managed. For example, recreational pig hunting via quad bikes in remote areas can spread weeds and promote erosion along tracks and wetlands. Targeted tourism surveys can provide information on visitor numbers and activities, will help to focus management needs, and can help reduce visitor impacts on land and water quality.



## Catchment scale monitoring

### Land use intensity and disturbance mapping

The systematic mapping of land use and human disturbance should be conducted annually across the eastern Cape York catchments. A multi-metric disturbance index of human land use needs to be developed to properly identify the spatial and temporal scale of human impacts to water quality. Land use (area of grazing, horticulture/cropping, roads, rural residential, mining, forestry, conservation) and land disturbance (gullies, fire scars, pests and weeds, vegetation cover, roads, tracks, fence lines, borrow pits, bare ground, agricultural tillage, construction sites, human dwellings, industrial sites) need to be monitored over time. High-resolution satellite imagery can be used for both property management and catchment wide assessments. Satellite imagery can be used effectively for the mapping of fire (NAFI), vegetation cover (NDVI), land clearing and forestry (Landsat), road, track and fence density (SPOT imagery), rural residential and urban development, and mining activities. However, these data must be validated with accurate ground surveys of existing condition, and the resolution of disturbance mapping must be increased (for example, the use of Landsat data (30m resolution) within the Statewide Landcover and Trees Study (SLATS) program is not accurate enough to detect many of the land use disturbances occurring on Cape York). Into the future, more detailed disturbance indices should be conducted with LiDAR topographic surveys and multispectral imaging. The land use/disturbance mapping with LIDAR should be analysed in conjunction with fine resolution soil mapping (1:25,000 for gully prone lands, cropping and urban lands and 1:100,000 for grazing lands) to identify areas within properties that represent higher risk to water quality and to support the spatial prioritisation of investments into improved management practices.

### End-of-catchment water quality monitoring: The Super Gauge approach

Improved end-of-catchment water quality monitoring is essential to measure real trends in loads of sediment, nutrients and other pollutants discharged to the northern Great Barrier Reef from eastern Cape York catchments. In order to detect both short-term and long-term changes associated with changing land use and land management, end-of-catchment water quality and discharge monitoring programs should be designed as per the Super Gauge approach detailed in Shellberg et al. (2016). Super gauges incorporate international standards of field and laboratory protocols for monitoring river pollutant loads and provide the accuracy needed to detect real changes in water quality over time.

The basic principles of the Super Gauge include:

- Continuous monitoring of water discharge, turbidity and other WQ indicators,
- Improved measurement of water discharge in tidal channels (end-of-catchment sites) using 'velocity index' methods,
- Automated samplers to collect nutrient and suspended sediment concentration (SSC) samples during flood events (turbidity threshold samplers),
- Collection of isokinetic width- and depth-integrated nutrient and suspended sediment samples to establish average concentrations across the river channel, to correlate to and correct point samples,
- Analysis of water quality data over time using high-accuracy event-scale data, shifts in rating curve behaviour, and comparison of event loads to actual catchment condition metrics to define catchment responses to input variables.

A pilot Super Gauge end-of-catchment monitoring project commenced in the Annan River estuary in 2015, in addition to event monitoring projects at the Pascoe River and Normanby Rivers. These projects were implemented by SCYC in partnership with CSIRO and DSITI and will be expanded upon in 2016. For example, continuous water quality dataloggers have been installed in the Normanby and Pascoe River mouths for the 2016 wet season.

It is recommended that a total of 5 to 10 end-of-catchment water quality monitoring and gauge sites be established or brought up to Super Gauge status for Eastern Cape York. Recommended river mouth sites include the Pascoe, Claudie, Stewart, Normanby, Kennedy, McIvor, Endeavour and Annan Rivers (Shellberg et al., 2016).

#### Catchment modelling

Improved empirical sediment and nutrient loads data collected through the end-of-catchment monitoring projects can also be used to calibrate models used for scenario analysis and to extrapolate empirical load data of pollutants discharged to the GBR from eastern Cape York rivers. Catchment models such as Source Catchments and the Griffith University Sediment Budget for Normanby Basin can be used to help assess the cumulative effects of management practice change at the end-of-catchments and at selected sites within catchments. Catchment models can be used to aid long-term prediction of water quality improvements at larger catchment scale through scenario development. However, theoretical sediment and nutrient budget models cannot replace accurate, long-term empirical data collection at end-of-catchment locations that are essential to detecting real and actual change. All model predictions should be treated as potential scenario outcomes that can only be verified with empirical data over the long-term.

### Validate freshwater and marine water quality – ecosystem health relationships

The goal of the Eastern Cape York WQIP is to improve or maintain good water quality to support healthy freshwater wetlands, rivers, estuaries and marine environments, and to sustain the diversity of plant and animal life (including human) that depend upon these habitats. Monitoring of freshwater, estuarine and marine ecosystems is necessary to validate the relationships between water quality and ecosystem health, and thus to ensure that land management actions are achieving the end goal of maintaining healthy ecosystems. Some monitoring of water quality and ecosystem health has already occurred across eastern Cape York. However, for the majority of government-funded land management projects, there has been no monitoring of the downstream benefits (or lack there-of) to water quality and ecosystem health. Additional monitoring of the effects of sediments and nutrients on freshwater and marine ecosystems is needed to measure the success of land management actions and to ensure that the targets developed in the WQIP are appropriate. Since much of the eastern Cape York freshwater and marine environment is considered to be in High Ecological Value (HEV) condition, the monitoring of aquatic ecosystems is also necessary to provide an early warning of changes resulting from the intensification of land use which is currently occurring in some catchments.

Detailed freshwater ecosystem health monitoring is required for the Olive-Pascoe, Claudie, Stewart, Normanby and Endeavour Basins. Marine water quality and ecosystem health should be monitored along a gradient from the estuaries of each of the major catchments in these basins to open coastal waters.

### Freshwater aquatic ecosystems

Some ecosystem health studies have already been conducted in eastern Cape York, providing a baseline condition and methodology for further studies. Targeted freshwater wetland condition assessments, biodiversity surveys and long-term wetland monitoring projects have been implemented in the Normanby and Annan catchments by Traditional Owner ranger groups, South Cape York Catchments, the Cape York Marine Advisory Group, Qld Department of Primary Industries (DPI), Qld Parks and Wildlife (QPW) and private landholders such as the South Endeavour Trust. Specific methods for assessing the condition of Cape York freshwater wetlands and monitoring changes in response to management actions have been developed and utilised across the region (Howley and Stephan 2009; adapted for I-tracker by NAILSMA in 2014). The ongoing utilisation of these methods will assist with the long term assessment of wetland water quality and ecosystem health and provide a tool for reporting on the effectiveness of management actions for improving wetlands health.

As a component of the current WQIP program, James Cook University staff carried out a detailed study on fish community condition in relation to wetland condition and water quality in the Violet Vale wetland complex (Ebner et al., 2015). Similarly, the wetlands and springs of the eastern Kimba Plateau have been surveyed for their wetland and fish biodiversity and water quality in relation to the establishment of the new Olkola National Park (CYPAL) (Carroll and Coates, 2015; Shellberg et al., 2015). A ‘Bush Blitz’ biodiversity program on Olkola Country also greatly added to this knowledge of aquatic ecosystems. In addition, a rapid assessment of water quality and ecological health indicators in eastern Cape York rivers undertaken by DSITI as part of a Q-Catchments assessment of Cape York River Basins in 2014 and 2015.

In addition to the water quality monitoring detailed in the sub-catchment and catchment sections, recommendations for monitoring freshwater aquatic ecosystems include the following:

- Baseline studies of wetland condition, aquatic biodiversity and water quality for High Ecological Value (HEV) aquatic ecosystems downstream from grazing and horticultural land, or subject to other water quality threats such as recurring hot fires, road erosion and weeds and feral animals. Previously identified (unsurveyed) wetland sites include Polly’s Lake and Pelican Lake in Rinyirru National Park, and Christmas Lake at Kings Plains Station. Other wetland sites will be identified through an assessment of the HEV aquatic ecosystems and a land disturbance and threats analysis*.

- Continued monitoring of wetland condition and water quality at sites where land management actions have already been implemented or are proposed. Existing monitoring sites include:
  - Keatings Lagoon- feral animal fencing project (Annan River Basin)
  - Pooles Lagoon- weed management site (Annan river Basin),
  - Jack Lakes- site of cattle impacts, weed exclusion zone and CYPAL joint management strategies (Normanby Basin),
  - Wetland monitoring by the Lama Lama rangers and SCYC including before and after feral animal exclusion fencing (Normanby and Stewart Basin),
  - Monitoring of wetland condition and water quality in Rinyirru NP in response to on-going feral animal and weed management programs (Normanby Basin),
  - Muck river wetlands (Cape Melville NP; Jeannie Basin)- on-going weed and feral animal management,
  - Spring and creek monitoring of groundwater dependent ecosystems (GDE) around Lakeland (Normanby Basin).

- Measurements of river channel and wetland in-filling by sediments to document the rate of in-filling (and associated loss of habitat) resulting from upstream accelerated erosion.

- Monitoring the response of iconic, keystone, rare and/or culturally important species such as freshwater turtle, sawfish, freshwater mussels and barramundi in disturbed river and wetland systems. Monitoring of culturally significant freshwater mussels which have been declining in the Annan River is being undertaken by the Yuku Baja Muliku rangers. This monitoring will help to document the response of such species to elevated sediment and nutrient concentrations, feral animals and harvest impacts of human activity, as well as identify priority refuge areas for implementing management actions to maintain healthy habitat.

*A detailed freshwater wetland strategy is being developed separately as part of the WQIP.

## Marine monitoring

Marine Monitoring in the Cape York NRM region currently includes ambient marine water quality monitoring by AIMS, Princess Charlotte Bay flood plume monitoring under the GBR Marine Monitoring Program (2012-2015), coral condition surveys by AIMS and QPW Marine Parks rangers, seagrass monitoring by local scientists and Traditional Owner groups (Archer Point and Starcke River mouth) and by James Cook University (JCU) for the GBR Marine Monitoring Program (Flinders Isles, Bathurst Bay, Flinders Isles, Piper Reef, Shelbourne Bay). Mangrove surveys have been conducted by the Rinyirru Land Trust rangers and Mangrove-Watch (JCU) at Princess Charlotte Bay. Many of these efforts are summarised in Coppo et al., 2016 (Appendix 7).

Existing marine monitoring programs should be maintained, however new sites need to be added to establish baseline condition and monitor long-term changes in marine ecosystem condition in response to changes in land management. The mapping and monitoring of the areas of influence of river flood plumes will be used to identify priority marine ecosystem monitoring sites.

Priorities for the eastern Cape York marine monitoring program based on proximity to river mouths and end-of catchment monitoring sites:

- Marine Water Quality monitoring:
  - New marine ambient and event water quality monitoring transects should be established to investigate water quality gradients from the mouth of the Pascoe, Claudie, Stewart, Normanby, Endeavour and Annan Rivers to the outer reefs. Monitoring sites should coincide with seagrass and coral reef monitoring sites.

- Coral Reefs (listed with rivers of influence):
  - Fringing and inshore coral reefs adjacent to river systems and reef fish populations,
  - Dawson, Egret & Boulder Reefs (Annan/ Endeavour Rivers),
  - Conical Rock (McIvor River),
  - Clack Reef & Flinders Isles reefs (Normanby River/PCB),
  - Hannah, Wilke, etc. (Stewart River/ northern PCB),
  - Far northern reefs to be identified.

- Seagrass meadows in the following areas/within the influence of the following rivers:
  - Walker Bay (Annan River)- monitoring conducted by CYMAG (2005-2009),
  - Endeavour estuary- seasonal monitoring conducted by CYMAG (2005-2009),
  - Starke River- existing baseline mapping by Juunjuwarra rangers (2013-2014),
  - Bathurst Bay- current MMP site (Muck River),
  - Stanley Island (Flinders Isles)- current MMP site (Normanby Basin),
  - Corbett Reef seagrass meadows– (Normanby Basin area of influence),
  - Piper Reef/Palmer Islands (north of Pascoe River)- current MMP site,
  - Yum Yum (Pascoe River)- monitoring by Traditional Owners,
  - Shelbourne Bay- current MMP.



- Crown-of-thorns starfish (COTS):
  - Continue current monitoring of COTS on reefs in south-eastern Cape York region and Princess Charlotte Bay,
  - Increased control efforts in source areas of COTS outbreaks,
  - Improved research into the correlation between local river nutrient output (Normanby, Jeannie, Endeavour Basins) and COTS outbreaks in the Cape York region.

- Flood plumes:
  - Satellite monitoring of flood plume area of influence –Annan/Endeavour, McIvor, Jeannie, Normanby, Stewart and Olive-Pascoe.

- Shipping
  - Ship frequency,
  - Ship sediment re-suspension plumes (Coast Watch),
  - Case studies near shipping channel-
  - Sediment deposition on reefs,
  - Turbidity dataloggers,
  - Coral condition

**Table 21:** Summary of Paddock, Sub-catchment, Catchment and Marine Monitoring Requirements

| Scale | Land Use / Management | Monitoring Details / Indicators |
|---|---|---|
| **Paddock** | Grazing | Ground Cover (% veg)<br>• BACI plots<br>• Plot scale<br>• NDVI |
| | | Stocking Rate in riparian zone |
| | | Financial viability |
| | | Wetland/ Riparian condition<br>• Cattle pads<br>• Number of hooves/m2<br>• TRARC/CY Wetland Condition Assessment |
| | | Rainfall-run off response |
| | Fire | • Fire frequency (NAFI)<br>• Fire timing/intensity (NAFI)<br>• Scar height<br>• Riparian burn frequency and other metrics<br>• Ground cover<br>• Nested water quality monitoring |
| | Roads/tracks/fences | BMP uptake<br>• Fence and road location<br>• Type of maintenance appropriate to road/fence type<br>Number of whoaboys and other BMPs |
| | | Plot:<br>• Rill density<br>• Erosion score<br>Gully/rills per kilometre of road or fence |
| | | Clearing width |
| | | Traffic |
| | | Slope and erosion threat |
| | | Rainfall-runoff response |
| | | Terrestrial LIDAR monitoring of erosion rates |
| | Gullies | Measure area and rate of increase (GPS, aerial photos, LiDAR) |
| | | Grass cover inside and out |
| | | Cattle track density inside and out |
| | Horticulture | Rainfall-runoff studies |
| | | Gauging of run-off:<br>• Flumes<br>Nutrient concentration and suspended sediments |
| | | Inner row cover |
| | | Compaction tests |
| | | Area under cultivation |
| | | Rate of fertilizer and pesticide application |
| | | Water use |
| | | Crop yield |
| | Feral Animals | Pugging/ vegetation ground cover in wetland & riparian zones |
| | | Number of pigs, cows & horses<br>• Camera traps |
| | | Water Quality<br>• Turbidity |
| **Sub-Catchment** | Urban/ Peri-urban | Nutrients and sediment run-off |
| | | Storm water runoff:<br>• sediment<br>• nutrients<br>• hydrocarbons<br>• trash<br>• solvents |
| | | Area of clearing, extent of BMPs used in development, area of exposed soil |
| | | Road/track density |
| | | Impervious cover area |
| | | Dump/sewage treatment plant/Industrial development<br>• Storm water run-off |
| | Mining and Logging | Monitor downstream water quality impacts of development and rehabilitation in conjunction with BMP implementation. |
| | Water Quality | Expand existing gauge network<br>• Normanby<br>• Annan (Oaky Creek)<br>• Endeavour (Right Branch)<br>• McIvor<br>• Claudie |
| | | WQ monitoring<br>• Turbidity threshold sampling (refrigerated pump sampler)<br>• Community/Ranger WQ monitoring – not volunteer.<br>• Ambient & flood |
| | Water Quantity | Continue and expand water flow monitoring in Lakeland region |
| | Fire | NAFI – Extent and timing of fires<br>Other indicators to be advised. |
| | Vegetation Cover | NDVI and other satellite metrics |
| | Roads/tracks/fences density | SPOT imagery at high resolution |
| | Horticulture | Area |
| | Grazing | Area |
| | Visitors | Impacts:<br>• Fire<br>• Weeds- number of new incursions<br>• Tracks and off-road use<br>• Road traffic<br>Use targeted tourism surveys |
| **Catchment** | Water Quality | Super gauges at end of-catchment estuary sites.<br>5 – 10 key sites at river mouths: Pascoe, Claudie, Stewart, Normanby, Kennedy, McIvor, Endeavour and Annan Rivers |

| | | |
|---|---|---|
| **Freshwater Aquatic Ecosystems** | Grazing, Fire, Feral animals and weeds, gully erosion | Baseline studies of wetland condition, aquatic biodiversity and water quality<br>• HEV sites including Polly and Pelican Lake, Christmas Lagoon, others to be identified<br>• Wetland condition assessments as per Cape York Wetland Condition Assessment methods (Howley and Stephan 2010)<br>• Indicators to be monitored are site dependent<br>Continue existing wetland monitoring projects<br>• Keatings Lagoon- feral animal fencing project (Annan River Basin)<br>• Pooles Lagoon- weed management site (Annan river Basin)<br>• Jack Lakes- site of cattle impacts, weed exclusion zone and CYPAL joint management strategies (Normanby Basin)<br>• Wetland monitoring by the Lama Lama rangers and SCYC including before and after feral animal exclusion fencing (Normanby and Stewart Basin)<br>• Monitoring of wetland condition and water quality in Rinyirru Natl Park in response to on-going feral animal and weed management programs (Normanby Basin)<br>• Muck river wetlands (Cape Melville NP; Jeannie Basin)- on-going weed and feral animal management<br>• Spring and creek monitoring of groundwater dependent ecosystems (GDE) around Lakeland (Normanby Basin).<br>New Sites for monitoring to be identified based on implementation of land management actions |
| | Grazing, fire, roads, gully erosion | Rate of river channel and wetland in-filling by sediments |
| | All land uses | Iconic, keystone, rare and/or culturally important species populations (such as freshwater turtle, sawfish and barramundi) in disturbed river and wetland systems. |
| **Marine/ Coastal** | Coral reefs | Coral Indicators:<br>• Live coral<br>• Algal cover<br>• Fish<br>Monitor reefs in close proximity to rivers –<br>• Dawson, Egret & Boulder – Annan/ Endeavour<br>• Conical Rock – McIvor<br>• Flinders (fringing)<br>• Endeavour (fringing)<br>• Clack<br>• Stewart reefs<br>Northern Cape York reefs to be identified |
| | Seagrass meadows | Monitor meadows in close proximity to rivers:<br>• Walker Bay (Annan)<br>• Endeavour River mouth<br>• Starke River mouth<br>• Bathurst Bay<br>• Flinders Islands<br>• Pascoe<br>• Claudie |
| | Crown-of-Thorns | Expand current monitoring, control measures, and research into relationships to local river nutrient outputs |
| | Flood plumes | Satellite monitoring of flood plumes:<br>• Jeannie<br>• Annan/Endeavour<br>• Normanby<br>• Olive/Pascoe<br>• McIvor<br>• Stewart |
| | Shipping | Ship Frequency<br>Sediment resuspension plumes monitoring<br>Case studies:<br>• Sediment deposition on reefs<br>• Turbidity loggers<br>• Coral condition |



## Cost of implementing the Integrated Monitoring Program

The monitoring implementation budget should be split into the four essential core monitoring scales with approximately a quarter of the total budget allocated to each section:

1. Paddock Scale Monitoring (25% of total budget)
2. Sub-catchment Scale Monitoring (25% of total budget)
3. Catchment Scale Monitoring (Super Gauges) (25% of total budget)
4. Ecosystem Health Monitoring (25% of total budget)

Costs to implement the recommended monitoring program will be refined in early 2016. Table 22 provides a preliminary estimate of costs.

**Table 22:** Estimated Eastern Cape York Integrated Monitoring Program Costs

| **Program Component** | | **Initial year program development, setup and equipment costs** | **On-going annual costs** | **Potential Organisations Involved** |
|---|---|---|---|---|
| Monitor adoption of management practices | | $50,000 | $175,000 | Cape York NRM / Landcare, QDPI, Rangelands Alliance, Agforce, Growcom, Independent Auditors |
| Paddock and Property Scale Monitoring | | $150,000 | $550,000 | Land owners, Cape York NRM, SCYC, GU, CSIRO, Cook Shire Council (CSC) |
| Sub-Catchment Scale monitoring | Land Management Case Studies | $50,000* | $250,000* | Land owners, Cape York NRM, SCYC, GU, CSIRO, CSC |
| | Water quality monitoring at 10 gauge sites | $750,000 | $250,000 | DSITI, CSIRO, SCYC, Traditional Owner Ranger groups and local scientists |
| Catchment Scale | Land Use Disturbance Index and mapping | $250,000 | $125,000 | GU, DSITI, CYNRM, SCYC |
| | End-of-Catchment Water Quality Monitoring "Super gauge" sites (7) | $700,000 | $250,000 | DSITI, CSIRO, SCYC, Traditional Owner Ranger groups and local scientists |
| Aquatic Ecosystem Health | Freshwater Aquatic Ecosystems | $50,000 | $300,000 | Landowners, SCYC, QPW, JCU, Traditional Owner Corporations and Ranger groups |
| | Marine Ecosystems | $50,000 | $450,000 | SCYC, AIMS, JCU, Traditional Owner Corporations and Ranger groups |
| Review and Annual Reporting | | | $100,000 | Cape York NRM and SCYC |
| **Total Costs** | | **$2,050,000 / first year** | **$2,500,000 / annum** | Total cost over first 7 years = 17.05 million |

*in addition to paddock/property scale monitoring which will be incorporated in sub-catchment Case Studies.

Boulder Reef, off Cooktown, northern Great Barrier Reef (Photo: Jessie Price)



# CHAPTER 4: BACKGROUND TO WATER QUALITY IMPROVEMENT PLANNING IN THE GBR

Water quality determines the suitability of water for several purposes and is essential to our social and economic well-being, and ecological health. Water supports people, agriculture, animals and plants, and is central to the health of the whole ecosystem as it connects places, processes and species. The protection and improvement of water quality sustains economic and social activities and ensures ecological health for present and future generations. However, it is now widely recognised that the quality of water flowing into the Great Barrier Reef (GBR) lagoon from the land has deteriorated dramatically over the past 150 years. These changes can be detected using historic data such as coral coring and geochemical records.

A great deal of effort has been made by governments and the community to enhance water quality in the GBR, primarily through catchment management. The Queensland and Australian Government's Reef Water Quality Protection Plan (Reef Plan) initially established in 2003 and revised in 2009 and 2013, provides the foundation for this effort. Reef Plan 2013 states that its long term goal is to ensure that by 2020 the quality of water entering the reef from broadscale land use has no detrimental effect on the health and resilience of the Great Barrier Reef." The Plan includes the deliverable of 'a Water Quality Improvement Planning process (aligned with Healthy Waters Management Plan guideline under the Environment Protection Policy Water) to consider Reef Plan's long term goal and use of consistent modelling information to set regional and sub-regional water quality and management action targets that align with Reef Plan'.

In October 2014, the Australian Government's Reef Programme committed to funding a Water Quality Improvement Plan (WQIP) for the eastern Cape York catchments. This process builds on previous efforts to prepare the Catchment Normanby Water Quality Management Plan for the Normanby Basin (Howley et al., 2014).

The Normanby Catchment Water Quality Management Plan presented a solid technical foundation for the production of an Eastern Cape York Water Quality Improvement Plan for the Great Barrier Reef catchments within Cape York region. It presented current condition of water quality and identification of management actions to improve water quality in the Normanby Basin. It also presents draft environmental values for reaches within the Normanby Basin. The Eastern Cape York Water Quality Improvement Plan builds from these efforts.

## Purpose of a Water Quality Improvement Plan

A WQIP is designed to identify the main threats impacting waterways and the coastal and marine environment from land-based activities, and to identify and prioritise management actions that will protect, halt or reverse the trend of declining water quality within a region.

More specifically, the Eastern Cape York Water Quality Improvement Plan provides a framework to:

- Describe the current state of water quality and identify water quality threats in the region.
- Identify the priority water quality and ecosystem health threats for the region, in terms of:
  - Current water quality values highlighting those that are in decline or at risk, and key pollutant drivers, spatially and by sector;
  - Desired water quality environmental and use values that the community aspires to protect/ enhance;
- Estimate the implications and costs of intervention options:
  - Identify key pollutants to be reduced and key sources (sectoral and practices);
  - Estimate annual pollutant delivery at end-of-catchment (and where available, sub-catchment scale), progressing to estimates of loss to catchment waterways and groundwater as

information becomes available;
- Develop pollutant reduction targets to maintain the desired in-stream, coastal and marine values of the region; and
- As information becomes available, map the risk of off-site pollution at the smallest practical scale, and estimate and map as applicable production efficiency (yield/inputs) and pollution intensity (unit production/pollution e.g. Fine suspended sediment and dissolved inorganic nutrients).

- Define regional end-of-catchment pollutant reduction targets to maintain the coastal and marine values of the region.
- Define waterways of greatest ecological value in the region, and establish priority areas for protection, restoration, maintenance or adaptation of the ecological function and health of these areas.
- Estimate and clearly document the effectiveness of current management interventions.
- Develop and compare abatement costs for intervention options to protect desired values.
- Develop an implementation strategy in consultation with government, industry and community groups for managing water quality in the region and achieving the proposed targets, through identification of management practices and projects that can be adopted to meet targets and objectives in the most cost effective manner. This will guide strategic investment for addressing water quality threats to both fresh water and the Great Barrier Reef in the region for the next 5 to 10 years. Strategies for long term planning consistent with the Reef 2050 Long Term Sustainability Plan are also incorporated.
- Develop and agree with stakeholders on a robust, adaptive, relevant and transparent monitoring, evaluation and reporting and review framework for progress at all scales to ensure public accountability and community support for long term re-investment in water quality protection, by cost effective interventions.

## Legislative framework for WQIP development

### WQIPs and Healthy Waters Management Plans

The GBR Water Quality Improvement Plans are prepared consistent with the Framework for Marine and Estuarine Water Quality Protection (2002), and apply the framework described in the National Water Quality Management Strategy (NWQMS, 2000). In Queensland, this is linked through the Environmental Protection Act 1994 which is the main legislation for water quality in freshwater, estuarine and marine areas, and includes the Environmental Protection (Water) Policy 2009 (EPP Water) and the Environmental Protection Regulation 2008 (EPR, 2008).

The Environmental Protection (Water) Policy 2009 (EPP Water) seeks to achieve the object of the Environmental Protection Act 1994 in relation to Queensland waters—to protect Queensland's waters while allowing for development that is ecologically sustainable. Queensland waters include water in rivers, streams, wetlands, lakes, aquifers, estuaries and coastal areas.
This purpose is achieved within a framework that includes:

- identifying environmental values (EVs) for aquatic ecosystems, human uses/values (e.g. water for drinking, farm supply, agriculture, industry, cultural and spiritual values and recreational use)
- determining water quality guidelines (WQGs) and water quality objectives (WQOs) to enhance or protect the environmental values.

The EPP Water process to identify EVs and to determine WQGs and WQOs is based on relevant national guidance including the National Water Quality Management Strategy (NWQMS, 2000), Implementation Guidelines (1998) , the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) , and the Framework for Marine and Estuarine Water Quality Protection (2002). Additional Queensland guidelines and fact sheets have been prepared and are available from the EHP website. A summary of the process is shown below.

Section 24 of the EPP Water establishes Healthy Waters Management Plans (HWMPs) as a key planning mechanism to improve the quality of Queensland waters.

Key matters to be addressed in a HWMP include identifying:

- waters to which the plan applies
- issues affecting water dependent ecosystems, drinking water and natural flows
- waterway uses and values (otherwise known as 'Environmental Values' and abbreviated as 'EVs')
- management goals and Water Quality Objectives (WQOs) to protect identified EVs
- ways to protect the environmental values for the water
- ways to monitor and assess the effectiveness of the protection.

In catchments draining to the GBR, regional NRM bodies and Councils (in consultation with EHP) have prepared WQIPs under the Australian Government's Coastal Catchments Initiative (2006-2009). EHP worked with WQIP project teams to ensure that the EVs and WQOs were established consistent with the Environmental Protection (Water) Policy 2009 requirements.

Where Water Quality Improvement Plans adequately address matters specified under the EPP Water for HWMPs, they may be accredited as HWMPs. In April 2015 EHP publicly released a Guideline on HWMPs (emailed to NRM CEOs), which provides more information on the scope and process recommended for HWMPs. The HWMP guidelines are available from the EHP website at http://www.ehp.qld.gov.au/water/policy/water_quality_improvement_plans.html.

It is important to note that this process was not completed for the Cape York region prior to the commencement of the current WQIP project, and that Environmental Values (EVs) and Water Quality Objectives (WQOs) developed under the Queensland legislation have either been scheduled or are in review for every other GBR NRM region. This process requires substantial community consultation, and was therefore a necessary starting point for the Eastern Cape York Water Quality Improvement Plan.

### State Planning Policy State Interest - water quality

- Seeks to ensure that development is planned, designed, constructed and operated to protect the environmental values of Queensland waters. (available from http://www.statedevelopment.qld.gov.au/about-planning/state-planning-policy.html)
- Requires consideration of the construction and operational phases for proposed development assessed under the Sustainable Planning Act 2009, for areas generally greater than 2500m2. Activities including building and construction on lots smaller than this threshold must minimise impact under the general environmental duty provisions of the Environmental Protection Act 1994.
- Requires reductions in the loads known to be generated as a result of urbanisation, by percentages specified for the relevant climatic region across Queensland, as identified on the SPP interactive mapping system ('Cape York/FNQ') for key pollutants of TSS, TN, TP and gross pollutants.' The SPP interactive Mapping System is at http://www.statedevelopment.qld.gov.au/planning/state-planning-instruments/spp-interactive-mapping-system.html.
- Allows for local governments to adopt alternative, locally appropriate, solutions to stormwater management in their planning schemes.

# CHAPTER 5: ENVIRONMENTAL VALUES

This component of the Water Quality Improvement Plan is led by Queensland Government Department of Environment and Heritage Protection. Staff inputs to the Eastern Cape York Water Quality Improvement Plan are summarised below. The work parallels consultation activities undertaken by Cape York NRM and South Cape York Catchments (SCYC) with local stakeholders in response to timelines established for the WQIP project. The standard process for defining Environmental Values in Queensland is presented in Figure 26.

The project team has reviewed GIS and other data sources on waterway uses/values as an input to the development of draft Environmental Values (EV's) mapping (discussed below). Table 23 presents a summary of main datasets. These serve as a cross correlation to the local level stakeholder consultations undertaken by Cape York NRM and SCYC. Environmental Values definitions are presented in Table 24 and a summary of draft Environmental Values for major sub-catchments defined by Cape York NRM and SCYC are presented in Table 25.



**Table 23.** GIS Datasets analysed in draft Environmental Values mapping.

| Dataset/source | Informs | Output |
|---|---|---|
| Qld land use mapping project (QLUMP) | Informs identification of all EVs | mapped |
| Remnant vegetation mapping /imagery (Qld Govt) | Identifies areas previously cleared for human activities | mapped |
| Historic land use - Hooper, C (2009) North Queensland<br><br>Deserted Towns: Torres Strait - Cape York, pp39-47 | Identifies locations of historic towns, mining areas and airfields | mapped |
| Regional plan | Identifies intended planning/land use throughout CY region (including areas for conservation) | mapped |
| Cadastral (leasehold, grazing entitlements, freehold, etc.) | Assists in locating properties permitted to water stock, other purposes. | mapped |
| Maritime Services Qld – boat ramps/ jetties | Recreation, human consumer | Interpreted for recreation |
| Beachsafe | Identifies level of beach safety for recreation (swimming etc.) | Interpreted for recreation |
| Maritime Safety ports limits | Identifies extent of port boundaries (industrial use) | mapped |
| Qld government enterprise protected estates | National parks and other protected estate designations | mapped |
| National parks etc. local maps/plans (from QPWS website) | Provide information on facilities and recreation opportunities in NPs | Interpreted for recreation |
| Qld government point source discharge database, Wastewater tracking and electronic reporting system (WaTERS) | Identify any large scale point source dischargers, licenced under legislation – sewage treatment, mines | Interpreted for discharges |
| SIR database (Qld Govt) | Various EVs including industrial use, grazing | Interpreted for EVs |
| Aquatic conservation assessments (EHP) | Aquatic ecosystem current condition (naturalness aquatic and catchment, other criteria) | Reviewed and mapped |
| Other technical report sources | various | |

## Mapping / GIS base layers

The following draft mapping (GIS) has been prepared by Department of Environment and Heritage Protection in the format expected for scheduling under the EPP Water. Details of mapping are expected to change as further information is received from local stakeholders.

Base layers

- Project area boundaries
- Basin/sub-basin boundaries
- EVs sub-catchment units
- Rivers, waterways

Data source mapping

- Land use
- Regional planning
- Water use entitlements
- Protected estate
- Historical mining uses
- Water quality monitoring sites
- Port boundaries
- Marine park zoning, fish habitat areas, other conservation layers
- National/world heritage, directory of important wetlands

Draft EPP Water mapping layers

- Preliminary draft evs based on available datasets/ interpretation (see table below)
- Water types (freshwater, estuarine, coastal/marine etc.)
- Plume line location (GBRMPA and other party input)
- Aquatic ecosystem mapping:
  - Level of protection/management intent—legislative basis
  - Level of protection/management intent—additional technical inputs

Draft Environmental Values maps have been prepared for the whole planning region (Figures 4 to 10 from page 24), with a separate map also produced for coastal waters (Figure 11 on page 31).

## Progress of scheduling Environmental Values and Water Quality Objectives

Environmental Values and Water Quality Objectives developed in accordance with Environmental Protection Policy (EPP) Water requirements can, subject to government approval, be listed in schedule 1 of the EPP Water. One of the key requirements is that the chief executive must ensure there has been consultation with the community, including industry and commerce sectors (refer EPP Water ss 11, 12).

Environmental Values and Water Quality Objectives have been scheduled in the EPP Water for a number of regions, including the following regions covered by 1st generation water quality improvement plans (WQIPs).

- Mackay-Whitsunday region
- Wet Tropics
- Townsville (Black and Ross River basins).

Scheduled Environmental Values and Water Quality Objectives therefore reflect local community views on waterway uses and values, and Water Quality Objectives based on local water quality data (where sufficient data exists). Once scheduled, Environmental Values and Water Quality Objectives become the source for consideration in development assessments, licensing, water sensitive urban design and other decision making processes and other activities.

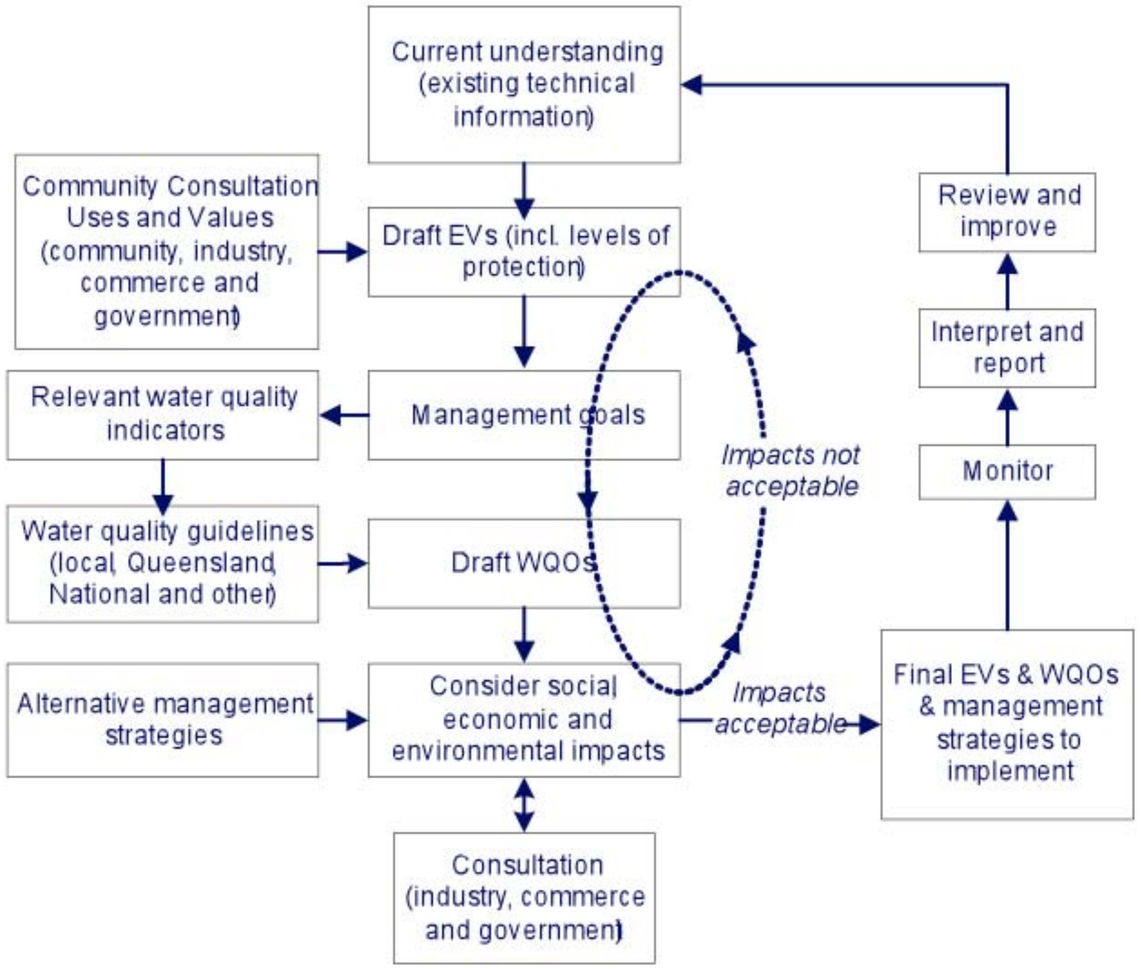



**Figure 26:** Queensland process for defining Environmental Values and Water Quality Objectives.

**Table 24:** Definitions of Environmental Values used in the Eastern Cape York Water Quality Improvement Plan

| Definitions of Environmental Values |
|---|
| **Aquatic ecosystem**<br>'A community of organisms living within or adjacent to water, including riparian or foreshore area.' (EPP (Water), schedule 2 - Dictionary)<br>The intrinsic value of aquatic ecosystems, habitat and wildlife in waterways and riparian areas, for example, biodiversity, ecological interactions, plants, animals, key species (such as turtles, platypus, seagrass and dugongs) and their habitat, food and drinking water.<br>Waterways include perennial and intermittent surface waters, groundwaters, tidal and non-tidal waters, lakes, storages, reservoirs, dams, wetlands, swamps, marshes, lagoons, canals, natural and artificial channels and the bed and banks of waterways.<br>(This EV incorporates the 'wildlife habitat' EV used in the South East Queensland Regional Water Quality Management Strategy). See below for more details on aquatic ecosystems, based on the EPP (Water). |
| **High ecological/conservation value waters**<br>'Waters in which the biological integrity of the water is effectively unmodified or highly valued.' (EPP (Water), schedule 2). |
| **Slightly disturbed waters**<br>'Waters that have the biological integrity of high ecological value waters with slightly modified physical or chemical indicators but effectively unmodified biological indicators.' (EPP (Water), schedule 2). |
| **Moderately disturbed waters**<br>'Waters in which the biological integrity of the water is adversely affected by human activity to a relatively small but measurable degree.' (EPP (Water), schedule 2). |
| **Highly disturbed waters**<br>'Waters that are significantly degraded by human activity and have lower ecological value than high ecological value waters or slightly or moderately disturbed waters.' (EPP (Water), schedule 2). |
| **Seagrass** (goal within the aquatic ecosystem EV)<br>Maintenance or rehabilitation of seagrass habitat. (Applies only to tidal waterways.) |
| **Irrigation**<br>Suitability of water supply for irrigation, for example, irrigation of crops, pastures, parks, gardens and recreational areas. |
| **Farm water supply/use**<br>Suitability of domestic farm water supply, other than drinking water. For example, water used for laundry and produce preparation. |
| **Stock watering**<br>Suitability of water supply for production of healthy livestock. |
| **Aquaculture**<br>Health of aquaculture species and humans consuming aquatic foods (such as fish, molluscs and crustaceans) from commercial ventures. |
| **Human consumers of aquatic foods**<br>Health of humans consuming aquatic foods, such as fish, crustaceans and shellfish from natural waterways. Note that in some areas oystering is a more specific goal identified under the human consumer EV (see below). |
| **Oystering** (goal within the EV of human consumers of aquatic foods)<br>Health of humans consuming oysters from natural waterways and commercial ventures. (Applies only to tidal waterways.) |
| **Primary recreation**<br>Health of humans during recreation which involves direct contact and a high probability of water being swallowed, for example, swimming, surfing, windsurfing, diving and water-skiing.<br>Primary recreational use, of water, means full body contact with the water, including, for example, diving, swimming, surfing, waterskiing and windsurfing. (EPP (Water), s. 6). |
| **Secondary recreation**<br>Health of humans during recreation which involves indirect contact and a low probability of water being swallowed, for example, wading, boating, rowing and fishing.<br>Secondary recreational use, of water, means contact other than full body contact with the water, including, for example, boating and fishing. (EPP (Water), s. 6). |
| **Visual recreation**<br>Amenity of waterways for recreation which does not involve any contact with water—for example, walking and picnicking adjacent to a waterway.<br>Visual recreational use, of a water, means viewing the water without contact with it. (EPP (Water), s. 6). |
| **Drinking water supply**<br>Suitability of raw drinking water supply. This assumes minimal treatment of water is required, for example, coarse screening and/or disinfection. |
| **Industrial use**<br>Suitability of water supply for industrial use, for example, food, beverage, paper, petroleum and power industries, mining and minerals refining/processing. Industries usually treat water supplies to meet their needs. |
| **Cultural and spiritual values**<br>Indigenous and non-indigenous cultural heritage, for example:<br>• custodial, spiritual, cultural and traditional heritage, hunting, gathering and ritual responsibilities<br>• symbols, landmarks and icons (such as waterways, turtles and frogs)<br>• lifestyles (such as agriculture and fishing).<br>Cultural and spiritual values, of water, means its aesthetic, historical, scientific, social or other significance, to the present generation or past or future generations. (EPP (Water), s. 6). |

**Table 25:** Draft Environmental Values of major sub-catchments of eastern Cape York

| Draft Environmental Values for major sub-catchments of eastern Cape York<br>HEV = high ecological value, SD = slightly disturbed, SMD = slightly/moderately disturbed, H = high use, M = medium use, L = low use | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Basin** | **Sub-catchment** | **Aquatic ecosystem** | **Irrigation** | **Stock water** | **Farm use** | **Aquaculture** | **Human consumption** | **Primary recreation** | **Secondary recreation** | **Visual appreciation** | **Drinking water** | **Industrial** | **Cultural value** |
| **Jacky Jacky** | Jacky Jacky Creek | HEV | - | - | - | - | H | M | H | H | - | - | H |
| | Escape River | HEV | - | - | - | L | H | - | M | M | - | - | H |
| | Harmer Creek | HEV | - | - | - | - | M | - | L | M | - | - | H |
| **Olive** | Glennie Creek | HEV | - | M | - | - | L | - | - | L | - | - | M |
| | Kangaroo River | HEV | - | - | - | - | M | - | M | M | - | - | H |
| | Olive River | HEV | - | M | - | - | M | - | H | M | - | - | H |
| **Pascoe** | Garraway Creek | HEV | - | L | - | - | M | M | - | M | - | - | H |
| | Yam Creek | HEV | - | L | - | - | M | - | - | M | - | - | M |
| | Hann Creek | HEV | - | L | - | - | L | - | - | L | - | - | M |
| | Pascoe River | HEV | - | L | L | - | M | - | M | M | - | - | H |
| **Lockhart** | Wilson Creek | HEV | - | - | - | - | M | - | M | H | - | - | H |
| | Claudie River | HEV | - | - | - | - | M | - | H | H | - | - | H |
| | Scrubby Creek | HEV | - | - | - | - | L | - | - | L | - | - | M |
| | Lockhart River | HEV | - | - | - | - | M | - | M | M | - | - | H |
| | Nesbit River | HEV | - | - | - | - | M | - | L | L | - | - | H |
| | Chester River | HEV | - | - | - | - | M | - | L | L | - | - | M |
| **Stewart** | Massey Creek | SD | - | H | - | - | M | M | M | M | - | - | H |
| | Breakfast Creek | SD | - | H | - | - | M | - | H | M | - | - | H |
| | Station Creek | HEV | - | M | - | - | L | - | - | M | L | - | M |
| | Stewart River | SD | - | - | - | - | M | - | H | M | M | - | H |
| | Balclutha Creek | HEV | - | - | - | - | M | - | L | M | - | - | H |
| | Running Creek | HEV | - | - | - | - | M | - | M | M | - | - | H |
| **Hann** | Annie River | SD | - | M | - | - | M | - | H | H | - | - | M |
| | Hann River | HEV | - | L | - | - | M | - | L | M | L | - | M |
| | North Kennedy River | HEV | - | M | - | - | M | - | H | H | - | - | M |
| **Normanby** | Bizant River | HEV | - | - | - | - | M | - | H | H | - | - | M |
| | Kennedy River | HEV | - | M | - | - | M | - | L | M | L | - | M |
| | Mosman River | HEV | - | M | - | - | M | - | - | M | - | - | M |
| | Deighton River | HEV | - | M | - | - | M | - | - | L | - | - | H |
| | Laura River | SMD | M | H | M | - | M | M | M | H | L | - | M |
| | Normanby River | SMD | - | H | - | - | H | - | H | H | - | - | H |
| **Jeannie** | Muck River | HEV | - | - | - | - | M | - | L | M | - | - | M |
| | Howick River | HEV | - | - | - | - | M | - | M | M | - | - | M |
| | Jeannie River | HEV | - | - | - | - | M | - | - | M | - | - | M |
| | Starke River | SD | - | - | - | - | M | - | - | M | - | - | M |
| | McIvor River | SD | L | M | L | - | M | - | M | M | L | - | M |
| **Endeavour** | Isabella Creek | SD | L | M | L | - | M | M | L | M | L | - | H |
| | Endeavour North Branch | SD | - | M | L | - | M | L | L | H | L | L | M |
| | Endeavour South Branch | HEV | L | L | L | - | L | - | - | L | L | - | M |
| | Endeavour Right Arm | HEV | - | L | L | - | M | - | - | M | L | - | H |
| | Endeavour River | SMD | M | M | M | - | M | - | H | H | L | L | H |
| | Oakey Creek | SMD | - | M | L | - | L | - | - | L | L | - | M |
| | Trevethan Creek | HEV | - | M | - | - | L | M | - | H | L | - | H |
| | Annan River | SD | - | M | - | L | M | H | H | H | M | - | H |



# CHAPTER 6: COMMUNITY AND SCIENCE CONSULTATION PROCESS

## The planning team

The planning team involved a partnership between South Cape York Catchments and Cape York NRM and the main people involved are shown in Table 26 below.

**Table 26:** South Cape York Catchments and Cape York NRM planning team.

| Name | Role in WQIP development |
|---|---|
| Will Higham | Project leader |
| Jason Carroll | Community consultation and implementation plan |
| Jessie Price | Community consultation and science synthesis |
| Christina Howley | Foundation monitoring and water quality synthesis |
| Jeff Shellberg | Foundation research and science advisor |
| Samantha Hobbs | Community Consultation |
| Sue Marsh | Community Consultation |
| Michael Goddard | Community Consultation |
| Desmond Tayley | Community Consultation |
| Lyndal Scobell | Communications Support |
| Kym Dungey | GIS Support |

### Consultation for the Cape York region

Many planning processes within Cape York region have attempted to consult with local people to gather the information that is required to support the planning purpose. The low population, spread across a large geographical scale, and difficulty of access, has led to inadequate processes for many consultations. Traditional Owners, graziers and farmers have expressed their concerns about the lack of adequate consultation when plans are published claiming that they have undertaken a rigorous consultation process. For example, "these people come for a meeting to talk about water, we told them lots of things, we never saw them again, they steal our thoughts" (P. Port, pers. comm. 2014).

The rationale behind good community consultation in this project is that the planning region is vast and little is known about large stretches of it. The land managers (graziers, farmers, Traditional Owners, Queensland Parks and Wildlife Service and other rangers) know their land and know what is happening on it. Because the planning region is so large, there is a real need for prioritisation. The prioritisation process needs to consider the available information on land disturbance, freshwater and marine environment condition, and land managers' knowledge.

When working with people over an extended consultation process, there is a need for give and take. The process was designed to ensure that the land managers would receive something of value in exchange for the critical information required for the plan. The process also utilised a field-based interaction between the planners and the land managers. Within Cape York region these 'on-Country' consultations provide the best possible planning results. Table 27 describes this critical information and the planning products they support.

**Table 27:** Critical information from land managers for Eastern Cape York Water Quality Improvement Plan planning products

| Critical Information from Land Managers | WQIP Planning Products Supported |
|---|---|
| Most valued water assets (wetlands, creeks, rivers, estuarine/coastal zones) | Environmental Values |
| Use/s of water assets (industry, urban, recreation) | Environmental Values |
| Threats to water assets | Catchment Land use Threats and Pressures |
| Management actions that could be implemented to improve land management and restore or preserve water assets | Management Actions and Management Practice Frameworks |
| Management actions previously implemented and their success rate | Management Actions and Management Practice Frameworks |

In exchange for providing critical information to the Eastern Cape York Water Quality Improvement Plan, Water Asset Summaries were produced for the land managers (Table 30). The summaries reproduce the information provided by the land manager in a short report for use in seeking investment in their own projects. This will not only benefit the land managers, but also ensure increased ownership and use of the whole Eastern Cape York Water Quality Improvement Plan and improve the chances of implementation action uptake. The Water Asset Summaries also support communication of the final Eastern Cape York Water Quality Improvement Plan. It is expected that implementation of this plan will result in the production of many more Water Asset Summaries that represent priority actions identified by the people of Cape York that align with Reef 2050 Plan targets and outcomes.

The communication process with grazing and agriculture land managers resulted in detailed implementation plans for agriculture and grazing (including gully management) that address the Reef 2050 Plan sediment reduction targets (Chapters 4 and 5). These implementation plans should be periodically reviewed and updated as part of an adaptive implementation strategy (see Chapter 2).

The three-stage process outlined in Table 28 was developed to efficiently and effectively build relationships with land managers, collect the required critical information and present the Eastern Cape York Water Quality Improvement Plan products. The timing of the delivery of the process in each basin is presented in Table 29. While every attempt was made to engage consistently across the entire planning area, there are some parts of the planning region that require targeted engagement during implementation to ensure that the Eastern Cape York Water Quality Improvement Plan represents the people of Cape York.

**Table 28:** Stages in the community consultation process

| Community Consultation Process |
|---|
| **Stage 1:** Meet land managers and explain consultation process and how informs the Eastern Cape York Water Quality Improvement Plan. Collect information about water assets, threats and pressures and management actions. |
| **Stage 2:** Present draft Environmental Values for comment & correction. Ground-truth Walking the Landscape results and the agriculture and grazing implementation strategies. |
| **Stage 3:** Present final draft of Eastern Cape York Water Quality Improvement Plan, Water Asset Summaries and agriculture and grazing implementation plans for comment & correction. |

**Table 29:** Community consultation in each basin

| Basin | Area | Stage 1 | Stage 2 | Stage 3 |
|---|---|---|---|---|
| Jacky Jacky | North | May 2015 | September 2015 | February 2016 |
| | South | *Implementation* | *Implementation* | *Implementation* |
| Olive | Olive River | *Implementation* | *Implementation* | *Implementation* |
| Pascoe | Pascoe River | May 2015 | *Implementation* | *Implementation* |
| Lockhart | North | May 2015 | December 2015 | February 2016 |
| | South | *Implementation* | *Implementation* | *Implementation* |
| Stewart | East | December 2014 | May 2015 | February 2016 |
| | West | December 2014 | May 2015 | February 2016 |
| Normanby | North | December 2014 | May 2015 | February 2016 |
| | Central | August 2015 | November 2015 | February 2016 |
| | East | April 2015 | November 2015 | February 2016 |
| | West | August2015 | November 2015 | February 2016 |
| Jeannie | North | *Implementation* | *Implementation* | *Implementation* |
| | South | August 2015 | December 2015 | February 2016 |
| Endeavour | Endeavour River | August 2015 | November 2015 | February 2016 |
| | Annan River | November 2015 | December 2015 | February 2016 |

Please Note: *Implementation indicates areas where further consultation is required in 2016 during implementation.*

**Table 30:** Water Asset Summaries produced for each drainage basin

| Drainage Basin | Catchment | Water Asset Summary |
|---|---|---|
| Jacky Jacky | Jacky Jacky Creek | Jacky Jacky Creek |
| | Jacky Jacky Creek | Lake Bronto and Lake Wicheura |
| | Escape River | **In 2016** |
| Olive | Olive River | **In 2016** |
| Pascoe | Pascoe River | **In 2016** |
| Lockhart | Claudie | Claudie River and Wetlands |
| | Lockhart River | **In 2016** |
| Stewart | Lower Stewart | Lower Stewart |
| | | Breakfast Creek |
| | | Scrubby Lagoon |
| | Upper | Station Ck |
| Hann | Kennedy | Grazing Case Study |
| | Annie River | Violetvale Case study |
| Normanby | Normanby | The Soak |
| | Normanby | Kings Lake |
| | Lakeland | **In 2016** |
| Jeannie | Starke River | Woo Yee Wetland |
| | Cape Flattery | **In 2016** |
| | McIvor | **In 2016** |
| Endeavour | Endeavour River | Endeavour River |
| | Annan River | Annan River |
| | Annan River | Keatings Lagoon Case Study |

### Walking the Landscape

A series of Walking the Landscape workshops provided the base resolution for describing ecosystem function and Environmental Values for the Eastern Cape York Water Quality Improvement Plan. These workshops combined the best available scientific expert knowledge and analysis with all available region-wide catchment data and scientific studies to describe the hydrological processes and attributes across all sub-catchments of the eastern Cape York basins, as well as the natural terrain attributes, ecological attributes, landscape modifications and any water quality or sedimentation issues. The Walking the Landscape process is a recognised method for defining Groundwater Dependent Ecosystems under the National Water Management Framework. Completing the Groundwater Dependent Ecosystems analysis during the early stages of implementation is recommended.

This process has provided the Eastern Cape York Water Quality Improvement Plan with a base layer of information for analysing risks to water quality, environmental values and water types, at a fine level of detail. The Eastern Cape York Water Quality Improvement Plan is the first Water Quality Improvement Plan in the Great Barrier Reef Catchment to use the fine-scaled Walking the Landscape Process as the first stage to systematically analyse risks to water quality, environmental values and water types.



Two workshops were held over five days total, covering the seven basins of the Eastern Cape York Water Quality Improvement Plan.

The landscape process and knowledge experts involved were:

- **Graham Herbert**, Hydrogeologist, Department of Natural Resources and Mines
- **Glynis Orr**, Hydrologist, Department of Natural Resources and Mines
- **Vince Manley**, Hydrographer, Department of Natural Resources and Mines
- **Neale Searle**, Hydrographer, Department of Natural Resources and Mines
- **Eda Addicott**, Botanist, Queensland Herbarium
- **Bruce Wannan**, Ecologist, Department of Environment and Heritage Protection
- **Donna Audas**, Catchment Scientist, Great Barrier Reef Marine Park Authority
- **Paul Groves**, Catchment Modeller, Great Barrier Reef Marine Park Authority
- **Jeff Shellburg**, Hydrologist
- **Christina Howley**, Water Quality Scientist
- **Andrew Hartwig**, NRM Specialist, Landcare Australia
- **Jason Carroll**, Freshwater Ecologist, South Cape York Catchments
- **Sue Marsh**, NRM Specialist, South Cape York Catchments
- **Mike Ronin**, Wetlands Specialist, Department of Environment and Heritage Protection (facilitator)

Following The Walking the Landscape workshops, Andrew Brooks and John Spencer met with Mike Ronin to incorporate Griffith University's spatial information for Normanby and Stewart Basins.

### Science synthesis

The development of the Eastern Cape York Water Quality Improvement Plan involved synthesis of all available scientific data with scientific expert opinion to create knowledge that was applied to the task of designing the implementation plan.

To ensure that the planning process utilised best available science a Science Advisory Panel was established (Table 31).

The primary role of this group was to provide technical input to the planning process and review planning products with meetings held as follows:

- **October 2014**: Two day establishment meeting
- **May 2015**: Eastern Cape York Water Quality Improvement Plan progress update and input to community consultation and WQIP process
- **June 2015**: Eastern Cape York Water Quality Improvement Plan progress update and input to EV's, Walking the Landscape and Science Synthesis workshop
- **August 2015**: Science Synthesis workshop
- **September 2015**: Eastern Cape York Water Quality Improvement Plan progress update
- **December 2015**: Review supporting studies
- **January 2016**: Review supporting studies
- **February 2016**: Review Water Quality Targets and comments on first draft plan
- **March 2016**: Review Water Quality Targets and comments on first draft plan

A number of specific studies have also supported the development of the plan and are available from South Cape York Catchments or Cape York NRM (Table 32).

The timelines for producing draft supporting studies was designed to provide analysed data to feed into a major synthesis event—a three-day synthesis workshop held in Cooktown between the 10th and 12th of August 2015. The August synthesis workshop brought together the key science and technical advisors to the Eastern Cape York Water Quality Improvement Plan.

The workshop and subsequent Science Advisory Panel meetings used science coordination and facilitation techniques to:

- Build consensus on the assets values and threats for Cape York
- Identify indicators to measure success of the water quality improvement plan
- Setting targets and objectives for improvement in line with Reef 2050 Plan, and
- Begin the development of a method for scoring the current state of the catchment with ideas for successful communication.

The scientific knowledge generated through these process has been incorporated into this plan as well as the final versions of the supporting studies.

During implementation of the Eastern Cape York Water Quality Improvement Plan it is recommended that an annual science synthesis event be conducted to synthesise the latest information and support ongoing adaptive management.

**Table 31:** Members of the Science Advisory Panel

| Member | Department/Org. | Field of expertise |
|---|---|---|
| Chella Goldwin / Kevin Gale | Australian Government | Australian Government |
| Christina Howley | Howley Consulting | Water Quality and aquatic ecosystems |
| Andrew Moss | Department of Science, Information Technology and Innovation | Water Quality |
| Dane Moulton | Department of Environment and Heritage Protection | EPP Water |
| Carol Honchin | Great Barrier Reef Marine Park Authority | Marine Water Quality Guidelines |
| Donna Audas | Great Barrier Reef Marine Park Authority | Freshwater Ecosystems |
| Mike Ronan | Department of Environment and Heritage Protection | Freshwater Ecosystems |
| Andrew Brooks | Griffith University | Catchment hydrology and sediment research sediment research |
| Jeff Shellberg | Private Consultant | Catchment hydrology, water quality and sediment research |
| John Armor / Dave Waters / Gillian McCloskey | Department of Natural Resources and Mines | Catchment Modelling |
| Jon Brodie | James Cook University | Marine Water Quality |
| Glen Holmes | Private Consultant | Marine Ecologist |



**Table 32:** Summary of the supporting studies used to assist Cape York NRM and South Cape York Catchments in the development of the Eastern Cape York WQIP.

| Supporting study | Delivery Partner / Consultant | Authors | Chapter # / Appendix # |
|---|---|---|---|
| **Current understanding - Waterway uses/aquatic ecosystem values** | | | |
| **Background to Water Quality Improvement Planning** | TropWater, JCU, Cape York NRM | Jane Waterhouse, Will Higham | Chapter 4 |
| **Environmental Values** | Department of Environment and Heritage Protection, SCYC, Cape York NRM | Dane Moulton, David Thames (GIS), Jess Price, Will Higham | Chapter 5 |
| **Community and Science Consultation** | Cape York NRM, SCYC | Will Higham, Jess Price | Chapter 6 |
| **Land use change** | TropWATER, JCU | Stephen Lewis | Appendix 3 |
| **Economic values of coastal and marine ecosystems** | TropWATER, JCU | Collette Thomas, Jon Brodie | Appendix 12 |
| **'Walking the Landscape' - Documenting knowledge of system function and process understanding** | Department of Environment and Heritage Protection | Mike Ronan, Julia Stevenson-Lyon | Appendix 14 |
| Water quality guidelines and targets | | | |
| **Super Guage approach - Annan River water quality synthesis** | Consultant, Howley Environmental, SCYC | Jeff Shellberg, Christina Howley, Jason Carroll | Appendix 4 |
| **Coastal and Marine Water Quality Guidelines** | GBRMPA | Carol Honchin | Appendix 5 |
| **Synthesis of marine water quality** | Howley Environmental | Christina Howley | Appendix 6 |
| **Synthesis of coastal and marine ecosystem condition** | TropWATER, JCU | Caroline Coppo, Len McKenzie, Jon Brodie | Appendix 7 |
| **Synthesis of Catchment Loads** | Howley Environmental | Christina Howley | Appendix 8 |
| **Fresh and Estuarine Water Quality Guidelines** | Howley Environmental | Christina Howley, Andrew Moss | Appendix 9 |
| Implementation and management options | | | |
| **Integrated Monitoring Program** | Howley Environmental, Cape York NRM, SCYC, Consultant | Christina Howley, Will Higham, Jason Carroll, Jess Price, Jeff Shellberg | Chapter 3 |
| **Grazing Implementation Strategy** | Cape York NRM | Will Higham | Appendix 15 |
| **Agriculture Implementation Strategy** | Cape York NRM | Will Higham | Appendix 16 |
| **Economics of grazing management** | Department of Agriculture, Fisheries and Forestry | Megan Star, Miriam East, Teresa Fox | Appendix 11 |
| **Cape York Fire** | Cape York NRM | Peta-Marie Standley | Appendix 13 |
| Regional spatial prioritisation | | | |
| **Disturbance Index** | Griffith University | John Spencer, Andrew Brooks, Graeme Curwen, Kenn Tews | Appendix 1 |
| **Gully Prioritisation** | Griffith University | Andrew Brooks, Graeme Curwen, John Spencer | Appendix 2 |
| **Relative risk assessment of degraded water quality on coastal and marine ecosystems** | TropWATER, JCU | Jane Waterhouse, Jon Brodie, Caroline Coppo, Dieter Tracey, Eduardo da Silva, Caroline Petus, Len McKenzie, Stephen Lewis, Christina Howley, Gillian McCloskey, Will Higham | Appendix 10 |

# REFERENCES


AIMS, 2015. Monitoring on the Great Barrier Reef. Retrieved 22 May, 2015, from http://www.aims.gov.au/docs/research/monitoring/reef/reef-monitoring.html

Anderson, C., 1983. Aborigines and Tin Mining in North Queensland: A Case Study in the Anthropology of Contact History. Mankind, 13(6), 473-498.

ANZECC & ARMCANZ, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Conservation Council, Agriculture Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ). National Water Quality Management Strategy (NQWMS), Australian Government, Canberra: http://www.environment.gov.au/water/policy-programs/nwqms/index.html

Australian Government, 2015. OzCoasts, Australian Online Coastal Information. Retrieved 18 May, 2015, from http://www.ozcoasts.gov.au/nrm_rpt/report_cards.jsp

Biggs, A.J.W., Philip, S.R., 1995. Soil Survey and Agricultural Suitability of Cape York Peninsula. Cape York Peninsula Land Use Strategy (CYPLUS), Natural Resources Analysis Program, Queensland. Dept. of Primary Industries Brisbane, QLD.

Brodie, J., De'ath, G., Devlin, M., Furnas, M., and Wright, M., 2007. Spatial and temporal patterns of near-surface chlorophyll a in the Great Barrier Reef lagoon. Marine and Freshwater Research (58), 342-353.

Brooks, A., Spencer, J., Olley, J., Pietsch, T., Borombovits, D., Curwen, G., Shellberg, J., Howley, C., Gleeson, A., Simon, A., Bankhead, N., Klimetz, D., Eslami-Endargoli, L., Bourgeault, A., 2013. An Empirically-Based Sediment Budget for the Normanby Basin: Sediment Sources, Sinks, and Drivers on the Cape York Savannah, Griffith University, Australian Rivers Institute, Final Report for the Australian Government Caring for Our Country - Reef Rescue Program, April 2013, 506pp. http://www.capeyorkwaterquality.info/references/cywq-229.

Brooks, A., Curwen, G., and Spencer J., 2015. A framework for prioritising gully management in the Normanby Basin Cape York. Australian Rivers Institute, Griffith University, Brisbane.

Carroll, J., Stephan, K., Howley, C., Seabrook, W., Wood, D., 2007. Annan and Endeavour Strategic Plan. South Cape York Catchments, Cooktown.

Carroll, J., Coates, J., 2015. Fish and Crustacean Survey of Kimba Plateau Springs and Creeks. In: J. Shellberg, M. Ross, A. Hogbin, N. Preece, K. Grimes (Eds.), Kimba Plateau Physical and Biological Diversity, Olkola Country, Cape York Peninsula. Published by Olkola Aboriginal Corporation, with funding from the Queensland Government's Indigenous Land and Sea Grants Program through the Department of Environment and Heritage Protection, pp. 54-58.

Coles, R., McKenzie, L., De'ath, G., Roelofs, A., Lee Long, W., 2009. Spatial distribution of deepwater seagrass in the inter-reef lagoon of the Great Barrier Reef World Heritage Area. Marine Ecology Progress Series 392, 57–68.

Coles, R.G., Grech, A., McKenzie, L., Rasheed, M. 2011. Evaluating risk to seagrasses in the tropical Indo-Pacific region. CERF 2011, 21st Biennial Conference of the Coastal and Estuarine Research Federation Conference Abstracts. Societies, Estuaries & Coasts: Adapting to Change. 6-10 November 2011, Daytona Beach, Florida, USA. p.43.

Commonwealth of Australia, 2015. Reef 2050 Long-Term Sustainability Plan. Commonwealth of Australia, Canberra. http://www.environment.gov.au/marine/gbr/long-term-sustainability-plan

Coppo, C., McKenzie, L. and J. Brodie, 2016. Status of Coastal and Marine Assets in the Eastern Cape York region, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication, James Cook University, Townsville, Report No. 15/65, **pp.

Davies, P.J. and Hughes, H., 1983. High-energy reef and terrigenous sedimentation, Boulder Reef, Great Barrier Reef. BMR Journal of Australian Geology and Geophysics 8:3:201-209. Bureau of Mineral Resources, Geology and Geophysics, Canberra.

Davies, P.L., 1995. Nutrients and suspended sediments in three near pristine tropical rivers on Cape York Peninsular, Southern Cross University.

Davies, P.J., and Eyre, B.D., 2005. Estuarine modification of nutrient and sediment exports to the Great Barrier Reef marine park from the Daintree and Annan River catchments. Marine Pollution Bulletin 51(1-4), 174-185.

Devlin, M., 2012. Flood plume monitoring in the Great Barrier Reef, 1994 - 2012. James Cook University, Townsville. https://eresearch.jcu.edu.au/tdh/data/f31cbf35-2c03-4c6f-a312-2f621b1fc5b5

Doupe, R.G., Schaffer, J., Knott, M.J. and Dicky, P.W., 2009. A Description of Freshwater Turtle Habitat Destruction by Feral Pigs in Tropical North-eastern Australia. Herpetological Conservation and Biology (4), 331-339.

Ebner, B. and Donaldson, J. 2015. Wetland Surveys for Aquatic Biodiversity at Violet Vale Station, James Cook University.

Eyre B.D., and Davies P.L., 1996. Task G6: Flood Impact Monitoring Study Sub-task: River and Estuarine Monitoring, Centre for Coastal Management, Southern Cross University.

Fabricius, K., De'ath, G., McCook, L., Turak, E., and Williams, D.M., 2005. Changes in algal, coral and fish assemblages along water quality gradients on the inshore Great Barrier Reef. Marine Pollution Bulletin 51(1-4), 384-398.

Great Barrier Reef Marine Park Authority, 2010. Water Quality Guidelines for the Great Barrier Reef Marine Park.

Great Barrier Reef Marine Park Authority, Townsville, 99p.

Great Barrier Reef Marine Park Authority, 2014. Great Barrier Reef Outlook Report, 2014. Great Barrier Reef Marine Park Authority, Townsville.

Great Barrier Reef Marine Park Authority, 2016. Cape York Technical Background document to HWMP. Great Barrier Reef Marine Park Authority, Townsville.

Halpern, B.S., Walbridge, S., Selkoe, K.A., Kappel, C.V., Micheli, F., D'Agrosa, C., Bruno, J.F., Casey, K.S., Ebert, C., Fox, H.E., Fujita, R., Heinemann, D., Lenihan, H.S., Madin, E.M.P., Perry, M.T., Selig, E.R., Spalding, M., Steneck, R., Watson, R., 2008. A Global Map of Human Impact on Marine Ecosystems. Science, 319, 948-952.

Howley, C., McCollum, I., O'Connell, K., Stephan, K. (2006). Cape York Peninsula Marine and Coastal Natural Resource Management Plan. Cape York Marine Advisory Group , Cooktown. Qld.

Howley, C., Stephan, K., 2009. Cape York Open Freshwater Wetland Assessment Methods. Cape York Marine Advisory Group (CYMAG), Cooktown, QLD.

Howley, C., Lyon, B., Frith, C., Frith, D., Johns, L., Carroll, J., and Stephan, K., 2009. Muck River Biodiversity and Wetland Condition Report, 2008 - 2009. CYMAG Environmental Inc., Cooktown, Qld.

Howley, C., 2010. Results of the Laura-Normanby River Water Quality Monitoring Project: An Assessment of Ambient Water Quality and Water Quality Impacts. CYMAG Environmental, Inc., Cooktown, QLD.

Howley, C.M., Shellberg, J.G., Stephan, K., Brooks, A.P., 2013. Normanby Catchment Water Quality Management Plan. Griffith University and Howley Environmental Consulting, Final Draft Report for the Australian Government Caring for Our Country - Reef Rescue Program, 88pp. http://www.capeyorkwaterquality.info/references/cywq-17, Cooktown, QLD.

Howley, C.M., Olley, J.M., Carroll, J., 2012. Annan and Endeavour River Freshwater and Estuarine Water Quality Report: An Assessment of Ambient Water Quality and Effects of Land Use 2002-2009. CYMAG Environmental Inc., Cooktown, Queensland.

Howley, C., 2012. Annan, Endeavour & Jeannie River freshwater & estuarine water quality report: Ambient Water Quality Monitoring Results 2002 - 2009. CYMAG Environmental, Cooktown, Qld.

Howley, C., 2015. Cape York Peninsula Marine Water Quality Synthesis Technical Report for the CYP Water Quality Improvement Plan. Howley Consulting, Cooktown.

Howley, C. , Huggins, R., Turner, R., Wallace, R., Warne, M., 2016. Eastern Cape York Sediment and Nutrient Load Report: Empirical Load Estimates from the Normanby, Annan and Pascoe Rivers. Technical Report for the Cape York Water Quality Improvement Plan. Howley Consulting, Cooktown

Howley, C., Devlin, M., & Burford, M. (2018). Assessment of water quality from the Normanby River catchment to coastal flood plumes on the northern Great Barrier Reef, Australia. *Marine and Freshwater Research, 69*(6), 859-873.

Howley,C., Carroll, J. and McCollum, I. (unpublished data). Mapping of coastal and reef seagrass meadows in south-east Cape York Peninsula, 2004- 2009. Cape York Marine Advisory Group. Cooktown, Qld.

Karfs, R., Holloway, C., Pritchard, K., Resing, J., 2009. Land Condition Photo Standards for the Burdekin Dry Tropics Rangelands: A Guide for Practitioners. Burdekin Solutions Ltd and Queensland Department of Primary Industries and Fisheries, Townsville.

Lewis, S., 2015. Land use change Cape York NRM region. Report No. 15/xx for the Cape York NRM, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication, James Cook University, Townsville.



Mackey, B.G., Nix, H. and Hitchcock, P. 2001. The Natural Heritage Significance of Cape York Peninsula. Anutech Pty Ltd, ANU, QLD EPA.

McCloskey et al. in review. Source Catchments 2015 modelling results for eastern Cape York Catchments.

McKenzie, L.J., Yoshida, R., Grech, A., Coles, R., 2010. Queensland seagrasses. Status 2010 – Torres Strait and East Coast. Fisheries Queensland (DEEDI), Cairns. 6pp.

McKenzie, L.J., Collier, C., Waycott, M., 2013. Reef Rescue Marine Monitoring Program Inshore Seagrass.

Annual Report for the sampling period 1st July 2011 to 31st May 2012. TropWATER, James Cook University, Cairns, p. 192.

Moss, A.J., Howley, C.M., 2016. Water Quality Guidelines for Fresh and Estuarine Waters of Eastern Cape York: A technical report for the Cape York Water Quality Improvement Plan. Produced for South Cape York Catchments and Cape York NRM by Howley Environmental Consulting and the Qld Department of Science, Information Technology and Innovation, Cooktown, Qld.

NWQMS, 2000. National Water Quality Management Strategy. Australian Government Department of the Environment. http://www.environment.gov.au/water/quality/national-water-quality-management-strategy.

Petus, C. and da Silva, E.T. unpublished. Princess Charlotte Bay: where do river plumes go? A first overview of the spatial and temporal variability of Princess Charlotte Bay River plumes using MODIS true color images. Prepared October 2013, TropWATER, James Cook University Townsville.

Port, P., 2014. Personal communication. Puntimu Outstation, Coen, Queensland, Australia.

Queensland Department of Environment and Resource Management, 2009. Queensland Water Quality Guidelines 2009.

Queensland Government, 2015. Reef Water Quality Protection Plan: Report Card 2013 and 2014 http://reefplan.qld.gov.au/measuring-success/report-cards/2014/catchment-indicators/

Queensland WetlandInfo, 2015. This reference needs to be defined

Rhode, K., 2015. Rainfall simulations of land management practices in the Normanby and Endeavour River catchments. Catchment Solutions. Mackay, Qld.

Rolfe, J., Shaw, K., English, B., Kernot, J., 2004. Regional Land Condition Assessment: Grazing Management to Improve Regional Ecosystems, Land Condition and Optimise Beef Production in the Northern Gulf. Queensland Department of Primary Industries and Fisheries, pp. 26.

Schaffelke, B., Anthony, K., Blake, J., Brodie, J., Collier, C., Devlin, M., Fabricius, K., Martin, K., McKenzie, L., Negri, A., Ronan, M., Thompson, A., Warne, M., 2013. 2013 Scientific Consensus Statement: Chapter 1 Marine and Coastal Impacts. Reef Water Quality Protection Plan Secretariat, The State of Queensland.

Shellberg, J.G., Brooks, A.P., 2013. Alluvial Gully Prevention and Rehabilitation Options for Reducing Sediment Loads in the Normanby Catchment and Northern Australia. Griffith University, Australian Rivers Institute, Final Report for the Australian Government's Caring for our Country - Reef Rescue Initiative, 312pp. http://www.capeyorkwaterquality.info/references/cywq-223.

Shellberg, J.G., Brooks, A.P., Rose, C.W., 2013. Sediment production and yield from an alluvial gully in northern Queensland, Australia. Earth Surface Processes and Landforms, 38, 1765-1778. DOI: 1710.1002/esp.3414.

Shellberg, J., Ross, M., Hogbin, A., Preece, N., Grimes, K. (Eds.), 2015. Kimba Plateau Physical and Biological Diversity, Olkola Country, Cape York Peninsula. Published by Olkola Aboriginal Corporation, with funding from the Queensland Government's Indigenous Land and Sea Grants Program through the Department of Environment and Heritage Protection, 120pp.

Shellberg, J., Howley, C., Carroll, J., 2016. The Need for a 'Super Gauge' Approach Using Surrogate Technologies and Improved Field and Laboratory Techniques to Accurately Monitor Suspended Sediment and Nutrient Loads Delivered to the Great Barrier Reef: A Case Study from the Annan River Catchment on the Cape York Peninsula. Report by South Cape York Catchments with support from the Commonwealth Scientific and Industrial Research Organisation, the Queensland Government, and the Australian Government's Cape York Water Quality Improvement Plan program. 47pp.

Spencer J., Brooks, A., Curwen, G., and Tews, K., 2016. A disturbance index approach for assessing water quality threats in Eastern Cape York. Australian Rivers Institute, Griffith University, Brisbane.

Standley, P.M., 2011. Three Action Research Projects: (i) Traditional Knowledge Revival Pathways Fire Program, (ii) Kuku Thaypan Fire Management Research Project and (iii) the Importance of Campfires to Effective Conservation - Cape York Peninsula Australia. Project Summaries in Ecological Management & Restoration, http://site.emrprojectsummaries.org/summaries/page/3/.

Standley, P.M., 2016. Cape York Fire. Cape York Natural Resource Management, Atherton, Queensland, Australia.

Stephan, K. and Howley, C., 2009. Jack Lakes Wetlands Biodiversity Assessment, November 2007 & June 2008. CYMAG Environmental Inc., March 2009

Sweatman, H.P.A., Johns, K.A., Jonker, M.J., Miller, I.R. and Osborne, K., 2015. Final report on coral reef surveys in Torres Strait, Report to the National Environmental Research Program, Reef and Rainforest Research Centre Limited, Cairns.

The State of Queensland, 2013. Reef Water Quality Protection Plan "Reef Plan". Reef Water Quality Protection Plan Secretariat. July 2013.

Terrain NRM, 2015. Wet Tropics Water Quality Improvement Plan 2015-2020. Terrain NRM, Innisfail. http://www.terrain.org.au/Projects/Water-Quality-Improvement-Plan

Thomas, C. and Brodie, J., 2015. Environmental-economic values of marine and coastal natural assets, Cape York Peninsula NRM marine region, Great Barrier Reef. TropWATER Report 15/59, James Cook University, Townsville, Australia, 47 pp.



Thompson, A., Costello, P., Davidson, J., Schaffelke, B., Uthicke, S., Liddy, M., 2013. Reef Rescue Marine Monitoring Program: Report of AIMS Activities - Inshore coral reef monitoring 2012. Report for Great Barrier Reef Marine Park Authority. Australian Institute of Marine Science, Townsville. 120 pp.

Townsend, S.A., and Douglas, M.M., 2000. The effect of three fire regimes on stream water quality, water yield and export coefficients in a tropical savannah (northern Australia). Journal of Hydrology 229(3-4), 118-137.

Townsend, S.A., and Douglas, M.M., 2004. The effect of a wildfire on stream water quality and catchment water yield in a tropical savannah excluded from fire for 10 years (Kakadu National Park, North Australia). Water Research 38, 3051-3058.

TropWATER James Cook University, 2013. The seagrass habitat map used is comprised of a composite of the survey data up to 2010 (observed habitat). Seagrass spatial data files supplied by TropWATER James Cook University.

Valentine, P., 2006. Compiling a case for world heritage on Cape York Peninsula. James Cook University, Townsville. 80pp.

Waterhouse, J., Tracey, D., Brodie, J., Lewis, S., Coppo, C., McKenzie, L., da Silva, E., Devlin. M., Maynard, J., Heron, S., Petus, C., 2016. Assessment of the relative risk of water quality to ecosystems of the Cape York NRM Region, Great Barrier Reef. A report to South Cape York Catchments. TropWATER Report 16/xx, Townsville, Australia.

# APPENDICES

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| **Appendix 14** | Walking the Landscape Basin Summaries |
| **Appendix 15** | Grazing Implementation Strategy |
| **Appendix 16** | Agriculture Implementation Strategy |

Cape York Natural Resource Management

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