Great Barrier Reef
Water Science Taskforce

Current Situation Analysis–July 2015

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Summary

The Great Barrier Reef (GBR) is the world's largest coral reef system, comprising approximately 3000 reefs and extending over 2000 km along the Queensland coast. The GBR was proclaimed a Marine Park in 1975 and listed on the World Heritage Register in 1981.The contribution of the GBR to the Queensland and Australian economy is estimated to be close to $6 billion a year, generating over 69,000 jobs across the tourism, recreation, commercial fishing, scientific research and management industries (Deloitte Access Economics, 2013). Agriculture is a dominant land use in the catchments adjacent to the GBR, employing over 35,000 people and contributing approximately $3.7 billion annually in gross value of production (Australian Bureau of Statistics, 2014). Approximately 77% of the area of the GBR catchment is grazing land or native and improved pasture, with approximately 4% under cropping including sugar cane, horticulture and grains (Waters *et al.* 2014). The catchments are home to approximately 1.2 million people.

Poor water quality caused by land based run-off, climate change, coastal development and events such as cyclones and crown-of-thorns starfish outbreaks are the key threats to the GBR. As identified through Chapter 3 of the 2013 Scientific Consensus Statement (Brodie *et al.* 2013), the greatest water quality risks to the GBR are from nitrogen discharges which provide excess nutrients and are associated with crown-of-thorns starfish outbreaks, and fine sediment discharge which reduces the light available to seagrass ecosystems and inshore coral reefs. At smaller scales, particularly in coastal seagrass habitats and freshwater and estuarine wetlands, pesticides can pose a high risk. A large proportion of sediment losses is derived from grazing lands, and the dominant source of nitrogen and pesticides is from cropping, predominantly sugarcane (Waters *et al.* 2014). It has long been recognised that coral reef resilience to gradual pressures such as climate change depends strongly on locally manageable stressors such as water quality (Burke *et al.* 2011).

Both the Queensland and Australian governments have invested in numerous regional and whole-of-GBR management initiatives in recent years to protect and improve the condition of the GBR. The current level of investment is more than $200 million a year collectively (Department of Environment, 2015), and is used to implement on-ground initiatives, management, research and monitoring activities. Investment by local government is also significant and focuses on reducing discharges from urban areas. The Queensland and Australian governments have, in 2015, each announced an additional $100 million in GBR funding, to strengthen existing programs and invest in new initiatives. The release of the joint Australian and Queensland Government's Reef 2050 Long-Term Sustainability Plan (Department of Environment, 2015) in early 2015 provides an overarching framework for protecting and managing the GBR over the next decades.

Voluntary agriculture management schemes, regulations and market-based instruments have been used by governments at various times and in numerous locations within the GBR catchments to improve the GBR condition, particularly targeting improved water quality. Investment prioritisation tools and programs have been developed and used to direct strategic investment to maximise GBR outcomes. Actions targeted at restoring ecosystem health have had a reduced focus compared to changing agricultural management practice in recent years.

The GBR Report Card for 2012 and 2013 (Department of Premier and Cabinet, 2014) indicated that improvements have been made in farming practices which has translated into predicted reductions in long-term average annual pollutant loads. However, while progress has been made toward the 2013 targets under the Reef Water Quality Protection Plan 2009, the targets have not yet been met.

The Queensland Government has announced ambitious new water quality targets to achieve the current Reef Water Quality Protection Plan 2013 (Department of Premier and Cabinet, 2013) long-term goal that by 2020 the quality of water entering the lagoon from broadscale land use has no detrimental impact on the health and resilience of the GBR. The new targets are to reduce nitrogen concentrations in run-off by up to 80% in key catchments such as the Wet Tropics and the Burdekin by 2025, and to reduce total suspended sediment in run-off by up to 50% in key catchments such as the Wet Tropics and the Burdekin by 2025. These targets were included in the Reef 2050 Long Term Sustainability Plan. Table 1 summarises the evolution of GBR water quality targets over the last six years and how they were derived.

Nutrients such as nitrogen and phosphorus in run-off can be present in various forms and monitoring distinguishes each type. Currently the Queensland Government's target for nitrogen does not specify the form of nitrogen. Both dissolved and particulate forms of nutrients are important in driving ecological effects. The scientific consensus is that increased nitrogen inputs are more important than phosphorus (Furnas *et al.* 2013). Dissolved, inorganic forms of nitrogen and phosphorus are currently considered to be of greater concern than particulate or the dissolved organic forms as they readily support algal and plankton growth (Brodie *et al.* 2013).

Scientific studies by Wooldridge *et al.* (2006, 2015) and Brodie *et al.* (2014) recommended 50-90% reduction in dissolved inorganic nitrogen in Burdekin and Wet Tropic catchments to meet the GBR Water Quality Guidelines

(2010). Brodie *et al.* (2014) concluded that a 50% reduction in fine sediment load was required across the Wet Tropics region to maintain GBR health.

Table 1: The evolution of Great Barrier Reef water quality targets and how they were derived

	Nutrient	**Sediment**	**Pesticides**	**Basis of targets (best available at time)**
2009 *Reef Water Quality Protection Plan*	• By 2013 there will be a minimum 50% reduction in nitrogen and phosphorus loads at the end of catchments	• By 2020 there will be a minimum 20% reduction in sediment load at the end of catchments. • By 2013 there will be a minimum of 50% late dry season groundcover on dry tropical grazing land.	• By 2013 there will be a minimum 50% reduction in pesticides at the end of catchments	• Stretch targets based on initial WQIPs, available data and expert opinion
2013 *Reef Water Quality Protection Plan*	• At least a 50% reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas by 2018 • At least a 20% reduction in anthropogenic end-of-catch loads particulate nutrients in priority areas by 2018.	• At least a 20% reduction in anthropogenic end-of-catch loads of sediments in priority areas by 2018.	• At least a 60% reduction in end-of-catchment pesticide loads in priority areas by 2018	• Source Catchments modelling of best practice • Nitrogen changed to DIN • No phosphorus target
2015 *GBR Water Science Taskforce*	• Reduce nitrogen run-off by up to 80% in key catchments such as the Wet Tropics and the Burdekin by 2025	• Reduce total suspended sediment run-off by up to 50% in key catchments such as the Wet Tropics and the Burdekin by 2025.		• Source Catchments modelling of best practice • Ecologically based in some areas (Wet Tropics)

Recent assessments and catchment modelling scenarios revealed that even with full adoption of best practices across the grazing and cane industries, some Reef Water Quality Protection Plan targets are still unlikely to be met (Thorburn *et al.* 2013, Waters *et al.* 2013, 2014). The 50% dissolved inorganic nitrogen reduction target is particularly challenging. Universal adoption of current 'best practice' (B class - refer to section 8.2.1) practices have been predicted to result in a 27% reduction in dissolved inorganic nitrogen, and even 'cutting edge' ('A' class) practices are estimated to achieve 34% reduction (Waters *et al.* 2013). Both of these reductions fall well short of the target. This emphasises the need to consider options beyond current changes processes as only transformational change will enable the targets to be met.

The Queensland Government's new five year, $100 million commitment has been allocated predominantly towards improving GBR water quality and specifically addressing the Government's ambitious nitrogen and sediment targets. The Great Barrier Reef Water Science Taskforce, which consists of experts in science, industry, government and the community, has been convened to help determine the most effective forms of investment in order to achieve the Queensland Government's ambitious water quality targets. The following page provides a summary of the risks to the GBR, sources of pollution and the response by governments.

Great Barrier Reef
Water Science Taskforce

Risks to reef health

Deteriorating water quality caused by catchment run-off is recognised as the most immediate system wide risk to Great Barrier Reef condition.

Great Barrier Reef Outlook Report 2014–Pressures on the Reef

The overall outlook for the GBR is poor and has worsened over the last decade. Highest risks are 1) climate change, 2) land-based run-off 3) coastal land-use change and 4) some aspects of direct use (such as fishing, shipping and port activities).

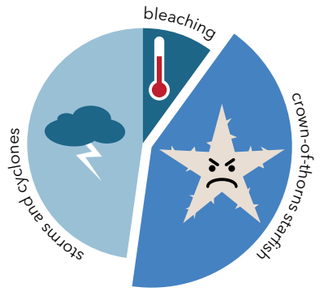
Water Quality Scientific Consensus Statement 2013

The greatest water quality risks to the GBR are from nitrogen discharge, associated with crown-of-thorns starfish outbreaks and their destructive effects on coral reefs, and fine sediment discharge which reduces the light available to seagrass ecosystems and inshore coral reefs. Pesticides pose a risk to freshwater and some inshore and coastal habitats.

Coral

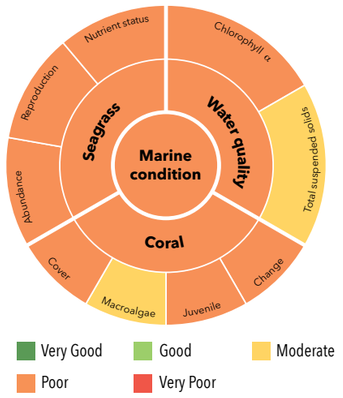
Major causes of coral loss on midshelf and offshore reefs:

- **48%** storms and cyclones
- **42%** crown-of-thorns starfish
- **10%** bleaching from ocean warming



source: Australian Institute of Marine Science

Great Barrier Reef marine condition 2013



Water quality relative risk assessment

A combination of qualitative and semi-quantitative assessments was used to estimate the relative risk of water quality constituents to Great Barrier Reef ecosystem health.

Region	Relative risk	Priority pollutants for management		
		Nitrogen	Pesticides	Sediment
Cape York	LOW			
Wet Tropics	VERY HIGH	VERY HIGH	HIGH	
Burdekin	HIGH	VERY HIGH*	VERY HIGH	VERY HIGH
Mackay Whitsundays	MODERATE	HIGH	VERY HIGH	
Fitzroy	HIGH		HIGH	VERY HIGH
Burnett Mary	UNCERTAIN**			HIGH

* Lower Burdekin and Haughton focus

** Most reefs and seagrass meadows in this region were not included formally in the analysis and therefore the validity of the result has high uncertainty.

Sources of pollution

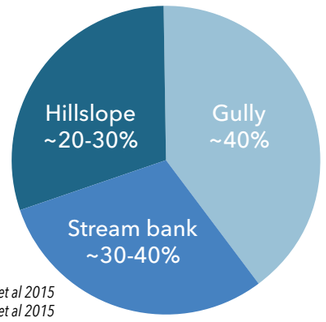
Water Quality Scientific Consensus Statement 2013

The main source of excess nutrients, fine sediments and pesticides from GBR catchments is diffuse source pollution from agriculture. Improved land and agricultural management practices are proven to reduce the runoff of suspended sediment, nutrients and pesticides at the paddock scale.

The main land uses contributing pollutant loads are rangeland grazing for sediment, rangeland grazing and sugarcane for total nitrogen and total phosphorus, and sugarcane for photosystem II inhibiting herbicides. The Wet Tropics, Burdekin and Fitzroy regions contribute most to these river pollutant loads.

Sediment

Grazing lands contribute 45% to the total suspended solids load with a further 39% from streambank erosion. A combination of gully and streambank erosion and subsoil erosion from hillslope rilling is the main erosion source.



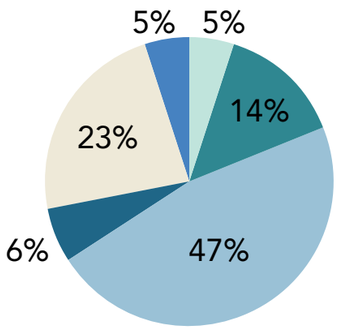
Bartley et al 2015
Wilkinson et al 2015

Nutrients

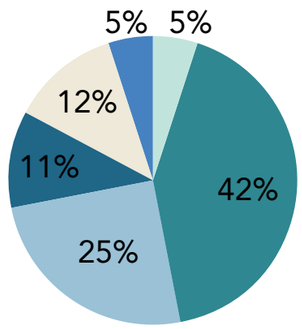
Grazing lands (40%) and sugarcane (31%) contribute mostly to the total nitrogen load. Grazing contributes particulate nitrogen, while cane contributes dissolved inorganic nitrogen.

Nitrogen, particularly dissolved inorganic nitrogen, from agricultural activities is linked to more frequent outbreaks of crown-of-thorns starfish.

Cape York | Wet Tropics | Burdekin | Mackay Whitsunday | Fitzroy | Burnett-Mary



Regional contribution (%) to total modelled anthropogenic baseline load for TSS

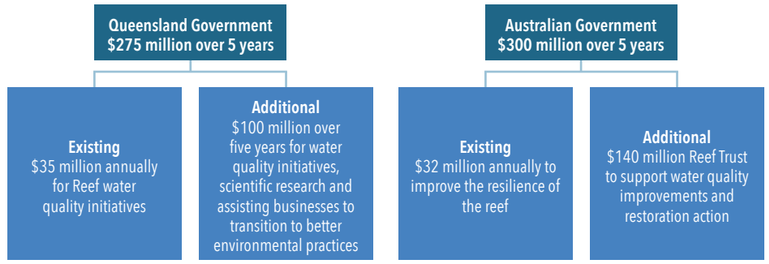


Regional contribution (%) to total modelled anthropogenic baseline load for DIN

Government response

Government investment will total **$2 billion over the next 10 years**

Water quality funding



Reef 2050 Long-Term Sustainability Plan

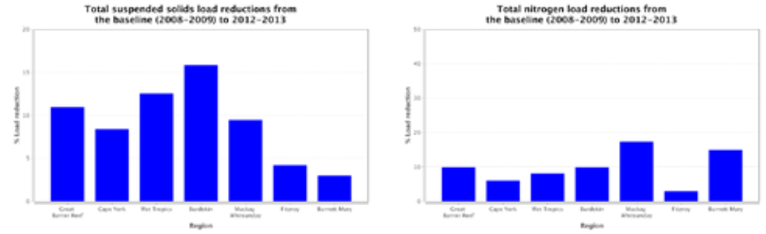
Vision: To ensure the Great Barrier Reef continues to improve on its Outstanding Universal Value every decade between now and 2050 to be a natural wonder for each successive generation to come.

Water quality outcome: Reef water quality sustains the Outstanding Universal Value, builds resilience and improves ecosystem health over each successive decade.

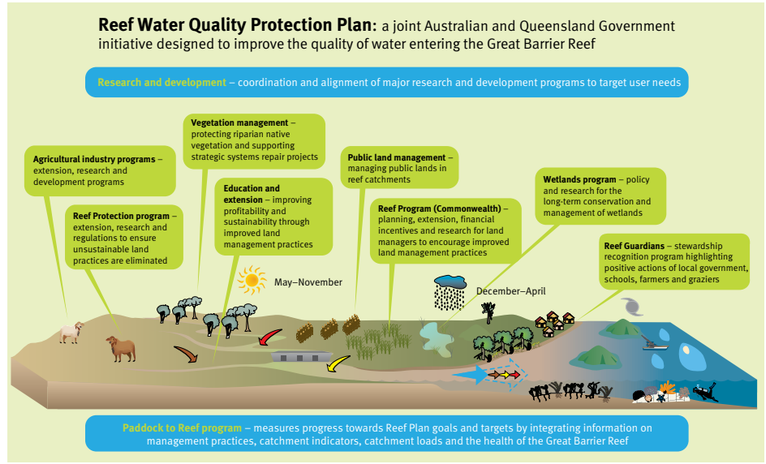
Queensland Government ambitious water quality targets by 2025

- Reducing nitrogen run-off by up to 80% in key catchments such as the Wet Tropics and the Burdekin by 2025
- Reducing total suspended sediment run-off by up to 50% in key catchments such as the Wet Tropics and the Burdekin by 2025.

Progress towards existing Reef Water Quality Protection Plan Targets



Key current Reef Water Quality Protection Plan programs



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1. Introduction

The Great Barrier Reef (GBR) is the world's largest coral reef system stretching some 2000 km along the Queensland coast, from Cape York in the north to the Wide Bay-Burnett region in the south. The GBR is an Australian and global icon, as a unique ecosystem which hosts one of the most diverse ranges of species on the planet. The GBR's importance was recognised by the World Heritage Committee in 1981 which listed it as a World Heritage property due to its "natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity." The catchments adjacent to the GBR are home to approximately 1.2 million people, with significant urban centres including Cairns, Townsville, Mackay, Rockhampton, Gladstone, Bundaberg, Hervey Bay and Maryborough. According to Deloitte Access Economics (2013) its contribution to the economy is significant, generating an estimated $6 billion annually and supporting over 60,000 jobs across various industries. The GBR is also a place of great significance to its Traditional Owners, who maintain a unique and continuing connection to the reef and adjacent coastal areas and to the populace of Queensland that use it for recreation, enjoyment or sustenance.

Despite its environmental, cultural and economic value, the GBR is faced with various threats to its long-term survival. Over the last century, the catchments adjacent to the GBR have undergone development for agricultural production, urban expansion, transport infrastructure, tourism and mining, while increased visitation, fishing and shipping has occurred within the GBR lagoon. Increased pollutants entering the lagoon from agricultural land use activities has been identified through the Great Barrier Reef Outlook Report 2014 (Great Barrier Reef Marine Park Authority, 2014) and the 2013 Scientific Consensus Statement (Brodie *et al.* 2013) as the key cause of deteriorating GBR water quality and a major issue that needs to be addressed.

Based on the most comprehensive time series data on coral reef condition (2,258 surveys of 214 reefs in mid and offshore areas over 1985–2012), De'ath *et al.* (2012) showed a major decline in coral cover of over 50% during the period. The three major drivers of decline included in this analysis were storms and cyclones, (48%), crown-of-thorns starfish (COTS), (42%), and coral bleaching (10%). Coral reefs go naturally through cycles of disturbance and recovery and the observed patterns were different between geographic regions. But the general trend over the last two decades was for reduced coral cover, juvenile corals and calcification of corals across the GBR (De'ath *et al.* 2009, Osborne *et al.* 2011, Thompson *et al.* 2014). Many recent studies (see high–level summaries in Burke *et al.* 2011, Schaffelke *et al.* 2013, Anthony *et al.* 2015 and Scheffer *et al.* 2015) have suggested that coral reef resilience to gradual threats such as climate change depends strongly on locally manageable stressors such as water quality. This was reinforced by De'ath *et al.* (2012) who suggested that in the absence of COTS (which have been linked with poor water quality), coral cover would increase by about 1% per year.

Inshore intertidal seagrass meadows along the GBR developed coast have been declining over the last three to five years and are currently in a poor condition, based on assessments of abundance, meadow size, reproductive effort and epiphyte load (Schaffelke *et al.* 2013, Grech *et al.* 2011, and Department of Premier and Cabinet, 2014). Light is the most critical variable affecting seagrass growth and survival. Pulses of suspended sediments from river runoff increase turbidity and this in turn reduces the levels of light reaching seagrass. As a consequence of the widespread loss of seagrass along the GBR coast in early 2011, stranding rates of turtles and dugong increased during that year which may have ongoing impacts for populations due to loss of reproductive animals (Schaffelke *et al.* 2013, and Great Barrier Reef Marine Park Authority, 2014). The ecosystem-level impacts of coastal development, including urban development, industrial and port operations are much less well understood than the effects of land runoff, but have been subject of recent reviews identifying important knowledge gaps (Grech *et al.* 2013, McCook *et al.* 2015 and Great Barrier Reef Marine Park Authority, 2014). However, the need to address these pressures has been explicitly included in the Reef 2050 Long Term Sustainability Plan (Reef 2050 Plan).

In June 2012, the World Heritage Committee expressed grave concern about the status of the GBR World Heritage Area and put Australia on notice that "World Heritage in Danger" listing was being considered. The World Heritage Committee noted a report from the UNESCO reactive monitoring mission (UNESCO, 2012) that visited Australia earlier that year, which recognised that Australia's management of the GBR World Heritage Area is in many respects international best practice, while also stressing the need for stronger action to reverse the GBR's declining condition.

In 2014, the World Heritage Committee stated that it would consider Australia's progress in 2015, "with a view to considering, in the case of confirmation of the ascertained or potential danger to its Outstanding Universal Value, the possible inscription of the property on the List of World Heritage in Danger." The World Heritage Committee requested that the Australian Government undertake a range of steps to ensure that the Outstanding Universal Value of the property is not compromised. One of the key components in response to the World Heritage Committee has been the development of the Reef 2050 Plan which was released on 21 March 2015 by the

Queensland and Australian Governments. In June 2015, UNESCO released its findings, recommending that the GBR not be placed on the "World Heritage in Danger" list but clearly requesting that all commitments under the Reef 2050 Plan be implemented with a progress report in 2016.

The protection and management of the GBR is a high priority for the Queensland Government, which committed to the following actions under the 'Saving the Great Barrier Reef' plan (Australian Labor Party, 2015).

- Convene a high-level taskforce to determine the best possible approach to achieve up to an 80% reduction in nitrogen run-off and up to 50% reduction in sediment run-off from key catchments into the Great Barrier Reef by 2025.
- Provide an additional $100 million over five years towards water quality initiatives, scientific research and helping businesses transition to better environmental practices in the primary production and fishing industries.
- Prohibit the sea-based disposal of capital dredge spoil within the GBR World Heritage Area.
- Reduce Queensland's carbon emissions by reintroducing nation-leading tree clearing laws.
- Reinstate world class coastal planning laws.
- Repeal the former government's water laws which have a detrimental effect on the GBR catchment systems and allow for over allocation of Queensland's precious water resources.
- Work with the Australian Government and the International Maritime Organisation to develop a new vessel class which will ensure bulk goods carriers travelling in the World Heritage Area meet stringent safety codes.
- Fight to ensure the Australian Government pays a fair share to help save the Great Barrier Reef.

The purpose of this document is to provide a current situation analysis for the GBR in terms of present scientific opinion, funding investments, management interventions and progress made towards existing water quality and land management targets.

2. Economics of the Great Barrier Reef

2.1. Tourism, recreation and research

According to Deloitte Access Economics (2013) the total Australia-wide value-added economic contribution generated in GBR in 2012 through tourist, recreational, commercial fishing and scientific research and management activity was $5.7 billion with employment of approximately 69,000 people.

This Australia-wide value-added economic contribution is driven by just over $7 billion expenditure in the region (Deloitte Access Economics, 2013). A large proportion of the value-added contribution and employment generated stems from the tourism industry, with almost $5.2 billion of value added, and approximately 64,000 jobs generated through the sector and over 18 million visitor nights each year (Deloitte Access Economics, 2013).

Recreation, which covers household recreational activity by those who live in the catchment area, contributed just over $240 million in value-added contributions and about 2800 jobs (Deloitte Access Economics, 2013). Table 2 below summarises the approximate economic contribution to Australia of these industries within the GBR.

Table 2: Economic contribution to Australia (source: Deloitte Access Economics, 2013)

	Direct expenditure ($ million)	Value-added contribution ($ million)	Employment positions
Tourism	6,410	5,180	64,300
Recreation	330	240	2,800
Commercial Fishing	190	160	1,000
Scientific research and management	110	100	900
Total	7,040	5,740	69,000

2.2. Agriculture

The beef, sugarcane and horticulture industries in the GBR catchments are a significant source of the region's employment and contribute approximately $4.5 billion annually in gross value of production according to the Australian Bureau of Statistics (2014).

2.2.1. Sugar cane

The Queensland cane industry is worth an estimated $1.7–$2 billion annually and produces 95% of Australia's sugar. The industry in Queensland directly provides 15,600 jobs and is the third largest raw sugar supplier in the world. Approximately 15% of employees in coastal Queensland are directly or indirectly involved in the cane industry (Australian Bureau of Statistics, 2014).

2.2.2. Grazing

The grazing industry within the GBR catchments has an annual gross production value of approximately $2.25 billion. Queensland produces nearly half of Australia's beef products, with the industry employing more than 20,000 people and an additional 8000 in meat processing. The Burdekin and Fitzroy catchments are the two prime Queensland grazing areas, with approximately 3800 graziers operating in the area covering over 24 million hectares (Australian Bureau of Statistics, 2014) which is approximately the same size as the United Kingdom.

2.3. Ecosystem accounting

The Australian Bureau of Statistics has developed an experimental ecosystem account for the GBR region. The account is consistent with the System of Environmental-Economic Accounting 2012–Experimental Ecosystem Accounting framework (Australian Bureau of Statistics, 2015) (SEEA–EEA), which was drafted by the United Nations, European Union and the World Bank. The framework will provide a common set of terms, concepts, classifications and an integrated accounting structure for measuring ecosystem services and condition, in both a physical and monetary terms. The potential value of this framework is acknowledged, however improvements to biophysical analysis and spatial economic scale may be needed to increase reliability. A preliminary evaluation of the economic value of the coastal and marine assets has also been completed in a number of the Water Quality Improvement Plans (WQIPs) (for example Thomas and Brodie 2014).

3. Current Great Barrier Reef science

Both the Australian and Queensland government have adopted an adaptive management approach informed by scientific evidence to manage the GBR. Summarised below are key scientific findings that underpin current interventions.

3.1. 2013 Scientific Consensus Statement

In support of the development of the Reef Water Quality Protection Plan 2013 (Department of Premier and Cabinet, 2013) a multidisciplinary group of scientists, with oversight from the Reef Water Quality Protection Plan Independent Science Panel, was established to review and synthesise the significant advances in scientific knowledge of water quality issues in the GBR and to reach consensus on the current understanding of the system. The resulting output is the 2013 Scientific Consensus Statement (Department of Premier and Cabinet, 2013). The overarching consensus was:

'Key Great Barrier Reef ecosystems are showing declining trends in condition due to continuing poor water quality, cumulative impacts of climate change and increasing intensity of extreme events.' Specifically:

- The decline of marine water quality associated with terrestrial runoff from the adjacent catchments is a major cause of the current poor state of many of the key marine ecosystems of the GBR.
- The greatest water quality risks to the GBR are from nitrogen discharge, leading to algal growth and organic enrichment, and associated crown-of-thorns starfish outbreaks and their destructive effects on coral reefs, and fine sediment discharge which reduces the light available to seagrass ecosystems and inshore coral reefs. Pesticides pose a risk to freshwater and some inshore and coastal habitats.
- Recent extreme weather—heavy rainfall, floods and tropical cyclones—coupled with catchment modification have severely impacted marine water quality and GBR ecosystems. Climate change is predicted to increase the intensity of extreme weather events.

- The main source of excess nutrients, fine sediments and pesticides from GBR catchments is diffuse source pollution from agriculture.

Improved land and agricultural management practices are proven to reduce the runoff of suspended sediment, nutrients and pesticides at the paddock scale. Note that although it was not mentioned in the primary conclusions, the identification of groundwater as a potential source of dissolved nutrients to the GBR lagoon has also been recognised as being important (Hunter, 2012).

The Scientific Consensus Statement summarised and highlighted regional variations which are important for defining and prioritising management needs.

For example, it was concluded that overall, nitrogen poses the greatest risk of pollution to coral reefs from catchments between the Daintree and Burdekin rivers, and is associated with outbreak cycles of crown-of-thorns starfish. The risk to seagrass and inshore reefs from suspended sediment discharge is greatest in the Burdekin and Fitzroy regions. At smaller scales, particularly in coastal seagrass and wetland habitats, pesticides can pose a high risk. Based on preliminary findings, the Mackay Whitsunday and Burdekin regions are considered to be at highest risk based on the assessment of six commonly used photosystem II inhibiting herbicides.

The ranking of relative risk of degraded water quality between the GBR regions is the following (from highest to lowest) (Brodie *et al.* 2013):

1. Wet Tropics
2. Fitzroy
3. Burdekin
4. Mackay Whitsunday
5. Burnett Mary
6. Cape York

Figure 1 shows the dominant land uses and priority pollutants and results of the overall relative risk ranking in each GBR region.

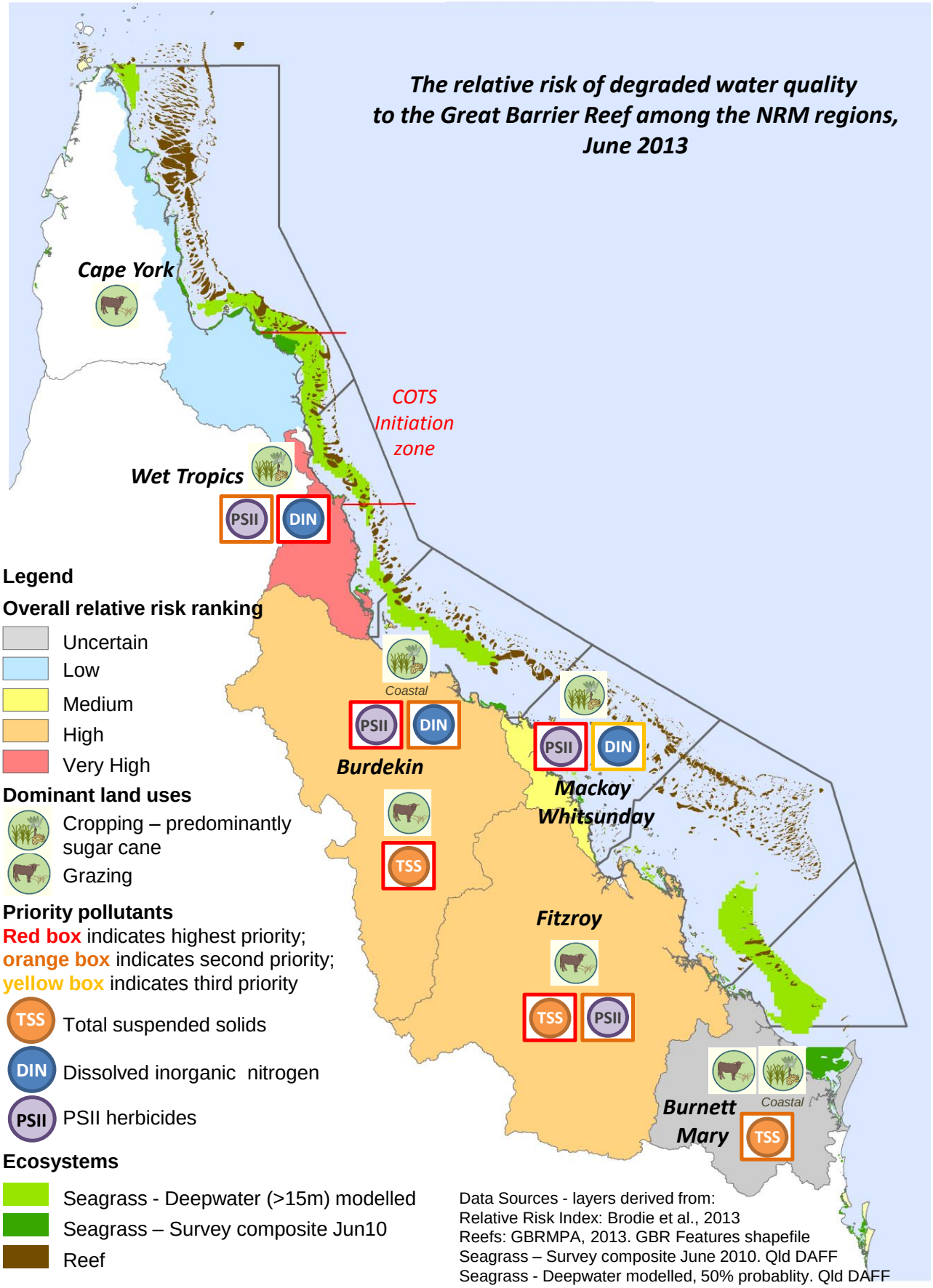


Figure 1: Illustration of the overall outcomes of the assessment of the relative risk of degraded water quality to Great Barrier Reef coral reefs and seagrass (source: Brodie *et al.* 2013, Scientific Consensus Statement – Chapter 3).

3.2. Reef Water Quality Protection Plan Research, Development and Innovation (RDI) Strategy 2013–2018

The Reef Water Quality Protection Plan RDI Strategy (Department of Premier and Cabinet, 2014) covers biophysical and socio-economic research, development and innovation related to the effects of broadscale land use on water quality and reef health. The strategy includes the contemporary priorities for research, development and innovation which have been identified in close consultation with Reef Water Quality Protection Plan partners. No specific funding is currently allocated towards implementing this strategy.

3.3. Great Barrier Reef Outlook Report 2014

Every five years, the Great Barrier Reef Marine Park Authority (GBRMPA) prepares an outlook report for the GBR (Great Barrier Reef Marine Park Authority, 2014). Underpinned by the best available scientific information, the report provides an independent assessment of the health, condition, use, management arrangements and long-term outlook for the GBR. The 2014 outlook report concludes:

> "The system as a whole retains the qualities contributing to its Outstanding Universal Value as recognised in its listing as a world heritage property. The assessments of biodiversity and ecosystem health show that the northern third of the Great Barrier Reef Region has good water quality and its ecosystem is in good condition. In contrast, key habitats, species and ecosystem processes in central and southern inshore areas have continued to deteriorate from the cumulative effects of impacts."
>
> "Notwithstanding positive actions since 2009, the greatest risks to the Great Barrier Reef have not changed. Climate change, poor water quality from land-based run-off, impacts from coastal development, and some remaining impacts of fishing remain the major threats to the future vitality of the Great Barrier Reef."

The outlook report assessed the risk of current and potential threats to the GBR as follows.

- Climate change causing sea temperature increases, altered weather patterns, ocean acidification and sea level rise were identified as long-term, system-wide risks.
- Land-based run-off including nutrients, sediments and pesticide runoff caused by agriculture as well as marine debris were recognised as immediate, system-wide risks.
- An immediate, local or regional risk from coastal land use change such as clearing and modifying coastal habitats and artificial barriers to flow. Coastal development influences the Region through both the legacy of past development actions, such as broadscale clearing of catchment habitats for agriculture and smaller scale current and future actions for agricultural, urban, industrial and island development.
- Another immediate, local or regional risk is direct use including illegal fishing, collecting and poaching, incidental catch of species of conservation concern, retained take of predators, disposal and resuspension of dredge material, and retained take from unidentified or unprotected spawning aggregations.

An independent assessment of management effectiveness undertaken for this report recognised the difficulties in achieving positive outcomes, given the complexity of the high-risk issues, the geographic extent and the time scales of the threats and the diminishing resource base to implement actions.

3.4. Great Barrier Reef Region Strategic Assessment 2012–14

A comprehensive strategic assessment of the GBR World Heritage Area and adjacent coastal zones was undertaken by the Australian and Queensland governments between 2012 and 2014 (Great Barrier Reef Marine Park Authority, 2014). The Great Barrier Reef Strategic Assessment examined the values of the GBR, threats to those values from cumulative pressures on coastal development and ports as well as land runoff, and actions required to protect them. The process was conducted under Part 10 of the *Environment Protection and Biodiversity Conservation Act 1999* to form part of the Australian Government's response to the World Heritage Committee's concerns about development impacts on the World Heritage Area. The assessment was separated into the marine and adjacent coastal environments with the outcomes informing the development of the Reef 2050 Plan.

The assessment found that a number of natural processes vital to the healthy functioning of the marine environment, such as sedimentation, nutrient cycling and connectivity, are in decline, particularly in central and southern inshore areas. Overall the assessment found the outstanding universal value of the GBR World Heritage Area remains largely intact and the GBR remains one of the most resilient tropical marine ecosystems in the world. However, the accumulation of impacts through time and over an ever-increasing area is diminishing the GBR's health. The assessment concluded the health of the GBR is likely to continue to decline, particularly inshore in

central and southern areas, and management is not keeping pace with the impacts that are acting on the system. Without additional management intervention, there is a risk of further declines in the condition of biodiversity and heritage values and the community benefits they support.

3.5. Synthesis of National Environmental Research Program (NERP) Tropical Ecosystem Hub GBR Water Quality Research Outputs 2011-14

The National Environmental Research Program (NERP) funded water quality research under the Tropical Ecosystem Hub to address issues of concern for the management, conservation and sustainable use of the GBR and its catchments. NERP research projects investigated water quality and climate effects on the GBR, correlations between river flow and GBR turbidity and the link between seagrass loss and flood plume conditions, pesticides and fine sediments and their potential impacts on GBR ecosystems, cumulative impacts on coral and seagrass communities, long-term historical records of change in the GBR and revised spatially complex risk assessments of terrestrial inputs and coastal development. A final synthesis report is available that outlines the key findings of the program.

3.6. Reef Water Quality Protection Plan Reef Report Cards

An annual report card is produced by the Queensland and Australian Governments which measures progress towards Reef Water Quality Protection Plan's (Department of Premier, 2013) goals and targets. The information in these reports determines the success of the Reef Water Quality Protection Plan and identifies whether further measures need to be taken to address water quality in the GBR. Overall these reports indicate improvements in water quality from agricultural runoff but at a rate that is insufficient to meet Reef Water Quality Protection Plan's goals and targets. For further information on the Report Cards and the Paddock to Reef Monitoring, Modelling and Reporting Program please refer to Section 9.

3.7. Supporting studies for the Water Quality Improvement Plans

By the end of 2015, all of the GBR Natural Resource Management (NRM) regions will have developed or updated their Water Quality Improvement Plans (WQIPs). To support these processes, a number of studies have been commissioned to collate, analyse and synthesise current knowledge relevant to the plans. Examples of these studies include: assessment of the status and values of freshwater, coastal and marine values including ecosystem services and economic values of the marine regions, development of regional, end-of–catchment, load targets (Reef Water Quality Protection Plan and ecologically relevant), synthesis of management practice options and associated costs, assessment of the relative risk of degraded water quality on coral reefs and seagrass, spatial prioritisation of management options, and in some regions, cost benefit analysis of the actions required to meet the targets. While the scope of these studies varies to some degree among regions, there has been some effort to achieve consistency where possible. The final reports are available online for the Wet Tropics and Burnett Mary studies; others are still in preparation. The full suite of technical reports will provide a comprehensive resource of regionally specific information to guide GBR water quality management in conjunction with the actual WQIPs.

3.8. Relevant ongoing research initiatives

Research into water quality is funded by a number of dedicated programs. These programs work together to foster collaboration between researchers and develop integrated outputs that meet the needs of users. Key programs include:

- The Australian Government National Environmental Science Program (NESP) Tropical Water Quality Hub which aims to provide innovative research for practical solutions to maintain and improve tropical water quality from catchment to coast. The Hub is administered by the Reef and Rainforest Research Centre (RRRC), and is predominantly interested in water quality related issues in fresh, estuarine and marine waters, although most funding will be allocated to projects that occur in marine waters or those with relevance to marine waters (e.g. managing catchment run-off). The geographic area of interest is limited to the GBR region and its contributing catchments as well as the Torres Strait.
- The Great Barrier Reef Foundation which develops and coordinates a range of reef research initiatives, including the eReefs project which will produce powerful catchment to reef visualisation, communication and reporting tools.
- Research and Development Corporations which provide funding to improve the productivity and sustainability of Australia's agricultural, fish and forestry industries including:
    - Sugar Research Australia

    - Meat and Livestock Australia
    - Horticulture Innovation Australia
    - Dairy Australia
- Queensland Wetlands Program which supports projects that will result in long-term benefits to the wise use, management, conservation and protection of Queensland's wetlands including those in catchments of the GBR.

4. Current policies, plans and partnerships

The Australian and Queensland governments are committed to working together to protect the GBR. This commitment is captured in the Great Barrier Reef Intergovernmental Agreement 2009, signed by the Prime Minister and Queensland Premier in June 2009, which provides a framework for the management of the GBR split between the two levels of government. The 2009 Intergovernmental Agreement replaces a 1979 agreement—The Emerald Agreement, recognising contemporary challenges such as climate change and catchment water quality that had not been foreseen. Schedules, recording detailed commitments of governments, may be added to the agreement from time to time. The schedules currently appended are:

A. The Great Barrier Reef Region and World Heritage Area.
B. Protocols for the Operation of the Great Barrier Reef Ministerial Forum.
C. Joint Field Management Program for the Great Barrier Reef Marine Park and Queensland national and marine parks within the Great Barrier Reef World Heritage Area.
D. Climate Change and the Great Barrier Reef.
E. Fishing and Collection of Fisheries Resources in the Great Barrier Reef World Heritage Area.
F. Reef Water Quality Protection Plan 2013.

Currently there are numerous GBR wide and regional policies, plans and partnerships designed to address specific issues and provide direction towards achieving nominated targets.

4.1. Reef-wide

4.1.1. Reef 2050 Long-Term Sustainability Plan

The Reef 2050 Long-Term Sustainability Plan (Reef 2050 Plan) (Department of Environment, 2015) is the Australian and Queensland government's overarching framework for protecting and managing the GBR from 2015 to 2050, and is a key component of the Australian Government's response to the recommendations of the UNESCO World Heritage Committee. The Reef 2050 Plan addresses the findings of the Great Barrier Reef Marine Park Authority's Outlook Report 2014 and builds on the strategic environmental assessment of the World Heritage Area and adjacent coastal zone completed in 2014.

The overarching vision of the Reef 2050 Long-Term Sustainability Plan is "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 identifies the biggest long-term threat as climate change, and notes that global action is needed to respond to this. Developing ecosystem resilience in the face of a variable and changing climate is a key principle of the plan, and by improving water quality, maintaining biodiversity, and ensuring port development and shipping has minimal impact on the GBR, the Reef 2050 Plan is building the GBR's resilience and targeting activities over which governments and other stakeholders have control.

The Plan outlines ambitious targets and actions across the following seven key areas:

1. biodiversity,
2. ecosystem health,
3. water quality,
4. heritage,
5. community benefits,
6. economic benefits
7. and governance

Driven through the Reef 2050 Plan, the following improvements in GBR management are anticipated to occur.

- Tightening controls on port development in the World Heritage Area.
- Banning the disposal of dredge material across the entire World Heritage Area.

- Protecting greenfield areas by restricting new port development in and adjoining the Great Barrier Reef World Heritage Area to within current port limits (these port limits are long-established and fixed in regulations under the Queensland *Transport Infrastructure Act 1994*).
- Further reducing sediment, nitrogen and pesticides running into the Reef lagoon by working with land managers to put in place accredited best management farm practices.
- Building the capacity for local government and industry to improve water quality management in urban areas.
- Strengthening engagement with Traditional Owners in the management of the Great Barrier Reef.
- Improving the ecological sustainability of fishing in the Reef, including reviewing the regulatory structure of fishing, establishing new net-free zones and enhancing compliance with regulations.
- Building on existing safeguards for shipping management, including a focus on pilotage requirements and consideration of a new vessel class and strengthening port control inspections.
- Strengthening protection of natural wetlands and riparian vegetation.

The Reef 2050 Plan aims to protect the Reef's Outstanding Universal Value with more than a hundred major actions to support dozens of targets, across the seven themes. The water quality targets include:

- improving water quality by reducing dissolved inorganic nitrogen loads in priority areas by at least 50% by 2018, on the way to achieving an 80% reduction in nitrogen by 2025, and;
- reducing pesticide loads by at least 60% in priority areas by 2018.

The Reef 2050 Plan builds on existing targets such as those in the Reef Water Quality Protection Plan 2013. The Reef 2050 Plan brings together program and project-level efforts to ensure a coordinated and efficient approach to address threats to the GBR and its catchments. The Australian and Queensland governments will ensure that sufficient financial and other resources are available to implement the Reef 2050 Plan and achieve outcomes. The Queensland Government election commitments align with the Reef 2050 Plan and will strengthen its delivery. Figure 2 below demonstrates the governance arrangements for the Reef 2050 Plan.

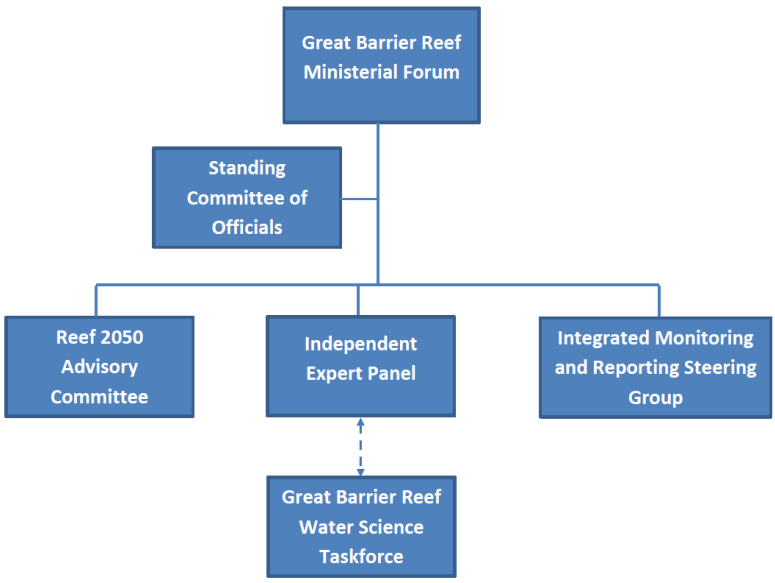


Figure 2: Reef 2050 Long-Term Sustainability Plan governance

4.1.2. Reef Water Quality Protection Plan 2013

The Reef Water Quality Protection Plan 2013 (Department of Premier and Cabinet, 2013) is a joint commitment between the Australian and Queensland governments designed to improve the quality of water in the GBR. The plan builds on the 2003 and 2009 Reef Water Quality Protection Plans and identifies actions that will help minimise the risk to the GBR from declining water quality entering the lagoon from adjacent catchments, including improving land management to reduce non-point source pollution. The Reef Water Quality Protection Plan sets ambitious targets for improved water quality and land management, and identifies actions to improve the quality of water entering the GBR. Annual report cards are produced measuring success against the targets through the Paddock to Reef Monitoring, Modelling and Reporting Program. The Reef Water Quality Protection Plan is a significant part

of the overall strategy of both governments to protect and preserve the GBR. It incorporates and supports the actions of industry, community groups and government that impact on the health of the GBR and links with a number of other legislative and planning initiatives.

4.1.3. Reef Trust

In September 2013 the Australian Government announced the development of the Reef Trust. The aim of the Reef Trust is to improve the health and resilience of the GBR through pooling and strategically allocating resources, leveraging existing on-ground activities and establishing innovative partnerships. The Reef Trust is jointly coordinated between the Australian and Queensland governments, with advice from the Australian Institute of Marine Science (AIMS) and other experts. The Reef Trust is one of the key mechanisms to assist in the delivery of the Reef 2050 Plan, and focuses on known critical areas for investment. The Reef Trust is underpinned by an investment strategy (Department of Environment, 2014), with the Australian Government funding the various investments. The initial investment stage of the Reef Trust which commenced in 2014 has focused on projects delivering on the following.

- Erosion control in priority grazing regions.
- Improving fertiliser efficiency on sugar cane farms in the Wet Tropics.
- Increasing protection of dugongs and marine turtles.
- Controlling crown-of-thorns on high value tourist reefs.

The second phase of Reef Trust investments, which was announced in early 2015, includes projects which address the following issues.

- Gully erosion in priority grazing areas.
- Nutrient runoff in the Burdekin region.
- Controlling crown-of-thorns starfish.

Over time the Reef Trust will evolve to increase its investment capacity by incorporating alternative resourcing mechanisms, such as private investment through business, industry and community partners, as well as Queensland and Australian Government GBR-related offsets.

4.1.4. Great Barrier Reef Marine Park zoning plans of management

The Great Barrier Reef Marine Park is a multiple-use area. The Great Barrier Reef Marine Park Zoning Plan 2003 provides for a range of ecologically sustainable recreational, commercial and research opportunities and for the continuation of traditional activities. Zoning is designed to manage cumulative impacts on the GBR in addition to water quality, and helps to manage and protect the values of the marine park that people enjoy. Each zone has different rules for the activities that are allowed, the activities that are prohibited, and the activities that require a permit. Zones may also place restrictions on how some activities are conducted.

Plans of management are generally prepared for intensively used, or particularly vulnerable groups of islands and reefs, and for the protection of vulnerable species or ecological communities. Plans of management complement zoning by addressing issues specific to an area, species or community in greater detail than can be accomplished by the broader reef-wide zoning plans. There are currently four plans of management within the Great Barrier Reef Marine Park, namely the:

- Cairns Area Plan of Management,
- Hinchinbrook Plan of Management,
- Shoalwater Bay (Dugong) Plan of Management, and;
- Whitsunday Plan of Management

Early indications are that zoning is having a positive impact on fish numbers, with fish numbers and average fish size increasing (McCook *et al.* 2010, and Emslie *et al*. 2015).

4.1.5. Queensland marine park zoning plans

The Queensland Government establishes marine parks over tidal lands and waters to protect and conserve the values of the natural marine environment while allowing for its sustainable use. They protect habitats including mangrove wetlands, seagrass beds, mudflats, sandbanks, beaches, rocky outcrops and fringing reefs. The principal way of managing marine parks is to develop a zoning plan which clearly identifies the different zones within the park. The Marine Park Regulation 2006 or the relevant zoning plan usually state the objectives for each zone and list the activities that are:

- Unrestricted,
- allowed with a permit, and;
- prohibited.

A zoning plan may also designate specific locations where special management rules apply. Different levels of protection apply in different zones. Information guides use coloured areas on maps to indicate different zones, and tables to indicate what activities are/are not permitted in each zone. As subordinate legislation, zoning plans are legally enforceable, and penalties apply for breaches. Marine park zoning plans are in place for the GBR coast and the Great Sandy region.

4.1.6. Declared fish habitat areas

Queensland Government's declared fish habitat area (FHA) network provides long-term protection for fish habitats that are essential to sustaining the state's fisheries. FHAs are areas protected from physical disturbance associated with coastal development and declared under *Queensland's Fisheries Act 1994* and are designed to address local cumulative impacts to the GBR in addition to water quality. They are part of Australia's Nationally Representative System of Marine Protected Areas, and fit within the International Union for the Conservation of Nature and Natural Resources (IUCN) Protected Area Management Category VI – 'Managed Resource Protected Area'. Declaration of FHAs aims to ensure fishing for the future by protecting selected inshore and estuarine fish habitats to sustain local and regional fisheries. All habitat types (e.g. vegetation, sand bars and rocky headlands) within a declared FHA are equally protected from direct physical disturbance and coastal development. There are 70 declared FHAs along the Queensland coast including a large number within the GBR region.

4.2. Regional

4.2.1. Regional Natural Resource Management Bodies

There are 56 regional Natural Resource Management (NRM) bodies located throughout Australia, 14 of which are located within Queensland. Largely community-based, Queensland's regional NRM bodies provide an important link between governments and communities. They also work collaboratively with volunteer and grass-roots organisations (e.g. Landcare), rural industry groups and landholders. Projects funded through regional NRM bodies focus on on-ground activities that protect, improve and restore waterways and rangelands by addressing weeds and pests, and improving soil, vegetation and water quality at a river catchment or other landscape level.

Regional NRM bodies located in GBR catchments are key delivery agents for Australian and Queensland Government GBR programs. They are also responsible for coordinating regional initiatives with GBR water quality benefits, including regional report card partnerships and WQIPs. The six regional NRM bodies located in GBR catchments are:

- Cape York Natural Resource Management (Cape York),
- Terrain NRM (Wet Tropics),
- NQ Dry Tropics (Burdekin),
- Reef Catchment (Mackay Whitsunday),
- Fitzroy Basin Association (Fitzroy), and
- Burnett Mary Regional Group (Burnett Mary).

4.2.2. Mackay Whitsunday Healthy Rivers to Reef Partnership

The Mackay Whitsunday Healthy Rivers to Reef Partnership, launched on 1 October 2014, consists of 28 partners from community, industry, science, tourism, agriculture and government. The geographic area of the Partnership covers the Don, O'Connell, Proserpine, Pioneer and Plane basins, the urban area of Mackay, the ports of Abbot Point, Mackay and Hay Point, marinas, and the coastal marine area. The partnership is hosted by the Reef Catchments and NQ Dry Tropics regional bodies and supported by the Queensland, and local governments and industry associations and companies. The Mackay Whitsunday report card takes a nested approach to reporting and will align and integrate a range of regional monitoring programs. The partnership is also seeking to take a whole of catchment approach to planning and integrate management approaches across organisations (e.g. WQIP, Reef Water Quality Protection Plan and the Reef 2050 Plan and other activities of partners that can help improve waterway health). The partnership draws on existing programs and collaborations where possible to ensure as much consistency across Queensland report cards and utilises the Reef Water Quality Protection Plan Independent Science Panel to ensure scientific rigour.

4.2.3. Gladstone Healthy Harbour Partnership

The Gladstone Healthy Harbour Partnership (GHHP) is a forum to bring together parties (including community, industry, science, government, statutory bodies, and management) to maintain, and where necessary, improve the health of Gladstone Harbour. The partnership is hosted by the Fitzroy Basin Association and supported by the Queensland, and local governments and industry associations and companies. The GHHP is informed by open, transparent and independent peer-reviewed science, through an independent science panel. The panel brings together key experts to take a strategic approach towards an integrated research and monitoring program for the Gladstone Healthy Harbour Report Card. The report card informs the management of the harbour and its surrounds in order to achieve the vision set by the GHHP. The pilot report card was released in December 2014 with the first full report card to be released by December 2015.

4.2.4. Fitzroy Partnership for River Health

The Fitzroy Partnership for River Health was established following the flooding of Ensham mine during the 2008–09 wet season. Reports prepared in response to this event pointed to the benefits from an integrated monitoring and reporting system for water quality in the Fitzroy Basin. The partnership is hosted by the Fitzroy Basin Association and supported by the Queensland, and local governments and industry associations and companies. The first completely integrated waterway health report card for the Fitzroy Basin, covering the 2010–11 year was released in May 2013. The third report card covering the 2012–13 year was released in December 2014.

4.2.5. Water quality improvement plans

Water quality improvement plans (WQIPs) were initially developed as a part of the Australian Government's former Coastal Catchments Initiative, and have more recently been developed or updated as a part of the Australian Government's Reef Programme.

A WQIP is designed to identify the main issues impacting waterways and the coastal and marine environments from land-based activities, and to identify and prioritise management actions that will halt or reverse the trend of declining water quality within a NRM region. More specifically, the WQIPs provide a framework to:

1. Describe the current state of water quality and identify water quality issues in the region.
2. Identify the priority water quality and ecosystem health issues for the region, in terms of:
    - current water quality values highlighting those that are in decline or threatened, and key pollutant drivers, spatially and by sector;
    - desired water quality environmental and use values that the community aspires to protect/enhance;
3. Estimate the implications and costs of intervention options (including status quo) based on least cost risk abatement:
    - identify key pollutants to be reduced and key sources (sectoral and practices);
    - estimate annualised 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. nutrient, TSS, pesticide).

4. Define regional end-of-catchment pollutant reduction targets to maintain the coastal and marine values of the region.
5. 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.
6. Estimate and clearly document the effectiveness of current management interventions.
7. Develop and compare abatement costs for intervention options to protect desired values.
8. 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 in water quality issues in the region for the next 5 to 10 years. Strategies for long term planning consistent with the Reef 2050 Plan are also incorporated.
9. 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 the least cost interventions.

WQIPs are an important component of the Reef Water Quality Protection Plan, addressing key GBR water quality issues on a regional scale. Each of the NRM regions along the GBR coast has WQIPS at varying stages of development. Table 3 below summarises the status of WQIPs in each of the NRM regions as of June 2015.

Table 3: Status of water quality improvement plans in the Great Barrier Reef regions

Region	Status of WQIPs
Cape York	Plan for eastern catchments of Cape York (Jacky Jacky, Olive-Pascoe, Lockhart, Stewart, Normanby, Jeannie, Endeavour and Annan Rivers) – draft expected to be developed by the end of 2015.
Wet Tropics	Plan has consolidated and updated 3 previous catchment based WQIPs (Douglas, Barron and Tully) into a regional WQIP – final version expected to be available July 2015.
Burdekin Dry Tropics	Update to existing WQIP for region's rural catchments (Belyando, Bowen Broken Bogie, Cape Campaspe, Lower Burdekin, Suttor and Upper Burdekin) – draft expected to be developed by the end of 2015. The existing WQIP for region's urban catchments (Black and Ross) is not being revised, however, a whole of region approach is being adopted for the underpinning scientific studies.
Mackay Whitsunday	Update to existing regional WQIP which includes the Pioneer, O'Connell, Plan and Proserpine catchments – currently out for public consultation; final version expected to be available by the end of 2015.
Fitzroy Basin	Plan for the Fitzroy and Coastal catchments (Styx, Shoalwater, Waterpark Creek, Boyne and Calliope) – draft expected to be developed by the end of 2015.
Burnett Mary	Plan has consolidated and updated 3 previous catchment based WQIPs (Burnett-Baffle, Burrum and Mary) into a regional WQIP – final version is available online.

An urban water management plan has been developed to minimise the impact of stormwater from urban areas on the GBR. A regional collaboration, the project was managed by Healthy Waterways with the Reef Urban Stormwater Management Improvement Group (RUSMIG), which represented key urban stakeholders in the GBR catchment, to provide guidance throughout the process. Through this project several resources were developed including a generic WQIP framework for urban areas.

5. Targets and management goals

5.1. Background on targets

Water quality targets have been an important part of the framework for driving GBR water quality improvement over the last decade. There have also been a number of regional research projects (e.g. in the Wet Tropics, Wooldridge *et al.* 2006, Brodie *et al.* 2014) that have attempted to link end-of-catchment loads to marine water quality, and in particular, estimate the load reduction required to achieve marine water quality guidelines. These projects have informed the Queensland Government's new targets.

As part of its election commitments for the GBR, the Queensland Government set the following ambitious targets:

- Reducing nitrogen run-off by up to 80% in key catchments such as the Wet Tropics and the Burdekin by 2025
- Reducing total suspended sediment run-off by up to 50% in key catchments such as the Wet Tropics and the Burdekin by 2025.

These targets are designed to reverse the declining condition of the GBR and direct efforts towards achieving the Reef Water Quality Protection Plan's long-term goal to ensure that by 2020 the quality of water entering the lagoon from broadscale land use has no detrimental impact on the health and resilience of the GBR (i.e. water quality guidelines for relevant parameters will be met).

These targets have been adopted in the Reef 2050 Plan, released in March 2015 by the Queensland and Australian Governments.

The Queensland Government's targets exceed the Reef Water Quality Protection Plan 2013 targets for 2018 which include:

- at least a 50% reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas, and
- at least a 20% reduction in anthropogenic end-of-catch loads of sediments and particulate nutrients in priority areas.

The Reef Water Quality Protection Plan also includes a pesticide target:

- to reduce end-of-catchment pesticide loads by 60% by 2018,

The Queensland Government's election commitment does not include a pesticide target.

The Reef Water Quality Protection Plan 2013 targets built on the Reef Water Quality Protection Plan 2009 targets, which were primarily drawn from regional WQIPs, as well as other best available data, information and expert opinion at the time. In reviewing the Reef Water Quality Protection Plan 2009, the objective was to develop a suite of integrated targets which would meet the 2020 goal. A suite of science activities informed the development of the Reef Water Quality Protection Plan 2013 and its targets, including:

- an updated Scientific Consensus Statement,
- an assessment of the relative risk of degraded water quality on coral reef and seagrass ecosystems, and;
- catchment modelling of different practice change scenarios.

Modelling of management practice scenarios conducted by Waters *et al.* (2013) indicated that some of the Reef Water Quality Protection Plan 2013 targets for sediment and pesticides could be achieved if industry was operating at best practice. However, the scenario modelling indicated that best practice would not deliver the targets set for nitrogen. Catchment loads of particulate and organic forms of nitrogen and phosphorus are greater than those of dissolved nutrients (Waters *et al.* 2014). These nutrient forms eventually become bioavailable, but the rates at which this happens is unknown and which is a significant knowledge gap. The Reef Water Quality Protection Plan 2013 clearly states:

"Based on the latest information drawn from new catchment modelling, the Reef Plan 2013 goals and targets have been refined. Reef Plan targets are now linked to the load reductions expected using best practice land management. The exception is the nutrient target (remaining at 50%) which will be difficult to meet even using best practice. It will require new thinking and approaches to deliver substantial nutrient reduction in the Wet Tropics and Burdekin regions."

The Reef Water Quality Protection Plan 2013 also outlines the desire to continually improve targets to ensure they are based on best-available information and will help ensure reef water quality guidelines are met (Figure 3).

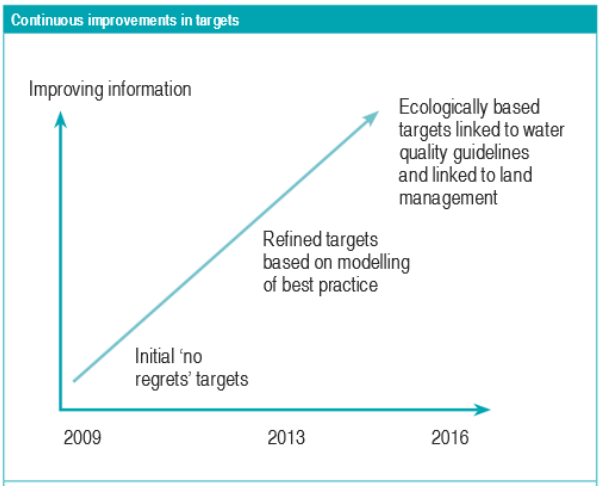


Figure 3: Continuous improvement of Reef Water Quality Protection Plan targets

5.2. Policy Context

The National Water Quality Management Strategy (NWQMS) outlines a consistent process for water quality planning and is implemented in all states through their environmental protection policies.

Queensland has in place the Environmental Protection (Water) Policy 2009 (EPP Water), which commenced in 2009. It sets out a framework that includes:

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

The processes to identify EVs and to determine WQGs and WQOs are based on the National Water Quality Management Strategy (NWQMS, 2000), Implementation Guidelines (1998) and further outlined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000).

This component of the planning process is based on using best available information to set water quality objectives (WQOs) to protect the community's values and uses for their waterways (e.g. the reef ecosystems and recreational uses). For the GBR, the Great Barrier Reef Marine Park Authority (GBRMPA) water quality guidelines have the best available information for chlorophyll *a* (a eutrophication health indicator and an indicator of nutrient runoff), sediments and pesticides. The challenge is to determine reductions in the catchment loads for these parameters that will result in the WQOs being met in the GBR lagoon. As shown in the graphic below (Figure 4), catchment models can be used to estimate current and possible future loads, and marine water models can be used to simulate the movement and transformations of these pollutant loads in the GBR lagoon and predict resultant water quality concentrations (for comparison with WQOs). Catchment models are available for the GBR catchments and a GBR marine water model is being developed by the eReefs project which is due for completion by the end of 2015. In the absence of the eReefs model, empirical models that relate catchment loads to WQOs in the GBR lagoon (Wooldridge *et. al.* 2006) have been used in the GBR WQIPs (summarised in the next section). In the recent GBR regions' WQIP updates, Brodie *et al.* (2014) have called targets developed by this process "ecologically relevant targets (ERTs)".

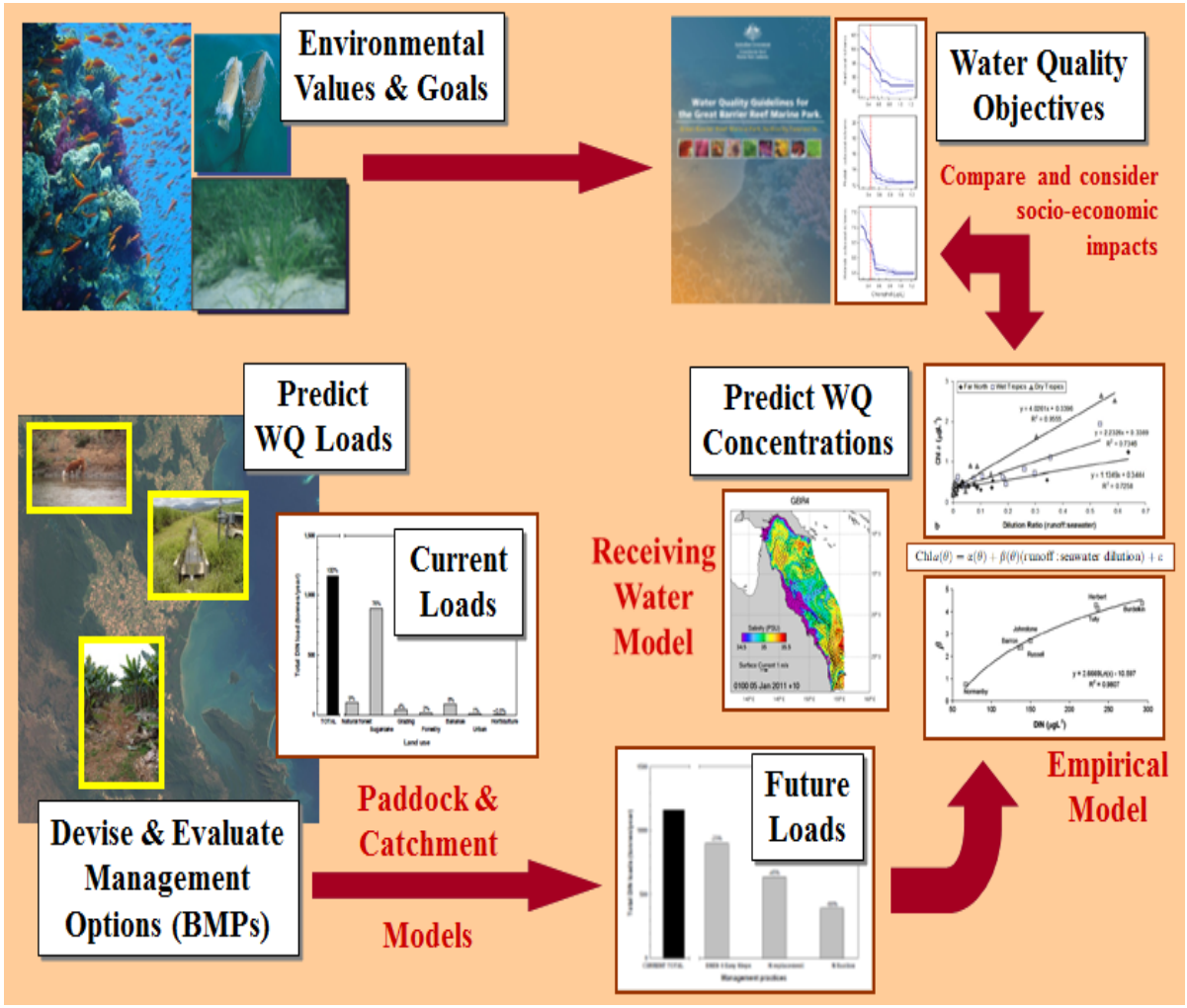


Figure 4: Water quality target setting process

5.3. Supporting Scientific Findings

Wooldridge *et al.* (2006) conducted a study in the Wet Tropics and Burdekin regions which developed an empirical model to link the dissolved inorganic nitrogen (DIN) delivered from the catchments in flow events and resultant chlorophyll *a* in the marine waters. The study found that to ensure concentration levels of chlorophyll *a* did not exceed 0.45 µg/L (the current GBRMPA marine water quality guideline); a reduction of 50-80% in DIN delivered to the GBR lagoon from Burdekin and Wet Tropics catchments was required. ERTs using the above findings were first established for the Tully WQIP (2009) and further updated by Brodie *et al.* (2014) for the whole of the Wet Tropics region in its WQIP (2014). The improved Wooldridge *et al.* (2006) model in Brodie *et al.* (2014) established that reductions in DIN levels of 50-80% were required for the individual Wet Tropics catchments to maintain the health of the GBR ecosystem (refer to Table 4). This level of reduction in DIN was predicted through the improved empirical model by Wooldridge (2009) to significantly minimise the risk of future crown-of-thorns starfish outbreaks, and increase coral resilience to thermal bleaching as a result of climate change. Through developing an understanding of the impacts of sedimentation and turbidity on coral communities and seagrass, and the relationships between end of catchment loads and turbidity in marine waters, Brodie *et al.* (2014) were able to determine Wet Tropics ecologically relevant targets for suspended sediments. Fine fraction or clay fraction sediment (<4 µm) was identified as the sediment most threatening to the GBR as it frequently contains other contaminants and travels widely in flood plumes (Lewis *et al.* 2014). Through this work it was concluded that a 50% reduction of the fine sediment fraction (<4 µm) was required across the region to maintain ecosystem health (refer to Table 4). A reduction of 50% of the <4 µm sediment load corresponds to varying overall reductions in total suspended solids (TSS) load for each river (normally in the range 10-25% reduction).

Photosystem II inhibiting (PSII) herbicides are acknowledged as the main pesticides of concern to the health of the GBR, with their greatest impacts in freshwaters, coastal wetlands and near coastal waters. Concentrations of pesticides (not loads) are important to gauge the risk to marine waters, however not all pesticides are of equal toxicity. Therefore to develop pesticide ecologically relevant targets for the Wet Tropics region, Brodie *et al.* (2014) normalised photosystem II inhibiting herbicide loads to reflect their toxic effects and then examined the reductions required to ensure concentrations remain within ecologically relevant threshold concentrations. This was done

through updating a model developed by Lewis *et al.* (2011) with new monitored load data. The analysis suggested that most Wet Tropics catchments required a (acknowledged conservative) 70-90% reduction of photosystem II inhibiting herbicide loads, although two catchments require no reductions beyond current estimates (refer to Table 4). While this ERT based on a load reduction was provided, it was recommended that the Guideline concentration (e.g. 0.08µg/L for diuron equivalent) be adopted as the actual ecologically based target.

The targets developed by Brodie *et al.* (2014) have been included as a part of the draft Wet Tropics WQIP, developed by Terrain Natural Resource Management, along with additional ecologically based targets for phosphorus (refer to Table 4 below). Similar targets are expected to be included in WQIPs being developed by the regional NRM bodies across the GBR regions.

A report was commissioned by the World Wildlife Fund (WWF) to synthesise the current knowledge on the impacts of pollutant loads on the GBR and to recommend ERTs (Holmes, 2014). This report recommended targets of 70-80% reduction in DIN be adopted.

Table 4: Summary of pollutant load reduction targets for basins in the Wet Tropics region. The table shows two sets of targets: Reef Plan Targets (RPT) and Ecologically Relevant Targets (ERT) for Total Suspended Solids (TSS), Dissolved Inorganic Nitrogen (DIN), Particulate Nitrogen (PN), Dissolved Inorganic Phosphorus (DIP), Particulate Phosphorus (PP) and PSII Herbicides (PSII). Source: Brodie *et al.* (2014).

River	Daintree-Mossman	Barron	Russell-Mulgrave	Johnstone	Tully	Murray	Herbert
TSS RPT	20%	20%	20%	20%	20%	20%	20%
TSS ERT[1]	50% reduction in fine fraction (< 4 μm) SS	50% reduction in fine fraction (< 4 μm) SS	50% reduction in fine fraction (< 4 μm) SS	50% reduction in fine fraction (< 4 μm) SS	50% reduction in fine fraction (< 4 μm) SS	50% reduction in fine fraction (< 4 μm) SS	50% reduction in fine fraction (< 4 μm) SS
DIN RPT	50%	50%	50%	50%	50%	50%	50%
DIN ERT	50%	50%	70%	80%	80%	80%	80%
PN RPT	20%	20%	20%	20%	20%	20%	20%
PN ERT	50%	50%	50%	50%	50%	50%	50%
PP RPT	20%	20%	20%	20%	20%	20%	20%
PP ERT	50%	50%	50%	50%	50%	50%	50%
DIP RPT	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified
DIP ERT	50%	50%	50%	50%	50%	50%	50%
PSII RPT	60%	60%	60%	60%	60%	60%	60%
PSII ERT (diuron equivalent conc.)	<0.08 $\mu g.L^{-1}$	<0.08 $\mu g.L^{-1}$	<0.08 $\mu g.L^{-1}$	<0.08 $\mu g.L^{-1}$	<0.08 $\mu g.L^{-1}$	<0.08 $\mu g.L^{-1}$	<0.08 $\mu g.L^{-1}$
PSII ERT (load)	0	0	82%	83%	73%	70%	90%

[1]Note that calculations of the TSS load reductions required based on actual particle size analysis from monitored data are available for the Barron, Johnstone, Tully and Herbert basins are presented in Brodie et al., (2014). These ERTs are typically lower than the ERTs presented above. It should be noted however that it is only possible to measure progress towards the 20% reduction in total SS using the Source Catchments model at this time.

5.4. Future ecologically relevant targets

The Reef Water Quality Protection Plan 2013 has an action to undertake a mid-term review of the Plan's goal, timeframe and targets once the eReefs' marine waters model is complete and information is available to consider GBR-wide ecologically based water quality targets. This action is due in 2016 and is dependent on the timely delivery of the eReefs project at the end of 2015 by the Great Barrier Reef Foundation. As indicated above, it is proposed that eReefs will produce the marine models needed to run scenarios to estimate the pollutant load reductions required to meet the GBRMPA marine water quality guidelines. From this, the required end of catchment pollutant load reductions can be determined to inform GBR-wide ecologically relevant targets.

5.5. Investment prioritisation tools and processes used to date

The effective prioritisation of GBR investment is critical to ensuring that available funding is used in a targeted way to achieve optimum results. Below is a summary of some of the key investment prioritisation processes and tools that have been used in recent years for determining GBR investments.

5.5.1. Relative risk assessment of degraded water quality to GBR ecosystems

In 2013, a combination of qualitative and semi-quantitative assessments was used to estimate the relative risk of water quality constituents to GBR ecosystem health from major sources in the GBR catchments, focusing on agriculture and land uses (Brodie *et al.* 2013). This assessment led by TropWATER James Cook University and funded by Queensland Government provided the basis to one of the chapters of the Scientific Consensus Statement, guided the priorities identified for management in the Reef Water Quality Protection Plan 2013, and provided input to the Australian Government prioritisation. The semi-quantitative assessment was based on a multi-criteria analysis methodology, taking into account marine risk and catchment load inputs. For assessment of the marine risk, a suite of water quality variables was chosen that represent the pollutants of greatest concern 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 solids (TSS) and chlorophyll *a* obtained from daily remote sensing observations, and the distribution of key pollutants including TSS, dissolved inorganic nitrogen (DIN) 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 influence of Crown of Thorns Starfish (COTS) on coral reefs, and the differential influence of river discharges on the COTS initiation zone was also included. 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, particulate nitrogen, 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. The information was then combined in a qualitative way to make conclusions about the relative risk of degraded water quality to coral reefs and seagrass meadows among the NRM regions to guide management priorities.

This assessment is currently being applied at a regional scale for each of the WQIPs.

5.5.2. Reef Trust cost-effectiveness assessment

On behalf of the Australian Government, the Australian Institute of Marine Science (AIMS) used a cost-effectiveness tool to assess the proposed interventions for consideration through Phase 2 of Reef Trust investment. These assessments are outline in the AIMS technical report (Addison and Walshe, 2015). For each proposed management intervention the cost-effectiveness is estimated by drawing on costings of the management interventions, expert judgement about environmental benefit of the interventions, and value judgements about the relative importance of Reef Trust natural values. The environmental benefits were characterised via four objectives (Reef Trust natural values): seagrass, inshore coral reefs, mid-shelf coral reefs and wetlands. Experts were asked to consider intervention with a fixed level of investment. The cost-effective protocol is restricted to assessment of the estimated return on investment for specific environmental outcomes under the administration of the Reef Trust. Other social and economic considerations need to be considered alongside synergies and complementarities with other programs which contribute to GBR outcomes.

5.5.3. Queensland NRM Program Investment Prioritisation

The Queensland Regional Natural Resource Management Investment Program (Department of Natural Resources and Mines, 2013) prioritised investment under the priorities of weed and pests, sustainable agriculture and water quality. Regional NRM bodies were expected to focus on projects that provided on-ground outcomes across these priorities. In regions in proximity to the GBR, it was expected that projects also help support agreed partnership plans aimed at protecting the GBR. Project applications were assessed by senior officers with sufficient expertise in the subject matter areas from the Queensland Government, with technical experts providing advice to ensure that the outcomes proposed, and methodologies undertaken are appropriate for each project.

Applicants were assessed against criteria which considered: targeted, maximum and measurable impact on natural resources or natural resource management in Queensland; value for money; and inclusive and transparent approach. The Queensland Government negotiated a funding agreement with each successful region.

5.5.4. Multi-Criteria Analysis Shell for Spatial Decision Support (MCAS-S)

The Multi-Criteria Analysis Shell for Spatial Decision Support (MCAS-S) is a software tool developed by the Australian Bureau of Agricultural and Resource Economics and Sciences that brings the multi-criteria analysis (MCA) process into the decision-makers' realm. The Australian Government has used the tool to draw together the lines of evidence from water quality monitoring, modelling, research and management practice change in a way that enables input from GBR stakeholders and exploration of data inputs and potential solutions. The results of this analysis have been used to identify the sub-catchments, industries and practices where investments are likely to deliver the biggest improvements in water quality. This tool was used as part of the prioritisation project by the Australian Government to inform investment through their Reef Programme (Australian Government, 2014).

5.5.5. Reef Resilience Investment Strategy

The World Wildlife Fund (WWF) Australia, the Marine Conservation Society, and the University of Queensland have undertaken a project to develop a method for prioritising cost effective actions to boost the health and resilience of the GBR and its species. This method is outlined in the Reef Resilience Investment Strategy summary (Klein *et al.* 2014). The methodology involves the following seven step process in order to prioritise a proposed project:

1. Define conservation objective
2. Identify threats
3. List management projects
4. Estimate benefit of projects
5. Calculate cost of projects
6. Estimate feasibility
7. Prioritise projects

Case studies involving the management of Flatback turtles and the management of sediment runoff have been applied to this methodology. Further research, including the use of more robust data in some cases, would be required to inform decisions.

5.5.6. Investment Framework for Environmental Resources (INFFER)

INFFER is a tool used for developing and prioritising projects designed to address environmental issues such as reduced water quality, biodiversity, environmental pests and land degradation. INFFER is designed to help environmental managers achieve the most valuable environmental outcomes with the available resources. INFFER assists decision makers to assess and rank environmental and natural resource projects, comparing aspects such as value for money, degrees of confidence in technical information and the likelihood of achieving stated goals. In the GBR, this tool has been utilised by the Burnett Mary Regional Group for various applications including the WQIP, Terrain NRM for the Wet Tropics WQIP and NQ Dry Tropics for the update of the Burdekin WQIP.

5.5.7. Future needs

It is recognised that there is a need to develop a consistent approach to spatial prioritisation for management within and across NRM regions for the future. There is also scope to address some of the limitations identified in the tools identified above to ensure that a robust process is established in time to inform investment decisions over the next 2-3 years and beyond.

6. Current instruments in use across governments

6.1. Regulations

The reef protection regulations were introduced in 2009 as part of the Queensland Government's commitment under the Reef Water Quality Protection Plan. The regulations applied to the management of fertilisers, agricultural chemicals and sediment with respect to commercial sugar cane growing and cattle grazing on a property of more than 2000 hectares in the Wet Tropics, Burdekin Dry Tropics and Mackay Whitsunday regions.

The legislative requirements are identified in the *Environmental Protection Act 1994* and the *Chemical Usage (Agricultural and Veterinary) Control Act 1988*. The legislation places requirements on the use of fertilisers and chemicals, including record keeping, as well as the requirement to hold an Environment Risk Management Plan (ERMP) for specific operators.

6.1.1. Environmental risk management plans

An Environmental risk management plan (ERMP) is a property plan required to be completed by sugarcane growers on more than 70 (hectares) ha in the Wet Tropics catchment and cattle graziers on more than 2000ha in the Burdekin. ERMPs specify management actions aimed at reducing the risk of sediment, fertiliser and pesticides leaving a property and entering the GBR lagoon. The Minister can direct an ERMP to be prepared under certain circumstances, for example if a property is found to have hazards that contribute to impacts on GBR water quality or a hot spot where routine monitoring has found poor water quality in a certain part of a catchment. An ERMP holder is required to submit an annual report identifying actions against an action plan which is considered by the

Government.

6.1.2. Requirements regarding fertilisers

All commercial sugar cane growers in the Wet Tropics, Burdekin Dry Tropics and Mackay Whitsunday regions are required to:

- keep records regarding amounts of fertilisers and soil conditioners, soil test results, and how optimum amounts of nitrogen and phosphorous were calculated – supporting information must be retained for five years,
- undertake soil tests, and;
- use soil test results and a regulated method to calculate and apply no more than the optimum rate of nitrogen and phosphorous.

6.1.3. Requirements regarding pesticides

All commercial sugar cane growers and graziers over 2000 ha, in the Wet Tropics, Burdekin Dry Tropics and Mackay Whitsunday regions are required to:

- keep records regarding amounts of agricultural chemicals applied on the farm – supporting information must be retained for five years,
- follow conditions on the use of ametryn, and tebuthiuron (graziers only) designed to reduce the risk of movement into adjacent water bodies, such as restricting application when rainfall is forecasted that will result in the loss of pesticides into water bodies, and;
- attain chemical training qualifications if applying or supervising the application of diurion, hexazinone, ametryn, atrazine and tebuthiuron.

In 2012, the Queensland Government began a transition away from regulations to a voluntary industry driven system. The Government planned to review the regulations once best management practice programs had taken effect.

6.2. Voluntary initiatives

Best management practice (BMP) programs use a continuous improvement principle, and include rigorous accreditation and reporting systems. They aim to move primary producers to best practice as part of a whole-of-farm management approach.

6.2.1. Cane Best Management Practice program

In November 2012, the Queensland Government signed a Deed of Contribution with Queensland Cane Growers Organisation Ltd. (CANEGROWERS) to support the development and implementation of a BMP program for cane growers. The funding associated with phase 1 of the program was $3.345 million which ran until December 2014. The Cane BMP is an industry-led, voluntary program available to all cane growers across Queensland, with the aim of providing the industry with a mechanism to benchmark their practices, create action plans for continuous improvement, and demonstrate the importance of environmental stewardship to a profitable and sustainable cane industry.

Through the program, the following seven modules were developed and delivered.

1. Soil Health and Nutrient Management.
2. Irrigation and Drainage Management.
3. Weed, Pest and Disease Management.
4. Crop Production and Harvesting Management.
5. Farm Business Management.
6. Natural Systems Management.
7. Workplace Health and Safety.

Table 5 summarises the uptake of the Cane BMP program from December 2013 up until December 2014. In December 2014 the Queensland Government entered into another agreement with CANEGROWERS to extend support for the program, with $5.855 million in funding allocated through to December 2017.

Table 5: Cane BMP uptake from December 2013 to December 2014

Regions	Growers completing self-assessment (at least one module)	Growers achieving accreditation
Wet Tropics	356	1 (3 modules)
Burdekin	73	0
Mackay Whitsundays	141	2 (1 module per grower)
Burnett Mary	114	0
TOTAL	**684**	**3**
Approximate % of Growers in Queensland	**20**	**0.1**

Note: The approximate number of commercial cane growers across Queensland is 3500.

6.2.2. Grazing Best Management Practice program

The grazing BMP program was initiated in 2009 in the Fitzroy catchment as a partnership between AgForce, Fitzroy Basin Association (FBA) and the Department of Agriculture and Fisheries. In 2012, the program was extended to the Burdekin catchment in partnership with the North Queensland Dry Tropics Regional Group to provide graziers with a voluntary alternative to the ERMP mandate under the *Environmental Protection Act 1994*. Enforcement of the reef protection regulations was suspended during the development and pilot of the Grazing BMP program, with the Queensland Government investing $1.9 million in the program from December 2013 to June 2014, which was managed by FBA. In 2014, the program was extended into the Burnett Mary region with the participation of the Burnett Mary Regional Group (BMRG). For 2014–15, the budget for the program is $631,500, with over $4 million requested for the ongoing investment in the three GBR catchments for 2015–17.

Through the program, five modules have been developed which have been delivered through central workshops, on-property small groups and one-on-one assistance. Online completion is available for any grazier wishing to undertake self-assessment. The five modules that have been produced listed below.

1. Grazing Land Management (GLM).
2. Soil Health.
3. Animal Health and Welfare.
4. Animal Production.
5. People and Business.

Uptake of the program by graziers has demonstrated a great interest in an industry standard. The voluntary nature of the grazing BMP has been a significant incentive for graziers to undertake the program. Table 6 summarises the uptake of the Grazing BMP program from 2012 up until December 2014.

Table 6: Grazing BMP uptake for 2012 to 2014

Grazing BMP	Delivered to June 2014			To December 2014			Total
	Burdekin	Fitzroy	Other	Burdekin	Fitzroy	Burnett Mary	
Total modules completed	538	1251	176	162	243*	45	2415
Soils and GLM completed	215	650	84	70	103	18	1140
Businesses undertaking complete program (5 modules)	89	34		27	23	9	182
Ha GLM	1,014,772	968,276	NA	125,445	87,446	65,899	2,261,838
Business audited	5	6	-	-	-	-	11
Modules completed by businesses without ERMP	270	-	-	-	-	-	270
Total Properties	146	470	60	37	154	9	876
Percentage of properties (approx.)	19%	15%	-	5%	5%	-	-

* (includes 13 reassessments)
Fitzroy – 3083 properties (Commercial cattle grazing properties, ABS 2010–11)
Burdekin – 772 properties (Commercial cattle grazing properties, ABS 2010–11)

6.3. Extension services in GBR catchments

The Queensland Government through the Department of Agriculture and Fisheries provides extension services to support growers and graziers to adopt better farming and business practices within GBR catchments. A number of other organisations also provide extension services at a regional scale, including the Cane Productivity Services, the Regional NRM groups and industry groups. Specialist extension staff and agricultural economists provide:

- hands-on technical assistance,
- economic support,
- on-farm assistance to trial new practices,
- information resources,
- economic decision support tools, and;
- research into improved farming systems.

6.4. Market-based instruments

Market-based instruments are policy tools that use the economic principles of market trade to maintain or improve the natural environment. Market based instruments are thought to harness the competitive pressure of markets to achieve an environmental outcome at least-cost. The diffuse nature of pollution and other unique catchment characteristics will be determinative in designing and implementing market based programs to improve water quality in the GBR.

6.4.1. Reef Trust tender

Through the initial phase of Reef Trust investment a competitive $5 million tender process was used to provide financial incentives for sugar cane farmers in the Wet Tropics region to undertake actions that improve nitrogen use efficiency, therefore providing water quality outcomes for the GBR in terms of reduced fertiliser runoff. This process supports the findings of the Scientific Consensus Statement 2013, which identified the Wet Tropics as the region with the highest relative risk of degraded water quality from nitrogen on reefs and seagrasses in the GBR. A similar process ($3 million) is likely to be carried out in the Burdekin region during the second phase of Reef Trust investment (from July 2015). As a market based instrument the competitive tender can be a cost-effective way to address nutrient loads in a system that combines nutrient management with irrigation management.

6.4.2. Offsets

Offsets can help to provide long-term environmental benefits, while providing flexibility for proponents to compensate for residual impacts on a protected matter, once all reasonable avoidance and mitigation measures have been applied. While not yet used as such, the Reef Trust may provide a mechanism for the pooling of funds paid to offset actions that have residual impact on matters of environmental significance in the GBR. Guidance will be developed for potential proponents on the requirements for making offset contributions to the Reef Trust and the method which relevant agencies will use to calculate the size of the financial offset required for a particular residual significant impact. Investment in projects funded through the pooling of offset funding will be delivered within the geographical boundaries of the GBR.

7. Current levels of investment across governments

7.1. Australian and Queensland government investments

The Australian and Queensland governments have in the past invested significantly in protecting and managing the GBR. Currently the two governments contribute more than $200 million a year to GBR management initiatives. Table 7 below summarises the Australian and Queensland government's investments for 2014–15. Over the next 10 years, the combined Australian and Queensland governments' investment in GBR management is predicted to reach $2 billion.

Table 7: Australian and Queensland government's GBR funding for 2014–15 (source: Reef 2050 Long-Term Sustainability Plan, Department of Environment, 2015). Blue indicates Australian Government funding, Green indicates Queensland Government funding.

Government agency	Funding ($ million)	Category	Focus
Australian Institute of Marine Science	15.1	Research	Undertaking research that supports the protection and ecologically sustainable use of the marine environment.
Australian Maritime Safety Authority	21.5	Management On-ground delivery	Promoting maritime safety and protection of the marine environment; preventing and combating ship-sourced pollution in the marine environment; providing infrastructure to support safety of navigation in Australian waters; providing a national search and rescue service to the maritime and aviation sectors.
Australian Research Council Centre for Excellence for Coral Reef Studies	2	Research	Undertaking integrated research for ecologically sustainable use and management of coral reefs.
Australian Government Department of	55	Management	Addressing the threats of declining water quality and climate change to the Great Barrier Reef World Heritage Area and enhancing the Reef's

Environment Reef investments including Reef Trust		Research On-ground delivery	resilience through ecosystem rehabilitation and species protection, including: • funding on-ground water quality, system repair, urban and species protection activities • water quality monitoring and reporting • research and development for water quality improvements and enhancing the Reef's resilience • crown-of-thorns starfish control and research • land and sea country Indigenous partnerships
Great Barrier Reef Marine Park Authority	30	Management On-ground delivery	Protecting and conserving the biodiversity and heritage values of the Great Barrier Reef Region and managing ecologically sustainable use.
National Environmental Research Program National Environmental Science Programme	3.5	Research	Providing science through the Tropical Ecosystems Hub of the National Environmental Research Program on the management, conservation and ecologically sustainable use of the Great Barrier Reef and its catchments.
Maritime Safety Queensland	28	Management On-ground delivery	Promoting maritime safety and protection of the marine environment; preventing and combating ship-sourced pollution in the marine environment; providing infrastructure to support safety of navigation in Queensland waters.
Queensland Department of Agriculture and Fisheries	11	Management Research On-ground delivery	Providing best management practice extension and production efficiency in agriculture and fisheries protection and management in the Great Barrier Reef and its catchments.

Queensland Department of Environment and Heritage Protection	13	Management On-ground delivery	Providing extension; promoting industry-led management practices; coastal planning and management; identifying and conserving built heritage in GBR catchments.
Queensland Department of Natural Resources and Mines	16	Management Monitoring On-ground delivery	Undertaking on-ground water quality, system repair, hydrological monitoring and reporting in GBR waterways.
Queensland Department of Premier and Cabinet	9	Management On-ground delivery	Coordinating Reef Water Quality Protection Plan implementation and the Queensland Government's contribution to field management of the Great Barrier Reef Marine Park.
Queensland Department of Science, Information Technology and Innovation	1	Management	Undertaking water quality report card modelling for GBR catchments.
Total for 2014-15	**205.1**		

In addition, both the Australian and Queensland governments have announced additional $100 million GBR funding over five years which will commence in 2015-16, summarised in Table 8.

Table 8: Australian and Queensland government's additional GBR funding commencing 2015-16. Blue indicates Australian Government funding, Green indicates Queensland Government funding.

Government Agency	Funding ($ million)	Focus
Australian Department of Environment (through Reef Trust)	100	Implementing the Reef 2050 Long Term Sustainability Plan through addressing the threats of declining water quality and climate change to the Great Barrier Reef World Heritage Area and enhancing the Reef's resilience through ecosystem rehabilitation and species protection.
Queensland Department of Environment and Heritage Protection	90	Part of the Queensland Government election commitment over 5 years which will include water quality initiatives, scientific research and helping business transition to better environmental practices in the primary production and fishing industries.
Queensland Department of Agriculture and Fisheries	10	Part of the Queensland Government election commitment over 5 years. This component is focused on net fishery licence buy back scheme.
Total of additional money commencing 2015-16	200	

7.2. Local government

Local Governments annually invest in activities that will benefit the GBR and their role in reducing the impact of human activity on the GBR is significant, and vital in ensuring that Australian and Queensland investments can be

directed in a more targeted fashion. RMCG (2015) found that in 2013–14, 15 surveyed councils (of the 27 in the GBR catchments) collectively invested up to $622 million in activities relevant to reef health (including improving water quality, ecosystem health, biodiversity and community awareness). More than half of this amount was directed to water quality improvement through activities such as wastewater and stormwater management and a similar level of investment was forecast for 2014-15. Many of these projects are driven by environmental standards and local governments work collaboratively with the Queensland and Australian Governments to meet requirements of state and national environmental regulators. Properly accounting for the local governments' relevant activities and expenditure is vital to presenting a complete picture of investment that contributes to protecting and managing the GBR and the investment by the many communities residing within reef catchments.

8. Progress to date

8.1. Reef Water Quality Protection Plan Report Card 2012 and 2013

Results from the Reef Report Card 2012 and 2013 (Department of Premier and Cabinet, 2014) (the most recent Report Card) are outlined in Table 9 and 10 below and show progress from the 2009 baseline up to June 2013.

Table 9: Reef Water Quality Protection Plan Report Card 2013 results against Reef Water Quality Protection Plan 2009 water quality targets (Department of Premier and Cabinet, 2014)

Reef Water Quality Protection Plan 2009 targets	2013 report card results						
	GBR-wide average	Cape York	Wet Tropics	Burdekin	Mackay Whitsunday	Fitzroy	Burnett Mary
By 2013, a minimum 50% reduction in annual average total nitrogen loads at the end of catchments	10%	6%	8%	10%	17%	3%	15%
By 2020, a minimum 20% reduction in annual average total sediment loads at the end of catchments	11%	8%	13%	16%	9%	4%	3%
By 2013, a minimum 50% reduction in annual average pesticide loads at the end of catchments	28%	n/a	26%	13%	42%	5%	28%

Table 10: Reef Water Quality Protection Plan Report Card 2013 results against Reef Water Quality Protection Plan 2009 land and catchment management targets (Department of Premier and Cabinet, 2014)

Reef Water Quality Protection Plan 2009 targets	2013 report card results						
	GBR Wide	Cape York	Wet Tropics	Burdekin	Mackay Whitsunday	Fitzroy	Burnett Mary
By 2013, 80% of sugarcane growers will have adopted improved management practices	49%	n/a	45%	55%	49%	39% of grain growers	55%
By 2013, 80% of horticulture producers will have adopted improved management	59%	n/a	50%	63%	66%	42%	50%

practices							
By 2013, 50% of landholders in the grazing sector will have adopted improved management practices	30%	48%	23%	54%	69%	28%	19%
By 2013, a minimum 50% late dry season groundcover on grazing lands	84%	n/a	94%	82%	91%	84%	92%

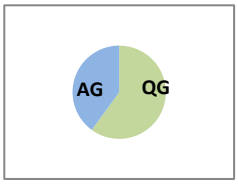
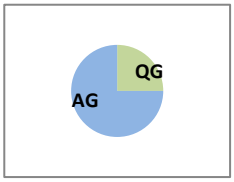
The 2013 Report Card results indicate that improvements in water quality have fallen well short of reaching the Reef Water Quality Protection Plan targets for 2013, particularly in nitrogen and pesticide runoff. Grazing practice adoption targets were met across some of the regions, while sugarcane and horticulture targets were not met across the whole of the GBR. These results suggest that existing initiatives are not sufficient in meeting water quality and land management targets.

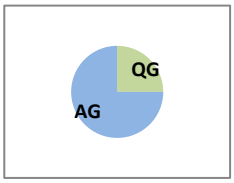
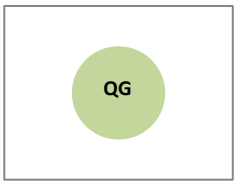
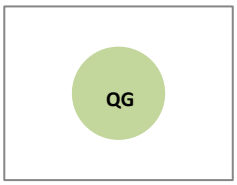
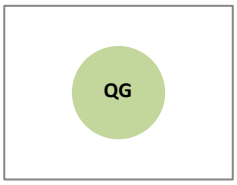
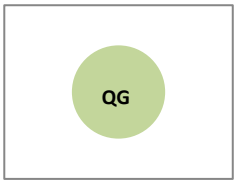
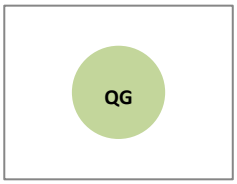
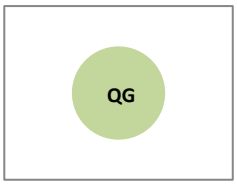
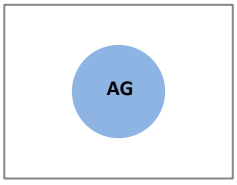
8.2. Reef Water Quality Protection Plan Paddock to Reef Program

The Reef Water Quality Protection Plan's (Department of the Premier and Cabinet, 2013) primary focus is diffuse source pollution from broad-scale land use. The Reef Water Quality Protection Plan sets ambitious targets for improved water quality and land management and identifies actions to improve the quality of water entering the reef.

The Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (Paddock to Reef program) is a collaborative evaluation program involving governments, industry bodies, regional natural resource management bodies, landholders and research organisations. The program design is based on the concept that improvements in agricultural management practices result in reduced losses of sediments, nutrients and pesticides to catchment waterways, which is then measured as reduced loads of pollutants at 'end of catchment' sites prior to discharge to the GBR receiving environment. Over time, it is anticipated that these reductions will provide better water quality in the GBR lagoon, ultimately leading to improvements in marine ecosystem health over time. The monitoring and modelling from the Paddock to Reef program is used to measure and report on progress towards Reef Water Quality Protection Plan's goal and targets through annual report cards. Funded jointly by the Australian and Queensland governments, the program is an innovative approach to collecting and integrating data and information on agricultural management practices, catchment indicators, catchment loads and the health of the GBR. The program comprises ten inter-related components which are integrated through a common assessment and reporting framework (refer to Table 11).

Table 11: Paddock to reef monitoring components (AG = Australian Government, QG = Queensland Government)

Components	Funding	Delivery Agency	Description
Management practice adoption		Queensland Department of Agriculture and Fisheries	Estimates management practice benchmarks and change across major agricultural industries of the reef catchments
Paddock monitoring		Queensland Department of Natural Resources and Mines	A range of paddock trials are conducted in various regions to provide on-ground evidence of water quality improvements from different land management practices. Results from trials are detailed in a series of case studies

Paddock modelling		Queensland Department of Natural Resources and Mines	Models a suite of farm management scenarios to assess water quality improvements across different soil and climatic zones.
Ground cover		Queensland Department of Science, Information Technology and Innovation	Annual mapping and reporting of ground cover levels; also used to improve water quality model parameterisation. Ground cover affects soil processes including infiltration, runoff and surface erosion. Low ground cover increases sediment loss.
Riparian vegetation		Queensland Department of Science, Information Technology and Innovation	Mapping and reporting on riparian vegetation extent and cover every four years; also used to improve water quality model parameterisation. Riparian vegetation helps remove water-borne pollutants and provides stability to stream banks and adjoining areas to reduce sediment loss.
Wetland extent		Queensland Department of Science, Information Technology and Innovation	Mapping and reporting on the historic and current extent of wetlands and change in wetland extent every four years. Wetlands provide a natural filtration system to protect water quality. Destruction of wetlands can result in increased sediment and nutrients flowing into the reef.
Wetland values and processes		Queensland Department of Science, Information Technology and Innovation	Assessing and reporting on the state of, and pressures on, wetland environmental values and associated wetland processes to inform management of wetlands and catchments for improved landscape function and water quality.
Catchment loads monitoring		Queensland Department of Science, Information Technology and Innovation	Tracks long-term trends in water quality entering the Great Barrier Reef lagoon from high priority catchments and is used to validate the modelling.
Catchment loads modelling		Queensland Department of Science, Information Technology and Innovation / Department of Natural Resources and Mines	Estimates average annual loads of key pollutants for each of the 35 catchments draining to the Great Barrier Reef and assesses changes against baseline levels due to improvements in land management.
Marine monitoring		Great Barrier Reef Marine Park Authority	Assesses trends in ecosystem health and resilience indicators for the Great Barrier Reef in relation to water quality and its linkages to end-of-catchment loads.

The data captured through the Paddock to Reef Program includes numerous water quality indicators at paddock, sub-catchment and catchments scales, catchment terrestrial indicators and marine monitoring indicators. Table 12 summarises the available data generated through the program.

Table 12: Paddock to reef indicator data

Indicator types	Indicators
Water quality indicators	Discharge Total nitrogen (TN) Total dissolved nitrogen (TDN) Dissolved organic nitrogen (DON) Total suspended solids (TSS) Particle size analysis (at select sites) Pesticides and herbicides (at select sites) Oxidised nitrogen (NOx) Ammonia (NH_3) Total phosphorus (TP) Total dissolved phosphorus (TDP) Dissolved phosphorus (DOP) Filterable reactive phosphorus (FRP)
Catchment indicators	Groundcover (Groundcover Index) Riparian mapping of GBR Catchments Wetlands mapping Land use mapping

Marine indicators	Coral cover and composition Macroalgal cover on coral reefs Density of hard coral juveniles Quality of coral reef sediments Seagrass abundance and species composition Seagrass reproductive effort Seagrass nutrient status Cover of macroalgae and epiphytes in seagrass meadows Seagrass canopy height Seagrass meadow edge Water quality: Temperature Salinity Total nitrogen (TN) Total dissolved nitrogen (TDN) Dissolved organic nitrogen (DON) Oxidised nitrogen (NOx) Ammonia (NH_3) Total phosphorus (TP) Total dissolved phosphorus (TDP) Dissolved phosphorus (DOP) Filterable reactive phosphorus (FRP) Total suspended solids (TSS) Particulate organic carbon Dissolved organic carbon Coloured dissolved organic matter Pesticides and herbicides Turbidity and chlorophyll by autonomous loggers Suspended sediments and chlorophyll a by remote sensing

8.2.1. Measuring Adoption of Management Practices

Best management practices are defined in Reef Plan Water Quality Risk frameworks for each major agricultural industry. These frameworks identify the management practices with greatest potential influence on off-farm water quality, and articulate a reasonable best practice level which can be expected to result in a moderate-low water quality risk. The levels described for each practice, where relevant, are:

- High Risk (superseded or outdated practices),
- Moderate Risk (a minimum standard),
- Moderate-Low Risk (Best practice), and;
- Lowest Risk (innovative practices expected to result in further water quality benefits, but where commercial feasibility is not well understood).

The sugarcane and grazing water quality risk frameworks (formerly ABCD frameworks for management practices) were revised in late 2013. These were reviewed by the Reef Water Quality Protection Plan Independent Science

Panel and have been significantly improved to focus on the critical practices that relate to water quality risks. The standards within the revised management frameworks have been raised compared to the previous ABCD framework that the modelling scenarios were based on. Under this framework, 'A' practices were considered cutting edge, 'B' was best practice, 'C' was common and 'D' was unacceptable management practice.

For grazing the framework describes the management practices based on their likely impacts upon land condition, soil erosion and water quality. Management system data for grazing for the Reef Report Card 2012 and 2013 were restricted to:

- completed Reef Rescue Water Quality grants projects (generally including training plus hard infrastructure improvements),
- a smaller group of highly intensive training/consultancy courses, and;
- a small section of Natural Resource Management body and/or Queensland Government extension projects with documented impacts of management system change.

Any management changes which graziers have implemented without direct influence or assistance from recognised service providers has not been captured. As such, the results are likely to be a conservative estimate of the degree of management practice improvement.

The ABCD management practice framework for the sugarcane industry includes practices relating to nutrients, herbicides, soils, on-farm water management (irrigation and drainage), record keeping and planning. Management system changes identified in the Reef Report Card 2012 and 2013 are restricted to those identified by regional Natural Resource Management bodies as an outcome of completed Reef Rescue Water Quality Grants projects, which generally include hard equipment or infrastructure improvements plus planning and/or training. Any management changes without direct influence or assistance from regional Natural Resource Management bodies and the Reef Rescue initiative were not captured, with the exception of growers engaged in the Queensland Government's *Reefocus* extension program in 2012 and 2013. Therefore, the degree of change reported is likely to be a conservative estimate.

For horticulture, the improved land management practices are described within the Growcom Farm Management System – the accepted industry best practice program – and regional Natural Resource Management body ABCD management practice frameworks. The reported number of growers adopting improved practices is limited to those that successfully implemented Reef Rescue Water Quality Grants, as an outcome of their engagement with Growcom Farm Management System from 2008 to 2013. This is likely to provide a conservative estimate of the number of growers implementing improved practices.

Paddock monitoring conducted through collecting run-off during actual rainfall events from a uniform portion of a paddock provides on-ground evidence of the effects of specific farm management practices on water quality. Paddock modelling is also used, which involves modelling a suite of farm management scenarios that represent the management practice combinations that existed at the baseline and subsequent improvements to these practices across soils and climate zones.

8.2.2. Measuring Pollutant Loads

End of catchment pollutant load reductions are one of the main targets used to gauge water quality improvement. This is based on the principle that a reduction in end of catchment loads represents improvements in the water quality entering the GBR, and that this will ultimately lead to improved ecosystem health.

End of catchment pollutant loads are measured using a combination of monitoring and modelling techniques. The Source Catchments modelling framework is used to model pollutant loads (sediment, nutrients and pesticides) for the 35 catchments in the GBR region (refer to Waters *et al.* 2014). The model generates runoff and pollutant loads for each land use within a sub-catchment, and runoff and pollutants are transported through a node-linked stream network to the end of the catchment. Rainfall and therefore river discharge can vary considerably between years, particularly in the large dry catchments of the Burdekin and Fitzroy region; therefore it is important to address this variability when assessing likely improvement as a result of management changes. To address this, the model is run using the same long term climate period to remove the influence of climate on estimated load reductions to generate annual average pollutant loads. Accordingly, the management factors that are changed in the model annually are based on spatial reporting of management practice adoption date for each region. This allows for the relative load reduction attributed to the areas of improved management practices to be reported. Modelled load estimates are validated against monitored data at 25 sites across the GBR catchments. Improvements in water quality as a result of adopting improved management practices are determined by linking paddock model time series outputs to catchment models. This approach allows for reporting of the estimated load reduction attributed to the areas of improved management practices (and essentially removes the 'climate' signal and interannual variability). Modelled load estimates are then validated against monitored data at 25 sites across the GBR catchments.

The targets are set against a 'baseline' condition defined by the management characteristics in 2008 and can be reported as a total load or anthropogenic load for each parameter. The anthropogenic load is the component associated with human influence since European development, and is calculated as the difference between the total load and the estimated pre-European loads. The model is then re-run for the same climate period using annually updated proportions of ABCD areas to reflect investment in improved management practices since the baseline year. The relative change in pollutant loads from the anthropogenic baseline after investment reflects the load reduction due to changes in management practices.

Progress towards Reef Water Quality Protection Plan targets at the GBR wide and regional scales is estimated by determining how much the modelled pollutant load has reduced from the baseline average annual modelled anthropogenic load, presented as a percentage reduction.

8.2.3. Measuring marine response

Monitoring of the water quality and condition of the inshore ecosystems of the GBR commenced in 2005 as part of the Marine Monitoring Program (MMP).

The MMP is managed by the Great Barrier Reef Marine Park Authority and monitoring is conducted by the Australian Institute of Marine Science, James Cook University, University of Queensland, Bureau of Meteorology and community volunteers. The MMP assesses the health of key marine ecosystems (inshore coral reefs and intertidal seagrasses) and the condition of water quality in the inshore Reef lagoon and contributes to the annual Reef Report Card. The program is critical for the assessment of long-term improvement in water quality and marine ecosystem health associated with the adoption of improved land management practices in the Reef catchments.

To date the program has not had enough resources to monitor the full set of receiving waters and has collected very few measurements in the Cape York and the Burnett Mary regions. The lack of data from Cape York is especially significant because the relatively undisturbed landscapes provide a natural reference point within the GBR for trends in water quality. Remote sensing used as part of the program experiences limitations due to issues such as cloud cover during the Wet Season.

To link end-of-catchment loads with marine water quality and ecosystem condition requires sophisticated models. A large collaborative venture eReefs is building a suite of coupled models for the coastal seas to simulate the transport, fate and impacts of sediments, nutrients and pollutants exported from the catchment models in the Paddock to Reef program. The combination of all these models will inform decisions on catchment, coastal and marine management in the near future.

9. Achievability of current targets

Catchment modelling scenarios carried out by Waters *et al.* (2013, 2014) to inform GBR water quality revealed that even with full adoption of best practice across the agricultural industry as at 2013, some Reef Water Quality Protection Plan targets are still unlikely to be met. The eWater Cooperative Research Centre (CRC) Source Catchments modelling framework was used to generate sediment, nutrient and herbicide loads entering the GBR lagoon from 35 GBR catchments. Data was collected for each industry under an 'A' (cutting edge), 'B' (best practice), 'C' (common) and 'D' (unacceptable) management practice frameworks that were current for 2009–13. Changes in improved management practices were assessed annually against the baseline year (2008–09). In 2013, additional scenarios were also run to determine if the targets could be met by shifting to an 'All A' practice adoption.

From modelling a range of management scenarios (Waters *et al.* 2013, 2014) and experience in the regional assessments for the WQIPs undertaken to date (Wet Tropics, Mackay Whitsunday and Burnett Mary) it is clear that there are significant challenges in meeting the targets in the specified timeframes.

- It is estimated that the photosystem II herbicide load reduction target (50%) could be met in most regions by 100% adoption of best practice ('All B' scenario – 62% reduction), whilst an 'All A' scenario could achieve a 92% reduction.
- It is clear that the dissolved inorganic nitrogen targets remain ambitious in all regions, and that even with widespread adoption of 'cutting edge' practices the reductions are likely to be around 34%. It is predicted that widespread adoption of best practice at the time ('All B' scenario) will achieve a 27% reduction across the GBR.
- For TSS, the achievements of widespread adoption of best management practices are also predicted to fall short of the targets across the GBR (13%),

It is clear that the nutrient and sediment targets will not be achievable using current best management practices in

agricultural land uses alone. Additional options such as large scale implementation of more precise and innovative management approaches in agriculture, restoration of ecosystem functions through actions such as restoration of hydrological connections and rehabilitation of riparian areas, and even consideration of land retirement in marginal areas will be required.

In addition Thorburn, Wilkinson and Silburn (2013) and Thorburn *et al.* (2013) have also cast doubt in the achievability of the current targets, and pointed to the need for a greater understanding of issues including the accumulation of nitrogen in groundwater and the management of gullies to prevent erosion.

A repeat of the catchment modelling scenario analysis is intended to be run in late 2015 using the updated land management frameworks to examine the achievability of the updated Reef Water Quality Protection Plan targets to 2018.

10. Challenges

As identified in the Introduction of this document, the GBR is an area of immense environmental, cultural and economic value, with the long-term survival of the GBR a top priority for both the Queensland and Australian Governments along with the wider community. There are multiple issues impacting the health of the GBR, some of which are beyond local management, such as changes in climate and time lags in expected condition response. However, improving the quality of water entering the GBR lagoon has consistently been identified by science and Government bodies as a threat that can be improved at local and regional scales and will improve both health and resilience of the reef to other impacts.

The identification of fine suspended sediments and dissolved inorganic nitrogen as key threats has resulted in a series of ambitious 'headline targets' to guide interventions to improve reef health. Although progress has been made in recent years in developing and implementing changes, such as improved agricultural practices to minimise sediment, nutrient and pesticide run-off entering the GBR lagoon, the effectiveness of these initiatives is limited without widespread adoption. Moreover, even if uptake of new practices was 100%, Waters *et al.* (2013, 2014) have shown that this might not suffice in meeting water quality targets for nitrogen. This means that effective means of increasing adoption rates, whether through incentives, market based instruments, extension, regulations or a combination of these approaches, must be also be extended with new innovative thinking, solutions, initiatives and tools to reduce the impact of farming practices on GBR water quality. This must be supported by a significant resource commitment for the investigation and development of innovative land management practices and other solutions.

There is also a clear role for holistic landscape management, and the need to develop an integrated understanding of the benefits of pollutant load reductions combined with the benefits of activities that aim to restore ecological functionality in the floodplain and coastal ecosystems. Current understanding of the linkages between coastal ecosystem functionality and water quality outcomes is conceptual, and is yet to be quantified. However, it is probable that activities that restore ecological functions such as hydrological connectivity and retention of water in the floodplain, will have downstream water quality benefits, at least in moderate flow events (there is limited retention time in the floodplain in high flow events), as well as more substantial benefits for system functions such as productivity and connectivity. It is assumed that both sets of actions will be required to reduce water quality pressures on the GBR and build the resilience of the coastal and inshore ecosystems to other pressures such as a changing climate, however, further research and development is required to improve the knowledge base.

As discussed in this report, there is a degree of uncertainty regarding some of the datasets used to assess improvements in management practices as well as changes in GBR condition. For improvements in agricultural management practices, only those farmers adopting management practice change through particular designated schemes have been included for consideration under Reef Water Quality Protection Plan reporting. This has ultimately led to Reef Water Quality Protection Plan Report Card results which are estimates of the degree of management practice change. Reducing the impacts of agricultural runoff entering the GBR will remain the main focus of the Queensland Government to improve the condition of the GBR. In the future, an improved understanding of the on-ground conditions in the catchments, the rate of management practice adoption and the water quality outcomes of these practices will be needed to measure the success of GBR management investment. This may require new or innovative monitoring techniques and understanding.

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