Broadening and enhancing reef protection regulations

Consultation Regulatory Impact Statement

September 2017

Queensland Government

Prepared by:
Office of the Great Barrier Reef

Updated January 2018: to reflect the new department name, Department of Environment and Science (former Department of Environment and Heritage Protection) and the new closing date for submissions - refer to page 14 for further detail.

September 2017

Table of contents

List of tables

List of measurement abbreviations

ha	hectares
kt/yr	kilo tonnes per year
kt/ha/yr	kilo tonnes per hectare per year
t/yr	tonnes per year
t/ha/yr	tonnes per hectare per year
kg	kilogram
mg/L	milligram per litre
N	nitrogen
P	phosphorus

Executive summary

The government proposes to broaden and enhance the existing reef protection regulations. This Consultation Regulatory Impact Statement assesses the costs and benefits of implementing a Great Barrier Reef protection regulation package under the *Environmental Protection Act 1994* to reduce nutrient and sediment pollution across reef catchments. It has been prepared by the Office of the Great Barrier Reef within the Department of Environment and Science.

The Great Barrier Reef is the world's largest coral reef ecosystem, stretching some 2300 km along the Queensland coast. Considered an Australian and global icon, the Great Barrier Reef is a unique ecosystem which hosts one of the most diverse range of species on the planet. The Outstanding Universal Value of the reef was recognised by the World Heritage Committee in 1981, when it was listed as a World Heritage property.

A recent estimate suggests that the Great Barrier Reef contributed $3.9 billion and over 33,000 jobs to the Queensland economy in 2015-16 alone (Deloitte, 2017). The reef also has many non-commercial values, such as recreation, cultural and non-use values. An overwhelming majority of survey respondents in Australia and overseas recently confirmed that they value the Great Barrier Reef and want to see it protected (Deloitte, 2017). People believe that the reef should be protected for a variety of reasons, such as the right of future generations to visit it, the moral and ethical duty to protect it, and that the world would simply not be the same without it.

The social, economic and iconic asset value of the Great Barrier Reef is estimated at $56 billion (Deloitte, 2017). This estimate was based on the value of Great Barrier Reef tourism, recreation and on the non-use values held by Australians for the reef. This is seen as conservative as it does not include the value of the importance of the reef to Traditional Owners, the rest of the world, and to Australia's 'brand'. Evidence suggests that all of these values are very high. Additionally, in reality the Great Barrier Reef is priceless as it cannot be replaced.

The Queensland Government encourages continued economic growth in the reef catchments in Queensland and believes these opportunities can be realised in an environmentally sustainable way. This includes new industry opportunities, such as biofuels and preparation of a North Queensland Regional Plan, which will support sustainable growth in the agricultural sector as a key regional opportunity.

The problem – the impact of poor water quality on the Great Barrier Reef

Successive reports since the late 1990s have identified that the Great Barrier Reef is showing declining trends in condition. The recent *2017 Scientistic Consensus Statement: Land use impacts on Great Barrier Reef water quality and ecosystem condition* identifies that poor water quality remains one of the leading causes of the poor state of coastal and reef ecosystems (Waterhouse et. al. 2017). The greatest water quality risks to the reef are from discharges of nutrients, fine sediments and pesticides.

Murky water from increased nutrients and sediment reduces light, smothering corals, seagrasses and other plants, affecting their growth and survival as well as the survival of turtles, dugongs, fish and other animals that depend on them for food and shelter. Increased nutrient levels are also thought to be linked to outbreaks of the coral eating crown-of-thorns starfish. Fine sediments reduce the light available to seagrass ecosystems and inshore coral reefs. Pesticides pose a risk to freshwater ecosystems, but are outside the scope of the regulatory package.

The reef receives run-off from 35 major catchments within the six reef regions that drain 424,000 square kilometres of coastal Queensland. The main source of excess nutrients and fine sediments

from Great Barrier Reef catchments is diffuse source pollution from agriculture. Other uses, including urban areas contribute relatively small and concentrated pollutant loads, but these can be important at local scales. The loads from different catchments are quite varied, but result in significant cumulative impact on the reef which is also facing other stressors such as climate change and impacts from direct uses like shipping and fishing.

The cumulative effect of multiple pressures substantially reduces the health and resilience of the reef. Widespread coral bleaching occurred in the northern parts of the reef in 2016 and 2017. In response, the Reef 2050 Independent Expert Panel advised in July 2017 that accelerating the adoption of better land management practices to improve the quality of water to the reef should be an immediate strategy.

The recent recovery of inshore reef communities during a period of low rainfall and run-off between 2012 and 2015 in central and southern sections demonstrates the inherent ability of these ecosystems to recover in the right conditions. This provides a strong case for reducing the pollutant loads being delivered to the reef to improve the resilience of the marine ecosystems to cope with a changing climate (Waterhouse et al. 2017).

Previous efforts to improve water quality have not achieved sufficient change

The Queensland and Australian governments have made significant investments to support the agricultural industry to adopt improved practices. These have been coordinated through the joint Reef Water Quality Protection Plan initially since 2003, with successive updates in 2009 and 2013. The plan sets targets for improved water quality and land management practices and identifies actions to achieve them.

The Queensland Government has been investing $35 million per year on water quality for many years and has recently bolstered that investment by $90 million over five years. This has included investment in voluntary and incentives programs and support such as extension for the adoption of improved practices. The Australian Government has also invested significantly in incentives and grants to improve water quality, through Reef Rescue, the Reef Program and now through the Reef Trust. These investments have seen improvements, but have not been sufficiently successful in engaging with or improving the management practices of all contributors to the cumulative reef water quality problem.

The Queensland Government acknowledges substantial efforts that many growers have made to improve their practices. The latest 2015 Great Barrier Reef Report Card shows some improvement in cutting the amount of nutrient and sediment pollution from land-based activity. However, it also shows that progress is too slow, not widespread enough and that the present trajectory will not meet the reef water quality targets for a healthy reef. This has been confirmed by the 2017 Scientific Consensus Statement which also states that there is an urgent need for the use of a variety of policy mechanisms, including regulatory tools to accelerate the adoption of practice change (Waterhouse et al. 2017). The 2017 Scientific Consensus Statement also states that the rates of adoption of improved land management practices have slowed after a period of early uptake, challenging expectations of meeting the targets entirely from voluntary reforms (Waterhouse et al. 2017).

At 31 August 2017, there are 206 sugarcane growers out of approximately 3700 growers and 82 graziers out of approximately 8500 graziers that have been accredited as implementing best practice for water quality under government supported industry-led Best Management Practice (BMP) programs. A re-invigorated compliance program has found high non-compliance with the current nutrient application standards. However, there has been notable improvements in compliance in follow-up inspections.

The proposal to broaden and enhance the existing reef protection regulations seeks to ensure minimum practice standards are utilised across key industries and land uses in all reef catchments. This will eliminate high polluting out-dated approaches which are the main source of pollution to the reef. The improved practices have profitability and productivity outcomes, while reducing the potential for nutrient and sediment run-off. If all landholders across the agricultural, and urban sectors reduce their pollution loads, it is anticipated this will make a substantial contribution towards achieving the water quality targets and improved reef health.

Other non-regulatory tools and initiatives can then be focused on achieving additional reductions by supporting industries and communities to implement other innovative solutions, and engaging in catchment restoration to address legacy issues such as accelerated gully erosion.

Great Barrier Reef Water Science Taskforce

In recognition of the need to accelerate an improvement of water quality in the Great Barrier Reef, the Queensland Government convened the Great Barrier Reef Water Science Taskforce (the GBR Taskforce) in 2015. The GBR Taskforce was charged with providing advice on the best possible approach to achieving the water quality targets for nutrients and sediment.

In May 2016, the GBR Taskforce identified that transformational change was required to meet the water quality targets. It recommended that the government implement staged regulations as one key component of a mix of instruments to reduce water pollution throughout the reef regions. It suggested that all key industries should play their part. A re-invigorated regulatory approach was to include a broader range of activities across the agricultural, urban and industrial sectors to better address the cumulative impacts of multiple pollutant sources on reef water quality.

The proposed regulatory package seeks to:

- Set nutrient and sediment **pollution load limits** for each reef catchment to target responses for managing risks to water quality.
- Provide the ability to **apply minimum practice standards** targeting nutrient and sediment pollution for key industries in reef catchments.
- Require fertilser **re-sellers to keep and produce records** on request, of nutrient application advice provided to their clients to improve nutrient management outcomes.
- Establish a **water quality offset framework** that can apply across industry sectors as a measure to manage water quality impacts for new, expanded or intensified development in the context of the new catchment pollution load limits.

Objective of the proposed regulatory package

The objective of the proposed regulatory package is to address poor water quality from pollutants derived from land-based activities across reef catchments by ensuring that:

- The water quality targets for nutrients and sediments are taken into account by decision-makers.
- Regulatory responses are proportionate to the risks posed by poor nutrient and sediment water quality from key land uses across reef catchments.
- New development can occur without compromising the water quality gains made to date, while also minimising regulatory burden on existing activities.
- Good performers that utilise practices with low water quality risks are recognised and rewarded.
- The regulatory approach allows for the improvement of existing industry-led BMP programs or the development of new programs to provide participants with an alternative pathway for meeting regulatory requirements.

Consultation

This Regulatory Impact Statement follows ongoing consultation with key stakeholders including the agricultural, industrial and urban sectors, conservation groups, other government departments, local governments and Natural Resource Management bodies since August 2016. Broader public consultation was also undertaken through a public discussion paper that was released in March 2017.

Options considered

Two options have been considered to accelerate improved reef water quality:

- Option 1 – The current approach – no additional legislation
- Option 2 – Enhance and broaden reef protection legislation

Option 1 maintains the current status quo. Reef regulations already exist under the *Environmental Protection Act 1994* to regulate diffuse water pollution from sugarcane and grazing practices as agricultural environmentally relevant activities (ERAs) in three of the six reef catchments. They were re-invigorated in early 2016 through targeted compliance activity after being effectively 'turned off' under the LNP administration in favour of a voluntary approach, such as industry-led BMP programs and incentives.

While sugarcane and grazing activities are the dominate sources of nutrient and sediment pollution, other agricultural activities – such as banana, horticulture and grains production – as well as intensive (point source) land uses – such as sewage treatment plants, aquaculture and mining activities also contribute to poor reef water quality. Progress on reducing pollutant loads from these sources would continue to be slow under this option.

Intensive activities, such as sewage treatment plants are regulated under the *Environmental Protection Act 1994* as prescribed and resource ERAs. While the current regulatory approach for these activities is generally considered to be effective, the provisions for limiting nutrient and sediment pollutants from new development could be improved.

Under this approach, the current BMP programs for agricultural management practices would continue to be supported. While they are valuable as a mechanism to demonstrate industry leadership and result in lower risk water quality practices, the current rate of uptake will not be enough to make sufficient progress towards the water quality targets. In addition, growers operating under BMP or like programs will not be formally recognised as meeting accepted industry practice in the existing regulated catchments, as is proposed under Option 2.

This option does not provide for the significant practice and management change that is required at a sufficient scale to support meeting the water quality targets for a healthy reef.

Under ***Option 2***, catchment load limits for nutrients and sediments will be established at the river basin level across the catchments of Cape York, the Wet Tropics, Mackay Whitsunday, the Burdekin, Fitzroy and the Burnett Mary. The load limits will be based on the latest water quality science and will be used to inform decision-makers about how best to manage risks to water quality. The load limits will be included in the Environmental Protection (Water) Policy 2009.

The reach of the current reef regulations for agricultural ERAs will be broadened from the Wet Tropics, Burdekin and Mackay Whitsunday catchments to all reef catchments. Additionally, the regulation will be extended to cover key agricultural activities that have water quality impacts. To achieve this, the current definition of agricultural ERAs in the *Environmental Protection Act 1994* will be expanded. The revised definition will include commercial cattle grazing and the commercial

production of cane, bananas, other horticulture crops and grain crops. An agricultural ERA will be required to meet a minimum practice standard aimed at eliminating outdated, high polluting agricultural practices. New agricultural ERAs will also be required to meet higher standards with regards to farm design.

Option 2 will encourage producers to engage with programs that support them to adopt improved practices and that also have other benefits, such as dedicated technical assistance, and preferential access to grants programs and other support. The government will provide producers with an alternative pathway for complying with regulated standards. Producers accredited against BMP or like programs will be deemed as complying with the minimum regulatory standards. This will recognise and reward those producers that are already meeting these standards.

Where catchment load limits apply, new, intensifying and expanding ERAs will also be required to avoid, mitigate or offset significant residual nutrient and sediment loads. This will apply to agricultural ERAs and other prescribed and resource ERAs that are regulated under the *Environmental Protection Act 1994*. This will ensure that new activities do not result in worsening water quality.

The regulatory proposals will work in alignment with a raft of non-regulatory tools to accelerate improved reef water quality. They include improved monitoring and modelling of catchment pollutant loads, improved communication strategies, as well as education and on-ground extension to support producers adopt improved management practices. These strategies form part of the broader adaptive management framework of the Reef 2050 Water Quality Improvement Plan 2017-2022, which is proposed to replace the current Reef Water Quality Protection Plan 2013. This framework will promote co-operative partnerships and integrated approaches, and taking action based on best available evidence and the learnings from previous approaches.

The new *Planning Act 2016* and planning framework came into effect on 3 July 2017. It is not proposed to further regulate diffuse pollution from urban development through the proposed regulations and urban development will not be subject to the catchment load limits. The recently commenced planning framework includes important State policy to achieve best management practice for erosion, sediment and stormwater from urban development. This includes requirements to not only prevent water pollution during the building phase but also to achieve best practice stormwater management post-construction.

This option is anticipated to result in significant reductions in nutrient and sediment pollutant loads and is more likely to achieve improved reef ecosystem health over time compared to Option 1. As such, this is the preferred option to accelerate improved reef water quality.

Costs and benefits

Tables 1 and 2 summarise the impacts of the proposed regulations. A full impact assessment is contained in Appendix 1.

Financial outcomes for producers will vary based on climate, markets and differences between a property's business structure, as well as its biophysical characteristics and other adoption barriers that may include accessing the necessary capital to initiate change. Some producers may find implementing the new regulations difficult to afford, particularly if capital costs are involved and they are currently experiencing financial difficulty. However, the minimum regulatory standards aim to maintain or increase productivity and profitability over time and in many cases, initial up-front costs can be covered within three to ten years. Affordability is addressed in Appendix 1, Sections A9.2 and A9.3.

The Queensland Government believes that the benefits of the regulatory package justify the costs and generates the greatest net benefit to the community compared to the option of maintaining the current approach.

The incremental benefit of the expected change in water quality from the proposed regulations cannot be monetised at present. However, the estimated load reductions are significant enough to expect to see improved ecosystem health over time as a result of improved water quality. These reductions will also contribute to the resilience of the Great Barrier Reef to recover from other impacts, such as coral bleaching.

This in turn helps to protect the valuable commercial benefits derived from the Great Barrier Reef, particularly from the tourism and fishing industries, estimated at $3.9 billion per year. It also helps protect the large non-use and recreation values supported by the reef, that contribute to its combined social, economic and iconic asset value recently estimated at $56 billion (Deloitte, 2017). The large size of these monetised values indicates the magnitude of the value of the Great Barrier Reef. This helps give confidence that the gap between monetised costs and benefits in this Regulatory Impact Statement (approximately $456 million in present value[1] over ten years) is a worthwhile investment to protect these values.

Table 1 - Summary of estimated benefits from the proposed regulations

Benefits

Present value of benefits over ten years: **$356 million**

Benefits by sector

Sector	Present value benefits ($) over 10 years	Equivalent annual value benefits ($)
Agriculture	355,427,514	54,553,315
Government	177,793	27,289

Sugarcane, most likely benefits of minimum regulatory standards for an average property

Region	Average size (ha)	Annual Profit
Wet Tropics	150	$9,000
Burdekin	106	$7,844
Mackay Whitsunday	150	$44,100
Burnett Mary	200	$49,000

The sensitivity analysis in Section A9.3 (Appendix 1) includes a worst case for sugarcane where per hectare costs might be indicative of a smaller property or one unable to source cheaper machinery. The total annual profits expected ($17.7 million a year) are significantly lower than the “most likely” case ($63.1 million).

Dissolved inorganic nitrogen reduction from minimum regulatory standards (total)

Region	Dissolved inorganic nitrogen load reduction (t)	% reduction in overall load per catchment	% move towards 2025 target
Wet Tropics	961	19%	24%
Burdekin	286	10%	13%
Mackay Whitsunday	465	38%	48%
Burnett Mary	140	16%	20%
TOTAL	**1,852**		

[1] **Present value** is the total value of the future benefit stream (ten years) in present day terms - this allows costs and benefits to be compared at the point where decisions are made.

Benefits

Sediment reduction from minimum regulatory standards (total)

Region	Fine sediment load reduction (t)	% reduction in overall load per catchment	% move towards 2025 target
Wet Tropics	95,100	6%	12%
Burdekin	531,000	12%	24%
Mackay Whitsunday	54,000	9%	18%
Fitzroy	324,000	18%	36%
Burnett Mary	162,000	13%	26%
TOTAL	**1,166,100**		

The ability to manage pollution loads from new activities through water quality offsets results in:

- 186 tonnes of averted dissolved inorganic nitrogen and 25,000 tonnes of averted sediment for new sugarcane production, and 26,000 tonnes of averted sediment from new grazing production.
- 70 tonnes of averted dissolved inorganic nitrogen for increased loads in sewage treatment plants.

The presence of a regulation requiring the offset of significant residual pollution is likely to encourage innovation in farm design and practices to minimise residual pollution.

Other prescribed and resource ERAs, apart from sewage treatment plants that commonly cause water pollution are not expected to increase significantly in the ten year analysis period, and therefore are not included in the impact assessment.

Profitability

The benefits to the agricultural sector consider improved profitability and productivity associated with operating under improved management practice standards. Not all producers are guaranteed to make these profits. Improved land condition from implementing the minimum regulatory standards is expected to lead to improved profitability for the grazing sector in the long term (>15 years). However, this is outside the 10 year time period for this analysis.

Table 2 - Summary of estimated costs from the proposed regulations

Costs

Present value of costs over ten years: **$853 million**

Sector	Present value costs ($) over 10 years	Equivalent annual value costs ($)
Agriculture	783,251,024	120,218,435
Industry (sewage treatment plants, banana industry group and fertiliser re-sellers)	53,639,950	8,233,007
Government	15,924,664	2,444,221

The regulatory proposals are estimated to cost $131 million per year to government, agricultural producers, sewage treatment plant operators, the banana industry group related to recognition of the industry BMP program and fertiliser re-sellers.

Costs

Cost of minimum regulatory standards

Sugarcane, most likely costs of minimum standards, for an average property

Region	Average size	Total (one-off)	Total (ongoing)
Wet Tropics	150	$17,495	$7,290
Burdekin	106	$39,827	$3,901
Mackay Whitsunday	150	$42,545	$39,885
Burnett Mary	200	$184,395	$30,450

The sensitivity analysis in Section A9.3 (Appendix 1) includes a best case for sugarcane where the total capital costs are less than half the most likely analysis ($67.4 million compared to $142.6 million). It is possible these costs are indicative of larger, more modern or efficient farms.

Grazing, most likely costs of minimum standards, for an average property

Region	Average size	Total (one-off)	Total (ongoing)
Cape York	20,000	$112,379	$29,082
Fitzroy	7000	$40,359	$14,080
Burnett Mary	5000	$136,579	$21,502
Wet Tropics	2000	$55,579	$11,995
Burdekin	20,000	$112,379	$29,075
Mackay Whitsunday	2000	$55,579	$17,395

The sensitivity analysis in Section A9.3 (Appendix 1) includes a worst case scenario for grazing which has much higher capital costs and losses in farm profit. These costs might represent the situation for a smaller property or one with unfavourable farm characteristics. The ongoing grazing costs are based on the value of stock removed to reduce grazing pressure. Improved land condition is expected to lead to improved profitability in the long term (>15 years), which means that in time these ongoing costs should fall. However, this is outside the 10 year time period for this analysis.

Cost of water quality offsets

Dissolved inorganic nitrogen based on a 1% increase in sugarcane production per year, not taking into account farm design standards

Indicative total offset cost ($/year)	Cumulative total cost ($)
4,609,740	**43,186,478**

Sediment based on a 1% increase in sugarcane production per year, not taking into account farm design standards

Indicative total offset cost ($/year)	Cumulative total cost ($)
1,082,491	**10,141,353**

Sediment based on a 0.1% increase in grazing per year, not taking into account farm design standards

Indicative total offset cost ($/year)	Cumulative total cost ($)
1,153,520	**10,424,555**

Dissolved inorganic nitrogen based on a 1% population increase per year, all sewage treatment facilities treat at best practice. The cost of offsets are likely to be cheaper for the industry than alternative methods to reduce residual pollution

Annual population growth	Annual residual nitrogen pollution (t)	Indicative offset cost ($/year)	Cumulative cost ($)
21,159	**7.72**	**1,795,606**	**16,160,451**

Have your say

Due to the Queensland state election being called on 29 October 2017, consultation was put on hold. Consultation has now re-opened from Monday 22 January 2018 with submissions closing on **Monday, 19 February 2018.**

This is a Consultation Regulatory Impact Statement. Our assessment of impacts may change in response to issues raised by stakeholders and the presentation of additional information. We invite all interested parties to make written submissions on the Regulatory Impact Statement. We will take into account all submissions received by 19 February 2018.

Please note, other than the new department name and the updated closing date, the Regulatory Impact Statement has not changed and previous submissions remain valid. However, you can re-submit if you wish to make changes to your original submission.

Electronic submissions:
officeofthegbr@ehp.qld.gov.au

Written submissions:
Reef regulations RIS Submission
The Office of the Great Barrier Reef
Department of Environment and Science
GPO Box 2454
Brisbane, QLD, 4001

Enquiries:
Enquiries can be directed to:
Reef Policy Unit, Office of the Great Barrier Reef
Department of Environment and Science
Phone: 13 QGOV (13 74 68)

IMPORTANT NOTE ABOUT CONFIDENTIALITY
In the interests of transparency and to promote informed discussion, the Department of Environment and Science would prefer submissions to be made publicly available wherever this is reasonable. However, if a person making a submission does not want that submission to be public, that person should clearly note on the front page of the submission that they claim confidentiality in respect of the document (or any part of the document).

While the department will endeavour to identify and protect material claimed as confidential as well as exempt information and information, which disclosure of which, would be contrary to the public interest (within the meaning of the *Right to Information Act 2009* (RTI)), it cannot guarantee that submissions will not be made publicly available. There is a possibility that the department may be required to reveal confidential information as a result of a right to information request.

1. Introduction

The Department of Environment and Science is seeking feedback from the community and affected stakeholders on the proposal to broaden and enhance the existing reef protection regulations. The proposed Great Barrier Reef protection regulation package under the *Environmental Protection Act 1994* seeks to improve reef water quality to help preserve the high values held for the Great Barrier Reef and increase the resilience of the reef to other pressures, such as climate change.

This Consultation Regulatory Impact Statement provides the costs and benefits for implementing the proposed regulation package. It has been prepared by the Office of the Great Barrier Reef with technical assistance from the former Department of Science, Information Technology and Innovation.

The proposed reef regulations respond directly to the Great Barrier Reef Water Science Taskforce (the GBR Taskforce) recommendation to use regulations as part of a mix of tools to reduce nutrient and sediment pollution from reef catchments to accelerate progress towards meeting the reef water quality targets.

The GBR Taskforce recommended that staged regulations apply to the agricultural, urban and industrial sectors across the reef catchments to address the cumulative effects of land-based run-off on the reef from key industries. Figure 1 shows the geographical extent of the reef catchments.

The government proposes the introduction of legislation for the agricultural and industrial sectors. Recent changes made under the *Planning Act 2016* are considered to be sufficient at this stage to address run-off from urban development and stormwater management.

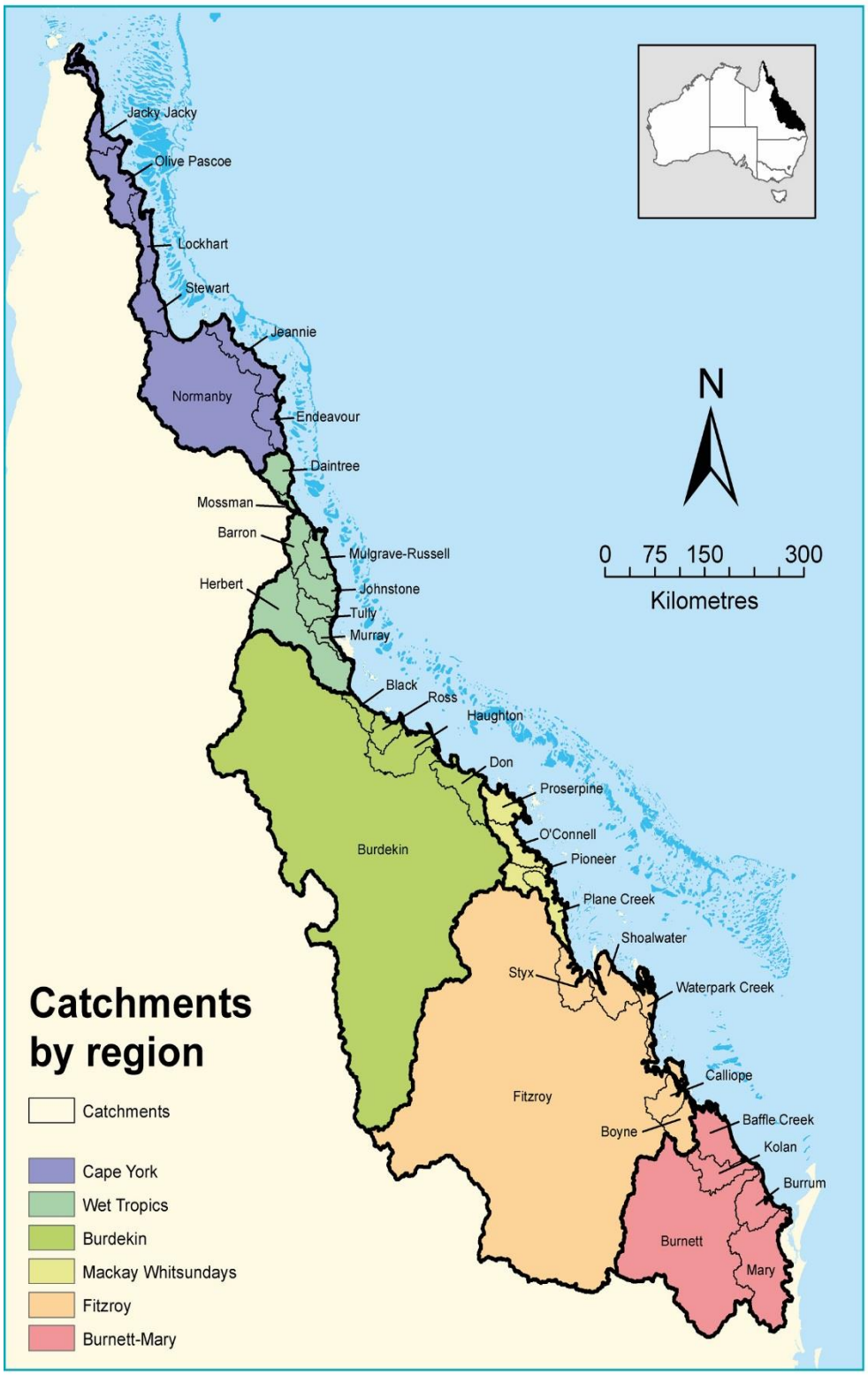
Two options are considered in order to accelerate improved reef water quality:

- Option 1 – The current approach – no additional legislation
- Option 2 – Enhance and broaden reef protection legislation

Under Option 2, the proposed regulations seek to manage pollutant loads from key industries across all reef catchments that contribute to poor reef water quality. They aim to eliminate outdated, high polluting agricultural practices and apply minimum regulatory standards that have improved water quality outcomes and move producers to precision agriculture. New agricultural activities will be required to apply at least the minimum regulated standards as well as meet higher standards with regards to farm design. New agricultural and point source activities will also be required to offset any significant residual loads following the implementation of required standards. This will ensure that new activities do not result in worsening water quality.

Section 2 of this Regulatory Impact Statement provides an overview of the problem of poor water quality and its impact on the Great Barrier Reef and why government intervention is proposed. Section 3 outlines the proposed options for addressing the problem of poor water quality with reference to the results of the impact assessment (cost benefit analysis) contained in Appendix 1. Section 4 provides a summary of the recommended option and why this option is preferred over maintaining the current approach. Section 5 provides a summary of the feedback received on the public discussion paper released on the proposed regulations.

Great Barrier Reef regions and catchments



Cape York
- Jacky Jacky Creek
- Olive Pascoe
- Lockhart River
- Stewart River
- Normanby River
- Jeannie River
- Endeavour River

Wet Tropics
- Daintree River
- Mossman River
- Barron River
- Mulgrave-Russell River
- Johnstone River
- Tully River
- Murray River
- Herbert River

Burdekin
- Black River
- Ross River
- Haughton River
- Burdekin River
- Don River

Mackay Whitsunday
- Proserpine River
- O'Connell River
- Pioneer River
- Plane Creek

Fitzroy
- Styx River
- Shoalwater
- Waterpark Creek
- Fitzroy River
- Calliope River
- Boyne River

Burnett Mary
- Baffle Creek
- Kolan River
- Burnett River
- Burrum River
- Mary River

The Great Barrier Reef stretches more than 2300 kilometres along Queensland's coastline. It receives run-off from 35 catchments which are spread over six natural resource management regions.

Figure 1: Geographical extent of the reef catchments

2. Background – water quality and pollutant sources

It is well established by science that the health of the reef has declined due to climate change, and poor water quality generated by land-based activities. Collectively, these pressures impact on the health of marine and coastal ecosystems. The overarching consensus of the *2017 Scientific Consensus Statement: Land use impacts on Great Barrier Reef water quality and ecosystem condition* is that key Great Barrier Reef ecosystems continue to be in poor condition (Waterhouse et al. 2017).

Excess nutrients from the fertilisers used in agriculture leach into the soil and then groundwater, or are washed into creeks by rain or irrigation releases. These excess nutrients are linked to outbreaks of the coral eating crown-of-thorns starfish, and excessive algal growth that outcompetes corals and increases the susceptibility of corals to disease. Sediments are generated through the process of erosion, whereby soil particles are removed from the landscape in water. The soil can be surface soil from hillslopes or subsoil from scalds, gullies or streambanks. The soil particles can be mobilised by run-off or, in the case of streambank erosion, stream flow and are transported to reef waters, making it cloudy and preventing corals and seagrass getting the sunlight they need to thrive. Erosion is a naturally occurring geomorphological phenomenon that is exacerbated predominantly by grazing, but also by cropping (Waterhouse et al. 2017).

According to Queensland government estimates (Queensland Government Statistician's Office 2015) approximate total population growth of 211,600 is expected over the next ten years in the Great Barrier Reef regions. Increased population will likely increase industrial development, which generates activities with nutrient and sediment releases, such as sewage and wastewater treatment.

Pollution loads from reef catchments have increased substantially since European settlement. Mean-annual nutrient and fine sediment loads delivered to the reef lagoon have been modelled as representing an approximate two fold increase in dissolved inorganic nitrogen, and an approximate five fold increase in fine sediment for the entire reef catchment (Waterhouse et al. 2017). Pollutant loads by land use in each reef catchment can be found at Appendix 2.

Maintaining the status quo is likely to lower the resilience of the Great Barrier Reef and greatly increases the risks to the long-term health of the whole Great Barrier Reef ecosystem. This would not only be bad news for the reef but also for those Queenslanders seeking to grow and maintain their reef-dependent businesses.

The recent recovery of inshore reef communities during a period of low rainfall and run-off between 2012 and 2015 in central and southern sections of the Great Barrier Reef demonstrates the inherent ability of these ecosystems to recover in the right conditions. This provides a strong case for reducing the pollutant loads being delivered to the reef to improve the resilience of the marine ecosystems to cope with other stressors such as a changing climate (Waterhouse et al. 2017).

The Queensland and Australian governments have made significant investments to support the agricultural industry to adopt improved practices in addition to other initiatives to improve water quality. These have been coordinated through the joint Reef Water Quality Protection Plan initially since 2003, with successive updates in 2009 and 2013. The plan sets targets for improved water quality and land management practices and identifies actions to achieve them.

The Queensland Government has been investing $35 million per year on water quality for many years and has recently bolstered that investment by $90 million over five years. This has included investment in voluntary and incentives programs and support such as extension for the adoption of improved practices.

The Australian government has also invested significantly in incentives and grants to improve water quality, through Reef Rescue, the Reef Program and now through the Reef Trust. Investments total approximately $500 million from 2009 until June 2018 with additional funding announcements made more recently, although not all of this is for water quality. The investments to date have seen improvements, but have not been sufficiently successful in engaging with or improving the management practices of all contributors to address the cumulative reef water quality problem.

The Queensland Government acknowledges substantial efforts that many growers have made to improve their practices and continues to support industry-led BMP programs. BMP programs encourage the adoption of industry practices that have been designed to improve water quality and have profitability and productivity outcomes. They provide a number of benefits to program participants by harmonising multiple market and non-market requirements and also address other aspects of farm business such as workplace health and safety.

Over the last 18 months there has been a notable increase in producers benchmarking or self-assessing their practices against practices that reduce water quality risks through BMP programs; an initial step for engagement. Benchmarked cane businesses cover 270,000 hectares, or approximately 67% of the total land under cane. Benchmarked grazing businesses cover 12,438,066 hectares, or approximately 40% of the total land area under grazing. However accreditation, which independently verifies that producers are implementing practices with water quality benefits has been slow. There are 206 accredited sugarcane growers out of approximately 3700 growers and 82 accredited graziers out of approximately 8500 graziers. The rates of adoption of improved land management practices slowed after a period of early uptake, challenging expectations that targets can be met entirely from voluntary reforms (Waterhouse et al. 2017).

While the latest 2015 Great Barrier Reef Report Card shows some improvement in cutting the amount of nutrient and sediment pollution from land-based activity, it also shows that progress is too slow and the present trajectory will not meet the reef water quality targets. The latest Great Barrier Reef Report Card also shows that not enough land is being managed using the practices that we know successfully reduce water pollution. This has been confirmed by the 2017 Scientific Consensus Statement.

The 2017 Scientific Consensus Statement has also identified that gullies and streambank erosion are more important sources of sediment than previously thought. While the management of these sources is a substantial challenge, there is improved confidence in a number of existing land management practices that seek to improve ground cover and land condition, and prevent or slow erosion from gullies and streambanks.

The 2017 Scientific Consensus Statement has also found strong evidence that reduced stocking rates will improve ground cover, water quality, and long-term profitability and sustainability. However, the historically marginal economics of many grazing enterprises often prevent these outcomes in favour of achieving short-term income.

Despite government and industry efforts, as well as the benefits of participating in BMP programs, the current approach is being undermined by those who are yet to adopt improved practices.

Reef protection measures already exist under Chapter 4A of the *Environmental Protection Act 1994* to manage diffuse pollution from agricultural environmentally relevant activities (ERAs). Agricultural ERAs are currently defined as commercial sugarcane growing and certain cattle grazing activities in the priority catchments of the Wet Tropics, Burdekin and Mackay Whitsunday. These activities are required to implement particular farming practices in these catchments.

The regulations for sugarcane and grazing were introduced by the previous Labor administration in 2009. However, in 2012 the LNP administration 'turned off' regulatory compliance, preferring to rely on voluntary measures, such as industry-led BMP programs and incentives programs, including those administered by the Australian Government.

The regulations have been re-invigorated through a targeted compliance program operating since early 2016. It has found high on-farm non-compliance with the current regulated nutrient application standards. However, growers are generally responding positively to compliance engagement and there has been notable improvement in compliance in follow-up inspections.

By focusing on certain sugarcane and grazing activities, the current provisions are considered to be limited in scope. While these activities are the dominate sources of nutrient and sediment pollution, other agricultural activities – such as banana, horticulture and grains production – as well as intensive land uses that have point source emissions – such as sewage treatment plants, aquaculture and mining activities – also contribute to poor reef water quality. The provisions have been criticised for ignoring the polluting practices of other agricultural sectors in close proximity to regulated growers, and also because only three of the six reef regions are currently included.

The GBR Taskforce recommended broadening and enhancing existing reef protection regulations to accelerate improved water quality towards meeting the reef water quality targets. There is an urgent need for a variety of policy mechanisms, including regulatory tools to accelerate the adoption of practice change (Waterhouse et al. 2017).

3. Consideration of options

The options considered to accelerate the improvement of water quality from the reef catchments are:

- Option 1 – The current approach – no additional legislation
- Option 2 – Enhance and broaden reef protection legislation

Option 2 seeks to broaden and enhance the existing provisions under the *Environmental Protection Act 1994* for the management of diffuse pollution from agricultural activities and point source pollution from industrial activities on reef water quality. The *Environmental Protection Act 1994* provides the legal framework to protect the environment in Queensland within the context of ecologically sustainable development. It provides for a wide range of tools, such as environmental standards and obligations, compliance tools and environmental offences for regulating the ongoing management practices of agricultural landholders and point source operations. Using this existing legal framework will minimise legislative complexity. Appendix 3 provides a brief summary of the alternative legislative frameworks that were considered for regulating agricultural activities.

Costs and benefits are referred to throughout this section for Option 2. These are summarised from Appendix 1, which outlines the full impact assessment for this option. The costs and benefits draw heavily on the bio-economic modelling in a significant recent report *Costs of achieving the water quality targets for the Great Barrier Reef* (Alluvium 2016). The Alluvium Report provided the costs and benefits of several policy interventions to reduce nutrient and sediment pollution, including improved land management practice change.

While this is the best available data, there are some differences between the practices and the practice change estimates in the Alluvium Report compared with the proposed regulatory changes. Additionally average figures have been used for cost estimates. In reality there are significant differences between the costs different properties face depending on factors such as farm size, geographical location, financial situation and past investment in various management activities. This

means that in some cases the costs and water quality benefits of certain practices will be an over or an under-estimation. The impact assessment is over 10 years.

For further detail on the costs and benefits of the regulatory proposals refer to Appendix 1.

3.1 Option 1 – The current approach – no additional legislation

Summary of Option 1

- Agricultural ERAs are cattle grazing (on a property of more than 2000 ha) and commercial sugarcane growing and in the catchments of the Wet Tropics, Mackay Whitsunday and Burdekin.
- Sugarcane growers and graziers are required to comply with particular farming practices. These include applying fertilisers and chemicals using prescribed methodologies and keeping associated records.
- Environmental Risk Management Plans are required for properties growing sugarcane on more than 70 ha in the Wet Tropics and grazing cattle on more than 2000 ha in the Burdekin.
- BMP programs will not be formally recognised as an alternative means of complying with minimum regulatory standards.
- New agricultural ERAs are not required to address significant residual water pollution following the implementation of regulated management standards.
- All other ERAs (point source activities) for intensive land uses that may discharge nutrients or sediment are regulated under the *Environmental Protection Act 1994* through an environmental authority.
- The Environmental Protection (Water) Policy 2009 guides regulatory decision-making under the *Environmental Protection Act 1994* to manage the water quality impacts of ERAs.
- A Voluntary Market Based Mechanism for Nutrient Management allows prescribed and resource ERAs to offset water quality impacts in order to meet current water quality standards.

Benefits and costs of Option 1

- No additional costs to landholders or government
- No additional water quality improvements

3.1.1 Current framework for agricultural activities

Specific Great Barrier Reef protection measures already exist under Chapter 4A of the *Environmental Protection Act 1994* and form the main tool for regulating pollution from sugarcane and grazing activities. Cattle grazing (on a property of more than 2000 ha) and commercial sugarcane growing in the catchments of the Wet Tropics, Mackay Whitsunday, and Burdekin are defined as agricultural ERAs.

The Chapter 4A provisions regulate the application of fertilisers and soil ameliorants, the keeping of records about the application of agricultural chemicals, fertilisers, soil conditioners, and soil tests for sugarcane and grazing. Additional requirements for an accredited Environmental Risk Management Plan apply to sugarcane growing on more than 70 ha in the Wet Tropics and cattle grazing on more than 2000 ha in the Burdekin with more than 100 standard cattle units. The Minister can also require a person undertaking an agricultural ERA to have an accredited Environmental Risk Management Plan to target particular issues. Alternative methods to those specified for undertaking soil tests, fertiliser and chemical application can be approved under an accredited Environmental Risk Management Plan.

A targeted compliance program for Chapter 4A was reintroduced in early 2016, to re-invigorate compliance with the regulated standards after they stopped being enforced in 2012 in favour of voluntary approaches, such as industry-led BMP Programs. The initial focus of the compliance program has been on the fertiliser, soil testing and record keeping compliance provisions for sugarcane production. The initial results of compliance inspections indicate that there are still high levels of non-compliance. However, growers are generally responding positively to compliance engagement and there has been a notable improvement in compliance in follow-up inspections. Operators accredited against a BMP program are a low priority for proactive compliance.

The Environmental Risk Management Plan provisions have not yet been a focus of the renewed compliance program and there are currently only a few still in place, all due to expire by August 2018. However, under Option 1 approximately 1000 landholders would have to re-do their Environmental Risk Management Plans.

3.1.2 Current framework for prescribed and resource ERAs

Under the *Environmental Protection Act 1994*, prescribed and resource ERAs for intensive land uses require an environmental authority before an activity is undertaken. These activities have different potential environmental risks with some having a higher likelihood of impacting on water quality, particularly through point source discharges. Examples of these activities include sewage treatment, wastewater treatment, aquaculture and some extractive and petroleum activities. Some of these ERAs release nutrients and/or sediment to land or waters and may contribute to the cumulative issue of poor water quality in the Great Barrier Reef. Table 3 shows the industry sectors likely to discharge nutrient and sediments.

Table 3 - Type of industries that release nutrients and sediments to land and water

Sector – nutrient release to land	Sector – nutrient release to water	Sector – sediment release to water
Aquaculture	Aquaculture	Aquaculture
Food processing	Energy	Extractive
Metal-mineral processing	Food processing	Water treatment
Resource activities (mining of mineral sand, black coal, lead, silver, and zinc)	Resource activities (mining of mineral sand, black coal, iron ore, nickel, gold, lead, silver, zinc, other metals)	Resource activities (drilling, costeaning, pitting, geological surveys, bulk sampling, exploratory activities)
Sewage treatment	Sewage treatment	
	Petroleum activities	
	Metal mineral processing	
	Non-metallic mineral	

Industrial land use is already highly regulated and comprises a small proportion of development; approximately 0.3%, in all Great Barrier Reef catchments (DSITIA, 2012). Within individual catchments, industrial land use comprises between 0.11% and 0.70%. However, the GBR Taskforce acknowledged that these relatively small loads of pollutants can still have significant localised impacts on the reef, particularly on inshore areas.

To obtain an environmental authority, the proponent must make an application in accordance with the requirements of the *Environmental Protection Act 1994*. If the activity proposes to release pollutants to waters, it is assessed against the Environmental Protection (Water) Policy 2009. This includes consideration of the:

- environmental values of the receiving environment

- possible impacts due to the proposed activity and all associated risks to the environmental values
- strategies to mitigate the identified risks to the environmental values.

The administering authority will then consider what conditions should be placed on the environmental authority to mitigate any risks to environmental values.

3.1.3 Current framework for water quality offsets

The Voluntary Market Mechanism for Nutrient Management provides offset solutions for any regulated prescribed and resource ERAs in Queensland, to meet the water quality objectives in the Environmental Protection (Water) Policy 2009, while delivering an overall improvement in water quality through environmental authority conditions. The policy has been updated and is out for public consultation until 30 September 2017.

Under the policy, the ERA holder is responsible for ensuring that a water quality offset is delivered and maintained and meets the design criteria. The ERA holder may contract management actions to a third party (e.g. landowner, NRM body, manager, broker), but the legal responsibility for the water quality offset will remain as a requirement of the environmental authority. The activity is also responsible for monitoring and reporting water quality effects in order to demonstrate the efficacy of the water quality offset.

3.2 Option 2 – Enhance and broaden reef protection legislation

Summary of Option 2

It is proposed to amend the *Environmental Protection Act 1994* to:

- Set nutrient and sediment **pollution load limits** for each of the 35 river basins that flow to the Great Barrier Reef lagoon in order to target responses for managing risks to water quality.
- Expand the definition of an agricultural ERA so that **minimum practice standards** apply to key industries across the reef catchments s.
- Remove the Environmental Risk Management Plan provisions.
- Require fertilser **re-sellers to keep and produce records** on request, of nutrient application advice provided to their clients to improve nutrient management outcomes.
- Establish a **water quality offset framework** as a measure to manage water quality impacts for new, expanded or intensified agricultural and prescribed and resource ERAs in the context of the new catchment pollution load limits.

Benefits and costs of Option 2

- Option 2 provides an estimated financial benefit to agricultural producers of $54 million per year from improved on-farm profitability.
- Option 2 would result in benefits with estimated reductions in nutrients and sediments:
  - 1852 tonnes of dissolved inorganic nitrogen as a result of the minimum practice standards for sugarcane, which is a 13-48% move towards the 2025 water quality target across the reef catchments.
  - 1,166,100 tonnes of sediment as a result of the minimum practice standards for grazing, which is a 12-36% move towards the 2025 water quality target across the reef catchments.
  - 186 tonnes of dissolved inorganic nitrogen and 25,000 tonnes of sediment from introducing offsets for new sugarcane production, and 26,000 tonnes of sediment from offsets for new grazing production.
  - 70 tonnes of averted dissolved inorganic nitrogen from introducing offsets for increased loads in sewage treatment plants.
  - Although it is not possible to monetise water quality benefits, the load reductions are significant enough to expect to see improved ecosystem health over time as a result of improved water quality. This in turn helps to protect the valuable commercial and non-commercial values derived from the Great Barrier Reef. This gives confidence that the gap between monetised costs and benefits in this RIS (approximately $456 million in present value over10 years) is a worthwhile investment to protect these values.
- Option 2 costs $131 million per year (in present value terms over 10 years) in direct costs to government, agricultural producers, sewage treatment plant operators, the banana industry group related to recognition of the industry BMP program and fertiliser re-sellers.

3.2.1 Catchment pollution load limits

Catchment load limits will apply in all 35 reef catchments (at the river basin scale) in order to require:

- Agricultural ERAs to meet minimum regulatory standards.
- New, expanding or intensifying, agricultural, prescribed and resource ERAs to avoid, mitigate or offset significant residual pollution loads.

The GBR Taskforce recommended that the existing targets to reduce water pollution to the reef by 2025 should be refined and set at the 35 river basin scale. The GBR Taskforce also recommended that catchment pollution load limits for nutrients and sediments should be set in legislation to help drive load reductions to meet the water quality targets. The new Reef 2050 Water Quality Improvement Plan 2017-2022 (previously the Reef Water Quality Protection Plan 2013) will establish new river basin scale targets.

The 35 river basin water quality targets are expressed as percentage load reductions required by 2025, from a 2013 baseline. They are targets to reduce anthropogenic (human caused) pollution and take into account nutrient and sediment run-off from natural areas. They take into consideration all land-based pollutant sources including urban and industrial activities. Progress towards the targets is measured at the end of catchment, which means the cumulative impact of all activities in the catchment is taken into consideration in this assessment.

The targets have been developed using the latest science involving a combination of:

- The eReefs biogeochemical model which tracks nutrients and sediments in the marine environment and connects the impact of these pollutants to water clarity and indicators of ecosystem health.
- Paddock to Reef catchment modelling for the 35 river basins in the Great Barrier Reef region under the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program
- Other expert scientific knowledge to estimate the load reductions required to meet the Great Barrier Reef Marine Park Authority (GBRMPA) water quality guidelines for reef ecosystem protection.

Further detail on how the targets have been developed can be found in the report titled *Development of basin specific ecologically relevant pollution load reduction targets for the Great Barrier Reef* (Brodie et al., 2017).

It is proposed that catchment load limits for each of the 35 river basins will be included in the Environmental Protection (Water) Policy 2009. This policy already guides decision-making in relation to water quality outcomes. The inclusion of catchment load limits in legislation provides a direct link to the consideration of the water quality targets in regulatory decision-making. The proposed catchment load limits mirror the river basin targets. They are outlined in Table 4.

Table 4 - Proposed catchment load limits

NRM Region	Catchment	Dissolved inorganic nitrogen reduction target (t)	Fine sediment reduction target (kt)
Cape York	Jacky Jacky Creek	0	0
	Olive Pascoe River	0	0
	Lockhart River	0	1
	Stewart River	0	2
	Normanby River	0	15
	Jeannie River	0	2
	Endeavour River	0	3
Wet Tropics	Daintree River	0	0
	Mossman River	52	0
	Barron River	52	0

NRM Region	Catchment	Dissolved inorganic nitrogen reduction target (t)	Fine sediment reduction target (kt)
	Mulgrave-Russell River	300	16
	Johnstone River	350	100
	Tully River	190	17
	Murray River	120	8
	Herbert River	620	99
Burdekin	Black River	ND*	ND*
	Ross River	74	ND*
	Haughton River	640	0
	Burdekin River	100	840
	Don River	0	55
Mackay Whitsunday	Proserpine River	110	0
	O'Connell River	130	96
	Pioneer River	140	35
	Plane Creek	260	0
Fitzroy	Styx River	0	0
	Shoalwater Creek	0	0
	Waterpark Creek	0	0
	Fitzroy River	0	390
	Calliope River	0	15
	Boyne River	0	6
Burnett Mary	Baffle Creek	16	11
	Kolan River	34	6
	Burnett River	150	85
	Burrum River	93	3
	Mary River	180	130

* ND: Not determined

Two options are considered for applying catchment loads limits:

1. Set catchment load limits in all reef catchments
2. Set catchment load limits in a sub-set of reef catchments

The preferred option is to set catchment load limits in all reef catchments. The preferred option creates a clear and concise regulatory boundary and is all-inclusive. There are no equity considerations, as all basins will be treated the same from a legislative perspective. This approach is relatively straight-forward as it takes a whole-of-reef approach. This approach also more adequately addresses cumulative loads across the whole reef region from relevant industries.

The alternative option applies catchment load limits only in certain catchments on a risk basis. The 2017 Scientific Consensus Statement assigns a relative spatial priority for water quality improvement to each of the 35 river basins based on the assessment of pollutant exposure and risk to coastal and marine ecosystems (Waterhouse et al., 2017).

This option is not preferred as applying catchment load limits in selected river basins could produce perverse outcomes by influencing the pattern of development. Operators are likely to consider investing in a catchment without additional requirements. This may produce poorer outcomes for the reef by worsening water quality in catchments without load limits.

It is proposed that the catchment load limits are updated in response to future changes to the Reef 2050 Water Quality Improvement Plan and the Scientific Consensus Statement which are reviewed every five years. This means that the load limits are responsive to new science and technological improvement. It is also proposed that regulatory standards for existing and new activities are reviewed in alignment with these timeframes and that where there hasn't been adequate progress towards the catchment load limits, these standards must be amended to support a reduction in nutrient and sediment loads. The update of catchment load limits will also provide a driver for the review of regulatory responses in general.

3.2.2 Agricultural activities

3.2.2.1 Define agricultural ERA

The reach of the current reef regulations for agricultural ERAs will be broadened from the Wet Tropics, Burdekin and Mackay Whitsunday catchments to all reef catchments. The regulations will also be extended to cover the key agricultural activities that may have a water quality impact to the reef. To achieve this, the current definition of agricultural ERAs in the *Environmental Protection Act 1994* will be expanded.

Within the definition for an agricultural ERA, distinctions will made between:

- An **existing** agricultural ERA – an ERA, which was in operation at the date of commencement of the legislation.
- A **new** agricultural ERA – the start of an agricultural ERA on land not previously used for that agricultural ERA, or on land which has not been used for an agricultural ERA in the previous five years.
- An **expansion area** to an agricultural ERA – an increase in any five year period in the area of an agricultural ERA (excluding areas used for vegetated buffers).
- An **intensified** agricultural ERA – a change in type of agricultural ERA, which involves an increase in the amount of fertiliser or water used.

The commencement of crop rotation or crop sequencing or changes in the extent or type of crop rotation or crop sequencing will not constitute a new or intensified agricultural ERA.

Two options are considered for the type of activities required to apply minimum standards:

1. Commercial operators
2. Commercial and non-commercial operators

The preferred option is for the regulatory package to apply only to commercial activities. The revised agricultural ERA definition will include commercial cattle grazing and the commercial production of cane, bananas, other horticulture crops and grain crops. Guidance material will be developed to assist landholders to determine whether they are undertaking a commercial activity.

The alternative option would apply the regulations to all agricultural activities – commercial and non-commercial. While this approach seems simple and transparent, it is likely to require significant additional government compliance and enforcement resources. It is unlikely that non-commercial operations are operating at a significant enough scale to contribute in a measurable way to cumulative water quality impacts to reef water quality.

Non-commercial activities, such as hobby farms, are required to meet the 'general environmental duty' under the *Environmental Protection Act 1994*, which is an obligation for all companies and individuals in Queensland. The Department of Environment and Science can also require remedial action under the *Environmental Protection Act 1994* regarding general water quality pollution issues for an operator, should an issue arise.

Based on available data from the latest 2015 Great Barrier Reef Report Card and the latest available Australian Bureau of Statistics data (ABS, 2016), the number of commercial agricultural activities in the reef regions is estimated to be approximately 13,000 (consisting of approximately 8500 graziers and 4500 growers i.e., sugarcane, horticulture, bananas and grains).

The approximation of 12,580 for commercial sugarcane, grazing and banana activities is used in the impact assessment section. This aligns with the latest 2015 Great Barrier Reef Report Card data (Appendix 1, Table 6).

3.2.2.2 Establish and improve minimum practice standards

The proposed regulations for existing operators aim to eliminate those unacceptable practices that have a high risk to water quality across the reef catchments. Significant investment and effort by both industry and government has occurred since the introduction of the original reef protection legislation in 2009 to further develop the scientific basis and demonstrate the worth of certain practices. Minimum standards set a base level of required practice and are aimed at replacing approaches that are known to pose a high risk to water quality, while also moving towards precision agriculture.

All agricultural ERAs will be required to comply with minimum practice standards that will be regulated through commodity specific codes. It is also proposed that timeframes are set in legislation to state when regulated minimum standards come into effect and when they must be reviewed. This will give producers certainty about how the changes will impact them and time to adopt these standards, where necessary.

It is proposed that the regulated standards are reviewed in alignment with the proposed timeframes for reviewing the catchment load limits, i.e. every five years. Where there hasn't been adequate progress towards the load limits, then these standards must be amended to achieve further reductions in nutrient and sediment loads.

The proposed practice standards for sugarcane, grazing and bananas are included in Appendix 4, along with the justification for these standards.

A staged approach is proposed for the application of improved minimum standards for sugarcane growing. Under the initial stage, canegrowers will be expected to meet the minimum standards immediately following the commencement of the legislation, with the exception of the Burnett Mary region, which will commence their regulatory obligations after twelve months. The minimum standards reflect the current requirements in Chapter 4A, with some additional minor proposed requirements. These are the requirement to ensure no ground based broadcast fertiliser application, that fertiliser boxes are calibrated and the use of measures that will minimise sediment erosion such as trash-blanketing.

The requirement to ensure no ground based broadcast fertiliser applications has not been costed. This is because only a very small number of sugarcane farmers are estimated to be undertaking this practice, and as such, the overall cost is likely to be small.

The additional cost of calibrating fertiliser boxes is $19,500 across all operators who are estimated to be carrying out D class practices. The cost of minimising sediment release to receiving waters cannot be estimated as it is not known precisely which activities will be required on various properties. However, many operators already undertake activities necessary to minimise sediment. For example, in the Wet Tropics and Mackay Whitsunday, almost all growers utilise green trash blanketing, which helps minimise sediment run-off. In the Burdekin, many growers have laser levelled beds and/or utilise retention ponds, which catch sediment.

Case Study: Sustainable practices boost productivity and profitability

Changing farming practices (and particularly nitrogen rates) can seem like a daunting task and sometimes the potential benefits are not clear. One example project where producers have changed practices that have improved both their bottom line and reduced their impacts on local waterways and the reef is the Burdekin Nitrogen Trials (RP20) project. The trials were established to determine whether the industry Six Easy Steps method provided adequate nitrogen application rates following the 2009 introduction of regulations for nitrogen and phosphorous inputs in sugarcane production. The trial data showed that where a trial site was run for more than one year, the Six Easy Steps method (aligning with the proposed Stage 1 minimum standard) is more profitable to the farmer 100% of the time. In fact, some producers have gained up to $50,000 in profitability as a result of farm management adjustments. Where variation in yields was observed between farms in the Burdekin it has been found to be primarily due to soil types and farm management, rather than nitrogen rates. This project demonstrated that high nitrogen application rates do not compensate for poor farm management practices – good farm management is the key component for achieving high yields.

Funded by the Department of Environment and Science, RP20 has been a successful collaboration between cane farmers in the Burdekin, Sugar Research Australia and the Queensland Government.

Under the second stage, where growers are not already doing so, they will be required to adopt a nutrient management plan approach in all reef catchments within two years of the commencement of the legislation. Nutrient management planning is a methodical approach to planning farm nutrient requirements, tailoring the fertiliser rate and blend to each part of the farm independently according to its past performance. Many growers are already undertaking nutrient management planning, supported through Queensland and Australian government programs, such as Reef Trust. Those growers will be able to continue to use their nutrient management plans following commencement of the legislation.

Agricultural management practices are categorised as A, B, C and D level practices under the Reef Water Quality Protection Plan water quality risk frameworks. The minimum practices under Stage 1 most closely align with C water quality standard management practices for sugarcane, while the practices under Stage 2 most closely align with B level practices. Movement from D through to A level practices represents improved water quality benefits.

Minimum standards will apply for the first time in the Burnett Mary region. The estimated total cost to the Burnett Mary region of moving from class D to C (Stage 1) would be approximately $680,000 as an initial cost, and $170,000/year as an ongoing cost.

There are anticipated high capital costs for any machinery or infrastructure that a producer may find is necessary to implement the new management standards under Stage 2, which applies in all catchments. These capital costs total $142 million, with ongoing maintenance costs of $14 million a year. However, many growers have already invested in this kind of equipment, through their own

efforts or with the support of Australian Government programs such as Reef Rescue. Additionally, these costs are expected to be more than offset by increased profits of approximately $54 million a year. It is important to note that not all businesses will realise these profits.

The requirement to implement property specific nutrient management plans is proposed to be accompanied by an implementation strategy and support program to assist growers not already involved in an incentive program – acknowledging that this transition can require upfront costs and agronomic expertise. Both the Queensland and Australian governments are providing funding to growers to prepare nutrient management plans through the Queensland Reef Water Quality Program and Reef Trust. The proposed implementation strategy and support program would complement these investments.

Case Study: Benefits of doing nutrient management planning

Nutrient management planning is a methodical approach to planning farm nutrient requirements that has multiple benefits to growers. An example of how nutrient management planning is done is the Department of Environment and Science funded project, *Complete nutrient management planning for cane farming project (RP161).* In this project, over 100 Burdekin farmers are working with a locally trusted private agronomy firm to create tailored nutrient management plans for their farms.

Initially soil tests are done and then the work involves personalised one-on-one support to provide whole-of-farm nutrient management planning, tailoring the fertiliser rate and blend to each part of the farm independently according to its past performance. Once the fertiliser rates and blends are worked out for individual parts of the farm, the agronomist then looks at the issue practically to narrow down the number of products the farmer needs to purchase and apply, which then forms part of the agronomic advice provided. In addition, the agronomists provide fertiliser box calibrations to help the grower adjust rates as required throughout their farm. Farm decision support is provided to growers throughout the year with high value agronomist support at their fingertips. Irrigation and weed management are addressed if necessary. Each grower is also provided industry Six Easy Steps training to ensure they understand how to calculate optimal nutrient rates for their farm in the future.

Overall, growers on this project agree that they have learnt what the optimum fertiliser application rates for their farm are and that they may need to vary depending on specific farm conditions, which can save them money when accompanied by good farm management.

Graziers and banana growers in all reef catchments will have a 12 month transitionary period to meet new regulatory standards.

For grazing, the new minimum standards most closely align with the B class management practices. Graziers currently in class D are assumed to move first to class C, and then they are included in the costs of moving from C to B. The total cost over five years of moving graziers from class D to class C is $6.8 million or $5,600 per property. There are no capital costs included in this estimate, which is likely to be an under-estimate. The total cost of moving from C to B is $148 million in capital costs and then an ongoing $32.5 million per year. This ranges from $5.54-$27 per hectare for capital costs (depending on the region), with an assumed 10% cost in annual maintenance, and ongoing costs of $0.6 to $3 per hectare in reduced profits.

The non-financial costs for the adoption of the proposed practices are discussed in Section A5.3 in Appendix 1. Section A9.2 also discusses the potential affordability of the proposed regulations on the various sectors.

The water quality benefits from applying minimum standards to sugarcane and grazing are significant. The estimated water quality benefit of improved practices in the sugarcane sector is approximate to 1,852 tonnes of averted dissolved inorganic nitrogen. Dissolved inorganic nitrogen reductions range from 10% of the current dissolved inorganic nitrogen load in the Burdekin, 19% in the Wet Tropics, 16% in the Burnett Mary and 38% in the Mackay Whitsunday region. Reductions in sediment are expected in all catchments, ranging from 6% for the Wet Tropics, 9% in Mackay Whitsunday, 12% in Burdekin, 13% in Burnett Mary and 18% in the Fitzroy.

There has been less economic analysis carried out on best management practices for bananas than for the sugarcane and grazing industries, and robust estimates of the costs of the practices for an average property do not exist (Harvey et al., 2016). For this reason, the costs of the minimum standards have not been calculated. Overall, the studies that have been done suggest that there are financial benefits to carrying out best management practices. It should be noted that even simple measures, such as increased soil and leaf testing may involve some implementation costs and issues such as limited testing capacity and quarantine procedures for soil samples from Far North Queensland due to the risk of Panama TR4 disease.

To meet the minimum standards there are additional costs for growers associated with learning, record keeping and compliance inspections. The cost to government includes developing the minimum standards, recognising BMP or like programs to allow operators accredited against these programs to be deemed compliance with minimum standards, and undertaking compliance inspections.

Minimum standards for grains and the horticulture industry are yet to be developed. These industries will be regulated at a later date due to the lower water quality risk associated with these sectors and the complexity in developing standards for these activities. For example, there are over 100 different crops covered under the horticulture industry, and there has not been the level of research, in areas like nutrient requirements, across these crops as there has been in sugarcane. As such, it is not possible to implement nutrient management standards at this stage that support water quality, productivity and profitability outcomes. Accordingly, proposed farm management standards for horticulture and grains are not subject to this Regulatory Impact Statement. When developed, appropriate regulatory impact assessment will be undertaken to determine the costs and benefits of the proposed minimum standards.

3.2.2.3 Additional requirements for expansion areas, intensification and new agricultural ERAs

The GBR Taskforce stated that the regulations should ensure: no net decline in water quality from intensification and expansion in the agricultural sector; that load limits should be used as part of the decision-making for approving new development; and that a water quality offset framework be established as a measure to deal with the impacts of new or expanded development in the context of catchment load limits.

Two options are considered for regulating new agricultural ERAs and existing agricultural ERAs that expand or intensify:

1. Regulation through commodity specific codes containing farm design and/or management practice standards.
2. Regulation through an environmental authority that stipulates the farm design and/or management practice standards as licence conditions attached to the authority.

The preferred option is to regulate these activities through commodity specific codes that outline the required standards. New agricultural ERAs in all catchments will be required to comply with the minimum practice standards and will also be required to meet farm design standards. Existing

agricultural ERAs that expand or intensify will be required to continue to meet minimum practice standards. They will not be required to retro-fit their existing operation to new farm design requirements.

The proposed standards for sugarcane, grazing and bananas are included in Appendix 4, along with the justification for these standards.

In some instances, farm design standards will be supported by existing requirements under other regulatory regimes, for example:

- Clearing native vegetation including those for 'high-value agriculture' under the *Vegetation Management Act 1999*.
- Earthworks within a Wetland Protection Area under the Planning Regulation 2017 – activities include the draining and filling of wetlands for diversions, which change the hydrology of wetlands, introduce pollutants, or increase the amount of sediment flowing downstream.
- Developing irrigation for a proposed cropping or pasture area.

The proposed farm design standards prescribe detail that will assist applicants in complying with these other requirements, specifically in relation to matters dealing with sediment loss and retaining excess nutrient or fertiliser. As such, the additional cost of these requirements is assumed to be low. It is also likely that a new business would use best management practices to ensure private financial benefits. The cost to government for developing farm design standards is estimated to be approximately $125,000.

The alternative approach for regulating new development would stipulate the farm design and/or practice standards as licence conditions under an environmental authority. This is not the preferred option because it would create a differential regulatory environment where some agricultural ERAs operate under a code and others require an environmental authority. It would also create additional regulatory burden without any additional environmental benefits. This is because an assessment process would not add value, as site-specific factors do not affect the proposed standards.

New agricultural ERAs, as well as existing agricultural ERAs that expand or intensify in all catchments will also be subject to a deemed condition that a water quality offset must be provided where there is significant residual pollution load. Further details about the proposed offsets framework are outlined below in Section 3.2.4.

3.2.2.4 Environmental Risk Management Plan provisions

It is proposed to remove the Environmental Risk Management Plan provisions to reduce regulatory burden, particularly for farmers already operating at best practice. Their role will be replaced by the minimum standards. An accredited Environmental Risk Management Plan is currently required for higher risk sugarcane and grazing activities, which are defined by certain thresholds. The Minister can also require a person undertaking an agricultural ERA to have an Environmental Risk Management Plan to improve the quality of water being released from the relevant agricultural property; or because the agricultural ERA is causing or may cause unlawful environmental harm. An Environmental Risk Management Plan in this context can be used as both an upfront requirement or as a compliance tool.

The removal of the Environmental Risk Management Plan provision will save growers and the government a combined total of $1.3 million without having a negative impact on water quality. This is because the proposed regulatory package provides a suite of measures to address water quality, bolstered by a compliance and enforcement program. While it is an offence not to have an

Environmental Risk Management Plan where it is required, there is no legal requirement to implement an Environmental Risk Management Plan.

It is proposed that existing compliance and enforcement tools under the *Environmental Protection Act 1994* – such as transitional environmental programs, environmental protection orders and direction notices – be amended so that these tools can be used to encourage compliance with the proposed commodity specific minimum standards, should this be required.

3.2.2.5 Pathways for complying with minimum practice standards

Under the proposed regulatory framework the following pathways would be available for agricultural ERAs to meet minimum regulatory standards:

- Government pathway – comply with the regulated minimum practice standards.
- Industry-managed pathway – become accredited against a recognised industry program.

Government pathway – for complying with minimum standards

Agricultural ERAs will be required to meet commodity specific codes, which contain the minimum standards. A risk based compliance program in alignment with the Department of Environment and Science's Regulatory Strategy will monitor compliance with minimum standards.

The compliance approach will include the development of education resources and information guidelines to promote an awareness and understanding of the regulatory requirements. Depending on the nature of any non-compliance with the minimum regulatory standards, the Department of Environment and Science may provide an opportunity for operators to voluntarily fix the problem, or take stronger action. It will be an offence for a person carrying out an agricultural ERA not to comply with the commodity specific code, with a corresponding penalty. The government has a reef compliance budget of $1.65 million per year for the next five years.

Alternative industry-managed pathway – for complying with minimum standards

There are opportunities for industry and government to continue to work together to encourage good performance and the further uptake of minimum standards. It is proposed that BMP or other industry-led programs that provide similar water quality outcomes are formally recognised in the *Environmental Protection Act 1994* in order to provide operators with the legal ability to meet regulated standards. Examples of this already exist, such as where the Smartcane BMP program is recognised under the *Liquid Fuels Supply Act 2016* as meeting the sustainability criteria for the supply of biofuels.

Providing the ability to formally recognise BMP or like programs builds on and recognises the significant investment made to date by government and industry in these programs for water quality, as well as productivity and profitability outcomes. This approach will also recognise and reward those producers that are already meeting these standards. Agricultural operators would be deemed to have complied with the minimum standards if they are accredited against a recognised program and will not be proactively targeted for compliance activities. This strategy also acknowledges the growing importance of building an improved voluntary compliance culture within industry.

The criteria for recognising programs and an assessment process for this will be included in subordinate legislation. These criteria would be guided by requirements of the existing BMP program agreements, including a third party accreditation process for verifying that producers meet program requirements. It is also intended that the industry-managed pathway outlined could be used for new agricultural ERAs to meet the required farm design standards and/or the required management practices.

While agricultural operators participating in recognised programs wouldn't be the focus of government compliance activities, the department would retain the ability to undertake compliance and enforcement action where non-compliance is suspected.

The practice standards required under the regulations would be the same regardless of the pathway an agricultural ERA chooses in order to meet minimum regulatory standards. There are additional requirements for landholders seeking accreditation as BMP programs are generally broader than providing an avenue for program participants to meet the water quality standards. These broader requirements are not subject to the proposed regulations. Participation in BMP or like programs has not been fully costed as BMP accreditation is voluntary.

3.2.2.6 Record keeping requirements for fertiliser resellers

It is proposed that fertiliser re-sellers are required to retain records of sales together with the results of any associated soil tests and any recommendations about the use of fertiliser products. Those records must be produced upon request by an authorised officer under the *Environmental Protection Act 1994.*

Specifically, fertiliser re-sellers will be required to retain records of the following information about sales of fertiliser to a person carrying out an agricultural ERA, for a period of five years:

- name of customer
- location of property where agricultural ERA is conducted
- amount and date of sale of nitrogen and phosphorous fertiliser to the customer
- any recommendations made in association with the sale including:
  - results of soil analysis
  - recommended fertiliser product
  - recommended rate of application
  - recommended method of application
  - recommended timing and frequency of application.

A fertiliser re-seller is defined as a person or business that sells, for commercial gain, fertiliser containing nitrogen and or phosphorus to an operator of an agricultural ERA.

A large proportion of agricultural producers receive their soil testing and fertiliser advice from fertiliser re-sellers. Advice and recommendations received by producers have a significant impact on what practices, particularly regarding fertiliser rates, are applied on-farm and their subsequent water quality risk. Many producers accept this advice and trust that it is accurate and aligned with best practice for their farm.

These records will be used as evidence as part of compliance activities. For example, where local monitoring shows there are high levels of nutrients in a watercourse but the records of local growers indicate that they are complying with nutrient management requirements, the Department of Environment and Science may seek the records of fertiliser sales as a second line of evidence to verify how much fertiliser has been sold for those properties.

It is anticipated that the cost of keeping the proposed records should be reasonably low as any record keeping system can be used, such as a spreadsheet. No historical analysis interrogating multiple forms of records will be needed. At the end of a consultation or sales activity, a re-seller will need to record some key pieces of information. This should not take longer than a quarter of an hour. If every cane and banana farmer consulted a re-seller once a year, this would represent an annual cost to all resellers of $49,809.

3.2.3 Point source activities

Point source activities that result in significant point source emissions to air, water and land are already regulated under the *Environmental Protection Act 1994*. The inclusion of catchment load limits in the Environmental Protection (Water) Policy 2009 will be an additional consideration when making an application for a new environmental authority or to amend an existing environmental authority.

Where a catchment load limit applies, the proponent would be required to provide information about the total residual nutrient or sediment load based on the proposed release. If there is a significant residual pollution load, the proponent would be required to provide a water quality offset. The offsets policy and calculator would be available to help operators in making this determination (see Section 3.2.4). Where an offset is required, a condition would state that an offset must be provided in accordance with the applicable offsets policy.

The requirement for the consideration of catchment load limits will apply to applications made after the commencement of the broadened reef regulations when the offsets framework commences. Prescribed and resource ERAs that do not release to land or waters within a reef catchment, such as dredging for maritime port facilities, will not be impacted by the proposed regulatory package.

3.2.4 Establish a water quality offsets framework

Water quality offsets are actions that work to counterbalance any potential or proposed increase in nutrients and sediments to waters with at least an equivalent reduction elsewhere, either on or off-site. The purpose of water quality offsets is to allow for new development so these activities don't compromise progress towards meeting the water quality targets. There is currently no statutory framework requiring mandatory water quality offsets in Queensland.

The water quality offsets framework would apply to new, expanding or intensifying, agricultural, prescribed and resource ERAs that could not otherwise avoid or mitigate nitrogen and sediment pollution to waters. Prescribed and resource ERAs will be assessed against new provisions in the *Environmental Protection Act 1994*, while agricultural ERAs, will be required to self-assess against an offsets policy. A water quality offsets policy would be developed to enable parties to determine whether a significant residual load will result from their activity and require an offset. If no significant residual load exists then there would be no further requirements.

While the *Environmental Offsets Act 2014* allows for additional offsets policies, the preferred approach is to establish a water quality offsets framework under the *Environmental Protection Act 1994*. The preferred approach will be less complex to establish and easier for stakeholders to understand.

Complex amendments of the *Environmental Offsets Act 2014* would be required to include the water quality framework and self-assessable activities. The *Environmental Offsets Act 2014* currently only deals with offsets required under a permit (prescribed activity), and cannot be applied to self-assessable activities. These problems are resolved if water quality offsets are established under the *Environmental Protection Act 1994*. Establishment of the framework under the *Environmental Protection Act 1994* would allow the offset policy to align with the *Environmental Protection Act 1994* terminology and definitions and with the rest of the water quality management framework making it easier to understand for landholders. Because the self-assessable framework would be applied by landholders it needs to be as clear and simple as possible. This would not be the case under the *Environmental Offset Act 2014*.

The framework under the *Environmental Protection Act 1994* will, where possible, utilise tools under the *Environmental Offsets Act 2014* for delivering and securing future offsets. It will also be consistent with the policies and tools relevant to the *Environmental Offsets Act 2014* to avoid duplication and potential confusion, particularly if offsets for both water quality and matters of environmental significance are required for a particular proposal.

The framework under the *Environmental Protection Act 1994* will provide the legislative basis for:

- determining the rights and responsibilities of all parties
- making a water quality offset policy
- outlining a process by which offsets can be assessed and approved
- defining the agency authorised to administer, oversee and enforce offsets.

A water quality offset policy will be established to provide further guidance regarding how offsets will be applied and delivered.

Figure 2 outlines the key steps in a water quality offsets framework that could apply to both new agricultural activities and prescribed and resource ERAs in reef catchments.

Figure 2: Water Quality Offsets Framework

Further work on the development of the water quality offsets policy will be undertaken in consultation with stakeholders. The water quality offsets policy will provide information on how to calculate and deliver a water quality offset. This would include, who the policy applies to, the objectives and principles of the policy, the relationship with other offsets policies, types of offsets, delivery of offsets, monitoring and compliance arrangements, and evaluation and review.

An offsets calculator or look up table would be attached to the water quality offsets policy to support the determination of a significant residual load from agricultural, prescribed and resource ERAs. For agricultural ERAs, the calculator would consider factors such as: area of land that is being expanded, activity type, local and regional climate and topography, as well as management practices and any other avoidance and mitigation proposals. For prescribed and resource ERAs, the calculator

would consider: activity type, release limits and volumes, wet weather bypasses, and any avoidance and mitigation proposals.

The water quality offsets policy would also need to define appropriate offsets ratios to allow for a margin of safety when estimating offset delivery. Offsets ratios are a common mechanism employed when like for like pollutant reduction actions cannot be exchanged on a one-to-one basis. An appropriate offsets ratio ensures that biophysical and scientific uncertainty associated with water quality benefits are not overestimated, and can actually be delivered.

An activity would be required to provide notice to the administering authority nominating the way in which the offset obligation will be delivered. It is proposed that the notice would be kept on a public register to enable transparency and accountability. Failure to notify would be an offence under the *Environmental Protection Act 1994*. In order to lower transaction costs and provide flexibility in managing risks and liability, it is proposed that the activity will be able to notify that they wish to deliver an offset through:

- a financial settlement
- an action determined by the entity undertaking the new activity
- a combination of financial and otherwise as determined by the entity undertaking the new activity, or
- recognition that an offset provided under another State or Commonwealth Act for the same activity also provides a water quality benefit which satisfies the relevant condition (this will avoid 'double dipping').

Where a financial settlement option is chosen, financial settlements would be provided to the Department of Environment and Science and quarantined to ensure that they are used for water quality offsets. Any funds received could be allocated towards management and protection of key environmental areas and functions that contribute to enhanced water quality at the regional landscape scale.

There may also be possibilities for tying into other government, non-government organisation or private initiatives where an offset has dual benefits, e.g., riparian restoration or carbon abatement. Alternatively the fund could approve payments to Reef Trust projects that meet approved delivery arrangement criteria.

Following notification of the proposed offset, and prior to undertaking an activity, agreed delivery arrangements, similar to those under the *Environmental Offsets Act 2014*, would apply. The agreed delivery arrangement would be legally binding upon the person carrying out the agricultural ERA or the holder of the relevant environmental authority. It would be an offence to fail to comply with an agreed delivery arrangement.

There are a range of management actions that have the potential to reduce nutrients and sediments such as: revegetating and stabilising river banks, hillslope reshaping and pasture renovation, building better road surfacing and drainage to reduce the flow of nutrients and sediments into waterways or improving stormwater systems on farms or in urban areas.

The water quality benefits of regulating new activities cannot be precisely calculated due to uncertainty over future economic growth and the associated pollution load. However, it is known, that unmitigated exponential growth in water pollution from new activities, will make it more difficult and more costly to meet the water quality targets.

If sugarcane grows by the estimated 1% a year (as outlined in Section A6.1 in the Appendix 1), then the offsets will result in 186 tonnes of averted dissolved inorganic nitrogen and 25,000 tonnes of averted sediment. The averted sediment from new grazing production is estimated to be 26,000 tonnes for an estimated growth rate of 0.1% per year. The averted pollution from sewage treatment plants is estimated to be around 7.7 tonnes of dissolved inorganic nitrogen a year, or 69.5 tonnes over 10 years, based on population projections for each region. Other prescribed and resource ERAs that commonly cause water pollution are not expected to increase significantly in the ten year analysis period, and therefore are not included in the impact assessment.

The financial costs of averting additional pollution through a water quality offsets framework depend on various factors, such as the willingness of private landholders to supply the offsets. The overall demand for offsets is also important, as the cheapest offsets are taken up first.

An indication of potential costs is provided by the draft Reef Trust calculator. These are based on the benchmarked estimates in Rolfe and Windle (2016), which in turn were based on evaluations of Reef Rescue grants, water quality tenders, water quality improvement plans and bio-economic modelling. The costs of reducing dissolved inorganic nitrogen are assumed to be $150,000/t/year. The risk-adjusted costs are $232,500/t/year – these include a multiplier of 1.55 to account for time delay in the draft Reef Trust calculator. The costs for sediment reduction are assumed to be $259/tonne for all catchments, with a risk adjusted figure of $401/tonne.

The costs to government to develop the framework including the calculator would be $0.84 million in upfront costs and $0.35 million in annual costs. The costs of monitoring, reporting and evaluation activities are to be met by proponent would be incorporated in the cost of an offset where a financial payment was made.

Section A9.2 of Appendix 1 discusses the potential affordability of the proposed regulations on the various sectors, including water quality offsets.

4. Recommended option

The analysis of the costs and benefits of the two options conclude that Option 2 will generate the greatest net benefit to the community.

4.1 Assessment of Option 1

Option 1 is not the recommended option.

In relation to agricultural sources of nutrients and sediment, this option is too limited as it only applies to three of the six Great Barrier Reef regions and only to sugarcane and grazing. In order to significantly improve the trajectory towards the water quality targets, all pollutant contributing land uses must play their part in all catchments. This is particularly the case as the water quality issue is one of many small impacts cumulatively making a larger impact.

While this option does not provide for any additional water quality benefits, it is noted that benefits will continue to accrue from incentives and voluntary effort. However, based on the experience of the last decade, it is anticipated the improvements to water quality from this approach will be too slow to meet the targets. The benefit of a regulatory underpinning is that it will bring all operators up to a minimum baseline, which will enable incentives and voluntary efforts to target even more beneficial practices from a water quality perspective.
Some of the current provisions of Chapter 4A are still valuable, particularly in relation to fertiliser application and record keeping. However, the Environmental Risk Management Plan provisions are not considered suitable to continue. They are overly burdensome in design, for both industry and

government. All producers captured by the requirements are required to prepare the plan regardless of whether they are already operating at best practice. There are also insufficient enforcement provisions. The voluntary BMP programs are valuable as they are a mechanism to demonstrate industry leadership and have resulted in reductions in water pollution.

In relation to the industrial and resources ERAs, the current regulatory approach is generally considered to be effective. However, there is still an issue of residual nutrient and/or sediment pollution for new activities that has the potential to add to the pollution burden, making it more difficult to meet targets. The Voluntary Mechanism Market Based Mechanism for Nutrient Management allows for offsetting to meet standards set within the environmental authority but is both voluntary and doesn't address residual impacts. The water quality offsets proposals in Option 2 address this issue.

4.2 Assessment of Option 2

Option 2 is the recommended option. The benefits of the regulatory proposals justify the costs and generates the greatest net benefit to the community compared to the option of maintaining the current approach. This option proposes a regulatory approach designed to address the cumulative nature of the Great Barrier Reef water quality problem. Successive advice has indicated that the water quality targets required to maintain reef ecosystem health cannot be achieved unless improved practices are achieved more widely and at a much faster rate.

It is designed to complement voluntary efforts and reward and recognise good performers and early adopters through inclusion of an industry-managed pathway for compliance as an alternative way to meet regulatory requirements. It will also complement funding and incentives schemes as recipients of many programs have already undertaken actions that enable them to meet minimum standards.

Option 2 is estimated to cost $131 million per year to government, agricultural producers and industry (sewage treatment plant operators, the banana industry group related to recognition of the industry BMP program, and fertiliser resellers) over 10 years. This is made up of $120 million for agricultural producers, $2 million to the government and $8 million to industry. This includes capital expenditure and administrative costs to agricultural producers and administrative costs to government.

In terms of benefits, this option would result in an estimated financial benefit to agricultural producers of $54 million per year from improved on-farm profitability over 10 years. However, it is important to understand that not all producers are guaranteed to make these profits and some will find related upfront costs difficult to afford. Financial outcomes will vary based on climate, markets and differences between a property's business structure, as well as its biophysical characteristics and other barriers to adoption such as accessing the necessary capital to initiate change.

Implementation of this option would result in significant water quality benefits with the following estimated reductions in nutrients and sediments:

- 1,852 tonnes of dissolved inorganic nitrogen as a result of the minimum practice standards for sugarcane, which is a 13-48% move towards the 2025 water quality target across the reef catchments.
- 1,166,100 tonnes of sediment as a result of the minimum practice standards for grazing, which is a 12-36% move towards the 2025 water quality target across the reef catchments.
- 186 tonnes of dissolved inorganic nitrogen and 25,000 tonnes of sediment from introducing offsets for new sugarcane production, and 26,000 tonnes of sediment from offsets for new grazing production.

- 70 tonnes of dissolved inorganic nitrogen from introducing offsets for increased loads in sewage treatment plants.

The incremental benefit of this change in water quality cannot be monetised at present. However, these load reductions are significant enough to expect to see improved ecosystem health over time as a result of improved water quality. These reductions will also contribute to the resilience of the Great Barrier Reef to recover from other impacts, such as coral bleaching. This in turn helps to protect the valuable commercial benefits derived from the Great Barrier Reef, particularly from the tourism and fishing industries, estimated at $3.9 billion a year. It also helps protect the large non-use and recreation values supported by the Great Barrier Reef that contribute to its combined social, economic and iconic asset value recently estimated at $56 billion (Deloitte, 2017).

While placing a monetary value on the Great Barrier Reef is fraught, the large size of estimated monetised values for the Great Barrier Reef do give an indication of the magnitude of its value. This gives confidence that the gap between monetised costs and benefits in this Regulatory Impact Statement (approximately $456 million in present value over 10 years) is a worthwhile investment to protect and improve the health of the Great Barrier Reef. Accordingly, this option generates the greatest net benefit to the community.

5. Consultation

5.1 Stakeholders

The Office of the Great Barrier Reef has undertaken comprehensive consultation with stakeholders on the proposed changes under the reef regulatory package since August 2016, shortly after the Queensland Government provided in principle support to progress reef regulations. The Office of the Great Barrier Reef established the Agricultural Stakeholder Advisory Group inviting nominations from the key agricultural sectors impacted by the reef regulatory proposals. The Agricultural Stakeholder Advisory Group is comprised of 12 peak agricultural bodies: AgForce, Australian Banana Growers' Council, Australian Sugar Cane Farmers Association, Australian Sugar Milling Council, CANEGROWERS, Cattle Council of Australia, Fertiliser Australia, Growcom, Meat and Livestock Australia, Queensland Farmers Federation, Sugar Research Australia and the Reef Alliance.

The Office of the Great Barrier Reef has also consulted with conservation groups on the development of the proposed regulatory package. Groups include the Australian Marine Conservation Society, World Wide Fund for Nature (WWF), Environmental Defenders Office Queensland and the Queensland Conservation Council. The Office of the Great Barrier Reef has also consulted with peak representatives from urban and industrial sectors including the Australian Prawn Farmers Association, Local Government Association of Queensland, North Queensland Bulk Ports, Property Council of Australia, Queensland Resources Council, Queensland Water Directorate and the Urban Development Institute of Australia. NRM bodies have also been consulted.

5.2 Discussion paper consultation summary

The discussion paper – *Enhancing regulations to ensure clean water for a healthy Great Barrier Reef and a prosperous Queensland* – was publically released by the department for a nine week consultation period between March – May 2017. An extension to mid-May 2017 was provided on request from stakeholders in the Mackay Whitsunday area following damage by Tropical Cyclone Debbie.

The discussion paper outlined the proposed reef regulatory proposals at a high level, with a series of questions provided for stakeholders to respond to. The Office of the Great Barrier Reef held 17 information sessions across all reef catchments with attendees a mix of industry representatives

from the agricultural, urban, industrial and local government sectors. Grower representatives also attended some sessions. The sessions provided an opportunity for key stakeholders to learn about the proposed reef regulations, and provide feedback to guide the development of policy options. Six information sessions were cancelled due to Tropical Cyclone Debbie. Consultation was conducted via telephone in these areas upon request, and departmental officers also attended a previously cancelled meeting with Mackay sugarcane stakeholders.

In total, 48 submissions were received on the discussion paper, with the majority of submissions received from the agricultural sector, and smaller contributions from other key stakeholder groups (Table 5).

Table 5 - Number of submissions from each stakeholder sector

Stakeholder group	Number of submissions
Agricultural stakeholders	18
General public (individuals)	10
Urban development and industrial stakeholders. This stakeholder group includes submissions made by local governments.	8
Conservation groups	6
Research bodies	3
NRM groups	2
Great Barrier Reef Marine Park Authority	1
TOTAL	**48**

5.3 Summary of submissions

There was a wide range of views represented in the public consultation submissions. Submissions and feedback received by all stakeholders and the general public were generally supportive of efforts to protect the reef. Common themes included the ongoing support for BMP or like programs, targeting any regulations to the worst polluting industries and practices, and that minimum practice standards are industry relevant and result in measurable on-ground outcomes. Minimising additional burden on already regulated industries was raised, as well as ensuring water quality offsets don't result in perverse outcomes, increased burden, or confusion with current offsets frameworks. There was also general support across all stakeholder groups and the general public for robust scientific evidence to support the case for regulation.

The majority of submissions also agreed that regulations should encourage innovation and be supported by other measures such as education and extension, incentives and improved water quality monitoring programs. A key concern from submissions was the need for further incentives and continued funding for existing initiatives and programs. Some stakeholders indicated strong support for applying regulations to all relevant agricultural, urban and industrial sectors in the reef catchments.

Some agricultural stakeholders acknowledge the government's proposal to introduce a regulatory approach, while others are strongly opposed to regulation, such as the southern reef catchments (i.e., the Fitzroy and Burnett Mary regions). There was also some concern from NRM bodies regarding the introduction of regulation in those areas. The majority of the feedback received from the agricultural sector supported maintaining the existing voluntary use of BMP programs and incentives.

Urban and industrial stakeholders generally believe their sectors are already heavily regulated for water quality outcomes. They have concerns about additional regulatory burden and cost, referring to the smaller pollutant contribution from their industries compared to the agricultural sector. Some stakeholders did however support continual improvement in standards across the urban and industrial sectors and were not against the review of minimum standards.

Conservation groups support a regulatory approach and want stronger and faster action.

6. Consistency with other policies and regulation

6.1 Consistency with authorising law

The proposed amendments are consistent with the *Environmental Protection Act 1994*.

6.2 Consistency with other legislation

No inconsistencies with other legislation have been identified.

6.3 Competition principles agreement

The guiding principle of the Competition Principles Agreement, under the National Competition Policy is that legislation should not restrict competition unless it can be demonstrated that the:

- benefits of the restriction to the community as a whole outweigh the costs, or
- objectives of the legislation can only be achieved by restricting competition.

The proposed regulations will create differential regulatory arrangements in the market by limiting the regulatory net to certain activities in reef catchments in Queensland. This means operators in these areas will have additional regulatory imposts that are not applicable to businesses in other areas of the state or country.

The rationale for limiting the regulatory net to reef catchments is simple. The pollution is geographically limited. Activities in the reef catchments are the source of nutrient and sediment loads that flow to reef waters, and reducing pollution from these areas will achieve greater improvements in water quality for the Great Barrier Reef. Competing agricultural and industrial activities in other areas of the state and country are not located adjacent to such an important asset and are not having the same effect on an internationally significant resource.

As shown in Appendix 1, the impact on sewage treatment plants is likely to be minimal. Although it is not clear how significant the new regulatory costs are to individual cane and banana businesses, these industries do not have many businesses located outside the Great Barrier Reef catchments. Ninety-four per cent of bananas grown in 2014-15 were from the Wet Tropics region, and much of the remaining production was in other Great Barrier Reef catchments (Harvey et al 2016). Approximately 95% of Australia's sugar production is in Queensland, and over 85% of this production is in the Great Barrier Reef catchments (Harvey et al 2016a). As such, there are not many businesses outside of the regulated industries that are likely to face a competitive advantage from the introduction of the proposed reef regulations.

There is a possible significant regulatory burden on grazing businesses in the Great Barrier Reef compared to other Queensland graziers from the changes to the existing minimum standards. The significance of this burden is not clear as there are many factors involved in affordability, such as large variations in farm financial situations. However, the proposed regulations are still justifiable even if we assume that there is a significant impact. In terms of the principles outlined above:

- As discussed throughout this Regulatory Impact Statement, the Queensland Government believes that the water quality benefits to the Great Barrier Reef justify the potential costs to the grazing industry.
- These objectives can only be achieved by restricting competition as the pollution is geographically dependent. Only grazing properties within the Great Barrier Reef catchments are contributing pollution to the Great Barrier Reef. There is no rationale to extend the regulation to other geographic locations.

7. Fundamental legislative principles

The proposed regulatory framework are consistent with the Fundamental Legislative Principles under the *Legislative Standards Act 1992*. These principles were considered during the development of the proposed regulatory framework. It is not intended to create inconsistencies with maintenance of 'the rights and liberties of individuals, and the institution of Parliament' as laid out in the Fundamental Legislative Principles. Whilst the preferred option includes record keeping requirements that will facilitate compliance activities, these do not breach the Fundamental Legislative Principles.

8. Implementation, evaluation and compliance support strategy

8.1 Implementation

It is proposed that the implementation of minimum standards be phased in over time starting with sugarcane, grazing and bananas across all reef catchments once the regulatory package commences in 2018. Minimum standards for grains and horticulture will commence at a later date.

The following transitional arrangements will be implemented:

- **Environmental Risk Management Plans**: Currently accredited Environmental Risk Management Plans will lapse when they expire. As at 31 August 2017 there were eight cane plans still accredited, which are due to expire by November 2017. There are also 20 grazing plans still accredited, which are due to expire at the end of August 2018.
- **Existing sugarcane production**:
  - Stage 1 management practices on commencement of the regulation for all reef catchments except the Burnett Mary (as well as Cape York and Fitzroy where it is not typically grown).
  - Stage 2 management practices within two years of the commencement of the regulation for all reef catchments.
- **Expanding or intensifying sugarcane production**:
  - Stage 2 management practices on commencement of the regulation.
- Stage 2 management practices plus offset for significant residual loads on commencement of offsets policy.
- **New sugarcane production**
  - Farm design standards plus Stage 2 management practices on commencement of the regulation.
  - Farm design standards plus Stage 2 management practices plus offset for significant residual loads on commencement of offsets policy.
- **Existing grazing and banana production** – Management practices within one year of commencement of the regulation.
- **Expanding or intensifying grazing and bananas:**

    - Minimum standards on commencement of the regulation.
    - Minimum standards plus offset for significant residual loads on commencement of the offsets policy.
- **New grazing and bananas**:
    - Farm design standards plus management practices on commencement of the regulation.
    - Farm design standards plus management practices plus offset for significant residual loads on commencement of offsets policy.
- **Existing, new, expanded or intensified horticulture and grains** – Minimum standards to be developed.
- **New industrial development:** offset for significant residual loads on commencement of the offsets policy.

8.2 Evaluation

Several measures will be used to evaluate water quality improvements, and therefore the effectiveness of the framework, relative to the current situation. These include:

- The proposal to review the management standards for agricultural ERAs in alignment with the five year review of the Reef 2050 Water Quality Improvement Plan and Scientific Consensus Statements.
- Great Barrier Reef Report Cards use information from the Paddock to Reef Monitoring and Modelling Program. This program measures and reports on progress towards the Reef 2050 Water Quality Improvement Plan goal and targets, including the water quality targets and identifies whether further measures are needed to address reef water quality.
- Future updates of the Scientific Consensus Statement will continue to comprehensively review and assess the latest scientific evidence for water quality in reef catchments. These will help inform any updates, where required, to the prioritisation of reef catchments with regards to the risk analysis of pollutant loads.

8.3 Compliance

A risk based compliance program that will cover the proposed new reef regulations has been developed by the Department of Environment and Science. The additional cost to the compliance program from the reef regulations (i.e., additional to current compliance) is assumed to be approximately $1.65 million per year based on the current budget. A compliance prioritisation model is used by the Department of Environment and Science in order to target high-risk sites.

The current compliance program under Chapter 4A of the *Environmental Protection Act 1994* is targeted at sugarcane activities across three reef catchments. As a result of the proposed regulations, compliance against Chapter 4A will broaden to include grazing, bananas, horticulture and grains as agricultural ERAs within all six reef regions. Proactive compliance activity is undertaken by the Department of Environment and Science on a risk basis, with targeted activities notified in an annually prepared compliance plan.

It is proposed that the following will assist in the compliance approach:

- Desktop audits, maps, and satellite imagery to assist in compliance planning and prioritisation.
- Minimum standards will include sufficient record keeping which can be provided on request.
- Guidance material will be developed to describe what is meant by an agricultural ERA (for existing and new activities), and what records or data may be used to demonstrate compliance with an agricultural ERA.

- Incorporating meaningful thresholds in compliance prioritisation that can be easily adapted to changes in risk e.g., region, activity, proximity to watercourses, and temporal seasons.

The following enforcement tools will be available to remedy non-compliance with minimum standards for agricultural ERAs:

- penalty infringement notices
- transitional environmental programs
- direction notices
- environmental protection orders
- investigation and prosecution

Non-commercial activities, such as hobby farms, are required to meet the 'general environmental duty' under the *Environmental Protection Act 1994*, which is an obligation for all companies and individuals In Queensland. The Department of Environment and Science can require remedial action under the *Environmental Protection Act 1994* regarding general water quality pollution issues, should an issue arise.

Agricultural ERAs accredited under recognised BMP or like programs will not be the focus of government compliance programs. However, the department will retain compliance and enforcement powers and the ability to request records.

Prescribed and resource ERAs are already subject to a compliance program, which will include the new requirements for these activities, when they commence.

Glossary

Terms	Meaning
35 river basins	Within the six reef regions there are 35 major river basins. River basins are often referred to as catchments.
ABCD framework	ABCD management practice frameworks were first developed in 2008 to represent different levels or standards of management practice within different industries for different water quality parameters (i.e. sediment, nutrients and chemicals). The 2013 water quality risk frameworks replace the ABCD frameworks with an equivalent risk to water quality: A = Lowest risk; B = Moderate-Low risk; C = Moderate risk; D = High risk.
Best Management Practice (BMP)	Best management practices articulate a reasonable best practice level which can be expected to result in a moderate-low water quality risk.
Catchment	An area of land bounded by natural features such as hills, from which drainage flows to a common point, usually ending in a river or creek and eventually the sea. Reef catchments are any terrestrial areas that drain into the Great Barrier Reef Marine Park.
Catchment loads	Catchment loads are an estimated measurement of the amount of a pollutant, e.g., nutrients or sediments, flowing past a defined end point of a catchment. They are most often calculated based on measurements made at monitoring stations in waterways.
Diffuse pollution	Non-point source pollutants (i.e., without a single point of origin or not introduced into a receiving stream from a specific outlet). The pollutants are generally carried off the land by stormwater. Common non-point sources are agriculture, forestry, urban areas, and historical mining sites.
Environmental Authority	An approval, issued under the *Environmental Protection Act 1994*, for an environmentally relevant activity.
Environmentally Relevant Activity (ERA)	An activity which, when carried out, may release a contaminant that may cause environmental harm. A list of ERAs is contained in Schedule 2, 5 and 6 of the Environmental Protection Regulation 2008.
Expansion	Increasing the size or scale of an activity that may increase the relative contribution to dissolved inorganic nitrogen or sediment loads, unless a better management standard is incorporated.
Great Barrier Reef Report Card	An annual report card which measures progress towards the goals and targets in the Reef Water Quality Protection Plans and now the Reef 2050 Water Quality Improvement Plan 2017-2022. The 2015 Great Barrier Reef Report Card is the latest progress report.
Intensification	Increasing the inputs or outputs of an activity that may increase the relative contribution to dissolved inorganic nitrogen or sediment loads.
Minimum standards	The minimum practice standards that are acceptable when carrying out an activity.
Natural Resource Management (NRM) region	The six NRM regions that cover the Great Barrier Reef are: Cape York, Wet Tropics, Mackay Whitsunday, Burdekin, Fitzroy and Burnett Mary. The reef regions are often referred to as reef catchments.
Nutrients	Nutrients are the natural chemical elements and compounds that plants and animals need to grow. Carbon, hydrogen and oxygen are abundant nutrients in nature, but nitrogen and phosphorus are not always so freely available. They promote plant growth, making

Terms	Meaning
	increased levels (e.g. from excess fertilisers) an issue for the Great Barrier Reef. Dissolved inorganic nitrogen is the key concern for reef water quality impacts.
Point source pollution	Any discernible confined and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, discrete fissure, or other discrete source where pollutants are or may be discharged. For example a sewage treatment plant is a source of point source pollutants.
Pollutant loads	A measurement of land-based run-off entering the Great Barrier Reef lagoon, for example nutrients and sediments.
Reef 2050 Long-Term Sustainability Plan (Reef 2050 Plan)	The Reef 2050 Long-Term Sustainability Plan is a joint Australian and Queensland government overarching strategic document. The plan states tangible outcomes, objectives and measurable targets identified across seven themes: biodiversity; ecosystem health; heritage; water quality; community benefits; economic benefits and governance, to form an integrated management framework.
Reef Water Quality Protection Plan	This is a joint Australian and Queensland government strategic plan for water quality. The plan sets targets for improved water quality and land management practices and identifies actions to improve the quality of water entering the reef. The plan was originally established in 2003 and is updated every five years. The Reef Water Quality Plan 2013 will be replaced by the Reef 2050 Water Quality Improvement Plan 2017-2022. This plan supports the water quality theme under the Reef 2050 Long-Term Sustainability Plan.
Regulatory Impact Statement	A systematic approach to critically assessing the expected impacts of proposed regulatory policy options. Regulatory Impact Statements are prepared in accordance with *The Queensland Government Guide to Better Regulation.*
River basin targets	The water quality targets will be updated to take into account finer scale monitoring and modelling. The targets will be set for each of the 35 river basins. These targets are based on marine water quality objectives.
Scientific Consensus Statement	The 2017 Scientific Consensus Statement: Land use impacts on Great Barrier Reef water quality and ecosystem condition is a foundational document which provides the scientific understanding underpinning the (draft) Reef 2050 Water Quality Improvement Plan 2017-2022. It was collated by a multidisciplinary group of scientists, with oversight from the Independent Science Panel. The 2017 Scientific Consensus Statement provides an update to the last statement published in 2013.
Sediments	Sediments in water are measured as 'total suspended solids' or 'total suspended sediment', and are characterised by different particle sizes, for example, clay, silt and sand. It is the fine fraction (silt and clay) that is of greatest concern to marine ecosystem health. Fine (<16 µm) sediment moves furthest into the marine environment. This leads to increased turbidity and reduced light for seagrasses and coral, reducing their growth. When this sediment settles, it can have detrimental effects on the early life stages of corals, and in more extreme conditions, can smother corals and seagrass.
Water quality	The chemical, physical, biological and radiological characteristics of water. It is a measure of the condition of water relative to the

Terms	Meaning
	requirements of one or more biotic species and/or to any human need or purpose.
Water Quality Improvement Plans	Water Quality Improvement Plans support delivery of the Reef 2050 Water Quality Improvement Plan. They are designed to identify the main issues impacting waterways and the marine environment from land-based activities. They also identify and prioritise management actions to meet the objectives of the Reef 2050 Water Quality Improvement Plan.
Water Quality Risk Frameworks	The Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (Paddock to Reef program) has developed water quality risk frameworks for each agricultural industry based on the ABCD framework.

Appendix 1: Impact assessment

A1. Introduction

This impact assessment is in three main parts.

- Sections A3, A4 and A5 outline the costs and benefits of expanding the definition of an agricultural ERA and introducing new minimum standards.
- Sections A6, A7 and A8 outline the costs and benefits of regulating new, expanding or intensifying, agricultural, prescribed and resource ERAs.
- Section A9 discusses the overall costs and benefits for the proposed regulations.

This assessment estimates costs for both the regulated activities and for the government. Please note that the costs allocated to landholders in this assessment may or may not be borne by landholders as there are many incentive schemes currently available and planned for the future. For example, the Reef Trust funding supports farm action for improved water quality through grants and reverse auctions across the Great Barrier Reef. There are also current and planned extension programs to assist landholders with meeting their regulatory obligations.

Some landholders will already be undertaking some or all of the proposed regulated activities and will, accordingly, have lesser impacts. However, the costs in this analysis are likely to be indicative of the possible overall costs if all commercial operators in all the Great Barrier Reef catchments are included in the regulations.

A2. Background assumptions

This section describes the background assumptions that underpin the calculations in the rest of the assessment.

The assessment period is 10 years, with regulations coming in at different stages, as outlined throughout this Appendix. The costs and benefits are restricted to Queensland. However, there are significant social and economic benefits of the Great Barrier Reef to other parts of Australia and the rest of the world, as discussed in Section A9.1.

The value of time used for landholders and industry is the average of all industries from the Australian Bureau of Statistics employee earnings and hours summary from May 2016 (ABS 2017). This figure is an approximation of the indicative worth of an hour's time for an individual. The average is $49.35 per hour including 24% on-costs and superannuation. Government time was based on hourly rates per staff level with on-costs, leave and superannuation included.

The number of commercial agricultural activities and total area for the key industries are shown in Table 6.

Table 6 - Number of landholders and area by industry

Region	Industry	Number	Area (ha)
Cape York			
	Grazing	48	2,160,000
Wet tropics			
	Grazing	935	698,000
	Sugarcane	1,343	136,000
	Bananas	260	11,000
Burdekin			
	Grazing	983	12,400,000

Region	Industry	Number	Area (ha)
	Sugarcane	556	83,000
Mackay Whitsunday			
	Grazing	416	304,000
	Sugarcane	1,380	136,000
Fitzroy			
	Grazing	3,666	12,700,000
Burnett Mary			
	Grazing	2,495	2,660,000
	Sugarcane	498	86,000
TOTAL			
Grazing		8,543	30,922,000
Sugarcane		3,777	441,000
Bananas		260	11,000
TOTAL		**12,580**	**31,374,000**

(Great Barrier Reef Report Card 2015)

Agricultural management practices are categorised in this analysis by the Reef 2050 Water Quality Improvement Plan water quality risk frameworks. In general these practices are referred to as A, B, C and D, as seen in Tables 7 and 8.

Table 7 - Paddock to Reef classification of management practices in the sugarcane industry

Water quality risk	Lowest	Moderate-Low	Moderate	High
	A	B	C	D
	Innovative	Best practice	Minimum	Superseded

(Alluvium 2016)

Table 8 - Paddock to Reef classification of management practices in the grazing industry

Water quality risk	Very low	Low	Low to moderate	Moderate to high
Resource condition objective	Practices highly likely to maintain land in a good **(A)** condition and/or improve land in lesser condition	Practices are likely to maintain land in good or fair condition **(A/B)** and/or improve land in lesser condition	Practices are likely to degrade some land to poor **(C)** condition or very poor **(D)** condition	Practices are highly likely to degrade some land to poor **(C)** condition or very poor **(D)** condition

(Alluvium 2016)

The figures in Tables 9 and 11 represent the approximate number of landholders in each water quality practice category. These figures are the best estimates from the Department of Agriculture and Fisheries, but as they are a composite of a variety of sources, do not always match the numbers in Table 6. They are largely based on 2014 data. In reality, landholders might use a variety of practices that are likely to align to more than one risk category.

Table 9 - Number of landholders in each practice category - grazing

Region	A	B	C	D
Wet Tropics	117	117	584	0
Burdekin	10	274	527	172

Region	A	B	C	D
Mackay Whitsunday	18	129	146	123
Fitzroy	154	502	2,122	888
Burnett Mary	120	1,142	1,202	30

(Personal correspondence Department of Agriculture and Fisheries 2017)

Table 10 - Area in each practice category - grazing

Region	A	B	C	D
Wet Tropics	56,109	99,712	542,179	0
Burdekin	47,951	3,559,969	7,331,415	1,460,666
Mackay Whitsunday	17,147	125,257	72,861	88,735
Fitzroy	1,001,821	1,686,730	6,247,733	3,763,716
Burnett Mary	44,236	1,171,490	1,443,697	578

(Personal correspondence Department of Agriculture and Fisheries 2017)

Table 11 - Number of landholders in each practice category - sugarcane

Region	A	B	C	D
Wet Tropics	25	37	1,214	68
Burdekin	17	17	445	78
Mackay Whitsunday	0	199	1,107	74
Burnett Mary	10	41	360	85

(Personal correspondence Department of Agriculture and Fisheries 2017)

Table 12 - Area in each practice category - sugarcane

Region	A	B	C	D
Wet Tropics	3,278	4,350	124,178	4,648
Burdekin	2,492	4,153	68,105	8,306
Mackay Whitsunday	0	12,455	101,705	4,344
Burnett Mary	409	10,331	64,842	10,804

(Personal correspondence Department of Agriculture and Fisheries 2017)

Data for Cape York is not as readily available as for other regions. Where necessary, assumptions have been made about the possible costs of the regulations for this region, and are noted in the text.

It is assumed that current regulations have a 100% compliance rate, and that the new regulations will similarly have a 100% compliance rate. Although there may be non-compliance with the current regulations, it is likely there will be some non-compliance with the new regulations as well. This does mean that some costs and benefits will be over- or under-estimated. Where this is likely, it is noted in the text.

The costs and benefits in this assessment have drawn heavily on the modelling in a significant recent report *Costs of achieving the water quality targets for the GBR* (Alluvium 2016). This report was the result of a large study that used the best information available to estimate the costs and benefits of meeting the Queensland Government's water quality targets. It did this through evaluating seven policy interventions (or solution sets) using a consistent process across the Great Barrier Reef catchments. The estimates were peer reviewed by staff from the Departments of Environment and Science, Agriculture and Fisheries, Natural Resources and Mines and Science, Information

Technology and Innovation and economists from the GBR Taskforce as well as other national and international experts.

The policy intervention used as the basis for many of the estimates in this Regulatory Impact Statement is the land management practice change set. These practice changes are outlined in Tables 13 and 14. At times there are some differences in the practices Alluvium have included in their practice change estimates and the proposed regulatory changes from the Department of Environment and Science.

Table 13 - Changes in management practices for nutrient management in sugarcane - Alluvium 2016

D to C (high risk to moderate risk)	C to B (moderate risk to low risk)
Rule of thumb N rates now based on soil tests and 6ES	Better timing of nutrient applications
Investment in a stool splitter for sub-surface nutrient application rather than surface applied	Electronic record keeping and calibration undertaken regularly
Written records are undertaken	Geo-referenced soil testing with hand held GPS
Soil tests are undertaken and fertiliser is based on District Yield Potential (DYP)	Include legume and mill mud application in N budget
Calibration of fertiliser boxes at the start of the season	Drop N rates to farm yield potential (FYP) – below 6ES standard
Risk assessment before applying nutrients	Apply different nutrient regimes between paddocks
Legume N contribution recognised in N budget	Develop a nutrient management plan

Table 14 - Changes in management practices for sediment management in grazing lands - Alluvium 2016

Land management practice category	Changes in management practice
Moderate to high risk to low to moderate risk (D-C)	Long-term stock and stocking rate records documented in diaries, paddock records etc. Land condition is assessed based on pasture yield, and of dry season cover.
	Numbers in each paddock recorded annually. Use common sense and rules of thumb to account for effects of animal class and size/age.
	Some land types are managed separately.
	Residual cover is managed by observed amount of pasture and ground cover at the end of the dry season and try to keep enough residual pasture for stock.
Low to moderate risk to low risk (C-B)	Most of the different land types are managed separately. Numbers in each paddock recorded at each muster. Account for different animal class and size/age.
	Objective measure of safe stocking rate calculations, including property map and based on historical data, subjective assessment of resource condition.
	Use long-term experience to look at stock numbers and pasture available in each paddock after the wet season. Cattle numbers adjusted to ensure adequate residual pasture and ground cover at break of season.
	Regularly observe ground cover, density of 3P (palatable, perennial and productive) grasses and land condition. Aim to maintain paddock and ground cover specific to region, rainfall and land type.

Land management practice category	Changes in management practice
	Fencing is implemented to manage selectively grazed areas also use wet season spelling and use of fire and 'lick' to even out grazing.
	Pastures/paddocks wet seasoned spelled on a regular basis.
	Stocking rates and frequently used pasture spelling are used to recover degraded country.

It is important to note that there are limitations to the Alluvium analysis. In particular, average figures have been used, whereas in reality there are significant differences between the costs different properties face depending on factors such as farm size, geographical location, financial situation and past investment in various management activities. This flat rate does not take into account the reduction in the cost-effectiveness per tonne of pollution abated as adoption of the management practices approaches 100%. The impact of climate was not considered. As a result, these costs should be seen as indicative of the possible range of costs rather than a definitive answer on the total or individual costs.

The assumption that A, B, C, D land management practices lead to A, B, C, D land condition has not yet been confirmed due to time lags between management changes and system response. Similarly, the relationship between ground cover and management class is complicated. Some grazing properties might have high ground cover even with higher risk and practices, and vice versa.

The analysis uses a constant dollar approach where annual values are based on the current year (i.e. no inflation is included). A discount rate of 7% has been used in the overall analysis.

Please note that throughout this analysis rounding of figures presented in the text has occurred. This means that the totals in the various tables may be slightly different than would be expected.

A3. Costs of minimum practice standards for agricultural ERAs

It is proposed that the *Environmental Protection Act 1994* is amended to provide the ability to apply minimum practice standards targeting nutrient and sediment pollution for key industries across the Great Barrier Reef. There are proposals to update and expand existing standards for sugarcane and grazing, and introduce a minimum standard for bananas. Details on these proposals are in Sections A3.1-3.3. The proposed practice standards are outlined in Appendix 4.

Proposed farm management standards for horticulture and grains have not yet been developed, and are not discussed in this impact assessment. This analysis assumes that only commercial operators will be subject to the regulations. If non-commercial properties are included, then the costs will be higher than discussed here.

Landholders will be able to meet the new minimum standards either through complying with the standards or through becoming accredited against a recognised industry BMP or like program. The practice changes under the BMP accreditation option will be the same. There would be a small additional cost in time for landholders seeking BMP accreditation. However, landholders may choose to participate in BMP programs to lower their risk profile and probability of being targeted for compliance, or for the broader benefits associated with BMP programs. Landholders who join BMP programs may also be seeking to meet other outcomes, such as the sustainability criteria for supplying biofuels. As it is not possible to determine how many landholders will choose to participate in recognised BMP or like programs to meet the regulatory requirements, this has not been costed. The costs are based on self-regulation.

A3.1 Sugarcane new minimum standards

There will be two main stages in the proposed minimum standard changes for sugarcane. Stage 1 is revised minimum standards, and Stage 2 consists of more refined nutrient management. Stage 1 would commence as soon as the regulatory package commences, while Stage 2 would be introduced after two years.

For Stage 1, the key differences between the current regulations for the Wet Tropics, Burdekin and Mackay Whitsunday regions and the proposed minimum standards are the requirement to ensure no ground based broadcast fertiliser application, calibrate fertiliser boxes, and also the use of measures that will minimise the release of soil to receiving waters. It is assumed these are the only additional cost for the currently regulated catchments from moving to the new minimum standards. It is assumed these are C level practices, so the cost will only fall upon those in the D management category in the Wet Tropics, Burdekin and Mackay Whitsunday regions.

This assessment assumes that the three regulated catchments have full compliance, which may not be the case, as in reality compliance levels are known to vary. As such, if any currently non-compliant landholders in the Wet Tropics, Burdekin or Mackay Whitsunday become compliant under the proposed regulations, then the costs and benefits will not have been captured.

The requirement to ensure no ground based broadcast fertiliser applications has not been costed. This is because only a very small number of sugarcane farmers are estimated to be undertaking this practice, and as such, the overall cost is likely to be small.

The cost of minimising sediment release to receiving waters cannot be estimated as it is not known precisely which activities will be required on various properties. For example, minimum tillage may be appropriate for some properties, but the number is unknown as the appropriateness is determined by soil type. However, costs should be reasonably low as appropriate mitigation should be relative to the farming system in place. Requirements wouldn't include changes to farm design or machinery (such as controlled traffic). The standards also allow farmers to choose one of three main management options (green cane trash blanketing, laser levelling away from watercourses or recycling pit/constructed wetlands to capture run-off), and most properties are probably doing one of these actions already. Similarly, the rules that are applicable for the areas with over 3% slope are likely to be carrying out one of the new required practices already.

The additional calibration costs have been estimated for the three currently regulated regions (Table 15). It has been assumed that all fertiliser boxes are already set up, and that the additional cost is performing the calibration. The calibration exercise is assumed to take 20 minutes three times per season (i.e., once prior to the season, and then twice more throughout the season). Mechanical drive controllers then take an hour to calibrate, whereas the time for an electronic controller is probably minimal, so is not costed here. The proportion of the industry that has an electronic controller is assumed to be 70%, and the mechanical drive 30%.

Table 15 - Additional costs of fertiliser calibration

Region	Calibration costs ($ total)	Adjustment to mechanical drive ($ total)
Wet Tropics	3,020	3,020
Burdekin	3,465	3,465
Mackay Whitsunday	3,287	3,287
TOTAL	**9,772**	**9,772**

All catchments, including the currently unregulated Burnett Mary catchment will be required to meet the Stage 2 minimum standards within two years of the regulation commencing. This is assumed to be a new regulation and a new cost for every region. However, it is known that a number of growers already undertaken nutrient management planning. For the purposes of this impact assessment, the actions required under the new nutrient management plan requirement are assumed to be similar to those outlined as B class practices by Alluvium in Table 13.

For the Burnett Mary, the revised current minimum standards will apply for the first time, and as such all costs are additional.

As shown in Table 16, the cost to complete initial soil testing, mapping and nutrient management plans to move from class D to C is approximately $8,000 per farm (Alluvium 2016). For subsequent years it would be $2,000 per farm. After five years, a new round of soil testing, mapping and nutrient management plans are completed, with the lower cost for the subsequent years again.

The total costs to the Burnett Mary region of moving from class D to C (Stage 1) would be approximately $680,000 as an initial cost, and $170,000 per year as an ongoing cost.

Table 16 - Cost of nutrient management planning (D to C practices)

Activity	One-off cost* ($/property)	Ongoing cost^ ($/property)
Soil testing, mapping and nutrient management plans	8,000	
Soil testing, mapping and nutrient management plans		2,000

*this needs to be done every five years ^this cost is incurred in the years in between soil testing and nutrient management plans (Alluvium 2016)

The costs for the Stage 2 minimum standards are shown in Table 17 as a per hectare cost, and also as a total for each region. The capital costs have accounted for any new required machinery or infrastructure to implement the new management actions, such as a rotary hoe and variable rate fertiliser box. The changes in farm profits are the changes in income as a result of the changed management practice minus the direct costs of growing the crop. There are high capital costs of $142 million, and ongoing costs of $14 million a year. However, these are expected to be more than offset by increased profits of $54 million a year. Caution needs to be taken in interpreting the change in farm profits, as discussed in Section A5.3. The “most likely” estimates from the range presented by Alluvium have been used.

Table 17 - Cost of moving sugarcane C-B

Region	Capital cost ($ /ha)	Total capital costs ($)	Maintenance cost ($/ha/year)	Total maintenance costs ($/year)	Change in farm profit ($/ha/year)	Total change in profits ($/year)
Wet Tropics	114	14,686,164	11.4	1,468,616	60	7,729,560
Burdekin	372	28,424,892	37.2	2,842,489	74	5,654,414
Mackay Whitsunday	281	29,799,769	28.1	2,979,977	294	31,178,406
Burnett Mary	920	69,594,320	92	6,959,432	245	18,533,270
TOTAL		**142,505,145**		**14,250,515**		**63,095,650**

Alluvium (2016). These calculations include all area in categories C and D (as D would have been regulated to a C class).

A3.2 Grazing new standards

For grazing, the new minimum standards most closely align with the B standard management practices. Table 14 outlines the management practices required for category B in the Alluvium report. There is a proposed 12 month period before these regulated standards come into effect.

It is likely that these costs are an underestimate, as the price of cattle (and thus the opportunity cost of reducing cattle numbers to increase ground cover) has increased since the Alluvium work was carried out (Central Queensland University, personal correspondence). Another reason that these costs are likely to be an underestimate is because the Alluvium modelling assumed that any infrastructure work to stabilise streambanks or remediate gullies that was necessary to achieve the shift from D to C management practice would already have been carried out. There is no clear way to calculate what these costs would be under the new regulations. These costs are potentially high. Note that the proposed approach focuses on preventing accelerated erosion and the management of run-off by maintaining high levels of ground cover.

Producers in class D are assumed to move first to class C, and then they are included in the costs of moving from C to class B (Table 20). The "most likely" estimate from the Alluvium modelling is used here. For graziers, a key cost involved in moving from class D to C practices in the Alluvium modelling is maintaining ground cover of 30% at all times throughout the year. This costs approximately $4,000 a year per property for the five years that the Alluvium Report identified as the length of time that it takes to move to class C condition. There is a property planning cost of $8,000 for the five year period, which includes mapping of land types, cover and calculation of long-term carrying capacity, infrastructure and current erosion issues. These costs are only applicable to those landholders in class D moving to class C. These costs are summarised in Table 18.

Table 18 - Cost of moving from D to C practices per property - grazing

Activity	Annual cost ($/year over five year per property)
Management planning	1,600
Achieving 30% cover	4,000

Alluvium 2016

This is a cumulative cost of $6.8 million for the Great Barrier Reef catchments per year for five years as shown in Table 19.

Table 19 - Cost of moving from D to C practices - grazing

Region	Total annual costs ($)(five years)
Cape York	37,632
Wet Tropics	0
Burdekin	963,200
Mackay Whitsunday	688,800
Fitzroy	4,972,800
Burnett Mary	168,000
TOTAL	**6,830,432**

(For Cape York, it is assumed the same proportion in each management class as the Burdekin)

In addition to moving from class D to C practices, the proposed minimum standards for grazing include a shift to many class B practices. The total costs assume that all the properties that moved from class D into class C need to move to class B, as well as those currently in class C. As not all class B practices are regulated, these costs are likely to be over-estimates.

The changes in farm profit represent the forgone income for landholders taking cattle out of production. Improved land condition is expected to lead to improved profitability in the long term (>15 years) (Eberhard et al 2017), which means that in time these ongoing costs should fall. However, this is outside the time period for this analysis.

The total cost of moving from C to B class practice is $148 million in capital costs and then an ongoing $32.5 million per year as shown in Table 20. The annual costs are maintenance costs plus the loss in profits. These total figures are high due to the large land area taken up by grazing. On a per hectare basis (also presented in Table 20) the costs are not as high. They range from $5.54-$27 per ha for capital costs (depending on the region), with an assumed 10% cost in annual maintenance, and ongoing costs of $0.6 to $3 per ha in reduced profits.

Table 20 - Cost of moving from C to B practices - grazing

Region	Capital cost ($/ha)	Maintenance cost ($/ha/year)	Change in farm profit ($/ha/year)	Total capital costs ($)	Total annual costs ($/year)
Cape York*	5.54	0.554	-0.6	10,889,424	2,268,302
Wet Tropics	27	2.7	-3.1	14,638,833	3,144,638
Burdekin	5.54	0.554	-0.6	48,708,129	10,146,061
Mackay Whitsunday	27	2.7	-3	4,363,092	921,097
Fitzroy	5.54	0.554	-0.6	55,463,427	11,553,212
Burnett Mary	10	1	-2.1	14,442,750	4,477,253
TOTAL				148,505,655	**32,510,563**

Alluvium 2016; DAF figures for area of D and C practice.
*Assumed the same costs and proportion in classes C and D for Cape York as in the Burdekin

A3.3 Bananas new standards

The practices proposed for the banana industry are a mix of practices aligning with both C and A/B reef water quality standards. There has been less economic analysis carried out on best management practices for bananas than for the sugarcane and grazing industries, and robust estimates of the costs of the practices for an average property do not exist (Harvey et al. 2016). For this reason, the costs of the minimum standards have not been calculated here.

Overall, the studies that have been done suggest that there are financial benefits to carrying out best management practices. Van Grieken et al. (2010) found that there was a large gain in net present value for banana growers moving from D to C practices and C to B practices, but not from B to A practices. Similarly, case studies carried out by the Department of Agriculture and Fisheries in 2016/17 (Cook et al. 2016; Cook and Kukulies 2016a; Cook and Kukulies 2016b) and the Department of Natural Resources and Mines in 2013 (Armour et al. 2013a) found that there were financial benefits to moving to best management practices, such as reduced fertiliser application, grassed inter-rows, laser levelling, sediment traps and the use of canola as a fallow crop. The financial benefits were realised through reduced costs such as reduced fertiliser, labour and fuel costs. Alternatively, one study found that grassed inter-rows led to a small decrease in gross margin (though had a large impact on water quality) (Roebeling et al. 2007).

Many of the proposed best management practices for banana farming concern appropriate fertiliser application rates (and supporting practices such as soil and leaf testing, calibration of fertiliser equipment and application to beds and not inter-rows) that would be expected to produce a net financial benefit. However, despite the evidence suggesting that the practices might be financially

beneficial in the short term, it is estimated that only just over half of the banana growing area in the Wet Tropics follows best management practice (Great Barrier Reef Report Card 2015). This indicates that either the financial benefits are not as high as suggested or that there are other barriers to adoption. For example, access to credit might be difficult for some growers. Non-financial barriers are discussed in Section A5.3.

Some other practices around sediment management may or may not carry a financial benefit; however, as with the standards for cane it is expected that the flexibility of the standards will allow for mostly beneficial works to be carried out.

Although this impact assessment hasn't costed participation in recognised BMP or like programs to meet regulatory requirements, the banana BMP program will still have to be established as part of the proposed alternative pathway for producers to meet regulatory requirements. It has been assumed that it will take two staff members from the Australian Banana Growers Council one month to finalise the details of their BMP program for recognition with the Department of Environment and Science. This is a one-off cost of $15,792.

A3.4 Learning costs

The transaction costs (or indirect costs) of complying with regulations may be significant (Table 21). For example, Coggan et al. (2014) found that the transaction costs associated with the Reef Rescue funding program were 38% of the funding received: $8,389 on average per farm. A significant proportion of this cost was simply seeking information about the required activities. Similarly, the reef regulations will impose a cost burden on landholders who need to find out what the regulations entail and understand what they need to do to comply. It has been assumed this takes one day per property, at a cost of $395 per property. These figures include all the properties in Table 6.

Table 21 - Learning costs associated with new regulations

Region	One-off cost ($) per region
Cape York	18,951
Wet Tropics	1,002,043
Burdekin	607,622
Mackay Whitsunday	709,090
Fitzroy	1,447,395
Burnett Mary	1,181,684
TOTAL COST – all GBR catchments	**4,966,785**

A3.5 Record keeping

In addition to the costs of moving to best management practice, there is a cost to all landholders of demonstrating they meet the regulated standards, either through gaining BMP accreditation, or through their own adequate record keeping. Some of these records are mandated. In other cases, landholders will probably choose to keep records in order to demonstrate that they are compliant. The cost of additional record keeping is estimated here.

For sugarcane growers in the Wet Tropics, Mackay Whitsunday and Burdekin regions, there is no additional cost as they are already obliged to keep records. For growers in the Burnett Mary, this cost is estimated to be around three hours over the course of the season. This is a cost of $148 per property, or $73,732 for the region.

For graziers, the BMP accreditation process involves an estimated five days to carry out record keeping and gather together the required information. As not all records would be required for the proposed new regulations, an estimate of three days (eight hours per day) is used for the potential

costs of the record keeping required by the new regulations. This cost is $1,184 per property. This is assumed to be a one-off cost, with a one-day time commitment in following years to update records. It has been assumed that this cost applies to all graziers in all catchments as the record keeping requirements are different to the current requirements.

Additional costs for all regions are shown in Table 22.

Table 22 - Additional cost of record keeping - grazing

Region	Total one-off cost ($)	Total ongoing costs ($)
Cape York	56,854	18,951
Wet Tropics	1,107,459	369,153
Burdekin	1,164,312	388,104
Mackay Whitsunday	492,730	164,243
Fitzroy	4,342,186	1,447,395
Burnett Mary	2,955,198	985,066
TOTAL	**10,118,739**	**3,372,913**

There are non-quantified costs and benefits to this record keeping. A benefit is that good records allow for better management decisions to be made in the future. However, there is also a non-financial hassle factor to having to record actions at the end of a work day.

Banana growers are already obliged to keep extensive records, as part of the Banana BMP Environmental Guidelines (King, 2016). For this reason, no additional costs have been recorded.

A3.6 Compliance inspection

There is also a cost to being inspected for compliance with the new regulations. The number of compliance inspections of sugarcane properties in the three currently-regulated catchments (Wet Tropics, Burdekin and Mackay Whitsunday) in recent years was used as a guide. The cost of a compliance inspection to the landholder is the time taken. This time effort has been based on the time it takes to be audited for the BMP accreditation (or the Freshcare standard for bananas), which is approximately two and half hours for sugarcane and bananas, and one day (eight hours) for grazing.

The inspection costs for sugarcane and grazing have only been applied to the newly regulated catchments (Cape York, Fitzroy and Burnett Mary) as a compliance program is already being implemented in the other regions (Table 23).

Table 23 - Cost to landholders of compliance inspections

Region	Cost – sugarcane region total ($/year)	Cost – grazing region total ($/year)	Bananas region total ($/year)
Cape York	n/a	332	n/a
Wet Tropics	n/a	n/a	563
Burdekin	n/a	n/a	n/a
Mackay Whitsunday	n/a	n/a	n/a
Fitzroy	n/a	25,381	n/a
Burnett Mary	1,077	17,274	n/a
TOTAL	**1,077**	**42,987**	**563**

A3.7 Fertiliser re-seller requirements

It is proposed that fertiliser re-sellers will have to keep a range of records relating to their clients, such as soil sampling results, the amount of fertiliser sold to each customer, and any recommendations made about the type, rate, method and timing of fertilisers. It should be noted that fertiliser re-sellers may not hold all of this information, and the intention is not that they have to source it.

In the department's view the cost of recording nutrient advice going forward should be reasonably low as any record keeping system can be used, such as a spreadsheet. No historical analysis interrogating multiple forms of records will be needed. At the end of a consultation, a re-seller will just need to record some key pieces of information. This should not take longer than quarter of an hour. There should not be a need for major changes to sales systems.

If every cane and banana farmer consulted with a fertiliser re-seller once a year, this is an annual cost of $49,809.

A4. Costs to government of minimum practice standards for agricultural ERAs

A risk based compliance program that will cover the proposed new reef regulations has been developed by the Department of Environment and Science. The additional cost to the compliance program from the reef regulations (i.e., additional to current compliance) is assumed to be approximately $1.65 million per year based on the current budget. A compliance prioritisation model is used to target high risk sites. As a result, it is not expected that the removal of Environmental Risk Management Plan requirements will have any negative impacts on water quality.

Developing the minimum standards (applicable for all options) is estimated to take around six months with a staff cost of $175,416. These costs are summarised in Table 24.

Table 24 - Cost of minimum standards to government

Item	Cost ($)
Compliance program (annual)	1,650,000
Development of standards (one-off)	175,416
Finalising bananas BMP standard	9,216

It is assumed there is no additional cost to the BMP or like programs that are already rolling out. This is because it is not possible to determine how many landholders will choose to participate in recognised BMP or like programs to meet the regulatory requirements. However, in order to allow for an alternative industry-managed pathway under a BMP program for bananas, this program will need to be recognised by the Department of Environment and Science. As a program already exists, it is assumed this will take one staff member one month to complete this, which is a one-off cost of $9,216.

A5. Benefits of new minimum standards for agricultural ERAs

A5.1 Water quality benefits

The benefits of the new minimum standard regulations are taken from the Alluvium report and are expressed as reductions in dissolved inorganic nitrogen and fine sediments, and thus improved water quality for the Great Barrier Reef. The social and economic benefits of improved water quality are discussed in Section A9.1. Here, the estimated water quality benefits from the new minimum standards for existing operators are discussed.

Table 25 summarises the expected benefits from sugarcane moving from D to B class practices. As most sugarcane farmers are currently in category C, there are high benefits expected from moving to B class practices. The dissolved inorganic nitrogen reductions range from 10% of the current dissolved inorganic nitrogen load in the Burdekin to 38% in the Mackay Whitsunday region.

Table 25 - Benefits of all sugarcane moving to B

Region	Dissolved inorganic nitrogen load reduction (t)	% reduction in overall load per catchment
Wet Tropics	961	19%
Burdekin	286	10%
Mackay Whitsunday	465	38%
Burnett Mary	140	16%
TOTAL	**1,852**	

(Alluvium 2016)

The possible benefits for sediment are shown in Table 26. Reductions in sediment are expected, ranging from 6% for the Wet Tropics to 18% in the Fitzroy. There is no estimate for the sediment reduction in Cape York region.

Table 26 - Benefits of all grazing moving to B

Region	Fine sediment load reduction (t)	% reduction in overall load per catchment
Wet Tropics	95,100	6%
Burdekin	531,000	12%
Mackay Whitsunday	54,000	9%
Fitzroy	324,000	18%
Burnett Mary	162,000	13%
TOTAL	**1,166,100**	

(Alluvium 2016)

The Alluvium modelling of the benefits of regulation assumed 100% compliance which is unlikely to be the case, especially given the diffuse nature of the pollution and thus the difficulty in monitoring. The modelling also assumed that the practices proposed were effective in reducing sediment and nitrogen, and that there was no time lag in the benefits being realised, which is particularly unlikely to be the case for grazing land recovery. As such, it is likely these benefits are a maximum. One exception is that this estimate of the benefits assumes a baseline of full compliance for the sugarcane areas of the Wet Tropics, Burdekin and Mackay Whitsunday regions with current regulations, i.e., that all operators are already at class C practices and so there are no water quality gains to be made from landholders moving from D to C practices. However, if currently non-compliant landholders do start complying with the new regulations this could deliver some further water quality benefits. However, there is no way to estimate what this likely future compliance rate could be.

A5.2 Environmental Risk Management Plan removal

The regulatory proposals include a proposal to remove the current requirement for Environmental Risk Management Plans.

Approximately 1000 landholders have had to prepare Environmental Risk Management Plans under the current reef regulations. Assuming this takes around 15 hours, this will be a total saving of $740,280. There are also ongoing savings of one day per year for the renewal, which represent a total saving of $394,816 per year.

The savings to the Department of Environment and Science in assessment officer's time is estimated to be three and a half hours per application, representing a one-off total saving of $177,793.

A5.3 Increased profitability and non-financial barriers to change

As seen in Table 20 there are expected to be increased profits to sugarcane businesses who operate at a B level rather than a C level. Assuming that all businesses would have otherwise only operated at a C level (which is not known, but does represent the most common practices in the industry), the gain is $54 million a year across all catchments. For an average business this represents a profit of between $7,844 (Burdekin) and $49,000 (Burnett Mary). Alluvium caution that the change in farm profit is, in many cases, so small relative to the total farm gross margin, that the impact of the change in the management practice will be difficult to identify.

It is important to understand that not all producers are guaranteed to make these profits. Financial outcome will vary based on climate, markets and differences between a property's business structure, as well as its biophysical characteristics.

The option of gaining a farm profit by moving to B standards currently exists for sugarcane growers. However, most have not made the shift, which indicates a range of financial and non-financial barriers exist. It is possible that the profit is not as large as modelled. The information about the financial benefits may not be clear or believable to individual landholders. Necessary skills or knowledge about the shift may not exist. Some landholders may have difficulties accessing the necessary capital to initiate change, and may not be well placed financially to bear the cost of the changes until positive returns are expected after several years. This is supported by the 29% of sugarcane growers in an ABARES survey in 2015 who noted that cash flow was the biggest barrier to adopting research and development outcomes for their business (Valle and Martin 2015).

Individual risk preferences are likely to be important in the decision to adopt or not adopt practices (Rolfe and Gregg 2015). Risks include concerns about the trialability, complexity and flexibility of practices, as well as risks associated with markets, climate in the near and long term, and social and industry factors.

There are also likely to be transaction costs associated with the change to the new standards that have not been captured in these costs. In particular, the time and effort involved in learning about new systems and implementing them could be significant.

Pannell et al. (2014) concluded that non-financial barriers could be as high as the profit gain for land management change for graziers in the Burnett Mary. The existence of large non-profit barriers can help explain low adoption in other sectors too, such as sugarcane.

These barriers to change are likely to exist for all agricultural industries in the Great Barrier Reef. These factors all mean that although the change to B standard will be regulated, there are likely to be costs that haven't been captured in this Regulatory Impact Statement. Landholders may also need support with the shift.

A6. Costs of regulating new, expanding or intensifying, agricultural, prescribed and resource ERAs

New regulatory requirements are proposed for new agricultural and industrial activities. The offset costs for sugarcane, grazing and sewage treatment plants are estimated in this section.

Expansion areas, intensification and new agricultural ERAs in all river basins will be required to comply with the minimum practice standards and will also be subject to a deemed condition that a

water quality offset is provided, in accordance with the proposed Water Quality Offset Policy, where there is significant residual pollution load. These agricultural ERAs will be required to keep records and notify the department where an offset is required.

New agricultural ERAs will be required to meet farm design standards. Expansion areas and intensification of agricultural ERAs will not be required to retro-fit their existing operation to new farm design requirements. It is likely that these standards will be complementary to those covered in other regulations. As such, the additional cost is likely to be low. It also seems likely that a new business would use best practice when starting a new enterprise, particularly if the practices are likely to yield positive private financial benefits. Again, this suggests that additional costs are likely to be low.

An alternative option is to regulate new agricultural activities as prescribed ERAs under the *Environmental Protection Act 1994* through the requirement to have an environmental authority. This would be a standard authority, rather than a site specific authority. The conditions of the environmental authority would stipulate farm design and/or management practices to be met on site. This is not a preferred option by the government. The costs for this sub-option are discussed in Section 6.1.1.

A6.1 Costs for new, expanding or intensifying, agricultural ERAs

Forecasting agricultural growth over the next 10 years is very difficult to carry out. There are a wide variety of factors that can influence the viability of agricultural businesses, such as world commodity markets, input costs, availability of infrastructure, water, appropriate soils and supply chains.

A recent ABARES report forecasts a 1% expansion in the area each year under sugarcane cropping by 2021/22 (ABARES 2017). This 1% expansion is used in this impact assessment, however, it seems likely to be an overestimate as recent Australian Bureau of Statistics environment accounts showed a large decrease in the area under sugarcane production of -4.1% between 2011 and 2016 (ABS 2017a). However, this is the only known official forecast of the sugar area. The Australian Bureau of Statistics environmental accounts showed an increase in grazing area of 0.5% from 2011-2016, or 0.1% a year. Without an official forecast for changes in the area for grazing, this annual figure of 0.1% is used in this analysis. Similarly, horticulture (which includes bananas) showed an increase in area of 0.5% over five years, or 0.1%. This annual growth rate is used in this analysis.

Tables 27 and 28 show the increase in sugarcane and grazing area expected in each region. The percentage increase is cumulative over each year of the analysis period (nine years after allowing for a 12 month lead in). However, in the interests of clarity only, the increase in years one and nine are presented in the tables.

Table 27 - Forecast annual increase in new sugarcane production

Region	Average property size	Increase in area (ha) – year one	Increase in area (ha) – year nine	Increase in number of properties – year one	Increase in number of properties – year nine
Wet Tropics	150	1,360	1,473	9	10
Burdekin	106	830	899	8	8
Mackay Whitsunday	150	1,360	1,473	9	10
Burnett Mary	200	860	931	4	5

Table 28 - Forecast annual increase in new grazing production

Region	Average property size	Increase in area (ha) – year one	Increase in area (ha) – year nine	Increase in number of properties – year one	Increase in number of properties – year nine
Cape York	20,000	2,225	2,243	0.11	0.11
Wet Tropics	2,000	719	725	0.36	0.36
Burdekin	20,000	12,772	12,878	0.64	0.64
Mackay Whitsunday	2,000	313	316	0.16	0.16
Fitzroy	7,000	13,081	13,189	1.87	1.88
Burnett Mary	5,000	2,740	2,762	0.55	0.55

(Great Barrier Reef Report Card 2015; Alluvium 2016. Cape York assumed to be the same the Burdekin)

Bananas are currently only grown on a large scale in the Wet Tropics. The estimated increase in area under banana production is 11 ha per year. Banana farms are an average size of 83.4 ha in the Tully region and 34.1 ha in the Innisfail region, which is an overall average of 59 ha. This is an estimated increase of 0.19 properties a year.

The precise amount of significant residual pollution will be modelled as part of the water quality offsets calculator development. However, indicative estimates of dissolved inorganic nitrogen loss and sediment loss from sugarcane and grazing operating at class B management practices are shown in Tables 29 and 30 (personal correspondence, Department of Science, Information Technology and Innovation 2017). This does not take into account any water quality improvements as a result of the farm design management actions, and as such are likely to **be an overestimate.** Indeed, the presence of a regulation requiring the offset of significant residual pollution is likely to encourage innovation in farm design to minimise residual pollution. These figures represent the amount of pollutants estimated to reach the Great Barrier Reef itself, or the export amount, rather than the amount generated at the paddock level. While natural state, or normally occurring, contributions of dissolved inorganic nitrogen and sediments have been removed from these calculations, it must be emphasised these are just rough estimates.

Table 29 - Residual pollution from sugarcane per hectare

Region	Dissolved inorganic nitrogen (tonnes/ha/year)	Sediment (tonnes/ha/year)
Wet Tropics	0.0125	2.2
Burdekin	0.0047	0.4
Mackay Whitsunday	0.0036	1.1
Burnett Mary	0.0043	0.3

(DSITI personal communication)

Table 30 - Residual pollution from grazing per hectare

Region	Sediment (tonnes/ha/year)
Cape York	0.066623
Wet Tropics	0.162568
Burdekin	0.144386
Mackay Whitsunday	0.196156
Fitzroy	0.040128
Burnett Mary	0.066091

(DSITI personal communication)

Table 31 outlines the expected total residual pollution from this increase in activity for sugarcane. The amount increases each year (as the 1% growth is cumulative), but for ease of reading only the first and last year are presented here to give a range. If sugarcane expands by 1% a year, there are likely to be 19.83-21.47 tonnes of additional dissolved inorganic nitrogen and 2,699-2,923 tonnes of additional sediment after B level standards are met per year. In year nine the cumulative additional load from sugarcane will be approximately 186 tonnes of dissolved inorganic nitrogen and 25,000 tonnes of sediment across all reef catchments.

It should be noted that there are a lot of factors that can make these numbers go up or down, such as soil type, slope, irrigation practice and capture of run-off water.

Table 31 - Total increased residual pollution from sugarcane

Region	Additional dissolved inorganic nitrogen year 1 (tonnes)	Additional dissolved inorganic nitrogen year 9 (tonnes)	Additional sediment year 1 (tonnes)	Additional sediment year 9 (tonnes)	Cumulative dissolved inorganic nitrogen load year 9 (tonnes)	Cumulative sediment load year 9 (tonnes)
Wet Tropics	8.59	9.30	1,799	1,948	80.44	16,850
Burdekin	3.03	3.28	120	130	28.41	1,123
Mackay Whitsunday	4.62	5.00	761	824	43.29	7,130
Burnett Mary	3.59	3.88	20	22	33.61	188
TOTAL	**19.83**	**21.47**	**2,699**	**2,923**	**185.75**	**25,291**

Table 32 outlines the expected total residual pollution from this increase in activity for grazing. The amount increases each year (as the 0.1% p.a. growth is cumulative), but for ease of reading only the first and last year are presented here to give a range. If grazing expands by 0.1% a year, there are likely to be around 2900 tonnes of additional sediment after B level standards are met per year. In year nine the cumulative additional load from grazing will be approximately 26,000 tonnes of sediment across all reef catchments.

Table 32 - Total increased residual pollution from grazing

Region	Additional sediment year 1 (tonnes)	Additional sediment year 9 (tonnes)	Cumulative sediment year 9 (tonnes)
Cape York	148	149	1,340
Wet Tropics	117	118	1,056
Burdekin	1,844	1,859	16,665
Mackay Whitsunday	61	62	555
Fitzroy	525	529	4,744
Burnett Mary	181	183	1,636
TOTAL	**2,877**	**2,900**	**25,996**

The costs of water quality offsets are unknown at this point. Many of the cheaper costs in the Alluvium modelling are not available as they would become regulated actions under these proposals (e.g., moving sugarcane from D to C and B practices).

These costs depend on various factors, such as the willingness of private landholders to supply the offsets. The overall demand for offsets is also important, as the mitigation costs rise sharply further along the cost abatement curve i.e., as cheaper options are taken up by earlier offsets. An indication

of potential costs is provided by the draft Reef Trust calculator. These are based on the benchmarked estimates in Rolfe and Windle (2016), which in turn were based on evaluations of Reef Rescue grants, water quality tenders, water quality improvement plans, and bio-economic modelling. The costs of reducing dissolved inorganic nitrogen are assumed to be $150,000/tonne/year. The risk-adjusted costs are $232,500/tonne/year – these include a multiplier of 1.55 to account for time delay in the draft Reef Trust calculator. The costs for sediment reduction are assumed to be $259/tonne for all catchments, with a risk adjusted figure of $401/tonne.

Indicative offset costs for a 1% increase in sugarcane growing area are shown in Tables 33 and 34. These use the higher risk adjusted costs from the Reef Trust. The total offset costs for dissolved inorganic nitrogen and sediment are approximately $5.7-6.2 million/year if sugarcane expands by 1% a year (as with earlier tables, the range of the values between years one and nine are presented).

The cumulative costs in year nine are also presented. This is around $53 million for sugarcane. These costs represent a landholder offsetting their residual load contribution every year over the time period, with the area increasing by 1% a year. In reality, a one-off discounted payment is likely to be required based on the projected pollution load over a defined period of time. In this analysis, however, the real (non-discounted) cumulative costs over the nine years are presented as an indication of the total cost.

It is important to note that this cost relies upon a 1% increase in area each year. In recent years there has been a decrease in area under sugarcane production, so it is possible that this cost would never eventuate.

Table 33 - Indicative dissolved inorganic nitrogen offset costs, sugarcane

Region	Indicative total offset cost year 1 ($/year)	Indicative total offset cost year 9 ($/year)	Cumulative total cost year 9 ($)
Wet Tropics	1,996,171	2,161,567	18,701,179
Burdekin	705,131	763,555	6,606,036
Mackay Whitsunday	1,074,448	1,163,473	10,065,992
Burnett Mary	833,991	903,093	7,813,272
TOTAL	**4,609,740**	**4,991,688**	**43,186,478**

Table 34 - Indicative sediment offset costs, sugarcane

Region	Indicative total offset cost year 1 ($/year)	Indicative total offset cost year 9 ($/year)	Cumulative total cost year 9 ($)
Wet Tropics	721,211	780,969	6,756,688
Burdekin	48,056	52,038	450,214
Mackay Whitsunday	305,167	330,452	2,858,966
Burnett Mary	8,057	8,725	75,485
TOTAL	**1,082,491**	**1,172,184**	**10,141,353**

Indicative offset costs for a 0.1% increase in grazing area are shown in Table 35. These use the higher risk adjusted costs from the Reef Trust calculator. The total offset costs for dissolved inorganic nitrogen and sediment are approximately $1.2 million/year if grazing expands by 0.1% a year (as with earlier tables, the range of the values between years one and nine are presented). The cumulative costs in year nine are also presented. This is around $10 million for new grazing. As with the sugarcane calculations, these costs represent a landholder offsetting their residual load contribution every year over the time period, with the area increasing by 0.1% a year. In reality, a one-off discounted payment is likely to be required based on the projected pollution load over a

defined period of time. In this analysis, however, the real (non-discounted) cumulative costs over the nine years are presented as an indication of the total cost.

Table 35 - Indicative sediment offset costs, grazing

Region	Indicative total offset cost year 1 ($/year)	Indicative total offset cost year 9 ($/year)	Cumulative total cost year 9 ($)
Cape York	59,437	59,929	537,146
Wet Tropics	46,868	47,255	423,550
Burdekin	739,483	745,599	6,682,836
Mackay Whitsunday	24,630	24,833	222,582
Fitzroy	210,491	212,231	1,902,240
Burnett Mary	72,612	73,212	656,203
TOTAL	**1,153,521**	**1,163,059**	**10,424,557**

The residual water pollution from bananas is not known at present, but given the low levels of expansion expected, the offset cost is not likely to be high.

A6.1.1 Costs for option 2(a) – establishing an environmental authority for new, expanding or intensifying, agricultural ERAs

Making a standard application for an environmental authority involves the applicant filling out an online form, which is assumed to take an hour, and submitting it to the Department of Environment and Science. This cost is applied to all new operators as identified in Tables 27 and Table 28.

Applicants would also have to pay a one-off application fee of $609, and an annual fee for each threshold of an ERA, which is a standard minimum fee of $630.00. There is a 7% fee to apply online, and this has been applied to the estimated 25% of applications that are completed online.

Based on past applications, it has been assumed 75% of applications will be done in hard copy rather than online. Each hard copy application takes an administrative officer 45 minutes to process. This is a cost of $33 per application. Based on the expected applications, this is $848/year. The costs increase incrementally across the years as the expansion in agricultural area and new entrants continues. However, as the application figures are so low the increase in subsequent years is minimal, with a total annual cost in the final year of $911.

As with the previous section, the costs increase incrementally across the years as the expansion in agricultural area and new entrants continues. For the sake of clarity, only the first and final years are shown in Tables 36 and 37

Table 36 - Additional costs for new agricultural ERAs for an environmental authority - sugarcane

Region	Value of time to fill out form ($/year)	Application fee ($/year)	Annual fee ($/year)	Cumulative annual fees ($) – year 9
Wet Tropics	447	5,618	5,769	47,801
Burdekin	386	4,852	4,982	41,282
Mackay Whitsunday	447	5,618	5,769	47,801
Burnett Mary	212	2,665	2,736	22,670
TOTAL	**1,494**	**18,753**	**19,257**	**159,554**

Table 37 - Additional costs for new agricultural ERAs for an environmental authority - grazing

Region	Value of time to fill out form – ($/year)	Application fee ($/year)	Annual fee ($/year)	Cumulative annual fees ($) – year 9
Cape York	5	69		563
Wet Tropics	18	223		1,820
Burdekin	32	396		3,233
Mackay Whitsunday	8	97		793
Fitzroy	92	1,158		9,462
Burnett Mary	27	340		2,775
TOTAL	**182**	**2,282**		**18,646**

A6.2 Costs for new, expanding or intensifying prescribed and resource ERAs

A key water quality risk is the increase in nitrogen pollution from sewage treatment plants as a result of population growth. Other prescribed and resource ERAs that commonly cause water pollution are not expected to increase significantly in the ten year analysis period, and therefore are not included in the costing.

Forecast population growth has been taken from Queensland Government estimates (Queensland Government Statistician's Office 2015). Where local government areas straddle more than one Great Barrier Reef region, or are not completely within one region, the proportion in each region has been applied to the population growth estimates (for example, 28% of Barcaldine Shire is within the Burdekin region, so it has been assumed that 28% of the Burdekin population growth will occur in the Burdekin region). This process is not precise, so all population figures are estimates. An approximate total population growth of 211,600 is expected over the next ten years in the Great Barrier Reef regions.

Based on the formula for calculating the peak design capacity of sewage treatment works in the Environmental Protection Regulation 2008, it has been estimated that each additional person generates 200 litres of wastewater a day. At the industry best practice release limit of 5mg/l this results in 1 gram of residual nitrogen pollution per day (personal correspondence, Department of Environment and Science and former Department of Science, Information Technology and Innovation 2017). This means, overall, that the additional population growth is expected to generate approximately 7.7 million grams (7.7 tonnes) of nitrogen per year. Using the risk-adjusted cost of offsets from the Reef Trust calculator as a guide ($232,500/tonne) this is $1.8 million a year. These costs are presented for each region in Table 38.

The cumulative costs in year nine are also presented (these are nine years after allowing for a 12 month lead in), and total around $16 million. These costs represent the sewage treatment plants offsetting their load contribution every year over the time period, as the population increases each year. In reality, a one-off discounted payment is likely to be required based on the projected pollution load over a defined period of time. However, here the real (non-discounted) cumulative costs over the nine years are presented as an indication of the total cost.

Table 38 - Expected increase in pollution from population growth and possible offset costs

Region	Annual population growth	Annual residual nitrogen pollution (tonnes)	Indicative offset cost ($/year)	Cumulative cost ($) year 9
Cape York	60	0.02	5,092	45,826
Wet Tropics	3,274	1.19	277,840	2,500,558
Burdekin	5,534	2.02	469,629	4,226,662
Mackay Whitsunday	1,567	0.57	132,980	1,196,816
Fitzroy	3,482	1.27	295,491	2,659,421
Burnett Mary	7,242	2.64	614,574	5,531,168
TOTAL	**21,159**	**7.72**	**1,795,606**	**16,160,451**

A7. Costs of regulating new, expanding or intensifying, agricultural, prescribed and resource ERAs – government

A7.1 Offset framework development

The most significant cost to the government of regulating new activities, for the purpose of requiring a water quality offset, is the cost of establishing and managing an offsets scheme. The possible costs have been based on the experiences of the teams managing the current biodiversity offsets policy within the Department of Environment and Science, the Office of the Great Barrier Reef, and the Reef Trust section of the Australian Government's Department of the Environment and Energy.

The one-off costs include development of water quality monitoring to capture non-agricultural practices, collation of input cost components, cost/risk modelling, developing an offsets register and development of a calculation formula. There is also a cost for stakeholder consultation and calculator design, and the web development of the calculator.

Ongoing costs include managing the offsets register, offset fund establishment, administration and management. These activities are related to the proposed role of the government as the purchaser of the offset liability, which results in it needing to source new offsets.

These costs assume a relatively low level of offset transactions – the biodiversity offsets team within the Department of Environment and Science have managed approximately 50 transactions ranging from very small cases to large ones. It is not known how many offsets will be required under the proposed reef regulations, but it is not expected to be high. If the numbers are significantly higher, then these costs will be an underestimate.

Table 39 - Offset scheme costs

	Cost ($), one-off	Cost ($), ongoing per year
Establishment of policy and calculator development	841,666	
Offset fund management		356,521

A7.2 Development of standards for new, expanding or intensifying, agricultural ERAs

As with the regulations for new minimum standards for existing activities, regulating new activities will also require the development of new standards. These costs are the same as for development of the minimum standards – six months for three staff members. This is $127,617 as a one-off cost.

A8. Benefits of regulating new, expanding or intensifying, agricultural, prescribed and resource ERAs

The water quality benefits of regulating new activities cannot be precisely calculated due to uncertainty over future economic growth and the associated pollution load. However, if sugarcane grows by the estimated 1% a year, then the offsets will reduce future residual pollution from sugarcane of 186 tonnes of dissolved inorganic nitrogen and 25,000 tonnes of sediment over the nine years. Averted residual sediment pollution from grazing (0.1% annual growth) is estimated to be 26,000 tonnes of pollution. For both industries this is a significant amount of averted pollution.

The averted pollution from sewage treatment plans due to population growth is likely to be around 7.7 tonnes of dissolved inorganic nitrogen a year, or 69.5 tonnes over the analysis period.

Additionally, new economic activities threaten the possibility of meeting the water quality targets, particularly if there are new developments that are not anticipated at present. Not only would significant expansion in diffuse and point source pollution threaten this Queensland Government commitment, but it would increase the costs significantly. This is because the costs rise sharply as various responses are deployed – i.e. when the cheaper policy options have been used, only more expensive options remain (Alluvium 2016). This means that as pollution loads increase the overall cost of alleviating one additional tonne increases.

Under option 2 of regulating new agricultural operators the government will receive fees from issuing environmental authorities. This is the cost discussed in Section A7.1 to agricultural operators of $609 as a one-off application fee and $630/year for an annual fee. These have been multiplied by the expected number of new properties in each year (Tables 27 and 28). Between the first and final years of the analysis period, the Department of Environment and Science is expected to receive $21,154-$22,728 from application fees for issuing environmental authorities, and $21,700-$23,107/year from annual fees.

A9. Results

The present values of the overall costs and benefits of both the preferred package of options, and of one alternative, are presented here.[2] As key benefits cannot be monetised, this analysis does not present a net present value (the difference between the present cost and the present benefit).

The calculation has assumed many regulatory actions start in year two not year one to allow for regulations to be phased in. As discussed previously, the sugarcane nutrient management standards would start after two years (i.e., in year three).

Option 2 – Costs

Table 40 - Present value of costs

Present value of costs ($)	852,815,638
Equivalent annual value of costs ($/year)	130,895,663

As shown in Table 40, the present value of the costs is $853 million, or an annual equivalent annual value of $130 million over 10 years.

Government costs are estimated at $1.2 million as a one-off cost – primarily associated with developing the offsets calculator. Ongoing costs are around $1.3 million per year for most of the

[2] **Present value** is the total value of the future benefit stream (ten years) in present day terms - this allows costs and benefits to be compared at the point where decisions are made. This can also be presented as an "**equivalent annual value**", which is an annual value for each of the ten years of the analysis.

years of the analysis period, which is primarily the compliance program's costs. The present value of the government's costs are approximately $16 million.

Option 2 – Benefits

Table 41 - Present value of benefits

Present value of benefits ($)	355,605,307
Equivalent annual value of benefits ($/year)	54,580,604

The present value of quantified benefits is $355.6 million, or an equivalent annual value of $54 million over ten years (Table 41). Most of this is generated by the expected increase in profit for sugarcane operators operating at B rather than C standard. Care must be taken in interpreting these assumed profits, as there are likely to be significant differences between actual financial outcomes for sugarcane businesses. There are likely to be significant non-profit costs that have not been quantified in this analysis, as discussed in Section A5.3.

There are expected to be significant water quality benefits that were not able to be monetised, as discussed in Section A9.1. For this reason, the net costs and benefits of the proposals cannot be directly compared.

Option 2(a)
Option 2(a) is the same as Option 2 but with new activities required to apply for an environmental authority. This increases the costs to landholders through fees, but also increases revenue to the government. This means both costs and benefits are slightly higher than in Option 2.

Table 42 - Present value of costs Option 2(a)

Present value of costs ($)	853,340,036
Equivalent annual value of costs ($/year)	130,976,150

Table 43 - Present value of benefits Option 2(a)

Present value of benefits ($)	356,379,859
Equivalent annual value of benefits ($/year)	54,699,487

This is not a preferred option by the government.

A9.1 Benefits of improved water quality

The overall benefits of water quality from the reef regulations are an expected reduction of:

- 1,852 tonnes of dissolved inorganic nitrogen as a result of the minimum practice standards for sugarcane, which is a 13-48% move towards the 2025 water quality target across the reef catchments.
- 1,166,100 tonnes of sediment as a result of the minimum practice standards for grazing, which is a 12-36% move towards the 2025 water quality target across the reef catchments.
- 186 tonnes of dissolved inorganic nitrogen and 25,000 tonnes of sediment from introducing offsets for residual agricultural pollution for new sugarcane production, and 26,000 tonnes of sediment from offsets for residual pollution for new grazing production.

- 70 tonnes of dissolved inorganic nitrogen from introducing offsets for increased loads in sewage treatment plants.

We do not know the marginal value of improved water quality (i.e., the dollar value of a tonne less of sediment or nitrogen). However, we do know that the Great Barrier Reef is very valuable to the people of Queensland and Australia. Indeed, its status as a World Heritage Area denotes its value internationally.

There are many commercial benefits derived from the Great Barrier Reef, namely in the tourism industry. A recent estimate suggests that the reef contributed $3.9 billion in value and over 33,000 jobs to the Queensland economy in 2015-16 (Deloitte 2017). There are also many non-commercial values to the reef, such as recreation, cultural and non-use values. An overwhelming majority of survey respondents in Australia and overseas recently confirmed that they value the Great Barrier Reef and want to see it protected (Deloitte 2017). People believe that the reef should be protected for a variety of reasons, such as the right of future generations to visit it, the moral and ethical duty to protect it, and that the world would simply not be the same without it.

The economic, social and iconic asset value of the Great Barrier Reef is estimated at $56 billion (Deloitte 2017). This is seen as a conservative estimate as it does not include the values of the importance of the reef to Traditional Owners, the rest of the world, and to Australia's 'brand'. Evidence suggests that all of these values are very high. And of course, the Great Barrier Reef is actually priceless as it cannot be replaced.

Improved water quality will help preserve the high values held for the Great Barrier Reef and increase the resilience of the Great Barrier Reef to other pressures such as climate change (Waterhouse et al. 2017).

A9.2 Affordability

This section briefly discusses the potential affordability of the proposed regulations on the various sectors.

Agriculture is the dominant land use in the adjacent catchments, generating approximately $6.2 billion of gross value production in 2015-16 (ABS 7503.0) and employing approximately 20,000 people (DAF personal correspondence 2017). The impacts of the proposed reef regulations on regional employment or development are not known. However, it unlikely that an industry of this size will face noticeable changes in value of production or employment.

None of the regulated agricultural industries are likely to have the power to pass on any cost increases to consumers.

Section A9.3 includes sensitivity testing around the key assumptions for grazing and sugarcane costs. This can help with understanding the possible range of costs within a region.

To help increase understanding of the impact of the costs of the proposed regulations on an individual grazing property, the total costs associated with the regulations for the average size properties in each region have been calculated. **These are not new calculations or additional costs – they are just presented in a different manner.** This is simply to help increase the understanding of what the costs might mean to a typical property in each region. It should be noted that the range of property sizes varies greatly in most regions. Additionally, as noted earlier, the costs are all averages and will not accurately represent all properties due to significant differences between farming

businesses and land types even within a region. The average property sizes are taken from the Alluvium report.[3]

Sugarcane

Table 44 includes the costs of sugarcane moving from C to B practices for an average property. Due to the profits expected from moving from C to B practices, the annual costs are actually a saving. The costs include one-off learning costs for all properties, and record keeping and compliance inspection costs for the Burnett Mary properties.

Table 44 - Costs of sugarcane moving from C to B for an average property

Region	Average size (ha)	One-off costs ($)	Annual net savings ($)
Wet Tropics	150	17,495	7,290
Burdekin	106	39,827	3,901
Mackay Whitsunday	150	42,545	39,885
Burnett Mary	200	184,395	30,450

It can be seen that for an average property, there can be significant one-off costs, depending on the region. However, there are also large ongoing savings expected from improved farm profitability that would soon repay these initial costs. As discussed in Section A5.3, care needs to be taken when assuming farm profits will occur across a region. However, these figures do indicate that on average the industry might not face significant costs in the short term from landholders moving to class B practices. This does assume though that they can afford the initial capital costs.

For a matter of comparison, in 2013/14, the average farm business profit in an ABARES survey was a loss of $14,300 (Valle and Martin 2015).[4] Cash receipts were $462,000 and cash costs $372,300 per farm. This indicates that some sugarcane farmers without savings will struggle to afford to make the required practice changes. It should be noted that this result did occur in a year that was unusually dry in Southern Queensland and after Tropical Cyclone Ita negatively impacted yield in Far North Queensland. In addition, there is great diversity within the industry – the top 25% of performers with over 250 hectares made a higher profit of $158,700 per farm, while the bottom 25% of farms had under 50 hectares, a farm business profit of $55,700 per farm, and generally relied upon off-farm income sources. Sugarcane growers face a range of challenges such as price volatility on the world market, risks from adverse weather and pest and disease outbreaks (Harvey et al 2016a). These challenges affect economic performance from year to year and from region to region (Harvey et al 2016a), which means it is difficult to make blanket conclusions about affordability.

Offset costs for any expansion in the sugarcane industry are high at $5.7-6.2 million/year if sugarcane expands by 1% a year. This is high compared to the value generated by the expansion – given an approximate value of $2 billion, the value of a 1% increase in sugarcane is $20 million. This means the offset costs may be enough to suppress new growth in sugarcane in the Great Barrier

[3] The authors note for the grazing properties "These size estimates were based on a combination of work completed under the WQIPs and other programs such as Reef Rescue, Reef Program and Property Identification Codes. It is acknowledged that there is large variance in property size, however for the purposes of this study they were standardised to a regional average." It has been assumed that Cape York is the same as the Burdekin for costs and size due to similarities in land types and management.

[4] "Farm business profit: return to the resources used in the business (capital and management). This is a measure of longer–term business profitability, taking into account the requirement to replace some capital over time (capital depreciation) and also accounting for changes in inventories of farm products *farm cash income + change in trading stocks – depreciation – imputed labour costs"*

Reef. However, if the area expanded is lower, as seems possible given past contraction of the industry, so too are the offset costs. It also seems possible that there could still be improvements in yield and profitability from sugarcane in Queensland without any expansion in area or intensification as the smaller, less profitable farms become consolidated into larger, more profitable enterprises. This consolidation process has been apparent in the cane industry in recent years (Harvey et al 2016a). The new regulations could potentially hasten this process of consolidation of smaller, less profitable farms into larger, more profitable farms.

Grazing

Table 45 and Table 46 includes the costs of a grazing property moving from D to C class practices, and then C to B class practices for an average size property. Table 46 only includes moving from C to B class for an average size property. The learning, record keeping and compliance inspection costs are included as well as the costs of changing management practices. The one-off costs are the same in each table because they only exist for the C to B movement in this analysis. There are potentially significant capital costs associated with the move from D to C, but as noted earlier, these were not available. As such the costs in Table 45 and Table 46 are likely to be an under-estimate.

Table 45 - Costs of grazing moving from D to B practices for an average property

Region	Average size, ha	Total one-off costs ($)	Total ongoing costs ($)
Cape York	20,000	112,379	$29,082
Wet Tropics	2,000	55,579	$11,995
Burdekin	20,000	112,379	$29,075
Mackay Whitsunday	2,000	55,579	$17,395
Fitzroy	7,000	40,359	$14,080
Burnett Mary	5,000	136,579	$21,502

Table 46 - Costs of grazing moving from C to B practices for an average property

Region	Average size, ha	Total one-off costs ($)	Total ongoing costs ($)
Cape York	20,000	112,379	$23,482
Wet Tropics	2,000	55,579	$11,995
Burdekin	20,000	112,379	$23,475
Mackay Whitsunday	2,000	55,579	$11,795
Fitzroy	7,000	40,359	$8,480
Burnett Mary	5,000	136,579	$15,902

The average cost per grazing property – moving from D to B practices – ranges from an approximate one-off cost of $40,000 in the Fitzroy to $112,000 in the Burdekin, and ongoing costs of $12,000/year in the Wet Tropics to $29,000/year in the Burdekin. The significance of these costs is likely to vary depending on the financial situation of the grazing property in question. Table 47 contains the average farm profits over the last 10 years for specialist beef properties in Queensland. This suggests that the high one-off costs are likely to be problematic for all regions, and even the smaller ongoing costs may be enough to reduce profits below zero in some areas. Some regions already have negative average profits. It should be noted that there are significant variations between years, so affordability does vary from season to season. Recent years have seen particularly poor profits due to drought.

Table 47 - Average farm profits, grazing

GBR Region[5]	Average farm profit 2006-2016 ($/property)[6]
Cape York	225,603
Wet Tropics	-41,686
Burdekin	32,022
Mackay Whitsunday	-41,686
Fitzroy	274
Burnett Mary	-28,856

Source: Meat and Livestock Australia 2017

Bananas

As with sugarcane, there are expected profits for an average banana farm meeting best management practices. This is discussed in more depth in Section A3.3. However, the same caution must be used as for sugarcane in assuming this will be the case for every property. It is also likely that some businesses will struggle to afford any upfront capital costs.

Point source activities

The cost to sewage treatment plants is relatively small at $1.8 million per year across the whole Great Barrier Reef region or $16 million by the final year. This cost is minimal compared to other costs the industry faces, such as the $719 million in new infrastructure and ongoing operational costs of $33 million per year that Queensland Water estimated would be needed to upgrade all remaining plants within the Great Barrier Reef region to best practice standard (Queensland Water 2016).

The offsets are likely to be cheaper for the industry than alternative methods to reduce residual pollution. One estimate of $1,000/new person would mean a cost of $190 million over the analysis period due to a forecast population growth of 190,431 people (Smart et al 2016).

A9.3 Sensitivity testing

Best and worst cases for agriculture

A key cost in the impact assessment was the cost of agricultural producers moving from C to B class practices. The Alluvium modelling provided worst and best case estimates for moving from C to B management practices in sugarcane and grazing. These were calculated to capture differences in economies of scale, enterprise heterogeneity and farm layout, as well as differences in the ability of a landholder to modify current capital equipment and source second hand capital equipment. These costs have been applied as a sensitivity analysis, and can help illuminate a possible range in costs between different farms.

[5] There are no exact matches in regions between the Great Barrier Reef and ABARES data, but the closest ABARES regions geographically were used. These were Cape York and the Queensland Gulf for Cape York, North Queensland Coastal - Mackay to Cairns for Wet Tropics, Central North for the Burdekin, North Queensland Coastal - Mackay to Cairns for Mackay Whitsunday, Darling Downs and Central Highlands for the Fitzroy and South Queensland Coastal- Curtis to Moreton for Burnett Mary.

[6] These are 2016/17 dollars. “Farm business profit equals farm cash income plus buildup in trading stocks, less depreciation expense, less the imputed value of the owner manager, partner(s) and family labour.”

The best case for sugarcane is shown in Table 48. The expected annual increase in profits are around $11.5 million higher than in the most likely analysis ($75.7 million a year compared to $63.1 million a year), and the capital costs are less than half the most likely analysis ($67.4 million compared to $142.6 million). It is possible these costs are indicative of larger, more modern or efficient farms.

Table 48 - Best case for sugarcane moving C to B

Region	Capital cost ($ /ha)	Total capital costs ($)	Maintenance cost ($/ha/year)	Total maintenance costs ($/year)	Change in farm profit ($/ha/year)	Total change in profits ($/year)
Wet Tropics	78	10,048,428	7.8	1,004,843	73	9,404,298
Burdekin	148	11,308,828	14.8	1,130,883	3.9	10,162,663
Mackay Whitsunday	106	11,241,194	10.6	1,124,119	294	31,178,406
Burnett Mary	460	34,797,160	46	3,479,716	316	23,904,136
TOTAL		**67,395,610**		**6,739,561**		**74,649,503**

The worst case for sugarcane is shown in Table 49. These per hectare costs might be indicative of a smaller property or one unable to source cheaper machinery, for example. The profits expected ($17.7 million a year) are significantly lower than the "most likely" case ($63.1 million), and the capital costs are just over double the "most likely" estimate ($288 million compared to $143 million).

Table 49 - Worst case for sugarcane moving C to B

Region	Capital cost ($ /ha)	Total capital costs ($)	Maintenance cost ($/ha/year)	Total maintenance costs ($/year)	Change in farm profit ($/ha/year)	Total change in profits ($/year)
Wet Tropics	345	$44,444,970	34.5	$4,444,497	47	$6,054,822
Burdekin	709	$54,175,399	70.9	$5,417,540	15	$1,146,165
Mackay Whitsunday	692	$73,385,908	69.2	$7,338,591	-76	-$8,059,724
Burnett Mary	1533	$115,965,318	153.3	$11,596,532	245	$18,533,270
TOTAL		**$287,971,595**		**$28,797,160**		**$17,674,533**

The best case for grazing is shown in Table 50. The area costs might be indicative of larger, more fortunately situated properties. The overall capital costs are estimated to be around $65 million less than the most likely analysis ($84 million for the best compared with $149 million), and the annual costs around $10 million less per year ($25.4 million compared with $32.5 million).

Table 50 - Best case for grazing moving C to B

Region	Capital cost ($/ha)	Maintenance cost ($/ha/year)	Lost farm profit ($/ha/year)	Total capital costs ($)	Total annual costs ($/year)
Cape York*	2.5	0.25	0.6	4,914,000	1,670,760
Wet Tropics	18	1.8	2.1	9,759,222	2,114,498
Burdekin	2.5	0.25	0.6	21,980,203	7,473,269

Region	Capital cost ($/ha)	Maintenance cost ($/ha/year)	Lost farm profit ($/ha/year)	Total capital costs ($)	Total annual costs ($/year)
Mackay Whitsunday	18	1.8	2.2	2,908,728	646,384
Fitzroy	3.4	0.34	0.6	34,038,927	9,410,762
Burnett Mary	7.2	0.72	2.1	10,398,780	4,072,856
TOTAL				**83,999,860**	**25,388,529**

* assumed to be the same as the Burdekin region

The worst case for grazing has much higher capital costs and losses in farm profit as shown in Table 51. These costs might represent the situation for a smaller property or one with unfavourable farm characteristics. The regional totals are capital costs of approximately $1.5 billion compared to $149 million for the most likely estimates, and annual costs of $1.3 billion (taking into account maintenance costs and lost profits) compared with $32.5 million for the "most likely" estimates.

Table 51 - Worst case for grazing moving C to B

Region	Capital cost ($/ha)	Maintenance cost ($/ha/year)	Lost farm profit ($/ha/year)	Total capital costs ($)	Total annual costs ($/year)
Cape York*	49.41	4.941	22.61	97,120,296	54,154,246
Wet Tropics	35.1	3.51	3.9	19,030,483	4,017,546
Burdekin	49.41	4.941	22.61	434,416,722	242,230,624
Mackay Whitsunday	49.5	4.95	5.5	7,999,002	1,688,678
Fitzroy	86.79	8.679	86.79	868,893,659	955,783,025
Burnett Mary	44.1	4.41	4.9	63,692,528	13,446,200
TOTAL				**1,491,152,690**	**1,271,320,319**

*assumed to be the same as the Burdekin region

The overall best and worst case costs can help provide a guide for the possible range in costs for the overall changes in reef regulations.

Taking into account the best cases for the sugarcane and grazing, the overall present value of costs is $603 million, with an annual equivalent value of $85.9 million a year. These are lower than the estimates using the most likely figures, though not substantively. The present value of the benefits is higher at $420 million, or an annual equivalent value of $59.8 million a year.

Taking into account the worst cases for sugarcane and grazing, the overall present value of costs is $9.2 billion, and an annual equivalent value of $1.3 billion. These are substantially higher than the calculations based on the most likely figures. The benefits are lower at $102 million in present value and $14.5 million in annual equivalent value. This difference is due to the reduced expectation of profits for cane.

Discount rates

A standard 7% discount rate has been used in this analysis.

If a lower rate of 3% (sometimes called a social discount rate) is used, the present value of costs is $951 million and the present value of benefits $434 million. The equivalent annual value for the costs is $122.1 million and the equivalent annual value for the benefits is $50.9 million.

If a higher rate of 10% is used, the present value of costs is $728 million and the present value of benefits $309 million. The equivalent annual value for the costs is $126.4 million and the equivalent annual value for the benefits is $50.3 million.

Appendix 2: Land use by NRM region

Monitoring and scientific modelling show that sugarcane is by far the greatest contributor to the dissolved inorganic nitrogen that is transported to the Great Barrier Reef (contributing 78% of the anthropogenic load). This is primarily from applied fertilisers. Urban areas contribute 9% of the anthropogenic dissolved inorganic nitrogen load, and may be important at local scales. Grazing areas contribute approximately 4% of the anthropogenic dissolved inorganic nitrogen load transported to the reef, but this mostly originates from low concentrations of dissolved inorganic nitrogen over very large areas (EHP, 2017).

Monitoring and scientific modelling shows that grazing (49%) and streambank erosion (34%) are the greatest contributors of anthropogenic fine sediments delivered to the reef. Sugarcane cropping (8%) and dryland (non-irrigated) cropping (4%) also contribute to the fine sediment loads delivered to the reef. Urban and other land uses, including mining and industrial, contribute less than 1% to the fine sediments discharged onto the reef (EHP, 2017).

Figure 3 below shows the proportion of anthropogenic dissolved inorganic nitrogen and fine sediment generated by land use type in reef catchments.

Proportion of anthropogenic dissolved inorganic nitrogen and fine sediments generated by land use type in the Great Barrier Reef catchments

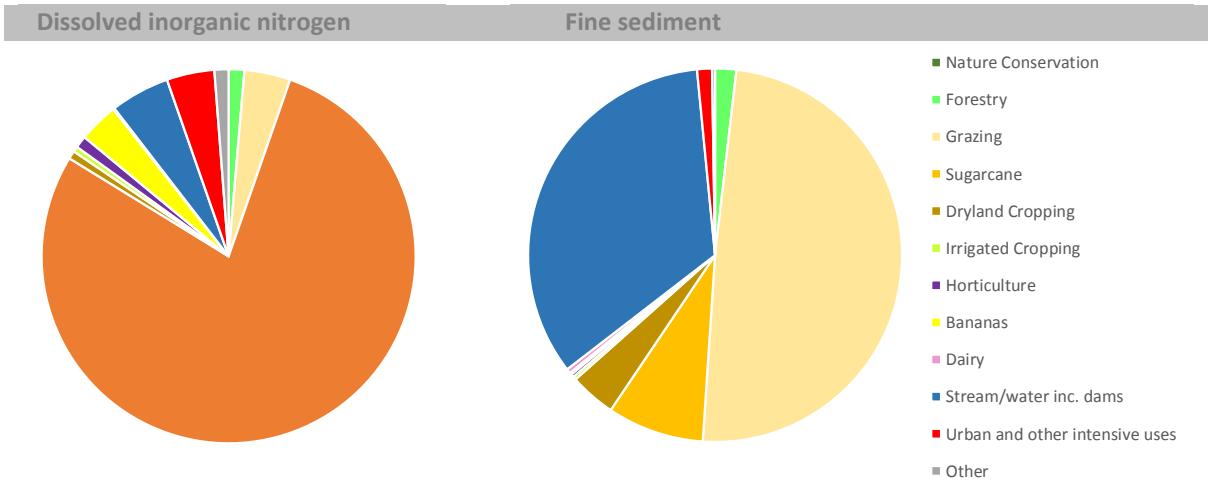


Figure 3: Proportion of anthropogenic dissolved inorganic nitrogen and fine sediment by land use type in reef catchments

The data presented below for each reef NRM region uses modelled loads of end-of-catchment anthropogenic dissolved inorganic nitrogen and total suspended solids (McCloskey et al., 2017). Further information on the loads from reef catchments (with the NRM regions) can be found at http://www.reefplan.qld.gov.au/about/catchment-targets/.

Cape York

Compared to southern Great Barrier Reef regions, Eastern Cape York remains relatively undisturbed by modern industrialisation and development, and the relatively good water quality in the northern Great Barrier Reef reflects this. Forestry and mining account for less than 1% of the total area of Cape York, but can be significant sediment sources where they occur within or near rivers and

creeks. Urban and industrial land use represents less than 1% of the total area, but has important localised water quality implications due to the intensity of this land use. Proximity to the inner lagoon means that their impacts may be substantial. The townships at Lockhart, Laura and Lakeland, Cooktown, Hope Vale and several other peri-urban precincts are sources of water quality pollution, including sediment and nutrients (CYNRM & SCYC, 2016).

Table 52 - Percentage contribution of anthropogenic dissolved inorganic nitrogen and fine sediment from Cape York land uses

Land use	Dissolved inorganic nitrogen (%)	Total suspended solids (%)
Nature conservation	0	0
Dryland cropping	4	1
Forestry	2	0
Grazing	90	86
Horticulture	0	0
Irrigated cropping	1	0
Sugarcane	0	0
Bananas	1	0
Dairy	0	0
Urban	1	0
Other	1	0
Streambanks for TSS / sewage treatment plants for dissolved inorganic nitrogen	0	12

Horticultural activities (intensive, irrigated and dryland) cover less than 1% of land area in eastern Cape York. Crops grown include bananas, mangoes and passionfruit (45 ha) and vegetable production (3 ha). Irrigated (3,100 ha) and dryland (2,000 ha) cropping, including maize, sorghum and coffee, cover less than 1% of land area (McCloskey et al., 2014). In addition, there are 154 hectares under production of broadacre crops (ABS, 2016).

Wet Tropics

Major port and vessel facilities in the Wet Tropics are located in Cairns, Mourilyan and Lucinda, with several marinas near the urban settlements of Port Douglas, Yorkeys Knob, Cairns and Cardwell (Terrain NRM, 2015). The largest urban areas are located in the Barron and Mulgrave-Russell basins. Urban encroachment due to population growth and tourism development is occurring in the region along the coast (Terrain NRM, 2015).

Table 53 - Percentage contribution of anthropogenic dissolved inorganic nitrogen and fine sediment from Wet Tropics land uses

Land use	Dissolved inorganic nitrogen (%)	Total suspended solids (%)
Nature conservation	0	0
Dryland cropping	0	0
Forestry	2	2
Grazing	0	2
Horticulture	1	1
Irrigated cropping	0	1
Sugarcane	80	74
Bananas	8	7

Land use	Dissolved inorganic nitrogen (%)	Total suspended solids (%)
Dairy	0	1
Urban	6	5
Other	2	2
Streambanks for TSS/ sewage treatment plants for dissolved inorganic nitrogen	1	6

Sugarcane production covers 8% of the total land area (Hateley et al., 2014), with approximately 1,343 growers managing 136,000 hectares (Great Barrier Reef Report Card 2015). One hundred and forty-seven cane growing businesses are BMP accredited in the Wet Tropics, representing over 25% of the cane growing area. The latest catchment loads data show that sugarcane produces 1.2 t/ha/yr of fine sediment (Hateley et al, 2014), and contributes 28% of TSS loads (Waterhouse et al., 2017). Grazing covers 33% of total area (Hateley et al, 2014), with approximately 935 graziers managing 698,000 hectares of land (Reef Report Card, 2015). Grazing (including dairy) contributes 16% of the total TSS export load (Waterhouse et al., 2017). Banana production covers 11,000 hectares, with 260 growers in this region.

Burdekin

Major industries within the Burdekin region include agriculture, mining, metals refining (three major refineries are located on the coastal plain adjacent to Townsville) and aquaculture (NQ Dry Tropics, 2016). The region supports a substantial mining industry which produces coal, mainly in the Bowen Broken Bogie and Belyando catchments, gold, silver and zinc in the Upper Burdekin and silver in the Suttor catchment. There are approximately 44 major mining sites currently operating in the region and 22 planned mines under assessment (NQ Dry Tropics, 2016). The major port facilities in the region include the Port of Townsville in Cleveland Bay, and the Port of Abbot Point coal terminal in Abbot Bay. Urban areas represent 0.2% of total land area in the Burdekin. Urban expansion is occurring around the main regional centre of Townsville, and may also occur near new, major mine sites (NQ Dry Tropics, 2016).

Table 54 - Percentage contribution of anthropogenic dissolved inorganic nitrogen and fine sediment from Burdekin land uses

Land use	Total suspended solids (%)	Total suspended solids (%)
Nature conservation	0	0
Dryland cropping	1	0
Forestry	0	3
Grazing	0	25
Horticulture	2	1
Irrigated cropping	1	0
Sugarcane	85	0
Bananas	0	0
Dairy	0	0
Urban	0	5
Other	0	0
Streambanks for TSS / sewage treatment plants for dissolved inorganic nitrogen	10	66

In 2010-11, sugarcane from the area was worth $227.3 million (NQ Dry Tropics, 2016). Approximately 556 growers manage 83,000 hectares of sugarcane in the region (Great Barrier Reef Report Card 2015) and of those, 24 businesses are BMP accredited. There are approximately 983 graziers managing 12.4 million hectares of land and 37,000 kilometres of streambanks in the Burdekin region (Great Barrier Reef Report Card 2015). 38graziers are BMP accredited (BMP partnership data). Approximately 200 horticulture producers farm 25,000 hectares of land in the region (Great Barrier Reef Report Card, 2015). Approximately 44 growers manage 123,000 hectares under grain crops in this region (Great Barrier Reef Report Card 2015). Banana production covers just 23 hectares, with only three businesses in this region (ABS, 2016).

Mackay Whitsunday

The Mackay Whitsunday region supports industries from adjacent regions' coalfields, such as mining services, transport, and port facilities. Aquaculture operations are also located along the coastline. Continued growth will be focused on the coastal zone with flow-on growth attributable to major mining projects, which are largely located outside the region (Reef Catchments, 2014). Urban and intensive land uses account for 3% of land area in the region (Folkers et al, 2014).

Table 55 - Percentage contribution of anthropogenic dissolved inorganic nitrogen and fine sediment from Mackay Whitsunday land uses

Land use	Dissolved inorganic nitrogen (%)	Total suspended solids (%)
Nature conservation	0	0
Dryland cropping	0	0
Forestry	1	2
Grazing	0	20
Horticulture	0	0
Irrigated cropping	0	0
Sugarcane	91	36
Bananas	0	0
Dairy	0	0
Urban	4	3
Other	1	0
Streambanks for TSS / sewage treatment plants for dissolved inorganic nitrogen	3	39

The Mackay Whitsunday region produces approximately one third of Australia's sugar. Approximately 1380 cane growers manage 136,000 hectares of land in this region and of those, 26 businesses are BMP accredited. Approximately 416 graziers manage 304,000 hectares of land and 2300 kilometres of streambanks in the region (Great Barrier Reef Report Card 2015). Horticulture is a small sector with just 10 businesses and 686 hectares under production. Similarly, 11 businesses manage 589 hectares under grain production (ABS, 2016).

Fitzroy

There is extensive coal mining in the Bowen Basin. Mining in the Fitzroy represents approximately 70% of Queensland's coal mines (Waterhouse et al, 2015). Urban areas represent approximately 0.3% of land area in the Fitzroy, with major centres located at Gladstone and Rockhampton.

Table 56 - Percentage contribution of anthropogenic dissolved inorganic nitrogen and fine sediment from Fitzroy land uses

Land use	Dissolved inorganic nitrogen (%)	Total suspended solids (%)
Nature conservation	0	0
Dryland cropping	9	16
Forestry	7	2
Grazing	47	39
Horticulture	1	0
Irrigated cropping	0	0
Sugarcane	0	0
Bananas	0	0
Dairy	0	0
Urban	1	0
Other	1	0
Streambanks for TSS / sewage treatment plants for dissolved inorganic nitrogen	33	42

The Fitzroy is dominated by grazing. Approximately 3666 graziers manage 12.7 million hectares of land and 39,000 kilometres of streambanks in the Fitzroy region (Great Barrier Reef Report Card 2015). Thirty graziers are BMP accredited (BMP partnership data). In addition, approximately 100 horticulture producers farming 7700 hectares of land (Great Barrier Reef Report Card, 2015). Approximately 600 grain growers manage about 914,000 hectares of land (Great Barrier Reef Report Card 2015).

Burnett Mary

Mining is one of the major industries in the Burnett Mary region. Mining of black coal, gold, kaolin and limestone occupies approximately 0.07% of land area in the region. Intensive production uses, including aquaculture, feedlots, macadamia nut and mango production are developing in the region. In addition, industrial and port development is under consideration at the river mouth in the Burnett Basin. The total urban land use area is 2.3% of the total area. The largest urban areas are Maryborough, Hervey Bay and Bundaberg. (BMRG, 2015).

Table 57 - Percentage contribution of anthropogenic dissolved inorganic nitrogen and fine sediment from Burnett Mary land uses

Land use	Dissolved inorganic nitrogen (%)	Total suspended solids (%)
Nature conservation	0	0
Dryland cropping	1	0
Forestry	1	3
Grazing	16	25
Horticulture	1	1
Irrigated cropping	1	0
Sugarcane	67	0
Bananas	0	0
Dairy	0	0
Urban	7	5
Other	0	0

Land use	Dissolved inorganic nitrogen (%)	Total suspended solids (%)
Streambanks for TSS/ sewage treatment plants for dissolved inorganic nitrogen	6	66

Approximately 498 sugarcane growers manage 86,000 hectares of land in the Burnett Mary region (Great Barrier Reef Report Card 2015), of which nine businesses are BMP accredited. Approximately 2495 graziers manage 2.7 million hectares of land (Great Barrier Reef Report Card 2015). Eight graziers are BMP accredited (BMP partnership data). There are approximately 280 horticulture producers farming around 23,000 hectares of land (Great Barrier Reef Report Card 2015). There are 17 banana businesses and 602 grains businesses managing 184 hectares and 22,686 hectares of land respectively.

Appendix 3: Consideration of other legislative frameworks

In addition to the *Environmental Protection Act 1994*, other legislative options in the *Planning Act 2016* and the *Water Act 2000* were also considered to regulate minimum practice standards for existing and new agricultural operators in the Great Barrier Reef catchments.

Planning Act

The planning framework provides regulatory tools for regulating new land uses, including imposing conditions on a development permit, or by setting requirements in self-assessable codes about the nature and scale of development proposals. For example, a development permit will state the activity that is approved by the permit, the scale of the activity that is permitted, any requirements regarding the location of the activity on the site and any critical design characteristics for the construction of facilities for the activity.

The Planning Act could be used to manage the impact of new agricultural development activities and is currently used to regulate some ERAs such as feedlots together with the *Environmental Protection Act 1994*. However, the planning framework cannot easily be applied to existing agricultural activities to manage ongoing farm practices and requiring new operators to adhere to minimum practice standards that do not relate to the way the land is developed for agriculture is also problematic. The *Environmental Protection Act 1994* was considered more appropriate for regulating ongoing environmental impacts, such as pollutant run-off and farm management systems. It also allows for the minimum practice standards to be improved over time if water quality targets are still not being achieved or if new innovative approaches are proven beneficial and recommended for broad application.

Water Act

Access to water, particularly through irrigation, is assumed to be a key driver behind expansion and intensification of agricultural land use. Poor irrigation practices by existing operators can also lead to surplus run-off.

Water use is regulated under the *Water Act 2000* which provides a framework for the planning, allocation and use of surface water and groundwater in Queensland, including regulating major water impoundments (such as dams and weirs) and extraction through pumping for irrigation and other uses. The *Water Act 2000* provides a system of interrelated plans, licences and permits for the regulation of in-stream (watercourses, lakes and springs) and overland water flow and groundwater.

Options considered under the *Water Act 2000* included preparing water use plans for Great Barrier Reef catchments. Under the Act, water use plans can be prepared if the Minister is satisfied there are risks that water use may cause negative effects on land and water resources, including deteriorating water quality. A water use plan could then include standards for water use practices to be adopted by irrigators.

The *Water Act 2000* was considered too narrow in focus to be able to prescribe broader minimum practice standards required of agricultural activities beyond how water is used, such as the management of excess nutrients or sediments or farming activity such as clearing, replanting and broadacre ploughing.

Appendix 4: Minimum regulatory standards for existing and new agricultural production in Great Barrier Reef catchments

1. Minimum standards for existing operators

1.1 Sugarcane growing

A staged approach is proposed for the application of improved minimum standards for sugarcane growing. The initial stage will require growers to meet the current regulated standard – with some amendments – from the date the regulations commence in all reef catchments, with the exception of the Burnett Mary. The next stage will expand on these standards by requiring a more refined nutrient management approach within two years for all reef catchments from the date the regulations commence. The minimum regulatory standards focus on optimum nutrient application

The proposed approach for minimum standards for sugarcane growing:

- Promotes the adoption of practices considered to present a lower risk to reef water quality than other approaches (as supported by evidence gathered through the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program and other research programs).
- Recognises that there are significant benefits in ensuring widespread compliance with the current minimum standards.
- Aims to optimise fertiliser use to maximise efficiency and reduce losses, while also seeking to maintain profitability and productivity.
- Recognises that optimising fertiliser use maintains and improves farm profitability.
- Recognises that a profitable and sustainable sugarcane industry is important to Queensland and that nutrient management needs to be refined to reduce nutrient run-off and ensure the long-term health and resilience of the reef.
- Recognises that nutrient management strategies required to improve nutrient use efficiency can vary from farm to farm and within farms.
- Anticipates that the knowledge and tools to assist the adoption of practices that maximise nutrient use efficiency will continue to improve over time and requires ongoing investment.

The results of many field trials (e.g., the RP20 Burdekin nitrogen trials), and information outlined in the 2014 sugarcane nutrient use efficiency review by Sugar Research Australia, justifies the current minimum standards for nutrient use. Current research and trials and the Sugar Research Australia review have also outlined that finer scale nutrient management – for example addressing yield constraints, soil health issues, and improving irrigation efficiency – can be applied to improve nutrient use efficiency beyond that achieved through adopting current minimum standards.

The Stage 1 minimum standards for existing sugarcane growers are outlined in Table 58 below.

Table 58 - Stage 1: Application of revised minimum standards across all reef catchments

It is proposed that the following current minimum standards for sugarcane growing are maintained: 1. Soil sampling and analysis: soil sampling regime must align with the minimum regulated method as used for existing farms. 2. Calculating nutrient rate: • Calculating and applying the optimum amount of N and P • Adjusting N rates after small crop (other than legumes) production (Southern region / Burnett Mary region only) • Mill mud nutrient deductions must be made from bag N and/or P fertiliser application rates

3. Record keeping: growers are required to keep records of soil tests, use of N and P fertilisers and agricultural chemicals.

It is also proposed that the following minimum standards are additions:

4. Placement of fertiliser: no ground based broadcast fertiliser application is practiced.
5. Calibration: Fertiliser equipment calibrated prior to the season, change of product and crop stage, i.e. plant and ratoon.
6. Soil loss controls: the use of measures that will minimise the release of soil to receiving waters. At least one of the following practices are utilised:
    - A green cane trash blanket is retained on suitable soils after harvest with sufficient volume to mitigate sediment loss
    - Laser levelling away from water course
    - Recycle pit or constructed wetland designed to capture run-off is in place.

Where cane is grown on land with a gradient greater than 3% (King, 2016) a green cane trash blanket is in place after harvest and:

- Diversion banks are in place to divert surface water flows away from blocks/areas of exposed soil, **OR**
- All drainage structures are wide vegetated spoon drains designed to collect run-off and slow water velocity, **OR**
- All drainage water must enter silt trap or similar structure prior to release from farm, **OR**
- Uniformly dense vegetated grass buffers with minimum ground cover and a minimum width are in place, **OR**
- Contour banks that intercept run-off before it concentrates and channel it into stable grassed waterways, or grassed areas adjacent to a paddock are in place, **OR**
- Fallow crops are established prior to wet season maintaining sufficient ground cover.

It is proposed that guidance material will be developed to assist with implementation of some or all of the standards relating to sediment control. For example, information on specifications for buffer zones, spoon drains etc. could be developed taking into account differing regional conditions. This material would likely be based on existing information, such as the Queensland Soil Conservation Guidelines (DSITI, 2015).

Under Stage 1:

- Growers in all reef catchments with the exception of the Burnett Mary will be required to meet the full set of revised minimum standards.
- Growers who are already undertaking nutrient management planning as described in Stage 2 will also be considered as meeting the Stage 1 minimum standards.

Stage 2 – Transition to refined nutrient management across all reef catchments

Reflecting the full industry Six Easy Steps methodology, it is proposed that grower's in all reef catchments transition to a more refined nutrient management approach – within two years of the commencement of the revised reef protection regulations – based on the implementation of a whole of farm nutrient management plan. The nutrient management plan would document a finer scale nutrient management approach, which considers crop varieties and classes, soil types, soil data, yield limitations (e.g. water logging, sodicity) and previous history (i.e., use of mill mud, legumes, yield, ameliorants) across management zones.

Scientific evidence as well as economic evidence is improving suggesting that using finer scale information, combined with a holistic whole of farm management approach can lead to a significant improvement in productivity, nutrient use efficiency and reduced loss of nutrients to waterways. For example, nutrient rate trials under two known yield constraints, waterlogging and sodicity, found that yields on sodic soils were not impacted by application rates up to 35% below the standard recommended rates, with the trials conducted on waterlogged areas generating similar results. Trials conducted in the Wet Tropics under favourable weather conditions showed no significant yield differences for varied rates ranging from 80 to 160 kg/N/ha.

The requirement to implement property specific nutrient management plans is proposed to be accompanied by an implementation strategy and support program to assist growers not already involved in an incentive program – acknowledging that this transition can require upfront costs and agronomic expertise. Both the Queensland and Australian governments are providing funding to growers to prepare nutrient management plans through the Queensland Reef Water Quality Program and Reef Trust. The proposed implementation strategy and support program would complement these investments.

Growers would also still be required to undertake soil sampling and analysis and keep records of soil tests, use of N and P fertilisers and agricultural chemicals. They would also be required to continue to calibrate fertiliser application equipment prior to the season and at each product change. Measures would also need to be adopted to minimise the release of soil to receiving waters.

1.2 Grazing

Under this approach all commercial grazing businesses would be required to meet minimum standards. Under the current approach an Environmental Risk Management Plan is required for cattle grazing on more than 2000 ha in the Burdekin with more than 100 standard cattle units. The use of Environmental Risk Management Plans to manage the hazards and risks associated with nutrients, sediments and chemicals will be removed under the proposed regulations. As at 31 August 2017 there were 20 grazing Environmental Risk Management Plans still accredited (all due to expire by August 2018).

The greatest risk to water quality from grazing activities is due to loss of soil (sediment) through processes of erosion (gully, streambank and hillslope erosion). The amount of sediment coming from hillslope erosion as opposed to gully or streambank erosion varies substantially from catchment to catchment. Natural rates of erosion vary depending on complex interactions between land type characteristics (surface and subsurface soils, vegetation types, land condition, etc.), slope, location, historical management/use and climatic effects. Regardless, maintaining good land condition and ground cover is the key management lever that growers have to reduce accelerated soil erosion and sediment run-off.

Over time, a suite of grazing land management principles have been developed by science and accepted by industry and government as optimal to reduce soil losses. These reduce erosion rates regardless of the natural variability encountered across the landscape or the type of grazing business enterprise being undertaken. They provide the basis for the proposed minimum regulatory standards for grazing. The proposed approach focuses on preventing accelerated erosion and the management of run-off by maintaining high levels of ground cover.

Grazing land management trials, such as the Wambiana property trial show that moderate stocking around the long-term cattle carrying capacity for the land can increase gross margin returns over the longer-term, within 10 years. These benefits result from improved cattle condition, lower operating costs, and a more stable income, including during drought periods.

It is proposed that graziers are provided with a 12 month transitionary period to meet the new standard. The proposed minimum standards are detailed in Table 59.

Table 59 - Minimum standards for grazing properties

Minimum standards for grazing properties
1. A property map that assists in property planning and grazing land management is required and includes: • estimated fence line location • estimated water point location • land types based on grazing land types for region • measured paddock areas • estimated land type areas • areas of erosion
2. A suitable method is being used to calculate stocking rate and followed for each paddock (before dry season starts or soon after).
3. Land condition is assessed annually using photo monitoring sites (or equivalent technique) and documented for representative land types and grazing management adjusted accordingly to improve degraded land.
4. The use of measures that will minimise the release of soil to receiving waters by maintaining the land in good condition and using measures to promote the recovery of land where land is in poor or declining condition. *Notes:* • *Land condition is defined by the proportion of ground cover and density of perennial pasture species. An indication of poor land condition is where the proportion of ground cover for a land type is consistently lower than for similar land types in the surrounding local area.* • *Measures may include strategies to manage total grazing pressure such as managing stock numbers so that there is sufficient residual pasture at the start of the wet season to minimise soil loss, a planned program of wet season spelling for affected land, establishing/adding watering points (e.g. off-stream watering point), and sub-dividing areas (e.g. fencing to land type, fencing off frontage country) for improved management.* • *It is proposed that guidance material will be developed to assist with implementation of some or all of standards relating to sediment control. For example, information on specifications for linear features could be developed taking into account differing regional conditions. This material would likely be based on existing information, such as the Queensland soil conservation guidelines (DSITI, 2015).*
5. Records of fertiliser use are kept, including areas treated, fertiliser rates applied, and any soil testing done prior to application (existing requirement).
6. Records of agricultural chemical application are kept including date of application, location and area of paddock(s) treated (including map details), product trade name, application rate, spray conditions, and operator details (existing requirement).

These standards reflect landscape and climatic variability, and the inherent difficulty in prescribing particular practices, or stipulating fixed stocking rates, across all grazing circumstances within a catchment. Standards that do not reflect this variability can have unintended consequences for grazing production in certain areas. For example, a grazing strategy or erosion management technique in one location may have a completely different effect (e.g., negative production and/or water quality outcomes) in another location due to differing climatic conditions, and local soil and vegetation characteristics.

In implementing the proposed standards, graziers are given flexibility and will be expected to select the particular suite of practices appropriate to meet the standard in their specific circumstance. The consequence of this will be that the practices will be appropriate for the particular grazing enterprise, and its location, while at the same time represent the most reasonable and practical approach to minimise site specific erosion impacts on water quality.

1.3 Bananas

New regulated minimum standards are being proposed for banana production to reduce sediment and nutrient run-off. Science has shown the total loads of sediment and nutrients generated from banana production is less than that from cane and grazing, based on a smaller industry footprint. However, it is also known that the banana industry – which is based within the high priority area of the Wet Tropics – can produce higher amounts of nutrient and sediment loss per hectare than cane and grazing and can be a significant contributor to poor water quality.

The proposed new regulated standards have been designed to remove those practices that have the highest risk to water quality, specifically those practices that lead to over-fertilisation and fertiliser loss and those that lead to excessive erosion and soil loss. They have been designed with consideration of the accepted industry standards within the Banana Industry BMP Guidelines, and to also maintain or improve producer profitability and productivity.

The proposed minimum nutrient standards require growers to:

- Take soil and leaf tests to establish fertiliser application rates (adjustment approach) **OR** not use more than a maximum amount of fertiliser in a year.
- Keep records of soil tests and use of fertilisers and agricultural chemicals.
- Only apply fertiliser to the bed area and not the inter-row.
- Calibrate fertiliser application equipment six monthly and at each change of product.

Unlike the sugarcane industry, the banana industry does not have an accepted industry standard nutrient management methodology. Consequently, the current proposal is seeking feedback on two options. The first option uses a maximum rate based on the Industry BMP guidelines and expert advice. While the second option uses the adjustment approach, which is a more refined approach using site specific information. This latter approach however has not yet achieved broad industry uptake and does not have the same level of scientific validation or detailed methodology as the cane nutrient methodology: the Six Easy Steps.

Research from 11 banana farms in the Tully-Murray rivers region found that 280 kg N/ha was the annual average, however this was thought to be lower than the industry average (Faithful and Finlayson, 2004). Other research has demonstrated that in some areas a plant crop can be grown on 150 kg N/ha/year, and a ratoon crop on 250 to 300 kg N/ha/year (Stuart Lindsay, QDPIF, pers. comm. 2006; ACTFR, 2007).

Research does not extensively cover phosphorus use in banana crops. Some industry literature from fertiliser companies outlines that phosphorus application rates are around 40kg/ha/yr, whilst more recent studies (King, 2016) have shown that the phosphorus requirements are 21 kg P/ha/year for plant crops and up to 50 kg P/ha/year for ratoon crops (ACTFR, 2007).

As with the approach taken with the grazing standards, the proposed minimum sediment standard requires growers to use measures that will minimise the release of soil to receiving waters. Erosion management on banana farms typically relates to maintenance of inter-rows and roadways, farm contouring and stormwater control, and maintaining and remediating erosion prone areas (e.g., streambanks and culverts). The sediment standard also proposes to deal with areas with a high risk

of sediment loss (including the inter-row space and headlands) and requires that the proportion of ground cover at all times is no less than 60%, consisting of living and/or dead material.

This standard reflects landscape variability, and the inherent difficulty in prescribing particular practices for all banana farms across the catchment. Like grazing, an erosion management technique used on one banana farm may have a completely different effect (e.g., negative production and/or water quality outcomes) if used on another farm in another location due to differing climatic conditions, and local soil and vegetation characteristics. In implementing the standard, banana growers are given flexibility and will be expected to select the particular suite of practices appropriate to meet the standard in their specific circumstance.

It is proposed that banana growers are provided with a 12 month transitionary period to meet the new standard. A summary of the proposed minimum standards for bananas are shown in Table 60.

Table 60 - Minimum standards for existing banana businesses

Minimum standards for existing banana businesses
Sediment loss controls • All inter-rows have at least 60% (living or dead) ground cover Where bananas are grown on land with a gradient greater than 3%: • Diversion banks are in place to divert surface water flows away from blocks/areas of exposed soil, **OR** • All drainage structures are wide vegetated spoon drains designed to collect run-off and slow water velocity, **OR** • All drainage water must enter silt trap or similar structure prior to release from farm, **OR** • Uniformly dense vegetated grass buffers with sufficient ground cover of a minimum width are in place, **OR** • Contour banks that intercept run-off before it concentrates; and channel it into stable grassed waterways, or grassed areas adjacent to a paddock, are in place, **OR** • Fallow crops are established prior to wet season maintaining sufficient ground cover. *Note: It is proposed that guidance material will be developed to assist with implementation of some or all of standards relating to sediment control. For example, information on specifications for buffer zones, spoon drains etc. could be developed taking into account differing regional conditions. This material would likely be based on existing information, such as the Queensland Soil Conservation Guidelines (DSITI, 2015).*
Soil and leaf sampling and analysis • Soil testing (for nitrogen [N] and phosphorus [P] content) and leaf testing (for N and P content) are used to determine the N and P requirement for plant and ratoon crops. Soil testing is undertaken: o prior to planting (or as close as possible to the time of applying fertiliser) o on representative soil types/groupings
Calculating nutrient rate Maximum nitrogen application for banana crops • Ratoons - 350 kg N/ha/year • Plant crops after a fallow period of at least six months - 250 kg N/ha/year Maximum Phosphorus application for banana crops • 60 kg/ha/year, **OR**

Minimum standards for existing banana businesses
Nutrient application rates are determined for plant and ratoon crops using adjustment method (using leaf and soil nutrient testing to determine nitrogen and phosphorus application rates) or another method that provides appropriate evidence for the application rates.
Placement of fertiliser • Banded surface application on the bed if wet weather precludes fertigation.
Calibration • Calibrate fertiliser application equipment six monthly and at each change of product. •
Record keeping • Growers are required to keep records of soil tests, use of fertilisers and agricultural chemicals

2. Minimum standards for new production

2.1 Sugarcane

New Greenfield sites will be required to meet farm design standards and management practice standards. Existing activities that expand and or intensify will be required to meet the same nutrient and soil loss standards proposed under Stage 2 for existing operators. The required standards are outlined in Tables 61 and 62 below.

New developments have the opportunity to put infrastructure and practices in place that will optimise production efficiencies and thus deliver the best possible reduction in sediment and nutrient loss and subsequently maximise water quality benefits and farm profit. The information below supports the standards for new activities and will also be used to develop guidance material to assist producers to meet the standards.

Standards for new sugarcane activities

Soil loss is a product of rainfall intensity, soil erodibility, slope length and gradient, cover and crop management and the management practices applied. Evidence shows that filter strips on gradients above 1% greatly decrease the amount of sediment retained from the cropped area prior to the filter strip (Karssies and Prosser, 1999). Structure, density and condition of filter strip vegetation is essential as the greatest deposition of sediment is achieved by vegetation that is uniformly dense at ground level (King, 2016). Tables for all the six bio-geographical regions of Queensland have been developed that demonstrate filter width to achieve set soil loss targets (t/ha/yr) based on slope, soil erodibility and ground cover (King, 2016).

Diversion banks are effective at preventing convergence and flow velocity, and decreasing erosive potential. Retaining crop residues and/or planting cover (or fallow) crops increases infiltration and the strength of soil aggregate, reducing sediment loss. Contour banks are an important component of preventing sediment loss with up to 80%of soil loss from the contour bay deposited in the contour channel. Properly constructed and maintained drainage structures slow water velocity allowing sediment to settle out (DSITI, 2015).

Controlled traffic is effective in reducing run-off and soil loss in sugarcane farming and research shows significantly less sediment loss from improved tillage practices when compared to conventionally cultivated cane land (Eberhard et al., 2017; Karssies and Prosser, 1999). Research also shows that under reduced or zero tillage, sediment loss is significantly lower (75%) than from traditional cropping practices (McIvor, 2012).

Research supports increasing irrigation efficiency to minimise run-off, deep drainage and denitrification. Expected losses of nitrogen from various irrigation systems given soil and other factors have been established (McIvor, 2012) and modelling shows that good farm and irrigation design increases irrigation efficiency and reduces nutrient losses.

Currently 85% of the area in Queensland practices green cane trash blanketing with only the Burdekin district not utilising this practice due to issues relating to furrow irrigation efficiency. In a study undertaken in the Mackay district, Rayment and Neil (1996) showed the introduction of green cane trash blanketing has had a major influence on reducing stream sediment levels. The value of green cane trash blanketing for soil erosion control was clearly demonstrated by Titmarsh et al. (1996, as cited in Turner et al. 2004) showing erosion levels of 0.1 tonne per hectare on trash blanketed areas and 11 tonnes per hectare from conventional cultivation (Rayment and Neil, 1996).

The uptake of green cane trash blanketing has been driven by both ecological and efficiency reasons, it has dramatically reduced the need for cane firing, protects soil from erosion during heavy rains and flooding and increases the amount of organic matter in the soil, improving composition and structure. It also assists in weed control and conserving soil moisture (CANEGROWERS website).

Fertiliser is not the only source of nutrient inputs. Other sources include legumes, which as a fallow crop can supply up to 300 kg N/ha, mill mud, which can supply around 400 kg N/ha and around 250 kg P/ha and irrigation water, which can supply up to 150 kg/N/ha. When determining fertiliser application rates, these sources need to be accounted for to minimise losses (McIvor, 2012) and also prevent impacts on crop and sugar yield from over-fertilisation.

Table 61 - Farm design standards for new sugarcane Greenfield sites in all river basins

Farm design standards for new sugarcane Greenfield sites in all river basins
Farm design standards – sediment loss controls • Diversion banks are in place to divert surface water flows away from blocks/areas of exposed soil. • A zonal or zero tillage system is utilised and soil cover is maintained throughout the wet season, e.g. fallow crops. • Contour banks that intercept run-off before it concentrates and channel it into stable grassed waterways, or grassed areas adjacent to a paddock are in place where cane is grown on gradients greater than 1% (Karssies and Prosser, 1999). • All drainage structures are wide vegetated spoon drains designed to collect run-off and slow water velocity, drainage water must enter silt trap or similar structure prior to release from farm. • Uniformly dense vegetated grass buffers with minimum ground cover and a minimum width are in place. • A controlled traffic system is in place for all field operations; e.g. bed forming, planting, spraying/fertilising, and harvesting. • Farm design and irrigation system is design to be matched to farm and soil specific characteristics to maximise crop water use and minimise loss or irrigation water off-farm. Irrigation system performance assessments are carried out on a regular basis and recorded in digital farm recording system. *Note: It is proposed that guidance material will be developed to assist with implementation of some or all of standards relating to sediment control. For example, information on specifications for buffer zones, spoon drains etc. could be developed taking into account differing regional conditions. This material would likely be based on existing information, such as the Queensland Soil Conservation Guidelines (DSITI, 2015).*

Farm design standards for new sugarcane Greenfield sites in all river basins
Calculating nutrient rate • All nutrient sources are accounted for when determining N and P application rates, e.g., legume fallow crops, mill mud etc.

Table 62 - Minimum practice standards for new sugarcane activities, including existing activities that expand and intensify, in all river basins

Minimum practice standards for new sugarcane activities in all river basins
Sediment loss controls At least one of the following practices are utilised: • A green cane trash blanket is retained on suitable soils after harvest with sufficient volume to mitigate sediment loss • Laser levelling away from water course • Recycle pit or constructed wetland designed to capture run-off is in place. Where cane is grown on land with a gradient greater than 3% (King, 2016) a green cane trash blanket is in place after harvest and: • Diversion banks are in place to divert surface water flows away from blocks/areas of exposed soil, **OR** • All drainage structures are wide vegetated spoon drains designed to collect run-off and slow water velocity, **OR** • All drainage water must enter silt trap or similar structure prior to release from farm, **OR** • Uniformly dense vegetated grass buffers with minimum ground cover and a minimum width are in place, **OR** • Contour banks that intercept run-off before it concentrates and channel it into stable grassed waterways, or grassed areas adjacent to a paddock are in place, **OR** • Fallow crops are established prior to wet season maintaining sufficient ground cover. *Note: It is proposed that guidance material will be developed to assist with implementation of some or all of standards relating to sediment control. For example, information on specifications for buffer zones, spoon drains etc. could be developed taking into account differing regional conditions. This material would likely be based on existing information, such as the Queensland Soil Conservation Guidelines (DSITI, 2015).*
Soil sampling and analysis Soil sampling regime must align with the minimum regulated method as used for existing farms.
Calculating nutrient rate Reflecting the full Six Easy Steps methodology, it is proposed that growers transition to a more refined nutrient management approach – within two years of the commencement of the revised reef protection regulations – based on the implementation of a whole-of-farm nutrient management plan. The nutrient management plan would document a finer scale nutrient management approach, which considers crop varieties and classes, soil types, soil data, yield limitations (e.g. water logging, sodicity) and previous history (i.e., use of mill mud, legumes, yield, ameliorants) across management zones.
Placement of fertiliser No ground based broadcast fertiliser application is practiced.
Calibration Fertiliser equipment calibrated prior to the season, change of product and crop stage, i.e., plant and ratoon.
Record keeping Growers are required to keep records of soil tests, use of fertilisers and agricultural chemicals.

2.2 Grazing

New Greenfield sites will be required to meet farm design standards and management practice standards. Existing activities that expand and or intensify will be required to meet the same standards for existing operators. The required standards are outlined in Tables 63 and 64 below.

Additional standards for new grazing developments promote the strategic use of infrastructure – fences, placement of off-stream watering points, roads and tracks to control stock movement and the timing and intensity of grazing, and thus promote good land condition for productivity and minimise the risk of sediment run-off (McIvor, 2012; Jones and Rohan, 2010).

This infrastructure not only enables maintenance of good land condition but aids in the recovery of degraded areas, for example through a planned program of wet season spelling or limiting cattle access to frontage country often prone to over grazing. These standards are supported in the *Reef Plan Paddock to Reef Grazing Water Quality Risk Framework;* a framework that ranks management practices according to the level of water quality risk.

Sediment source tracing in several catchments has identified that approximately 90% of fine sediment delivered to the Great Barrier Reef is from subsoil erosion (which could be derived from gully, bank, scald or deep rill erosion) (Waterhouse et al., 2017). Management practices reduce erosion of fine sediment by redistributing the pressure of agricultural activities away from areas vulnerable to erosion. In grazing lands, this involves using fencing and appropriate watering points that allows the separation of soil types with pasture that is preferentially grazed, riparian or frontage country (Eberhard et al., 2017), and gullied areas. Fencing and watering point infrastructure laid out in this way provides the ability to control where and when cattle graze, thus evening out grazing pressure and minimising localised overgrazing and land degradation. For example, Wilkinson et al., (2015) describes that the first step of gully erosion control is to fence around gullies to enable vegetation to grow with no or occasional grazing.

Linear features, including roads and tracks, are commonly associated with erosion on rural properties (Carey et al., 2015). They go on to explain how this erosion can reduce the usability of the road or track itself, affect access to other areas, increase the cost of maintaining the road or track, and or reduce the quality of water downstream. Well-sited and properly constructed property infrastructure can give many years of low-maintenance service, while poorly located and inappropriate improvements can create erosion problems and increase maintenance costs.

Table 63 - Farm design standards for grazing Greenfield sites in all river basins

Farm design standards for grazing Greenfield sites in all river basins
Farm design and sediment loss controls The following measures must be in place to manage stock access to degraded land and areas susceptible to erosion: • Off-stream watering points are positioned to attract cattle away from waterways and other vulnerable areas. • Fencing is in place around vulnerable areas to manage grazing pressure around gullies and streambanks, to control stock access and to promote the recovery of land in poor or declining condition. • Fencing infrastructure is in place to allow an appropriate pasture spelling regime to maintain grazing land in good condition e.g. a planned program of wet season spelling is established. • All linear features including roads, tracks and fences are positioned to avoid areas of high erodibility risk and wherever possible linear features should not be aligned across the slope

Farm design standards for grazing Greenfield sites in all river basins
at an angle. If this is unavoidable, cross-drainage structures such as whoa-boys must be installed at appropriate intervals (Carey et al., 2015). *Note: It is proposed that guidance material will be developed to assist with implementation of some or all of standards relating to sediment control. For example, information on specifications for roads could be developed taking into account differing regional conditions. This material would likely be based on existing information, such as the Queensland Soil Conservation Guidelines (DSITI, 2015).*

Table 64 - Minimum practice standards for new grazing activities, including existing activities that expand and intensify, in all river basins

Minimum standards for new grazing activities
1. A property map that assists in property planning and grazing land management is required and includes: • estimated fence line location • estimated water point location • land types based on grazing land types for region • measured paddock areas • estimated land type areas • areas of erosion
2. A suitable method is being used to calculate stocking rate and followed for each paddock (before dry season starts or soon after).
3. Land condition is assessed annually using photo monitoring sites (or equivalent technique) and documented for representative land types and grazing management adjusted accordingly to improve degraded land.
4. The use of measures that will minimise the release of soil to receiving waters by maintaining the land in good condition and using measures to promote the recovery of land where land is in poor or declining condition. *Notes:* • *Land condition is defined by the proportion of ground cover and density of perennial pasture species. An indication of poor land condition is where the proportion of ground cover for a land type is consistently lower than for similar land types in the surrounding local area.* • *Measures may include strategies to manage total grazing pressure such as managing stock numbers so that there is sufficient residual pasture at the start of the wet season to minimise soil loss, a planned program of wet season spelling for affected land, establishing/adding watering points (e.g. off-stream watering point), and sub-dividing areas (e.g. fencing to land type, fencing off frontage country) for improved management.* • *It is proposed that guidance material will be developed to assist with implementation of some or all of standards relating to sediment control. For example, information on specifications for linear features could be developed taking into account differing regional conditions. This material would likely be based on existing information, such as the Queensland Soil Conservation Guidelines (DSITI, 2015).*
5. Records of fertiliser use are kept, including areas treated, fertiliser rates applied, and any soil testing done prior to application (existing requirement).
6. Records of agricultural chemical application are kept including date of application, location and area of paddock(s) treated (including map details), product trade name, application rate, spray conditions, and operator details (existing requirement).

2.3 Bananas

New Greenfield sites will be required to meet farm design standards and management practice standards. Existing activities that expand and or intensify will be required to meet the same standards for existing operators. The required standards are outlined in Tables 65 and 66 below.

New banana developments should utilise permanent bed systems, practice minimal tillage, maintain soil cover through crop rotations and retain crop residues. As with other agricultural commodities, retaining ground cover increases soil organic matter, which increases infiltration and the strength of soil aggregate, and reduces sediment loss (Eberhard et al., 2017). Sediment loss under reduced tillage and increased soil cover conditions produces less than half the sediment loss of traditional practices (DSITI, 2015). Best management practices require that a minimum 60% ground cover should be maintained, with preference towards a living ground cover e.g., fallow crops (Banana BMP program).

Diversion banks, contour banks, and drainage structures are used to control sediment loss from runoff. Diversion banks incorporate channel slope and dimensions, rainfall, and catchment conditions to divert surface water flows away from high risk areas to reduce erosion (DSITI, 2015). Contour banks can trap up to approximately 80% of soil lost due to poor ground cover (Queensland Government, 2015). Properly designed drainage structures based on slope and hydraulic capacity slow water velocity and collect run-off; thereby, minimising erosion potential of water leaving farms.

Similar to cane farming, vegetated buffers in banana growing captures soil loss and prevent sediments from entering waterways. Karssies and Prosser (1999), investigated the impact of grassed filter strip gradients on sediment deposition immediately prior to the filter strip as water flow velocity decreases. For filter strip gradients above 1%there is a rapid decrease in the amount of sediment retained (per 100 m of filter strip) in the cropped area prior to the filter strip.

Karssies and Prosser (1999) go on to describe how structure, density and condition of filter strip vegetation is important as the greatest deposition of sediment is achieved by vegetation that is uniformly dense at ground level. Research also supports the minimum width of a filter strip to effectively trap sediment over most conditions, and these have been defined for the six bio-geographical regions of Queensland for varying rainfall erosivity, soil erodibility, slope and land cover.

Applying fertiliser fortnightly via fertigation in new banana developments will better synchronise the supply of nutrients with crop requirements, increase crop nutrient uptake and reduce nutrient losses (DSITI, 2015). Synchronising the supply of nitrogen to crop requirements can be achieved by applying a small amount of nitrogen at regular intervals, e.g. through fertigation of irrigated horticultural crops (Armour et al., 2013a). In Great Barrier Reef catchments, closely matching the amount of nitrogen applied to banana crops through fertigation has been shown to reduce nitrogen losses (DSITI, 2015; Armour et al., 2013b).

Table 65 - Farm design standards for banana Greenfield sites in all river basins

Farm design standards for banana greenfield sites in all river basins
Farm design and sediment loss controls • Diversion banks are in place to divert surface water flows away from blocks/areas of exposed soil • A permanent bed system is utilised and soil cover is maintained throughout the wet season, e.g. fallow crops

Farm design standards for banana greenfield sites in all river basins
• Contour banks that intercept run-off before it concentrates and channel it into stable grassed waterways, or grassed areas adjacent to a paddock are in place where bananas are grown on gradients greater than 1% (Karssies and Prosser, 1999). • All drainage structures are wide vegetated spoon drains designed to collect run-off and slow water velocity, drainage water must enter silt trap or similar structure prior to release from farm. • Uniformly dense vegetated grass buffers with sufficient ground cover at a minimum width are in place. *Note: It is proposed that guidance material will be developed to assist with implementation of some or all of standards relating to sediment control. For example, information on specifications for buffer zones, spoon drains etc. could be developed taking into account differing regional conditions. This material would likely be based on existing information, such as the Queensland Soil Conservation Guidelines (DSITI, 2015).*
Placement of fertiliser Farm is capable of suppling fortnightly application of fertiliser using fertigation system.

Table 66 - Minimum practice standards for new banana activities, including existing activities that expand and intensify, in all river basins

Minimum standards for new banana activities
Sediment loss controls • All inter-rows have at least 60% (living or dead) ground cover Where bananas are grown on land with a gradient greater than 3% (King, 2016): • Diversion banks are in place to divert surface water flows away from blocks/areas of exposed soil, **OR** • All drainage structures are wide vegetated spoon drains designed to collect run-off and slow water velocity, **OR** • All drainage water must enter silt trap or similar structure prior to release from farm, **OR** • Uniformly dense vegetated grass buffers with sufficient ground cover of a minimum width are in place, **OR** • Contour banks that intercept run-off before it concentrates; and channel it into stable grassed waterways, or grassed areas adjacent to a paddock, are in place, **OR** • Fallow crops are established prior to wet season maintaining sufficient ground cover. Note: It is proposed that guidance material will be developed to assist with implementation of some or all of standards relating to sediment control. For example, information on specifications for buffer zones, spoon drains etc. could be developed taking into account differing regional conditions. This material would likely be based on existing information, such as the Queensland soil conservation guidelines (DSITI, 2015).
Soil and leaf sampling and analysis • Soil testing (for nitrogen [N] and phosphorus [P] content) and leaf testing (for N and P content) are used to determine the N and P requirement for plant and ratoon crops. Soil testing is undertaken: o prior to planting (or as close as possible to the time of applying fertiliser) o on representative soil types/groupings
Calculating nutrient rate Maximum nitrogen application for banana crops • Ratoons - 350 kg N/ha/year

Minimum standards for new banana activities
• Plant crops after a fallow period of at least six months - 250 kg N/ha/year Maximum Phosphorus application for banana crops • 60 kg/ha/year, **OR** Nutrient application rates are determined for plant and ratoon crops using adjustment method (using leaf and soil nutrient testing to determine nitrogen and phosphorus application rates) or another method that provides appropriate evidence for the application rates.
Placement of fertiliser Banded surface application on the bed if wet weather precludes fertigation.
Calibration • Calibrate fertiliser application equipment six monthly and at each change of product.
Record keeping • Growers are required to keep records of soil tests, use of fertilisers and agricultural chemicals.

References

ABARES 2017. Agricultural commodities: March quarter 2017, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

ABS 2017. Employee Earnings and Hours, Australia, May 2016, cat number 6306, Australian Bureau of Statistics.

ABS 2017a. Land Account: Queensland, Experimental Estimates, 2011 – 2016, cat number 4609, Australian Bureau of Statistics.

ABS, 2016. Agricultural Commodities, Australia, state/territory and NRM - 2014-15, QLD tab. Available at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/7121.02014-15?OpenDocument

ACTFR, 2007. Plot-scale runoff of nutrients and sediment under varying management regimes on a banana and cane farm in the Wet Tropics, Queensland November 2002 to July 2006. ACTFR Project for Task 1, Catchment to Reef Project ACTFR Report No. 07/10

Alluvium 2016. Costs of achieving the water quality targets for the GBR, Department of Environment and Heritage Protection, Brisbane.

Armour, J., Masters, B. and Mortimore, C. 2013a. Grassed inter-rows in bananas in the Wet Tropics region. 2013 Paddock Case Study, Horticulture, RWQPP. Available from: http://reefplan.qld.gov.au/measuring-success/case-studies/assets/case-study-horticulture-grassed-inter-rows.pdf

Armour et al., 2013b. Nitrogen leaching from the root zone of sugarcane and bananas in the humid tropics of Australia, *Agriculture, Ecosystems & Environment*, **180**, 68-78.

Bartley, R., Waters, D., Turner, R., Kroon, F., Wilkinson, S., Garzon-Garcia, A., Kuhnert, P., Lewis, S., Smith, R., Bainbridge, Z., Olley, J., Brooks, A., Burton, J., Brodie, J., Waterhouse, J., 2017. Scientific Consensus Statement 2017: A synthesis of the science of land-based water quality impacts on the Great Barrier Reef, Chapter 2: Sources of sediment, nutrients, pesticides and other pollutants to the Great Barrier Reef. State of Queensland, 2017.

BMRG, 2015. Water Quality Improvement Plan for the Burnett Mary 2015, Burnett-Mary Regional Group, Bundaberg, Australia. 171 pp. http://www.bmrg.org.au/resources/publications/water-quality-improvement-plans/.

Bos, M., Pressey, R. L., and Stoeckl, N., 2014. Effective marine offsets for the Great Barrier Reef World Heritage Area, *Environmental Science & Policy*, 42 (2014), 1-15.

Brodie, J., Baird, M., Waterhouse, J., Mongin, M., Skerratt, J., Robillot, C., Smith, R., Mann, M., Warne, M. 2017. Development of basin specific ecologically relevant pollutant load reduction targets for the Great Barrier Reef. TropWATER Report No. 17/38, James Cook University, Published by the State of Queensland, Brisbane, Australia. pp. 68.

Burdekin Shire Council, 2015. Economic Development Strategy 2015-2010.

Coggan, A., Whitten, S. and Bennett, J. 2014,"Private transaction costs of participation in water quality improvement programs for Australia's Great Barrier Reef: Extent, causes and policy implications", *The Australian Journal of Agricultural and Resource Economics*, 59, 499-517.

Cook, S., Kukulies, T. 2017. The economic impact of Banana Best Management Practice adoption for growers in the Wet Tropics: RP140B Case Study Two, Department of Agriculture and Fisheries

Cook, S., Kukulies, T., Rattray, D. 2016. The economic impact of Banana Best Management Practice adoption for growers in the Wet Tropics: RP140B Case Study One, Department of Agriculture and Fisheries (DAF), Queensland.

Cook, S., Kukulies, T. 2016a. The economic impact of Banana Best Management Practice adoption for growers in the Wet Tropics: RP140B Case Study Two, Department of Agriculture and Fisheries (DAF), Queensland.

CYNRM & SCYC, 2016. Eastern Cape York Water Quality Improvement Plan. Cape York Natural Resource Management and South Cape York Catchments, Cooktown, Queensland, Australia.

Eberhard, R., Thorburn, P., Rolfe, J., Taylor, B., Ronan, M., Weber, T., Flint, N., Kroon, F., Brodie, J., Waterhouse, J., Silburn, M., Bartley, R., Davis, A., Wilkinson, S., Lewis, S., Star, M., Poggio, M., Windle, J., Marshall, N., Hill, R., Maclean, K., Lyons, P., Robinson, C., Adame, F., Selles, A., Griffiths, M., Gunn, J., McCosker, K., 2017. Scientific Consensus Statement 2017: A synthesis of the science of land-based water quality impacts on the Great Barrier Reef, Chapter 4: Management options and their effectiveness. State of Queensland, 2017.

EHP, 2017. Frequently Asked Questions: Draft Reef 2050 Water Quality Improvement Plan and 2017 Scientific Consensus Statement http://www.reefplan.qld.gov.au/about/assets/faqs-reef-2050wqip-2017scs.pdf

EHP, 2017. Guideline – Application requirements for activities with impacts to water. Available at: http://www.ehp.qld.gov.au/assets/documents/regulation/era-gl-water-impacts.pdf

EHP, 2016. Assessment guideline – Assessing applications for sewage treatment works. ESR/2015/1652, Version 3.00, Effective 12 Sep 2016.

EHP, 2014. Regulatory Strategy, Version 2. Available at: https://www.ehp.qld.gov.au/management/planning-guidelines/policies/pdf/regulatory-strategy.pdf

Deloitte Access Economics, 2017. At what price? The economic, social and icon value of the Great Barrier Reef, Great Barrier Reef Foundation.

DSITI, 2015. Soil conservation guidelines for Queensland, available at: https://publications.qld.gov.au/dataset/soil-conservation-guidelines.

DSITIA, 2012. Land use summary 1999-2009: Great Barrier Reef catchments. Queensland Department of Science, Information Technology, Innovation and the Arts, Brisbane.

Eberhard, R., Thorburn, P., Rolfe, J., Taylor, B., Ronan, M., Weber, N., Flint, N., Kroon, F., Silburn, M., Bartley, R., Davis, A., Wilkinson, S., Lewis, S., Star, M., Poggio, M., Windle, J., Marshall, N., Hill, R., Maclean, K., Lyons, P., Robinson, C., Adame, F., Selles, A., Griffiths, M., Gunn, J., McCosker, K., 2017. Scientific Consensus Statement 2017: A synthesis of the science of land-based water quality impacts

on the Great Barrier Reef, Chapter 4: Management options and their effectiveness. State of Queensland, 2017.

eWater, 2010. Source catchments: Realising whole-of-catchment water management. Available at: http://ewater.org.au/h2othinking/?q=2010/08/source-catchments-realising-whole-catchment-water-management

Faithful, J., and Finlayson, W., 2005. Water quality assessment for sustainable agriculture in the Wet Tropics-A community-assisted approach. Marine Pollution Bulletin, 51 (2005), 99-112.

Folkers, A., Rohde, K., Delaney, K., and Flett, I., 2014. Mackay Whitsunday Water Quality Improvement Plan 2014-2021, Reef Catchments, December 2014.

Great Barrier Reef Water Science Taskforce, 2016. Final Report May 2016. Queensland Government.

Harvey, S., Cook, S. and Poggio, M. 2016. Economic assessment of best management practices for banana growing, Report to the Department of Environment and Heritage Protection through funding from the Reef Water Quality Science Program, RP140B Initial synthesis report, Department of Agriculture and Fisheries (DAF), Queensland.

Harvey, S., Poggio, M., Thompson, M. and Holligan, E. 2016a, Understanding the economics of improved management practices and systems on sugarcane farms, Department of Agriculture and Fisheries (DAF), Queensland.

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

Jones, P., and Rohan, P., 2010. Best-bet practices for managing the grazing lands of the Fitzroy Woodlands - A technical guide of options for optimising animal production, profitability and land condition. Available at: https://futurebeef.com.au/wp-content/uploads/TechGuide-Fitzroy-Woodlands-May-2012.pdf

King, N., 2016. Banana Best Management Practices – Environmental Guidelines for the Australian Banana Industry, Queensland Department of Agriculture and Fisheries.

Meat and Livestock Australia 2017, *Farm survey data for the beef, slaughter lambs and sheep industries*, http://apps.daff.gov.au/MLA/ Last accessed 7th August 2017.

McCloskey, G.,Ellis, R., Shaw, M., Waters, D., 2014. Modelling reductions of pollutant loads due to improved management practices in the Great Barrier Reef catchments – Cape York NRM region, Technical Report. Queensland Department of Natural Resources and Mines, Cairns, Queensland.

McCloskey, G., Waters, D., Baheerathan, R., Darr, S., Dougall, C., Ellis, R., Fentie, B., Hateley, L., 2017. Modelling reductions of pollutant loads due to improved management practices in the Great Barrier Reef catchments: updated methodology and results—Technical Report for Reef Report Card 2015. Queensland Department of Natural Resources and Mines, Brisbane.

McIvor, J., 2012. Sustainable management of the Burdekin grazing lands – A technical guide of options for stocking rate management, pasture spelling, infrastructure development and prescribed burning to optimise animal production, profitability, land condition and water quality outcomes. Available at: http://futurebeef.com.au/wp-content/uploads/BurdekinGrazing_final-04a.pdf

NQ Dry Tropics, 2016. Burdekin Region Water Quality Improvement Plan 2016. Better Water for the Burdekin. NQ Dry Tropics, Townsville.

Pannell, D., Roberts, A. and Park, G. 2014. Economic analysis of grazing systems for water quality improvement in the Burnett Mary catchment. Report provided for the Water Quality Improvement Plan for the Burnett Mary 2015.

Queensland Government, 2015. Run-off control measures for erosion control in cropping land. Retrieved from: qld.gov.au/environment/land/soil/erosion/management.

Queensland Government, 2013. Queensland Environmental Offsets Policy 2017 (Version 1.4), Biodiversity Integration and Offsets, Department of Environment and Heritage Protection, State of Queensland.

Queensland Government Statistican's Office 2015. Queensland Government Population Projections, 2015 edition, http://www.qgso.qld.gov.au/subjects/demography/population-projections/

Queensland Water, 2016. Sewage treatment plants in Great Barrier Reef catchments, Industry paper.

Reef Report Card, 2015. Great Barrier Reef Report Card 2015 Results, available at http://www.reefplan.qld.gov.au/measuring-success/report-cards/2015/assets/gbr-2015report-card-detailed-results.pdf

Rivera, J., de Leon, P., and Koerber, C., 2006. Is Greener Whiter Yet? The Sustainable Slopes Program after Five Years, *The Policy Studies Journal*, 34 (2), 195-221.

Roebeling, P. C., Webster, A. J., Biggs, J. and Thorburn, P., 2007. *Financial-economic analysis of current best management practices for sugarcane, horticulture, grazing and forestry industries in the Tully-Murray catchment.* Report to the Marine and Tropical Sciences Research Facility. Reef and Rainforest Research Centre, Cairns.

Rolfe, J. and Gregg, D. 2015. Factors affecting adoption of improved management practices in the pastoral industry in GBR catchments. *Journal of Environmental Management*, **157**, 182-193.

Rolfe, J. and Windle, J. 2016. Benchmarking costs of improving agricultural water management in GBR catchments. Report to the National Environmental Science Programme, Reef and Rainforest Research Centre Limited, Cairns.

Smart, J. B., Hasan, S., Volders, A., Curwen, G., Fleming, C. and Burford, M. 2016. A tradable permit scheme for cost-effective reduction of nitrogen runoff in the sugarcane catchments of the Great Barrier Reef. Report to the National Environmental Science Programme, Reef and Rainforest Research Centre Limited, Cairns.

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

Turner, J.D., Mason, F.M., Willcox, T.G. (2004). The revolution of resource management in the Australian sugarcane industry. 13th International Soil Conservation Organisation Conference. http://www.tucson.ars.ag.gov/isco/isco13/PAPERS%20R-Z/TURNER.pdf

Valle, H., and Martin, P., 2015. Australian sugarcane farm businesses: financial performance, 2013–14, ABARES research report prepared for Sugar Research Australia and the Queensland Government Department of Agriculture and Fisheries, Canberra, December.

Van Grieken, M.E., Webster, A.J., Poggio, M., Thorburn, P. Biggs, J., Stokes, C. and McDonald, C. 2010. Implementation costs of Agricultural Management Practices for Water Quality Improvement in the GBR Catchments CSIRO: Water for a Healthy Country National Research Flagship.

Waterhouse, J., Schaffelke, B., Bartley, R., Eberhard, R., Brodie, J., Star, M., Thorburn, P., Rolfe, J., Ronan, M., Taylor, B., and Kroon, F., 2017. Scientific Consensus Statement: A synthesis of the science of land-based water quality impacts on the Great Barrier Reef, Chapter 5: Overview of key findings, management implications and knowledge gaps. State of Queensland, 2017.

Waterhouse, J., Flint, N., and Johnson, J., 2015. Fitzroy WQIP Supporting Studies: Key findings, gaps and recommendations. A report to the Fitzroy Basin Association to support the Fitzroy Water Quality Improvement Plan. November 2015. Available at http://riverhealth.org.au/wp-content/uploads/2016/02/Synthesis-Report-FinalDarft_2015_11_20-.pdf

Waters, DK, Carroll, C, Ellis, R, Hateley, L, McCloskey, GL, Packett, R, Dougall, C, Fentie, 2014. Modelling reductions of pollutant loads due to improved management practices in the Great Barrier Reef catchments – Whole of GBR, Technical Report, Volume 1, Queensland Department of Natural Resources and Mines, Toowoomba, Queensland (ISBN: 978-1-7423-0999).

Wilkinson S, Hawdon A, Hairsine P, and Austin J. 2015. Gully Toolbox: A technical guide for the Reef Trust Gully Erosion Control Programme 2015–16