FITZROY BASIN WATER QUALITY IMPROVEMENT REPORT

DECEMBER 2008

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Editors: Nathan Johnston, Gavin Peck, Phillip Ford, Cameron Dougall, Chris Carroll

ISBN: 978-0-9758172-2-3

Published by the Fitzroy Basin Association
Level 4
34 East Street
Rockhampton Qld 4700
Australia
www.fba.org.au

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INTRODUCTION

SUPPORTING MATERIALS

This report draws on many reports and documents. A full list is available in the references. The supporting reports outlined below have been commissioned by the Fitzroy Basin Association Incorporated (FBA) with funds secured under the Australian Government's Coastal Catchments Initiative (CCI) with findings enriching our current knowledge of the region to enable production of this report. Similar to the *Central Queensland Information Paper* (*CQ Info Paper*), this report has been produced to allow considered incorporation of targets, action and information into the *Central Queensland Strategy for Sustainability 2004 and Beyond* (*CQSS2*). This report builds upon these supporting reports and utilises similar frameworks to allow seamless transition. Please read both the *CQ Info Paper* and the *CQSS2* in conjunction with these supporting reports.

SUPPORTING REPORTS:

Final Report for the Ground Cover Monitoring in the Fitzroy Basin Project Department of Primary Industries and Fisheries Queensland (DPI&F)

Enhanced sediment and nutrient modelling and target setting in the Fitzroy Basin Department of Natural Resources and Water Queensland (NRW)

Gully Density Mapping and Modelling for the Fitzroy Basin, Queensland, Australia NRW

Simulating the Response of Keppel Bay coastal waters to potential changes in Sediment and Nutrient Loads Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Assigning Local Water Quality Trigger Values to Coastal and Marine Assets FBA

PARTNER REPORTS:

Central Queensland Strategy for Sustainability - 2004 and Beyond FBA

Central Queensland Information Paper Coastal Cooperative Research Centre (Coastal CRC)

AIM AND SCOPE

REPORT AIMS

1 Highlight new knowledge and information resulting from Australian Government's Coastal Catchments Initiative (CCI) funding for Fitzroy, and other research.

2 Recommend targets and actions for inclusion in the next iteration of the *CQSS2*.

3 Provide key information and outcomes for regional reef rescue implementation plan years 2-5.

4 Provide guidance on research priorities and influence/align with policy/legislation

REPORT SCOPE

This report focuses on:

- The Fitzroy Basin and receiving waters influenced by it
- Agricultural Land; Surface Water Quality (WQ) and Great Barrier Reef (GBR) Assets
- Rural diffuse sources of pollution
- Incentive-based approaches to encourage adoption of Best Management Practice (BMP)

PROJECT HISTORY

ACTIONS TAKEN UP TO REPORT RELEASE
Commissioning
Modelling Meeting
Catchment Modelling Contract
Groundcover Assessment Contract
Interim Water Quality Target Set
Receiving Waters Contract
Marine and Coastal Assets Water Quality Trigger Values Expert Panel Workshop
Project meetings
Catchment Model Report
Receiving Waters Model Report
Coastal and Marine Water Quality Trigger Values Report
Advisory Panel Meetings and Retreat
Groundcover Assessment Report
Draft Water Quality Improvement Report
Peer Review Workshop and Findings
FBA Board Review
Final Water Quality Improvement Report
ACTIONS REQUIRED POST REPORT RELEASE
Consultation
Incorporation of targets and actions into CQSS

REPORT LAYOUT

Figure 1 outlines the report layout including the relationships between the different sections. This has been provided to help guide the reader through the report.

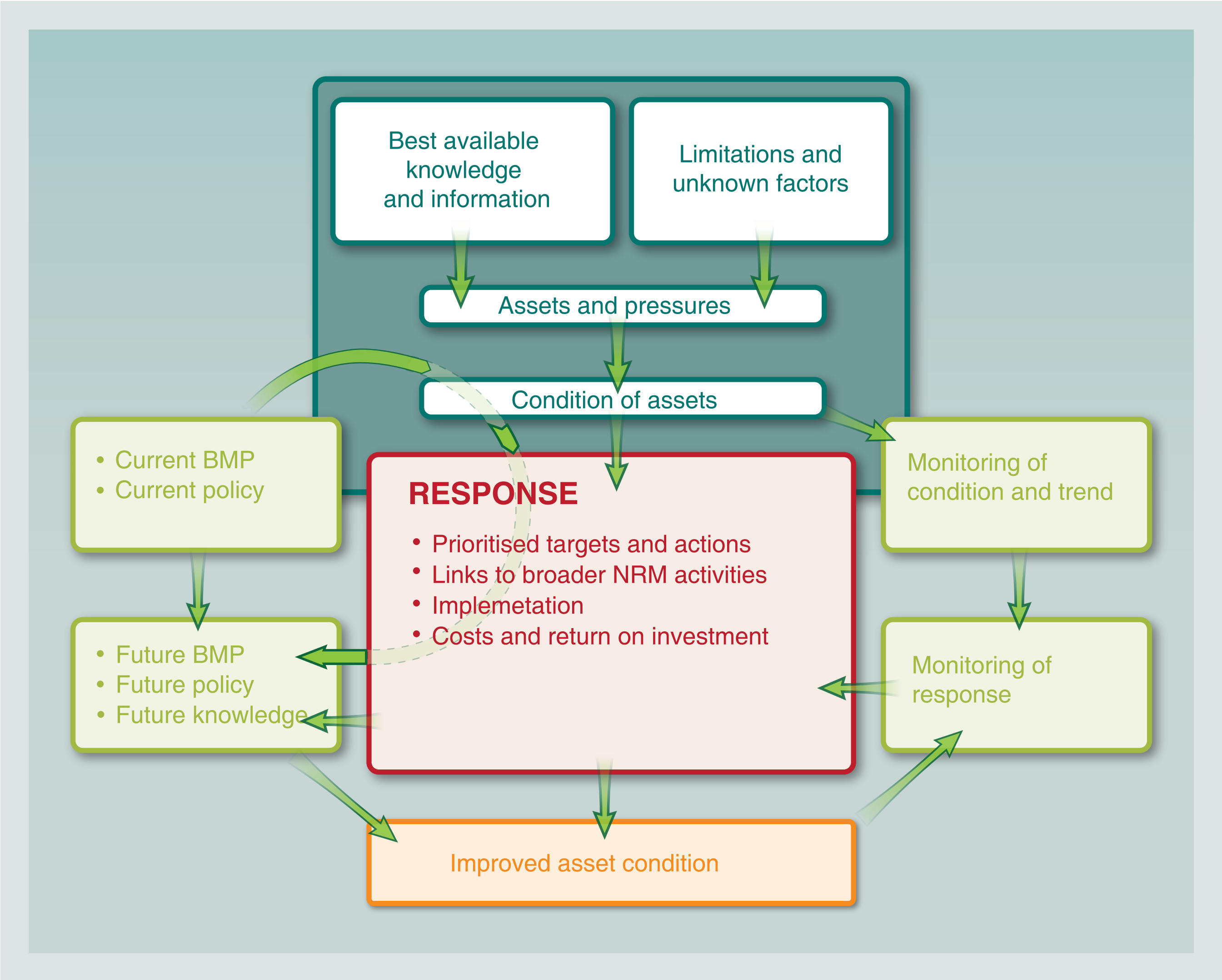


Figure 1 Program Logic For report layout. New information is synthesised for Land, water and GBR assets. Pressure and current state (condition) are quantified. The required response (improvement) in land assets is outlined along with the resulting responses for water and GBR Assets. BMP and policy required todeliver the improvement are outlined. Targets are set relating to the recommended response.

ROADMAP FOR NWQMS

This report has been produced specifically to enable considered assessment of local water quality targets for incorporation into the *CQSS2*. For this reason the *CQSS2* has been used as a framework for preparation of this report.

The report includes many components that can be found in a water quality improvement plan (WQIP) as outlined in the Framework for Marine and Estuarine Water Quality Protection (1) within the National Water Quality Management Strategy (NWQMS). The NWQMS provides information and tools to help communities manage their water resources to meet current and future needs. It provides policies, a process and a series of national guidelines for water quality management (2).

Table 1 provides a roadmap for those familiar with the NWQMS to locate sections within this report that correspond to components of a WQIP.

Table 1 Report roadmap linking this report with components of a WQIP as outlined in the NWQMS

Component of WQIP outlined in the NWQMS (2)	Covered?	Where?
1a) Delineate the marine and estuarine waters to which the plan applies and the catchment which contributes pollutants to those waters	Yes	GBR asset
1b) Identify the environmental values of those marine and estuarine waters;	Partly – no community consultation	GBR asset FBA Support Report
1c) Set out the water quality issues, pollutants of concern, and water quality objectives for those waters	Partly – objectives only relate to Estuarine and Marine Waters	WQ
Estimated Total Maximum Pollutant Loads	Partly	GBR
Estimated constituent point and diffuse source allocations	Diffuse Agricultural – Yes; Other – partly	WQ NRW Support Report
The estimated point source allocations to each licensed point source	Yes – although EPA data poor for mines	WQ NRW Support Report
Allocations to non-point sources of contaminants, including atmospheric deposition or natural background sources;	Yes	WQ NRW & CSIRO Support Reports
Margin of safety	Partly	Limitations
Decision support systems	No – further work required to determine impact of land use intensification	
Seasonal variation in pollutant load inputs	Yes	GBR CSIRO Support Report
1d) River flow objectives	Yes	GBR State water planning

ROADMAP FOR NWQMS

Component of WQIP outlined in the NWQMS (2)	Covered?	Where?
1e) Estimate the time required to attain and maintain water quality and river flow objectives	Partly	response Policy Section
1f) Describe management measures to ensure: discharges of pollutants are less than maximum pollutant loads for all sources environmental flow provisions will achieve the identified river flow objectives.	Partly	Diffuse Ag – Response Eflow – Policy Section Other – No
1g) Set out a timeline, including interim targets and milestones, for implementing management measures	Yes	Response
1h) Accountabilities for implementing source control measures & strategies for the maintenance of effort over time	Yes	Response
1i) Strategies for adaptive environmental management	Yes	Through *CQSS2*
1j) Processes for monitoring and/or modelling and reporting	Yes	Monitoring, Modelling and Reporting Section
1k) Provide time lines and costs for plan implementation	Yes	Response; & ROI
1l) Identify opportunities for market based approaches to implement the plan;	Yes	NCAP Guidelines
1m) Provide for the periodic review	Partly	Through *CQSS2*
1n) Public involvement and public reporting;	Yes	Involvement - Response; & Outcome Statement Reporting - Monitoring, Modelling and Reporting
1o) Identify the process and timing for revising the plan.	Yes	Through *CQSS2*
2a) Legal advice	No	
2b) Programs and funding committed to implementing the plan	Partly	ROI
2c) A “reasonable assurance” statement	Yes	Confidence in delivery - Response Uncertainties - Limitations

*Parties suitable for actions are outlined. Actions subject to agreement and sourcing of appropriate funds to complete measures
#Objectives only relate to Estuarine and Marine Waters
$Further work required to determine impact of land use intensification

EXECUTIVE SUMMARY

In 2008 the annual sediment load delivered to the Great Barrier Reef (GBR) from the Fitzroy Basin was 3,326,000 tonnes, which was 74 000 tonnes less than just three years prior. In addition, compared to 2005 levels, annual average nitrogen loads have reduced by 193 tonnes and phosphorus loads have been cut by 56 tonnes.

These dramatic changes are the result of improved agricultural management that is making a positive difference to land condition, in turn improving water quality in Keppel Bay and reducing pressures on GBR assets. The prevailing policy 40 years ago under the Brigalow Development Scheme resulted in some of the fastest rates of clearing ever recorded occurring right on our doorstep. This accelerated development opened up the richest grazing lands in Queensland. Central Queensland now accounts for one quarter of Queensland's cattle herd, covering 13% of the state's total land area. The scheme along with other development has also left a legacy of sediment delivery more than three times the levels generated before European settlement.

The Fitzroy Basin Association aspires to protect the GBR world heritage area from detrimental levels of contaminants whilst sustaining our economically and socially significant agricultural industry. To achieve this goal, we do not need to reach pre-European contaminant delivery rates, but simply continue the gains in improved agricultural management made since 2005, over the next two decades. This response requires hard work, a strong resolve and an immense financial commitment by agricultural enterprises with matching support from the public sector.

Cost estimates required to deliver a five year short-term target of 10% sediment load reduction stands at $90 million. Agricultural enterprises would contribute up to half of this cost based on their historical levels of investment in natural resource management. To attain this target, land management will improve across an estimated 2.5 million hectares of agricultural land. A twenty year intermediate target of 44% sediment reduction requires the implementation of best management practices (BMP) across all agricultural land by 2030. This will reduce sediment concentrations in Keppel Bay, resulting in minimal triggering of the Great Barrier Reef Marine Park Authority water quality guidelines that have been set to protect the GBR asset.

Sound policy, planning and institutional arrangements across the public sector are also required to support the aspiration of a healthy GBR. Targets set for improved practices within agricultural enterprises must be mirrored by the actions of industrial and mining sectors currently controlled using state and federal policy instruments. The cumulative impact of these sectors on the basin's waterways must be accounted for and capped, whilst encouraging innovative approaches to maintaining economic growth.

Targets have been set assuming improved management of current land uses across the Fitzroy. Current land use is not static. In fact, indications point to rapid land use intensification over the next two decades. Mines, gas-fields, urban development, industrial development, agricultural land use intensification and water infrastructure construction are all proposed future pressures that must be managed with the right mix of innovative approaches and legislative controls. Public sector development and planning authorities are faced with the daunting task of managing such pressures across the Fitzroy Basin whilst achieving the required reduction in contaminants delivered to the GBR.

Knowledge of the Fitzroy Basin has been expanded significantly. Land types have been mapped; spatially and temporally variable ground cover has been quantified; gully density has been mapped; grazing land condition has been calculated; D-condition grazing lands have been identified; contaminant delivery models have been updated and improved; local water quality trigger values have been set for coastal and

EXECUTIVE SUMMARY

marine assets; trigger values have been tested against current conditions in Keppel Bay using a receiving waters model; nutrient and pesticide delivery ratios have been calculated using monitored data; adoption rates have been recorded for some agricultural practices; fish barriers have been prioritised; interim local event based water quality guidelines have been set for freshwaters, and the list goes on.

This report clarifies current knowledge and uses this information as the basis for setting specific measurable, achievable, relevant and time-bound targets. Critical knowledge gaps required to reduce limitations and guide policy and management decisions relating to the Fitzroy Basin are also highlighted.

A framework for monitoring modelling and reporting is proposed to measure water quality and ecosystem health improvements from the land to the GBR. If adopted the framework will demonstrate the benefits achieved by the proposed responses and help determine the impact of any future land use intensification.

The Fitzroy Basin is a spectacular part of Australia with unique and varied landscapes that are close to the hearts of those who call it home. The aboriginal history contained within the sandstone escarpment country typified by Carnarvon National Park speaks to us of our region's ancient beauty. We share the spoils of the rich black farming soil of open downs and bluegrass country, and the productive grazing provided by Brigalow country, with pockets of virgin scrub recognised nationally as biodiversity hotspots. Our health and our livelihoods are connected to the waterways sprawling across one of the largest river deltas in Australia. We marvel at our fortune in living on the doorstep of the Great Barrier Reef World Heritage area, with nearby Keppel and Capricorn Bunker islands supporting diverse reef communities before stretching onward to the southern GBR.

Our communities thrive in these naturally beautiful landscapes rich in resources and opportunities. We understand it is a place worthy of protection, worthy of leaving in better condition for our children's children.

This report provides our response to enable and empower those willing to continue the work that has already begun and all are encouraged to join with us in this vision.

1 This is an estimated annual average figure delivered over the Fitzroy River Barrage

2 Sediment correlated to in-situ turbidity measurements taken at the Pelican Island marine monitoring site.

OVERVIEW OF THE FITZROY BASIN

At 142 600 km2 the Fitzroy Basin is the eastern seaboard's largest catchment and covers over a third of land influencing the GBR (7) (Figure 2). Named after New South Wales (NSW) Governor, Sir Charles FitzRoy, it is dissected by the Tropic of Capricorn and is characterised by a humid coastal and semi-arid inland subtropical climate. The basin consists of six major sub-catchments: Isaac/Connors, Nogoa, Comet, Mackenzie, Dawson and Fitzroy, which discharges to Keppel Bay.

Seasonal irregularity is a defining feature of the basin, with long dry spells often followed by intense wet season rainfalls. Mean annual rainfall varies from 600 mm in the west, to 800 mm in the east, peaking at 1000 mm in northern coastal areas (8). Due to its extreme size and fan like shape, the Fitzroy Basin is capable of producing large flooding. The highest recorded flood occurred in 1918 (Figure 19).

There are essentially two seasonal elements relevant to the basin. A hot summer period from November to April during which the majority of rain falls, supporting the growth of warm season crops. This is followed by a cool, occasionally wet to dry winter period from May to October. Although monthly evaporation rates are high, reaching 250 mm during summer, temperatures are generally not hot enough to be destructive to plants provided there is sufficient water available. On average, drought occurs every three years and there are only three good years in every ten, reinforcing that climatic variability is a major natural driver (9).

High seasonal variability and evaporation rates led to the construction of 29 dams and weirs across the basin to provide water security for agricultural, mining, industrial and urban use. The barrage is the last water storage before the mouth of the Fitzroy River and its construction at Rockhampton in 1970 effectively halved the length of the Fitzroy River estuary tidal extent to 56 km (10). Even with this restriction the estuary has a capacity of 500 000 million litres, equivalent to Sydney Harbour.

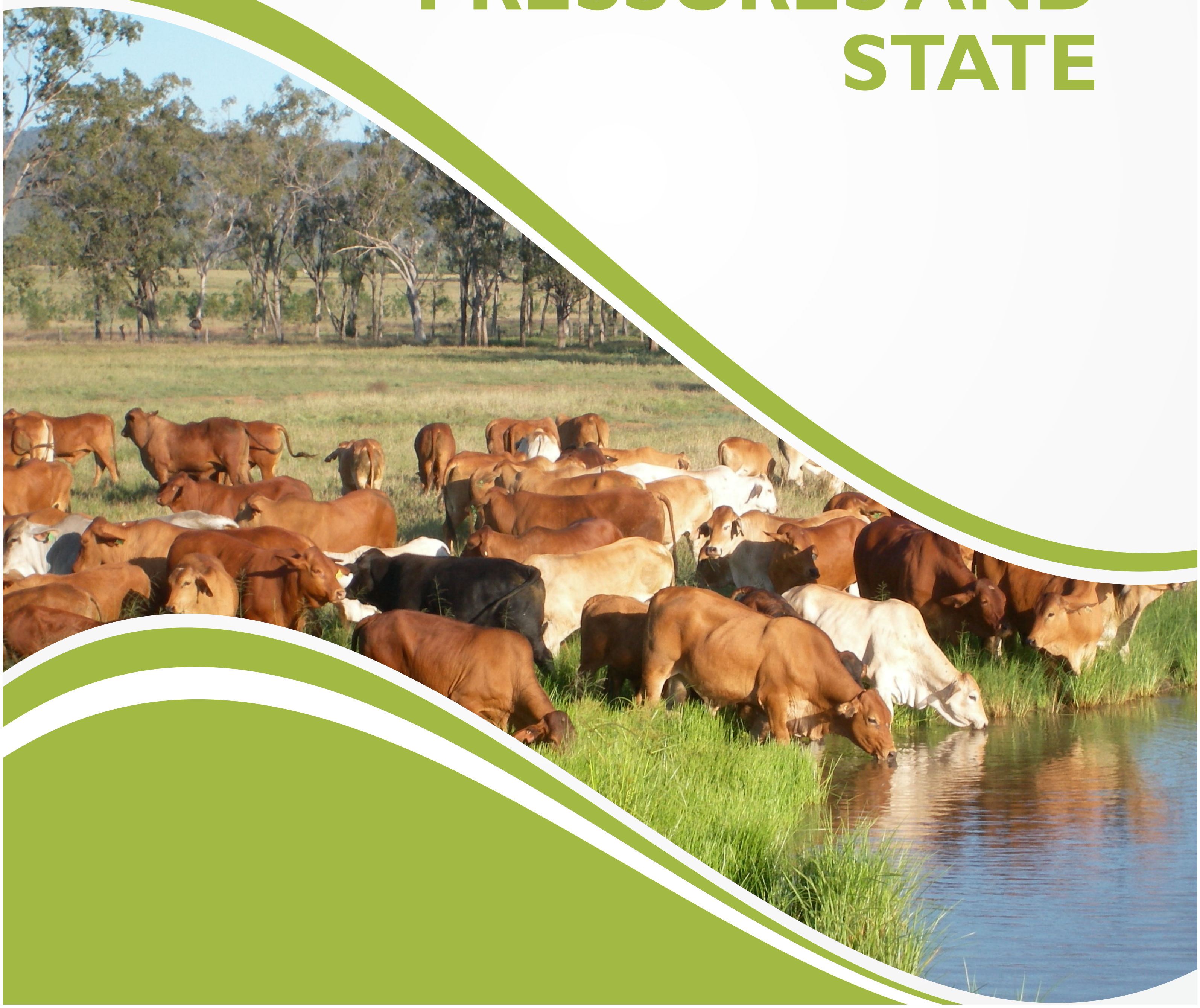
Rockhampton has a population of 60 000 and is the Fitzroy Basin's largest urban centre, situated near the mouth of the river. A further 60 000 people populate the Basin, residing in smaller rural and mining towns and on agricultural properties (8). The average agricultural property size within the basin is 4000 ha. Current land use across the basin is 81% for grazing; 6% for cropping; 6% for conservation; 5% for forestry; 1% for urban; 0.5% for mining and 0.5% for irrigation (6).

The Fitzroy Basin is home to significant floral and faunal assemblages with populations of known rare and threatened species, and internationally significant wetlands (8). It has the greatest diversity of native freshwater fish in Australia (11) and supports commercial and recreational fisheries significant to Queensland.

Figure 2 The Fitzroy Basin

The Fitzroy River mouth marks the beginning of waters described as the Great Barrier Reef World Heritage Area. Flood plumes discharged from large floods extend east across the Capricorn Bunker Group and north of Townsend Island, covering an area greater than 10 000 km2 (Figure 24). Plumes from average floods inundate Keppel Bay. Keppel Bay is home to reefs with some of the highest coral cover of any within the GBR (12). These inshore reefs are at risk from the impacts of sediment, nutrients, and chemicals (13). This risk is exacerbated by climate change, especially in the Southern GBR (14). Anecdotal evidence suggests the Capricorn coastline was once rich in coral communities stretching north from Emu Park and visible to local residents at low tide (15). These mainland fringing reefs have now disappeared, with coastal island reefs in Keppel Bay under threat.

LAND ASSET, PRESSURES AND STATE



LAND ASSET PRESSURES AND STATE

OVERVIEW

In natural resource management terms, assets are those things used or valued for the economic, social and environmental services they provide. By defining regional assets communities can: quantify the state (condition) of assets; determine activities placing most pressure on assets; determine if a response is necessary; and determine the best response to reduce identified pressures on assets and maintain/improve condition. This process has been conducted for the FBA natural resource management region with regional assets identified in the *CQSS2* (6).

This report explores new information and knowledge made available since the finalisation of the *CQSS2* for several key assets outlined in Table 2 and provides recommendations for refined actions to improve targeting of responses.

This report focuses primarily on land management and land use intensification pressures and the degradation caused by these pressures on in-stream and GBR water quality. Three assets are covered in detail - Land, Water and the GBR - discussed in that order to account for the flow-on effect of different pressures on the state of these assets. Land degradation impacts the state of water, and then degraded water impacts on the state of the GBR.

Agricultural land uses are focused on in greater detail due the dominance of these land uses across the basin, and more advanced knowledge of its cumulative impact compared to other land uses. The cumulative impact of other land uses is a current knowledge gap for the basin that must be investigated into the future to comprehensively quantify the extent of pressure being placed on assets.

Table 2 Assets defined within the CQSS2 that are covered in this report.

Asset	Covered in this report?
Land	Yes, covers land use and management impacting WQ
Water	Yes, covers surface WQ and environmental flows
Ecosystem Health and Biodiversity	No – covered partially under GBR section
Great Barrier Reef	Yes, WQ impacts on GBR.
Air	No
Cultural Heritage	No - impacted by actions
Economy	No - impacted by actions
Social	No - impacted by actions

The response required to reduce pressures placed on Land, Water and GBR assets are discussed in the Response section. Almost all of the on-ground responses focus on improving the condition of the land asset, which in turn will improve the condition of water and GBR assets. Figure 3 provides a visual explanation of the assets covered in this report including the linkages, pressures and BMP required.

The CQ Info Paper (9) is a partner document to this report, as it outlines a raft of information on assets covered in this report, as well as information for assets not covered in this report.

LAND PRESSURES AND STATE

The lands of the Fitzroy Basin are diverse and renowned for their productivity and natural beauty. The Fitzroy Basin straddles the Tropic of Capricorn and is defined by a series of ranges, which surround broad lowland areas. The Basin is bounded by the Great Dividing Range in the south and south west, the Drummond Range in the west, the Cherwell Range in the north west, the Denham and Carborough Ranges in the north, the Connors and Broadsound Ranges in the east, and the Dawes and Auburn Ranges in the south-east. The south-western sector of the basin is the most elevated and includes the rugged Carnarvon National Park (6).

Central Queensland (CQ) is blessed with extensive mineral deposits and highly fertile soils. The high fertility of the region supports a disproportionately high level of agricultural production. Large mineral deposits support a large number of mines, particularly for coal production.

Maintaining land condition in the Fitzroy Basin is necessary for continued sustainable development and the long term survival of our rural and regional communities. Caring for the land also benefits linked assets, by improving the quality of runoff that reaches downstream ecological communities living in waterways, rivers, estuaries and reefs.

HISTORY OF LAND USE

The Fitzroy Basin's rich natural resources provided for a healthy Aboriginal society for up to 60 000 years (6). Ludwig Leichardt explored the region in 1844 and pastoral settlement quickly followed (8). Over the next 10 years pastoral properties were established along the Dawson River, from present day Taroom to Moura. The Archer brothers followed Leichardt's advice

LAND ASSET PRESSURES AND STATE

Figure 3 Conceptual diagram summarising land, water quality, and GBR assets, pressures (left) and responses (right) for agricultural land uses across the Fitzroy Basin covered in this report.

and traced the Dawson along to its junction with the Fitzroy and down onto the coastal plain (9) where they established Gracemere station in 1855. This is now the location of the city of Rockhampton (8). Other settlers followed and a series of large stations covered the basin, providing the pastoral basis of the present regional social and economic setting (9).

From these humble beginnings land use and its resultant impact on water quality has intensified. Localised clearing was carried out during the first 100 years of settlement to make way for sheep and cattle grazing, cultivation and mining activities. Rates of land clearing increased dramatically under the Brigalow Development Scheme from the 1960s to 1980s, which resulted in some of the fastest rates of clearing recorded in the world (16). Some of the drivers for land use intensification are documented in Table 3.

LAND TYPE

Land with similar combinations of vegetation, soils and landforms are referred to as a "land type". Land types are a useful unit for describing the land assets of the Fitzroy Basin as they encompass the fertility, productivity, resilience and erosion hazard of the land.

The land resources of the Fitzroy Basin have been described and mapped using a variety of methods, at a range of scales, and for a variety of purposes (20). The land types used in this publication were described by Chillcott et al. (21) who identified the dominant land types of Central Queensland using information from sources such as Bourne and Tuck (22). These land types are mapped at a scale of 1:100 000 (4).

The 37 land types described for the Basin (21) are hard to differentiate at the Basin scale (see

Table 3 Drivers of land use and management that would have impacted upon water quality (17) (18) (19)

Period	Driver of intensification
1850 – 1920	Early pastoral activity
1870s	Clearing and more intensive use of scrub lands of the lower Fitzroy (Rossmoya, Barmoya area)
1880	Early mining – coal and gold
1901	Federation drought kills 90% of CQ's cattle herd
1902 – 1932	Prickly pear infestation leading to the abandonment of farms
1917	Disadvantaged Soldiers Settlement Act – leads to closer settlement, clearing and dryland farming in a number of districts
1922 - 1939	Theodore irrigation area established
1948	Queensland British Food Corporation commences broad acre farming on 199,655 Ha of the Central Highlands
1950s	Use of bulldozers for land clearing
1962 – 80s	Brigalow development scheme
1960's	Soil conservation service established, which leads to extensive use of contour banks and formed waterways in cropping country
1950 – 1980s	Introduction of tropically adapted cattle to CQ beef herds
1960s – 1980s	Large dams and weirs established, notably Fairbairn Dam
1970s	Low beef prices compared to grain prices lead to expansion in dryland cropping
1970s	Coal mining expansion begins
1990s	Widespread adoption of zero till and controlled traffic farming technologies in dryland cropping
Late 1990s – Early 2000s	Increased tree clearing in anticipation of a moratorium on tree clearing due to the Vegetation Management Act
2000s - Present	Expansion in coal mining; gas field development begins; pipeline laid to supply water to Capricorn Coast; planning for Intensive Agricultural Corridor; planning for major new water storages

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Appendix 4). For this reason they have been sorted into seven groups that reflect dominant land forms, fertility and erosion hazard. The groupings and geographic extent are described in Table 4 and Figure 4.

VALUE OF PRODUCTION

The Fitzroy Basin has some of the most productive lands in Australia supporting a high level of agricultural and mineral production for its land area. While the FBA region accounts for around 33% of the land area of the GBR catchments area, the table below demonstrates that the region produces a higher percentage of many agricultural products produced in Queensland.

Beef cattle production is the most widespread and valuable agricultural industry in CQ and is a good example of the fertility of the basin. The FBA region supports 2.8 million head of cattle. This amounts to about half (48%) of the herd in the GBR catchments, and almost one quarter (24%) of the Queensland herd, on just 13% of Queensland's total land area (23).

Table 5 shows the 2005-06 Farm-gate value of production in the FBA's region, including non-Fitzroy River coastal catchments (23).

Although coal mining covers less than one per cent of the basin's area, coal mining is the Fitzroy Basin's largest asset in terms of value of production. In 2007–08, Queensland exported approximately 152 million tonnes (Mt) of coal. Exports with a gross sales value of about A$16.5 billion were made to 32 countries with 85% of the state's operational coal mines located in the Fitzroy Basin (24).

Table 5 2005-06 Farm-gate value of production in the FBA's region, including non-Fitzroy River coastal catchments (23).

Land use	Fitzroy	% of GBR production
Cattle farm gate value	$830 m	51
Cereals for grain	$75 m	78
Cotton	$69 m	95
Fruit	$37 m	5
Wool	$13 m	24
Pigs	$11 m	13
Other	$65 m	53

Table 4 Land type groups across the basin (4)

Land type group	Land types included	Area (km2)	% of Fitzroy
Brigalow scrubs	Softwood Scrub on deep red clays; Brigalow Blackbutt / Yapunyah; Poplar Box with Brigalow / Bauhinia; Brigalow with Silver-leaved Ironbark or Poplar Box – strike ridge; Brigalow with melonholes; Brigalow with Softwood Scrub species; Softwood Scrub on clays or loams	39,567	28
Mountains and ranges	Lancewood / Bendee / Rosewood; Narrow-leaved Ironbark on mountains and ranges; Narrow-leaved Ironbark with Rosewood; Spotted Gum ridges; Mountain tall forest	34,468	24
Eucalypt Woodlands	Eucalypts and bloodwood on sandy tableland; Narrow-leaved Ironbark woodland; Serpentine ironbark; Eucalypts and Bloodwood on clay; Eucalypts and Bloodwood on loamy red tableland; Poplar box with Silver-leaved Ironbark; Gum-topped Box; Poplar Box with shrubby understorey; Silver-leaved Ironbark on texture contrast soils; Bull Oak	31,236	22
Alluvial	Poplar Box flats; Sand Flats Moreton Bay Ash / Blue Gum/ Bloodwood; Blue / River Red gum flats; Coolibah floodplain; Alluvial Brigalow	23,262	16
Bluegrass Downs	Mountain Coolibah woodland; Open Downs with Bluegrass	9,698	7
Sand	Yellowjack woodland; Cypress Pine; Shrubland / heath	2,290	2
Coastal	Coastal flats mixed Eucalypts on grey earths; Coastal sand dunes; Coastal Teatree plains; Marine plains	877	1

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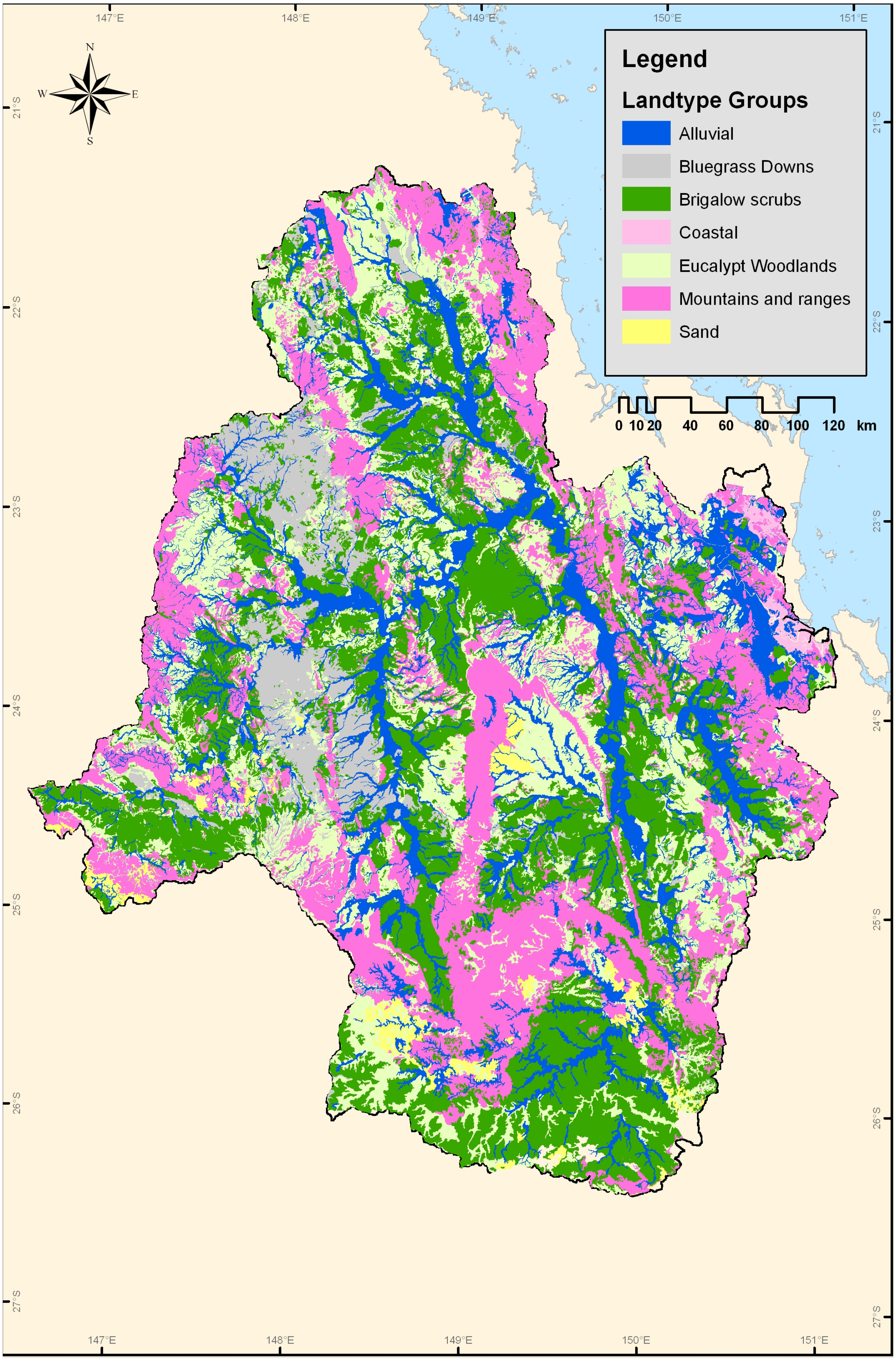

Figure 4 Land type groupings for the Fitzroy Basin (4)

LAND ASSET PRESSURES AND STATE

Table 6 Erosion rates for plot to small catchment scale studies in the Fitzroy Basin (4)

Land use	Location / Study	Land type	Scale	Sediment Size	Period	Rate (T/ ha/yr)
Mining	(Carroll, C. 2000)	Mines Rehab	Plot	Suspended + Bedload	93-99	0.5-70
Irrigation	(Carroll, C. 1995)	Downs	Furrow	Integrated	<1 yr	4-5
Cropping	Spottswood on farm (unpublished)	Brigalow with Softwood Scrub species	Small catchment	Integrated	00-01	5
Cropping	(Carroll, C. 1997)	Downs	Small catchment	Integrated	84-90	1-4
Cropping	Gordonstone on farm (unpublished)	Downs	Small catchment	Integrated	00-06	1
Cropping	Brigalow Catchment Study (unpublished)	Brigalow with Softwood Scrub species	Small catchment	Suspended	00-05	1
Grazing	Medway (Ciesiolka, C. 1987)	Narrow-leaved	Small catchment	Suspended	79-84	4
Grazing	Keilambete (Silcock, R.G. 2005)	Silver-leaved Inronbark	Plot	Suspended + Bedload	94-00	2-4
Grazing	Glentulloch (Silcock, R.G. 2005)	Poplar Box Flats	Plot	Suspended + Bedload	94-00	0.3-1.3
Grazing	Springvale (Ciesiolka, C. 1987)	Silver-leaved Ironbark	Small catchment	Suspended	79-84	0.7
Grazing	Spottswood Catchment Study (Unpublished)	Brigalow with Softwood Scrub Species	Small catchment	Suspended	00-06	0.5
Grazing	Brigalow Catchment Study (unpublished)	Brigalow with Softwood Scrub species	Small catchment	Suspended	00-05	0.27
Grazing	Gordonstone (Unpublished)	Downs	Small catchment	Suspended	02-07	0
Remnant	Brigalow Catchment Study (unpublished)	Brigalow with Softwood Scrub species	Small catchment	Suspended	00-05	0.18

LAND PRESSURES AND STATE

EROSION

Erosion is a major pressure on the land asset in Central Queensland (8). Accelerated rates of erosion reduce the productive potential of the land as well as delivering sediment, nutrients and increased flow rates to streams and ultimately the GBR. Rates of erosion at the plot to small catchment scale has been measured for a range of land use, management and land type combinations and are presented in Table 6.

The SedNet model constructs sediment and nutrient budgets and has been used to develop a catchment wide understanding of processes relating to erosion, and the delivery of sediments and nutrients to waterways, in the Fitzroy Basin (4). The predicted mean annual input of sediment to streams and the estuary for different erosion processes is shown in Table 7 and Table 8 respectively. Hillslope erosion has been found to be the dominant sediment delivering process.

The spatial distribution of sediment delivery to streams and to the estuary is shown in Figure 5 and Figure 6 respectively. High load producing areas are high rainfall and high slope parts of the basin, with the remainder being fairly evenly distributed indicating a potential lack of clearly delineated hotspots. The current assessment is typical of a hazard assessment. For this reason, the development of an erosion risk assessment is highlighted as an action in the response section of this report to improve targeting of erosion hotspots.

LAND ASSET PRESSURES AND STATE

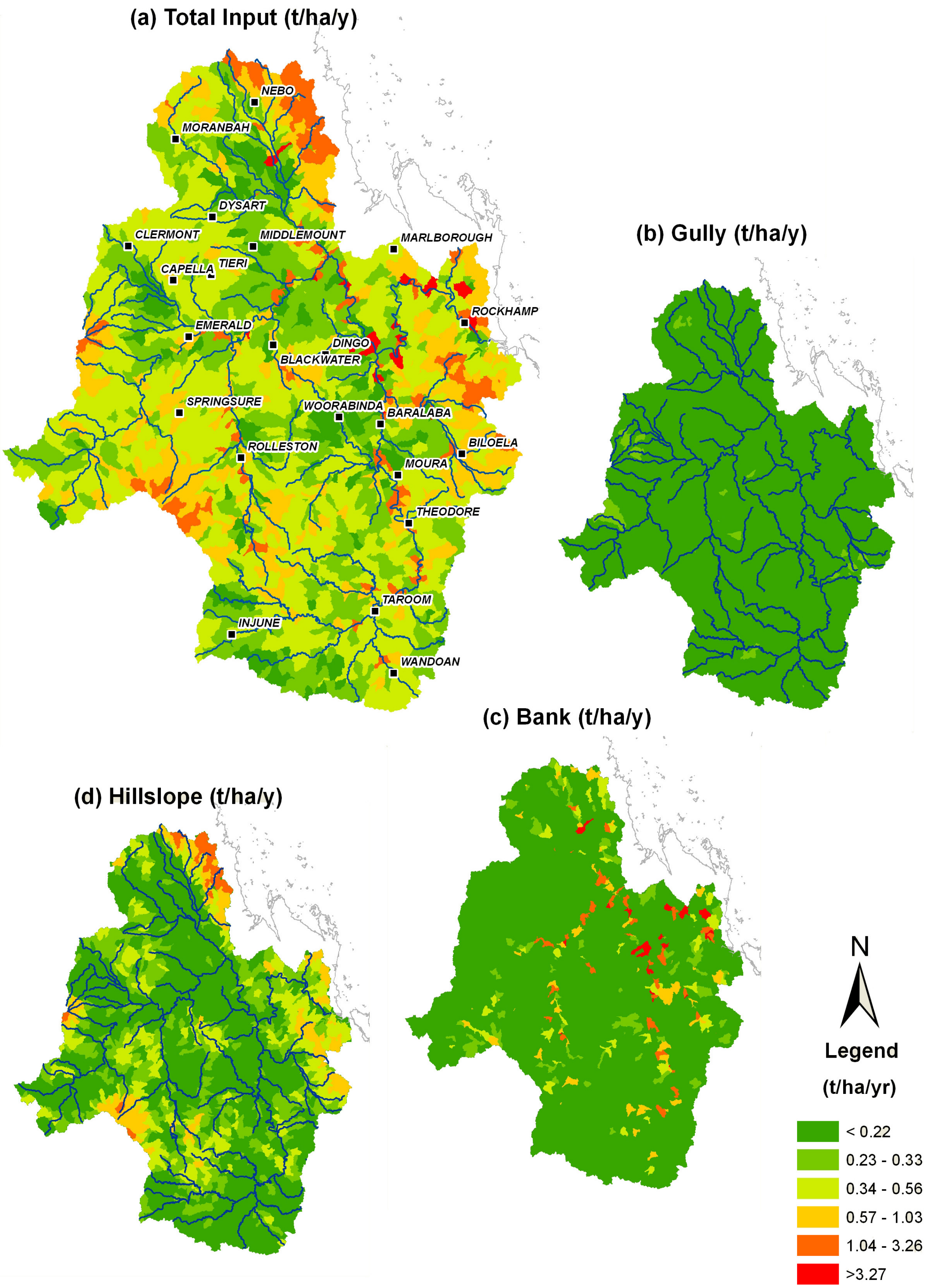

Figure 5 (a) Total suspended sediment supply to stream (t/ha/y), **(b)** gully, **(c)** bank and **(d)** hillslope (4)

LAND ASSET PRESSURES AND STATE

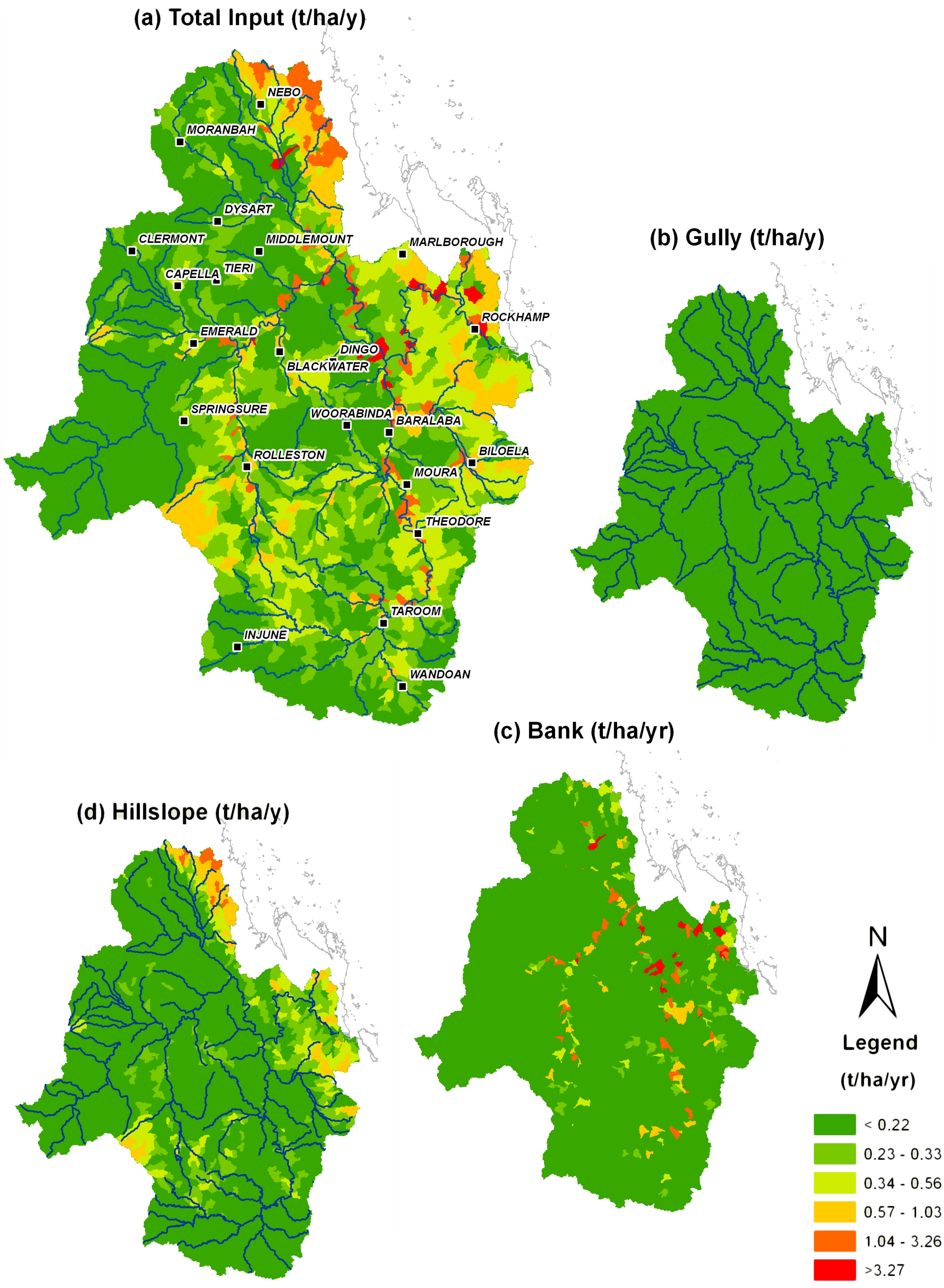

Figure 6 (a) SedNet predicted contribution to estuary (t/ha/yr), **(b)** gully, **(c)** bank and **(d)** hillslope (4)

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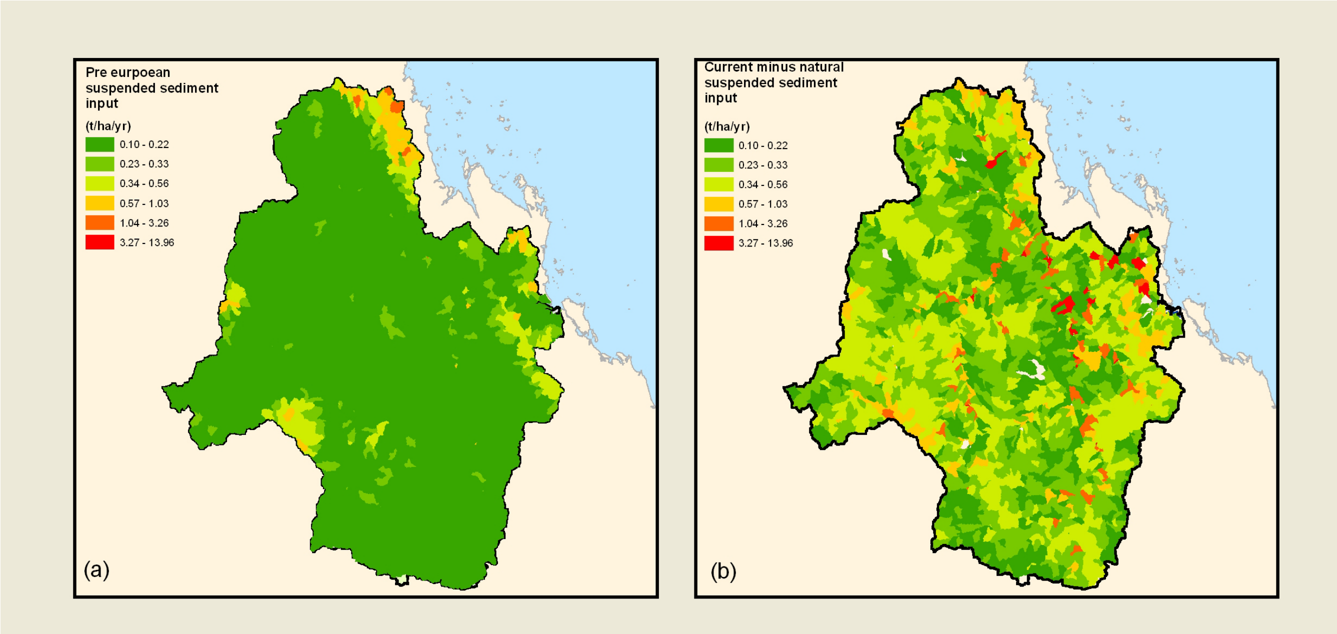

Figure 7 (a) SedNet predicted Pre European suspended sediment input (t/ha/yr), **(b)** SedNet predicted increase in suspended sediment input since European settlement (4)

PRE-EUROPEAN SETTLEMENT

SedNet estimates sediment inputs of 1100 kt/yr to the basin's waterways prior to European settlement. Therefore, current exports are almost triple Pre-European rates (4). Predicted increases in suspended sediment input since European settlement is shown in Figure 7.

To maximise return on investment, funding should be directed to those areas where there is the greatest potential to make a difference, which may be different to the areas producing the largest loads. The increase in sediment inputs since European settlement may be a useful tool in prioritising investment in improved land management as it indicates where the greatest change has occurred as a result of land development and management. However, Pre-European levels of erosion are unattainable due to a need to maintain the sustainability of social and economic aspects of the basin.

HILL SLOPE EROSION

The rate of hill slope erosion is influenced by a range of variables and can be described by the Revised Universal Soil Loss Equation (RUSLE). RUSLE is the basis of the SedNet model (4) and is expressed by the equation:

$$A = f(R \times K \times L \times S \times C \times P)$$

In this equation annual average soil loss (A) is described as a function of:

- R = rainfall erosivity factor – how heavy the rain is
- K = soil erodibility factor – a measure of the resistance of soil to erosion; heavy soils are more resistant, lighter soils are more erodible
- L = slope length factor – the longer the water runs downhill, the faster it travels and the more sediment it can carry
- S = slope steepness – the greater the fall in the landscape, the faster water runs, and the more sediment it carries
- C = crop and ground cover management (see below for explanation)
- P = support practice factor, a measure of the effect of soil conservation measures such as contour cultivation

Land managers have no control over factors R, K, L, or S. Therefore, ground cover management is essential to managing soil erosion, as P is also related to cover management.

Ground cover refers to any attached or detached organic material on the soil surface or material up to half a metre from the soil surface that acts to reduce the impact of a raindrop on the surface of the soil (25). High ground cover reduces the erosive forces

Table 7 Estimated suspended sediment inputs to streams (4)

Sediment inputs	Annual rate (kt/yr)	Annual rate as % of Total
Hillslope	2,274	67
Gully	821	24
Bank	314	9
Total	5,479	

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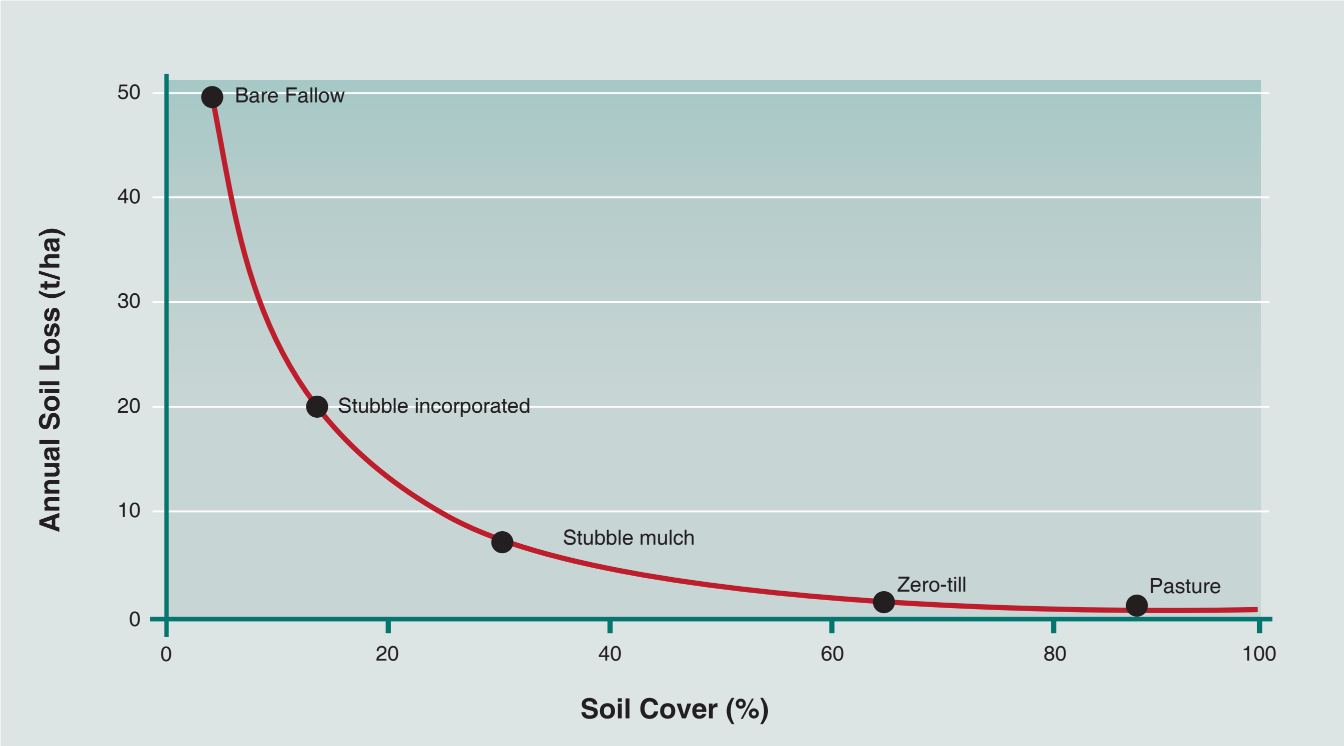

Figure 8 Effect of soil cover on soil loss (88)

of rain, anchors soil in place, increases infiltration, and reduces runoff and the spread of contaminants. In turn, this contaminant reduction minimises the impact on downstream assets. Figure 8 depicts the relationship between ground cover and soil loss. This cover/contaminant reduction relationship is similar for nutrients and many chemicals.

Figure 9 depicts mean cover by major sub-catchments across the Fitzroy Basin. The Fitzroy Basin has a mean cover of 65%, which is 10% higher than previous estimates used in SedNet modelling (26). Analysis shows that during drought mean cover can drop below 50% at a sub-basin scale. Mean cover is lower for the western catchment owing to a lower average rainfall. The Nogoa sub-basin has the lowest mean cover, due to cropping and low cover on grazing land. By comparison, the Connors River catchment has the highest mean cover. At less than 30% mean ground cover, open cut coal mines have the lowest cover of any land use category, followed by cropping, then grazing.

Figure 9 shows a strong correlation between annual rainfall and mean ground cover across Central Queensland. The main impediment to high cover, apart from seasonal influences, comes from land management practices. Farmers and graziers are implementing BMP to improve overall cover on their properties, however lack of skills, knowledge or financial resources can restrict widespread adoption of improved practices. Actions are highlighted in the response section of this report to empower graziers and farmers to implement BMP and improve cover on land they manage.

GULLY EROSION

Gully erosion is a significant land degradation process and a source of sediment to streams in the Fitzroy Basin. Mean gully density in the Basin is 1.1 km/km2 with a range from 0-7.47 km/km2 (27), as shown in Figure 10. In the Fitzroy, gullies deliver 26% of the total sediment budget. Although gully density is now well understood, gully volume and deliver ratios are poorly understood. Actions have been included in the response section of this report to improve our current understanding of gully volume and delivery ratios.

Each land type has a different susceptibility to forming gullies. This is an important factor when targeting risk areas of the landscape. Land types with the least overall mean gully density include; Coastal Mixed Eucalyptus Flats; Softwood Scrubs; Marine Plains; Poplar Box with Ironbark; Spotted Gum Ridges; Brigalow Softwood Scrub; and Open downs with bluegrass. Land types with the most overall mean gully density include: Lancewood/Bendee/Rosewood; Silver-leaved Ironbark/Bloodwood/Ghost Gum; Narrow-leaved Ironbark Ranges; Poplar Box Flats; Brigalow with ironbark and Poplar Box Strike Ridge (27). Actions are highlighted in the response section of this report to increase adoption rates of management of land types in order to reduce gully formation and cover degradation, which is responsible for accelerated gully formation.

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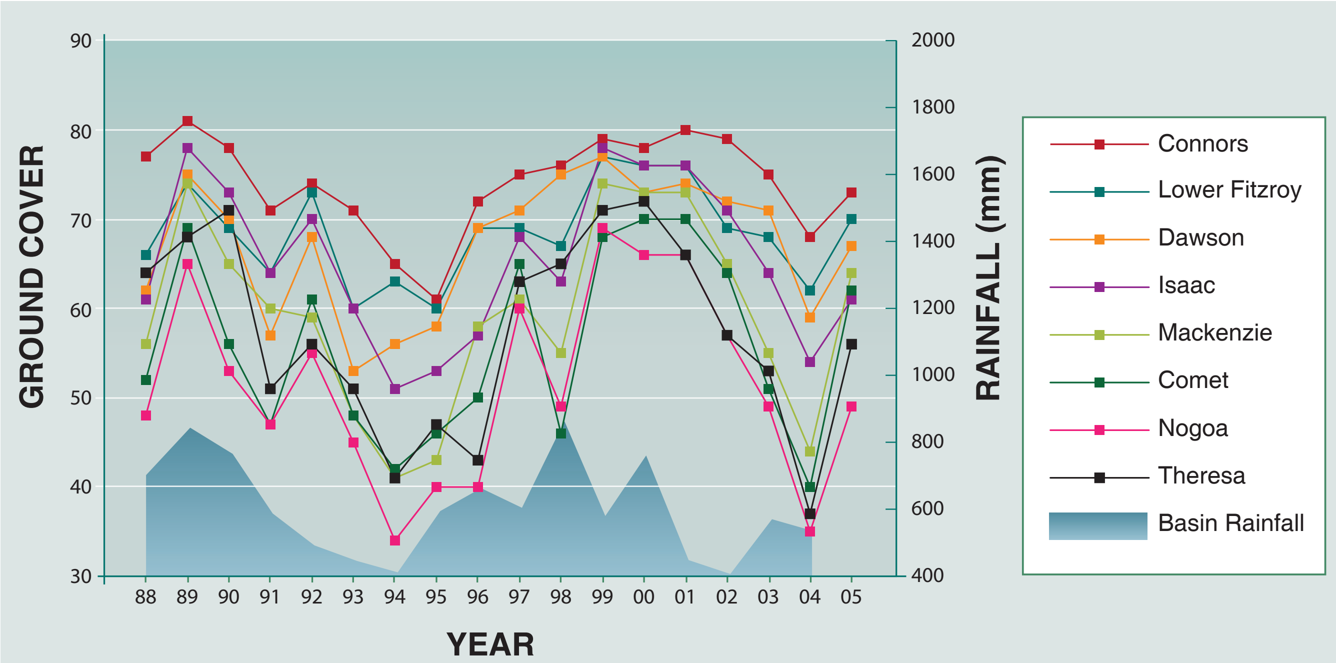

Figure 9 Fitzroy Basin Mean Ground Cover in relation to rainfall (1998-2005)

STREAM BANK EROSION

Stream bank erosion represents the smallest component of the sediment budget in the Fitzroy Basin (Table 7) despite the fact that some stream lengths can have very high sediment production per hectare (Figure 5). Riparian zones and floodplains are potential sediment and nutrient sources when in poor condition but can play a major role as sediment and nutrient traps when in good condition (28).

Riparian zones, wetlands and floodplains are some of the richest areas of biodiversity due to their close proximity to water. A riparian zone in good condition encourages greater biodiversity, holds banks together reducing bank erosion, and increases the capacity to filter sediments and nutrients contained in runoff.

State of the River assessments have been conducted by the State Government for all of the Fitzroy Basin's major tributaries. According to the assessment reports, roughly 65% of riparian zones in the Fitzroy Basin are in good condition (29) (30) (31).

Table 9 Summary of State of the River assessments across the Fitzroy Basin (29) (30) (31)

Sub-basin	Release Date	Condition	Comments
Dawson	1995	Moderate Condition	Poor in western, southern, north upland, and Don/Callide tributaries. Good in regulated Dawson, and upper Dawson sub-catchments
Fitzroy	2005	Moderate - Good	Good in Fitzroy River; Moderate to Good Fitzroy Eastern, Raglan, and Fitzroy Central Tributaries; Moderate in Fitzroy Central Tributaries
Isaac/ Connors	2005	Moderate - Good	Moderate to Very Good in Isaac River, Connors Range; Poor to Moderate in Isaac Western Uplands; Poor to Good in Isaac Northern and Central Floodplains
Comet	2000	Poor - Moderate	Poor to Moderate East Comet and West Comet
Nogoa	2000	Very Poor - Moderate	Poor to Moderate in Theresa, and Nogoa river and southern tributaries; Very Poor to Moderate in Nogoa Fairbairn and tributaries
Mackenzie	2000	Poor - Moderate	Poor to Moderate Mackenzie River, South and East Mackenzie, North Western Tributaries

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The average condition of riparian zones for the Fitzroy Basin is moderate.

Riparian zones, wetlands and floodplains are some of the best grazing country with rich, fertile soils and soils that last for longer periods before they dry out. As a result these areas can be preferentially grazed and become prone to increased rates of erosion. This preferential grazing often leads to uneven grazing pressure across the paddock. Fencing and watering infrastructure that separates rich, fertile frontage country helps to manage this proportionately higher grazing pressure within a paddock.

Current adoption rates for management of riparian zones are unknown; however FBA has worked with landholders in the last three years to protect more than 740 km of riparian zones with a stream order equal to or greater than three. The distance of river frontage protected is more than the length of the drive from Brisbane to Rockhampton. This indicates a general willingness on the part of graziers to manage grazing pressure on frontage country. Actions are highlighted in the response section of this report to increase adoption rates of management of frontage country in order to reduce bank erosion.

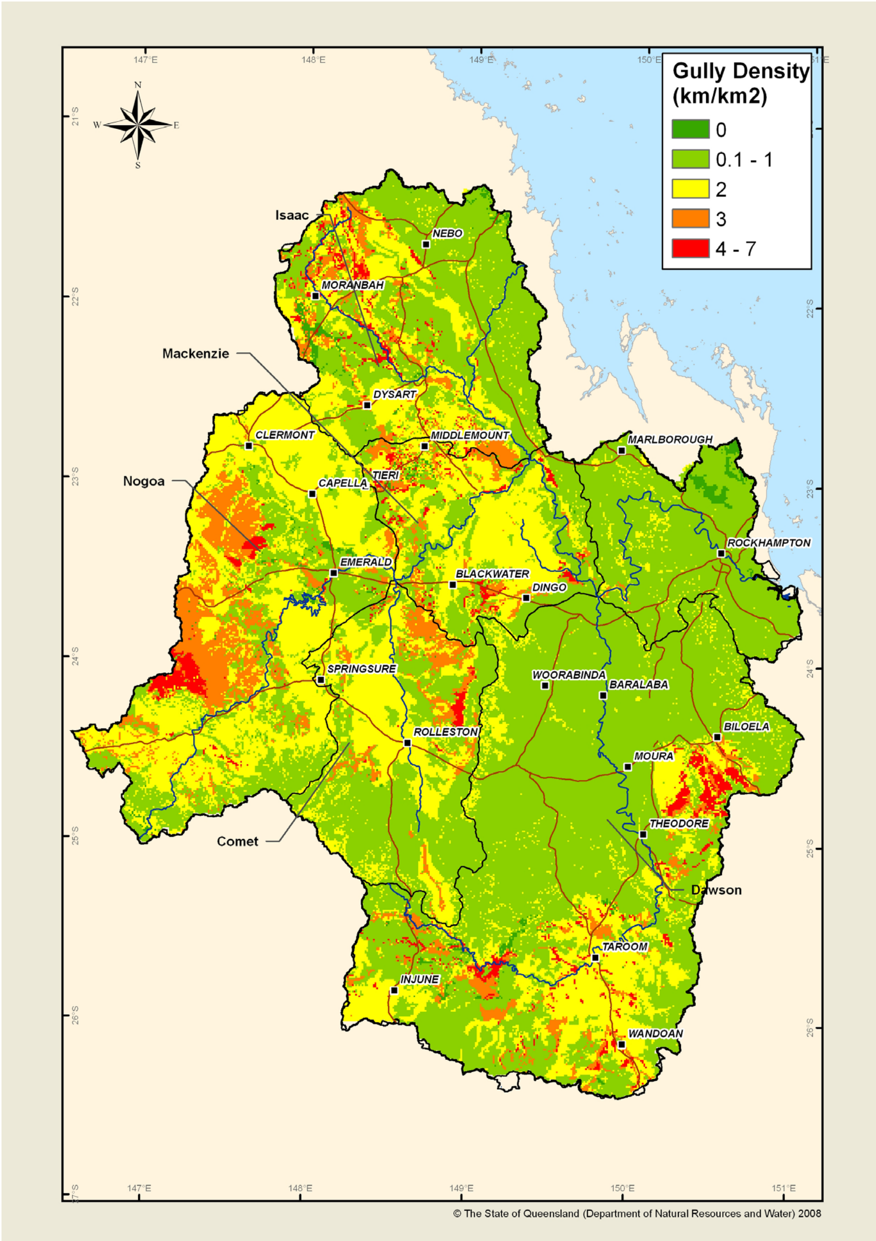

Figure 10 Spatial distribution of gully densities (1 km model) (4)

NUTRIENTS

There are two major causes of high levels of nutrients in streams: the use of fertilisers and accelerated erosion. Fertilisers are used throughout the region to improve yield of crops and pastures. When fertiliser application rates are higher than crops' needs, excess can leach from the soil or become washed away with runoff, which can place potential pressure on water quality and GBR assets. In the mid 1980s fertiliser application totals for the basin were 7000 t of nitrogen and 800 t of phosphorus (32). Updated application rates are currently unavailable and actions to collate current nutrient application rates are covered in the response section of this report. Most fertiliser application occurs in cropping lands of the Emerald and Dawson irrigation area and on open downs and floodplain dryland farming. Fertiliser application rates are directly related to fertiliser losses. Optimising fertiliser application rates in turn reduces nutrient losses in runoff.

Table 10 Current fertiliser application rates for Queensland

Crop	Phosphorus (range - kg/ha)	Nitrogen (range - kg/ha)
Horticulture	10-40	170-300
Cotton	10-20	100-160
Cereals	5-20	20-100

BMP to improve fertiliser application rates and minimise fertiliser loss are covered in the response section of this report. Current Queensland fertiliser rates for crops are specified in Table 10 (33).

AGROCHEMICALS

The use of chemicals is often necessary for agricultural enterprises to maintain profitability. However, recent studies of the impacts of pesticides on corals, seagrass and algae have highlighted the potential for some agrochemicals to damage marine organisms at relatively low concentrations (7). There are seven main chemicals in widespread use throughout the GBR that pose a threat to reef assets: diuron, atrazine, ametryn, simazine, hexazinone, 2,4- D and tebuthiuron (34).

In the Fitzroy Basin atrazine, diuron and tebuthiuron have been recorded in concentrations above water quality guidelines (7) on at least one occasion. These are residual herbicides in widespread use in CQ. Atrazine and diuron are used for weed control, particularly in sorghum, while tebuthiuron is used for woody weed control on grazing lands. Other residual chemicals are also in use and it is common for land managers to substitute one chemical for another depending on price and availability, so it is important to continue to monitor all chemicals present in runoff.

Concerns about the ecological and human health impacts of agrochemicals in water are valid, however they must be weighed against the alternative. Removal of some of these herbicides would have serious economic as well as environmental implications. For example, atrazine is often used for weed control in zero till (ZT) cropping systems instead of full disturbance tillage systems. ZT maintains much higher levels of ground cover thereby reducing runoff and erosion and the resultant sediment and nutrient loads from entering waterways.

In 2004, farmers working with the DPI&F's Central Queensland Sustainable Farming Systems (CQSFS) highlighted concerns about the frequent detection of atrazine in water quality samples in rivers and streams in CQ. In response to these concerns CQSFS developed and implemented an action learning process with CQ farmers to develop guidelines targeting effective weed control and minimise off-farm movement of atrazine. Through 'Keeping atrazine on the farm' (36), six strategies with accompanying management practices that can be implemented to minimise off-site movement of atrazine were identified. The strategies are to:

- Reduce runoff from paddocks treated with atrazine by practicing ZT farming, opportunity cropping, maintaining grassed waterways and vegetation buffers around sensitive areas, and providing water and sedimentation control areas such as silt traps.
- Reduce the amount of atrazine that is available to runoff in water by using banded application, alternative herbicides, incorporation of atrazine, planting alternative crops in areas where runoff is most likely to occur, applying lower rates of

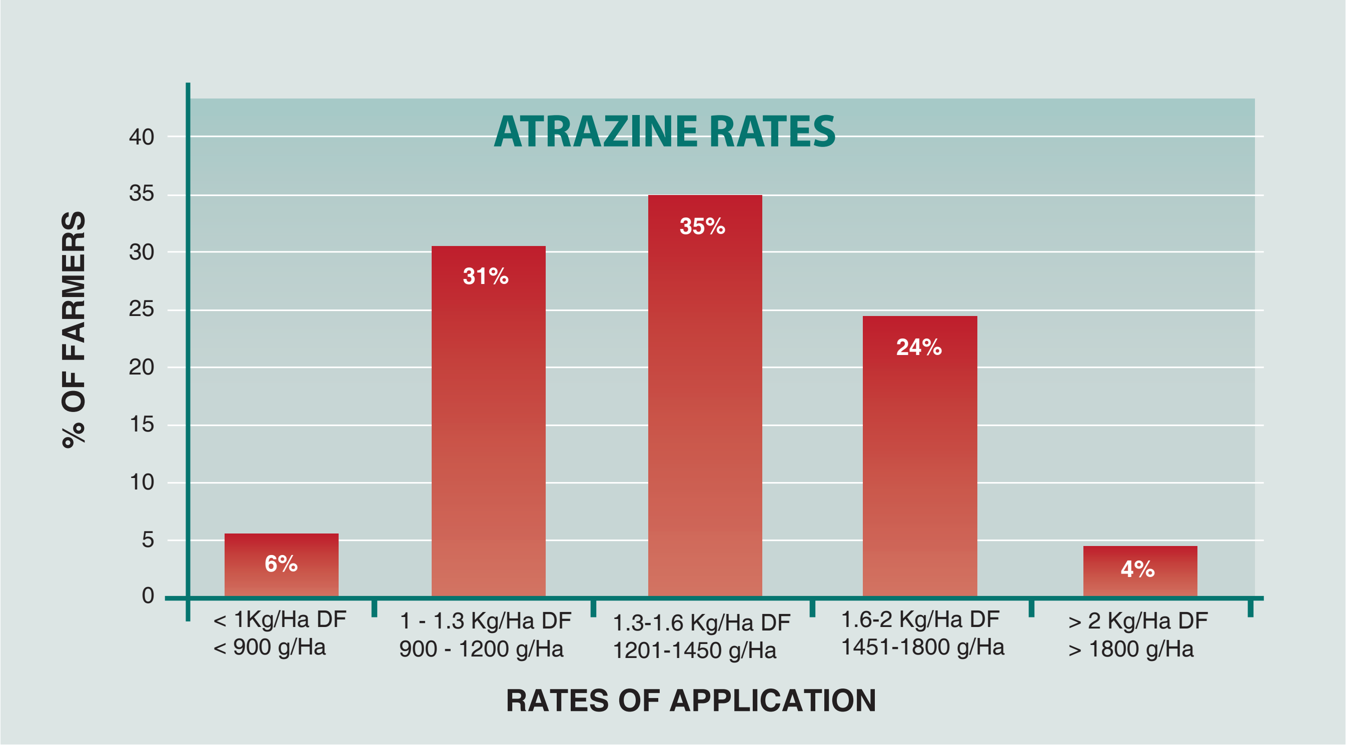

Figure 11 Rates of application of atrazine based on grower survey 2004 (35)

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atrazine for post-emergent weed control by using tank mixes or adjuvants, improving fallow weed management to reduce reliance on atrazine, avoiding planting sorghum in wide rows in weedy paddocks, and use of precision farming to avoid overlap and allow precise application of herbicides.
- Avoid application when runoff is expected. The risk of runoff is increased when the profile is full.
- Avoid application close to sensitive risk areas such as streams and waterways.
- Develop a farm plan, identifying areas with a high risk of runoff and herbicide loss.
- Assess the risk of atrazine movement off your paddock.

Growers involved in CQSFS in 2004 were surveyed. Of the farmers who grew sorghum in the 2004/05 season and used atrazine, 62% changed their management in some way with the aim of improving efficacy and minimising off-farm movement. Of those who had made no changes in that season, 60% planned to implement management changes over the coming five years. This represents a large proportion of farmers taking action to improve the management of atrazine. The flow on effect is that farmers will also start improving their overall management of chemicals (35).

Tebuthiuron is a residual herbicide used for the control of regrowth trees and woody weeds. Trees and shrubs reduce pasture growth through competition for water and nutrients. Woody weed and regrowth control is a necessary task to maintain profitable grazing enterprises due to the large area of the basin used for grazing (>80%). Tebuthiuron is preferred over mechanical woody weed control options by many landholders due to high efficacy rates, ease of application, and increasing costs of labour and diesel.

Blade ploughing is the main alternative to tebuthiuron for regrowth control. As with the use of herbicides in ZT cropping, the use of tebuthiuron in grazing lands can be a more environmentally palatable than the blade ploughing or tillage option because of these reasons:

- Blade ploughing is not suitable for soils with dispersive sub-soils. Blade ploughing can expose sodic and saline sub-soils causing erosion and increased sediment delivery.
- Blade ploughing creates extreme surface roughness in many soils which reduces runoff for several years after treatment. This can reduce e-flows if done over a large percentage of the catchment.

Large areas are normally only treated by aerial application. The aerial use of tebuthiuron has a number of restraints which help to reduce the likelihood of losses in runoff, these include:
- Detailed paddock inspection by the distributor or accredited appointee
- Application only by accredited applicators
- Not to be applied to erosion prone areas
- Not to be applied within 100 m of a recognized water course
- Not to be applied to land with greater than 20% slope
- Not to be applied during rainy condition, when wind exceeds 20 km/hr, or under conditions which will cause pellet movement to non-target areas during application

There is currently a poor understanding of agrochemical use (application rates, areas treated) and the fate of the chemical after application. Although agrochemicals are regularly detected in water samples, hotspots have not yet been pinpointed to a level that allows targeting finer than regional scale (e.g., tebuthiuron is used in all areas of the basin and there is not currently enough information to target high risk areas). Actions for monitoring and modelling effort to understand agrochemical risks to water quality in the Fitzroy Basin are detailed in the response section of this report.

SALINITY

Impacts of salinity have been identified as one of Australia's most serious environmental issues. In areas already affected, salinity has devastated ecosystems resulting in massive loss of habitat, biodiversity, native vegetation and water resource value. Salt loads from both diffuse and point sources pose threats to fresh water assets in parts of the Fitzroy Basin. Diffuse sources of salinity have been investigated by the Salinity risk assessment for the Fitzroy Basin (37). Point sources have not been adequately investigated. The current state of knowledge suggests that there is a far greater risk from point sources than diffuse sources.

Grouped catchment communities, known by FBA as Neighbourhood Catchments (NC), within the Fitzroy Basin were rated for salinity risk in the Salinity risk assessment for the Fitzroy Basin (37). Although the report did not specifically address the impact on the water assets, it did quantify catchment salt budgets and it can be deduced that diffuse sources of salt pose a threat to a small percentage of the stream assets of the Fitzroy Basin. The streams currently affected or likely to be affected in the future are smaller streams associated with irrigation areas and the granitic landscapes in the east of the catchment. There are currently 64 known salinity outbreaks in the Fitzroy Basin covering an area of 2226 ha (37).

Mine water discharge is an emerging issue with

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saline releases by these sources impacting on fresh water assets. The resultant mine discharges from the wet summer of 2007-08 dramatically raised the salinity levels in the Isaac, Mackenzie and Fitzroy rivers (38) impacting upon the water asset for both consumptive and environmental values. No cumulative impact of salt loading to streams from point sources study has been conducted at the date of writing this report. The rapid expansion of coal mining and coal seam gas wells currently occurring throughout the region suggests that the risk from salt to streams may increase dramatically. Actions are outlined in this report to address the risk that point source salinity discharges potentially place on the basin's freshwater ecosystems.

CURRENT AND FUTURE LAND USE

Agricultural production has the greatest footprint of any land use in CQ, with nearly 90% of the land under agricultural production. Figure 12 describes land use in the Fitzroy Basin.

Grazing for beef cattle production is the dominant land use by area and occurs in all areas of the basin. Dryland cropping is predominantly in the west of the catchment on the basalt derived Open Downs with Bluegrass land type. The main irrigation areas are the Emerald Irrigation Area and Theodore Irrigation Area, other more scattered areas of irrigation occur along all of the major river streams in association with weirs and water harvesting. Mining currently covers a relatively small area (0.38%) however it has been rapidly expanding in recent years (39) and has the potential for very large impacts on water quality due to mine water discharge, water harvesting, stream diversions and unstable landforms from mining spoil and slumping.

Generally speaking the more intensive a land use the greater potential for contaminants in runoff (Figure 13). For example, after taking seasonal variability into consideration, clearing of the Comet river catchment that reduced the amount of remnant vegetation from 83% to 38% of the land area, resulted in a 40% increase in runoff (40). It is also fair to assume this level of land clearing would have corresponded with an increase in sediment loads. Thornton et al, (41) reported soil loss of 0.18, 0.27 and 1 t/ha/yr sediment loss under remnant brigalow scrubs, buffel grass

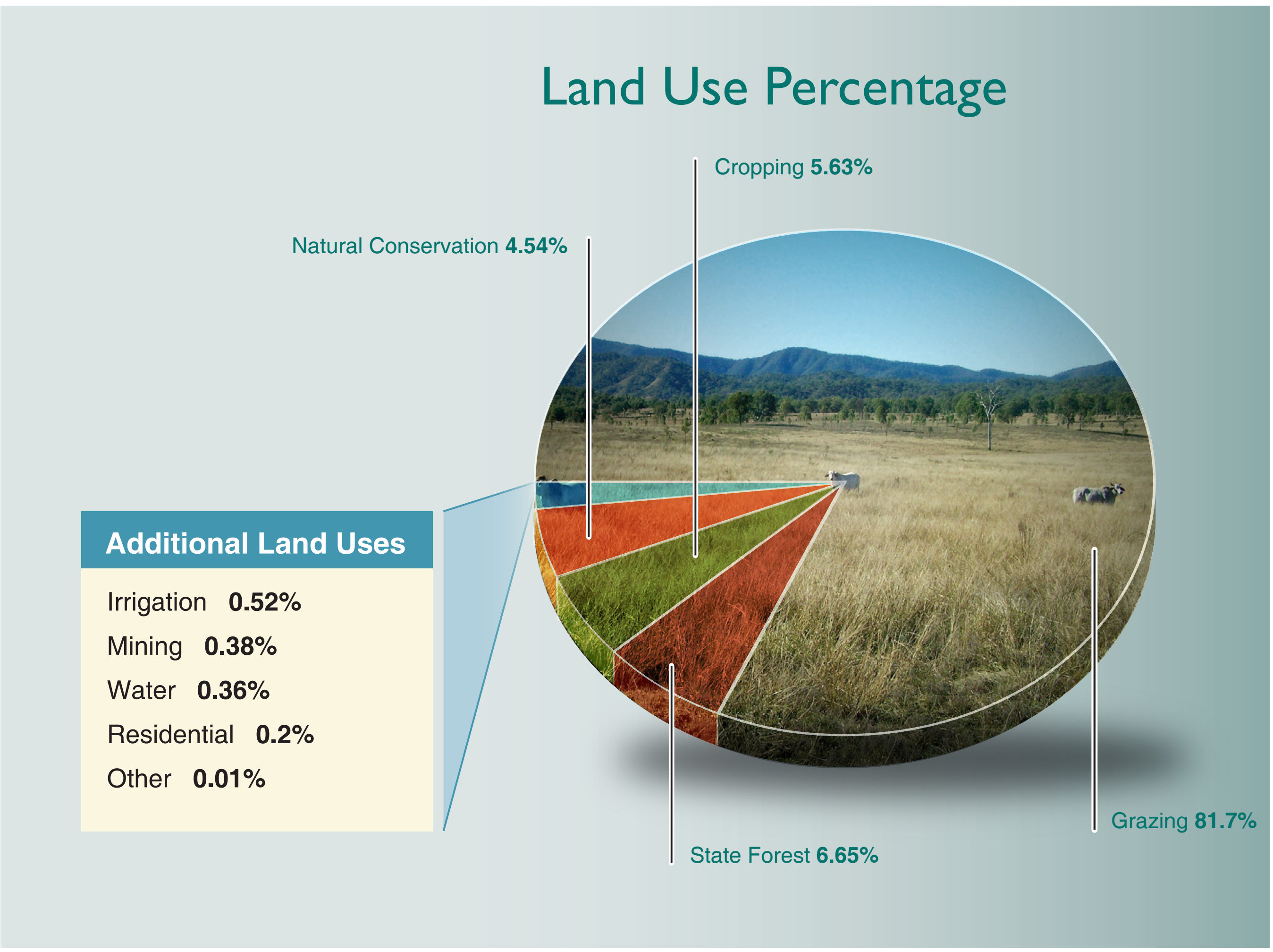

Figure 12 Current land use for the Fitzroy Basin

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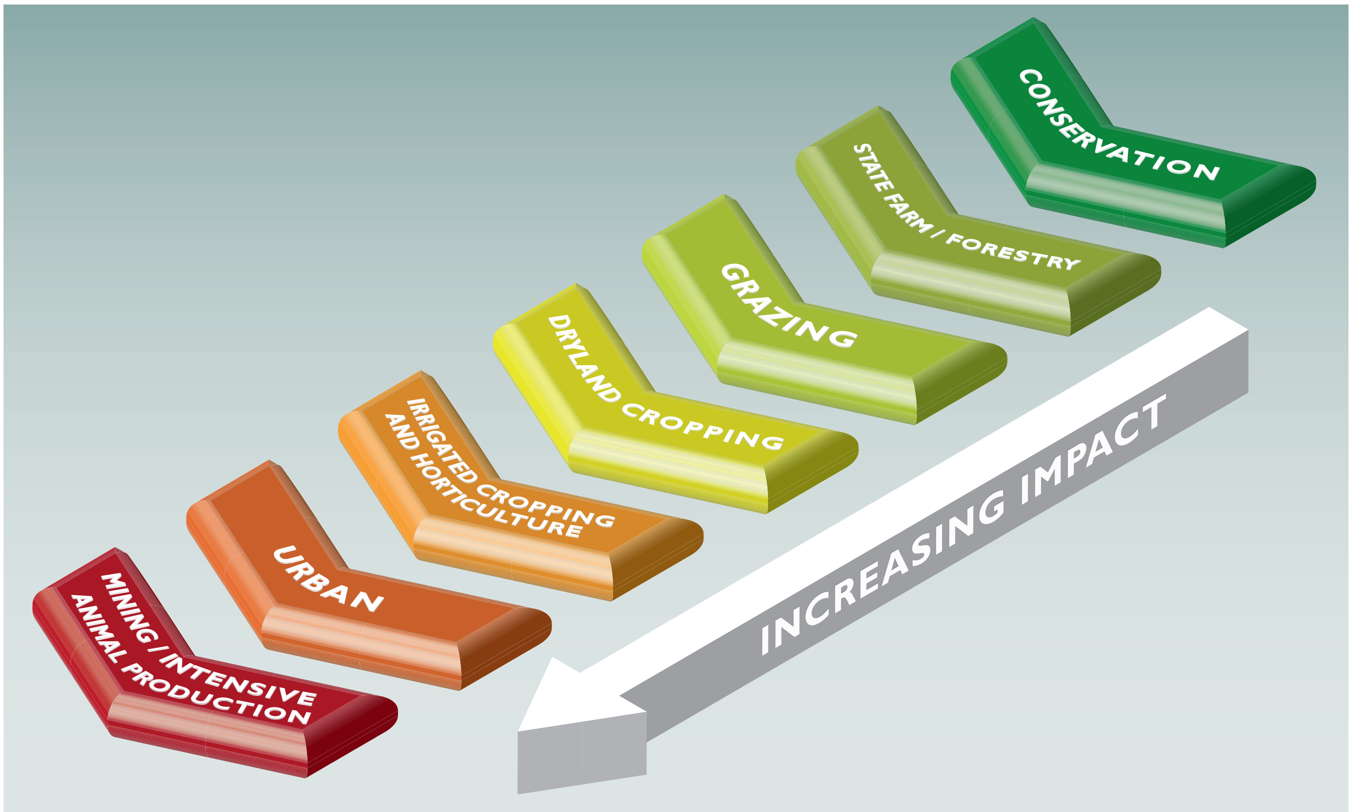

Figure 13 As a general rule, land use intensification increases pressure on land assets and water quality/use

pastures and dryland cropping land uses respectively. Further sediment loss results from plot to small catchment scale studies conducted in the Fitzroy Basin are summarised in Table 6. More intensive land uses also tend to increase the likelihood of other contaminants (e.g., salts, chemicals and nutrients) entering waterways.

Historically land use intensification had a major impact on water quality, with some of the drivers of the intensification in the Fitzroy Basin listed in Table 3. Figure 14 shows the extent of various land uses over time. This intensification of land use over the past 150 years has resulted in water quality declining.

There are many proposed activities throughout the basin that may intensify land use into the future. These include:

- Plans for 17 additional major coal mines.
- Proposed gas fields covering a large area, often where coal is too deep to mine. There are three natural gas refineries proposed for the port of Gladstone. Salt laden groundwater is a by-product of gas production.
- Urban centres are projected to double in size, with no firm decision to improve the basin's largest Sewage Treatment Plants (STP)
- Five dams and weirs are slated for construction or extension, which would have a combined capacity to capture 1 200 000 megalitres of water. Pipelines are being laid to connect the Capricorn Coast and Gladstone to the Fitzroy. Both regional centres have major urban expansion pressures and Gladstone is earmarked to become one of, if not, the largest industrial centres in Queensland.
- Irrigated cropping development may follow dam and weir construction especially along the Dawson and Fitzroy.
- A major agricultural and industrial corridor is planned for the Lower Fitzroy with several 15 000 head cattle feedlots earmarked, along with an industrial precinct.

Actions outlined in this report aim to halt and reverse the decline of water quality in the Southern GBR Lagoon based on the current level of land use intensification. However, policy initiatives will be required to deal with future land use intensification to ensure long term goals for sustainability are met in Central Queensland. This policy response is highlighted as an action in the response section of this report.

GRAZING LAND CONDITION

Grazing land condition is defined as the capacity of land to respond to rain and produce useful forage. Grazing land condition is impacted by soil condition, pasture condition and woodland condition (42). A land

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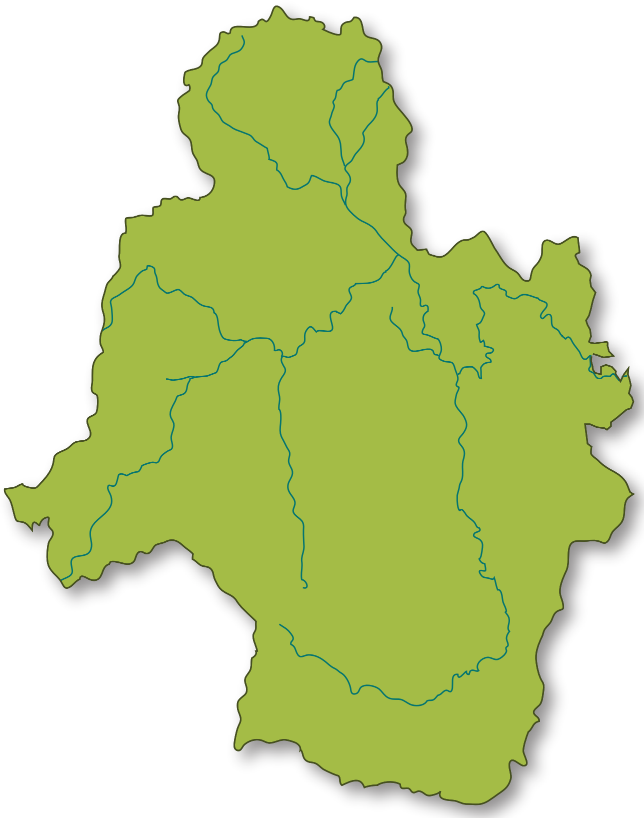
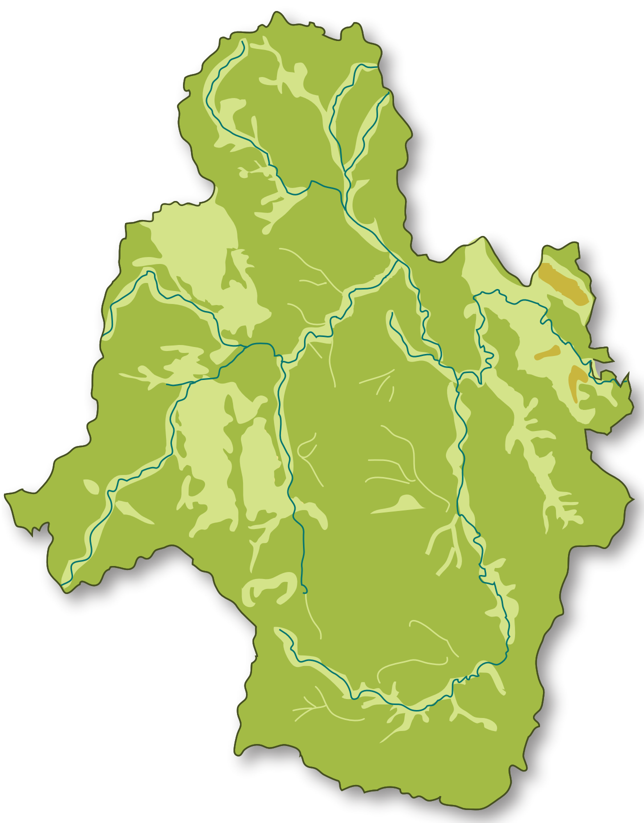


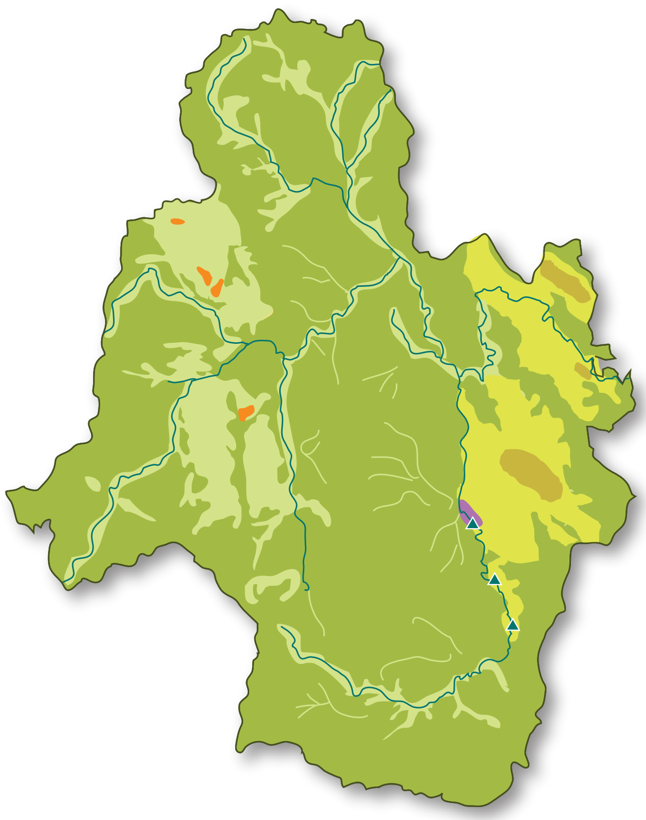
Land use Intensity: Pre-European

Legend

- Conservation or other low intensity use
- Uncleared grazing of native veg
- Cleared grazing
- Mix of cleared grazing & cropping
- Dryland cropping
- Irrigation
- Urban / mining / intensive animal production
- Gas fields
- Dams / Weirs



Land use Intensity: 1850-1900



Land use Intensity: 1900-1960

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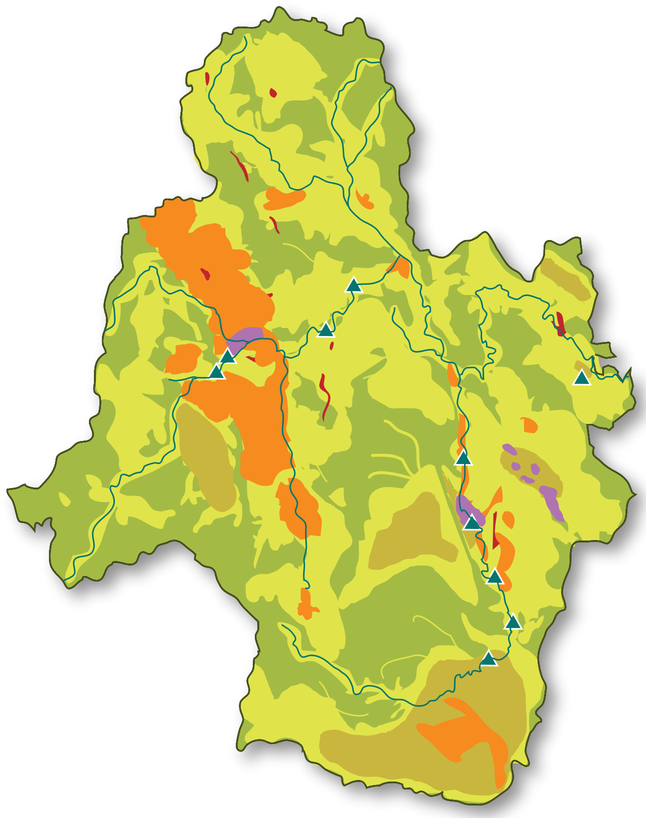
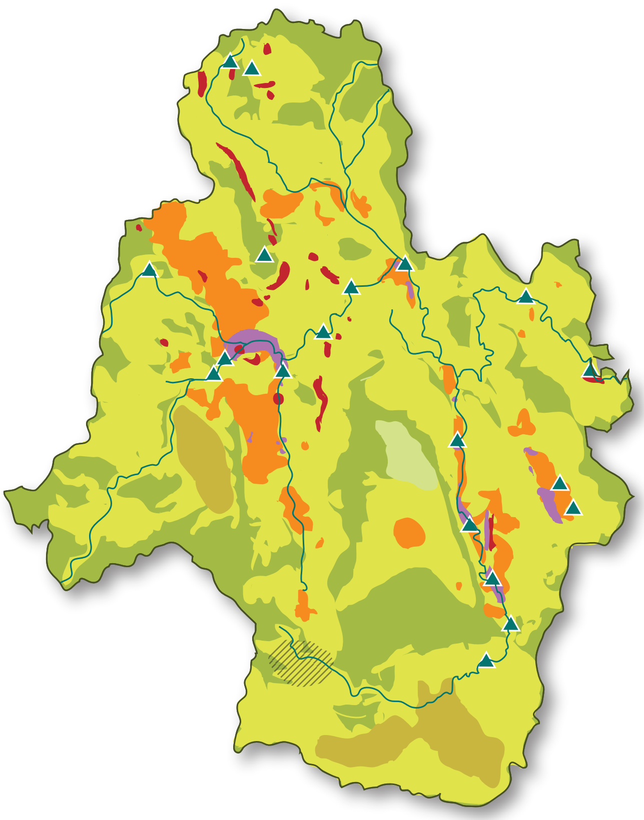
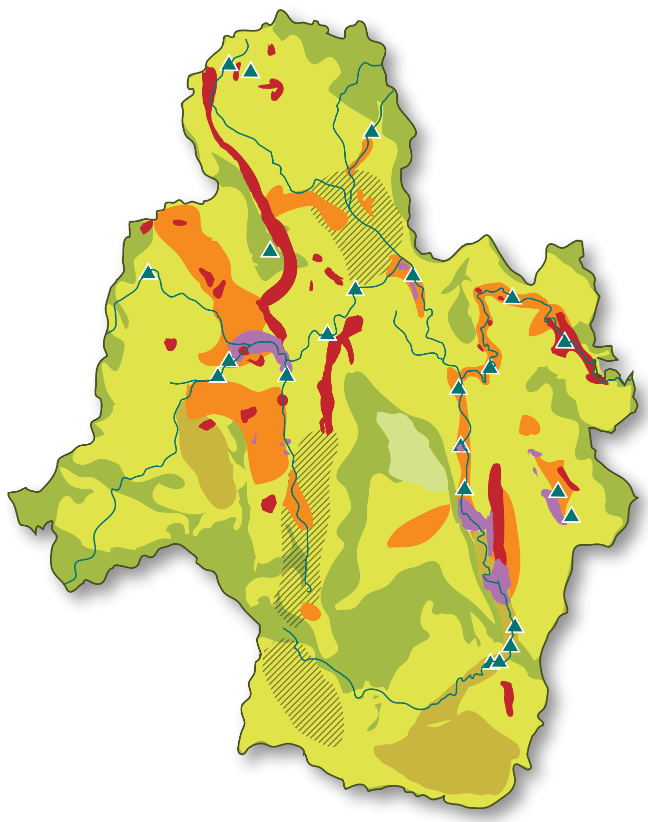
Please note: These maps have been prepared using various data sources, including local knowledge from individuals witness to changes within the area. The maps are designed to provide a visual representation of changes to land use intensity over time but are not completely accurate and require independent research before being used for any other purpose.



Land use Intensity: 1960-1980



Land use Intensity: Present



Land use Intensity: 2020

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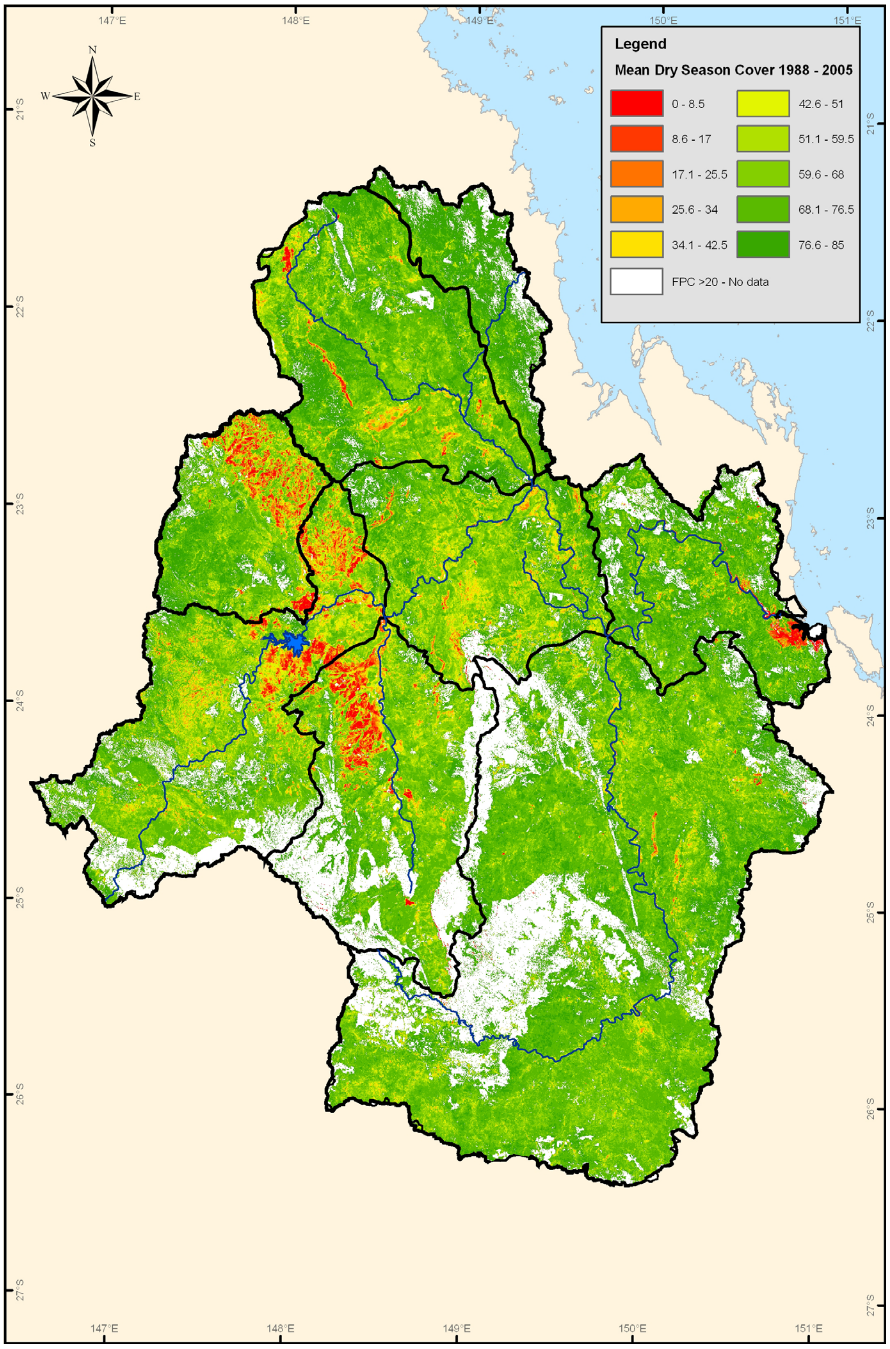

Figure 15 Fitzroy mean ground cover (1988-2005) (4)

condition classification system has been developed by DPI&F and Meat and Livestock Australia (MLA). The system classifies land condition from A to D, with 'A' being best and 'D' being worst. Land condition relates directly to productive capacity and contaminant runoff, and as such is a meaningful indicator for both grazier and scientist alike. Land condition classification is also separated into land types, thus accounting for the natural soil and vegetation variations between land types (21).

For the grazing land use, land condition and ground cover are considered more useful indicators of improving water quality than adoption rates of management practices, for these reasons:

1. They are a direct measure of land condition as opposed to assumed land condition resulting from a practice. The final effect of land management practices depends on the management skills of individual graziers.
2. It is easier and more reliable to measure land condition and ground cover than practice change for grazing enterprises. Surveys of graziers in the Fitzroy Basin have historically had low return rates, for example only 7% responded to a survey conducted by FBA in 2006 (43).
3. Land condition and ground cover data provides basin-wide coverage, as opposed to areas where adequate numbers of landholders responded to a survey.
4. They permit different management options, allowing for innovation in land management and the ability for graziers to respond to individual circumstances.

Land condition of the Fitzroy Basin has been estimated using both remote sensing and a rapid condition assessment (44). The average annual ground cover from 1988 to 2005 is shown in Figure 15, annual variation in cover is shown in Figure 9 and Appendix 3. There is variation in ground cover trends between land types indicating that although seasonal condition is the main driver of ground cover, certain land types are more resilient to grazing pressure and dry conditions whilst others are more susceptible (44).

Remote sensing has also been used to provide a surrogate measure of 'D' condition lands (45). Currently 4.5% of grazing lands are identified as being in 'D' condition across the region with this land further divided into: chronic 'D' condition; persistent 'D' condition; and marginal 'D' (Figure 16). Chronic 'D' condition land has less than 40% cover and has been identified using a single SPOT 5 image and represents a single snapshot in time. Persistent and marginal 'D' condition has been identified using LandSat and the Ground Cover Index (GCI). Persistent refers to those areas which averaged

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Table 11 Grazing land condition for the Fitzroy Basin and for each land type (44).

Healthy Grazing Land	% of Basin Currently in 'A' or 'B' Condition
Region	64
Alluvial Brigalow	66
Blue/River Red Gum flats	61
Brigalow / Blackbutt	73
Brigalow with ironbark or poplar box – Strike Ridge	59
Brigalow with melonholes	89
Brigalow with Softwood Scrub Species	70
Coastal Flats mixed Eucalypts	56
Coastal Sand Dunes	-
Coastal Teatree Plains	-
Coolibah Floodplain	58
Cypress Pine	23
Eucalypts / Bloodwood red loam	84
Eucalypts / Bloodwood: red/yellow	57
Gum-topped-Box	59
Lancewood / Bendee / Rosewood	34
Marine Plains	-
Mountain Coolibah Woodland	64
Mountain Tall Forest	-
Narrow-leaved Ironbark ranges	63
Narrow-leaved ironbark with Rosewood	67
Narrow-leaved Ironbark woodland	53
Open Downs with Bluegrass	41
Poplar Box Flats	68
Poplar Box with Brigalow/ Bauhinia	68
Poplar Box with Ironbark	71
Poplar box with shrub understorey	65
Sandflats / Moreton Bay Ash / Bluegum / Bloodwood	81
Shrubland/Heath	33
Silver-leaved ironbark / bloodwood / Ghost Gum	72
Softwood Scrub	73
Spotted Gum Ridges	42

Table 12 Fitzroy Basin cropping land current adoption rates – tillage practices (46)

Tillage Practice	Adoption Rate
Zero Tillage	32%
Minimum Tillage	50%
Conventional Tillage	18%

less than 40% cover over 20 years, while marginal refers to those areas which averaged 40-60% cover but with a declining trend.

Rapid condition assessments conducted by DPI&F found that 64% of grazing lands are in either 'A' or 'B' condition across the basin (44). Table 11 shows the percentage of different land types throughout the basin in 'A' or 'B' land condition.

Actions outlined in the response section of this report aim to increase adoption of BMP that result in land condition improvement.

CROPPING LANDS

Cropping covers over 800 000 ha of the region, an area more than three times the size of the Australian Capital Territory. Cropping lands typically have lower cover levels due to a historical requirement to cultivate the soil. This is evident when looking at the cover map for the region in Figure 15 and Appendix 3. There is a large band of land with low cover on open downs farming country stretching from Rolleston in the south through Springsure, Emerald and Capella, to Clermont in the north.

The GCI is used for creating maps in Figure 15 and Appendix 3. The GCI was developed for cleared grazing lands and has not been validated for other land uses. Ground cover in cropping lands is very dynamic depending on: the cropping cycle (e.g., a fast growing crop covers the ground quickly); stubble type (e.g., wheat stubble is thicker and more resistant to breaking down than chick pea stubble); and tillage (one tillage operation can dramatically reduce ground cover). Remote sensing of ground cover for cropping lands is being developed but is currently limited by the need for short time intervals between image capture and the associated cost of satellite imagery at an appropriate scale.

Due to these limitations, adoption rates of management practices are currently a more reliable indicator of erosion rates than yearly ground cover estimates for cropping enterprises. Tillage practices used by cropping enterprises can positively impact the cover present on cropping lands and dramatically reduce soil, nutrient and chemical losses (Figure 8). Estimated current adoption rates for the different tillage practices used across the region are outlined in Table 12. The promotion of BMP to encourage the uptake of improved tillage practices from conventional to minimum or zero tillage is a desired action highlighted in the response

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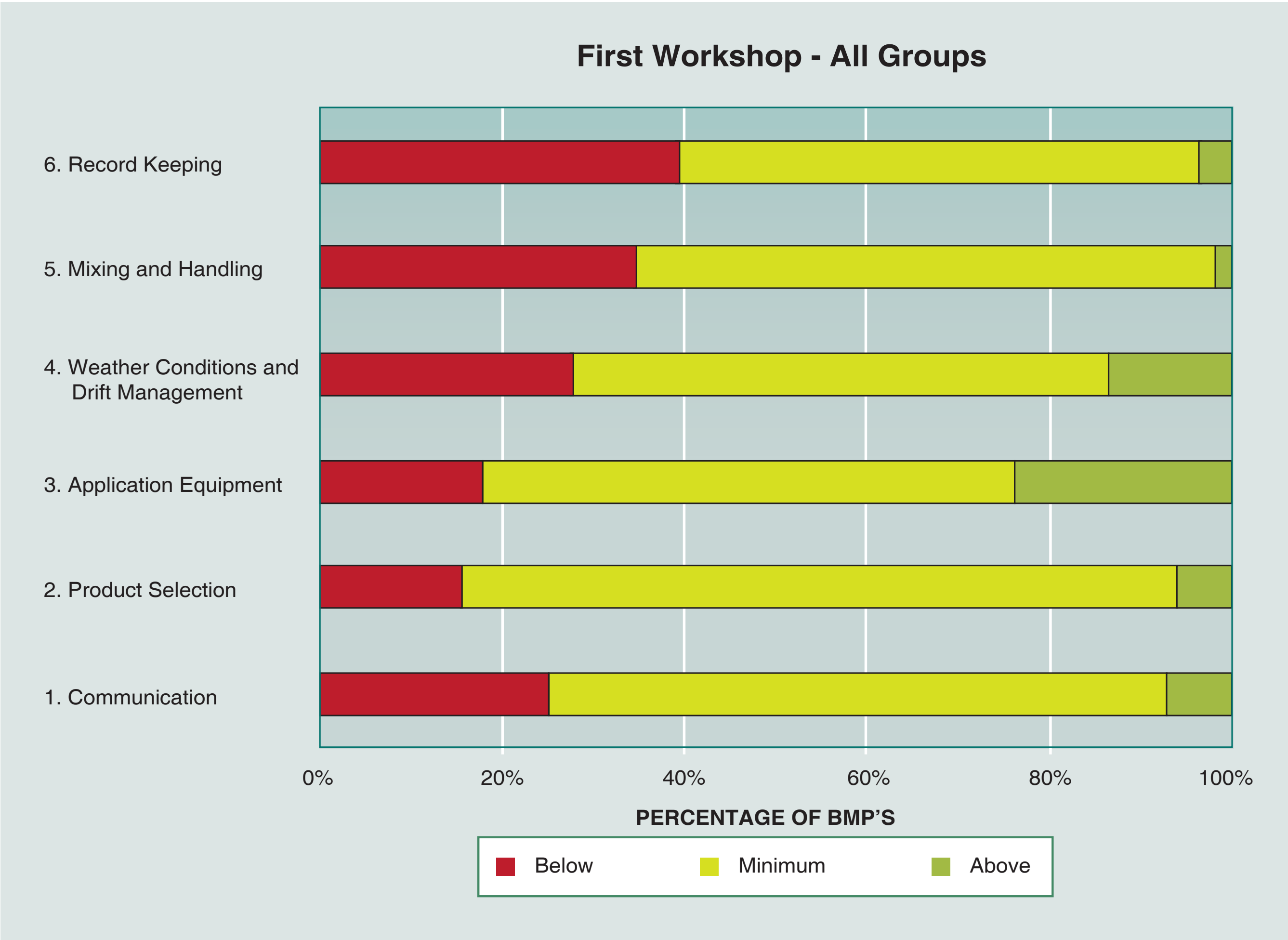

Figure 17 Adoption rates for BMP across 72 600 ha and 28 enterprises for the pesticide application module (49)

section of this report.

Adoption rate estimates for runoff management controls like contour banks across the Fitzroy are outdated. The most recent assessment was conducted in 1993/94. At that point in time 64% of the cropping land under cultivation had appropriate contour banks in place (47). Since the early 1990s cropping throughout the basin had been gradually declining until recent years when higher grain prices driven by interest in biofuels resulted in an increase of land under cultivation.

The Grains Best Management Practices (Grains BMP) program is developing a Farm Management System (FMS) for the grains industry in Queensland. The Grains BMP is a collaborative effort between AgForce, DPI&F and FBA. Five modules on cropping land management are either already developed or nearing completion. The five modules are:

1. Pesticide application
2. Property design and layout – including managing runoff
3. Making best use of rainfall – which includes ground cover management, tillage and opportunity cropping
4. Integrated pest management
5. Soil fertility management (48)

The pesticide application module has been piloted with growers in Central Queensland and on the Darling Downs. The other modules will be rolled out in Central Queensland in 2009. The Grains BMP requires landholders to assess their current farming practices, and rate themselves as being either below, at minimum or above industry standard. Growers then develop an action plan and prioritise those actions.

During the pilot phase, 28 enterprises participated in this process. Collectively, these enterprises managed 72 600 ha of cropping land, 46 000 ha of which was under ZT, and 11 500 ha under a fully matched controlled traffic farming (CTF) system. For the 28 enterprises involved, 71% of BMPs completed were either at minimum or above industry standard across all aspects of pesticide application (Figure 17).

In the future the Grains BMP will provide a whole of farming system approach to assist farmers to improve practices. It will provide an extension platform for extension agencies to engage grain growers, as

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well as providing industry and catchment data for understanding rates of adoption, which will assist in the development of future research and development. Increasing the adoption of the Grains BMP is a recommended action highlighted in the response section of this report.

IRRIGATION

Cotton is the main irrigated crop in the Fitzroy Basin. Cotton growing in the Fitzroy predominately occurs on the Dawson, Mackenzie, and Nogoa rivers in the upper catchment areas of the Fitzroy. Approximately 25 farmers in the Dawson Valley Irrigation Area (DVIA) near Theodore, and 80 in the Emerald Irrigation Area (EIA), recognise themselves as cotton growers within the industry. Production of cotton in the Fitzroy Basin in 2006 was more than 40 000 t. This represents 94% of the cotton produced in the GBR catchments, 20% of Queensland's production and is 11% of national production (23). However it is important to note that many of these farmers also grow a range of irrigated and dry land crops on their irrigated land.

The cotton industry has developed and implemented a recognised Farm Management System – the Cotton Best Management Practice (BMP). The FBA region's farmers are recognised as having a high implementation rate of the Cotton BMP. For over 10 years, Cotton Australia has supported development and implementation of Cotton BMP in the Fitzroy region. Increasing the adoption of practices identified in the Cotton BMP is a recommended action highlighted in the response section of this report.

While the horticulture industry in the Fitzroy region is small, it is significant with respect to state and national production of particular commodities. There are 167 growers who produce and vegetables to the value of around $21 million annually. The horticulture industry body GrowCom has developed a FMS that now includes water quality modules. Increasing adoption of this FMS among horticulturalists is a recommended action highlighted in the response section of this report.

Threats to the health of the GBR posed by irrigated cropping are:

- the accelerated delivery of sediments and associated nutrients
- nutrients applied as fertilisers
- pesticides over-applied and/or applied during adverse conditions

Currently little information is publically available on current adoption of management practices across irrigated cropping in the basin.

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SURFACE WATER QUALITY AND E-FLOW ASSET

Water and its use underpins the entire social, environmental and economic fabric of Central Queensland. As such, water is intrinsically linked to the culture of indigenous and non-indigenous people (6). Good water quality supports both aquatic biodiversity and human uses of the region's waterways (6).

The quantity and quality of runoff delivered to streams depends on the intensity and total amount of rainfall and catchment condition. Healthy streams and rivers are required to ensure that water delivered through the catchment is of high quality.

Average annual rainfall varies in a gradient across the catchment moving from >1000 mm in the north eastern coastal ranges to ~600 mm in the western catchments (Figure 18).

Delivery of rainfall and floods, like most of Australia, is highly episodic (Figure 19), and is linked to the southern oscillation index. Mean annual discharge is around 4800 Giga litres (1920-2005). The Connors River sub-catchment contributes about 50% of the total average annual flow (1974-2003). Other sub-catchments contribute around 10% each respectively (4).

Large quantities of water are required throughout the basin for cropping, mining and urban use. Due to the highly variable episodic climate a series of dams and weirs have been constructed to provide water security for dry periods.

Environmental flows (E-flows) support functioning rivers, create habitat for biodiversity and provide a pathway for migrating species. Aquatic biodiversity of the Central Queensland region reflects a transitional zone between tropical and temperate species as well as supporting several endemic species. Species have adapted to the extreme variability in riverine and coastal conditions related to episodic climate events. In many cases, connectivity between marine, freshwater lagoons and wetland habitats is vital to the life cycles and productivity of natural populations.

The Fitzroy Basin is home to 24 freshwater fish species including the golden perch, barramundi, saratoga and pacific blue eye (51). The importance of the Fitzroy Basin as one of the states' significant nurseries is highlighted from results of barramundi migration following the 1991 flood. Recaptures of tagged barramundi spanned around 1000 km of coastline from Hervey Bay to Mackay (Figure 20) (52). This provides evidence that infrequent large flows aid in maintenance of strong genetic diversity for the region's fisheries.

Studies indicate a beneficial link between freshwater flows and a range of species including banana prawn, barramundi, king threadfin and sand whiting. Flows

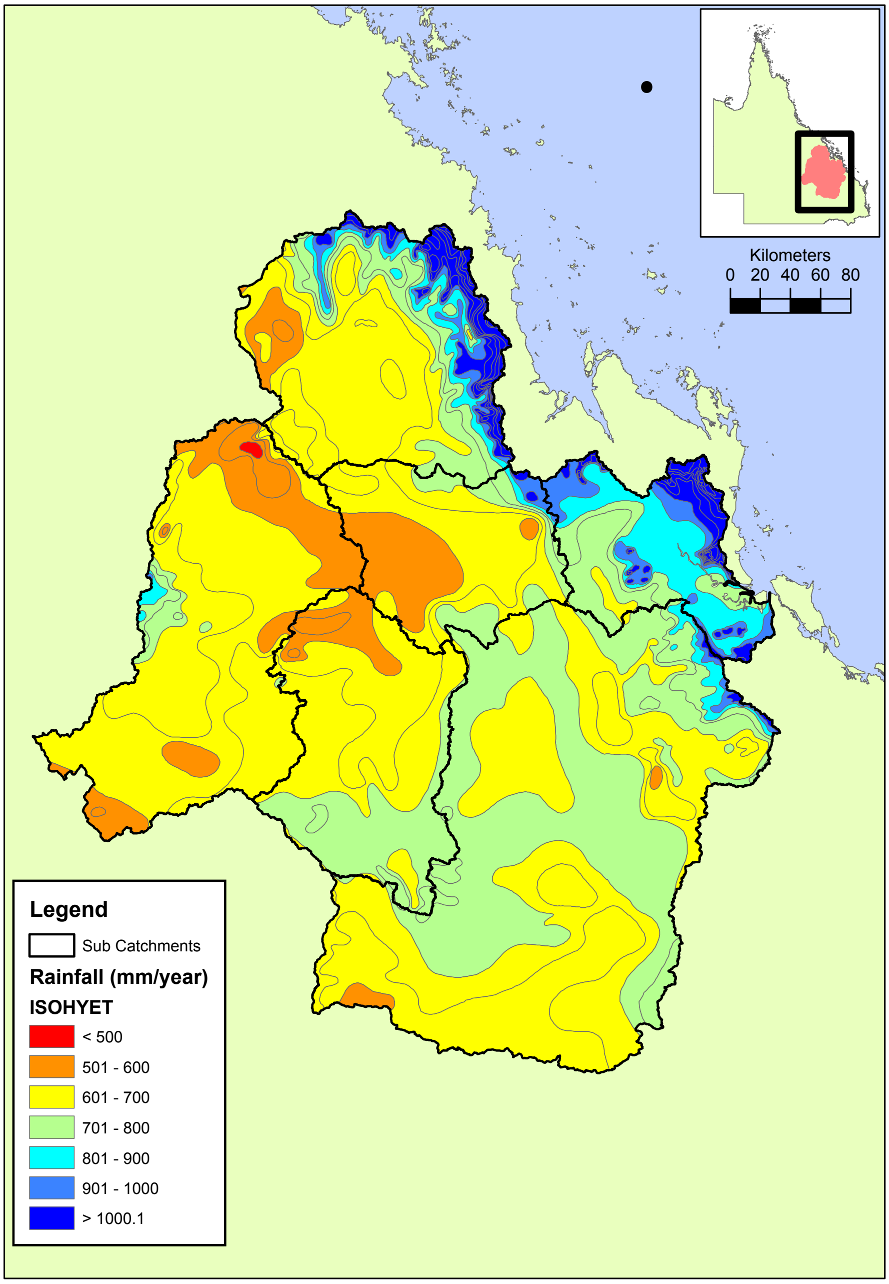

Figure 18 Mean annual rainfall for the Fitzroy Basin (NRW)

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also benefit fisheries such as inshore commercial net, trawl, offshore line and recreational line fisheries. The Central Queensland studies indicate that large summer flows enhance catches and appear to benefit both growth and recruitment of a number of species examined (Figure 21). The message is that fresh water flowing to the ocean is not wasted (53).

The quality of water required depends markedly on its purpose. Water is required for ecosystem, domestic, agricultural and industrial uses. The Australian and New Zealand Environment Conservation Council has released Australian guidelines for these different requirements and the Queensland Government has released guidelines applicable to aquatic ecosystems throughout Queensland.

The Fitzroy has one of the most extensive natural coastal floodplains on the east coast of Australia. There are more than 10 wetland groups listed on the Directory of Important Australian Wetlands within or influenced by the Fitzroy Basin with a total area covering about 7 500 km2 (9). The Fitzroy floodplain filters nutrients and sediments during large floods. These wetlands are home to 67 (54) species of birds and provide habitat for rare species such as the critically endangered Yellow Chat. Forty-six species of fish also inhabit the pools scattering the floodplain landscape (55).

SURFACE WATER QUALITY AND E-FLOW PRESSURES

Freshwater, coastal and reef aquatic ecosystems that receive runoff from the Fitzroy Basin are under threat from the deterioration in water quality brought about by changes in land use and outdated land management practices. Contaminants of particular concern for these ecosystems are sediments, nutrients, dissolved salts and agrochemicals.

Across the basin e-flows are challenged by society's need for water security in a warm, dry and variable climate. E-flows are required for healthy aquatic communities and are particularly important for fish recruitment and dispersal. There are currently 29 dams and weirs throughout the basin and most do not have adequate fishways to allow for natural fish migration. Three new dams and two modifications of existing dams are proposed for the basin with the potential to capture an additional 1 200 000 megalitres of water (Figure 22) (56).

The basin has elevated levels of suspended solids, nutrients and agrochemicals, which are often above levels suitable for ecosystem health as stated in the Queensland Water Quality and ANZECC guidelines. Contaminant laden waters can be exported to Keppel Bay and the GBR and are as a result of unsustainable land management and land use intensification. Many land managers are aware of the situation and are implementing BMP to improve water quality and the productivity and resilience of the land. To implement these BMPs usually requires substantial up-front capital and the decision to invest money in such activities can compete with other priorities.

FBA has helped move such BMPs up the list of priorities by offering co-contributions to agricultural enterprises. The implementation of BMPs that improve water quality are well under way in the Fitzroy. BMP identified in the *CQSS2* and implemented under the Regional Investment Strategy have helped to halt the decline in water quality entering the GBR lagoon. In the last three years it is estimated that landholders, in partnership with FBA, have reduced the long term annual average sediment load by 74 000 tonnes. Estimated long term annual average nutrient load reductions have also been achieved via collaborative BMP implementation. Estimates suggest that long term annual average total nitrogen (TN) and total phosphorus (TP) exports have been reduced by 193 t and 56 t respectively (4).

The implementation of such BMP marks the beginning of a journey to reduce the pressure that unsustainable land management places on good water quality for the health of freshwater and GBR ecosystems. However, more can be done. With ongoing support, landholders across the basin committed to continuous improvement of agricultural enterprises will maintain implementation of BMP to ensure water quality matches ecosystem needs. With this in mind, future land use intensification is now the major barrier to long term success. Appropriate policy is required from the State and Federal Government to ensure future intensification does not negate the positive work being done by landholders across the basin.

CURRENT STATE OF SURFACE WATER QUALITY AND E-FLOW

SEDIMENTS

Coarse sediments alter river habitats by infilling beds and degrading benthic habitat. Fine sediments interfere with feeding of organisms reliant on clear water for vision. Fine sediments can also impact on light penetration by reducing photosynthesis in submerged plants (28). Another role sediment plays is as a transport mechanism for pesticides, heavy metals and nutrients. These contaminants can readily bind to sediments and be transported in floods.

As floodwaters make their way from sub-catchments to the Fitzroy River coarser grained

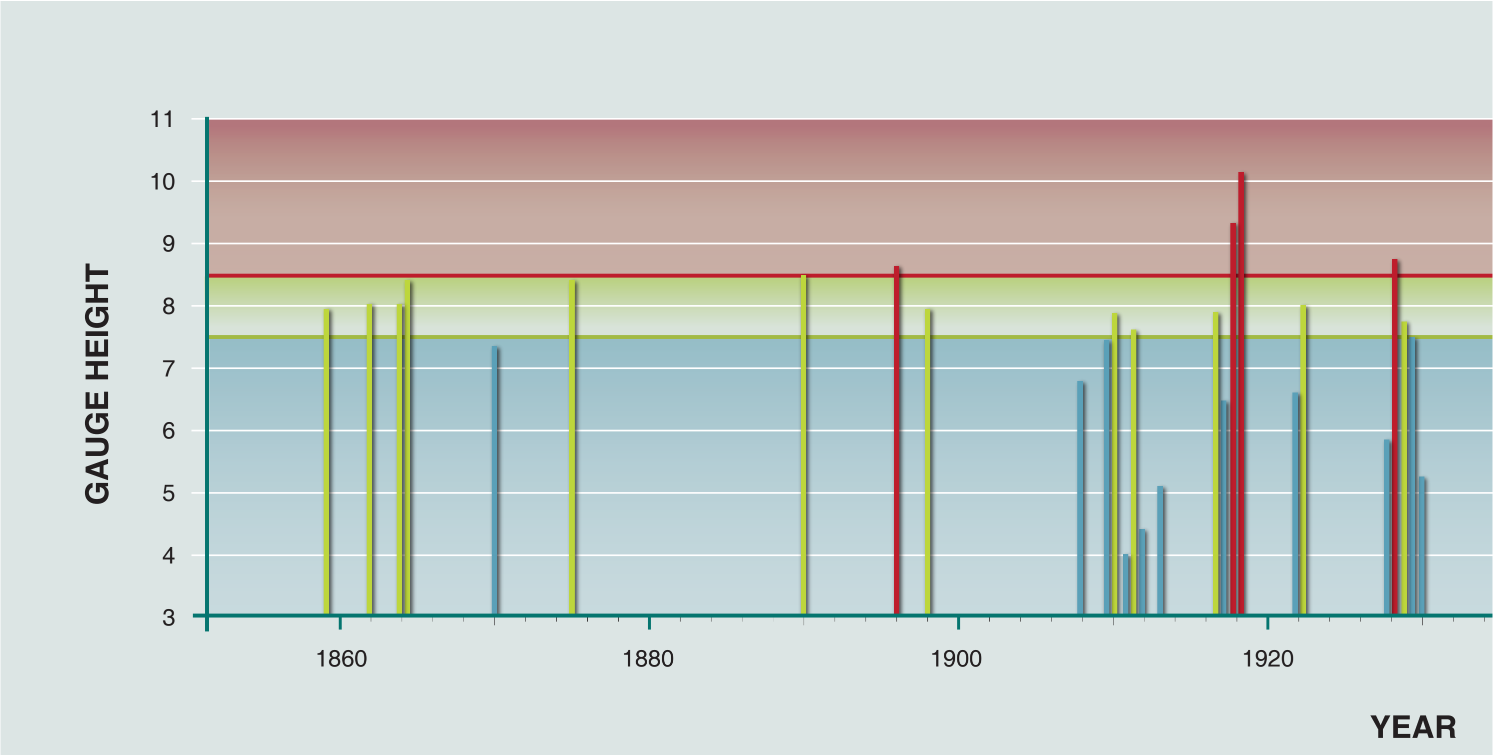

Figure 19 History of maximum flood peaks for the Fitzroy at Rockhampton (50)

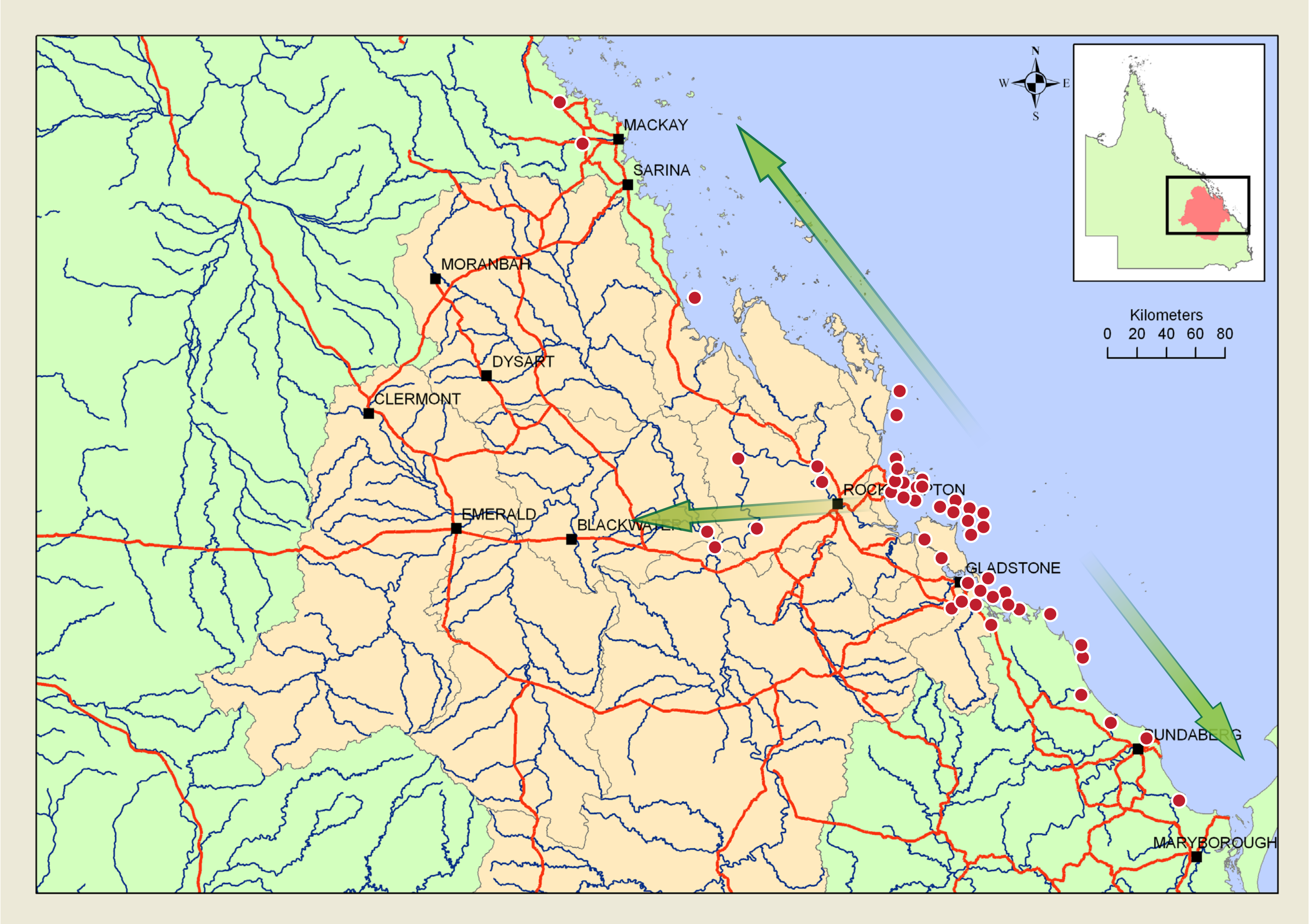

Figure 20 Barramundi recaptures following the 1991 flood (52)

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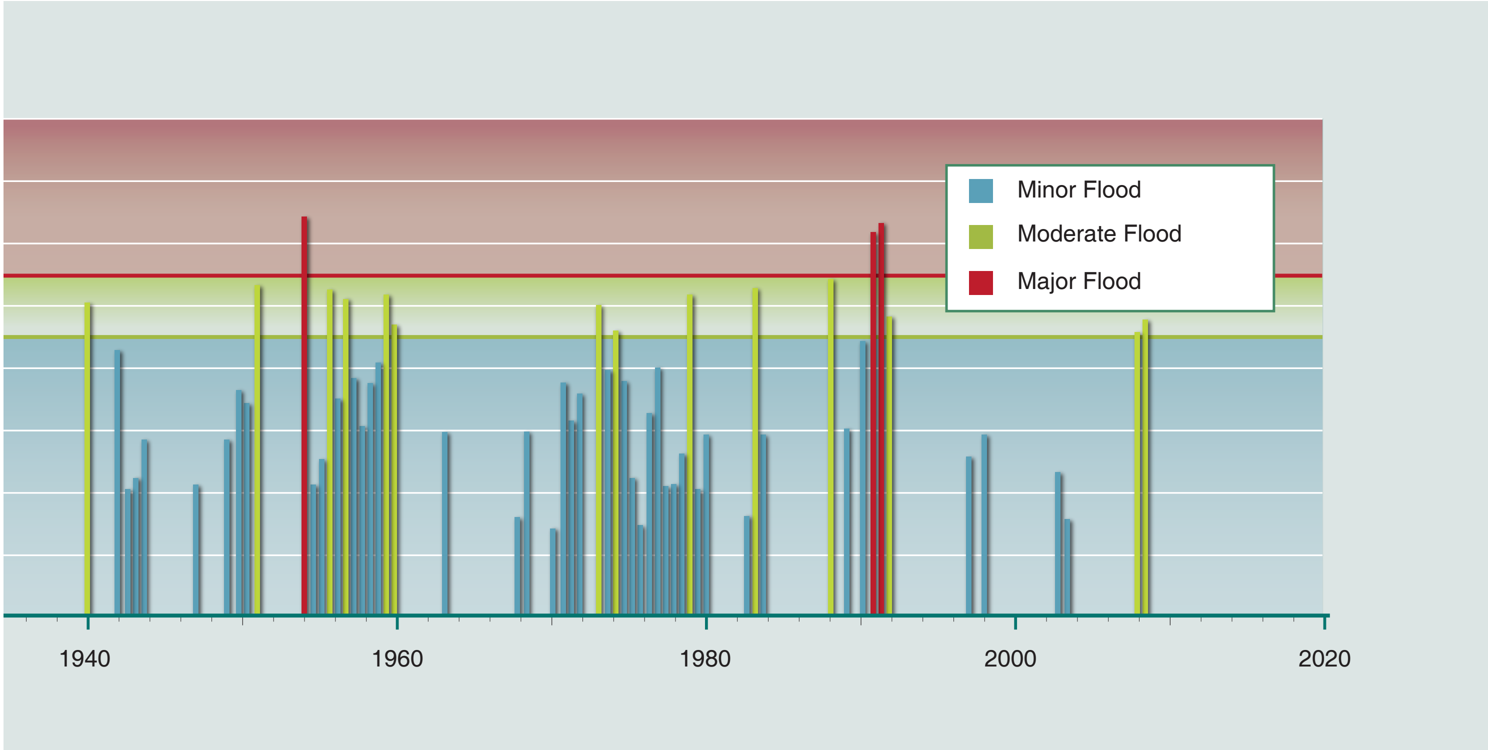

sediments can drop out while fine suspended particles continue to be transported downstream. Around 90% of the suspended sediment particles at the sub-catchment scale are below 14 microns in diameter whereas at the basin outlet around 90% are below 10 microns (7). This indicates relatively efficient suspended solids transport overall, often greater than 40%, due to the very fine particle sizes commonly found in runoff. Sediment Event Mean Concentrations (EMCs) also drop as floodwaters move down the catchment, most likely a function of flocculation and in-stream deposition (7).

Floodplains play an important role in this trapping and removal of sediments as they are carried with floodwaters. Extensive floodplains line the major streams, rivers and delta of the Fitzroy Basin and act as sediment sinks. Studies conducted in Medway Creek catchment (Nogoa River sub-catchment) indicate that substantial sedimentation occurs once floodwaters breakout onto the floodplain. Valley constrictions are of particular importance as they capture both local and sub-catchment sediments (57). Actions that improve management on floodplains are covered in the response section of this report

Long term annual suspended sediment export from the Fitzroy Basin to the GBR lagoon has recently been calculated at 3 400 000 tonnes (4). This is over three times the current pre-European estimate of 1 100 000 tonnes (4). Hillslope is the dominate erosion source comprising 67% of the total sediment contribution, with contributions of 24% from gully erosion and 9% from bank erosion. The modelling indicates that only 62% of the stream suspended sediment input is delivered to the estuary (4). However these contributions are inherently variable. For example radionuclide analysis of sediments carried in floodwaters during the 2008 Fitzroy floods suggest that 25-35% of sediment delivered to Rockhampton arises from material located within half a centimetre of the surface. Importantly this loss of material is directly related to surface erosion and activities that improve ground cover aid in reducing this loss (58). Such activities are covered in the response section of this report.

At the basin scale event based water quality is reviewed extensively. Data from these studies identify flood concentrations ranging between 0.1 g/l and 2 g/L (4) and event mean concentration of around 0.5 – 0.8 g/L (7). Sediment concentrations are not uniform across the basin, with sub-basins delivering waters with varying concentrations of sediments. Notably floods from western catchments generally have higher sediment concentrations compared to floods from the Connors, and lower Fitzroy area. Within the Nogoa and Comet rivers, cropping lands have been shown to deliver disproportionally higher concentrations of sediments (7). This land use has lower cover levels than surrounding areas.

Queensland Water Quality Guidelines (QWQG) for sediment in lowland streams in the central coast region currently stand at 0.1 g/L (59) placing all measured EMC values at the basin and sub-basin scales above this guideline. Sediment samples have been taken from the Fitzroy River estuary and Keppel Bay and indicate

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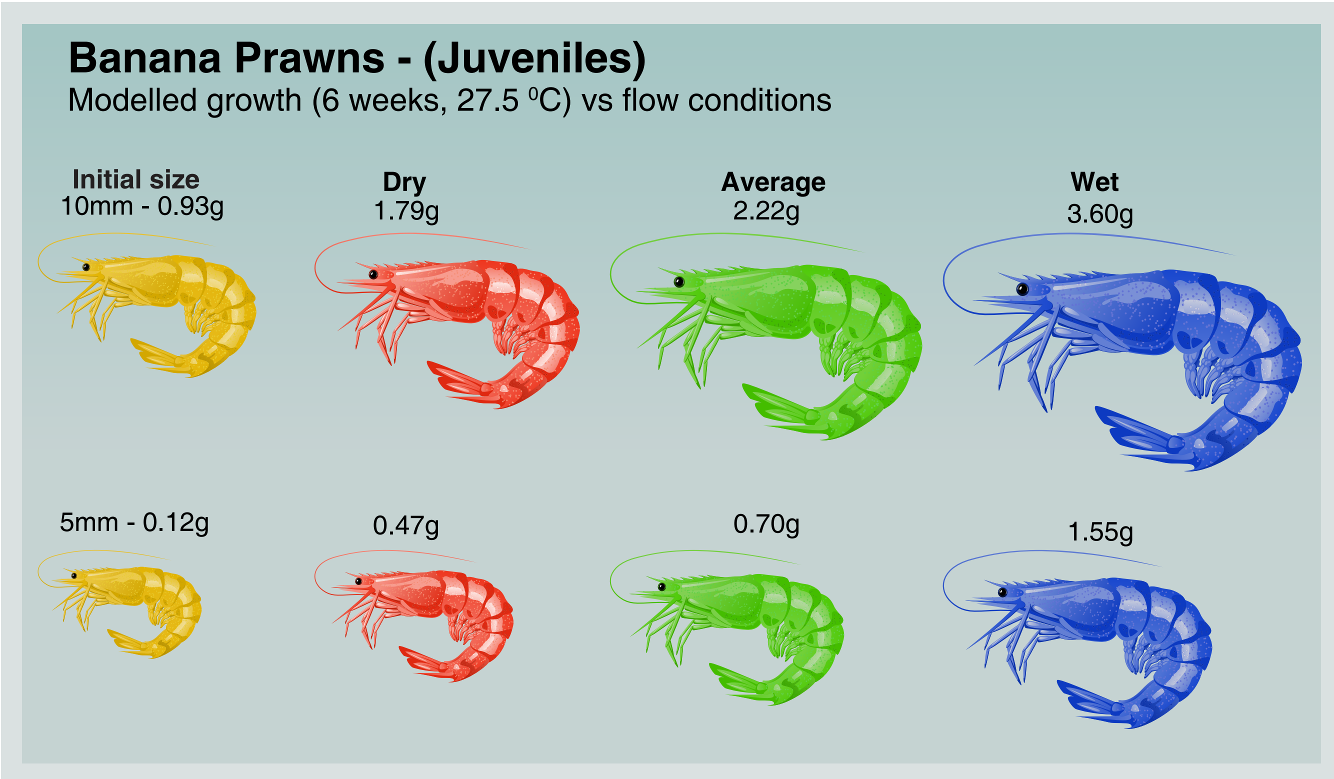

Figure 21 Response in banana prawn growth rates resulting from differing flow scenarios (53)

that a disproportionate ratio of sediments originated from the Thompson fold belt (60). The Thompson fold belt is located in the western section of the Nogoa sub-basin further highlighting the area for targeting as a hotspot.

Event based catchment scale monitoring conducted between 2005-2008 found mean suspended sediment concentrations delivered from catchment floodwaters to be 1.4 g/L (61). QWQG do not provide a concentration value for sediment in upland streams in the central coast region currently, but this figure is substantially above the ambient lowland stream figure of 0.1 g/L.

Given that sediment concentrations rarely fall below guidelines stated in the QWQG, these current sediment guidelines may not be suitable for the Fitzroy Basin in event conditions. Interim guidelines have been set for the FBA region based on the 80th percentile range of monitored data. The interim guideline for sediment is 2.2 g/L (61) and only relates to event conditions. Although these guidelines were set with datasets not meeting conditions outlined under the QWQG, it is the best available benchmark for comparison at this point in time. This current lack of knowledge is a gap that should be filled with the collection and analysis of appropriate data to allow for locally relevant sediment guidelines for lowland and upland waters to be set.

Land use and land management are the major drivers of high sediment levels in the basin's waterways, both of which are discussed in detail in the Land section.

NUTRIENTS

Nutrients are essential chemicals at normal concentrations however in excess amounts they cause severe ecological effects and degrade water quality (28). Nutrients in waterways are delivered in large quantities to the receiving waters where excess nutrients drive large algae blooms that restrict light penetration. Excess nutrients also favour macroalgae communities over corals, which have evolved to thrive in nutrient poor environments. Little is known about the transport of nutrients in the basin

Long term annual nutrient export from the Fitzroy River Basin to Keppel Bay has recently been calculated at 13 000 tonnes for TN and 3500 tonnes for TP. These loads are over twice the nitrogen and triple the phosphorus Pre-European estimates (4).

At a basin and sub-basin scale there is a strong relationship between Total Suspended Solids (TSS) and TP and a moderate relationship for TN allowing the targeting of sediment hotspots to also target nutrient hotspots (7). Event Mean Concentrations for nutrients in floodwaters at the sub-catchment scale are derived from samples collected between 1994 and 2008 (Figure 23). EMCs range from 1.09 mg/L in the Connors to 4.86 mg/L in the Nogoa for TN and 0.28 mg/L in the Connors to 1.87 mg/L in the Comet for TP (7). Ambient QWQG for TN and TP in lowland streams in the central coast region currently stand at 0.5 mg/L and 0.05 mg/L (59) respectively, placing all measured mean values at the basin and sub-basin scales above this guideline.

Event based catchment scale monitoring conducted between 2005-2007 found mean nutrient concentrations delivered from catchment floodwaters to be 2.9 mg/L for TN and 1.4 mg/L for TP (61). Ambient QWQG for TN and TP in upland streams in the central coast region currently stand at 0.25 mg/L and 0.03 mg/L (59) respectively placing measured mean values at the catchment scale above this guideline.

Given that nitrogen and phosphorus concentrations rarely fall below guidelines stated in the QWQG, these current nutrient guidelines may not be suitable for the Fitzroy Basin in event conditions. Interim guidelines have been set for event based flows in the FBA region based on the 80th percentile range of monitored data. The interim guidelines for nutrients are 3.7 mg/L for TN and 2.0 mg/L for TP (61) and only relate to event conditions. Although these guidelines were set with datasets not meeting conditions outlined under the QWQG, it is the best available benchmark for comparison at this point in time.

Recent reports confirm that on average the phosphorus particulate component comprised 80%

Figure 22 Proposed water storages for the Fitzroy Basin (56)

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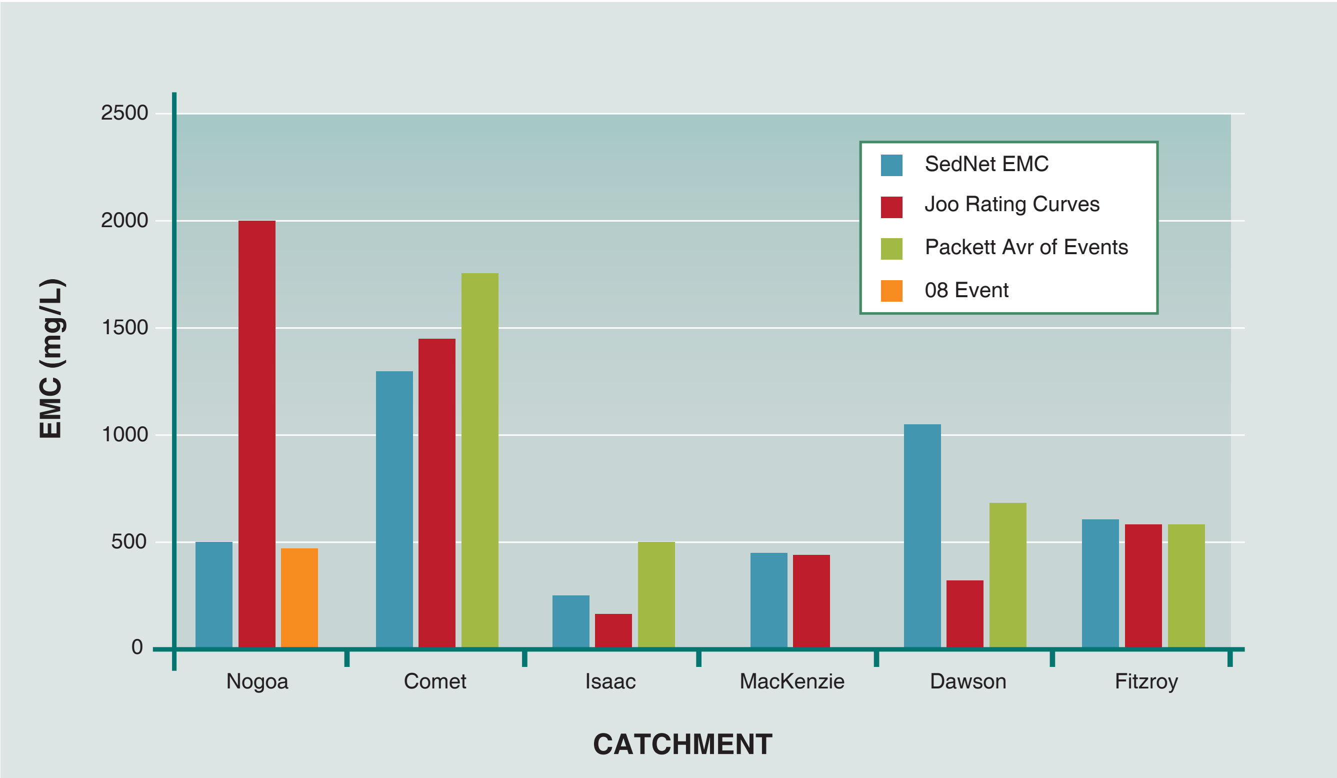

Figure 23 An EMC comparisons of multiple studies at a sub-basin scale shows variation in predictions. Generally speaking the Nogoa and Comet have higher sediment concentrations. Note the Mackenzie is measured below the junction of the Isaac as such it is dominated by Isaac flows (7).

of the total concentration with the dissolved fraction at 20% (7) while the nitrogen dissolved component comprised 50% of the total concentration (7). This finding highlights that past GBR load and risk exposure modelling for the Fitzroy Basin have underrepresented dissolved phosphorus load and risk exposure. Comparisons between figures previously used in modelling and risk assessment compared to nutrient species ratios from recently published monitoring results (7) are outlined in Table 13.

If monitored concentrations are representative of the long term average annual load (and there is no other comparable study to suggest otherwise) then past dissolved nitrogen and phosphorus loads have been significantly underestimated for the Fitzroy. This has important targeting implications for the GBR as current planning and policy like Reef Water Quality Protection Plan (RWQPP), Nutrient Management Zones (NMZ), and the Australian Government's Reef Rescue Package all emphasise the dissolved proportion of the nutrient budget.

The fact that dissolved forms of nitrogen and phosphorus in the Fitzroy are at ratios much higher than that expected in a 'dry' catchment presents particular challenges to the current conceptual understanding when it comes to catchment risk for the GBR. Efforts should be made to identify the potential sources of these dissolved nutrients and implement actions to minimise their loss. Current best knowledge would suggest that land uses where fertilisers are applied, such as irrigated and dryland cropping, would be the first place to start - but this needs to be confirmed. Actions are outlined in the response section of this report that highlight the need for

Table 13 Comparison of end of basin phosphorus and nitrogen species ratios used previously and published in recent studies (4) (7)

Nutrient Component	Packett study (% of total)	Previous estimate (% of total)
Particulate Phosphorus	80	94
Dissolved Organic Phosphorus	18	2
Filterable Reactive	2	4
Particulate nitrogen	50	83
Dissolved organic nitrogen	2	6
Dissolved inorganic	25	10

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Table 14 Current best estimate for nitrogen and phosphorus loads delivered from Fitzroy Basin

Phosphorus and nitrogen inputs (t/yr)	Modelled load (t/yr) (4)	Previous nutrient species ratio - annual rate as % of total (4)	Current best estimate - annual rate (t/yr)	Nutrient species as % of total (7)
Particulate phosphorus	3329	96	2834	80
Dissolved organic phosphorus	72	1	638	18
Filterable reactive	146	3	71	2
Total	3543		3543	
Particulate nitrogen	10 832	87	6487	50
Dissolved organic nitrogen	818	6	3244	25
Dissolved inorganic	1324	7	3244	25
Total	12 974		12 974	

monitoring to confirm these findings and to pinpoint the sources of dissolved nutrients in the basin.

Previous species ratios were used to predict current modelled nutrient estimates delivered to the Fitzroy estuary. This has lead to an under prediction in the amount of dissolved nutrients and an over prediction in the amount of particulate nutrients. Modelled nutrient loads have been combined with monitored nutrient species ratios to provide a best current estimate and is described in Table 14. These estimates have been developed using total nitrogen and total phosphorus loads estimated by Dougall in 2008 and nutrient loads, EMC's and nutrient species percentages calculated from monitoring data (7). These estimates require further refinements but may be more accurate than that reported previously (26) (4).

As with sediment, land use and land management are the major drivers of high nutrient levels in the basin's waterways, both of which are discussed in detail in the Land section. The exception is the sewerage treatment plant that discharges to the Fitzroy River Estuary. The point sources of nutrients drive eutrophic conditions in the upper estuary in the dry season. The upgrading of sewage treatment plants in Rockhampton to minimise the extent of eutrophication in the Fitzroy River Estuary during the dry season (62) is tabled as an action in the response section of this report.

AGROCHEMICALS

Pesticides inhibit the growth of aquatic plants and algae such as seagrasses and corals. The systemic use of photosystem-2 pesticides with long half-lives are of particular concern. Tebuthiuron and atrazine are the most commonly detected herbicides with the majority of water samples analysed returning a reportable concentration.

In 2008 Packett et al published the most compressive dataset. Concentrations are often above guidelines. There is a scarcity of published data at a at sub-basin and Neighbourhood Catchment scale.

Atrazine, diuron and tebuthiuron loads have been calculated with an event mean concentration above the guideline trigger values set in the Draft GBRMPA Water Quality Guidelines for at least one flood event at a basin scale (7). Given this fact, management for these pesticides is considered in the response section of this report with effort prioritised to tebuthiuron, diuron and atrazine.

Atrazine and diuron levels have exceeded the GBRMPA guidelines for only one flood event in 2004. The guideline value for these two herbicides is of moderate reliability. Industry and grower scale atrazine management has already been initiated post 2004 through the DPI&F's Central Queensland Sustainable Farming Systems and the Grains BMP (36). These activities have resulted in improvements in pesticide application and management and are likely to have contributed to the lower pesticide levels measured for atrazine and diuron in subsequent flow events. Actions have been tabled in the response section of this report that build upon work conducted to date.

The GBRMPA trigger value set for tebuthiuron is of low reliability (34). It is likely that the guideline for tebuthiuron has been set too low. The low reliability of the trigger value for tebuthiuron is a key knowledge gap that should be attended to and is highlighted in the response section of this report. Given that all measured flood events were found with tebuthiuron at levels exceeding GBRMPA guideline values, management response is also required whilst toxicology tests are being conducted as a precaution in case the current low reliability guidelines are correct. Guidelines for the application of tebuthiuron are

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already stringent. Response will be focussed on its use in high risk landscapes.

Other pesticides were detected but Event Mean Concentrations did not exceed the 99% ecosystem protection Guidelines set by GBRMPA. Land use and land management are the major drivers of high atrazine, diuron and tebuthiuron in the basin's waterways, both of which are discussed in detail in the Land section.

In many circumstances current point source licence conditions from mining operations relating to salinity allow releases above guidelines and may place considerable pressure on the natural ecosystem

SALINITY

Soluble salts occur naturally in aquatic ecosystems and are a vital component of the normal functioning of freshwater biota. They are ubiquitous in Australia's soils and are a remnant of geological history. Salts are also an integral part of the biochemistry of life in terrestrial and aquatic environments though for many freshwater aquatic animals exposure to high concentrations of salt can have toxic effects. Despite some views that salinity is natural and hence not a contaminant, it is now well recognised in the scientific literature that impacts from increased concentrations of salinity can have profound and measurable effects on riverine ecosystems (63).

Salinity data has been analysed across the Fitzroy and, based on the data, separated into three distinct salinity zones. These are Fitzroy North, Fitzroy Central and Callide. These zones have been developed using thousands of measurements taken by Environmental Protection Agency (EPA) and NRW.

Preliminary salinity guidelines have been set for the three zones based on the 75th percentile of these values (59) (Table 15). Some may argue that this is too stringent for use in point source releases however it is known that under base flow or low flow conditions where the evaporation potential exceeds the rainfall, in-stream salinity concentrations are likely to increase naturally.

Table 15 Salinity guidelines for the Fitzroy Basin (59)

Salinity zone	Preliminary guideline (us/cm)
Fitzroy Central	340
Fitzroy North	720
Callide	760

The extraction of coal seam gas involves dewatering of coals before gas extraction. This water which is often highly saline may also contain trace amounts of hydrocarbons derived from the coal formation. As with dewatering coal mines there are concerns about the potential impacts of continuous delivery of such waters to the coastal waters by the basin stream network. The flow regime may be changed from the highly episodic one that characterises the present natural regime, the salinity may be considerably higher than at present, and there may be an input of complicated mixture of non-natural organic compounds to the coastal waters. The use of evaporation basins as an alternative strategy for the disposal of the gas seam waters raises new risks of ensuring that the basins do not reconnect to the main water courses.

There are substantial coal and gas mines both operational and proposed throughout the Fitzroy Basin. A significant number of these mines release water to the natural environment. Disposal of saline water may contribute significantly to the volume of stream base flow particularly in ephemeral streams or in streams having limited base flow (63) such as the Fitzroy. If values higher than guideline are adopted for point sources releases in low flow conditions, risk of salinity exceeding natural conditions are heightened given that natural evaporation will concentrate salinity levels in natural waterways. There may be some room for the release of more saline waters in high flow conditions, but this would require proper risk assessment taking into account aspects such as cumulative impacts of all point source and different flow variables and this is something not currently available.

In many circumstances current point source licence conditions from mining operations relating to salinity allow releases above guidelines and may place considerable pressure on the natural ecosystem. A review of all licence conditions is recommended in the response section of this report to account for these new guidelines and the cumulative impact that point source releases exert across the Basin.

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ENVIRONMENTAL FLOW

The Water Resource (Fitzroy Basin) Plan 1999 was finalised by the Queensland Government in 1998 after release for public comment and subsequent discussions. The plan aims to "...provide for healthy river systems and aquatic ecosystems through the provision of e-flow management strategies" that are implemented through the development of a Resource Operations Plans. The Resource Operations Plan concentrates on management of water in areas where water resource development and use is greatest in the basin (64).

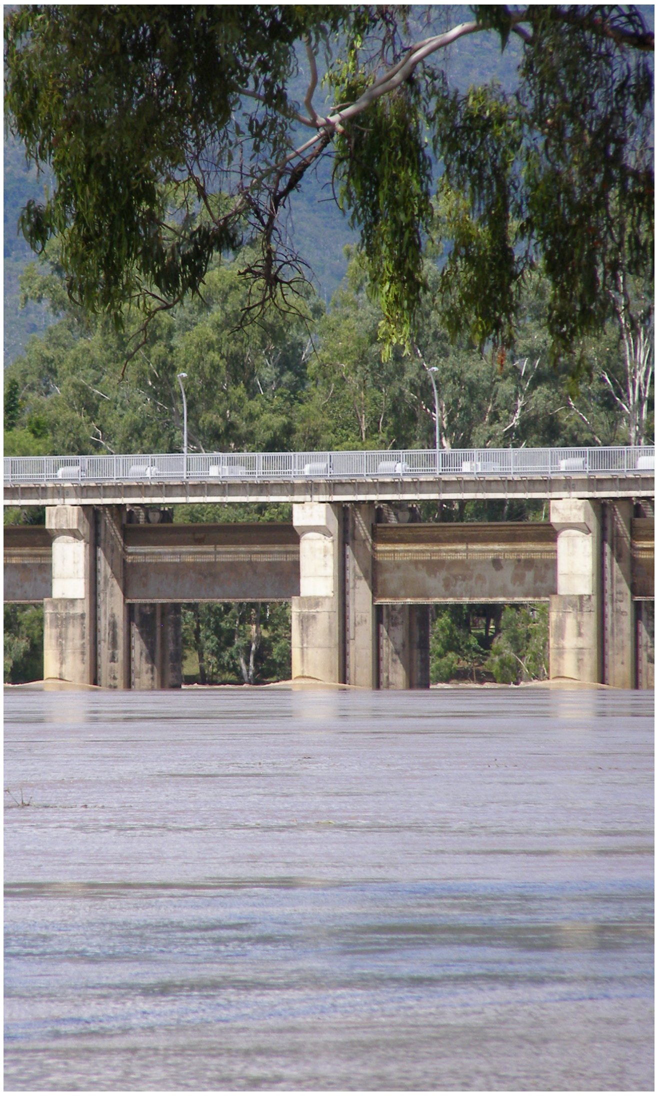
While the Water Resource (Fitzroy Basin) Plan and Resource Operations Plan have been developed using best available information, using expert advice and opinion, there are a number of issues requiring further development. The Water Resource (Fitzroy Basin) Plan document lists priority research areas for developing a better understanding of the ecological and physical processes within the river system (64).

Recent investigations for the Fitzroy Resource Operations Plan monitoring program have highlighted that interaction between the flow regime and ecosystem responses can be complex and distinct relationships are difficult to separate from other catchment influences. Recommendations were made for changing the current e-flows development process to a process that monitors hydraulic habitat requirements of identified flow related biota (64).

E-flows can also be important to estuarine ecosystems. Correlations between age structures of commercial catches of barramundi and rainfall during summer, indicate that the strongest year classes were those when river flows at the mouth were greater than 2.4 million megalitres or high coastal rainfall (64). Monitoring of fisheries response to flow is being conducted by NRW, DPI&F and CapReef. Actions are highlighted in the response section of this report that support continuation of such monitoring and allow for refined understanding of e-flow and fishery response leading to improved e-flow planning in state water planning.

Water infrastructure has the potential to influence aquatic ecosystems by limiting fish migration and changes to the flow regime. Mitigation of barrier effects has been attempted by the installation of fishways. A number of fishways have been installed within the Fitzroy Basin, including those at the Fitzroy River Barrage, Eden Bann Weir, Baralaba Weir and Moura Weir. However, other barriers to movement will still result from structures such as road culverts, small weirs and dams, private farm dams and causeways, as a comprehensive program of barrier mitigation has not been undertaken (64).

Impacts of e-flow on fish populations can be minimised with the construction of effective fishways. The fishway associated with the Fitzroy River Barrage was initially ineffective, which has been the case in many Australian fishways due to designs based on northern hemisphere salmonoid fisheries. Since the implementation of several modifications, the Barrage fishway still prevents passage by small individuals and some specific species, but generally its effectiveness has increased. All the major sub-catchments have major dams or weirs however there are several contiguous reaches where no barriers exist that are believed to be significant for maintaining populations of many aquatic species. Releases from several weirs are also thought to potentially impact aquatic ecosystems with several reported fish kills (e.g., downstream of Fairbairn Dam) and some unnatural release strategies (e.g., Eden Bann) (64). A recent report prioritised fish barriers for removal in the FBA region. Several barriers in the basin were highlighted for improvement. These include Tartrus and Eden Bann. Actions are highlighted in the response section of this report to overcome prioritised barriers (65).



GREAT BARRIER REEF ASSET, PRESSURES AND STATE

GBR ASSET, PRESSURES AND STATE

GBR ASSET

The GBR is internationally renowned as a place of great beauty and ecological significance and is protected as a Marine Park and a World Heritage Area. It is of immense social, economic and cultural value to the people of Australia (66). This area contains: six of the world's seven marine turtles; one of the world's most important dugong populations; more than 3000 species of fish and molluscs; one third of the world's soft coral and sea pen species; over 200 species of birds and one of Australia's most significant seabird rookeries; around 3000 coral reefs built from about 360 species of hard coral; 13% of the world's sea star species; and 3000 km2 of mangroves including 54% of the world's mangrove diversity (9).

The Fitzroy is also home the Australia's southernmost population of threatened estuarine crocodiles. The Fitzroy delta has a unique population of vulnerable Australian snub fin dolphins and the freshwaters are home to the vulnerable Fitzroy River Turtle. There are more than 13 mangrove species found with some at their northern and southern limits of range (9).

Sixteen continental islands located in the shallow basin to the north of Keppel Bay make up the Keppel Group. These islands are host to a patchwork of fringing reefs harbouring staghorn dominated coral communities with a high fish diversity and abundant cover. These corals are vulnerable to impacts caused by environmental stresses including elevated sea temperatures, degraded water quality, and physical damage (12). In the last two decades alone, reefs have been affected by flood plumes from the Fitzroy River (67), thermal bleaching events in 2002 and early 2006, and a shallow-water mortality event when a heavy rainfall event coincided with an extreme low tide in late 2006 (68) (69).

The Capricorn Bunker Group is also influenced regularly by the Fitzroy. This group is made up of a distinct group of 22 reefs is some 60 km offshore, straddling the Tropic of Capricorn. There are 16 coral cays, eight of which are vegetated. Typically these islands only rise a few meters above high water. These islands support some 75% of the GBR's total seabird biomass, the largest pisonia forest occurrence in Australia and the largest green turtle nesting site in the Southern GBR (70). Coastal marine assets have been mapped for Keppel Bay and beyond to include an area covering the 1991 flood plume extent. Delegates attending at a workshop held in 2008 utilised existing information and local knowledge to map these assets. Existing information was sourced from GBRMPA, DPI&F, and EPA. Coastal

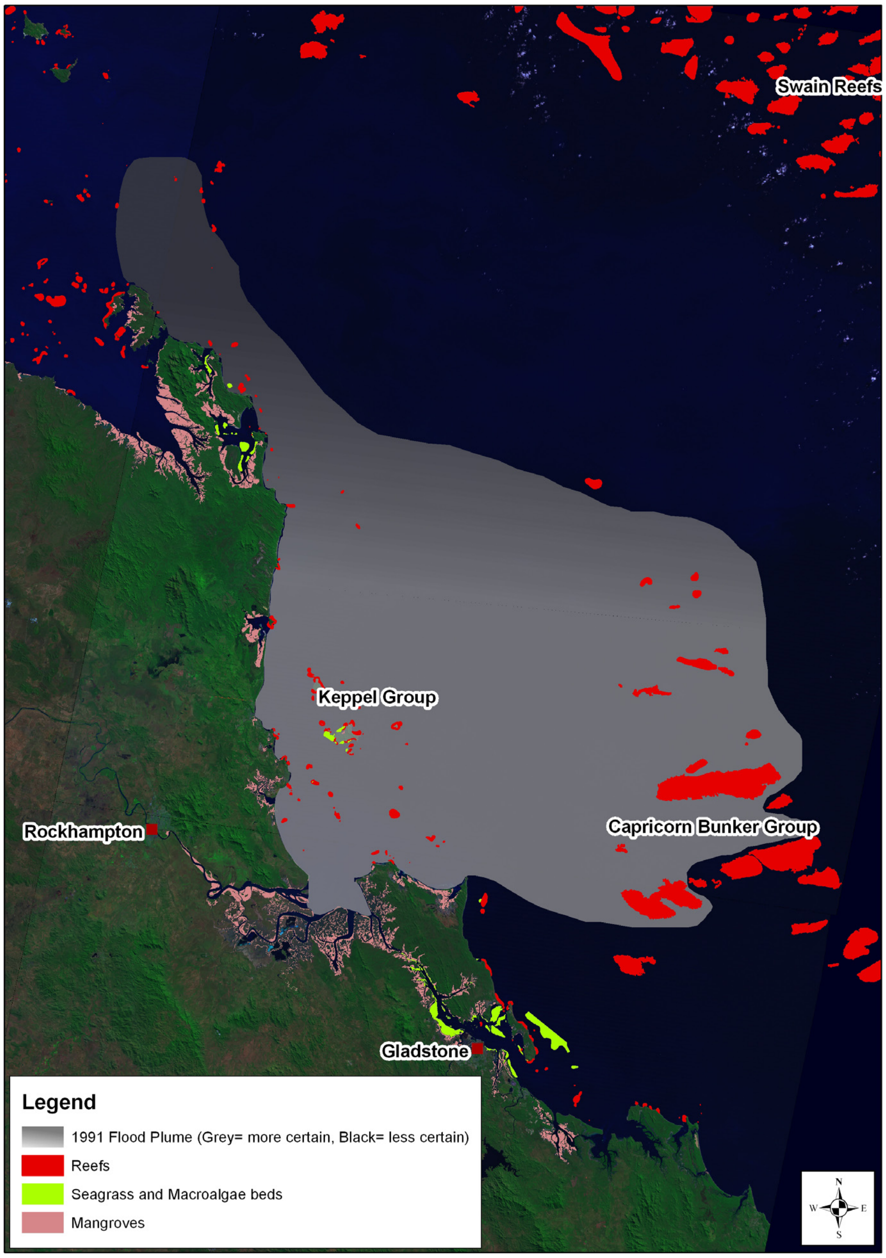


Figure 24 Current known extent of corals, seagrasses and mangroves within the influence of the Fitzroy Basin and the freshwater plume extent (89) from the 1991 flood (the third largest recorded flood for the Fitzroy Basin in the last century). Nutrient enriched waters and associated algae blooms would have extended well beyond this freshwater plume extent.

GBR ASSET, PRESSURES AND STATE

Table 16 Effects of four parameters of terrestrial runoff on organisms that interact with corals. Arrows indicate the relative strength and direction of response (arrows pointing up or down = increasing or decreasing, ▲ = moderate to strong, ▲ = weak effect); a dash indicates that a response is unlikely; empty cells indicate that insufficient data are available (73).

	Dissolved inorganic nutrients	Particulate organic matter	Light reduction	Sedimentation
Crustose coralline algae	▼			▼
Bioeroders	▲	▲		▼
Macroalgae	▲	▲	▼	▼
Heterotrophic filter feeders		▲	▲	▼
Coral diseases	▲			▲
Coral Predators		▲		

and Marine asset classes that were mapped include: reefs, seagrass, macroalgae and mangrove; crustacean and mollusc; fish; large marine animals; and birds (3) (Figure 24).

GBR PRESSURES

DECLINING WATER QUALITY

Changes in land use from natural forests, woodlands and grasslands to grazing, farming, urban and mining has resulted in removal of vegetation causing accelerated erosion and loss of nutrients from the land (71). Fertilisers have been used to boost production and chemicals applied to reduce impacts of weeds and pests. These contaminants place pressure on water quality across the GBR.

The impacts of water quality on the GBR asset have been demonstrated through laboratory and field studies and data synthesis and integration has enabled the development of guideline trigger values for corals to water quality parameters (72). These guideline trigger values have been adopted locally.

Strong links between coral health and water quality have been shown at multiple scales. The effect of coral health, coral reproduction, and abundance of other reef associated organisms is known to change along water quality gradients. Table 16 summarises the results of a review of existing reef studies from around the world to identify the main effects of nutrient and sediment related parameters on key coral reef organism groups. The data suggest that nutrient enrichment can lead to macroalgal dominance if light levels are sufficient, but leads to dominance by heterotrophic filter feeders if light becomes a limiting factor for macroalgae. It also shows that crustose coralline algae, which are essential settlement substratum for coral larvae, are negatively impacted by sedimentation, as later confirmed by laboratory experiments (72).

The distribution and growth of seagrasses is dependent on a variety of factors such as temperature, salinity, nutrient availability, substratum characteristics, and underwater light availability (turbidity). Terrigenous (land-based) runoff, physical disturbance, low light and low nutrients respectively are the main pressures on each of the four seagrass

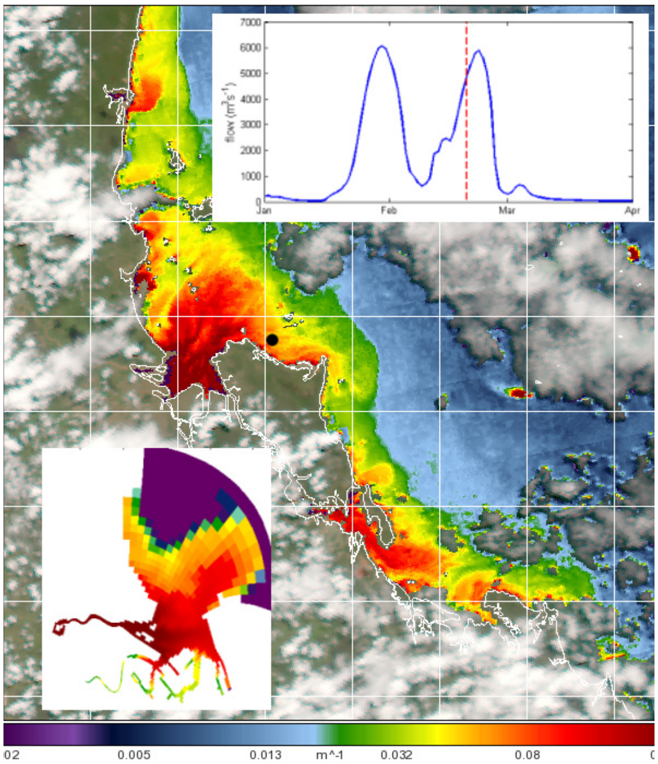


Figure 25 There is good correlation between modelled and remotely sensed information generated and captured for the 2008 flooding remotely sensed image of water absorbance (measure of light absorption and thus of turbidity), showing flood plumes (Top right insert shows discharge at Rockhampton and time of satellite overflight) entering Keppel Bay and dispersing northwards. Bottom left insert shows the modelled distribution of turbidity (5)

habitat types found in Queensland, and changes to any or all of these factors may cause seagrass decline (72).

The most common cause of seagrass loss is the reduction of light availability due to chronic increases in dissolved nutrients, which leads to proliferation of algae, thereby reducing the amount of light reaching the seagrass (e.g., phytoplankton, macroalgae or algal epiphytes on seagrass leaves and stems), or chronic and pulsed increases in suspended sediments and particles leading to increased turbidity. In addition, changes of sediment characteristics may also play a critical role in seagrasses loss (72).

Modelling and monitoring studies confirm that contaminants carried in river plumes are transported from the Fitzroy River Barrage into the GBR World Heritage Area including Keppel Bay and the Capricorn Channel. Remote Sensing closely aligns with model outputs showing dissolved matter being transported across and along the GBR lagoon (72) and supports the fact that contaminants are dispersed widely within the GBR (Figure 25). Large river discharge events (‘floods’) in the wet season are the major delivery mechanism of land-derived contaminants to the GBR – in GBR waters, concentrations of dissolved inorganic nitrogen (nitrate, ammonium), suspended sediment and dissolved inorganic phosphorus are many times higher in flood plumes than in non-flood waters (72).

Once contaminants reach Keppel Bay, their storage, transformation and transport determine the degree to which coral, seagrass and other GBR assets are impacted. This process can be separated into the initial flood pulse lasting several weeks (acute) and the long term breakdown through bacterial action and export through tidal re-suspension (chronic) (74). The duration and intensity of the chronic impact is likely to be proportional to the size of contaminant load delivered to Keppel Bay by the flood.

Virtually all sediments and nutrients are delivered to the Fitzroy River Estuary and Keppel Bay during the acute flood events. Most of the nutrient material that is transported down the river is in organic form attached to fine sediment particles. Flocculation causes these fine sediments and attached nutrients to be deposited close to the mouth of the Fitzroy estuary. During these events dissolved nutrients and pesticides are carried further into the Capricorn Channel and Bunker Group of Islands impacting the GBR. During these acute events exceedances of guideline trigger values occur for more water quality parameters and for longer durations (5).

Although greater concentrations of contaminants abound further into the Capricorn Channel in flood pulses, contaminants dumped at the mouth of the Fitzroy River during this time act as a large source of contaminants, well into the dry season with smaller events, and lasting several years with larger events.

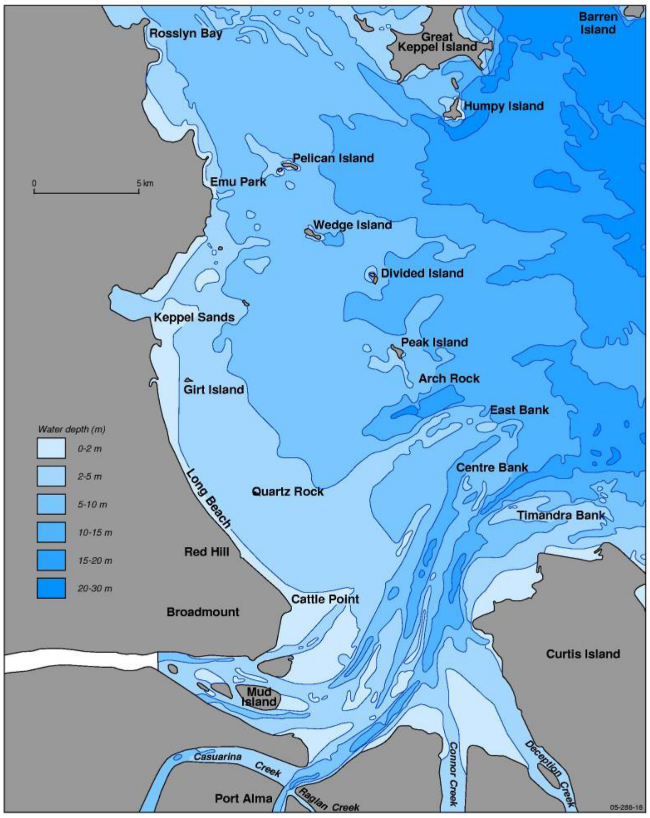


Figure 26 Bathymetry of the Fitzroy River Estuary depicting timandra channel

During the dry season, the deposited organic material breaks down through bacterial action releasing nutrients into the water column. In turn, these nutrients are consumed by phytoplankton and eventually converted into dissolved form when the phytoplankton die and decompose. Through mixing processes and currents much of the nutrients in their various forms are dispersed throughout Keppel Bay and to other parts of the GBR lagoon. Due to large five metre tides and its shallow wave churned expanse, the Keppel Bay acts as a biogeochemical reactor which transforms particulate and dissolved organic material input by the Fitzroy River and gradually ‘leaks’ it to other parts of the GBR lagoon (74). Although roughly one third of the matter is buried within the bay and takes no further part in biogeochemical cycling (74), enough is released and transported to maintain exceedances of guideline trigger values for many water quality parameters throughout the entire dry season (5). For this reason the total load of nitrogen and phosphorus rather than inorganic forms are used in targets presented in this report.

Keppel Bay plays the same contaminant storage, transformation and transport role for sediments. Sediments entering Keppel Bay are predominantly fine particles (greater than 80% are less than 10 um) (74). These fine sediments deposited during events are easily re-suspended by wave and tidal action well into

GBR ASSET, PRESSURES AND STATE

the dry season maintaining trigger value exceedances for turbidity and secchi depth. During the dry season, there is net export of suspended sediments out of Keppel Bay through the Timandra channel (Figure 26) equivalent to an annual rate of approximately two million tonnes (74). This is two thirds of long term average annual sediment load delivered over the Fitzroy River Barrage (4). This indicates that catchments with large infrequent flood regimes and large shallow coastal bays like the Fitzroy may pose similar or greater potential chronic risk to the reef than catchments with smaller frequent flood regimes.

Pesticide residues have been detected in Keppel Bay (75). This is expected given that pesticides have been detected in the Fitzroy River with concentrations ranging from 0.01 to 1.2 μg L-1. Tebuthiuron and atrazine were the most commonly detected herbicides with ~90% of water samples analysed returning a reportable concentration. A range of other pesticides were also detected less frequently, including hexazinone, prometryn, flumeturon and dieldrin (7). Pesticides are recognised as a threat to GBR ecosystems (mangroves, wetland plant communities, seagrass, coral reefs, phytoplankton communities) and are found up to 60 km offshore in wet season flood plumes (72). Herbicides found in the GBR waters have biological effects on coral zooxanthelle at concentrations below 1μg/L. Evidence is emerging that some pesticides not only affect the photosynthesis of the endosymbionts but also coral reproduction and that the existence of synergistic effects may have to be carefully considered in estimates of tolerance thresholds (72).

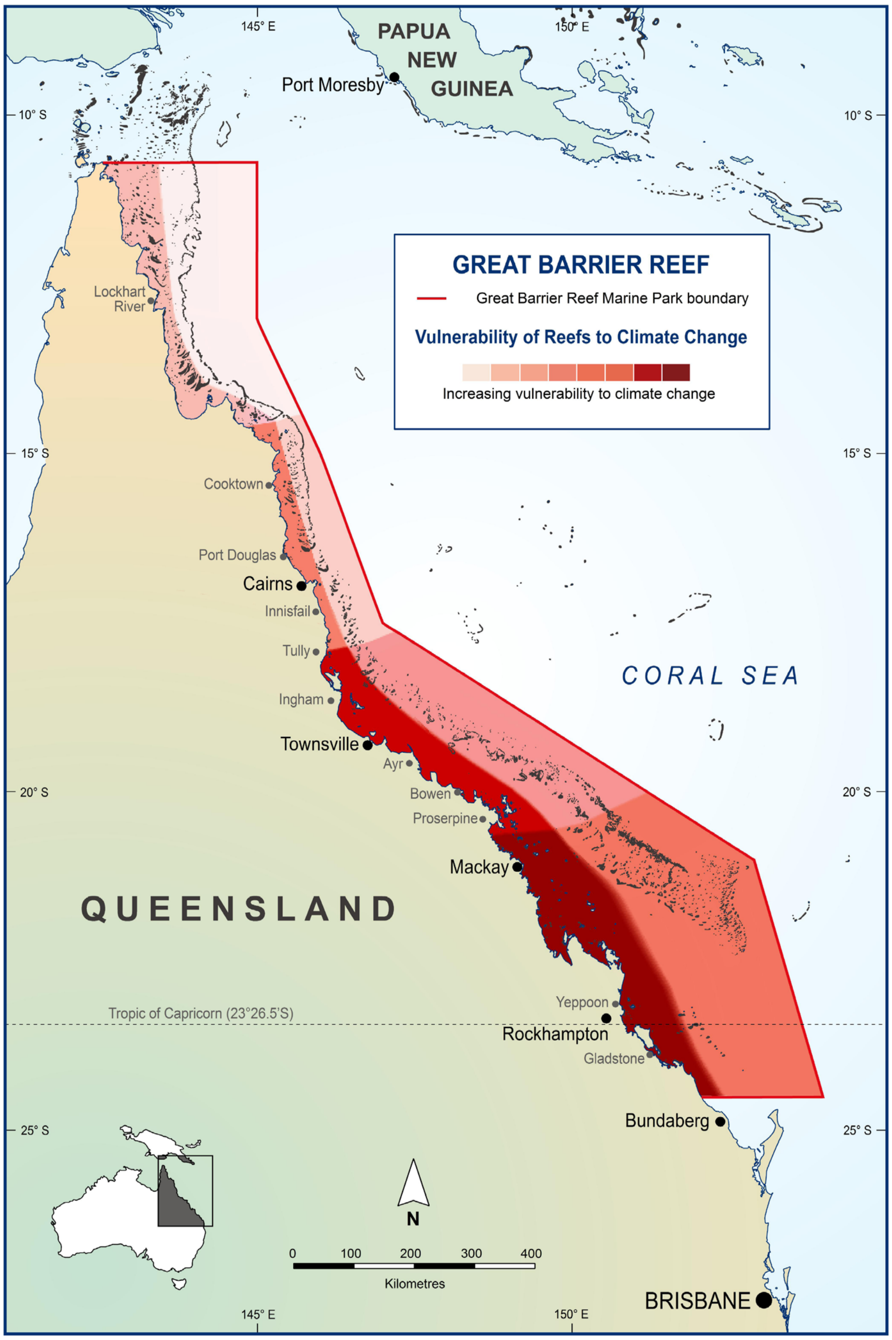


Figure 27 Map of Predicted vulnerability of coral reefs of the GBR to climate change (14). Map courtesy of the Spatial Data Centre, Great Barrier Reef Marine Park Authority.

CLIMATE CHANGE

The Southern GBR has been identified as the most at risk to the impacts of climate change (Figure 27). The resilience of coral communities is particularly challenged in areas where water quality is degraded, as chronically stressed corals are much less able to recover from bleaching events. Further, coral communities exposed to excess nutrients and sediments have substantially increased recovery times following major mortality events. Improving the quality of water entering the GBR will be a major contribution towards increasing the ability of communities such as corals and seagrass to cope with, and adapt to, climate change (14).

Climate change is also expected to result in greater intensity of rainfall events, leading to increased risk of erosion and flooding. Efforts to stabilise land areas prone to erosion and

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Table 17 Local water quality trigger values for coastal and marine assets (3)

	Water Body			
WQ Parameter	**Estuary**	**Enclosed Coastal**	**Coastal**	**Inshore**
NH^4 µg/L	10	8	n/a	n/a
NO^x µg/L	10	3	n/a	n/a
DON µg/L	260	180	n/a	n/a
PN µg/L	n/a	n/a	20[2]	20[2]
TN µg/L	300	200	n/a	n/a
FRP µg/L	8	6	n/a	n/a
PP µg/L	n/a	n/a	2.8[2]	2.5[2]
TP µg/L	25	20	n/a	n/a
Chl-a µg/L	4.0	2.0	0.45[1]	0.4[1]
DO (% sat_n) Lower – Upper	85-100	90-100	n/a	n/a
Turbidity NTU	8	6	n/a	n/a
Secchi m	1	1.5	10	11
TSS mg/L	20	15	2.0[2]	1.7[2#]
pH Lower – Upper	7.0 - 8.4	8.0 – 8.4	n/a	n/a
Sedimentation mg/cm^2/day	n/a	n/a	Maximum mean annual = 3 Daily Maximum = 15	

[1]Chlorophyll values are ~40% higher in summer and ~30% lower in winter than mean annual values.
[2]Seasonal adjustments for SS, PN and PP are approximately 20% of mean annual values.
[#] TSS has been raised to 2.0mg/L for inshore waters in the latest iteration of the Draft GBRMPA guidelines.
Please refer to list of acronyms.

investment in strategies to trap sediments and nutrients in the coastal zone (before they enter the marine environment) will become increasingly important in the face of climate change.

In the context of climate change, it will be particularly important to restore and maintain the resilience of the reefs in this region. Stress to reefs from degraded water quality, anchor damage, overfishing or other pressures can significantly undermine their natural resilience to large-scale disturbances such as elevated sea temperatures. Building resilience by reducing other sources of stress will give reefs in the Keppel Islands the best chance of coping with climate change (12).

GBRMPA proposes three management responses to reduce the impact of climate change on coral reefs of the GBR. The first is the protection of water quality. Deteriorating water quality from increased runoff of sediments, nutrients and agrochemicals is a threat to inshore coral reefs (66). Actions outlined in this report will implement BMP to reduce levels of these contaminants reaching the Southern GBR.

WATER QUALITY REQUIRED FOR PROTECTION OF GBR ASSETS

Good quality water is required for the health of coastal and marine ecosystems. Local water quality trigger values have been set that outline the quality of water required for protection of coastal and marine assets. These guidelines are outlined in Table 17. These values were set drawing upon the expertise of delegates attending a coastal and marine expert panel workshop. Attendees recommended that the best water quality guidelines to adopt locally for the present time are a combination of the QWQG and GBRMPA guidelines.

GBRMPA and QWQG guidelines provide guideline trigger values for different types of water bodies. The water body boundaries used in this report are set using descriptions outlined in these guidelines. The Fitzroy Receiving Waters Model has been developed by CSIRO for the Fitzroy and provides a means of predicting water quality. There are four types of waters delineated for the CSIRO Fitzroy Receiving Waters Model area. The water bodies delineated are ‘estuary’, ‘enclosed coastal’, ‘coastal’ and ‘inshore’ (3) and are depicted in Figure 28.

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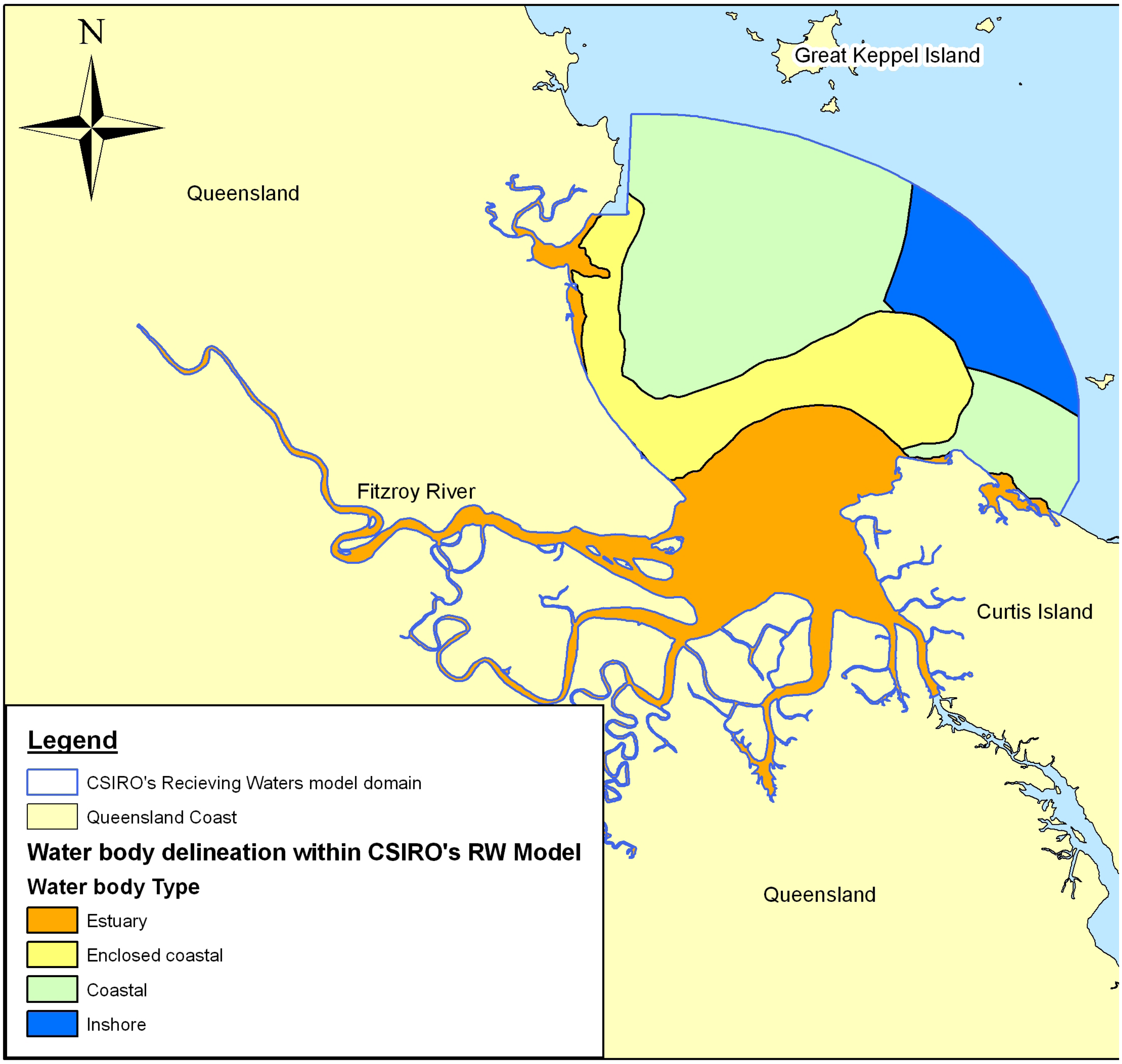

Figure 28 Water body deliniations used for coastal and marine water quality trigger values (3)

'inshore' waters are adopted from GBRMPA Water Quality Guideline for the GBR Marine Park. It is important to note that the GBRMPA and QWQG guideline values will be refined as better data becomes available into the future (3). This will subsequently impact the guidelines outlined in this report.

While GBRMPA guidelines have been set with the protection of GBR assets in mind, QWQG are set for ambient conditions and may not necessarily be related to the protection of GBR assets. The expert panel recommended that they be used for the short term but suggested that guideline values under the QWQG may be too stringent for the Fitzroy, especially sediment and clarity related parameters. In addition local data and modelling indicates that water body boundaries need to be refined. Refining of water quality guidelines and water body boundaries is required and is included as an action in this report. Until this action is completed, guidelines and water body delineations outlined in this report represent the best that is currently available.

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Table 18 The percent of time a water quality contaminant exceeded its trigger value in a water body and potentially placed coastal and marine assets of Keppel Bay at risk in 2004. The 2004 year represents a median year for the Fitzroy Basin (5)

	DRY SEASON				WET SEASON			
Contaminant \ Waterbody	Coastal	Enclosed Coastal	Estuary	Inshore	Coastal	Enclosed Coastal	Estuary	Inshore
sedimentation rate	0			0	0			0
carbon sedimentation	0			0	0			0
Secchi depth	2	0	0	0	22	0	0	0
TSS	42	0	23	0	100	2	78	13
TN		0	1			0	75	
PN	1			0	0			0
DIN		54	97			75	100	
NH_4		23	93			48	100	
NO_x		92	100			88	100	
DON		0	0			0	16	
TP		0	1			0	77	
PP	0			0	0			0
DIP		0	55			30	100	
Chl a	0*	0*	0*	0*	0*	0*	0*	0*
% O_2 saturation		1	5			27	32	

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Table 19 The percent of time a water quality contaminant exceeded its trigger value in a water body and potentially placed coastal and marine assets of Keppel Bay at risk in 2008. The 2008 year represents a 1 in 10 year flood for the Fitzroy Basin (5)

	DRY SEASON				WET SEASON			
Contaminant / **Waterbody**	Coastal	Enclosed Coastal	Estuary	Inshore	Coastal	Enclosed Coastal	Estuary	Inshore
sedimentation rate	0			0	0			0
carbon sedimentation	0			0	0			0
Secchi depth	70	0	0	0	41	2	4	13
TSS	94	14	20	8	78	74	80	28
TN		14	14			74	74	
PN	4			0	0			0
DIN		27	59			85	100	
NH_4		26	64			79	100	
NO_x		38	84			93	100	
DON		14	14			73	72	
TP		14	45			79	100	
PP	0			0	8			8
DIP		4	71			70	100	
Chl a	0*	0*	0*	0*	0*	0*	0*	0*
% O_2 saturation		12	4			16	0	

Note for Table 18 and Table 19: A traffic light colour system is used to highlight risk with shorter exceedance times coloured green (>10% time); medium exceedance times coloured yellow (10-20% time); and longer exceedance times coloured red (<20% time). *Modelled chlorophyll values have very high uncertainty and should not be used. Monitoring and remotely sensed data conflict with the modelled results and support the low confidence placed in modelled results.

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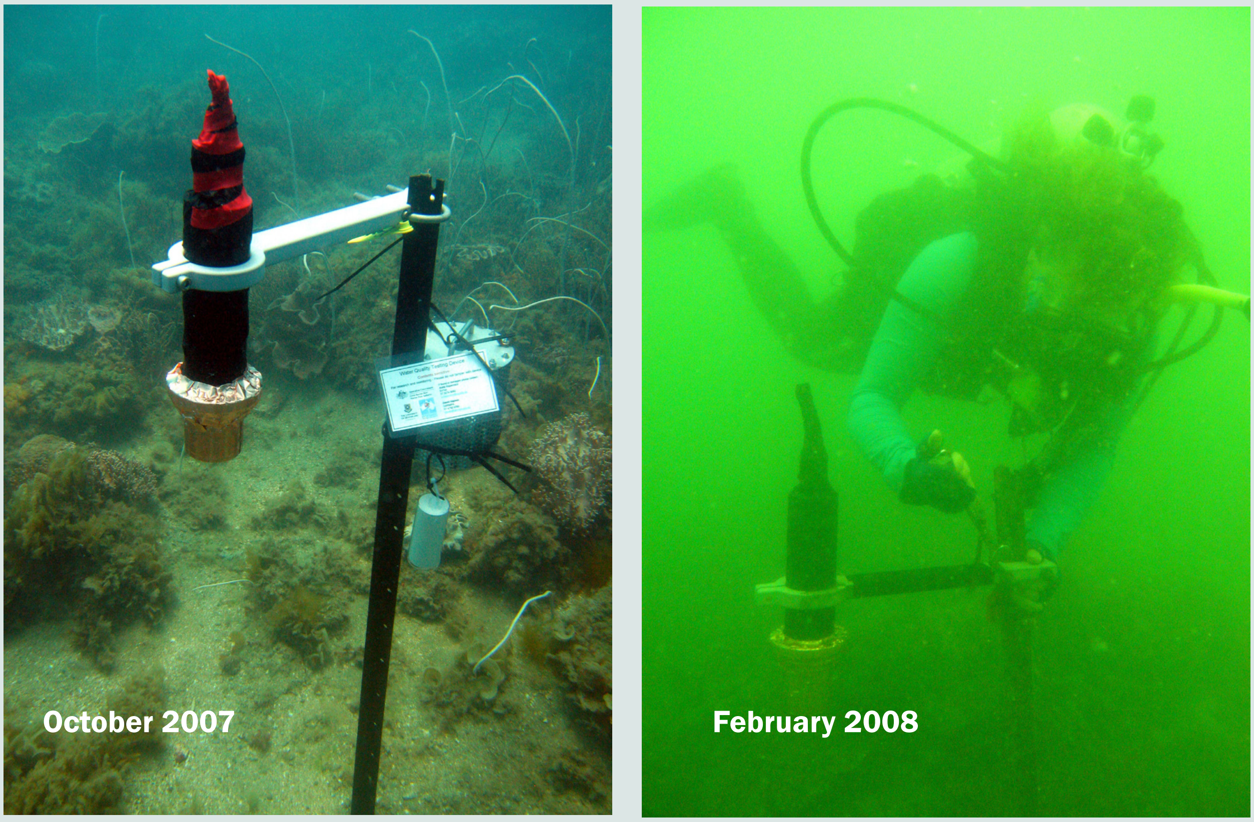


Figure 29 Visual changes in chlorophyll concentrations at Humpy Island evident before and during the 2008 Flood (76)

CURRENT STATE OF THE GBR

PREDICTED EXCEEDANCE OF LOCAL WATER QUALITY TRIGGER VALUES FOR COASTAL AND MARINE ASSETS

The CSIRO receiving water model has been used to determine the impact of water quality contaminants released from the Fitzroy Basin to coastal and marine assets. Water body delineations and guideline trigger values for Fitzroy Basin receiving waters were incorporated into the model to determine the current exceedance of local water quality trigger values related to coastal and marine assets. Each water body was analysed to determine the percentage of time each contaminant went over its particular trigger value. The mean of contaminant values detected within a water body was used for this exercise. Table 18 summarises the results for 2004, which relates to a median event in the Fitzroy and Table 19 summarises results for 2008, which relates to a 1 in 10 year flood event in the Fitzroy.

Generally sediment and nutrient concentrations present in Keppel Bay exceeded local water quality trigger values for extended periods of time. This suggests that coastal and marine assets are currently under pressure from poor water quality. Results of modelled current conditions for the GBR and associated coastal and marine assets in the Keppel Bay (5) are summarised further in Appendix 2.

MONITORED EXCEEDANCE OF LOCAL WATER QUALITY TRIGGER VALUES FOR COASTAL AND MARINE ASSETS

Monitoring of the Keppel Bay by the Australian Institute of Marine Science (AIMS) during the 2008 floods found:

- a contaminant gradient across the bay;
- that high turbidity started in late December;
- that high chlorophyll was present during the flood; and
- nitrogen, phosphorus, carbon, chlorophyll and suspended sediments were all 2 to 6 times above the long-term average (76).

AIMS conduct a long term monitoring program with automated monitoring of chlorophyll and turbidity at Pelican Island, Humpy Island (Figure 29) and Barren Island.

GBR ASSET, PRESSURES AND STATE

Table 20 The percent of time (measured in days) Chlorophyll and Turbidity were above GBRMPA guideline trigger values at three sites across Keppel Bay during 2007/08 (AIMs).

Location	% of time above GBRMPA Guideline – Chlorophyll	% of time above GBRMPA Guideline - Turbidity
Pelican Island wet season	55%	49%
Pelican Island dry season	44%	16%
Humpy Island wet season	35%	2%
Humpy Island dry season	38%	1%
Barren Island wet season	36%	0%
Barren Island dry season	34%	0%

This monitoring confirms that annual average water quality is above GBRMPA Guideline Trigger Values for extended periods of time (76) (Table 20). Monitoring data supports the modelled findings that coastal and marine assets are subject to unsatisfactory water quality for extended periods of time.

Results from both long-term monitoring and receiving waters modelling provide clear evidence that current contaminant concentrations are exceeding trigger values for coastal and marine assets in Keppel Bay and the Southern GBR. GBR assets are being placed at risk from poor water quality. Although a 1 in 10 year flood wet season results in local water quality trigger values being exceeded for more water quality variables and for longer periods of time, assets continue to be placed at risk throughout the dry season. Even in years with smaller flows, local water quality trigger values for sediment and nutrients are exceeded for extended periods of time. Coastal and marine assets within the Fitzroy Basin's influence continue to be threatened from elevated sediment and nutrient contaminants. Actions that reduce these elevated levels of sediments and nutrients are being implemented across the basin to minimise risk to the GBR. These actions must continue to be implemented to halt the decline in water quality throughout the Fitzroy Basin and across the Southern GBR. Actions outlined in the report are designed to provide the required management response.

RESPONSE

IMPLEMENTATION PLAN AND OUTCOME STATEMENT

A Fitzroy Basin Implementation Plan is proposed to better respond to and understand pressures placed on the Land, Water and GBR assets as outlined in the previous section. Outcomes and actions have been separated into Land, Water and GBR assets to allow seamless considered inclusion into the *CQSS2* as new targets and actions. Outcomes are separated into long term (50yr), intermediate term (10-20yr), and short term (5-10yr) timelines. Actions (1-5yr) are separated into four key areas: on-ground actions; sharing knowledge; building knowledge and planning, governance and partnerships.

Although formal agreement has not been negotiated potential implementers who may play leading and supporting roles in action implementation are proposed. It is likely that those implementing actions will differ from those proposed and naming of implementers does not infer responsibility but acknowledges the expertise possessed.

Many on-ground actions are implemented through the Neighbourhood Catchments Program. Detailed information relating to the Neighbourhood Catchments Program is provided below, including information on recommended BMP and prioritisation.

Short term and intermediate outcomes have been developed using best available knowledge to address pressures on assets.

SHORT TERM OUTCOMES (2014)

Short term outcomes have been developed to provide five year goals that are quantified, realistic, financially costed and measurable. These outcomes also articulate the likely response in water and GBR assets which are directly linked to uptake of BMP over the land asset.

Short term outcomes for land assets have been developed by:

- Fine tuning current BMP implemented through the Neighbourhood Catchments Program (Table 26).
- Doubling past yearly regional effort for BMP applicable to WQ improvement to meet the Caring for our Country National Outcome Statement to 'reduce the discharge of sediment and nutrients from agricultural lands to the Great Barrier Reef lagoon by 10 per cent' (Table 31)
- Using these figures to calculate area for BMP uptake likely after 5 years (Table 31). These figures are outlined in on-ground actions
- Totalling these figures to inform target MA1

Short term outcomes for water assets have been developed by:

- Determining the resource condition improvement for each BMP outlined in the land asset section (above).
- Multiplying the area implementing BMP from 2008-2013 by its resource condition improvement using the Fitzroy SedNet Model.
- Using SedNet model to calculate the long term annual average sediment, nitrogen and phosphorus reductions for the Fitzroy Basin receiving waters (Rockhampton at the barrage)
- Further details can be found in the report 'Enhanced sediment and nutrient modelling and target setting in the Fitzroy Basin' (4).

Short term outcomes for GBR assets have been developed by:

- Using sediment, nitrogen and phosphorus reductions figures outlined in the short term outcomes for water assets (above) as an input to the CSIRO Fitzroy Receiving Waters Model
- Using the CSIRO Fitzroy Receiving Waters Model to calculate the sediment, nitrogen and phosphorus export from the model domain (Figure 28) to GBR assets beyond the model domain (including the Keppel and Capricorn-Bunker Group of islands).
- Using the CSIRO Fitzroy Receiving Waters Model to determine the improvement in suspended sediment and nitrogen concentrations at the AIMs marine monitoring site at Pelican Island.

Further details can be found in the report 'Simulating the response of Keppel Bay coastal waters to potential changes in sediment and nutrient loads ' (5).

INTERMEDIATE OUTCOMES (2030)

Intermediate outcomes have been developed to indicate the extent of potential improvement from 100% BMP adoption across the Fitzroy Basin. Social and economic costs have not been accounted for and this is likely to result in outcomes not being fully realised. However, they provide an indication of the potential improvement in land management and subsequent water quality and GBR asset improvement within the boundaries of current land use and available BMP technologies.

Intermediate outcomes for land assets have been developed by modelling the results of:

- Improving ground cover for grazing lands to 'A' condition. This corresponds to a mean cover of approximately 80%. The feasibility of this assumption was assessed using a soil water balance – pasture growth model (GRASP) for

RESPONSE

a series of land types and GCI was assessed for paddocks known to be in consistently good condition (4). It is acknowledged that this may be too high for some of the poorer land types in the basin and as such is an area for target refinement.

- Reducing gully erosion by 25% to simulate impacts of improved land management
- Improving riparian condition along all streams

Intermediate outcomes for water assets have been developed by:

- Applying land improvements outlined above using the Fitzroy SedNet Model.
- Using the SedNet model to calculate the long term annual average sediment, nitrogen and phosphorus reductions for the Fitzroy Basin receiving waters (Rockhampton at the barrage) resulting from these improvements
- Further details can be found in the report 'Enhanced sediment and nutrient modelling and target setting in the Fitzroy Basin' (4).

Intermediate outcomes for GBR assets have been developed by:

- Using sediment, nitrogen and phosphorus reductions figures outlined in the intermediate outcomes for water assets (above) as an input to the CSIRO Fitzroy Receiving Waters Model
- Using the CSIRO Fitzroy Receiving Waters Model to calculate the sediment, nitrogen and phosphorus export from the model domain (Figure 28) to GBR assets beyond the model domain (including the Keppel and Capricorn-Bunker Group of islands).
- Using the CSIRO Fitzroy Receiving Waters Model to determine the improvement in suspended sediment and nitrogen concentrations at the AIMs marine monitoring site at Pelican Island

Further details can be found in the report 'Simulating the response of Keppel Bay coastal waters to potential changes in sediment and nutrient loads' (5).

Legend for Table 21, Table 22 and Table 23

Ind (Agricultural Industry) – A = All, G = Grazing, DLC = Dryland Cropping, IC = Irrigated Cropping, H = Horticulture

Potential implementer (this is a list of potential organisations. Naming of an implementer does not assume any responsibility of the organisation)

LH = Landholders, FBA = Fitzroy Basin Association, Ind = Industry, Agf = Agforce, DPI&F = Department of Primary Industries and Fisheries (Qld), Cons = Consultants, CQFA = Central Queensland Forestry Association, CA = Cotton Australia, GC = Growcom, QDO = Queensland Dairyfarmers Organisation, QCCCE = Queensland Climate Change Centre for Excellence, MLA = Meat and Livestock Australia, CSIRO = Commonwealth Scientific Industrial and Research Organisation, NRW = Department of Natural Resources and Water, R&D = Research and Development corporations, ABS = Australian Bureau of Statistics, EPA = Environmental Protection Agency, RRC = Rockhampton Regional Council, RC = Regional Councils, SD = State Development, QG = Queensland Government, AG = Australian Government, GBRMPA = Great Barrier Reef Marine Park Authority.

LAND

Table 21 Response and outcomes statement for the land asset

Outcome	
Long Term Outcome	
	By 2050 management of the region's land resources is ecologically, socially and economically integrated, sustainable and able to support a diverse range of uses
Intermediate Outcome	
RC1B	By 2030 grazing lands are A or B condition with a minimum end of dry season cover of 50% in western* catchments and 65% in eastern* catchments[2]

RC2B	By 2030 25% of gullies are stabilised			
RC3B	By 2030 riparian zones are in good condition#			
RC4B	By 2030 cropping lands are in good condition with a minimum cover of 50%[1]			
RC5B	By 2030 fertilizer and agrochemical application reflects best management			
Short Term Outcome				
MA1B	By 2014 managers of 30% of all land have implemented practices to improve regional land assets and reduce contaminants entering the GBR through implementation of A1B - A30B			
Performance Indicators				
	Ha land under BMP recorded and resultant contaminant delivery reduction assigned for each BMP An upward trend in long term average ground cover and riparian condition Ha managed through FMS			
On ground	**Action**	**BMP**	**Ind**	**Potential Implementers**
A1B	Develop PMPs, FMS and whole of system approaches with land managers to achieve MA1B	Property Management Plans	A	LH FBA Ind
A2B	Encourage optimal pasture utilisation rates to improve condition of land with chronic low ground cover, susceptible land types and gullies, to improve water quality and achieve MA1B	Managing land types and grazing pressure	G	LH FBA Agf DPI
A3B	Manage stock on floodplains and wetlands to improve ground cover, increase filtering capacity and minimise bank slumping to achieve MA1B	Managing riparian and wetland areas	G	LH FBA Agf DPI&F
A4B	Actively manage native forestry on private lands to improve cover and carbon sequestration to achieve MA1B	Farm Forestry	G	LH CQFA DPI Agf FBA
A5B	Manage stock access to increase ground cover and native flora and fauna numbers in remnant vegetation to achieve MA1B	Managing for Biodiversity	G	LH FBA Agf DPI
A6B	Improve grazing management to increase ground cover on land prone to salinity to achieve MA1B	Salinity	G	LH FBA Agf DPI
A7B	Introduce use of alternative methods for weed and regrowth management in sensitive zones currently managed using broad acre chemicals to achieve MA1B	Fertiliser and Chemical Minimisation	G	LH FBA Agf DPI

RESPONSE

A8B	Establish base station networks enabling precision farming on cropping lands to achieve MA1B	Fertiliser and Chemical Minimisation	DLC IC H	LH Cons FBA DPI Agf CA GC
A9B	Promote adoption of improved management practices on cropping lands to reduce offsite impacts of sediments, nutrients and agrochemicals to achieve MA1B	Sustainable Cropping and Fertiliser and Chemical Minimisation	DLC IC H	LH FBA DPI Cons Agf CA GC
A10B	Establish variable rate technologies and improvements in nutrient budgeting on cropping land to achieve MA1B	Fertiliser and Chemical Minimisation	DLC IC H	LH FBA DPI Cons Agf CA GC
A11B	Promote improved spray management on cropping land contributing to A9B	Fertiliser and Chemical Minimisation	DLC IC H	LH FBA DPI Cons Agf CA GC
A12B	Increase ground cover and infiltration on cropping land using minimum or zero tillage, control traffic farming and opportunity cropping contributing to A9B	Sustainable Cropping	DLC IC	LH FBA DPI Cons Agf CA GC
A13B	Manage cropping land runoff through contour banks, constructed wetlands and contaminant traps contributing to A9B	Sustainable Cropping	DLC IC H	LH FBA DPI Cons Agf CA GC
A14B	Implement runoff management, tail water protection and fertigation on irrigated land to achieve MA1B	Water Use Efficiency and Fertiliser and Chemical Minimisation	IC H	LH FBA CA GC QDO
A15B	Deliver satellite imagery and mapping products to landholders to aid in property management decisions to achieve MA1B	Property Planning	A	FBA Cons
A16B	Improve property layout and irrigation planning to support best management practices to achieve MA1B	Property Layout and Irrigation Planning	A	FBA GC QDO Cons

Sharing Knowledge	Action	Potential Implementer
A17B	Basin wide roll out of land management extension packages to achieve MA1B	DPI Ind Cons
A18B	Strengthen and extend grazier and grower support groups for systems approaches to agricultural land management to achieve MA1B	DPI Cons

A19B	Develop and deliver pesticide BMP module for residual herbicides as required to achieve MA1B	Ind DPI FBA
A20B	Develop and implement drought management package to help landholders adapt to climate variability and the effects of climate change to achieve MA1B	FBA DPI QCCCE
A21B	Develop or refine and deliver Farm Management Systems for beef, grains, cotton, horticulture and dairy industries that include modules to minimise water quality contamination to achieve MA1B	Agf CA DPI/MLA QDO GC
Building Knowledge	**Action**	**Potential implementer**
A22B	Update mapping data for land use, ground cover, riparian condition, and land condition to measure progress of MA1B	NRW DPI CSIRO
A23B	Improve understanding of interrelationships between economic, social and environmental aspects of grazing management enabling an integrated approach to achieve MA1B	R&D
A24B	Assess land condition of cropped and forested areas across the basin to measure MA1B	DPI NRW
A25B	Refine knowledge of contaminant generation rates across the basin to identify 'hotspots' for targeted action to support achievement of MA1B	R&D
A26B	Quantify and review adoption rates of land management practices that impact upon water quality to measure MA1	NRW ABS FBA Ind
A27B	Improve resolution of soil type mapping to enhance property scale planning and management to achieve MA1B	R&D
A28B	Refine fertiliser application guidelines for different land types across the basin to achieve MA1B	R&D
A29B	Develop and implement technologies to better understand and improve grazing management practices to achieve MA1B	R&D
Planning, Governance And Partnerships	**Action**	**Potential implementer**
A30B	Refine selection of Priority Neighbourhood Catchments using updated knowledge to achieve MA1B	FBA

* Eastern Catchments = Fitzroy, Isaac, Connors, Dawson. Western Catchments = Nogoa, Theresa, Comet, Mackenzie. Isohyets should be considered in lieu of catchments in the future.

Good condition riparian zones are described by regional EPA as having vegetation either side of the waterway at 50m (1st and 2nd order streams), 100m (3rd and 4th order streams) and 200m (=or>5th order streams).

1 From cropping cover in Figure 8

2 Improving ground cover for grazing lands to A condition. This corresponded to a mean cover of approximately 80%. The feasibility of this assumption was assessed using a soil water balance – pasture growth model (GRASP) for a series of land types and GCI was assessed for paddocks known to be in consistently good condition (4). This figure has been reduced from 80%.given that the target refers to minimum dry season cover and not average dry season cover.

RESPONSE

WATER

Table 22 Response and outcome statement for the water asset

OUTCOME	
Long Term Outcome	
	By 2050, the region's waterways sustain marine and freshwater resources with no net decline and, where required, an improvement in regional river health and water quality
Intermediate Outcome	
RC6B	By 2030 estuarine aquatic ecosystems maintained and improving with a 44% reduction in sediment; 33% reduction in nitrogen; and 39% reduction in phosphorus loads achieved through implementation of RC1B – RC5B
RC7B	By 2030 freshwater aquatic ecosystems maintained and improving with a 67% reduction for sediment; 63% reduction for nitrogen; and 67% reduction for phosphorus achieved through implementation of RC1B – RC5B
RC8B	By 2030 there is a measurable reduction of atrazine and tebuthiuron in waterways entering receiving waters achieved through implementation of RC1B – RC5B
Short Term Outcome	
MA2B	By 2014 long term average annual sediment load reaching receiving waters reduced by 10.9% achieved through implementation of MA1B
MA3B	By 2014 long term average annual nitrogen load reaching receiving waters reduced by 7.5% achieved through implementation of MA1B
MA4B	By 2014 long term average annual phosphorus load reaching receiving waters reduced by 5% achieved through implementation of MA1B
MA5B	By 2014 agrochemical load reduction targets are set
PERFORMANCE INDICATORS	
Predicted contaminant reduction (tonnes and %) quantified using catchment model scenarios based on Ha of land under BMP and resultant contaminant delivery ratio reduction for each BMP Basin scale monitoring results corrected for seasonal variability and contaminant residence times	

	ACTION	POTENTIAL IMPLEMENTER
On-ground		
A31B	Remove barriers to fish migration in the Fitzroy Basin identified in the regional fish barrier prioritisation report	FBA DPI
A32B	Improve quality of water discharged from sewage treatment plant at Rockhampton to improve dry season water quality in the Fitzroy River estuary	RRC
Sharing Knowledge		
A33B	Develop pesticide risk assessment map and delivery ratios for the Fitzroy Basin focussing on atrazine and tebuthiuron	FBA R&D

Building Knowledge		
A34B	Determine cumulative contaminant loads from existing and future point sources of pollution	EPA NRW
A35B	Determine cumulative contaminant loads from existing and future urban areas	RC SD NRW
A36B	Set water quality objectives for inland waterways of the Fitzroy Basin	EPA FBA
A37B	Refine water quality monitoring and modelling to allow for improved prioritisation of Neighbourhood Catchments	NRW
A38B	Refine contaminant delivery ratios for land uses across the Fitzroy with catchment, sub-basin and basin scale water monitoring and modelling	NRW
A39B	Quantify floodplain deposition processes throughout the Fitzroy Basin	R&D
A40B	Refine local water quality trigger values and water body boundaries	GBRMPA EPA FBA
Planning, governance and partnerships		
A41B	Develop policy responses to manage cumulative water quality impacts of regulated land uses with particular emphasis on point source discharges to natural waters	DPC EPA NRW FBA
A42B	Define water quality objectives and environmental values for the Fitzroy Basin	EPA FBA
A43B	Collect and analyse information to quantify the cumulative impacts of regulated activities on water quality	EPA

GREAT BARRIER REEF

Table 23 Response and outcome statement for the GBR asset

OUTCOME	
Long Term Outcome	
	By 2050 the regions reef assets suffer no net decline in current condition
Intermediate outcome	
RC8B	By 2020 length of exposure to detrimental water quality contaminant levels for reef assets reduced up to 90%[1] achieved through implementation of RC1B – RC5B
RC9B	By 2014 reef assets at Pelican Island experiencing high flow year peak wet season suspended sediment concentrations of 18.7mg/L and dissolved nitrogen concentrations of 317 µg/L compared to current conditions of 19.6mg/L for suspended sediment and 299 µg/L for dissolved nitrogen achieved through implementation of MA1B*
RC10B	By 2030 annual TSS exported from Keppel Bay[2] is reduced by 140kt in median flow years and 500kt in high flow years achieved through implementation of RC1B – RC5B
RC11B	By 2030 annual Nitrogen exported from Keppel Bay[2] is reduced by 120t in median flow years and 630t in high flow years achieved through implementation of RC1B – RC5B
RC12B	By 2030 annual Phosphorus exported from Keppel Bay[2] is reduced by 60t in median flow years and 210t in high flow years achieved through implementation of RC1B – RC5B

RESPONSE

Short Term Outcome		
MA6B	By 2014 reef assets at GBRMPA monitoring site near Pelican Island experiencing high flow year peak wet season suspended sediment concentrations of 13mg/L and dissolved nitrogen concentrations of 226µg/L compared to current conditions of 19.6mg/L for suspended sediment and 317µg/L for dissolved nitrogen achieved through implementation of RC1B – RC5B*	
MA7B	By 2014 annual Sediment exported from Keppel Bay[2] is reduced by 28kt in median flow years and 112kt in high flow years achieved through implementation of MA1B	
MA8B	By 2014 annual Nitrogen exported from Keppel Bay[2] is reduced by 900t in median flow years and 2400t in high flow years achieved through implementation of MA1B	
MA9B	By 2014 annual Phosphorus exported from Keppel Bay[2] is reduced by 160t in median flow years and 880t in high flow years achieved through implementation of MA1B	
Performance Indicators		
Predicted contaminant and exposure reduction (tonnes and time) quantified using Fitzroy Receiving Waters Model and inputs from catchment model scenarios based on Ha of land under BMP and resultant contaminant delivery ratio reduction for each BMP Sediment and chlorophyll data monitored by AIMS (commissioned by GBRMPA) at Pelican Island corrected for seasonal variability and contaminant residence times		
	ACTION	**POTENTIAL IMPLEMENTER**
Sharing knowledge		
A44B	Analyse, synthesise and present monitoring and modelling data for State of the Basin report	FBA R&D
Building Knowledge		
A45B	Strengthen and align monitoring and modelling program to support State of the Basin reporting	FBA QG AG R&D
A46B	Refine Fitzroy Receiving Waters Model to extend across the floodplain and into the southern Great Barrier Reef and to account for ecosystem health and agrochemical contaminants	R&D
A47B	Comprehensively map reef communities within the Fitzroy Basin's influence	R&D
A48B	Research impacts of tebuthiuron on Great Barrier Reef assets to refine GBRMPA low reliability trigger value for 99% ecosystem protection	GBRMPA R&D
Planning, governance and partnerships		
A49B	Establish governance and institutional arrangements for State of the Basin reporting	FBA All
A50B	Undertake regional consultation to review targets and actions in the Fitzroy Basin Water Quality Improvement Report for inclusion in the CQSS2	FBA
A51B	Develop a water quality improvement plan for coastal catchments of the FBA NRM region including Boyne, Calliope, Waterpark and Styx/Herbert Catchments	AG EPA FBA
A52B	Develop policy responses and targets that address pressures from land use intensification across the basin	QG AG FBA

1 Modelled TSS concentration in dry season for estuary water body reduced by 30% which resulted in a 90% reduction in the time trigger values for TSS were exceeded .

2 Keppel Bay in this case refers to the area outside of the CSIRO Fitzroy Receiving Waters Model domain (Figure 28).

* Figures modelled using CSIRO Fitzroy Receiving Waters Model. TSS correlates well with Turbidity. The turbidity sensor deployed at Pelican Island may be used to monitor TSS response. Dissolved Inorganic Nitrogen (DIN) is a component of dissolved nitrogen and has been directly linked to phytoplankton production. According to the models of Wooldridge et al. (2006) (77) a 5% reduction in DIN may deliver 3-20% reduction in chlorophyll a dependent on the DIN concentration already present. The chlorophyll sensor deployed at Pelican Island may be used to monitor dissolved nitrogen response

NEIGHBOURHOOD CATCHMENTS

THE DELIVERY APPROACH

One of the primary organisational focuses for FBA is the facilitated improvement of grazing and farming management practices on land to reduce sediment, nutrient and chemicals lost to waterways and the GBR. This is achieved through an integrated whole of Sustainable Production System approach - The Fitzroy Basin Neighbourhood Catchment Action Program (NC) (78). FBA uses the NC approach for engagement and investment to deliver short, medium, and long term outcomes and to ensure far-reaching legacy of investment. This approach has been evaluated by independent consultants on several occasions, with the most recent evaluation finding the approach to be successful in reaching short and medium term objectives and also finding evidence that long term objectives are likely to be reached. This evaluation found that using this approach as a basis for engagement and investment has led to resource managers improving Knowledge, Attitudes, Skills, Aspirations, and Practices (KASAP) (79).

The evaluation found the approach to be very effective in changing attitudes and actions of landholders with respect to the natural resource base of production systems. Further it found that participants became influential among their peers in becoming local champions and sources of information and knowledge regarding natural resource management, and concluded that change in condition of resources managed by participants is a valid assumption (79).

Experience and formal evaluation demonstrate that large percentages of the grazing community are not engaged through open calls for projects. Far higher rates of engagement can be achieved through active targeting of areas which develops a critical mass of interest and activity resulting in peer group support and pressure. This results in a greater impact, both in terms of biophysical and socio-cultural outcomes.

With this in mind, the NC approach works intensively in selected hotspot catchments to develop trust and strong relationships between landholders and field staff. This approach increases effectiveness and maximises the impact of neighbours working together. In a large catchment, like the Fitzroy Basin, landscape scale change is measurably achievable using this approach. The prioritisation of catchments results in areas of greatest need according to agreed criteria receiving the greatest effort. These criteria can be refined using new knowledge and tailored according to priorities of any given investment program to provide the best return on investment for a range of outcomes.

PRIORITISATION

Prioritisation of NCs involves multi-criteria analysis using a number of biophysical criteria combined with knowledge

Table 24 Information developed for Priority NC selection (81).

Regional Data Layer	Type of Data Layer	Relevance to water quality and the GBR
Biodiversity	Asset	Remnant vegetation is targeted for protection. The on-ground actions aim to reduce grazing pressure in these areas. This improves cover and reduces gullies
Riparian Assets	Asset	Riparian zones greater than 3rd order and natural wetlands are targeted for protection. On-ground activities aim to reduce grazing pressure. This minimise bank erosion, increases cover, improves sediment and nutrient filtering capacity
Coastal Assets	Asset	A condition rating based on Estuaries, Mangroves, Marine Mammals, Seagrasses Reefs and Seagrasses. Used to aid selection of NCs bordering the Coast
Salinity Risk	Pressure	Salinity scalds on grazing and grazing lands are targeted for remediation. Scalds have extremely low cover and are a high erosion risk
Erosion	Pressure	NCs with disproportionately high sediment and nutrient delivery ratios score highly. uses the SedNet Catchment Model
Weeds	Pressure	Very limited relevance
Cultural Heritage	Engagement	In some cases, areas protected under cultural heritage projects exclude grazing which improves ground cover

These regional data layers were used to score and rank each NC. This ranking was then reviewed by a local expert panel in each subregion and Priority Neighbourhood Catchments (PNC) were selected for targeted activity and engagement. This local expert panel allocated PNCs for targeted activity in the 2008/09 financial year as well as highlighting those beyond 2009 (Figure 30).

RESPONSE

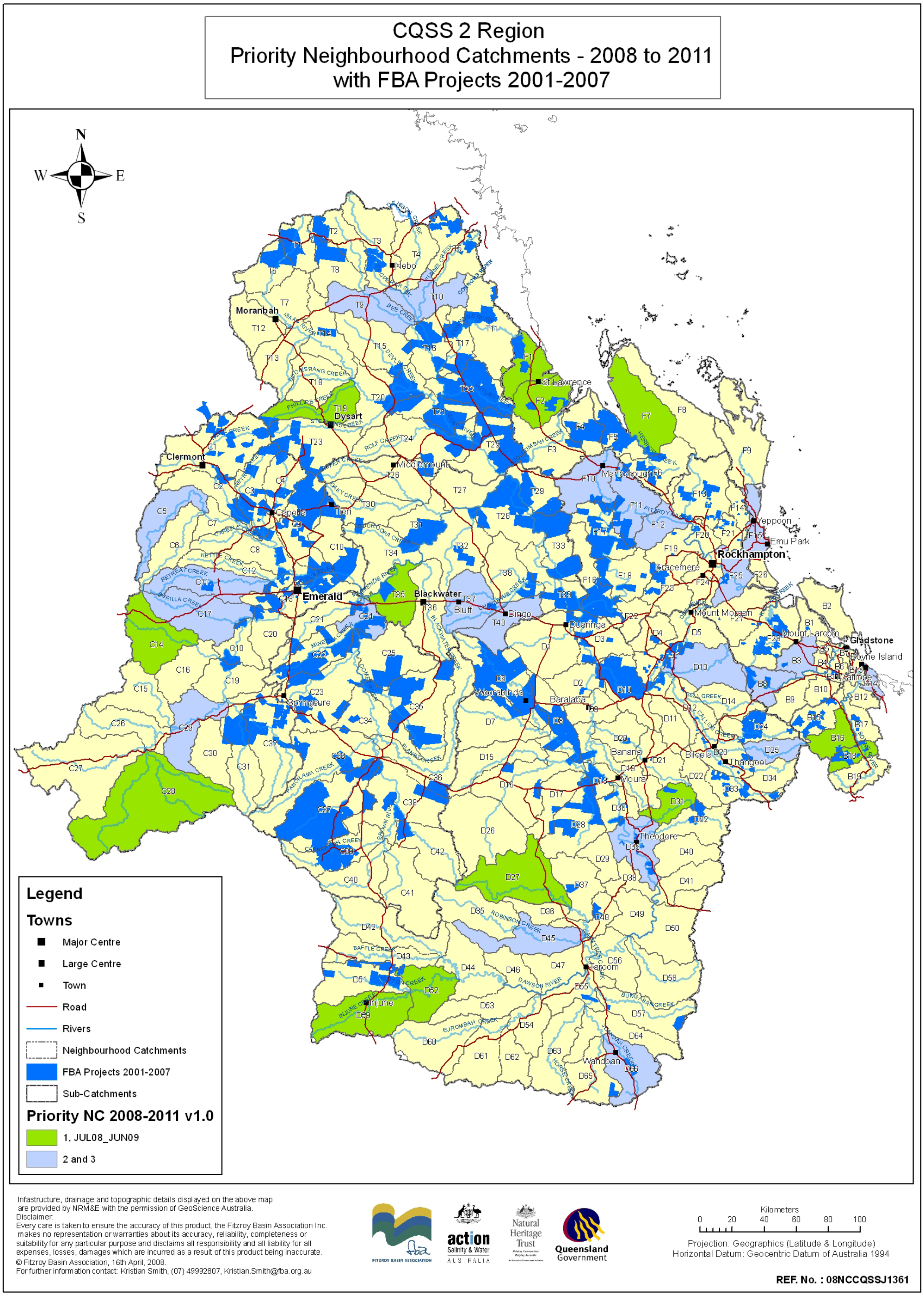


Figure 30 Priority Neighbourhood Catchments selected for the period 2008 to 2011. Those that will be worked in first are shown in green and those for the remaining two years in light blue. Properties on which FBA has undertaken projects in the past are also shown (81)

and interpretation from an expert panel made up of people with experiential knowledge, conventional scientific knowledge, and Indigenous knowledge. Many resource assessment study findings are applied in the process, providing datasets for analysis.

Once criteria have been set, datasets to quantify or qualify the criteria are incorporated into a GIS to rank catchments according to the criteria. These datasets are constantly being refined as new knowledge is gathered and made available for such use. The process is then subject to an expert panel for interpretation and to incorporate local knowledge. The process is endlessly variable depending on the purpose of the prioritisation (79).

The FBA NRM region covers over 150 000km^2. The region has been separated into over 200 NCs. Each NC ranges in size from 500 km^2 (similar to Mossman River Catchment (80) in Cairns) to 2000 km^2 (similar to Pioneer River Catchment in Mackay and Ross River Catchment in Townsville (80)) and enables targeted engagement and action in hotspot catchments. This ensures funds are invested into the region to deliver the best outcome for every dollar invested.

This targeting of hotspot catchments is known as NC Prioritisation and was first conducted in the FBA in 2004. Prioritisation occurs yearly to ensure the best available knowledge is used to make decisions and also to enable a swift realignment between regional outcomes and outcomes desired by federal and state initiatives such as Caring for Our Country.

NEIGHBOURHOOD CATCHMENT PRIORITISATION 2008

The most recent prioritisation occurred early in 2008 (81). Given that the *CQSS2* is an asset and pressure based planning document the best available NRM information representing these assets and pressures (and engagement for cultural heritage) were used in selection. This process is designed to be holistic in its approach to NRM assets, however most of the data layers used (Table 24) are relevant to WQ and the GBR.

NEIGHBOURHOOD CATCHMENT PRIORITISATION 2009 AND BEYOND

Even though prioritisation early in 2008 was robust and included many relevant assets and pressures related to water quality and GBR assets, the FBA acts under an ethos of continuous improvement and this prioritisation can be strengthened using the best available knowledge. For this reason a review of selected PNCs is scheduled for 2009. This review will account for new information from research and will also align with recently released outcomes from several funding initiatives. PNCs previously selected for targeted action between July 2009 and June 2011 (Figure 30) may be altered in accordance with new information received.

The outcome statement for Caring for Our Country has recently been released resulting in a shift in desired outcomes. These new outcomes have been considered in this report. Preparation of this report has resulted in new knowledge coming to hand of pressures placed on our GBR, Water and Land assets. These new data sources will improve our ability to target hotspot catchments. This new knowledge will be incorporated and considered in the PNC review scheduled for 2009 to ensure national and state outcomes align with regional aspirations and targets. Land based pressures are identified in Table 25 including the related water quality contaminants and BMPs that are required to reduce each pressure. BMPs highlighted in Table 25 are described in further detail in Table 26.

Table 25 New knowledge for inclusion in PNC review 2009

Data Layer (Pressures)	Water Quality contaminant targeted	Why is it relevant to poor Water Quality?	Relevant BMP to address pressure. Primary BMP/s underlined
Grazing Land use - C and D condition land/ low cover	Sediment and Nutrients	C and D condition grazing lands deliver disproportionately high ratios of sediments and nutrients.	On-ground: PMPs; <u>Managing land types and grazing pressure</u>; Farm Forestry Management Planning: Property Planning; PMPs; Industry FMS; Property Layout Planning Extension: Systems Approaches; Training; Workshops and Field Days
Grazing Land use – gully map – high gully density	Sediments and Nutrients	Gullies deliver 26% of total sediment loads to the receiving waters. Land under grazing with high gully density pose greater potential risk	On-ground: PMPs; <u>Managing land types and grazing pressure</u>; Managing for biodiversity; Farm Forestry Management Planning: Property Planning; PMPs; Industry FMS; Property Layout Planning Extension: Systems Approaches; Training; Workshops and Field Days

RESPONSE

Data Layer (Pressures)	Water Quality contaminant targeted	Why is it relevant to poor Water Quality?	Relevant BMP to address pressure. Primary BMP/s underlined
Grazing Land use – land types susceptible to low cover in drought	Sediment and Nutrients	Certain land types are less resilient to grazing pressure in times of drought. If cover is not maintained during drought, it takes cover levels longer to respond once the drought breaks. This results in higher potential erosion	On-ground: PMPs; Managing land types and grazing pressure; Farm Forestry Management Planning: Property Planning; PMPs; Industry FMS; Property Layout Planning Extension: Systems Approaches; Training; Workshops and Field Days
Grazing Land use Riparian zones 3rd order and above	Sediment and Nutrients	Bank erosion accounts for 7% total sediment and associated nutrient loads delivered to the receiving waters. Riparian zones in poor condition have higher bank erosion, low cover, and decreased sediment and nutrient filtering capacity	On-ground: PMPs; Managing for riparian and wetland areas Planning: Property Planning; PMPs; Industry FMS; Property Layout Planning Extension: Systems Approaches; Training; Workshops and Field Days
Grazing Land use Natural Wetlands	Sediment and Nutrients	Natural wetlands (not farm dams) connect with the river when in flood and if in poor condition do not provide the high filtering and contaminant trapping capacity that wetlands in good conditions do	On-ground: PMPs; Managing for riparian and wetland areas Planning: Property Planning; PMPs; Industry FMS; Property Layout Planning Extension: Systems Approaches; Training; Workshops and Field Days
Grazing and Cropping Land uses - Thompson Fold Belt Geology	Sediment and nutrients	Studies of sediments distributed in Keppel Bay and the Fitzroy River Estuary indicate disproportionally high levels of sediments occurring from this geology	On-ground actions: PMPs; Sustainable cropping; Salinity; Indigenous cultural heritage; Managing land types and grazing pressure; Managing for riparian and wetland areas; Managing for biodiversity; Farm Forestry Management Planning: Property Planning; PMPs; Industry FMS; Property Layout Planning Extension: Systems Approaches; Training; Workshops and Field Days
Grazing and Cropping Land types - High Salinity Risk	Sediment and nutrients	Areas with high salinity risk are prone to scalding associated with salinity resulting in low cover and increased erosion	On-ground actions: Sustainable cropping; Salinity; Water use efficiency ; Farm Forestry Management Planning: Property Planning; PMPs; Industry FMS; Property Layout Planning; Irrigation Planning Extension: Systems Approaches; Training; Workshops and Field Days

RESPONSE

Data Layer (Pressures)	Water Quality contaminant targeted	Why is it relevant to poor Water Quality?	Relevant BMP to address pressure. Primary BMP/s underlined
Cropping Land use – Low Cover	Sediment and nutrients	Cropping enterprises not employing minimum/ZT regimes usually have low cover values for longer periods of the year	On-ground actions: PMPs; Sustainable cropping Planning: Property Planning; PMPs; Industry FMS; Property Layout Planning Extension: Systems Approaches; Training; Workshops and Field Days
Dryland Cropping Land use	Agrochemicals (atrazine)	Atrazine is used extensively in dryland cropping enterprises and goes hand in hand with better tillage practices that reduce sediment and nutrient loads. However, EMC values for atrazine have been detected at the basin scale at levels above GBRMPA guideline values	On-ground actions: Sustainable cropping; Fertiliser and Chemical Minimisation Planning: Property Planning; PMPs; Industry FMS; Property Layout Planning; Irrigation Planning Extension: Systems Approaches; Training; Workshops and Field Days
Grazing land use - floodplain related non-remnant woodlands	Agrochemicals (tebuthiuron)	Tebuthiuron is a cost effective control for woody weeds. However, EMC values for tebuthiuron have been detected at the basin scale at levels above GBRMPA guideline values. The risk of tebuthiuron entering waterways increases the closer it is applied to waterways. Floodplains cleared of woodlands pose the greatest potential risk	On-ground actions: Fertiliser and Chemical Minimisation; Managing for riparian and wetland areas; Farm Forestry Management Planning; Property Planning; PMPs; Industry FMS; Property Layout Planning Extension: Systems Approaches; Training; Workshops and Field Days
Irrigated Cropping (includes Cotton)	Nutrients	Fertiliser application rates are greater on irrigated cropping land uses. As such this land use poses greater potential risk from fertiliser loss	On-ground actions: PMPs; Water use efficiency; Fertiliser and Chemical Minimisation Planning: Property Planning; PMPs: Industry FMS; Property Layout Planning; Irrigation Planning Extension: Systems Approaches; Training; Workshops and Field Days
Dairies and Feedlots	Nutrients	Dairies and Feedlots pose greater potential risk in nutrients lost from effluent and fertilisers used on irrigated pastures (dairy)	On-ground actions; PMPs; Water use efficiency ; Fertiliser and Chemical Minimisation Planning; Property Planning; PMPs; Industry FMS; Property Layout Planning; Irrigation Planning Extension; Systems Approaches; Training; Workshops

RESPONSE

BEST MANAGEMENT PRACTICES

A range of strategies have been developed and are used to deliver change. These can be loosely grouped under the following areas: planning; incentives and extension (78) and are outlined in Table 26.

BMP – what's in a name?
Whilst preparing this report various discussions occurred relating to use of the term 'BMP'. To align this report with terminology currently embraced at GBR scale, BMP has been used in this report as it refers to 'improved management practice' and not an industry based FMS or BMP. This also means that some of the BMP described throughout this report is not necessarily described as the best available - rather that there is a distinct improvement in a current land management practice that in turn improves current water quality.

Table 26 BMP implemented under the FBA's Neighbourhood Catchments Program designed to reduce sediment, nutrient and chemical losses

BMP	DESCRIPTION
On-ground actions	
Property Management Plans	Prerequisite documentation to secure funds for implementation activities. Other planning and consultancy costs are also considered. Also includes support implementation of FMS and whole of system approaches.
Sustainable cropping	Retention of ground cover, nutrients and chemicals through adoption and improvement of minimum and ZT, CTF and opportunity cropping. Managing runoff through contour banks, waterways and contaminant traps.
Salinity	Fencing an existing saline exposure to allow spelling and/or to fence a known recharge area to allow spelling and revegetation
Indigenous cultural heritage	Incentives to protect sites of Indigenous cultural value.
Water use efficiency	Tail water retention and runoff management infrastructure and farm layout and design
Fertiliser Chemical Minimisation	Spray management, systems improvements, variable rate technology, nutrient budgeting and reducing overlaps in spray application reducing the amount of nutrients and/or agrochemicals entering waterways. Includes base weather stations and handheld anemometers. Irrigation planning to increase uptake of fertigation. Also includes encouragement of other woody weed control options to reduce the broad acre use of residual herbicides (e.g., tebuthiuron and atrazine) in high risk landscapes
Managing land types and grazing pressure	Management of grazing pressure using fencing and water systems for vulnerable land types, coastal zones, scalds and gullies thus reducing sediments and nutrients entering waterways. Stewardships to encourage optimal pasture utilisation rates for water quality improvement including uptake of feed budgeting and meeting end of season pasture biomass targets. Incentives and stewardships for rehabilitating C and D land condition (areas of chronic low cover, scalds and gullies) to A and B land condition

RESPONSE

BMP	DESCRIPTION
Managing for riparian and wetland areas	Managing cattle access to riparian and wetland areas. Funding will be directed to streams that perform a wide range of riparian function (riparian vegetation, stable stream bank, floodplain, waterholes). Usually this means 3rd order streams and above. This could include areas to the floodplain edge if it improves riparian condition.
Managing for biodiversity	Reduce grazing pressure to increase cover and native flora/fauna numbers in native remnant vegetation. Using stewardships and fencing and watering systems to reduce sediments and nutrients entering waterways
Farm Forestry Management	Increasing active management of native forestry on private lands to achieve triple bottom line outcomes. Investigating use of carbon off-sets and trading to promote uptake of farm forestry. Encouraging regeneration of regrowth and/or plantation where both forestry and natural resource outcomes are possible
Planning	
Property Planning	Provision of imagery to aid in property management decisions that reduce sediment, nutrient and chemical loss.
PMPs	Support for development of PMPs that include activities to reduce sediment, nutrient and chemical loss.
Industry FMS	Development and refinement of FMS's which include modules to reduce sediment, nutrient and chemical loss
Property Layout Planning	Contribution to property layout planning that supports BMP that reduce sediment, nutrient and chemical loss
Irrigation Planning	Contribution to irrigation planning that supports BMP to reduce sediment, nutrient and chemical loss
TO Property Planning	Contribution to TO Property Planning that supports BMP to reduce sediment, nutrient and chemical loss
Extension	
Systems Approaches	Development and delivery of extension activities that allow landholders to improve agricultural enterprises and reduce sediment, nutrient and chemical loss using a whole of systems approach (e.g. Grains BMP, FutureBeef, CQ Sustainable Farming Systems)
Training	Training opportunities aimed at increasing BMP adoption that reduces sediment, nutrient and chemical loss (e.g. training in mapping and planning; training in new and emerging technologies supporting sustainable practice; and industry based training)
Workshops and Field Days	Workshops and field days aimed at supporting BMP adoption that reduces sediment, nutrient and chemical loss.

RESPONSE

The individual BMPs outlined in Table 26 deliver reductions for specific contaminants. These are outlined in Table 27.

Table 27 Water quality contaminant addressed by BMP

MANAGEMENT PRACTICE	SEDIMENT	PN AND PP	DIN AND FRP	CHEMICALS
Incentives				
Property Management Plans	Primary	Primary	Primary	Primary
Sustainable cropping	Primary	Primary	Primary	Primary
Salinity	Primary	Primary	Secondary	Secondary
Indigenous cultural heritage	Primary	Primary	Secondary	Secondary
Water use efficiency	Secondary	Secondary	Primary	Primary
Reducing Fertilizer/Chemical Application			Primary	Primary
Managing for land types and grazing pressure	Primary	Primary	Secondary	Secondary
Managing riparian zones and wetlands	Primary	Primary	Secondary	
Managing for biodiversity	Primary	Primary	Secondary	
Farm Forestry Management	Primary	Primary	Secondary	
Extension				
Systems Approaches	Primary*	Primary*	Primary*	Primary*
Workshops and Field Days	Primary*	Primary*	Primary*	Primary*
Training	Primary*	Primary*	Primary*	Primary*
Planning				
Property Mapping	Primary*	Primary*	Primary*	Primary*
Industry FMS	Primary*	Primary*	Primary*	Primary*
Property Layout Planning	Primary*	Primary*	Primary*	Primary*
Irrigation Planning			Primary*	Primary*
TO Property Planning	Primary*	Primary*	Primary*	Primary*

*Outcome dependant on individual activity

POLICY PLANNING AND INSTITUTIONAL ARRANGEMENTS

POLICY PLANNING AND INSITUTIONAL ARRANGEMENTS

Achieving water quality improvement in the GBR lagoon will require the right mix of institutional arrangements, planning and regulatory frameworks and fostering of innovation and beyond best practice through incentive and assistance measures to industry, particularly agricultural industries (82). Policy planning and institutional arrangements that support outcomes identified in Table 21, Table 22 and Table 23 are outlined in this section of the report.

INSTITUTIONAL ARRANGEMENTS AND POLICY

CENTRAL QUEENSLAND STRATEGY FOR SUSTAINABILITY - 2008 AND BEYOND (CQSS2)

The FBA is a community-based organisation that promotes sustainable development in Central Queensland. FBA involves the region's major natural resource management stakeholders who have an interest in the use and management of the Fitzroy Basin and the broader Central Queensland region. In 1992 a dedicated cross-section of regional stakeholders committed to the development of a catchment strategy held the Fitzroy Catchment Symposium. Sixteen years on the collective vision of these stakeholders is a reality.

The *CQSS2* is our region's stakeholder endorsed and accredited regional Natural Resource Management plan. This plan encompasses all of our collective aspirations. Our stakeholders believe the only way to ensure our plan remains relevant is to continually fine tune its targets and actions using an adaptive management approach. Our plan and its associated targets and actions aim to improve the natural resources of this region. Achieving these goals is at harmony with state and national visions aspiring to protect the GBR. We offer our support to this vision articulated through the RWQPP (83) and Caring for our Country (84) Reef Rescue Package initiative.

Targets and actions expressed in Table 21, Table 22 and Table 23 of this report are designed to be considered for incorporation in the next iteration or review of the *CQSS2*. Usual Board, Regional Coordination Group and Stakeholder consultation processes will be required before targets and actions are incorporated.

CARING FOR OUR COUNTRY AND THE REEF RESCUE PLAN

Under the Caring for our Country Initiative the Australian Government has pledged $2.25 billion to secure strategic outcomes across six national priority areas. Investment into targets and actions identified in this report will support many Caring for our Country Outcomes. Links to Caring for our Country Outcome Statement outcomes described in Table 21, Table 22 and Table 23 of this report contribute directly to the national priority areas of coastal environments and critical aquatic habitats, sustainable farm practices and community skills, knowledge and engagement outcomes under the Caring for our Country National Outcome Statement. Five-year outcomes outlined under these national priority areas that are also addressed in this report include:

- Reduce the discharge of dissolved nutrients and chemicals from agricultural lands to the Great Barrier Reef lagoon by 25 per cent.
- Reduce the discharge of sediment and nutrients from agricultural lands to the Great Barrier Reef lagoon by 10 per cent.
- Increase the community's participation in protecting and rehabilitating coastal environments and critical aquatic habitats.
- Assist at least 30 per cent of farmers to increase their uptake of sustainable farm and land management practices that deliver improved ecosystem services.
- Increase the number of farmers who adopt stewardship, covenanting, PMPs or other arrangements to improve the environment both on-farm and off-farm.
- Improve the knowledge, skills and engagement of at least 30 per cent of land managers and farmers in managing our natural resources and the environment.
- Improve the access to knowledge and skills of urban and regional communities in managing natural resources sustainably and helping protect the environment.
- Increase the engagement and participation rates of urban and regional communities in activities to manage natural resources and to help protect the environment.
- Position all regional natural resource management organisations to deliver best-practice landscape conservation and sustainable land use planning to communities and land managers within their regions. (84)

Strategies have been outlined to achieve caring for our country five year outcomes. Table 28 outlines actions in this report that contribute to these strategies.

REEF WATER QUALITY PROTECTION PLAN

The RWQPP seeks to 'halt and reverse the decline of water quality on the Great Barrier Reef within 10 years' (83). A range of activities are designed to meet RWQPP objectives.

Table 28 Linkages between actions outlined in this report and the Caring for our Country National Outcome Statement strategies

Caring for our Country Strategy (84)	FBA's Contributing Action
In Reef catchments, provide incentives to increase the adoption of improved land management practices by at least 30 per cent of agricultural land managers.	MA1B
Protecting high conservation value areas of vegetation through stewardship arrangements	A5B
- Establishing buffer zones and strategic fencing activities such as off-stream watering points for stock management and pasture/stock monitoring - Restoring wetlands	A3B
Improving chemical use, particularly fertiliser efficiency and developing and applying alternatives to, or using herbicides more efficiently	A7B, A8B, A10B, A11B, A14B
Reducing and managing acid sulphate soils and salinity	A6B
Through training measures and providing better access to knowledge, enhance the capacity and skills of the community to undertake actions that will protect and rehabilitate coastal waterways and wetlands, prevent coastal erosion, and protect important migratory bird sites.	A17B – A21B
Improve understanding of the link between land management practices and environmental impacts	A25B, A27B, A37B, A46B, A48B
Trial new technologies or land management techniques which may improve water quality in Reef catchments, Ramsar sites and priority coastal hotspot areas	A29B
Develop and apply new water quality monitoring techniques for nutrients, chemicals and sediments.	A37B
Continue and expand the existing Reef water quality monitoring program, including through implementing a coordinated catchment-wide water quality monitoring and measurement program.	A45B
Measure improvements in the water quality of rivers and streams flowing into high conservation value aquatic ecosystems, and use this information to better target further investments.	A37B
Support on-farm actions and investments that improve natural assets (including soil, water and biodiversity) and reduce the impact of invasive species. Support the use of flexible, innovative and cost-effective approaches, including market-based incentives, to deliver sustainable on-farm natural resource management and improve our natural assets.	A1B – A16B
Support the uptake of sustainable farming techniques and technology by providing information and advice on: –new technologies, sustainable farm practices, and ecosystems services –the management of emerging threats to sustainable food and fibre production, including weeds, salinisation and pest animals.	A17B-A21B
Contribute to enduring partnerships between relevant partners and stakeholders to enhance their active engagement in natural and cultural resource management. These partnerships will aim to align plans, investments and actions, promote inter-dependence and cooperation, and leverage cross-tenure action to achieve the specific targets and outcomes sought from Caring for our Country.	A41B, A49B – A51B
Provide information sessions on new technologies and sustainable farm practices to at least 30 per cent of land managers and farmers.	A17B –A21B

POLICY PLANNING AND INSITUTIONAL ARRANGEMENTS

Table 29 Linkages between actions outlined in this report and the RWQPP.

RWQPP Strategies and actions (83)	FBA's Contributing Action
A1	A1B, A20B, A21B,
A3	A21B
A4	A1B, A17B – A21B
B1	A17B – A21B
B2	A45B, A49B
B4	A45B, A49B
C1	A1B – A16B
D4	A36B, A40B, A42B, A50B, A51B
E4	A34B, A35B, A41B, A43B
F1	A37B, A44B, A45B, A49B
F2	A1B, A17B – A21B
F3	A37B, A44B, A45B, A49B
F4	A22B – A29B
G1	A36B, A40B, A42B, A51B
G3	A37B, A45B
H1	ALL
H4	A22B, A25B, A27B, A30B, A33B, A37B, A38B, A45B,
H5	A3B, A7B
I5/I6	A37B, A44B, A45B, A49B
I8	A50B

Outcomes described in Table 21, Table 22 and Table 23 of this report contribute directly to objectives described within the RWQPP including: reducing the load of pollutants from diffuse sources in the water entering the reef; and rehabilitating and conserving areas of the reef catchments that have a role in removing water borne pollutants (83). Strategies and actions have been outlined to achieve RWQPP outcomes. Table 29 outlines actions in this report that contribute to these strategies and actions.

RWQPP in its current form only focuses on current diffuse sources of pollution and not point sources of pollution or the risks from land use intensification. There are increasing mining, industry and urban development pressures in the Fitzroy Basin. Given this fact, the goal of halting and reversing the decline of WQ on the GBR may not be possible without incorporating actions to address development pressures from point source pollution.

NUTRIENT MANAGEMENT ZONES DISCUSSION PAPER

In response to Action D8 of the RWQPP the Queensland Government lead by DPI&F has developed a discussion paper providing policy options for the management of NMZ (33). This is not yet an endorsed policy and is based on a hazard assessment, but does provide options for nutrient management zone implementation.

LEGISLATION

The legislation affecting current condition of assets relevant to this report is identified below.

GREAT BARRIER REEF MARINE PARK ACT AND QUEENSLAND MARINE PARKS ACTS

In 1975 the Australian Government gazetted the Great Barrier Reef Marine Park under the Great Barrier Reef Marine Park Act. In 1979, the Australian and Queensland Governments signed the Emerald Agreement which provided for both governments to cooperatively manage the waters, reefs and islands of the GBR. In 1982 the Queensland Government enacted the Queensland Marine Parks Act 1982 to enable complementary zoning of the marine park. Zoning plans for sections of the reef have been gazetted and reviewed by both Governments under their respective legislation. Up until the early 2000s, conservation and management of the GBR centred around managing activities within the Marine Park itself by the GBRMPA and the Queensland agency responsible for marine parks, currently the Environmental Protection Agency (82).

WATER RESOURCE PLANNING

The Water Allocation Management (Fitzroy Basin) Plan (1999) was released in December 1999. The following year the Water Act 2000 was released and the Water Allocation Management (Fitzroy Basin) Plan was transitioned to the Water Resource (Fitzroy Basin) Plan 1999 as subordinate legislation under the Water Act. The Water Resource (Fitzroy Basin) Plan 1999 is implemented through the Fitzroy Basin Resources Operations Plan that commenced in January 2004. The Department of Natural Resources and Water is the Queensland agency currently responsible for this legislation. This legislation aims to provide for the sustainable management of water including the adequate provision for natural processes that underpin river health such as e-flow. The Water Resource (Fitzroy Basin) Plan is currently nearing the end of its statutory life and a process as required under Part 3 of Chapter 2 of the Water Act 2000 has commenced to have a replacement plan finalised by September 2010. It is necessary that a full review be undertaken to build on achievements of the last 9 years and to ensure that the new plan meets the on-going expectations of the community.

THE DELBESSIE AGREEMENT (STATE RURAL LEASEHOLD LAND STRATEGY)

The Delbessie Agreement came into effect in December 2007. This agreement is likely to impact positively on the current condition of agricultural land and downstream assets. The Agreement clarifies and strengthens the State's ability to take remedial action to address land degradation including: soil erosion, salinity or scalding; destruction of soil structure, including, for example, the loss of fertility, organic matter or nutrients; decline in perennial pasture grasses, pasture composition and density; low ground cover; thickening in woody plants; stream bank instability and slumping; the presence of any declared pest; water logging; rising water tables; and a process that results in declining water quality.

The impact of this agreement to the Basin's assets has not been quantified by NRW or in this report, but there are substantial areas of leasehold land throughout the Basin and it stands to reason that if remedial actions outlined in the Agreement are implemented it will aid in meeting targets and actions expressed in this report.

ENVIRONMENTAL PROTECTION ACT (EP ACT)

The object of the EP Act is to protect Queensland's environment while allowing for development that improves total quality of life both now and in the future, in a way that maintains the ecological processes on which life depends, known as ecologically sustainable development. Mechanisms used to achieve the objective of the Act include State of the Environment Reporting, Environmental Protection Policies to enhance or protect Queensland's environment, the use of environmental authorities, known as licences, or a development approval under the Integrated Planning Act 1997 to control certain environmentally relevant activities, the creation of environmental evaluations and environmental offences, and the ability to make environmental protection orders and to require development of environmental management programs (85).

The EP Act is broad ranging and encompasses issues such as air, water, noise and other issues. In relation to water the Act is administered through the Environmental Protection (Water) Policy, 1997.

OTHER RELEVANT LEGISLATION

Other legislation relevant to this report includes but is not limited to:

- Vegetation Act 1999
- Environmental Protection and Biodiversity Conservation Act 1999
- IPA 1997
- Coastal Catchment and Management Act 1999
- Fisheries Act 1994
- Nature Conservation Act 1998
- River Improvement Trust Act 1940
- Local Government Act 1993

INFRASTRUCTURE DEVELOPMENT AND PLANNING

CENTRAL QUEENSLAND REGIONAL WATER SUPPLY STRATEGY (CQRWSS)

The Central Queensland Water Supply Strategy was released in December 2006. It highlights future shortfalls in water supply with a major focus on the Fitzroy Basin and identifies preferred supply options to satisfy needs not likely to be met with primary drivers including trends in urban and industrial growth around the Capricorn and Curtis coasts; trends in mining and associated urban growth in the Bowen Basin and northern Surat coalfields; performance of existing supply schemes in combination with dry conditions in recent years; and a call by local government to chart a cooperative approach towards the development of a long-term strategy for meeting the water needs of the region (56).

While the plan itself has no statutory basis, nevertheless if all of the growth and associated intensification of land use were implemented, there would be an impact. Supply structures in this strategy may impact on assets identified in this report.

Indirect impacts of this strategy may include the large scale land-use intensification of natural grazing and dryland cropping systems to mining, irrigated cropping, urban, intensive animal production and industry. This impact has not been quantified in the Central Queensland Water Supply Strategy and may need to be addressed in future policy.

FITZROY INDUSTRY AND INFRASTRUCTURE STUDY (FIIS)

This study was commissioned by The Queensland Government, Rockhampton City Council, Fitzroy Shire Council, Livingstone Shire Council, Rockhampton Regional Development Limited and The Stanwell Corporation and is aimed to facilitate major industry development in the Rockhampton-Fitzroy area by

POLICY

POLICY PLANNING AND INSITUTIONAL ARRANGEMENTS

planning for the infrastructure needs of strategic development opportunities. The study identified two areas in the region. The first is an industrial precinct covering 2,500 ha and the second is an agricultural corridor primarily focussing on cattle feedlots covering several thousand hectares (86). A study (87) on feedlot impact predicts a small increase in nutrient loads from current conditions. The industrial precinct development may also impact water quality.

BOWEN BASIN COAL GROWTH PROJECT

The Bowen Basin coal measures are an important economic contributor in the Fitzroy Basin. There are approximately 35 mines now operating. A further 17 mines are in various stages of planning and development. This extensive and ongoing mine development has many potential impacts on water quality and water quantity in the basin. The increasing need for process water for coal washeries may reduce freshwater flows to the sea. This effect would be most severe during drought conditions. After extremely wet conditions mine dewatering has the potential to deliver mixtures of inorganic and organic pollutants which have never been experienced before by organisms in the river systems or in the receiving waters. This is both a major knowledge gap and a potential risk which needs to be addressed in subsequent phases of the planning process.

RECOMMENDED ACTIONS

Table 30 Recommended actions to improve policy, planning and institutional arrangements in the Fitzroy Basin

Item	Action	Recommended Actions	Potential Implementer
CQSS2	A53B	Consider targets and actions outlined in this report for inclusion in the *CQSS2* by 2009	FBA
Delbessie Agreement	A54B	Quantify basin scale impact from Delbessie Agreement to regional assets	QG
CQRWSS	A55B	Consider quantifying impact from potential land-use intensification and consider preparing a policy instrument to minimise impact	QG
	A56B	Consider incorporation of new flow recruitment response data to refine e-flow objectives in Water Resource Plan.	QG
NMZ Discussion Paper	A57B	Consider endorsing NMZ policy developed along with targets, actions and implementation plan	QG, AG, Ind, RBs
	A58B	Consider updating NMZ planning with correct input data	QG,AG
FIIS	A59B	Consider development of a basin scale contaminant load reporting system for new and existing infrastructure	QG
	A60B	Consider provision of contaminant load reporting system for adjusting of contaminant load reduction targets	FBA, AG
EP Act	A61B	Consider provision of more resources to properly address and act on pressures from cumulative impacts of mining and other regulated activities	QG
	A62B	Consider developing a basin scale contaminant load reporting system for new and existing mining operation	QG, FBA
	A63B	Consider implementing offsets program to ameliorate any WQ deterioration from new mines	Ind, FBA
RWQPP	A64B	Consider the continued resourcing of initiatives supporting actions identified in RWQPP	AG, QG
	A65B	Consider updating RWQPP to account for cumulative impact of new point source pollution and include actions for point source best practices	AG, QG, Ind

POLICY PLANNING AND INSITUTIONAL ARRANGEMENTS

Item	Action	Recommended Actions	Potential Implementer
Caring for our Country	A66B	Consider investing into regional actions consistent with Caring for our Country outcomes.	AG, FBA
	A67B	Consider investing into development of Water Quality Improvement Plans for Fitzroy Basin, Curtis Coast, and Capricorn Coast	AG
	A68B	In line with A67, prepare Water Quality Improvement Plans for Fitzroy Basin, Curtis Coast and Capricorn Coast	QG, FBA
EPP Water	A69B	Consider review of existing data and if necessary implement a monitoring and reporting program capable of providing statistically robust data for the setting of EVs and WQOs at Catchment, Sub-basin, and Basin Scale for event and ambient conditions.	QG
	A70B	Consider setting of EVs and WQOs at Catchment, Sub-basin, and Basin Scale for event and ambient conditions for inclusion in the Water EPP.	QG, FBA

RETURN ON INVESTMENT

RETURN ON INVESTMENT

This return on investment statement is designed to provide potential investors with an understanding of the water quality benefit being purchased when investing in actions outlined in Table 21, Table 22 and Table 23 of this report. Figures are based on past investments to the FBA region for water quality improvement between January 2005 and July 2007. The resultant long term average annual reductions in sediment and nutrient arising from this investment have been calculated using the Fitzroy SedNet model (4). Cost estimates used in this calculation include on-ground actions and associated administration and overhead costs.

Significant productivity gains are potentially available from actions outlined in the Neighbourhood Catchments Project, hence the minimum 50% private co-contribution required by graziers and farmers. As with any business there are various options available to improve the bottom line for grazing and farming enterprises. Options that provide public benefit to the GBR may not provide the best return for investment. The public contribution is designed to act as an incentive for graziers and farmers to prioritise activities known to deliver a benefit for the GBR. The 50% minimum co-contribution provided by landholders has not been included in calculations.

INPUT DATA

In the period from January 2005 to June 2007 field officers from FBA and subregions supported landholders with the development of 456 PMPs. Development of these PMPs resulted in BMP being implemented on 500,000 ha of land along 750 km of waterways. Table 31 details these BMP and the associated areas where the BMP was implemented.

BMPs outlined in Table 31 were grouped and entered as a scenario in the SedNet catchment model. Sediment and nutrient reductions resulting from implemented BMP were estimated (4).The cost of implementing these actions in the period Jan 2005 - June 2007 (including incentives, support of PMP preparation, technical assessment, contracting,

Table 31 Summary of BMPs implemented through the Neighbourhood Catchment project (Jan05 - Jun07). This summary was used to estimate water quality improvement for use in preparation of short term outcome statements outlined in Table 21, Table 22 and Table 23 of this report.

BMP	Program 2005-07	Five Year target - 2013	Linked to action
Improve ground cover in grazing lands (management to land type) (Ha)	68 717	343 585	A2B
Improve ground cover in farming lands (minimum/zero till/ controlled traffic) (Ha)	48 739	243 695	A8B, A9B, A10B
Rehabilitation of saline lands through exclusion fencing / ground cover increase (Ha)	1824	9120	A8B, A6B
Reduce deep drainage through CTF /opportunity cropping (Ha)	63 607	318 035	A12B
Management of grazing impacts on riparian zones (km)	714	3570	A3B
Management of grazing impacts on riparian zones (Ha)	47 455	237 275	A3B
Management of grazing impacts on wetlands (Ha)	6757	23 285	A3B
Management of grazing impacts on riparian zones – off-stream water points (km)	28	140	A3B
GBR Wetlands (Ha)	2049	10 245	A3B
Management of 'Endangered' Regional Ecosystems (Ha)	5418	27 090	A5B
Management of 'Not' and 'Of Concern' Regional Ecosystems (Ha)	123 750	618 750	A5B
FBA Biodiversity Stewardship Agreement (Ha)	121 592	607 960	A5B
FBA Biodiversity Tender Agreement (Ha)	8920	44 600	A5B
Management of grazing impacts on coastal ecosystem(Ha)	1638	8190	A3B
Total	500 466 ha 742 km	2 491 830 ha 3710 km	

RETURN ON INVESTMENT

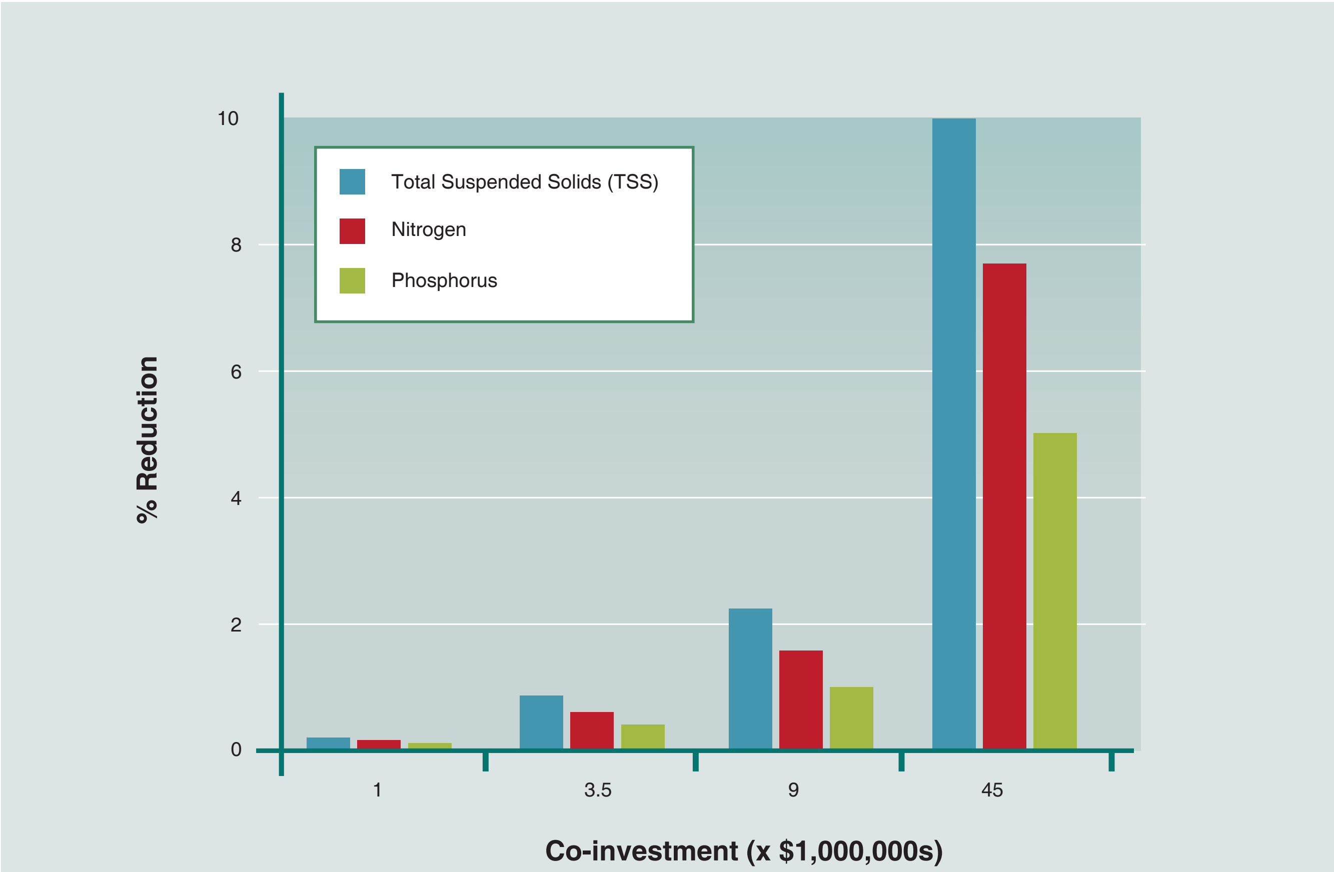


Figure 31 The estimated sediment, nitrogen and phosphorus reductions expressed in tonnes delivered to receiving waters given a particular investments to BMP implemented within the Fitzroy Basin.

Table 32 Return on investment for water quality improvement in the Fitzroy Basin region

Item	Co-contribution Implementation Cost	Load reduction estimates to receiving waters (tonnes/year)		
		TSS	N	P
FBA 2005-2007	$9 000 000	74 000	193	56
Every million	$1 000 000	8222	21	6
2014 Outcome	$45 000 000	370 000	965	280
1st yr Reef Rescue	$3 500 000	28 778	75	22
		Percent reduction from current total load		
FBA 2005-2007	$9 000 000	2.2	1.5	1.0
Every million	$1 000 000	0.24	0.17	0.11
2014 Outcome	$45 000 000	10.9	7.5	5
1st yr Reef Rescue	$3 500 000	0.84	0.58	0.39

administration and monitoring) was $9 000 000. These details provide the basis for return on investment calculations.

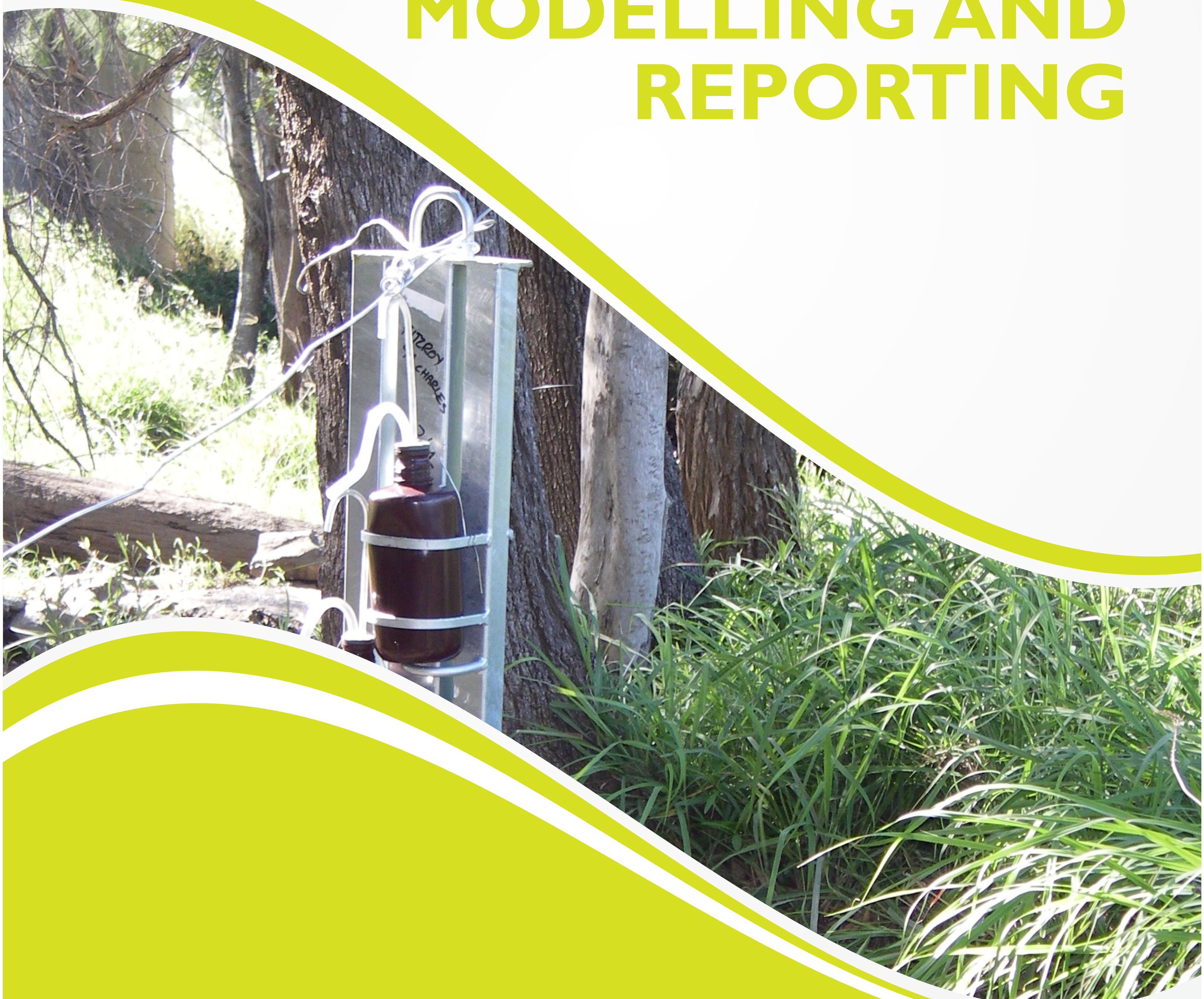
RESULTS

In summary each $1 000 000 invested by a third party to the Neighbourhood Catchments program results in a long term average annual load reduction of 8222 tonnes sediment, 21 tonnes nitrogen and 6 tonnes phosphorus. Return on investment figures have been summarised in Figure 31 and Table 32 to provide a visual appreciation of the percentage basin scale contaminant reduction given a particular co-investment. Figures relevant to Caring for our Country policy include $3.5 million which is the amount invested into the region under the first year of Reef Rescue Package implementation and $45 million which is the amount required to meet the 10% sediment reduction target outlined in the Caring for our Country Outcome Statement.

This return on investment statement is also linked to short term outcomes MA2B, MA3B and MA4B outlined in Table 22 of this report. These short term outcomes are:

- **MA2 -** By 2014 long term average annual sediment load reaching receiving waters reduced by 10.9% achieved through implementation of MA1B
- **MA3 -** By 2014 long term average annual nitrogen load reaching receiving waters reduced by 7.5% achieved through implementation of MA1B
- **MA4 -** By 2014 long term average annual phosphorus load reaching receiving waters reduced by 5% achieved through implementation of MA1B

MONITORING, MODELLING AND REPORTING



MONITORING, MODELLING AND REPORTING

OVERVIEW

Monitoring, modelling and reporting are three essential components of the natural resource adaptive management cycle of assessment, planning, and implementation operated by the FBA. These elements provide data and integrated information required to keep track of the:

- state of the land and water resources in the Fitzroy Basin
- effectiveness of efforts to improve the land and water condition
- progress towards objectives. Collectively they document how the social and physical environment of the region is changing over time (6).

Broad principals adopted by FBA in this monitoring and modelling strategy include:

- Avoiding duplication of effort and supporting meaningful interpretation of data
- Maximising existing systems and focusing on improved capacity for all participants
- Integrating into hotspot catchments process
- Being cost effective and appropriate for end use
- Being appropriate for scale it is undertaken
- Being cognisant of context and aware of opportunity for improvements

The value of the adaptive management cycle methodology is that it recognises that decisions, of necessity, must be made with imperfect knowledge in a changing environment. The ongoing monitoring, modelling and reporting provide the scope for integration of new information and analysis into the planning process and facilitate the evaluation and improvement of current practices, as well as the refinement of objectives.
This report draws on all these techniques in relating catchment processes and land management practices to impacts and deliveries to the coastal waters of the inner GBR. An overview of the arrangements required to provide these knowledge inputs is outlined in this section along with showing the clear linkages required between the monitoring, modelling and reporting and how they should be integrated to provide a rational basis for targets. These procedures also form a critical part of the ongoing planning process.

Some definitions:

- Monitoring involves the measurement of specific parameters which give objective indication of the bio-chemical status or condition of the land and enables the linking of land condition to GBR condition. Relevant examples are the concentrations of nutrients, toxicants, and sediment in water and the extent of ground cover.
- Modelling constructs simplified relationships between the various biogeophysical/chemical (or social /economic) processes occurring within the designated region and calculates the changes in other parameters. Models provide a tool for the integration and analysis of monitoring data, for interpolating and extrapolating observations to different spatial or temporal scales, and serve as tools for exploring the consequences of different potential management options. FBA makes extensive use of models for specific purposes and has drawn on the outputs of sediment transport models (SedNet) and a coupled biogeochemical model (CSIRO receiving waters) in the preparation of this report.
- Reporting, as the name indicates, presents the results of both monitoring and modelling in an evaluative framework which highlights system performance relative to norms, trigger levels for hazardous impacts and management targets. It also gives a mechanism to identify especially effective management practices which have led to achieving targets.

CASCADING CATCHMENTS FRAMEWORK: INTEGRATED MONITORING AND MODELLING PROGRAM

A Cascading Catchments Framework is recommended to support integrated monitoring and modelling in the Fitzroy Basin. Focusing on scales critical to answer the many data and reporting requirements, the Cascading Catchments Framework will monitor actions on the land and track the response in condition of downstream assets including ecosystem health and biodiversity, water quality and the GBR. The Cascading Catchments Framework approach outlined in Figure 32 captures key datasets required in evaluation and reporting for Caring for our Country National and Regional Outcomes Reporting; State of the Basin Reporting and RWQPP Water Quality Reporting.

INVESTMENT SCALE

Investment scale monitoring and modelling is required to capture high level information on condition of productive agricultural land and any resultant response in their condition due to adoption of BMP. This monitoring is designed to capture project information for all properties implementing actions in hotspot

MONITORING, MODELLING AND REPORTING

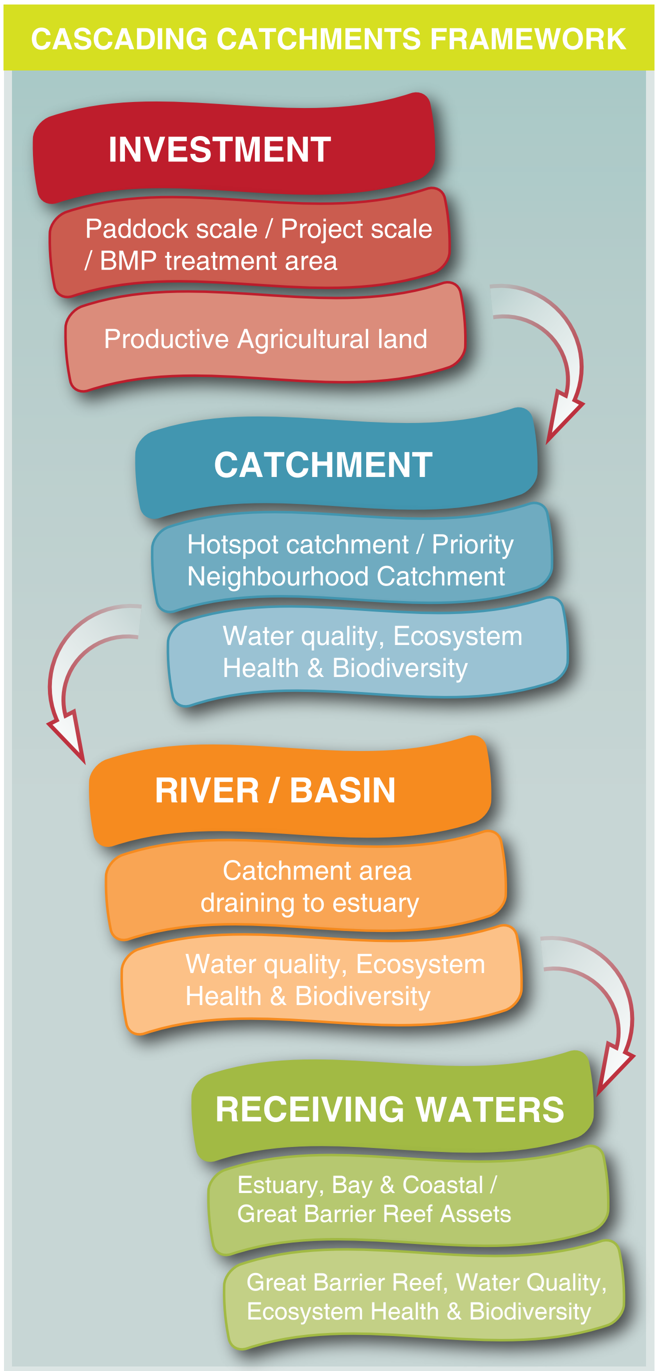


Figure 32 Conceptual diagram depicting Cascading Catchments approach.

catchments. Data collected can be used for State of the Basin Reporting and also as an input to modelling activities within the Cascading Catchments Framework to aid in quantifying water quality, ecosystem health and GBR asset improvement. Aggregated data can also be used as input for Reef Water Quality Partnership Water Quality Reports (as has been the case in the past). Drawing on experience with on-ground project implementation and modelling efforts undertaken in the Fitzroy Basin, a three tiered monitoring approach has been developed and is outlined in Table 33. Essentially these tiers provide:

Tier 1 = basic data capture and promotion
Tier 2 = quantitative data
Tier 3 = demonstration sites and research style monitoring.

TIER 1

Tier 1 monitoring data is collected by subregional field officers and other on-ground implementation officers working with landholders. Monitoring information is aggregated for input in modelling and reporting activities. The steps for collecting and aggregating information relevant to the Basin/River scale are:

1. Collecting project scale information and geo-referencing project area
2. Assigning BMP
3. Pre and post implementation monitoring
4. Reporting on enQuire Project Management Database.

Appendix 1 provides a detailed example of the monitoring data collected at this scale.

TIER 2

A program has been developed to cater for landholders willing to monitor and evaluate the outcome of their project in greater detail. This level of monitoring and evaluation provides quantitative natural resource condition information and is conducted with outside technical support. This information is collated for use in case studies and detailed performance stories. It is also reported in enQuire and will often provide informative data transferable to other similar projects across the basin relating to concentration reduction, erosion reduction, cover improvement or chemical/fertilizer reduction figures. These figures are useful in modelling and reporting. Table 34 highlights the monitoring activity associated with a particular BMP.

TIER 3

Collection of tier 3 monitoring data may be commissioned by the group administering incentives but is often conducted by research and monitoring specialists. This work addresses identified knowledge gaps. Often these paddock/catchment scale monitoring activities are conducted somewhat independently of investment initiatives (i.e. Caring for our Country). These activities provide valuable contaminant reduction figures that can be applied to BMP being implemented under investment initiatives. An example is the Brigalow Catchment Study. This research station was set up over 30 years ago and its monitoring provides improved understanding of different sediment and nutrient loss rates between

MONITORING, MODELLING AND REPORTING

Table 33 Tiered approach to monitoring relating to investment scale monitoring and modelling activities

Tier	Use	Frequency	Input data and Why	Who	Estimate - $
1	Promotion and model input	All projects	Landholder data and modelling input. Promotes monitoring to landholders. Simple and easy	Landholders supported by field officers	$100s to $1000s
2	Quantitative Data	Each hotspot catchment	Reporting and evaluation data for landholders, sub-regions and FBA. More detail, quantitative and requires extra effort	Eager landholders supported by field and technical staff	$1000s to $10 000s
3	Demonstration site/ research	Regional or cross-regional	Quantitative data, scientifically valid. Lots of effort. Data for regional/cross regional case studies	Technical staff or expert Monitoring/ Research Groups	$1000s to $100 000s

virgin Brigalow, Brigalow cleared for cropping and Brigalow cleared for grazing. Many other such studies exist and provide contaminant reduction figures for grazing and cropping management including different stocking rates and tillage regimes.

For BMPs being implemented where there is an incomplete understanding of associated contaminant reduction, there will be a need to add value to existing tier 3 monitoring activities.

FBA and Subregional groups currently run the investment scale monitoring program with targeted support requested from consultants, Queensland Government and Industry as the need arises.

CATCHMENT SCALE

Catchment scale monitoring is required to capture information on condition of hotspot catchments with a focus on productive agricultural land and water quality assets and any resultant response in their condition due to adoption of BMP. Monitoring is designed to quantify cumulative averages across the hotspot catchment. Data collected may be used for State of the Basin Reporting, Reef Rescue Package Regional Outcomes Reporting and Reef Water Quality Partnership WQ Report.

Catchment scale monitoring provides supporting evidence to assess investment. Its initial application is hampered by factors such as contaminant residence times and seasonal extremities but once these are understood data provides a baseline for monitoring condition and trend.

EVENT BASED WATER QUALITY MONITORING

An essential characteristic of the Fitzroy Basin is the very episodic nature and infrequency of large rainfall events; the associated transport of sediments, nutrients and agrochemicals; and the ultimate discharge into the GBR coastal waters. Event based water quality monitoring at hotspot catchment scale is conducted to obtain contaminant load data representative of water leaving the catchment.

This monitoring aims to:

- validate modelled outputs and track water quality improvements in line with on-ground actions
- provide catchment based water quality data for use in reporting and evaluation
- refine water quality models used to aid in the setting of water quality targets
- collect baseline water quality data at a hotspot catchment scale
- engage and involve landholders and stakeholders in monitoring, in turn encouraging those able to bring about management change at catchment scale

The program's monitoring plan provides further details. FBA currently runs the event based water quality monitoring program with support from landholders.

BASIN SCALE

Basin scale monitoring and modelling enables evaluation of cumulative impact of investments on assets at the basin scale. It is currently the scale most relevant to aims and outcomes of the Reef Plan and Reef Rescue Package which focus on sediment, nutrient and chemical reductions. To report progress against these aims and outcomes at basin scale requires inputs from investment scale monitoring. Data collected by FBA and regional stakeholders may be used for State of the Basin Reporting and Reef Rescue Package Regional Outcomes Reporting and Reef Water Quality Partnership Water Quality Reports.

REMOTE SENSING

Direct observation of all the useful parameters required for assessment of the state of the catchment

MONITORING, MODELLING AND REPORTING

Table 34 Tiered monitoring approach to BMP implemented. BMP descriptions are outlined in Table 26 and are linked to on-ground actions outlined in Table 21.

BMP	Tier 1 Min Requirement	Tier 2 Potential Options	Tier 3 Potential Options
Property Management Plans	PMP checklist and completion report	FMS	Externally audited FMS or EMS
Sustainable cropping	Ground cover monitoring and treatment area shapefile	Ground cover monitoring	Satellite imagery analysis, in crop, after rain events for erosion, etc
Salinity	Photo point and treatment area shapefile	Chloride profiles Soil moisture measurement for recharge	Piezometers EM Surveys
Indigenous cultural heritage	Photo points and treatment area shapefile	Cultural Survey	Archaeological assessment
Water use efficiency	Soil moisture monitoring; Pre/ post water use and treatment area shapefile	WUE calculations and benchmarking	
Fertiliser/chemical minimisation	Pre/post fertiliser/chemical application rates and treatment area shapefile	Simple water monitoring	Water Monitoring using control structures - Gauged Flumes
Managing for land types and grazing pressure	Photo point and treatment area shapefile	Stocktake including stock recordings. Bed and bank stability. Gully stability	LFA, Grasscheck, Botanal
Managing for riparian and wetland areas	Photo point, treatment area shapefile and stream distance	Modified stocktake considering native recruitment and exotic/ native split. Bed and bank stability	TRARC, vegetation surveys, other riparian condition assessment methodologies
Managing for biodiversity	Photo point and treatment area shapefile	Stocktake, bio-condition assessment	Bio-condition Assessment, Vegetation surveys, Fauna surveys
Farm Forestry Management	Photopoint; Pre/Post standing timber assessment; and treatment area shapefile	Monitoring Land Condition improvement Monitoring growth rates	

is impossible due to the size of the Fitzroy Basin. To overcome this problem the FBA makes extensive use of remote sensing. This suite of techniques is still very much a tool under development and is done in conjunction with other stakeholders. A specific example of the power and relevance of this technique in understanding system wide behaviour is the assessment of ground cover. This assessment provides an end of dry season Landsat image processed for cover – and known as the GCI. It is an important data input for SedNet modelling. It is also useful for detailing condition and trend of cover at the catchment scale because it can use historical images captured as far back as 1980s. NRW, DPI and CSIRO currently prepare the GCI product. Figure 33 shows the interannual changes in GCI for a drought year and for an average rainfall year.

WATER QUALITY MONITORING

Cognisant of lag times, contaminant reduction predictions can be compared to monitored estimates currently collected and infrequently reported by NRW. Currently this task is funded by NRW to meet their internal business priorities and commitment to monitoring resource condition and trend (Figure 34). For this reason some rivers in the GBR may not have sufficient monitoring to be applied for specific use under the Reef Rescue Package and RWQPP.

MONITORING, MODELLING AND REPORTING

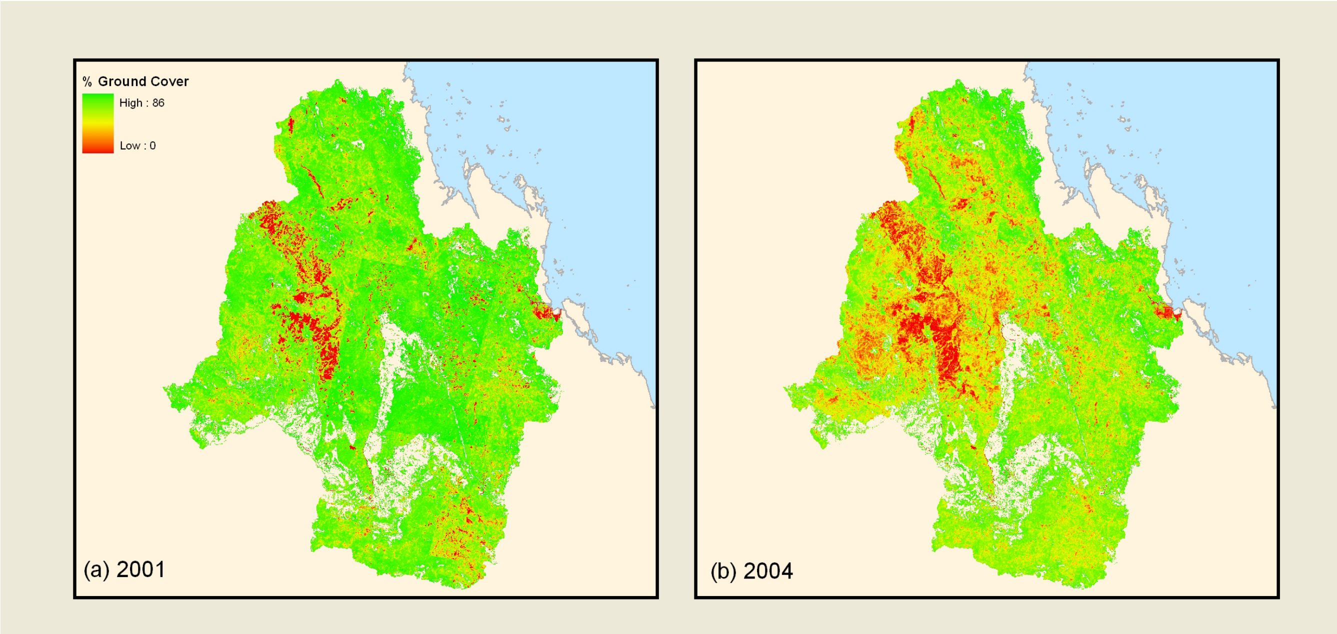


Figure 33 Interannual changes in Ground cover for a drought year and average rainfall year using the Ground Cover Index (GCI)

This monitoring provides vital data for flow EMC and is currently the only basin scale monitoring program collecting pesticides information. Results are used to test the validity of modelled estimates.

WATER QUALITY MODELLING

Water quality modelling at the basin scale is used to predict water quality improvements from on-ground changes being implemented at the investment scale.

Data collected from investment scale monitoring is aggregated and used as an input in basin scale modelling. Also used are contaminant reduction figures derived from tier 3 monitoring which are applied to projects undertaking similar BMPs. These inputs provide a basin scale contaminant reduction estimate from the associated investment. This reduction estimate is then available as an input to receiving waters scale monitoring/modelling and may provide Fitzroy Basin scale progress against Reef Rescue Package and RWQPP aims and actions. NRW currently run the SedNet modelling program for the Fitzroy Basin (Figure 34).

RECEIVING WATERS

Receiving waters scale monitoring and modelling is required to capture and analyse information on condition of receiving waters with a focus on productive GBR and water quality assets and any resultant response in their condition due to adoption of BMP. Monitoring is designed to quantify cumulative averages across the hotspot catchment. Data collected is used for State of the Basin Reporting, Reef Rescue Package Regional Outcomes Reporting and Reef Water Quality Partnership Water Quality Report.

Monitoring allows for determination of impacts from natural and anthropogenic processes, whilst modelling enables the separation of differing processes. Given that maintained and improved condition of GBR assets is the ultimate aim of ReefPlan Policy and the Reef Rescue Package initiative, it is prudent to monitor and report progress at this scale. It is also the most difficult scale to separate Reef Rescue Package improvements from other factors such as point source pollution (i.e. mining and sewerage treatment plants), urban diffuse pollution, seasonal variability and climate change. As with the basin scale, a combined modelling and monitoring program is the only way to quantify this successfully.

FITZROY RECEIVING WATERS MODELLING AND REMOTE SENSING

This approach uses best available data such as remote sensing and water quality data to populate a receiving waters model. It is widely acknowledged that the CSIRO Fitzroy Receiving Waters Model is the most advanced of any in the GBR catchments. Other catchments will require significant investment in this area. These models take outputs from basin scale models and predict water quality in the estuary, and the GBR World Heritage Area (Figure 25). This model is used to predict areas of the GBR enduring contaminant trigger values greater than those set in the FBA's Local Marine and Coastal Assets Guidelines (3). It also allows the prediction of ecological impact on GBR assets and the effectiveness of BMPs implemented in reducing this impact.

Remote sensing is a tool that helps to predict spatial flood plume extent of sediment and

MONITORING, MODELLING AND REPORTING

contaminants. If the sky is not too overcast it also has good temporal resolution using MODIS satellite imagery which is available twice daily. CSIRO Water for a Healthy Country Flagship currently supports remote sensing and receiving waters modelling in the Fitzroy Basin.

RECEIVING WATERS WATER QUALITY AND ECOLOGICAL HEALTH MONITORING

It is important to measure the condition of reef assets and the quality of water impacting these assets. Current monitoring for water quality focuses on sediments, nutrients, chlorophyll and pesticides and uses a mix of spot, logging, remote sensing and passive sampling techniques. Current monitoring of asset condition focuses on corals, seagrasses and crustaceans. This program is administered by GBRMPA and RRRC and relies on a broad suite of research and monitoring providers. Ambient water quality in estuarine waters is currently measured for sediments, nutrients, chlorophyll and other insitu measurements. This program is administered by EPA. Response in fish catch to flow is conducted for the Fitzroy River and Keppel Bay. This program is administered by CapReef.

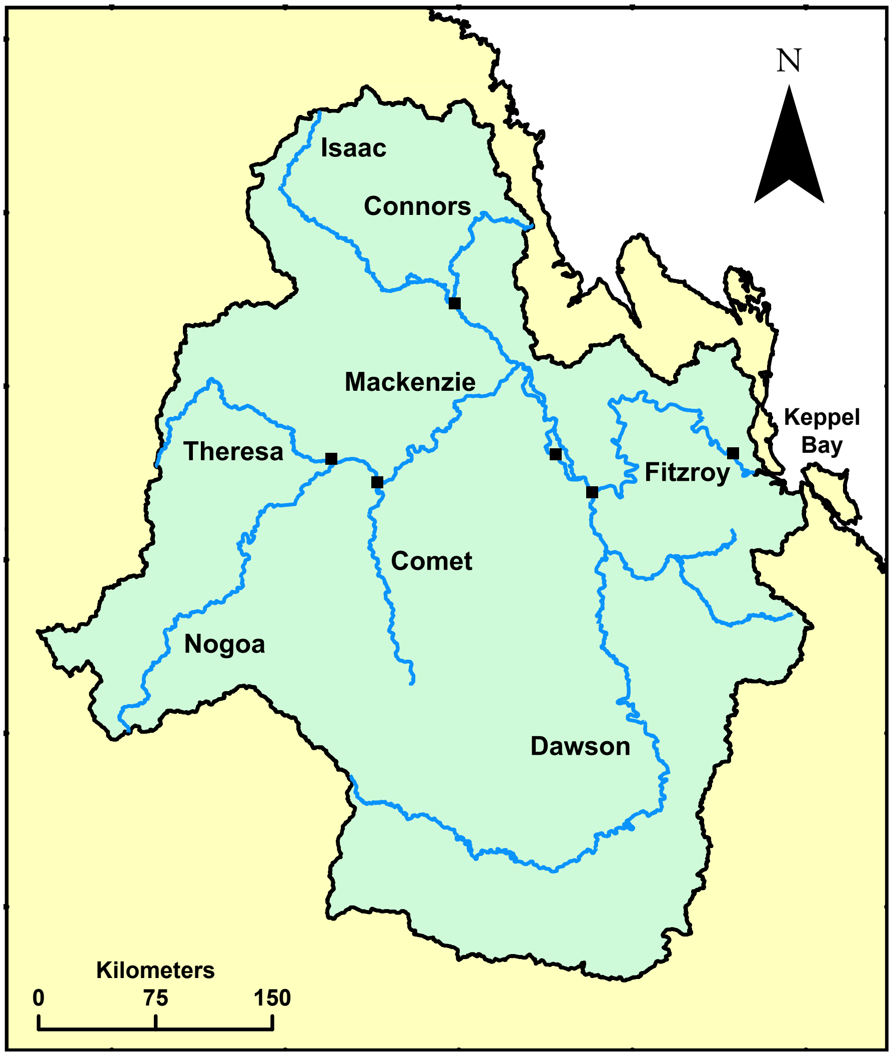


Figure 34 The Fitzroy River Basin and major tributaries (including Theresa Creek). Black squares mark water sampling locations (7) 34 The Fitzroy River Basin and major tributaries (including Theresa Creek). Black squares mark water sampling locations (7)

OTHER RELEVANT MONITORING AND MODELLING

In addition to monitoring data collected directly under the auspices of the FBA, critical supporting data is accessible from other agencies such as NRW (water quality monitoring at multiple sites in the sub-basin and basin scale across the catchment together with discharge data) , GBRMPA (routine monitoring data of water quality parameters at several stations in Keppel Bay together with automated monitoring devices permanently installed at several locations) and the EPA (water quality and physical parameters at multiple stations in the Fitzroy estuary). This data is collected under the monitoring programs of these other agencies and complements FBA's own efforts. This information sharing with the Queensland Government is covered by a formal agreement while in the other cases FBA uses close informal collaboration with the monitoring organisations. In addition, point sources such as sewage treatment plants (STP) discharging to the Fitzroy estuary are licensed and subject to mandatory reporting of nutrient discharges. The data from these external sources contributes towards characterizing the system at a level above the individual property. The water quality data from NRW integrates the effects of all the BMP activities at a sub-basin scale, while the EPA observations characterise the Fitzroy estuary. The GBRMPA monitoring provides data on the state of the Great Barrier Reef asset and over time, trends and changes in its condition. This water quality data (apart from the GBRMPA continuous logging in Keppel Bay) is based on regular sampling routines and thus rarely captures the episodic events which are so characteristic of the Fitzroy Basin.

STATE OF THE BASIN – A FRAMEWORK FOR INTEGRATED REPORTING AND EVALUATION

The Cascading Catchments integrated monitoring and modelling framework outlined above is offered as an approach that can provide data for asset condition and trend analysis including improvements from management practice. A State of the Basin Report is proposed as the mechanism to analyse and report such data. This could be prepared annually by the FBA and would provide the impetus for the collation, integration, analysis and interpretation of the different types of monitoring data gathered at multiple scales. Application of the models mentioned earlier would provide additional quantitative relationships and insights between the different data types. The confrontation of models with data would lead to the improvement of model veracity and power also. This extensive consolidated reporting strategy would also provide the FBA with insight into the overall effectiveness of implementation of the BMP and would contribute to the next cycle of the Adaptive Management process. The State of the Basin report would be an efficient and transparent mechanism to evaluate regional success of BMP adoption on:

- RWQPP aims;
- Caring for our Country Reef Rescue Package Outcomes;
- Reef Rescue Plan Regional Delivery Outcomes and;
- Targets and actions outlined in this report that are adopted in the *CQSS2*.

Table 35 outlines the identified linkages between the State of the Basin report and the other reporting mechanisms.

Clearly, the State of the Basin report is closely linked to the RWQPP Water Quality Report and Table 36 outlines much of the shared data for each report's development. With appropriate planning and collaboration this State of the Basin Report could provide basin scale data required for any future RWQPP Water Quality Report and in turn, data from the RWQPP Water Quality Report could be used to inform the State of the Basin Report.

Table 35 Reports that would utilise data and information collected under the Cascading Catchments Framework and the linkages

Report	Link between report and data collected in an integrated monitoring and modelling framework	Potential Implementer
State of the Basin	Report prepared using data collected in Cascading Catchments Framework	FBA
State of the Environment	Report prepared from NRM Regional Body data in reports like State of the Basin. Also using data from many other Stakeholders	Queensland Government
RWQPP Water Quality	Report prepared from GBR NRM Regional Body data in reports like State of the Basin. Also using data from other ReefPlan Stakeholders	Queensland Government, Reef Regional Bodies, Industry, other stakeholders
RWQPP Progress	Report prepared from GBR NRM Regional Body data in reports like State of the Basin. Also using data from other ReefPlan Stakeholders	Queensland Government, Reef Regional Bodies, Industry, other stakeholders
Caring for our Country Delivery Outcomes Progress Report	Report prepared using information from FBA generated in Enquire along with information in RWQPP Water Quality and RWQPP Progress reports generated by GBR stakeholders	Australian Government, Queensland Government, Reef Regional Bodies, Industry, other stakeholders
Reef Rescue Package Regional Outcomes Progress report	Report prepared using information from FBA generated in Enquire and the State of the Basin report	FBA, regional implementers

MONITORING, MODELLING AND REPORTING

Table 36 Summary of monitoring and modelling activities required as input data for use in a State of the Basin and ReefPlan Water Quality Report.

Activity	Asset	Indicator	Action required	Covered in recent RWQPP Report?	Who collects the data?
BMP adoption monitoring	Land Water	See Table 26	Expand program capable of monitoring adoption of improved management practice	Yes	FBA LH Ind
Hotspot catchment scale event based WQ monitoring	Water	TSS TN TP Clarity	Expand monitoring program capable of detecting water quality improvement for hotspot catchments	No	FBA LH
Ground cover monitoring	Land	Ground cover	Maintain ground cover condition and trend analysis for hotspot catchments	Yes	NRW DPI&F
Basin scale water quality modelling	Water	TSS TN TP NO_x FRP	Maintain modelling water quality improvements from BMP adoption at Basin Scale	Yes	NRW FBA
Basin scale event based water quality monitoring	Water	TSS TP TP NO_x FRP Chem	Expand water quality condition and trend monitoring program	Yes	NRW
Modelling and remote sensing of receiving waters	Water GBR	TSS TP TP NO_x FRP Chl Temp Salinity	Maintain modelling and remote sensing of water quality improvements from BMP adoption for Reef Assets and GBR water quality	No	CSIRO
Monitoring WQ and ecological health of receiving waters	Water GBR	TSS TP TP NO_x FRP Chl Chem Coral Seagrass Crustaceans	Maintain GBR condition and trend monitoring program	Yes	GBRMPA
Estuarine ambient water quality monitoring	Water	TSS TP TP NO_x FRP Chl`	Maintain ambient Water quality Monitoring Program	No	EPA
Fisheries response	GBR	Fish catch rates	Maintain condition and trend analysis for finfish capture rates	No	CapReef

LIMITATIONS

LIMITATIONS

All knowledge and information regardless of age has limitations to its use. This report utilises best available new knowledge and information, some of which still requires further refinement, testing and validation. There are thousands of limitations that could be mentioned, however this sections highlights the key ones for knowledge and information used in development of this report (Table 37). It also highlights how these limitations impact on use. Future actions have been outlined to help overcome these limitations. Please use original information sources listed in the references section of this report for more comprehensive details on limitations.

Table 37 Major limitations of data and information used in this report

Component	Limitation	Impact on use	Action
GCI	Product uses images from end of dry season	Depicts ‘worst case’ for season Cover for grazing country depicted lower than actual	GCI analysis to include products with expanded temporal resolution
	Errors in land use mapping	GCI applied or masked inappropriately as land uses change. Affects coverage of mapping, and calculation of average annual values per land type, NC etc	Use latest available version of land use mapping.
	Impacted by reflectance of differing soil types Potentially poor in cropping lands	Under or overestimation of cover for differing land types	Calibrate GCI to land types
	Trees interfere with GCI	Can’t be used for monitoring cover under trees. Impacted by regrowth and scattered trees	Mask areas of high tree coverage (FPC>20%) from GCI mapping. Also note limitations and devise complementary monitoring program for treed landscapes.
Surface Erosion	Uses GCI	Limitations of GCI impact on surface erosion estimates	Note limitation. Improve GCI and complementary monitoring
	Uses soils database which is severely limited	Under and overestimation of soil loss due to error in dataset	Improve soils data for the basin to a property scale useful for future modelling
Gully Erosion	Uses soils database which is severely limited	Under and overestimation of soil loss due to error in dataset	Improve soils data for the basin to a scale useful for model
	Gully volume and erosion rates not measured	Arbitrary gully volumes applied and erosion rates leading to under/over estimation of gully delivery ratios	Determine gully volume and delivery ratios
Bank Erosion	Bank height not measured for the basin	Arbitrary bank heights are applied leading to under/overestimation of bank delivery ratios	Determine banks heights for banks 3rd order and above across the basin
	Insufficient measurement of riparian zone condition	Over/underestimation of soil loss due to riparian condition	Conduct riparian condition assessment
Riparian	Buffering capacity of riparian works not modelled. Insufficient data available to parameterise existing models	Impact of riparian buffering in dry tropics not accounted	Experimental work, literature review and modelling on impact of riparian work in dry tropics.

LIMITATIONS

Component	Limitation	Impact on use	Action
Pesticides	Pesticide use and treatment area estimated	Over/underestimation of pesticide loss	Monitor pesticide use and treatment
SedNet Nutrient Module	Nutrient species ratios for the Fitzroy Basin do not match monitoring data	Modelled nutrient results for specific species may not be accurate	Update model and conduct research to quantify nutrient losses from land uses in the Basin
D-Condition Land	Errors associated with GCI are also applicable to D-condition land	Should be used as a guide. Must be groundtruthed for individual cases	Not recommended for major policy and regulatory approaches without groundtruthing
Land type Assessment	Variation of land types within land types not quantified	Difficult to ascribe changes in cover at this scale, to management or differing land types	Quantify variation and causative factors.
Local Asset Trigger Values	Guidelines developed for low trophic order species	Should only be used as arbitrary WQ guidelines for important high order species	
	Limited knowledge on spatial distribution, condition and abundance of coastal and marine assets	Assets may not exist in area	Improve understanding of spatial distribution, condition and abundance of coastal and marine assets as they apply to the influence of the Fitzroy Flood Plume
	Derived from GBRMPA and QWQG	Limitations articulated in guidelines apply to this report	
Fitzroy Receiving Waters Model	Limited Spatial Extent (a) Plume Influence; (b) Floodplain	Impact of management actions on specific assets outside model domain like Keppel Islands not available	Extend spatial extent of model domain to include assets of interest such as Keppel Islands
	Limited time scale of modelling	Underestimation of impact of management actions due to storage of contaminants from previous year.	Expand scenario runs to include management actions for lead in years
		Only 2003/04 and 2008 years modelled due to long run times for scenarios	Implement actions or model upgrades to reduce scenario run time
	Chlorophyll a estimates have very high uncertainty and do not match field data	Chlorophyll a should not be relied upon	Use remote sensing data to improve training data for chlorophyll a
	Flow : load relationships assumed not to change	It is not yet understood how the relative distribution of sediment and nutrient loads with flow will change in the scenarios considered.	
	Pesticides not included in the model	Impact of management actions on concentrations pesticides and assets can't be ascertained.	Compile data for sub-model development. Develop pesticide sub-model
	2008 Flood event not validated	Results for the 2008 flood event must be taken as preliminary	Validate 2008 flood event

ACRONYMS

Ag – Agricultural

AIMS – Australian Institute of Marine Science

ANZECC – Australian and New Zealand Environment Conservation Council (Water Quality Guidelines)

BMP – Best Management Practice. Relates to improved management practices and not industry FMS/BMP

BOM –Bureau of Meteorology

CCI – Coastal Catchments Initiative

Chl a – Chlorophyll a

CQ – Central Queensland

CQRWSS – Central Queensland Regional Water Supply Strategy

CQSFS – Central Queensland Sustainable Farming Systems

CQSS2 – Central Queensland Strategy for Sustainability – 2004 and Beyond

CTF - Controlled Traffic Farming

DO – Dissolved Oxygen

DON –Dissolved Organic Nitrogen

DOP – Dissolved Organic Phosphorus

DVIA - Dawson Valley Irrigation Area

E-flow – Environmental Flow

EIA – Emerald Irrigation Area

EM Surveys – Electromagnetic Surveys

EMC – Event Mean Concentration

EMS – Environmental Management System

EPP – Environmental Protection Policy

ERA – Environmentally Relevant Activity

EVs – Environmental Values

FBA – Fitzroy Basin Association

FMS – Farm Management System

FPC – Foliage Projected Cover

FRP – Filterable Reactive Phosphorus

GBR - Great Barrier Reef (World Heritage Area)

GBRMPA – Great Barrier Reef Marine Park Authority

GCI – Ground Cover Index

GIS – Geographic Information Systems

GRASP – GRASs Production, a pasture growth model

Ha – Hectares

ACRONYMS

IPA – Integrated Planning Act

KASAP - Knowledge, Attitudes, Skills, Aspirations, and Practices

Km – Kilometres

LFA – Landscape Function Analysis

mm – millimetres

MODIS - Moderate Resolution Imaging Spectroradiometer (Satellite)

NC – Neighbourhood Catchment

NH4 – Ammonia

NMZ – Nutrient Management Zones

NOx – Oxides of Nitrogen

NWQMS – National Water Quality Management Strategy

PMP – Property Management Plan

PN – Particulate Nitrogen

PNC –Priority Neighbourhood Catchment

PP – Particulate Phosphorus

QWQG – Queensland Water Quality Guidelines

R&D – Research and Development

ROP – Resource Operations Plan

RRRC – Reef and Rainforest Research Centre

RWQPP – Reef Water Quality Protection Plan

SedNet – Sediment network software model, physically based distribution model for catchment sediment transport

SPOT 5 – A type of satellite imagery

STP – Sewerage Treatment Plant

T – Tonnes

TN – Total Nitrogen

TOR – Terms of Reference

TP – Total Phosphorus

TRARC - Tropical Rapid Appraisal of Riparian Condition

TSS – Total Suspended Solids

WAMP - Water Allocation and Management Plan

WQ – Water Quality

WQOs – Water Quality Objectives

WUE – Water Use Efficiency

Yr – Year

ZT – Zero Tillage

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APPENDICES

APPENDIX 1

EXAMPLE OF TIER 1 MONITORING AND MODELLING PROCESS

1. Collecting project scale information and geo-reference project area/s

All landholder projects are mapped with information collected on the type of project, its location, the project area and the BMP being implemented (Table 31).

2. Assigning BMP implemented

The type of BMP being implemented is recorded for each treatment area. In most cases a contaminant reduction figure has been quantified for each BMP implemented through tier 3 monitoring and research with further research required for some. This information is entered in a 'management action' column within the project area attribute table. This process allows easy transfer of data to modelling applications.

3. Pre and post implementation monitoring

This step is aimed at involving landholders in monitoring their project area before and after treatment to increase knowledge and accountability of a project's success. Field officers provide assistance with monitoring and monitoring is linked to project completion reporting and payments. Each BMP has an individual monitoring activity and these are detailed in Table 34.

4. Reporting on Enquire Project Management Database

Investment scale reporting of project information and associated monitoring and evaluation will be done through enQuire reporting database. enQuire will act as the program and project management system and ensure results of actions from this region are able to be aggregated sensibly to the GBR catchment scale for whole-of-program reporting on Reef Rescue and other initiatives.

APPENDIX 1

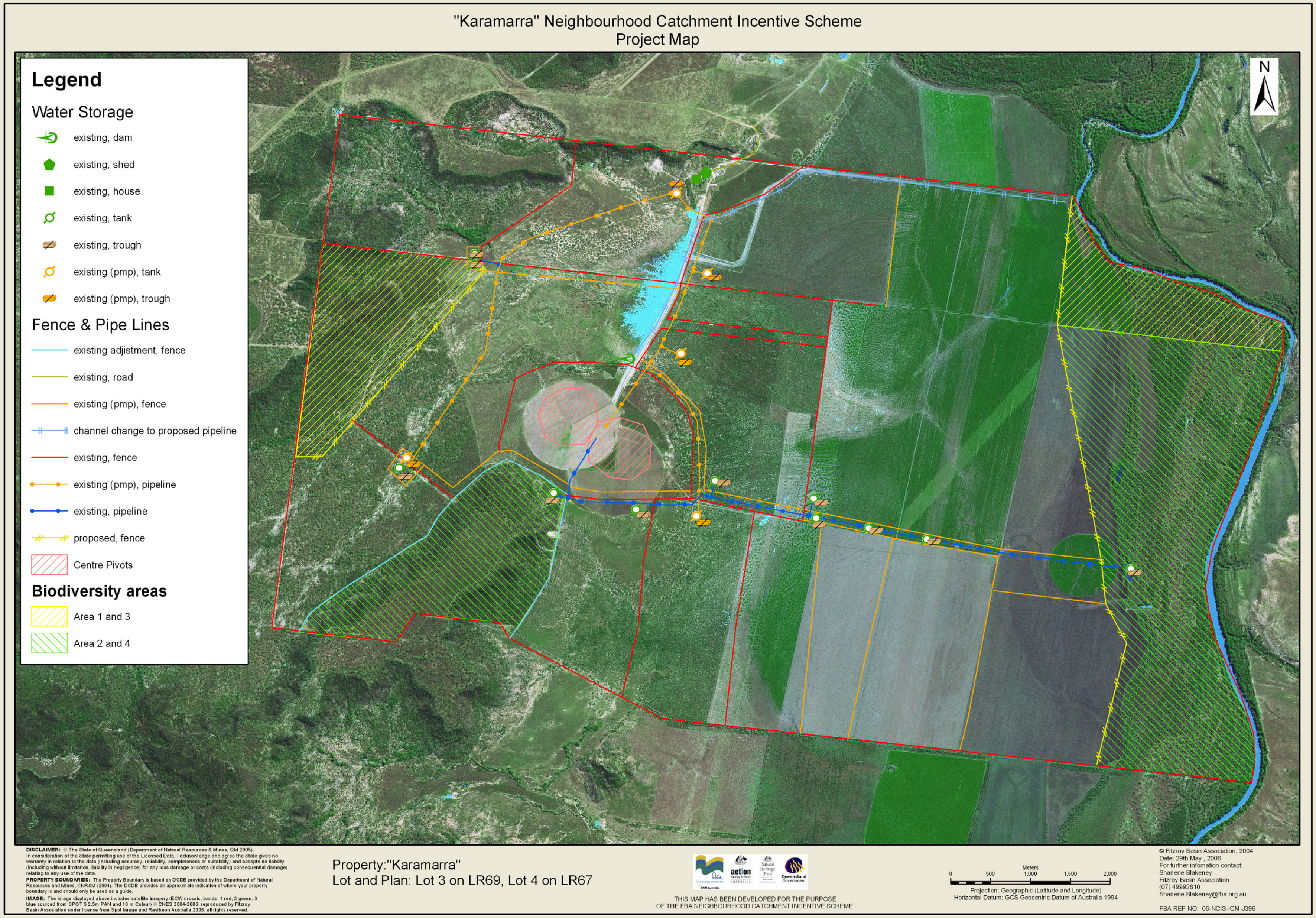

Figure 35 Project area map for property. This property is implementing cropping, riparian grazing, water use efficiency and biodiversity BMPs with multiple project areas each delivering water quality contaminant reductions determined by the BMP being implemented

APPENDIX 1

Figure 36 Example detailing BMP implemented on properties within a particular PNC. This information can then be used with a contaminant reduction estimate derived from tier 3 monitoring and input for modelling and reporting

APPENDIX 1

APPENDIX 2

EXCEEDANCE - WET SEASON MEDIAN YEAR FLOOD

Throughout the wet season of a median year in the Fitzroy, coastal and marine assets within GBR World Heritage area throughout Keppel Bay are subject to:

- Unsatisfactory water clarity for an extended period of time in the coastal water body
- Unsatisfactory concentrations of suspended sediments for an extended period of time in coastal, estuary and inshore water bodies
- Unsatisfactory concentrations of TN for an extended period of time in the estuary water body
- Unsatisfactory concentrations of dissolved oxygen and dissolved forms of nitrogen; and phosphorus for an extended period of time in enclosed coastal and estuary water bodies
- Unsatisfactory concentrations of TP and dissolved organic nitrogen for an extended period of time in the estuary water body
- All other contaminants were at satisfactory concentrations for extended periods of time.

EXCEEDANCE - DRY SEASON A MEDIAN YEAR FLOOD

Throughout the dry season of a median year in the Fitzroy, coastal and marine assets within GBR World Heritage area throughout Keppel Bay are subject to:

- Unsatisfactory concentrations of suspended sediments for an extended period of time in coastal and estuary water bodies
- Unsatisfactory concentrations of dissolved inorganic forms of nitrogen for an extended period of time in enclosed coastal and estuary water bodies
- Unsatisfactory concentrations of dissolved inorganic phosphorus for an extended period of time in the estuary water body
- All other contaminants were at satisfactory concentrations for extended periods of time

EXCEEDANCE - WET SEASON 1 IN 10 YEAR FLOOD

Throughout the wet season of a 1 in 10 flood year in the Fitzroy, coastal and marine assets within GBR World Heritage area throughout Keppel Bay are subject to:

- Unsatisfactory water clarity for an extended period of time in coastal and inshore water bodies
- Unsatisfactory concentrations of suspended sediments for an extended period of time in all water bodies
- Unsatisfactory concentrations of TN and TP for an extended period of time in estuary and enclosed coastal water bodies
- Unsatisfactory concentrations of dissolved forms of nitrogen; and phosphorus for an extended period of time in enclosed coastal and estuary water bodies

APPENDIX 2

- Unsatisfactory concentrations of dissolved oxygen for an extended period of time in the enclosed coastal water body

- All other contaminants were at satisfactory concentrations for extended periods of time.

EXCEEDANCE - DRY SEASON AFTER A 1 IN 10 YEAR FLOOD EVENT

Throughout the dry season after a 1 in 10 flood year in the Fitzroy, coastal and marine assets within GBR World Heritage area throughout Keppel Bay are subject to:

- Unsatisfactory water clarity for an extended period of time in coastal the water body

- Unsatisfactory concentrations of suspended sediments for an extended period of time in estuary, enclosed coastal and coastal water bodies

- Unsatisfactory concentrations of TN; TP; and dissolved forms of nitrogen for an extended period of time in the estuary, enclosed coastal and coastal water bodies

- Unsatisfactory concentrations of dissolved inorganic phosphorus for an extended period of time in the estuary water body

- Unsatisfactory concentrations of dissolved oxygen for an extended period of time in the enclosed coastal water body

- All other contaminants were at satisfactory concentrations for extended periods of time.

APPENDIX 3

GROUND COVER INDEX MAPS 1988-1996

APPENDIX 3

GROUND COVER INDEX MAPS 1997-2005

APPENDIX 4

LAND TYPES OF THE FITZROY BASIN