Mary River Threatened Aquatic Species Recovery Plan

MARY RIVER CATCHMENT COORDINATING COMMITTEE

Australian Government

The *Mary River Threatened Aquatic Species Recovery Plan* was developed by the Department of the Environment in partnership with the Mary River Catchment Coordinating Committee.

The Species Profile and Threats Database pages linked to this recovery plan is obtainable from: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

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Image credits

Front Cover: Left top to bottom and right top to bottom—Mary River turtle (*Elusor macrurus*), Mary River cod (*Maccullochella mariensis*) (Gunther Schmida), freshwater mullet (*Trachystoma petardi*) (Gunther Schmida), Australian lungfish (Gunther Schmida), Giant barred frog (*Mixophyes iteratus*) (Eva Ford).

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ABBREVIATIONS AND ACRONYMS

AMTD	Adopted middle thread distance
BM	Burnett Mary
BMRG	Burnett Mary Regional Group
BoT	*Back on Track* (Queensland species prioritisation framework)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DNRM	Department of Natural Resources and Mines (Qld)
EFAP	Environmental Flows Assessment Program
EHP	Department of Environment and Heritage Protection (Qld)
FA	*Fisheries Act 1994* (Qld)
FCRC	Fraser Coast Regional Council
GRC	Gympie Regional Council
DAFF	Department of Agriculture, Fisheries and Forestry (Qld)
DEHP	Department of Environment and Heritage Protection (Qld)
DNRM	Department of Natural Resources and Mines (Qld)
DNPRSR	Department of National Parks, Recreation, Sport and Racing (Qld)
DSITI	Department of Science, Information Technology, Information and Innovation (Queensland).
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for the Conservation of Nature
ISC	Index of Stream Condition
LBCCG	Lake Baroon Catchment Care Group
lidar	Light detection and ranging
MNES	Species that are listed under the EPBC Act are referred to as Matters of National Environmental Significance (MNES)
MRCCC	Mary River Catchment Coordinating Committee

MRTASRP	Mary River Threatened Aquatic Species Recovery Plan
MRTASRT	Mary River Threatened Aquatic Species Recovery Team
NCA	*Nature Conservation Act 1992* (Qld)
NSW DPI	New South Wales Department of Primary Industries
PIT	Passive Integrated Transponders
RAD	Queensland Government's Recovery Actions Database
Qld	Queensland
RE	Regional ecosystem
SCC	Sunshine Coast Council
TAG	Technical Advisory Group
TOWG	Traditional Owners Working Group
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WBW	Wide Bay Water Corporation
WoNS	Weeds of National Significance
WQIP	Water quality improvement plan
WWF	World Wildlife Fund

GLOSSARY

Adopted middle thread distance: the distance in kilometres to a specific point on the watercourse, measured along the middle of a watercourse, from the mouth or junction.

Alluvial plain: a level or gently sloping surface formed of sediments laid down by streams, generally during flooding.

Beneficial large wood: the logs, sticks, branches and other wood that fall into streams and rivers. This wood can influence the flow and the shape of the stream channel (formally known as 'large woody debris' [LWD] see below).

Biodiversity: diversity among and within plant and animal species in an environment.

Biopassage: the retention or restoration of waterway and wetland connectivity and the maintenance of aquatic conditions in order to facilitate the passage of all mobile aquatic species throughout their life cycle.

Chelid turtle: turtles that withdraw their necks sideways into their shells

Large woody debris: this is an important structural and functional component of stream ecosystems. Research over the past two decades has shown that LWD improves fish habitat by increasing types and sizes of pools, sediment storage, and scour. LWD also causes the "formation of stair-step profiles that result in the rapid dissipation of stream energy in high gradient systems." The practice of clearing out of woody debris in streams occurred in the past. Recent studies show that LWD is an important benefit to fish habitat and this research has caused fishery and forestry managers to re-evaluate woody debris practices. LWD also provides colonisation areas for different types of invertebrate organisms in streams and high densities of invertebrates on logs attract fish that feed on these invertebrates.

Declining: the numbers of species declining significantly over time and they may become vulnerable in the medium-term.

Demonstration reach: large scale river reaches or wetlands where a number of management interventions are applied and closely monitored to showcase the cumulative benefits of river/wetland rehabilitation on native aquatic fauna populations (Jackson 2008).

Endangered: where the species faces a very high risk of extinction in the near future.

Environment Protection and Biodiversity Conservation Act 1999 **(EPBC Act):** the Australian Government's key piece of environmental legislation. It enables the Australian Government to join with the states and territories in providing a national scheme of environment, heritage protection and biodiversity conservation. The EPBC Act focuses Australian Government interests on the protection of matters of national environmental significance with the states and territories having responsibility for matters of state and local significance.

First order stream: the smallest of streams, consisting of small tributaries that flow into and 'feed' larger streams sometimes recharged by surface water flow or spring fed. First and second order streams generally form on steep slopes and flow quickly until they slow down and meet the next order waterway.

Foliage projective cover: the percentage of the sample site occupied by the vertical projection of foliage only.

Gene pool: the number of genes in individuals in the breeding population. A large gene pool indicates high genetic diversity, increased chances of biological fitness, and survival. A small gene pool indicates low genetic diversity, reduced chances of acquiring biological fitness, and increased possibility of extinction.

Healthy river processes: processes involved with its ecological functioning, including hydrological and geomorphologic processes which keep the system in balance. When there is natural water flows with functional riparian vegetation, the flow rate, amount, oxygen levels and nutrient levels all stay in balance—this is what all species in the river require as habitat critical. They need a self-sustaining, functional flow regime. Factors which upset the balance include water extraction, flow controls, absence of riparian vegetation which impacts nutrient levels, salinity levels, pesticide pollution, sediment loading and effluent pollution.

Glides: these are the smooth, fast-moving area that often separates pools from riffles

Hydrology: the study of the movement, distribution and quality of water, including the hydrologic cycle, water resources and environmental watershed sustainability

Igneous rocks: rocks such as granite, formed through the cooling and solidification of magma or lava.

Index of stream condition: this index brings together data from a variety of sources to give a detailed overall picture of river condition.

Interbedded volcanics: a geological layer which was typically formed 250-300 million years ago through modification of volcanic deposits and which is now sandwiched between other geological layers which are not volcanic in origin.

Invertebrates: animals without backbones.

Macrophyte: an aquatic plant that grows in or near water and is emergent, submerged or floating.

Non-riverine wetlands: water bodies located outside of the main river channel that are either open water (for example, lake) or vegetated (for example, billabong) (Queensland Government 2012)

Point source: any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock,

concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.

Priority species: WWF describes these as species that are especially important, either for their ecosystem.

- species forming a key element of the food chain
- species which help the stability or regeneration of habitats
- species demonstrating broader conservation needs

  or for people
- species important for the health and livelihoods of local communities
- species exploited commercially
- species that are important cultural icons.

A 'priority species' approach is a strategy to deal with the complexity and any uncertainty in this system.

Queensland *Nature Conservation Act 1992*: this Act provides for the legislative protection of Queensland's threatened biota. As originally published, it provided for biota to be declared presumed extinct, endangered, vulnerable, rare or common. In 2004 the Act was amended to more closely align with the IUCN Red List categories.

Rainforests: trying to classify rainforests into types is not an easy task. Many other types of forest are classified by the main types of trees, but rainforest is distinguished by a multitude of species spread throughout the forest. Scientists have found it most useful to classify rainforests by their leaf size and different structural characteristics and complexity. Leaf size in rainforest trees is closely related with the wetness, temperature, fertility and altitude of a site. The simplest way of recognising the three main types of rainforest is:

- mesophyll (big leaves, longer than 12.5 cm)
- notophyll (medium sized leaves, 7.5–12.5 cm long)
- microphyll (small leaves, shorter than 7.5 cm)

Ramsar: the Convention on Wetlands of International Importance (the Ramsar Convention) was signed in Ramsar, Iran on 2 February 1971. The Ramsar Convention aims to halt the worldwide loss of wetlands and to conserve, through wise use and management, those that remain. The Convention encourages member countries to nominate sites containing representative, rare or unique wetlands, or that are important for conserving biological diversity, to the List of Wetlands of International Importance (Ramsar sites). Australia was one of the first countries to become a Contracting Party to the Convention and designated the world's first Ramsar site, Cobourg Peninsula in 1974.

Reach: a section of river with homogeneous geomorphic and hydrological conditions, containing a variety of potential habitat patches for flora and fauna.

Recruitment: the accession of reproductively mature individuals to a population that includes reproduction (for example germination or spawning) and the survival of young stages to maturity.

Reef Plan: a joint commitment between the Australian and Queensland Governments which aims to improve the water quality entering the Great Barrier reef by targeting land management practices that affect water quality. Reef Plan has been running since 2003 and will be reviewed in 2018.

Reverse sexual size dimorphism: this occurs when Australian freshwater females are larger than males of the species.

River systems approach: this method of planning fosters a holistic view based on a systemic approach that is embedded in strong linkages between the aquatic, estuarine and terrestrial ecosystems and the people and industries that rely on them.

Riffle: a short, relatively shallow and coarse-bedded length of stream over which the stream flows at higher velocity and higher turbulence than it normally does in comparison to a pool. As a result of the increased velocity and heightened turbulence, small ripples are frequently found. Riffles are usually caused by an increase in a stream bed's slope or an obstruction in the water.

Riparian: a riparian zone or riparian area is the interface between land and a river or stream— a river-side.

Sedimentary rocks: rocks, such as sandstone formed by the deposition of sediment.

SedNet: a simple, testable, physically-based model of catchment sediment sources and transport which can help to inform catchment management to give healthier catchments and rivers. <http://www.csiro.au/en/Organisation-Structure/Flagships/Water-for-a-Healthy-Country-Flagship/Ecosystems-and-Contaminants/Ecosystem-response-to-catchment-processes/SedNet-sediment-network-modeling-software.aspx>.

The Spring: the Species Recovery Information Gateway is a Queensland Government information storage system. It provides information about the conservation and recovery of Queensland's native plant and animal species particularly those at risk of extinction. The Spring provides useful resources and tools for groups and individuals involved with species recovery. It replaces and builds upon the Recovery Actions Database (RAD)—the original application which provided information on species recovery generated by the Back on Track species prioritisation framework. It is intended that the reporting functions of RAD will be integrated into The Spring. <http://www.ehp.qld.gov.au/wildlife/species-recovery/index.html>.

Standard regional ecosystem numbering in Qld: the Queensland Herbarium has developed a methodology for mapping regional ecosystems across Queensland. This results in regular updates to the descriptions and status of regional ecosystems. Regional ecosystem descriptions in the format of Sattler and Williams (1999) are maintained in the

Regional Ecosystem Description Database (REDD). Vegetation communities are amalgamated into the higher-level classification of broad vegetation groups (BVGs). <https://www.ehp.qld.gov.au/ecosystems/biodiversity/re_introduction.html>.

Threats: something likely to cause damage or danger.

Threatened: any species which is vulnerable to becoming endangered in the near future.

Tributary: a stream that flows to a larger stream or other body of water.

Umbrella species: whose conservation will also conserve other species.

Vulnerable: the species faces a high risk of extinction in the medium-term.

Wallum type ecosystems: a south east coastal Queensland / north-eastern New South Wales ecosystem characterised by flora-rich shrubland and heathland on deep, nutrient-poor, acidic, sandy soils and regular wildfire.

Water quality improvement plans: these identify the most cost-effective and timely projects for investment by all parties including the Australian, state and local governments, and community and environment groups. <http://www.environment.gov.au/topics/water/water-quality/water-quality-improvement-plans>.

Weeds of National Significance: thirty two Weeds of National Significance (WoNS) have been identified by the Australian Government based on their invasiveness, potential for spread and environmental, social and economic impacts. A list of 20 WoNS was endorsed in 1999 and a further 12 were added in 2012.

Executive summary

The Mary River is located on the northern fringe of the south-east Queensland region. The Mary River catchment is home to:

- 83 plants and animals listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- one ecological community listed in the EPBC Act, and
- the Ramsar listed Great Sandy Strait wetland.

The Mary River consists of about 3000km of major streams. From the south it flows from the Conondale and Blackall ranges northwards to the Burnett ranges, then flows east into the Great Sandy Strait at River Heads. The land and water resources of the catchment are integral to a range of industries, including agriculture, forestry, tourism and fishing.

Two approaches, a 'river systems' and a 'priority species' approach were used in the development of this plan. A river system approach was chosen because it fosters a holistic view which recognises the strong linkages between the aquatic and terrestrial environments and the natural resources, industry and the community. This approach can build on the decades of community-driven catchment management in the catchment. The priority species approach was selected because it deals with the complexity and any uncertainty in ecosystems (Lambeck 2009) which can be applied to the Mary River system. This recovery plan is the first national recovery plan that uses a river system approach.

Freshwater ecosystems throughout the world are under great pressure from human induced impacts. The Mary River has not escaped these pressures. For example, soon after European settlement in the region, gold mining released mine tailings into the river system, wide-scale land clearing occurred and sand and gravel extraction from the river bed rapidly changed the natural landscape. Impacts on the river are still occurring and the introduction and poor management of invasive plants and animals, continued clearing of vegetation and the introduction of water infrastructure like dams are still affecting the health of the Mary Rivers aquatic and terrestrial ecosystem. These impacts have contributed to the catchment being classified as between 'moderate' and 'poor' condition by the National Land and Water Resources Assessment (2002). Despite this, some relatively pristine areas remain. However the well-being of the river network is crucial for the survival and recovery of many threatened and endemic species that are found within the system.

This recovery plan focuses on five key species of the river system — a riverine turtle, three fish and one amphibian. These species were prioritised by using the 'priority species' approach and are:

- the 'endangered' Mary River cod (*Maccullochella mariensis*)
- the 'endangered' and endemic Mary River turtle (*Elusor macrurus*)
- the 'vulnerable' Australian lungfish (*Neoceratodus forsteri*)

- the ‘endangered’ giant barred frog (*Mixophyes iteratus*), and
- the ‘declining’ freshwater mullet (*Trachystoma petardi*).

Several criteria were used to select the five priority species. This includes:

- their conservation status under the EPBC Act
- the need for a revised recovery plan for the species, and
- the ecological niche these species occupy within the Mary River system.

This recovery plan prioritises the threats to these species. Some major threats include: weeds, which are constantly spread throughout the system (through floods); blockage to biopassage such as weirs and dams; predation of the priority species young by feral animals; and river and stream siltation resulting from land use that exacerbates soil erosion. The plan identifies actions to mitigate these threats. While some actions are specific to individual species, the majority of actions address system-wide threats and increase the stakeholder and community involvement in species recovery. This will help improve the river and catchment health.

The recovery plan also describes the:

- habitat needed for each of these species to breed, feed, move and find refuge from predators, and
- the environmental requirements through all stages of their life cycles.

Precise recovery planning for these species is constrained by lack of knowledge about:

- the species’ survival status
- some aspects of their ecology and biology, and
- the significance of the threatening processes.

The vision for the recovery plan is that within 100 years the status of the priority threatened species in the river has improved and the Mary River is supporting healthy populations of these species of national and international significance.

The overall long-term 100 year goals of the recovery program are that:

- healthy populations of the Mary River turtle, Mary River cod, Australian lungfish, giant barred frog and the freshwater mullet are present in the Mary River ecosystem and the listed species are down listed to a lower EPBC Act category, and
- there is improvement in the overall health of the Mary River that benefits all other native species indigenous to the catchment.

The seven recovery objectives guiding the plan are:

1	Maintain or increase the population of the five priority species.
2	Reduce threats to the five priority species and to the overall health of the Mary River.
3	Increase the quality, extent and connectivity of the habitat of the five priority species.
4	Undertake research and monitoring to close gaps in knowledge related to species recovery.
5	Ensure effective adaptive implementation of the plan
6	Increase society's capacity, sense of connectedness and motivation to contribute to the recovery of the five priority species and Mary River health.
7	Create opportunities for Indigenous people to make an input to the recovery process and opportunities for cultural connections as an integral part of the recovery of the five priority species.

To achieve these objectives, seven overarching actions have been identified:

Action 1: Manage threats to the priority species

Action 2: Manage threats to and improve habitat quality

Action 3: Conduct research essential for future management

Action 4: Coordinate implementation

Action 5: Secure resources for implementation

Action 6: Communicate effectively with partners and engage stakeholders and the community

Action 7: Involve and engage Indigenous people

These actions have been costed to provide an estimate of what it could cost to implement the highest priority actions over the first five years. The actions are further broken down into sub-actions. As a result, this recovery plan represents a comprehensive guide for the recovery process over the 10 year life of the plan. In addition, an implementation document providing additional information on the actions and sub actions has been developed to help guide implementation (Appendix 1).

Importantly, the actions that have been identified should have biodiversity benefits wider than the five priority species. About half of the EPBC Act listed plants and animals in the catchment use riparian (river-side) areas, the waterways of the catchment or need freshwater flows for all or part of their feeding, breeding and habitat requirements. The

implementation of this recovery plan will assist in the recovery of the riverine ecosystem through:

- improving water quality in the river
- increasing the ability of species to move within the landscape and the riverscape, and
- increasing the availability of riparian and in-stream habitats.

This recovery plan is designed to complement existing recovery plans for other threatened species and foster catchment management activities. It is not a substitute for detailed analysis of the specific needs and threats to all threatened species in the catchment.

Recovery planning in aquatic ecosystems must be dynamic and responsive to the multiple forms of connectivity which are inherent in a well-functioning river network. In the case of the Mary River, this connectivity stretches across 9600km^2. The river intersects with multiple land uses on mostly privately owned or leased land. It is a complex, interconnected social, economic and environmental system with a large number of stakeholders.

The performance criteria for this plan have been developed to guide this process and will be used in regular reviews of the recovery plan. Effective implementation of the plan will need to be underpinned by rigorous up-to-date science. The success of the plan will depend upon the extent to which affected and interested people across the spectrum of stakeholders continue to be engaged and contribute to the recovery process. It is through integrating these important elements that the ultimate goal of recovery for the five priority species and improvement in river and catchment health will be achieved.

1 Introduction

"Protection of freshwater biodiversity is perhaps the ultimate conservation challenge because it is influenced by the upstream drainage network, the surrounding land, the riparian zone, and—in the case of migrating aquatic fauna—downstream reaches." (Dudgeon et al. 2006).

1.1 Background

Throughout history Australian rivers have provided transport routes for Indigenous and non-Indigenous people and given access to food sources or transported resources to markets such as timber and agricultural produce. The Mary River ecosystem has been similarly used and exploited and transformed since European settlement. Water extraction and disposal of waste in the river, construction of dams, de-snagging of logs along the river and the affects of logging, agricultural industries and urban development have changed the way the Mary River functions. These impacts have greatly affected the quality and natural water flow of the Mary River and changed the surrounding landscape associated with the river system and the sea into which it discharges.

The river provides a significant supply of freshwater to the internationally-significant Ramsar-listed Great Sandy Strait wetlands. The Great Sandy Strait is home to the dugong, dolphins, migrating whales and migratory birds. In addition, significant recreational and commercial fisheries depend upon the freshwater flows from the Mary River. Hervey Bay, just to the north of the river mouth, contains the southern-most reef building corals on Australia's east coast (Zann et al. 2012).

1.2 Location

The Mary River is located on the northern fringe of the south-east Queensland region. It starts in the Conondale Ranges near Maleny and, with all its major tributaries, contains approximately 3000km of streams (Johnson 1996). The catchment covers 9595km^2 and stretches a distance of about 300km from Maleny to the river mouth at River Heads, west of Fraser Island (see Figure 1).

The Mary River catchment is located in the South East Queensland Bioregion (Interim Biogeographic Regionalisation for Australia or IBRA Bioregion). It is the southern-most catchment of the Great Barrier Reef. It is part of the 'Eastern Australia Rivers and Streams' ecoregion which is listed as one of the 200 highest conservation priority ecoregions in the world (Olson and Dinerstein 2002).

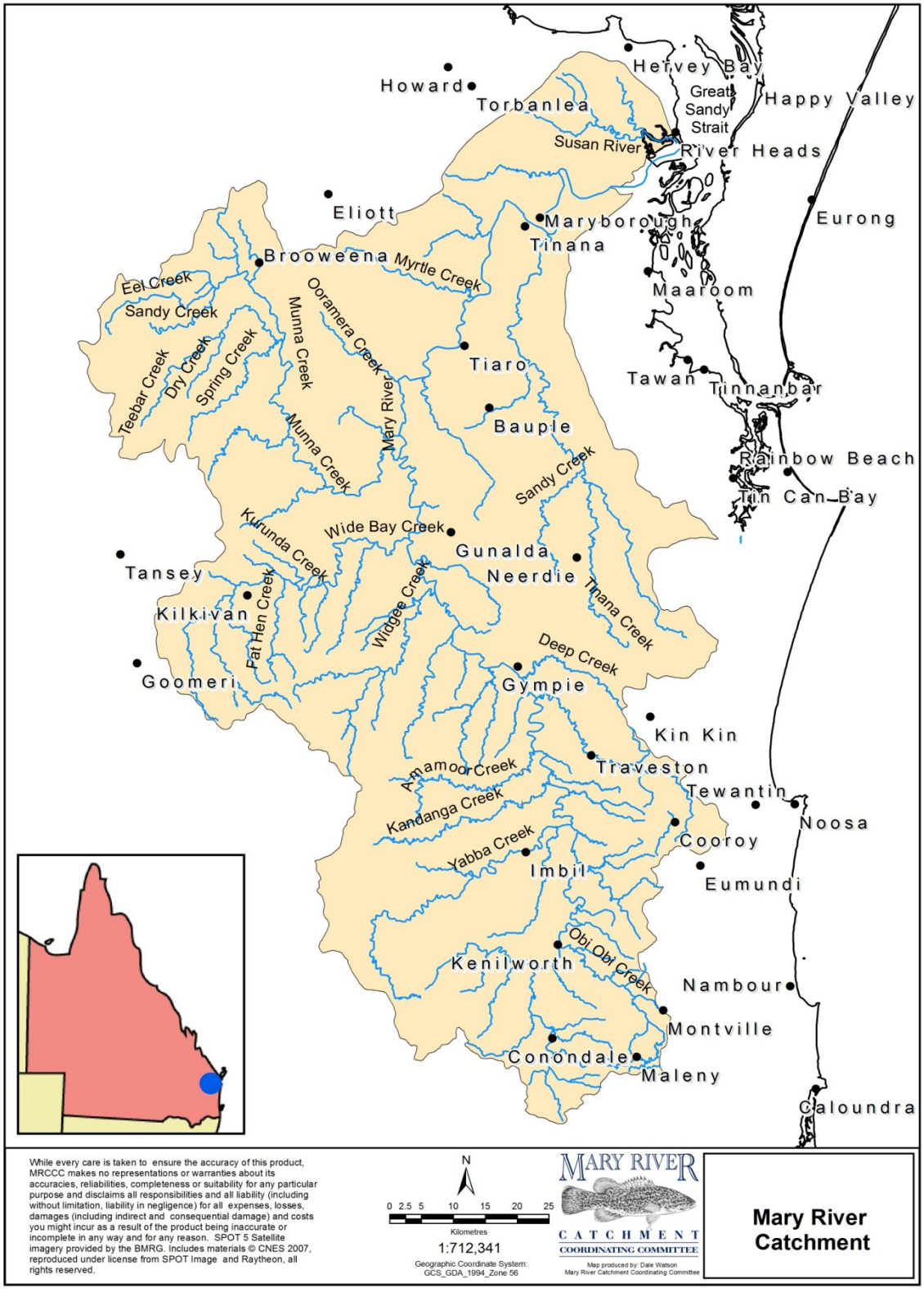


Figure 1: Map of the Mary River catchment area showing main tributaries

Source: MRCCC 2013

1.3 The ecological significance of the Mary River ecosystem

Arthington and Bunn (2008) regard the Mary River as 'highly significant' from a biodiversity and conservation perspective. The Mary River is considered to be highly representative of the rivers of the bioregion in which it is located (ie, large land areas characterised by broad, landscape-scale natural features and environmental processes that influence the functions of entire ecosystems).

The Mary River has close biological linkages to the neighbouring Burnett River and aquatic species share similar aspects of hydrology, biology and ecology. The Technical Advisory Group to the Recovery team that developed this plan, describes the Mary River as:

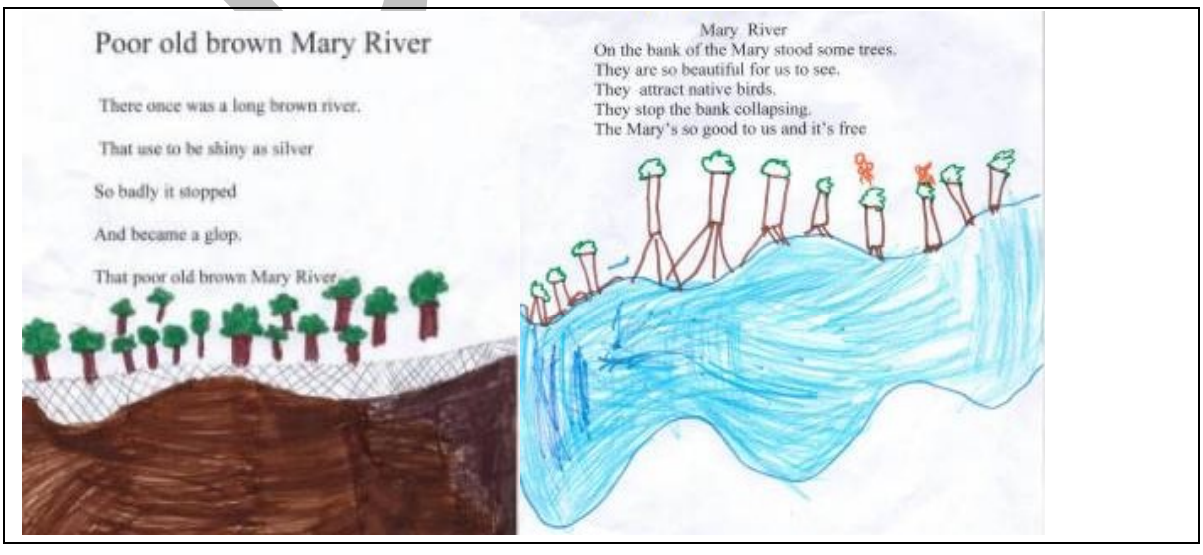
"*a high integrity and representative example of a south-east Queensland free-flowing riverine ecosystem, rich in unique species of national and international significance."*

1.4 Vision for the recovery plan

The *Mary River Threatened Aquatic Species Recovery Plan* is focused on ensuring a positive future for the Mary River.

The vision is: In 100 years' time, the status of the threatened species in the river has improved and the Mary River is supporting healthy populations of these species of national and international significance.

Achieving this vision will require significant improvement in the existing state of the river. Objectives and corresponding actions have been developed to help achieve this vision and are detailed in section 5.6. The current perception of the river by local children in the catchment could provide an indication of how much work is needed. The following limericks and drawings produced by members of Class 4/5MM at Gympie South State School summarise some of the issues that this recovery plan needs to address.



There once was a Australian lungfish called Noo
He didn't know what he could do
The river is a mess
It gives me lots of stress
I wish it would go back to blue

Water window into the future

In the year 2050, the last evidence of the Australian lungfish is about to disappear. The Mary River is in its' most worse position at the moment. The river is also 100 per cent filled with pollution. Nearly all the people who care about the river have either died or left. Some of the people who care about the river are trying to get it back to health.

1.5 Scope of recovery plan

The Mary River Threatened Aquatic Species Recovery Plan constitutes the formal national recovery plan for the EPBC Act listed species:

- Mary River turtle (*Elusor macrurus*); and
- Mary River cod (*Maccullochella mariensis*).

the plan also refers to the:

- Australian lungfish *(Neoceratodus forsteri*), which at time of writing has a recovery plan in preparation covering its the entire distribution;
- Giant barred frog *(Mixophyes iterates),* which has an existing recovery plan covering its entire distribution; and
- Freshwater mullet (*Trachystoma petardi*), which is not listed.

The choice of species is based on five criteria that were developed by the recovery team. Each priority species chosen satisfied at least three of the five criteria. The criteria were:

- The species is threatened
- A new or revised recovery plan is needed for the species
- Populations in the Mary River are a significant proportion of the entire national population and are in decline or under significant threat
- Actions that reduce threats, improve habitat or meet life cycle requirements of the species will also enhance key ecological functions and benefit other species in the catchment, and
- The species have community appeal (either through their iconic status or Indigenous/cultural value).

Figure 1 shows the geographic scope of this plan based on the catchment of the Mary River and its tributaries. The upstream boundary of the plan is defined by the distribution of the 'priority species' life cycles.

The downstream limit of the plan is the Great Sandy Strait Ramsar Site boundary at Beaver Rock north of Maryborough. The location of the downstream boundary also enables the plan to consider the water quality upstream and downstream of the two barrages. These barrages were installed for irrigation and urban water supply and separate the tidal reaches from the freshwater reaches. Freshwater mullet and numerous other fish species need to move between fresh and sea water for breeding and sometimes have difficulty because the fish ladders are not entirely effective to allow this passage.

The distance from the river's edge that has been adopted for the scope of this plan will vary for each of the five priority species and will be relevant to the ecological requirements specific to their survival.

1.6 Benefits/impacts to biodiversity

By focusing on the priority species, the plan identifies the recovery actions and management practices necessary to ensure:

- the long-term viability of the threatened and priority species, and
- the overall biodiversity of the Mary River system.

No adverse impacts to biodiversity are expected as a result of implementing actions in the plan. Appendix 2 lists the species which rely on the Mary River and associated riparian zones that will benefit from actions undertaken in this plan.

1.7 Social and economic benefits/impacts

The land through which the Mary River flows is generally fertile and productive. Prior to European settlement the Mary River was home to numerous Indigenous communities who placed great cultural significance upon the river. The Mary River now supports well-established urban communities, rural residential communities and agricultural enterprises. Four local government areas are located wholly or partly within the catchment and the river underpins much of their economic and social viability.

Implementation of this recovery plan will provide a number of social and economic benefits. Recommended recovery actions are compatible with the continuation of existing land uses. Actions will focus on using increased knowledge and implementing 'best practice' management. Improved planning and development will minimise impacts on the Mary River and the associated species it supports.

The recovery plan also focuses on promoting partnerships and voluntary participation in biodiversity management. It is therefore anticipated that there will be no significant adverse social or economic costs associated with the implementation of the plan. It is envisaged that any benefits to society will outweigh any disadvantages.

1.8 Social and economic benefits include:

- addressing community concerns about the continued loss of biodiversity, strengthening community networks, providing opportunities for leisure
- addressing landholder concerns about weeds, their economic impact and loss of agricultural productivity through stabilisation and restoration of riverbanks and improved ground cover and maintaining and improving the visual amenity of the river
- management of remnants of native vegetation, developing a seed resource base for regeneration and maintaining wild gene pools by increasing the population size of priority species
- providing public education regarding the protection and enhancement of the river and the species it supports
- maintaining the productivity of recreational and commercial fisheries
- improving river resilience to floods (improved flow regimes—reduced power of floods, lower sediment loads thus improved clarity; improvement of downstream ecosystems, for example seagrass beds in Hervey Bay etc.), and
- building social networks and capacity.

1.9 International agreements

The following international agreements and conventions are relevant to this recovery plan. This recovery plan is consistent with these obligations.

- Convention on Biological Diversity
- Ramsar Convention on Wetlands
- Convention on International Trade in Endangered Species of Wild Fauna and Flora
- China, Japan and Korean -Australia Migratory Bird Agreement
- Convention on Migratory Species
- UNESCO Man in the Biosphere Program, and
- UNESCO World Heritage Convention.

1.10 Plan preparation and consultation

The recovery plan was prepared by the Mary River Catchment Coordinating Committee (MRCCC) in collaboration with the Department of the Environment. The MRCCC is based in Gympie www.mrccc.org.au and represents 24 sectors across the Mary River catchment. They are a dedicated community group consisting of a small number of paid staff, with volunteer executive and delegate committees. It is intended that the MRCCC will undertake much of the coordination of the implementation of this plan.

This plan has been prepared under the Australian Government's EPBC Act. The focus of the plan is on aquatic threatened species. This is the first national recovery plan to focus on a river system. The MRCCC has worked closely with the Australian Government forming a recovery team, a technical advisory group and indigenous working group to develop this plan. These groups have laid a strong foundation for any future implementation of the recovery plan actions. The accompanying document provides additional supplementary information detailing the stakeholder engagement process and the membership of these two groups.

2 Mary River Catchment

The Mary River has significant cultural, social and economic importance for people within its catchment area. For thousands of years the river has been used by Indigenous peoples for hunting and gathering, as a meeting place and as a pathway for travel. During European settlement the river became a pathway for new emerging industries. It was used to transport red cedar timber logged in the upper catchment to the river mouth. The river was the means by which settlers arrived and freight was exported and imported via the port of Maryborough near the river mouth.

Today the river is used for domestic and urban water, irrigation water for agriculture and for recreational and commercial fisheries in the estuary. The river fuels the ecosystem on which nature-based tourism in the region depends. Ecosystem values are recognised in the designation of the Great Sandy Biosphere and Noosa Biospheres. These are the only two adjacent biosphere reserves in the world and significant parts of the Mary River catchment are included in these biospheres.

2.1 Indigenous culture

The Mary River has cultural and spiritual significance to the traditional owners of the area. The catchment area has associations with Indigenous people with several language groups, native title and cultural heritage interests. Broadly speaking, the Mary River catchment is separated between two main Indigenous groups;

- the Butchulla people, who are associated with the northern part of the catchment , and
- the Kabi Kabi people, who are associated with the southern part of the catchment.

A third group, the Jina burra people are connected with the southern part of the catchment. A number of other Indigenous peoples, such as the Wakka Wakka and Gubbi Gubbi have had historical associations with the river. Some names for the Mary River include '*Moonaboola*' and '*Numabulla'*. In the past tribes would travel along the river for significant gatherings such as the Bunya Festival in the Bunya Mountains and Diamond Scale Mullet gatherings in and around K'Gari (Fraser Island). Permission was granted at these times for people from outside the area to move in and share the bountiful food of bunya nuts or fish.

The river is associated with numerous Indigenous sacred sites, specific watering points, resource areas for food supplies and cultural landscapes. Before European settlement, the use of natural resources was tightly controlled by local Indigenous people to facilitate a caring for the land approach.

> ***Mimburi*—the environmental law of the Mary River people**
>
> *'Mimburi'* means 'continuous flow' in Kabi Kabi language. Before white settlement, a form of traditional environmental law operated amongst the Indigenous groups living in or passing through the catchment that preserved this flow. This law included knowledge of the species and of the times in their life cycles that were crucial to their ongoing survival. For example, during Dewfish or eel-tailed catfish *(Tandanus Tandanus)* nesting season *Mimburi* required that breeding dewfish not be caught. If a person broke this rule they could be punished. (B. Hand, pers comm. 2012: A. Bond, pers. comm. 2011)

2.2 Mary River since European settlement

The first Europeans to document their travels in the Mary River district were Andrew Petrie, of Brisbane; Wrottesley, an English aristocrat; Henry Stuart Russell, of Cecil Plains; Joliffe who had been a 'middle' in the Royal Navy; and five convicts. Together with two Indigenous people they made a trip to the district in May 1842 (McKinnon 1933). Early settlers accessed the river over land from the south and by water from the north. Some early accounts of the river in the vicinity of Tiaro/Maryborough region refer to the "jungle on the banks of the Mary" (Loyau 1897). This refers to the original riparian vegetation, of which only remnants remain today.

The river in the north was known as the Wide Bay River. A port was established at Maryborough in 1847 and provided settlers in the region with supplies and the ability to ship their products to market. The location is now known as the Old Maryborough Town site and is built upon an important Indigenous fishing spot, water source and crossing point for the Butchulla people in the area (Mathews 1995).

Rich grazing lands in the upper Mary River catchment attracted European settlers from the 1850s onward (Johnson and Saunders 2007). In 1867 gold was discovered in Gympie. The Mary River soon became heavily polluted due to the gold tailings being deposited in the river from the mining operation.

By the 1860s the lives and culture of the Indigenous people associated with the Mary River had been severely impacted as a result of disruption by the settlers and the native

mounted police (Brown 2000), who were deployed as a government-financed frontier force usually led by white police officers (Whittington 1965). Indigenous people assisted some of the early explorers including escaped convicts. These convicts who lived with the local Indigenous people often revealed the pathways and practices of the local people to the settlers.

In the 1870s timber fellers began harvesting timber in the upper Mary River catchment. The Mary River was used to float logs to the sawmills. At times rafts of these were reported to cover the width of the river. Thirty years later red cedar *(Toona ciliata)* (the most sought after tree) was practically wiped out in the area and approximately 30 per cent of the hoop (*Araucaria cunninghamii)* and bunya *(Araucaria bidwillii)* pine forests were also cleared (Johnson and Saunders 2007).

2.3 Population

The total population of the catchment area is around 150,000 people, living in urban areas, rural subdivisions and agricultural properties. Based on population by postcode it is estimated the population within the catchment area has grown from 81,000 in 1996 (Pointon and Collins 2000) to 95,194 in 2011 (ABS 2012). These figures do not include the people within the population centre of Hervey Bay (55,298 people in 2011) who also live within the catchment area.

As of 2009, the predominant land use in the catchment is beef cattle grazing (51 per cent of the land area), followed by forestry (21 per cent) and a range of other agricultural and horticulture industries (Fentie et al 2014). In 2009 the percentage of the catchment occupied by conservation areas was 18 per cent, residential area 5.8 per cent, sugar cane 2 per cent and horticulture 1 per cent. Figure 2 shows the distribution of different land uses throughout the catchment.

Data in the *Reef Water Quality Protection Plan* (State of Qld 2011a) indicate that 78.7 per cent of assessable[1] riparian areas in the Mary River catchment remain forested. Based on satellite imagery 'forested' is defined as 'having at least 11 per cent foliage projective cover'. Of the non-forested riparian area, 20.2 per cent was regarded as having high levels of ground-cover (more than 50 per cent ground cover) and 0.2 per cent had low levels of ground cover (less than 50 per cent). Land tenure in the catchment is predominantly freehold with another significant portion of the land being held in state forests. Plantation trees in the state forest are currently leased to HQ Plantations Pty Ltd who are responsible for land management. They are the largest tree plantation company in Queensland. Table **1** summarises the tenure as of 2003.

Table 1: Tenure of allotments of over 50 ha in the Mary River catchment area

Tenure	Area (ha)	Percentage
Freehold	401,460	42.4
State forest (leased under private control)	270,350	28.6

[1] 2.4 per cent of the riparian area could not be assessed due to cloud cover, topographic shadow or water within the riparian area.

Land lease (leasehold)	13,480	1.4
National park	5,770	0.6
USL (unallocated state land)	10,960	1.2
Reserves, parks etc.	6,170	0.7
Timber reserve	4,110	0.4

Source: (DNRM 2003)

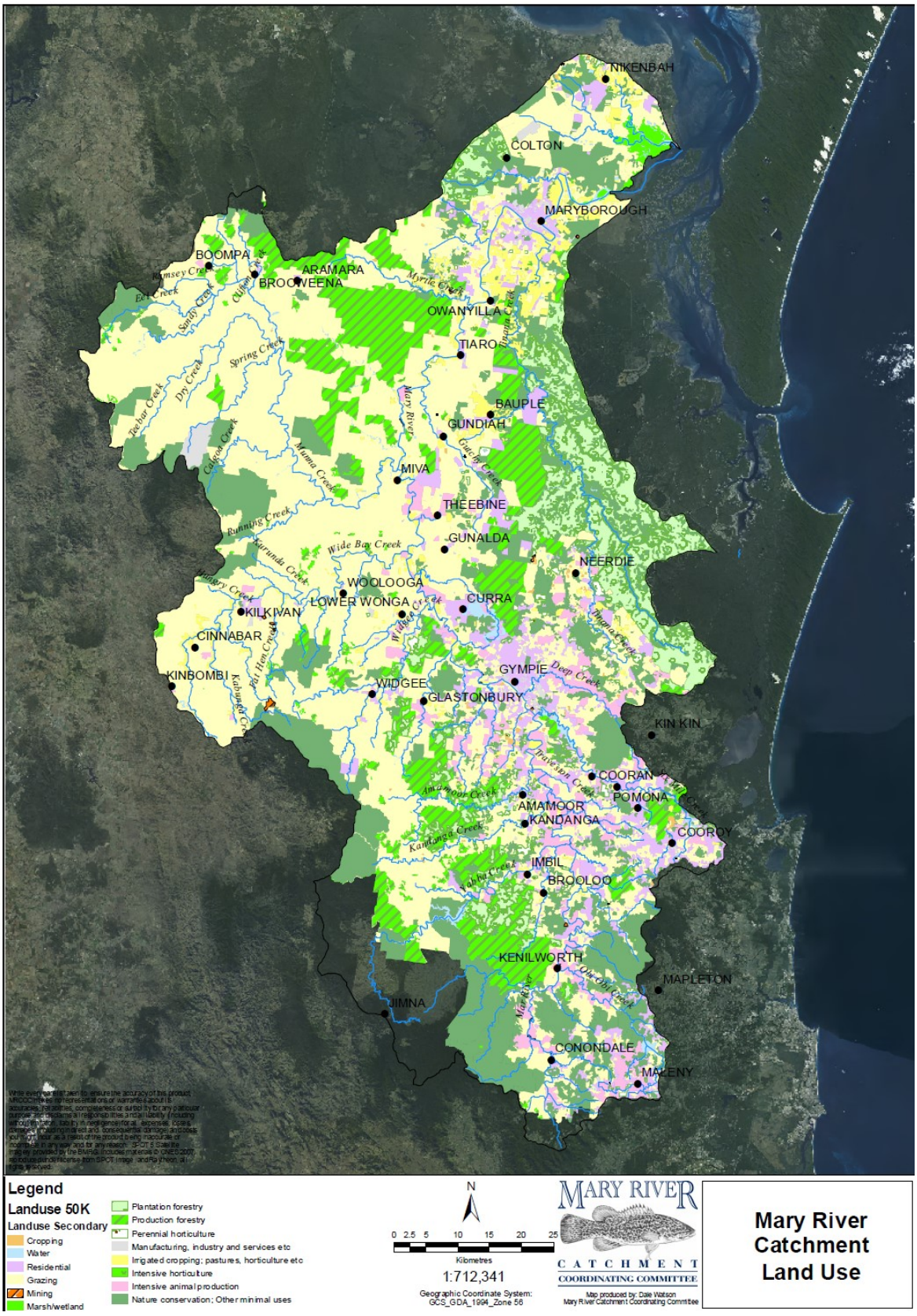


Figure 2: Land use in the Mary River catchment area Source: MRCCC 2013

2.4 Water resource use

Water extracted from the Mary River is used for irrigation, watering stock, domestic use and town water supplies. There are four water storage areas in the catchment, two tidal barrages, eight weirs and numerous urban water off-takes.

Groundwater is pumped from bores for irrigation and watering stock in some areas of the western part of the catchment such as Wide Bay Creek. Groundwater use is not regulated and anecdotal reports suggest a possible correlation between reduced levels of water in creeks and intense water extraction from bores.

The *Mary Basin Water Resource Plan* (State of Queensland 2006) and *Mary Basin Resource Operations Plan* (State of Queensland 2011b) stipulate how much water can be extracted from the Mary River. These documents do not regulate groundwater use, except for the area of the Cooloola Sandmass. To support the growing population of South East Queensland a new pipeline has been built. The Northern Pipeline Interconnector connects the Mary River to the South East Queensland water grid. This new integrated water infrastructure network was proposed by the Queensland Government following one of the state's worst droughts on record in 2006. It aims to provide a stable water supply for south-east Queensland, in particular the population of the Sunshine coast and Brisbane metropolitan areas. Therefore growth of Queensland's population and future water management strategies will have an impact on future water use of the Mary River.

2.5 Rainfall and climate

The average maximum temperatures vary from the low 20s to low 30s (ºC). The natural flow regime of the Mary River has been classified as unpredictable and intermittent by Kennard et al. (2010). Stream flow can be very different between the wet and dry areas of the catchment and during dry seasons. Typically this is between July to November and in extremely dry years the Mary River will cease to flow downstream of the Gympie town water intake. This occurred in August 2002 (Burgess 2009).

Rainfall typically occurs in the late summer and early autumn, although significant rainfall totals have been recorded in all months of the year and their occurrence is highly unreliable (Bridges et al. 1990). Mean annual rainfall varies considerably from 2000mm near Maleny in the south, to less than 800mm in the western parts of the catchments (Pointon and Collins 2000).

Generally, the Mary River upper catchment is much wetter than the north-western and lower catchment areas, which means that this part of the catchment contributes considerably more stream flow to the river than the lower catchment.

2.6 Geology

The Mary River catchment is classified as 'subtropical' and contains several large sub-catchments that differ in their rainfall, geology and infrastructure. The various soils types that have been derived over geological timeframes have shaped the vegetative growth that is evident in the catchment today.

The main trunk of the Mary River and its major western tributaries north of Gympie, are classified as moderate to high energy sand and gravel-bed streams. This means they are more likely to be eroded than other parts of the catchment. Coal bearing seams are also found in this part of the Mary River catchment.

2.7 Catchment features and infrastructure

There are two barrages damming the lower parts of Mary River system, one on the Mary itself and the other on Tinana Creek (a major eastern sub catchment occupying 14 per cent of catchment area). During periods of low flows connection between the river and the sea can be broken, as the water level in the barrages will drop below the fishway level.

Ecological impacts from this disruption can be significant. When the water is not moving, invasive aquatic plant infestations increase, dissolved oxygen is depleted and transpiration rates are greatly increased. This effect has adverse impacts on all the aquatic life in the Mary River.

The Obi Obi Creek, a major tributary in the south has been dammed to form Baroon Pocket Dam. The remnant native vegetation in this area is predominantly rainforest. Six Mile Creek has also been dammed to create Lake MacDonald. Yabba Creek to the south-west of Gympie was dammed to form Lake Borumba.

2.8 Stream flow

During the months from July to November stream flow is typically at its lowest due to low rainfall at this time of year. Peak demand for river water usually occurs during these months. The water is used mostly for irrigating crops or pasture for agricultural use. Water extraction along the Mary River is most apparent along the middle areas of the catchment. At times extraction may remove more water from the river than what is introduced through rain runoff (Burgess 2008).

Low freshwater flows from the Mary River combined with high evaporation levels can cause Hervey Bay to become an inverse estuary and hyper saline (ie, saltier than sea water) (Ribbe 2006). Under the inverse estuary conditions heavy salt water sinks to the bottom and modifies marine currents in Hervey Bay and the southern Great Barrier Reef Lagoon. As a result of severe droughts and the climatologically trend toward a drier Australian east coast, stream-flow out of the Mary River catchment area has reduced by at least 23 per cent over the last two decades (Gräwe et al. 2010). These predicted climate change trends are likely to contribute to further reductions in stream flow to the Mary River.

3 Catchment biodiversity

3.1 Biodiversity

The Mary River catchment is an area of high biodiversity. The southern part of the catchment is included in the Macpherson Macleay overlap where tropical and temperate floristic zones overlap (Burbidge 1960). The tributaries of the river extend across a range of soil types, differing annual rainfall totals and varied vegetation types. These range in the east from wallum type ecosystems (a south-east coastal Queensland/north-eastern New South Wales ecosystem characterised by flora-rich shrub land and heathland on deep, nutrient-poor, acidic, sandy soils impacted by regular wildfire) to rainforest in the south. Eucalypt woodland and pockets of dry rainforest are found in the west. A large proportion of the catchment has been cleared for grazing or timber plantations.

The high levels of biodiversity and the current state of the catchment can be reflected in the large numbers of species listed as threatened at the National and state levels. Fifty one animal and 32 plant species associated with the Mary River catchment are listed under the EPBC Act. Several of these are endemic to the Mary River (See Appendix 2). A further 21 species associated with the estuary are listed as migratory under the EBPC Act (7 of these are also listed as threatened under the EPBC Act) and one additional species associated with the estuary is listed as threatened under the EPBC Act. Around half of the EPBC listed species have a close association with riparian areas or rely directly upon rivers, creeks or freshwater flows for part or all of their life cycle. At a Queensland state level there are an additional 38 animals and 40 plant species from estuarine, terrestrial and aquatic environments that are not listed under the EPBC Act. These are listed as either endangered, vulnerable or near threatened under the Queensland Government's *Nature Conservation Act* 1992 (NCA) (WildNet 2013) (See Appendix 2).

The Mary River catchment is inhabited by one of the most species-rich freshwater turtle communities in Australia. Australia has eight genera of turtles and six of these are represented in the Mary River catchment. The monotypic (one representative) genus Elusor is endemic only to the Mary River system and is represented by the Mary River turtle (*Elusor macrurus*). The white-throated snapping turtle (*Elseya albagula*) is restricted to the Mary River and the neighbouring Burnett and Fitzroy River systems. In terms of freshwater turtle conservation, the Mary River is one of the most significant river systems in Australia (Moll and Moll 2004, Limpus 2008).

The estuary at the mouth of the Mary River supports the largest population of dugongs (*Dugong dugon*) on the east coast of Australia south of Torres Strait. Significant areas of the critically endangered ecological community, the 'Lowland Rainforest of Subtropical Australia' listed under the EPBC Act are also found in the catchment, often in riparian areas along the Mary River.

The Great Sandy Strait Ramsar site (DEH 1999) is a matter of national environmental significance. This site includes the tidal waters of the Great Sandy Strait, Mary River, Susan River, Kauri Creek, Tin Can Bay and the freshwater swamps and plant communities associated with the mangroves on Fraser Island and southwest of Rainbow Beach. Internationally significant populations of migratory birds designated under several international migratory bird agreements visit the Great Sandy Strait regularly. The western beach of the World Heritage listed Fraser Island is approximately 10 km east of the mouth of the Mary River.

Six species of freshwater mussels have been confirmed in the Mary River (K Walker, pers. comm. 2013; Walker et al. 2013; Jones and Byrne 2013). The Mary River system has one of the most diverse assemblages of mussels in Australia (H Jones, pers. comm. 2011). As is generally typical in Australian rivers, crustaceans and molluscs are the dominant invertebrate (animals without backbones) groups in the lowland catchment area whereas insects are the dominant invertebrates in the upper catchment area of the Mary River. Mussels take up particles, such as algae and bacteria, from the water and help maintain clean water in aquatic habitats. In addition, the shells of mussels help stabilise sediment at the bottom of lakes and rivers and provide shelter for small animals living in these habitats.

3.2 Catchment condition

The 2002 National Land and Water Resources Audit classified the Mary River catchment condition as between poor and moderate (National Land and Water Resources Audit 2002). Runoff and sediment loss from the Mary River catchment has contributed to destruction of seagrass meadows. For example, dugongs who survive on these seagrass meadows were reported to have dropped in population numbers from 2000 to 100 (Preen et al. 1995). Butler et al. (2013) reported coral death and suggest that this could have resulted from runoff in Hervey Bay. The National Action Plan for Salinity and Water Quality in 2000 (COAG 2000) recognised the Mary River catchment as a priority for remedial action. Numerous reports have identified that the Mary River catchment contains areas that require serious remedial action and include:

- *State of the rivers* report (Johnson 1996)
- Mary River Tributaries and Rehabilitation Plan (Stockwell 2001), and
- the Priority Action Program (MRCCC 2005).

3.3 Regional ecosystems

Sattler and Williams (1999) originally defined regional ecosystems as vegetation communities within a bioregion that are consistently associated with a particular combination of geology, landform and soil. Descriptions presented in Sattler and Williams (1999) were derived from a broad range of existing information sources including land system, vegetation and geology mapping and reports.

The Queensland Herbarium has developed a methodology for mapping regional ecosystems across Queensland. This results in regular updates to the descriptions and status of regional ecosystems. Regional ecosystem descriptions in the format of Sattler and Williams (1999) are maintained in the Regional Ecosystem Description Database (REDD). Vegetation communities are amalgamated into the higher level classification of broad vegetation groups (BVGs). It should be noted that this recovery plan applies to those REs at altitudes below 300m.

The Mary River catchment area contains approximately 11,000ha of the EPBC Act listed critically endangered ecological community of the ‘Lowland Rainforest of Subtropical Australia.’

Tributaries in the Mary River catchment contain numerous threatened riparian plant species such as *Cossinia australiana, Alyxia magnifolia* and *Choricarpa subargentea* (Stockwell et al. 2004). The western tributaries of the mid Mary River catchment are regarded as important for the recovery of *Macadamia integrifolia* and *Macadamia ternifolia* (Costello et al. 2009).

Table 2: Priority species, current conservation status, population in the catchment and relationship to other recovery plans

Priority species	**Conservation status**			**Percentage of natural population in the Mary River catchment**	**Relationship to existing recovery plans and conservation advices**
	Queensland		**C'wlth**		
	Back on Track[1] *(nb Regional not State ranks are used)*	***NCA Act 1992 / Fisheries Act 1994***	***EPBC Act 1999***		
Mary River cod	Critical	Not protected under NCA 'No Take' under the Fisheries Act 1994	Endangered	100% Populations elsewhere are entirely captive bred or are descendants of captive bred individuals.	This plan replaces *Mary River Cod Research and Recovery Plan* (Simpson and Jackson 1996)
Mary River turtle	Critical	Endangered under NCA	Endangered	100%	Existing conservation advice
Australian lungfish	Critical	Not protected under NCA 'No Take' under the Fisheries Act 1994	Vulnerable	50%	Complements the *National Australian Lungfish Recovery Plan* (Australian Government in prep)
Giant barred frog	High	Endangered under NCA	Endangered	~65%	Expands on Mary River specific aspects of the *Stream Frogs Recovery Plan* (Hines et al. 2002)
Freshwater mullet	Low	Not listed	Not listed	Most northerly population	No existing conservation advice or recovery plan

1. Back on Track Queensland species prioritisation framework for the Burnett Mary Region (Department of Environment and Resource Management 2010). Note: Back on Track ranks included in this table are the result of the criteria weighting process done by the Burnett Mary Regional Group to reflect how the organisation valued each criterion under Back on Track.

4 Priority species

4.1 Mary River cod (*Maccullochella mariensis*)

The Mary River cod is closely related to the Murray cod (*Maccullochella peelii peelii*) and the Eastern freshwater cod (*Maccullochella ikei*) (Nock et al. 2010). Mary River cod are endemic to the Mary River and represent a type of fish that is believed to have occurred throughout waterways in south-east Queensland. They were common in the catchment and early settlers used them for pig food. Over fishing and habitat deterioration has contributed to major population declines (Simpson 1994). Based on anecdotal reports their sharp decline occurred sometime between 1930s and 1960s (Simpson and Jackson 1996). Genetic population analysis has recently shown that there are separate genetic stocks in Tinana Creek (Huey et al. 2013).

Population status

The current status of the population is unknown although it is believed to inhabit 30 per cent of its original range (Simpson and Jackson 1996). The last broad scale population survey of the cod took place in 1994 (Jackson 2008) and a distribution study of cod habitat was conducted in 1998 (Pickersgill 1998). Simpson and Jackson (1996) estimated that the population consisted of less than 600 individuals in the Tinana, Six Mile and Obi Obi Creek systems, with an unknown number in the remainder of the river system. Targetted studies of reaches affected by management of water infrastructure have occurred in more recent years (DNRM 2016) and have focussed on genetics, movement, demography age and specific habitat requiremetns.

A Mary River cod captive breeding program operated from around the 1970s to 2000s by recreational anglers but since the late 1990's has included a conservation component. The program has released fingerlings in 85–90 per cent of their former range since 1998 (Jackson 2008). There are no data available to determine if the releases have resulted in any self-sustaining populations but stocking has not reduced the gene pool of the natural population (Huey et al. 2013). Recent studies of larval fish assemblages in Six Mile, Obi Obi and Tinana Creek have confirmed the presence of cod larvae in these systems, indicating that breeding is occurring (Dunlop 2016).

Distribution

Figure 3 depicts the known and likely distribution of the Mary River cod in the Mary River catchment. Compared with information in the *Mary River Cod Recovery Plan* (Simpson and Jackson 1996) the known distribution of the Mary River cod has slightly expanded.

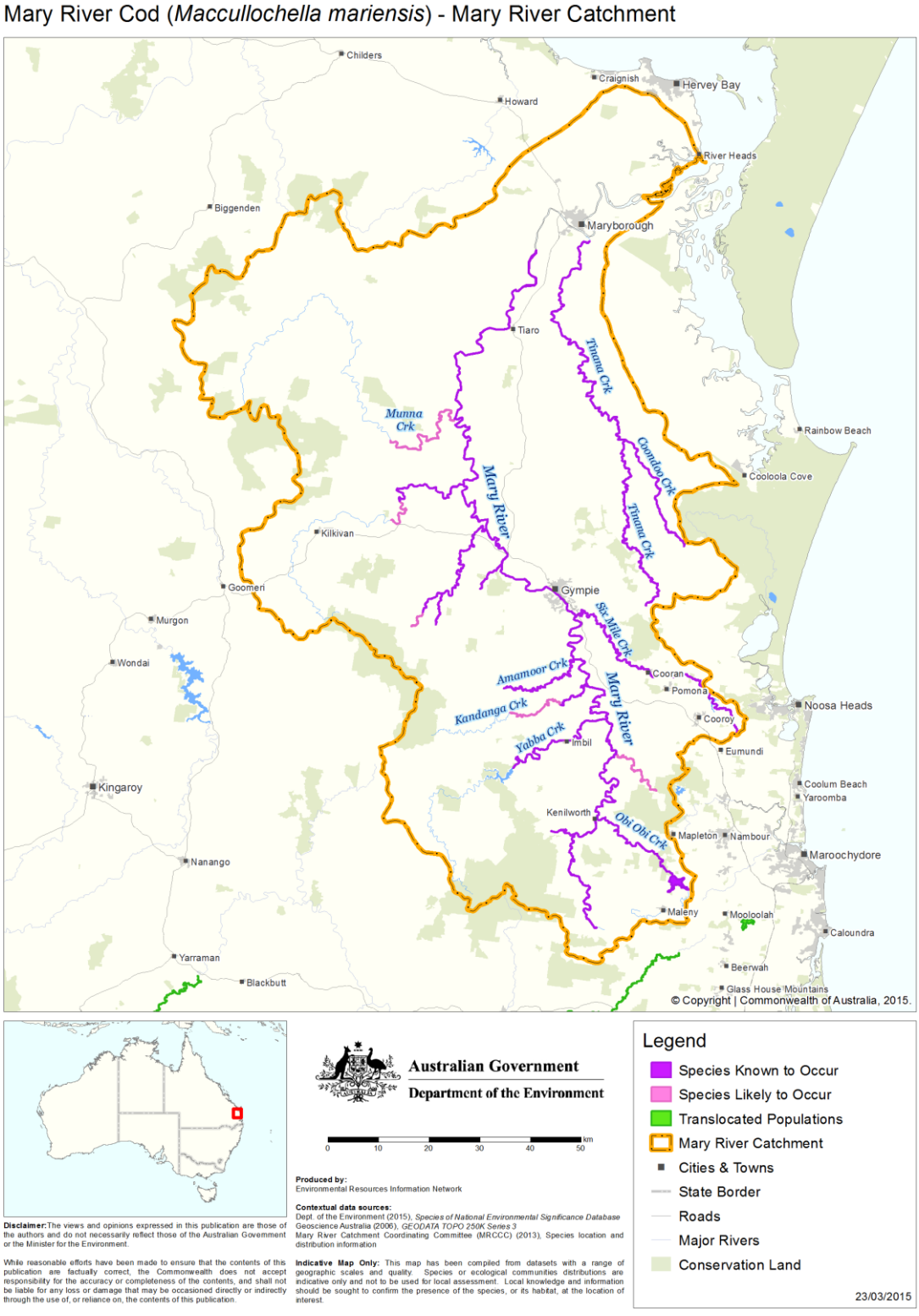


Figure 3. Distribution of Mary River Cod

4.2 Mary River turtle (*Elusor macrurus*)

The Mary River turtle occurs only in the Mary River and was formally described in 1994 (Cann and Legler 1994). It is one of two of the six turtle species in the Mary River and is considered a high risk of extinction, with a ranking of 41 on the global list of at-risk turtle species (Turtle Conservation Coalition 2011).

The Mary River turtle has a unique characteristic shared by only a handful of turtles in the world. It has a well-developed bimodal respiration and specialised gill system in its cloaca. Although the lungs are not involved there is an exchange of oxygen across the cloacal membrane and buccopharynx (mouth cavity) (Clark et al. 2008, FitzGibbon and Franklin 2010). The males of this species are the largest male turtles in the Mary River and amongst the largest freshwater turtles in Australia (Limpus 2008). The Mary River turtle is one of two Australian turtle species with reverse sexual size dimorphism where freshwater males are larger than the females.

Population status

Nest surveys indicate that the Mary River turtle has declined by about 95 per cent since 1974, with the majority of this decline occurring in the lower catchment (Flakus 2003). Current population trends appear to reflect weather variables rather than either an increase or decrease in the number of adult females (M Connell, pers. comm. 2013).

Distribution

The Mary River turtle is found from Kenilworth to the Mary River Barrage on the main trunk of the river, Yabba Creek downstream of Borumba Dam and in Obi Obi Creek below Baroon Pocket Dam. Their presence in Tinana Creek was based on one sighting (Flakus 2002, Limpus 2008) which has been recently corroborated by further confirmed sightings in 2014. Figure 4 depicts the distribution of the Mary River turtle.

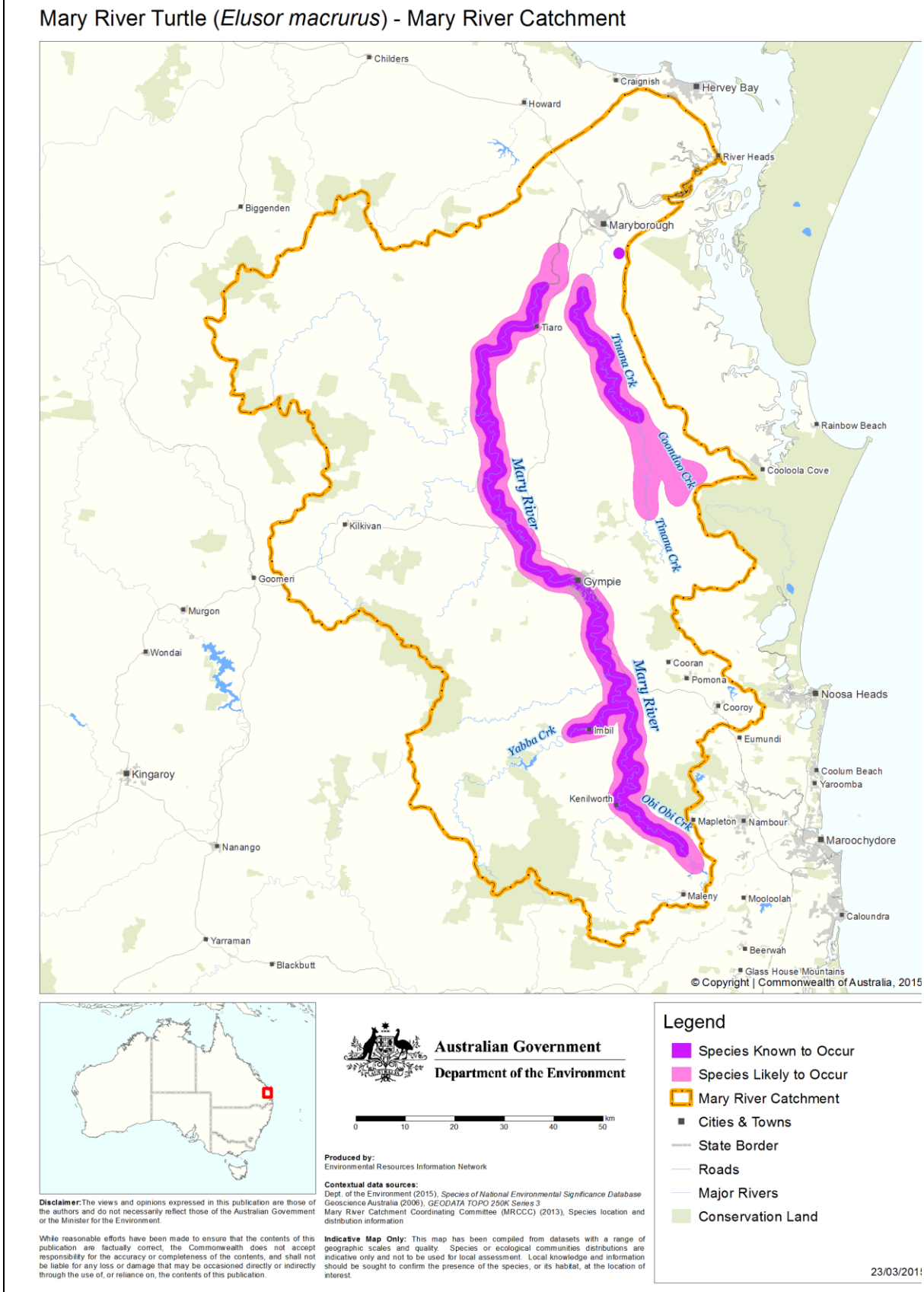


Figure 4. Distribution of Mary River turtle.

4.3 Australian lungfish (*Neoceratodus forsteri*)

Mystery of the Australian lungfish (Neoceratodus forsteri)
From the earliest times (1870) when Ceratodus (Epiceratodus forsteris Krefft 1870) became known to the scientific world and was described by Gerhard Krefft of the Australian Museum, no one, not even Indigenous Australians were able to find the very young fish: individuals even 3 kg in weight were scarce and only very rarely indeed were specimens 1 or 2 kg in weight taken.

From On the life history of Ceratodus, Thos Bancroft (1928)

The Australian lungfish is a prehistoric fish which occurs in a number of river systems in south-east Queensland. The fish has not changed for the last 200 million years (Joss 2004). When it first became known to the scientific world in the late 1800s it aroused tremendous curiosity and historically it is believed to have been more widespread throughout Australia. Researchers have speculated that Australian lungfish survival may be a result of a lack of large predators and an ability to out compete ray-finned fish during Queensland's long hot summers when water quality declines (Joss 2004). The ability of the Australian lungfish to breath air through its single lung provides it with an adaptation to low dissolved oxygen.

Population status

In 2003 it was estimated that breeding habitat had been reduced by about 26 per cent in the Mary and the Burnett River (Environment Australia 2003). Since the Paradise Dam was built in 2003 on the Burnett the breeding habitat for the Australian lungfish has been further reduced.

Distribution in the Mary River catchment

Surveys conducted by Queensland Department of Primary Industries and Fisheries (DPI&F) indicate that Australian lungfish are widely distributed throughout the Mary River and its tributaries. Figure 5 shows the distribution of the Australian lungfish in the Mary River catchment.

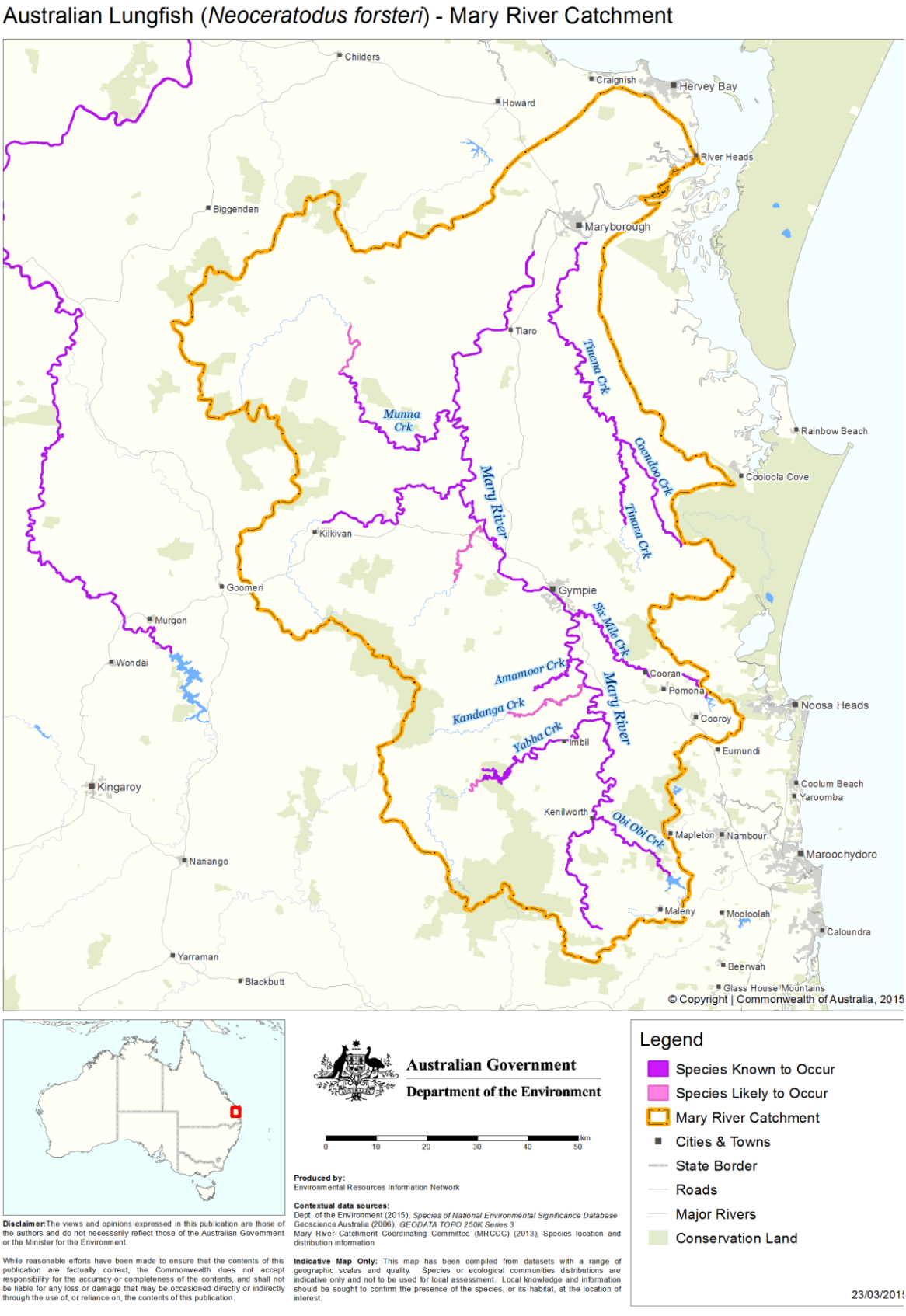


Figure 5. Distribution of Australian lungfish within the Mary River Catchment

4.4 Giant barred frog (*Mixophytes iteratus*)

The Giant barred frog is found in the upper Mary River catchment, which is the northern limit of the species' distribution. In Queensland it is found along the Maroochy River, the Stanley River, the Caboolture River, Burpengary Creek, Coomera River, Nerang River (Hines et al. 2002), Mooloola Creek, Canungra Creeks (H Hines, pers. comm. 2013) as well as in an isolated population in the Burrum catchment. The frog is also found in New South Wales. This frog is part of a group of frog species which have experienced rapid and unexplained declines in population, sometimes leading to local extinction (Hines et al. 2002).

Population status

It is estimated that the Mary River catchment contains approximately 65 per cent of the total Giant barred frog population (E. Ford and H. Hines, pers. comm. 2013). Declining numbers in this species and in several other rainforest-dependent frogs were noticed between the 1970s and 1980s (Hines et al. 2002) and the exact cause of this decline is not known. Possible contributing factors include chytrid fungus, increased UV rays, climate change, chemical pollution and habitat clearing (Hines et al. 2002). Over the last 15 years of MRCCC frog surveys, populations appear to be relatively stable in the Mary River and the known distribution of the species has been refined.

Distribution in the Mary River catchment

Figure 6 shows the known distribution of the Giant barred frog in the Mary River catchment.

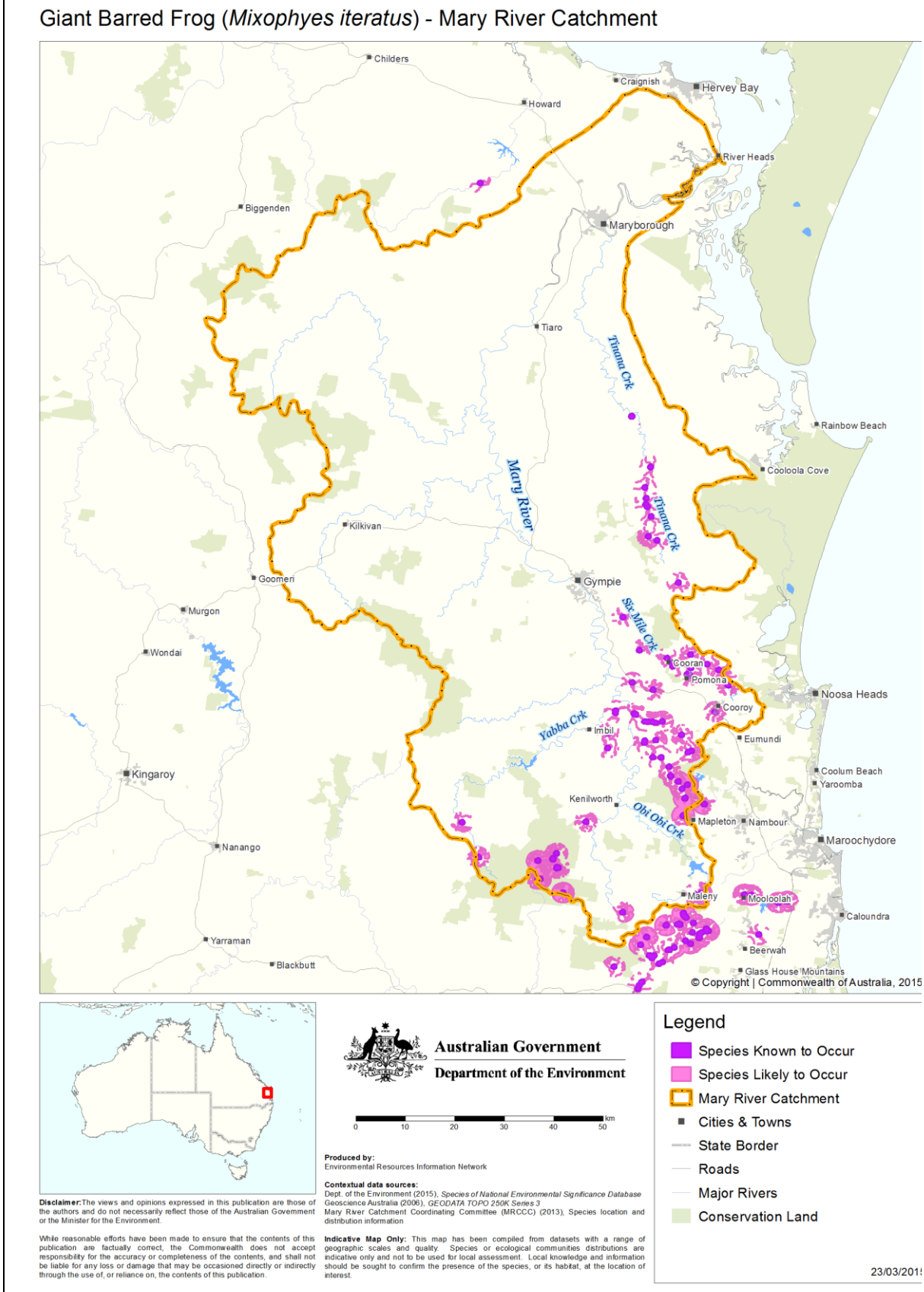


Figure 6. Distribution of Giant barred frog within the Mary River Catchment.

4.5 Freshwater mullet (*Trachystoma petardi*)

The Freshwater mullet is also known as the pinkeye, Richmond or river mullet and it is endemic to several east coast rivers (Stockwell et al. 2004). Its decline in the catchment is thought to be a result of restrictions limiting the movement between fresh and estuarine waters, as this is known to interrupt its breeding cycle (Riede 2004). Adult mullet will not breed in fresh water and young mullet born in the estuary may be prevented from reaching upper tributaries by impassable barriers. Stranding of mullet in saline water leads to reduced growth, reduced feeding opportunity and possible increase in predation (M. Hutchison, pers. comm. 2012).

Population status

There is no population estimate for the Freshwater mullet either within the Mary River or throughout its range. Queensland Government fisheries monitoring in the Mary River conducted between 2000 and 2005 only detected Freshwater mullet in 2000 and 2004 (Hagedoorn & Smallwood 2007) and more recent monitoring up to 2014 did not detect a single Freshwater mullet. The species appears to have almost vanished from the nearby Burnett, Kolan, Gregory, Burrum and Isis rivers (Kind and Brooks 2003).

Once the Freshwater mullet have declined in a river system it appears that their recruitment from adjacent waterways is difficult. This has been observed on the Mary and the Burnett Rivers following the installation of dam and barrage fish ways. These installations coincided with a rapid increase in sea mullet numbers, which utilise sea waters, compared with the slower recovery of freshwater mullet (Hutchison 2012).

Distribution in the Mary River catchment

Figure 7 shows the confirmed and possible distribution of the Freshwater mullet in the Mary River catchment.

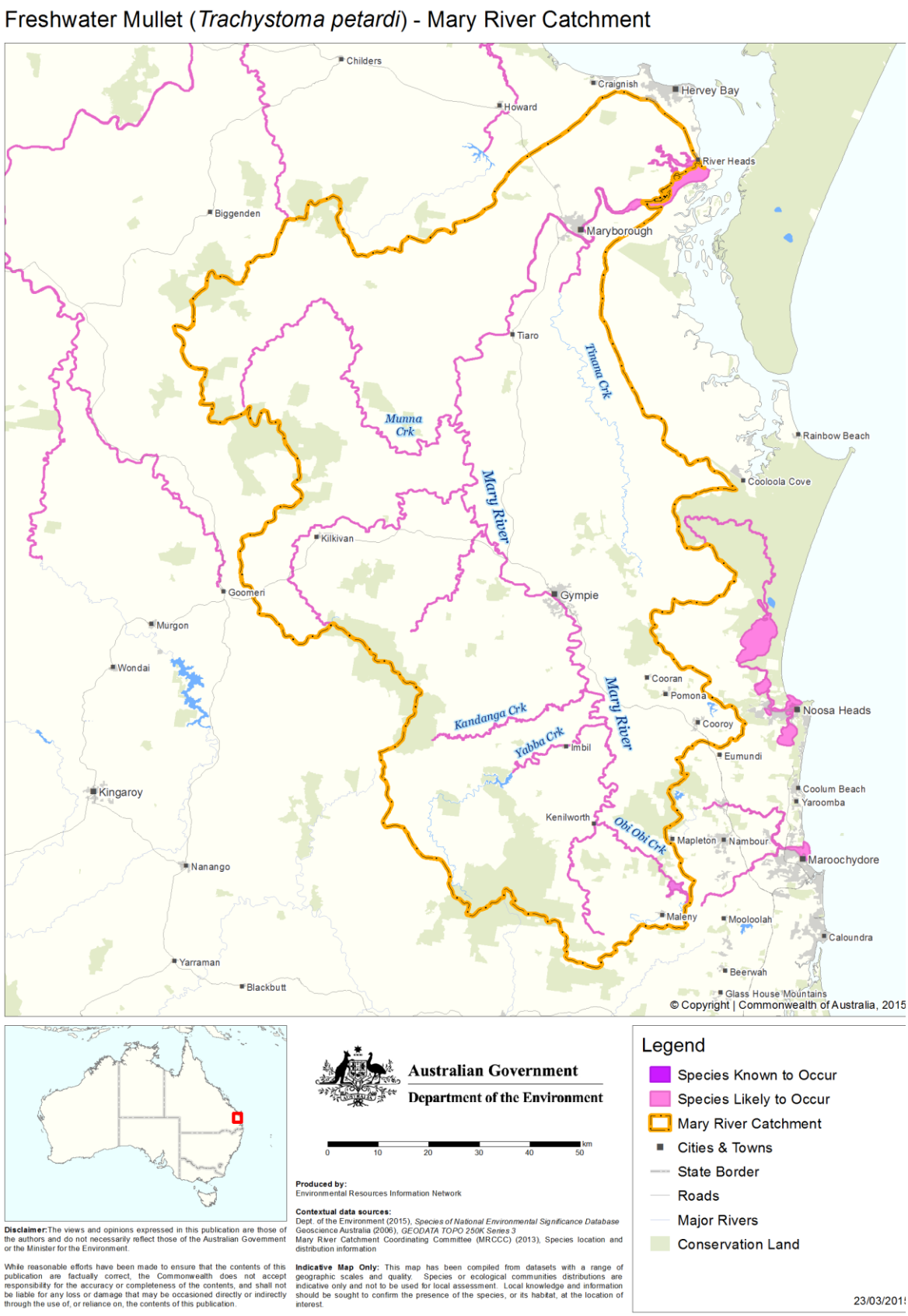


Figure 7. Distribution of Freshwater mullet within the Mary River Catchment

4.6 Habitat critical to survival of priority species

Each of the priority species in this plan has shared habitat requirements. Although adults of each of the priority species are relatively easy to locate juveniles are harder to find and in general there is little known about these juveniles. In order for any of these populations to recover it is crucial to consider the habitat requirements and potential threats that exist for all stages of the species' life cycle.

A lack of knowledge on juveniles is a key point of vulnerability regarding the recovery of these species. This means that a lack of recruitment into the adult population is difficult to detect. Even though adults may be present (if they are not breeding or their young are not surviving) the adults will not be replaced and the population will decline. This is a particular issue for the Mary River cod, Australian lungfish and Mary River turtle whose young must survive for more than a decade in order to mature and have an opportunity to breed.

Summer and spring seasons are crucial breeding periods for all of the priority species. At this time not only is breeding habitat required but the individual fish, turtles and frogs need to be able to access suitable breeding mates. Specific requirements for breeding are listed against each species. Juveniles of all species are vulnerable to predation, and improvements to habitat structure and threat abatement strategies that increase the chance of an individual surviving to breeding age are crucial interventions for conservation purposes.

Availability of habitat critical is essential for the survival of all of the five priority species and a definition is provided in Table 3. There is considerable overlap between the 'habitat critical' definition for the Australian lungfish, the Mary River cod, the freshwater mullet and the Mary River turtle. In the absence of barriers and other threats the entire river system is potential habitat for the freshwater mullet and all freshwater sections are potential habitat for the Mary River turtle, Mary River cod and the Australian lungfish. Being an amphibian the giant barred frog is more specialised in its requirements due to the vegetation type in which it tends to be found.

Table 3: Habitat critical characteristics

The habitat critical characteristics described below meet the requirements for the priority species' survival, growth, reproduction and recruitment.

Species	'Habitat critical' characteristics for survival, breeding and connectivity
All species	• Riparian zone providing diverse terrestrial and aquatic habitat features and healthy river processes
All species (except giant barred frog)	• Open water, free of exotic macrophytes[2], and that has complex in-stream structure including: beneficial large wood (various sizes of individual logs or log piles); undercut (riparian tree root stabilised) banks; rocky outcrops; and contiguous fringing riparian vegetation providing shade. • Deep pools, seasonal and perennial, riffle, run and glide habitats connecting perennial pools and allowing movement between reaches within distribution
Mary River cod	• Deep pools (>1.5 m) permanent waterholes • Shallower water (often found near riffles—feeding, may also spawn there) • Non turbid in-stream water quality during the spawning period • Natural base flows (sustained runoff) to inundate riffles and facilitate movement between deep pools (movement is generally downstream in winter and upstream in spring and associated with location of mates and spawning sites) . • Shading of water by fringing riparian vegetation

[2] A 'macrophyte' is an aquatic plant that grows in or near water and is either emergent, submergent, or floating. While macrophytes are an important part of a healthy river system, at times they can grow prolifically (especially exotic macrophytes) and limit open water habitat. The species being considered need at least some part of their habitat free of macrophytes.

Species	‘Habitat critical’ characteristics for survival, breeding and connectivity
	• Spring increases in stream water temperature to >20°C to initiate spawning behaviour • Water temperatures less than ~28°C for health and survival • Connectivity (fish passage) throughout entire reach network • Presence of appropriate spawning habitat
Mary River turtle	• Flowing, well oxygenated sections of streams • Slow moving, shallow water up and downstream of riffles for juveniles • Relatively deep (~1–5+ m) river pools with high dissolved oxygen concentrations, alternating with riffles and shallow stretches • Native macrophytes, invertebrates, algae, crustaceans, underwater shelter, submerged logs, twiggy and mid to small sized submerged trees • In-stream basking logs and rocks • Non submerged/available sand banks during the nesting season (regular floods are required to replenish sand banks) • Nest bank temperature <30°C
Australian lungfish	• Shallow, flowing stream sections with dense beds of submerged native macrophytes and water temperature between 18 and 28°C • Non turbid in-stream water quality during egg development (in macrophyte beds) • Natural base flow regime and prevention of rapid inundation/water level drawdown which can lead to egg/juvenile exposure /desiccation or alternatively egg /juvenile habitat scouring /inundation and associated stresses that is lower dissolved oxygen at

Species	'Habitat critical' characteristics for survival, breeding and connectivity
	depth. • Naturally timed elevated in-stream flows to facilitate fish movements between pools • Deep pools (>1.5 m) permanent waterholes
Giant barred frog	• Shallow, rocky freshwater streams to deep, slow moving streams • Permanent pools with undercut banks and other in-stream structures (for egg laying and tadpole survival) • Riparian rainforest with stable banks, canopy cover and leaf litter and associated wet sclerophyll forest • Low vegetation and grass • Connectivity of vegetation along river between sub-catchments, and/or connectivity between upper reaches of sub-catchments
Freshwater mullet	• Deep, slow-flowing pools • Connectivity between estuary and the upper reaches of the river, requiring both passage and sufficient flow to connect reaches • Seasonal flow pulses which enable movement of adults to spawn in the estuary and the sea and to return to the river

5 THREATS

5.1 Overview

The current status of the priority species and the overall health of the river can be attributed to a range of historical and current activities that have contributed to species population decline. The current known threats were prioritised using the Conservation action planning handbook (TNC 2007) which uses criteria based on the scope, severity and irreversibility of the threats risk. The significance of threats is ranked across the five priority species collectively.

The majority of the threats operate across the entire range of all the species in the plan. The threat rankings assigned have only taken into account how each threat affects that species within the Mary River system. The threat analysis tool used in the Australian lungfish recovery plan (Australian Government in prep 2016) was different to the threat analysis tool used in this recovery plan and hence the plans should not be directly compared.

5.2 Description of Threats

The threats have been categorised into four categories;

- System wide threats
- Species level threats
- Universal threats, and
- Potential threats.

System wide threats affect all species in the river and need addressing at the catchment or system-wide level. Their impacts also extend beyond the river catchment into the marine and estuarine environment. Species level threats operate at a scale specific to the species. Universal threats operate at a global scale however actions in this plan can be undertaken to help mitigate these impacts. Potential threats are threats that are not currently operating on the species but have the potential to operate in the future. The potential threats were not assessed in the prioritisation process.

The threats were assessed using the above criteria and using the Nature Conservancy Miradi software (TNC 2007), rating each threat as being either a high, medium or low threat to each of the five priority species. The significance of each threat across the five species was also determined and the overall level of threat each species is subjected to was determined. As a result of the threat analysis, objectives and actions were developed to address the threats, with higher ranked threats being given higher priority.

Threat	Overall threat ranking	Species rankings	
System-wide threats			
Poor integrity of riparian zone	High	Mary River cod	High
		Mary River turtle	Medium
		Australian lungfish	Medium
		Giant barred frog	High
		Freshwater mullet	Low
Poor water quality	Medium	Mary River cod	Medium
		Mary River turtle	High
		Australian lungfish	Low
		Giant barred frog	Low
		Freshwater mullet	Medium
Modifications of the Mary River geomorphology	Medium	Mary River cod	High
		Mary River turtle	Medium
		Australian lungfish	Medium
		Giant barred frog	Medium
		Freshwater mullet	Medium
Fishing and Recreation	Medium	Mary River cod	High
		Mary River turtle	Low
		Australian lungfish	Low
		Giant barred frog	N/A
		Freshwater mullet	Low
Invasive aquatic species	Medium	Mary River cod	Medium
		Mary River turtle	Medium
		Australian lungfish	Medium
		Giant barred frog	Low
		Freshwater mullet	Medium
Terrestrial weeds	Medium	Mary River cod	Medium
		Mary River turtle	Low
		Australian lungfish	Low
		Giant barred frog	Medium
		Freshwater mullet	Medium
Barriers to movement	Medium	Mary River cod	Medium
		Mary River turtle	Medium
		Australian lungfish	Medium
		Giant barred frog	N/A
		Freshwater mullet	Medium

Altered hydrology	Medium	Mary River cod	Medium
		Mary River turtle	Medium
		Australian lungfish	Medium
		Giant barred frog	Low
		Freshwater mullet	High
Altered catchment runoff regime / changed pattern of water flow	Medium	Mary River cod	Medium
		Mary River turtle	Medium
		Australian lungfish	Medium
		Giant barred frog	Low
		Freshwater mullet	High
Lack of riverine habitat managed for conservation	Medium	Mary River cod	High
		Mary River turtle	Low
		Australian lungfish	Medium
		Giant barred frog	Medium
		Freshwater mullet	Low
Species level threats			
Terrestrial predators, trampling and destruction of nests and habitat	High	Mary River cod	N/A
		Mary River turtle	Very high
		Australian lungfish	Low
		Giant barred frog	Medium
		Freshwater mullet	N/A
Chytrid fungus	-	Giant barred frog	Medium
Misidentification with cane toads	-	Giant barred frog	Medium
Illegal aquarium collection	-	Mary River turtle	low
Low gene pool variability	Medium	Mary River cod	High
		Mary River turtle	Medium
		Australian lungfish	Low
		giant barred frog	N/A
		freshwater mullet	Low
Universal threats			
Climate change	High	Mary River cod	High
		Mary River turtle	High
		Australian lungfish	High
		giant barred frog	Medium
		freshwater mullet	High
Potential threats			
Mining for coal and coal seam gas			
Increased demand for water extraction			

5.3 System Wide Threats

The threats listed in this section need to be addressed at a catchment scale.

Poor integrity of riparian zone

The riparian zone plays an important ecological role for the species in this recovery plan. If it is degraded there are a range of impacts that affect river health. There are a number of structural and functional roles which riparian vegetation plays and a loss of integrity of the riparian zones threatens the priority species survival and recovery in the following ways: .

Instability of the riparian zone - Bank slumping has been estimated to account for 66 per cent of sediment entering the Mary River (Fentie et al 2014). Trampling and erosion by cattle also contributes to this threat.

Lack of shading/water temperature and food web productivity impacts - shade is important for giant barred frogs, and impacts on water temperature which affects Mary River cod and Mary River turtles. Mary River cod prefer shaded areas (DNRM 2016) and are tolerant of a narrow range of temperatures. Any explosions of aquatic plants and low dissolved oxygen associated with high light levels are detrimental to the species. Freshwater mullet are susceptible to low levels of dissolved oxygen. In the Mary River system a riparian canopy cover of 40–50 per cent was found to be a trigger point for major changes in stream health when the stream would become a net producer of carbon (Bunn et al. 1999).

Lack of ground layer habitat/leaf litter - leaf litter is essential habitat for both juvenile and adult giant barred frogs and in-stream leaf litter can provide important habitat for juvenile Australian lungfish. Invertebrates that depend on leaf litter are a food resource for Mary River cod. Fruit and arthropods can be important sources of food for freshwater fish and other vertebrates (Bunn et al. 1999b). Small invertebrates could be a food source for larval and juvenile Australian lungfish. Mary River cod and turtles are also known to eat fruit from riparian vegetation.

Lack of provision/renewal of beneficial large wood - Tracking studies have found Mary River cod within 1 m of beneficial large wood 90 per cent of the time (Simpson and Jackson 2006) and cod larvae closely associated with this habitat (Dunlop 2016). Hollow logs may also be important for Mary River cod as an egg laying substrate. Captive breeding methods indicate hollow logs greater than 0.3m in diameter make for effective breeding sites, but it is unknown if this is the case in the wild. Woody debris provides basking spots for Mary River turtles and safe refuges for juvenile turtles and Australian lungfish. Debris may provide surfaces for giant barred frogs to lay eggs. Wood may provide surfaces for colonisation by algae which are believed to play an important role in food webs in large stream systems (Bunn et al. 1999b). Algae are a common food source for freshwater mullet and Mary River turtles.

Reduced availability of undercut root banks—bank undercuts provide breeding sites for giant barred frogs which use their powerful hind legs to flick eggs onto the roof of the undercut. Undercuts are also an important shelter for juvenile Mary River cod (DNRM 2016), Mary River turtle and Australian lungfish and possibly used as spawning sites for Mary River cod. Clearing of riparian vegetation and bank slumping can destroy these undercuts.

Reduced width of riparian zone - narrower riparian zones have less capacity to filter sediments and nutrients entering streams. The giant barred frog requires a riparian zone width of approximately 40m (Lemckert and Bassil 2000; Koch and Hero 2007). Established trees in riparian zones provide a seed bank for future generations and if removed, growth of new

seedlings is constrained. Trees supply large and small beneficial wood to the stream network. Narrower riparian zones also result in lower riparian species diversity, lower resilience and higher vulnerability to weed invasion and fire. Goannas are significant predators of Mary River turtle nests and there is speculation that narrowing the riparian zone may concentrate goanna populations and increase nest predation (M Connell, pers. comm. 2012).

Loss of mosaic of microhabitats - the loss of sandy banks for nesting by the Mary River turtle has a devastating effect for the continued survival of this species. A mosaic of habitats within the river is also associated with abundance of Mary River cod (DNRM 2016)

Introduced vine weeds - can have physical impacts by impeding growth of new trees, weighing down and breaking canopies of established trees, causing tree deaths and/or smothering the ground and inhibiting seedling growth. These processes can impact on bank stability as long term viability and integrity of riparian vegetation..

Lack of continuity of riparian vegetation - for giant barred frogs, gaps in the riparian zone are believed to be barriers to movement. These gaps also have impacts on water quality and in-stream habitat which may create barriers that constrain movement of aquatic species. Fragmentation reduces potential beneficial large wood, an essential element of in-stream habitat.

Poor water quality

Water quality is an important indicator of river health and the impacts of water quality for each of the priority species are described below.

Turbidity—Anecdotal reports identify numerous swimming holes in the river that were once deep and clear, but now are filled with sand and are covered in turbid water. Suspended sediment can smother and kill eggs of both the Mary River cod and Australian lungfish and in the case of Australian lungfish, make eggs more vulnerable to disease. Sediment can also smother spawning areas for Australian lungfish which are found in shallow beds of aquatic plants. This may impact on food supply for Mary River turtles that feed on these plants. Turtles have good eyesight above and below the water and turbidity has an unknown impact on their vision, food capture and avoidance of predators (M Connell pers. comm. 2013). Sediment may also smother biofilms (a combination of algae, bacteria and fungi) on which freshwater mullet feed. The impact of turbidity on giant barred frogs is unknown.

Temperature - Mary River cod and Mary River turtles only tolerate a narrow temperature range. Research has shown that juvenile turtles surface more often when water temperature is high as oxygen levels in the water are lower (Clark et al. 2008). This could increase their vulnerability to predator fish and birds of prey.

Dissolved oxygen - Clark et al. (2008) and Kuchling (2008) suggest that dissolved oxygen is extremely important for Mary River turtles, particularly juveniles. Low levels of dissolved oxygen can lead to fish kills of Mary River cod and may also impact on the eggs and larvae of Australian lungfish. Freshwater mullet are also susceptible to low levels of dissolved oxygen and invasive aquatic plants can have a significant impact on dissolved oxygen levels. The susceptibility of giant barred frog tadpoles to low oxygen levels is yet to be confirmed.

Salinity - salinity impacts on Mary River cod and giant barred frog tadpoles are unknown. Australian lungfish are known to be intolerant to salinity (Kind et al. 2008) which may also impact on survival or development of eggs. Mary River turtles are also not tolerant of high salinity levels and when washed over the barrages into the saline estuary they have difficulty surviving.

pH - the Mary River catchment area is identified (Perry and Bay 2003) as having high potential for soil acidification which could lead to changes in the pH of streams. Little is known about the impact of pH on the priority species. The Mary River cod, Giant barred frog and Australian lungfish are well established within the Tinana/Coondoo system which has a lower ambient level of pH (that is, it is more acidic) than the main river system where these species are also found.

Nutrients - elevated levels of nutrients can result in proliferation of aquatic macrophytes including weed species such as water hyacinth (*Eichhornia crassipes*) and salvinia (*Salvinia molesta*). Excessive growth of aquatic macrophytes can lead to declines in water quality and decrease the availability of breeding sites for both Australian lungfish and Mary River cod.

Pesticides / herbicides - there is limited evidence regarding the direct impacts of pesticides and herbicides on the priority species.

Modifications of the Mary River geomorphology

Activities that have caused modifications and alterations of the distribution and movement of sand and gravel in the Mary River and tributaries have affected riverbed and riverbank stability in the following ways:

Reduced replenishment of downstream sand banks - this has an impact on nesting of Mary River turtles, which unlike other turtles in the river, are totally dependent on sandy banks for nesting sites.

Loss of deep water habitat and undercuts - alterations can lead to changes in sediment movements that result in deep pools being filled with sediment and undercuts lost. Deep pools are important habitat for the Mary River cod, Mary River turtle, Australian lungfish and freshwater mullet. Loss of these pools is believed to increase predation of freshwater mullet. The undercuts also provide breeding sites for Giant barred frog, possibly Mary River cod and refuge for Australian lungfish and Mary River cod.

Instability of the riverbed - results from extraction of gravel and/or sand from the riverbed or construction of infrastructure that destabilises the river bed. Where this is occurring, erosion of the streambed and associated bed lowering puts existing riparian vegetation, future revegetation projects, riffles, deep pools and infrastructure such as roads and bridges at risk of damage during flooding.

Destabilising of riffle and glide zones - riffles play an important role in providing habitat for algae and large invertebrates which, in turn, fuel the food chain of the river. Juvenile Mary River turtles also have a strong association with these areas (Micheli-Campbell 2012; Micheli-Campbell et al. 2013) and adults forage predominantly in these areas (Micheli-Campbell et al submitted). Macrophyte beds that provide breeding grounds for Australian lungfish are often located around riffles and can be destroyed by destabilisation processes.

Fishing and recreation

Both legal and illegal fishing, as well as boat movements associated with recreational activities (like water skiing) can have detrimental impacts on the priority species. With the exception of freshwater mullet none of the priority species can be taken legally in the catchment. Mary River cod can be caught in stocked dams but not in the Mary River. If captured accidentally, removing hooks can lead to mortality or injury, particularly in the case of Mary River cod and turtle. During breeding, this stress may cause female cod to reabsorb eggs, while males may abandon nests resulting in the eggs and fry being predated. Freshwater mullet are caught

recreationally and commercially. Intentional kills of Mary River turtles and illegal take of Mary River cod and Australian lungfish are suspected to occur, but the extent of this is unknown.

Activities that concentrate fishing efforts in a particular area can increase accidental catches. Discarded fishing equipment such as hooks, fishing lines and traps pose a risk to the livelihood of these turtles. Boat movements causing boat strike are a threat to Australian lungfish and Mary River turtles. Aqua basking Mary River turtles are particularly vulnerable to boat strike. Adult lungfish spend considerable time in open water. The risk of strike from boats is greatest in big deep pools, barrages, dams and weirs where boats are more likely to be used.

Invasive aquatic species

Invasive aquatic species can include native and non-native species.

Plants - During times of low flow invasive non-indigenous or non-native species can have profound impacts on water quality. Invasive aquatic plants reduce the area of open water habitat and contribute to loss of the organisms living in the sediment which are an important component of the food web. Where invasive aquatic plants grow in extensive mats across the water surface they create barriers to movement, particularly for freshwater mullet. Invasive aquatic plants can also cause a decline in the quality of the breeding ground of Australian lungfish and reduce access to Mary River turtle nesting banks.

Animals - Introduced fish have an impact on threatened species through competition for food and habitat resources, predation or habitat deterioration. Some of these introduced fish have been stocked for recreational fishing purposes and are likely to predate on young turtles, Australian lungfish, giant barred frog, mullet and cod and compete with cod and turtles for food. They also pose a risk of introducing disease. Some invasive species, such as mosquito fish (*Gambusia holbrooki*), are well established in the catchment and predate on the young of some of the priority species. In October 2014 a sizeable Tilapia (*Orechcromis mossambicus)* population was identified near Tiaro and studies at the time determined that it was confined to this section of the river (MRCCC 2014). As of mid 2015 they have spread south to Gympie. These exotic fish impact on water quality and may predate juvenile turtles, cod and lungfish.

Terrestrial weeds

Direct and immediate impacts of terrestrial weeds such silver leaf (*Desmodium uncinatum*) include entrapment of young frogs. Other weeds like pasture grasses and various burrs can invade turtle nesting areas restricting the ability of turtles to dig nests. Roots can grow directly through turtle eggs killing the embryos. Weeds add to the fuel load increasing the risk of fire. chinese elm (*Ulmus parvifolia*) and camphor laurel (*Cinnamomum camphora*), can affect water quality by releasing poisonous leaves and fruit preventing any other vegetation growth under the tree canopy. Vine weeds, in particular cats claw creeper (*Dolichandra unguis-cati*), madeira vine (*Anredera cordifolia*), blue morning glory (*Ipomea indica*), coastal morning glory (*Ipomea cairica*), balloon vine (*Cardiospermum grandiflorum*) and pasture legumes can severely impact on riparian zone integrity.

Barriers to movement

Barriers in the river include dams, tidal barrages, weirs, road crossings, culverts and in-stream ‘farm dams’. Regardless of whether they are legal, they prevent movement of species, reduce access to mates and isolate the gene pool. This occurs with Mary River cod and Australian lungfish. Dams and barrages can pond water and interrupt natural sediment transport. The non movement of water can create conditions conducive to algal blooms and rapid growth of invasive plants.

Stranding can occur at barrages if a fish is too large to pass through the slots on the existing fish ways. Dams can cause mortality or injury of Mary River cod, Australian lungfish and Mary River turtles, either by passing through a spillway or falling over a dam wall. Deaths of lungfish have been recorded on large dam stepped spillways outside of the Mary River catchment. The extent of this type injury to the priority species on the types of impoundments in the Mary River catchment is uncertain and it should be considered a risk until research has confirmed otherwise. Little is known about use of fish passage devices by Mary River turtles.

The presence of three primary turtle nesting areas within the catchment highlights the potential importance of movement between these two areas. Kuchling (2008) proposed that turtle movement does occur and is significant for the species. The importance of long-distance movement for Mary River turtles is less well understood.

Altered hydrology

There is overlap between this threat and the threat posed by barriers. Causes of altered hydrology' includes flow regulation (as a result of barriers), and water extraction from the river for irrigation and urban water use. Shallow macrophyte beds can become exposed if the water level drops, impacting on the Australian lungfish as they use these beds for egg laying. Similarly giant barred frog tadpoles live in pools and draining these pools can cause tadpole death. Natural freshwater flow pulses trigger breeding responses in species such as freshwater mullet and any changes to the natural flow may impact on breeding. Altering the hydrology can impact on water quality and change the temperature regime and the sequence of pool riffles. Reduced flows impact on the salinity, currents and the ecology of Hervey Bay and the Great Sandy Strait (Gräwe et al. 2010).

There is little known about groundwater/surface water interaction in the Mary River catchment area.

Altered catchment runoff regime / changed pattern of water flow

This threat differs from altered hydrology and barriers in that it refers to the way in which changes in land use, ground cover and aquifer behaviour lead to changes in the regime and pattern of runoff. These changes include lower rates of infiltration, increased water runoff speeds and different patterns of flow that occur through changes to ground cover and changes in landforms associated with urban and in some cases agricultural areas. Impacts of such changes include declines in water quality, reduction in base flow and changes to the persistence of pools, loss of movement triggers, loss of connectivity, increased strandings and loss of habitat.

Lack of riverine habitat managed for conservation

Approximately 10 per cent of the stream network in the Mary River catchment is within National Parks. Additional sections of the river are covered by voluntary conservation schemes (such as Land for Wildlife). The South East Queensland Biodiversity Planning Assessment identified extensive riparian corridors within the Mary River catchment (Environmental Protection Agency 2006c). It recommended that all riparian/floodplain remnant vegetation below the 50-year maximum flood level be designated as being of State significance (Environmental Protection Agency 2006b). Outside of those areas already protected there are no direct mechanisms that allow certainty for long-term management of key habitat areas or protection from key threats.

5.4 Species level threats

The threats listed in this section need to be addressed at a species level.

Terrestrial predators, trampling and destruction of nests and habitat

Dogs, cats, foxes, goannas, water rats and possibly ravens predate on the priority species (Thompson 1983). Activities such as sand extraction and vehicles driving on nesting banks or stock grazing in these areas can also destroy Mary River turtle nests or sites. As the human population grows this is likely to be an ongoing threat. Carefully designed and managed public access points will help ensure site protection. Without intervention to protect nests mortality rates may be as high as 100 per cent (Limpus 2008). Female Mary River turtles are highly selective and show strong site loyalty to nesting sites (Micheli-Campbell 2012). Mary River turtles may change nesting site location as a result of the re-distribution of sand during floods. Permanent nesting sites are protected by Tiaro and District Landcare around Tiaro, Traveston Crossing Bridge and Kenilworth. The river has been surveyed at various times to determine the location of potential nesting banks. Trampling and grazing of the riparian zone by stock is also a threat to the giant barred frog, particularly the tadpoles. When stock has access to the river this can lead to macrophyte bed destruction, destruction of Australian lungfish eggs, trampling of turtles and damage to pools containing tadpoles. Feral pigs are known to eat frogs and destroy habitat. Cats and foxes may also eat frogs.

Chytrid fungus

The chytrid fungus is a threat to all frog species. Chytrid fungus is an infectious disease that causes death in amphibian species. Humans may contribute to spread of the disease through wet or muddy boots and tyres, fishing, camping, gardening or frog-survey equipment. It is necessary to have hygiene protocols in place to prevent potential spread of the fungus. Chytrid fungus is rated as a medium threat to giant barred frog.

Misidentification with cane toads

The giant barred frog can appear to resemble a cane toad and can be threatened by pest control activities targeting cane toads. This threat is rated as low due to the limited incidence of this occurring.

Illegal aquarium collection

Historical illegal collection of Mary River turtle eggs for the pet trade has had a great impact on the population. This continues illegally and Mary River turtles are available for purchase both in legal and illegal markets. There is an international demand for pet turtles with specific demand for threatened species (M. Connell, pers. comm. 2013). The illegal collection extent is unknown. Mary River turtles are available for purchase for a similar price to other species in the Mary River that are not endangered. This could be because its nests may be easier to locate than those of other species. For this reason the exact location of nesting banks is not widely publicised. This threat is rated as low.

Low gene pool variability

Captive breeding of Mary River cod has occurred since the 1970s and may have either reduced or increased this threat depending on the design of the stocking program. The only assessment of genetic diversity in the Mary River cod was completed in 2012 (Huey et al. 2013). Results indicate that the two sub-populations in the Mary River and Tinana-Coondoo

system are genetically distinct and both have low genetic diversity. The level of genetic diversity and a comprehensive body of scientific research of this phenomenon suggest that both genetic drift and inbreeding depression are a threat to the viability of the populations. There is currently no evidence that the fitness of the population has been affected by the levels of genetic variability. Inbreeding depression may still occur and the low genetic variability may affect the adaptability of the species (J Huey, pers. comm. 2012).

Relative to other turtles in the family Cheladie the Mary River turtle has low genetic variability (measured by mitochondrial DNA nucleotide variability) which has been attributed to the reduction in population size associated with egg harvesting for the pet trade, habitat changes and predation of nest (Schmidt et al in review). This indicates that there is a genetic bottleneck in the species.

5.5 Universal threats

Climate change

The consequences of climate change for the Mary River bring a range of threats for the species considered in this plan and include;

- increased water temperature
- increased summer precipitation
- lower winter precipitation
- more frequent intense weather events, and
- changes in flow regimes causing more erosion and risk of damage/loss of riparian zones through more extreme flood events.

Dowdy (2015.) predictions suggest a range of climatic changes in the Burnett Mary Region between now and 2030[3]. Base on the stabilisation scenario in which reflects some action on climate change (RCP4.5), tthe predicted changes which have high or very high confidence and are relevance to the Mary River ecosystem are: ;

- average annual temperature increase of 0.9ºC (very high confidence)
- an increase the number of days over 35 ºC from 12 per annum to 18 per annum (very high confidence),
- Fewer frost risk days (high confidence)
- More severe fire weather and increased evaporation (high confidence), and
- an increase in the intensity of precipitation (high confidence).

It is possible the changes in climate could exacerbate many existing threats to the priority species. If flood events do occur more frequently this can have a major impact on river habitat quality and water quality. The floods of 2011, 2012 and 2013 have illustrated that macrophyte beds can be almost completely obliterated in the main trunk of the river and may take up to two years to recover with normal years. The increase in hot weather will impact water temperature and nesting bank temperature. Although changes to total rainfall are less certain the increased evaporation and potential for increased drought periods (medium confidence) could exacerbate existing low flow periods during winter, spring and early summer. This will influence the connectivity of deep pools, the potential for aquatic weed blooms and resulting water quality.

The Mary River cod is vulnerable to these changes, particularly higher water temperatures, because of its sensitivity to temperature extremes. Mary River turtles incubated at higher temperatures tend to be less fit and are therefore likely to be more vulnerable to predation and less healthy in the wild (Micheli-Campbell et al. 2011). Giant barred frog breeding is dependent on semi-permanent pools which may dry up with longer dry periods and higher evaporation rates. Loss of connectivity in the river and evaporation of pools impacts on all the aquatic species.

[3] Predictions out to 2090 where also made but these are not discussed here because they are less certain due to the influence that contemporary global emissions trends will have. These predictions are also well outside the timeframe of this plan.

Increasing severity of drought could extend the periods of low flow in the river and increase the number of occasions when the river ceases to flow. Increasing flood severity can contribute to erosion and scouring of in-stream habitat features. Further research is needed to understand the role of specific adaptation requirements for the priority species.

5.6 Potential threats

These are considered likely to become current threats in the near future and will be assessed accordingly throughout the implementation phase of this plan.

Mining for coal and coal seam gas

Mining and its associated impacts may further exacerbate the existing threats. As of 2012, approvals had been granted for exploration for both coal and coal seam gas across an area of approximately 390,000ha[4] or 42 per cent of the catchment. Changes to water quality and hydrology are likely to be associated with mining. The impact of such activities may be significant particularly during times of drought. These exploration activities currently include areas that are regarded as:

- prime habitat for the Mary River cod, Australian lungfish and Giant barred frog within the Tinana Creek catchment, and
- prime habitat for Mary River turtle on the Mary River around Tiaro and Gundiah.

The direct impact of vegetation clearing associated with open cut coal mining and coal seam gas drilling potentially pose a threat to the hydrology of the catchment. The *Burnett Mary Bioregional Assessment* (Bennet 2012) established that all surface and groundwater systems considered within the catchment are vulnerable to the impacts from coal and coal seam gas mining. This assessment was overseen by an Independent Expert Scientific Committee on Coal Seam Gas and Coal Mining and coordinated by the Burnett Mary Regional Group.

Increased demand for water extraction

Based on predicted human population growth (section 2.3) within the catchment future demand for water could potentially increase. Increases are likely to come from the Hervey Bay region to the north and the Sunshine Coast to the south. The Mary River is also connected to the SEQ Water Grid at two points via the Northern Pipeline Interconnector. Population growth in South East Queensland could also place increasing demand on water resources within the catchment. Impacts could arise from both the method of extraction of additional water (for example, new infrastructure) and volume and timing of extraction. Water extraction is controlled through the *Mary Basin Water Resource Plan* (WRP) (State of Qld 2006) and the *Mary River Resource Operations Plan* (State of Queensland, 2011b).

[4] Approximately 20,000 ha is associated with coal seam gas and another 61,000 ha is subject to applications for both coal and coal seam gas. The remainder relates to coal only. About 40 per cent of the Exploration Permits for Coal have been granted. These estimates are based on geographic information system analysis of area covered by exploration according to the Geoscience and Resource Information Service, Queensland Government.

6 BIODIVERSITY MANAGEMENT

6.1 Guiding principles

The recovery plan is underpinned by a set of principles that:

- guide the core task of recovering populations of threatened species, and
- at the same time recognise the complex and interconnected social, cultural and economic role that the river plays.

These principles define the plan as being interconnected, strategic, scientific, aligned, adaptive, relevant, inviting, encouraging and coordinated. Each principle is described in more detail below:

Figure 8: Principles guiding the recovery plan

Interconnected: An Indigenous perspective on the river recognises that everything is connected. Within the constraints of the plan, this principle recognises that the priority species are connected with one another, with other species, to human culture and ultimately with a healthy river system. This plan embraces this complexity. An interconnected approach urges a person to think holistically in terms of the whole catchment and be mindful of the connections within the catchment.

Strategic: Communication about the recovery plan is linked to a clear set of goals and carefully targeted to the specific audiences. Opportunities are sought to piggy-back on existing activities and work with existing trends and interests among stakeholders. Actions have been prioritised strategically and are linked to sub-catchments.

Scientific: Sound scientific knowledge and the application of the precautionary principle in the absence of sufficient knowledge are essential for effective recovery. Science can be used to generate new knowledge about species and riverine ecology, about threats and their significance and about the effectiveness of recovery actions. It also underpins the design and analysis of monitoring and evaluation programs. This principle incorporates the concept of 'reciprocal science' (see Action 7.2) and the role of volunteers and the general community in recovery of the environmental values in the catchment.

Aligned: Information presented in the recovery plan and associated documents are closely aligned with other plans and regulations.

Adaptive: As new information comes to light and progress is made on recovery actions, adjustments to this recovery plan will be needed. The document can only be modified at the five year review process and as part of usual legislative processes as set out under the EPBC Act. The Recovery Team can guide an adaptive approach to implementation for the entire life of the plan.

Relevant: The recovery plan is linked to other plans and relevant landholder information on a sub catchment scale. Locally iconic species are used to help people identify with the recovery actions.

Inviting: The plan invites contributions and involvement from all stakeholder groups and encourages people to learn about and value their part of the river.

Encouraging*:* The plan recognises the existing activities that have been undertaken by landholders and numerous groups in the catchment and supports these existing activities as well as encouraging involvement of new groups and individuals.

Coordinated: Close cooperation between participants in the recovery process and all organisations with a stake in the outcomes of the plan forms the basis of a coordinated approach to recovery.

6.2 Recovery goals

The overall long-term 100 year goals of the recovery program are that:

- healthy populations of the Mary River turtle, Mary River cod, Australian lungfish, giant barred frog and the freshwater mullet are present in the Mary River catchment, and that the listed species are down listed to a lower EPBC Act category, and

- there is improvement in the overall health of the Mary River that benefits all other native species indigenous to the catchment.

6.3 Strategy for recovery

"If we wish to maintain a truly Australian river character, with naturally adapted flora and fauna, our target conditions for river management must replicate the natural variability in river structure and flow inherent in the Australian landscape. Hence, effective management is contingent on improving our knowledge of geomorphological interactions with ecological functioning in aquatic ecosystems." (Brierley 1999).

The strategy for recovery is based on a view that the priority species form an important part of an integrated system. Within this system numerous other species and the catchment community live with agriculture and the various other industries that are associated with the Mary River catchment. This approach is applicable to the river system because of the multiple forms of connectivity that exist. Actions in one location can have impacts at distant locations downstream.

By following the objectives and actions outlined in this plan changes can be made to assist with the recovery of the priority species. While some of these actions are very specific to the priority species the majority relate to achieving overall improvements. This includes habitat quality, river health and restoring or maintaining key ecological functions that are likely to benefit the priority species and a wide range of other species.

This recovery plan does not include a detailed consideration of threats to species other than the five priority species. It is not a substitute for species-specific analysis of impacts or mitigation of specific threats to any of the other listed species in the catchment.

6.4 Enablers and constraints to recovery

Many recovery actions are currently being undertaken in the catchment and there are highly skilled people within the community undertaking management and actions to deal with species recovery.

Lack of knowledge

The most important gaps in our ecological knowledge of the Mary River region relate to;

- the current population status of each species
- some aspects of their life cycles and behaviours (particularly the juvenile stage)
- how the species use the habitat (particularly juveniles), and
- the impact of particular threats.

These gaps are slowing down recovery planning and management for the range of species included in this plan.

6.5 Capacity and management

There is a need to increase people's capacity to manage recovery of the Mary River catchment. This, unfortunately, is constrained by limited resources. An adoption of a priority species approach is one strategy to address some of the resource and capacity constraints. Its purpose is to facilitate selection of actions which have multiple benefits for multiple species while avoiding creating a complex recovery program that stifles action. This strategy and some of the pitfalls to avoid in its implementation are discussed further in the accompanying supplementary information. Several of the recovery objectives presented in Section 6.11 seek to proactively address particular constraints to recovery.

6.6 Resources and capacity

Issues involving funding arrangements include:

- a need for adequate funding to address the recovery needs of all priority species
- a need for funding structures for securing long-term sustainability for recovery programs, and
- improving consistency and coordination of project funding sources to integrate management priorities across programs.

6.7 Knowledge-base systems

There is a need for:

- Information about long-term trends in regional conservation status, as monitoring baselines for most species are unknown (this makes it difficult to detect population decline in a timely manner), and
- Improved 'knowledge management', including better capturing and storing of knowledge in agency documentation, databases, monitoring and reporting systems. This improvement will result in increased knowledge regarding the status of threatened species, and improved project planning, information dissemination, sharing of knowledge and continuity in program management.

6.8 Community engagement and coordination

There is a need for:

- increasing community engagement, inter-agency engagement and coordination in recovery programs to address all recovery priorities
- increasing engagement with Indigenous stakeholders in recovery programs, and
- Increasing awareness levels among the urban and rural resident population about threatened species and recovery programs.

6.9 Previous and current conservation activities

The recovery of the species considered in this plan could not occur without ongoing support and commitment from the community. Many of these people rely on and use the Mary River and its tributaries. Decisions regarding recovery of the Mary River's threatened species will benefit from recognition that this recovery plan is a recent phase in the interaction history between the Mary River system and the community. Much can be learnt from the past impacts that have occurred on the Mary River to encourage better ways of managing the river and engaging people. Information gained from these ongoing programs, evaluation of the previous recovery plan for the Mary River cod (supplementary information) and other research has been used to inform the development of this recovery plan.

Existing community management and conservation action - The early 1990s saw a consolidation of prevailing attitudes in the catchment toward greater awareness and concern for the river. Some landholders have changed their land and water management practices accordingly. For example there has been a focus on enhancing, maintaining and protecting riparian zones.

Through the activities of the MRCCC over 850 Rivercare and catchment care projects have led to the planting of more than 600,000 trees and the fencing of approximately 400 km of stream length (out of approximately 3000 km of major streams). More than 20,000 ha are being managed in a more sustainable way.

The MRCCC has been responsible for driving much of the river restoration projects in the Mary River catchment and surrounding region. The first riparian restoration project, the Voluntary River Restoration Grants scheme, involved 225 landholders. It was estimated to have reduced faecal contamination and nutrients entering the river by the equivalent of removing a sewage treatment plant servicing 50,000 people (Kelly 1998).

The *Mary River Tributaries and Rehabilitation Plan* (Stockwell 2001) prioritised reaches in the river for rehabilitation. This plan was updated in 2005 (MRCCC 2005) and the results of the prioritisation of sections of the river are shown in Figure 4 along with the locations of MRCCC projects. In addition there are numerous other projects not shown on this map, undertaken by the Lake Baroon Catchment Care Group (LBCCG), Burnett Mary Regional Group and local Landcare groups past and present including Noosa and District, Barung, Gympie and Tiaro), the Greater Mary Association Inc. and the Lower Mary Coast and Catchment Care group.

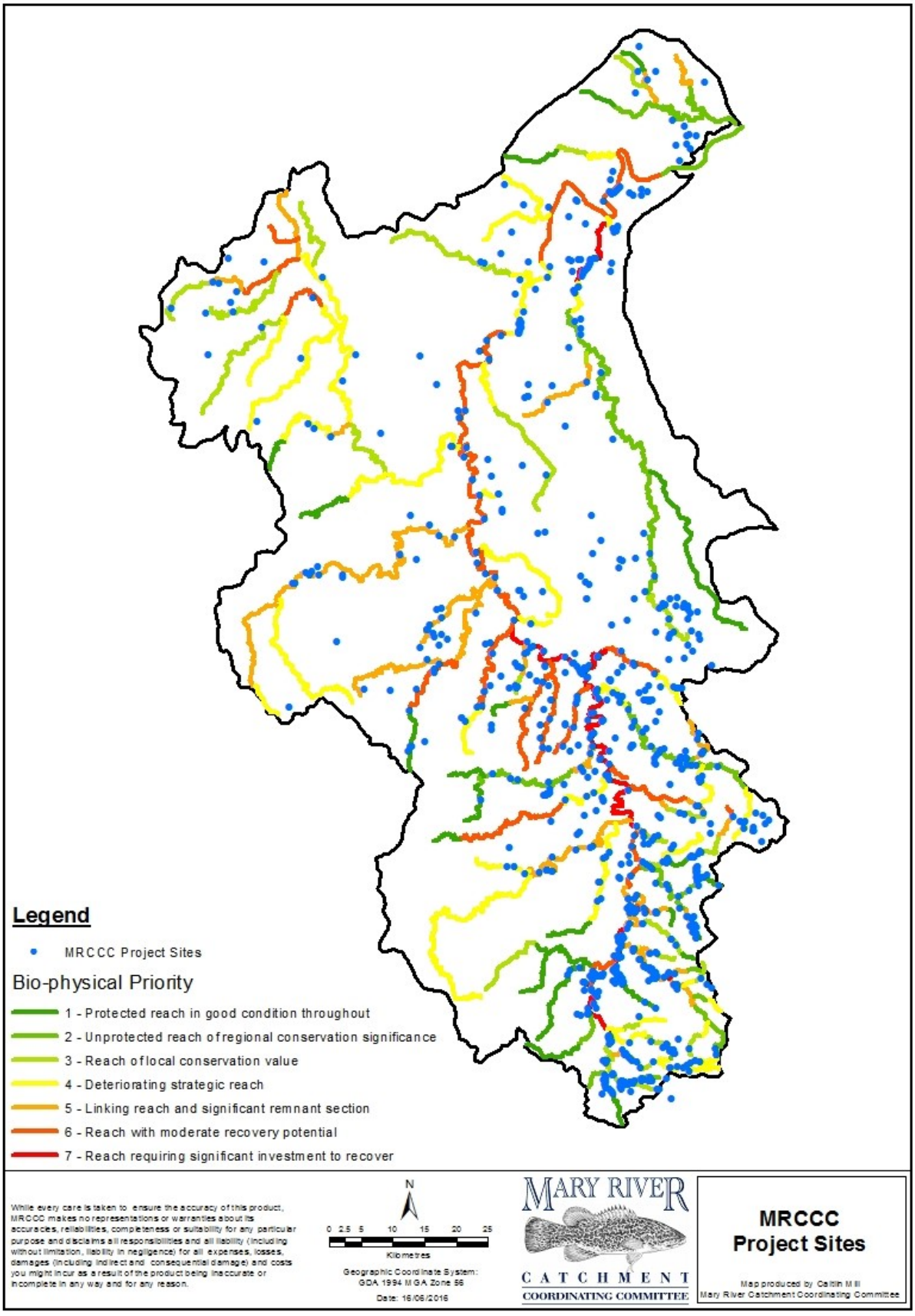


Figure 9: Location of MRCCC and LBCCG projects relative to the 2005 plan to prioritise reaches for rehabilitation. Source: MRCCC 2016

The Rivercare projects (known locally as this and not to be confused with the ceased Australian Government program of the same name) have facilitated and benefited from high levels of community involvement. Community organisations have played major roles in driving Landcare initiatives, protecting threatened species, revegetating areas and undertaking community awareness activities.

There is a history in the Mary River catchment of using iconic species to engage the community. Some examples include the Mary River Cod Network and the Mary River Turtle Project of Tiaro and District Landcare. The Mary River cod became a significant focal point of community engagement and landholder activities. After the Mary River Cod recovery plan was completed in 1996 the Mary River Cod Community Network was created. The *Codline* (formerly the *Cod catch up*), a Mary River catchment newsletter has been produced since 1998 with the 27th edition sent out in June 2016.

The Waterwatch Program which commenced in 2003 has been another important dimension of community involvement in the catchment. In 2016 the program supported eight networks involved in monitoring of water quality at over 100 sites with almost 100 volunteers.

The levels of engagement in river restoration and sustainable land management practices currently exceed existing capacity to provide advice and incentive funding. Continuing to support these activities is essential for the effective implementation of the recovery plan. These activities also need to be seen in a broad context of the social benefit that private landholders create when they take action to restore and protect riverbanks adjoining their property.

Existing recovery plans - This Recovery Plan will replace the Mary River Cod recovery plan. It will complement the Lungfish Recovery Plan, the National recovery plan for Stream-frogs of South East Queensland (which include the Giant Barred frog) and the Macadamia Recovery Plan. This Recovery Plan will also be adopted for the Mary River turtle.

The Mary River Cod Recovery Plan (Simpson and Jackson 1996) was reviewed in 2008 (Jackson 2008). The outcomes of the review indicated that although some objectives had been achieved, none of the criteria to assess the success of the recovery plan were fully met. A summary of the review is at included in the accompanying document.

6.10 Indigenous involvement in the river recovery

“These species are endangered, but so is our culture. Our culture is endangered. We need to protect these species and we need to maintain our culture.”

Alex Bond, *Kabi Kabi* Indigenous Knowledge holder commenting on this draft recovery plan in 2014.

Identifying opportunities for Indigenous leadership and involvement in river recovery has been a high priority in the recovery planning process. Several dedicated meetings have been held with Indigenous groups and individuals throughout the catchment. Discussion involved the content of the recovery plan and the actions that the recovery plan would recommend. The role of the recovery plan with respect to Indigenous people is to facilitate Indigenous aspirations regarding river recovery. This is closely intertwined with the social, cultural and economic aspirations, just as it is for the whole catchment community. Indigenous leaders in

the catchment have expressed a strong desire to be involved in river recovery and see an opportunity for this process to create positive outcomes for local Indigenous people, and to strengthen the cultural awareness and connection of both Indigenous and non-Indigenous people to the river. One of the seven objectives of the recovery plan is devoted to identifying and acting on these opportunities.

6.11 Objectives and performance criteria

The objectives were identified through consultation with the Recovery Team and the broader community.

Objective 1 Maintain or increase populations of priority species
The primary objective of this recovery plan is to increase the population size of the priority species
Performance criteria
1. Baseline understanding of recruitment levels of priority species is established.
2. Population health and distribution is documented for priority species by year 5.
3. Populations of the priority species increasing in size by year 10.

Objective 2 Reduce threats to priority species and to overall river health
Reduction of threats is essential for recovery of the priority species. This objective is focussed on the river ecosystem that supports the priority species. In order to function as habitat this system needs to contain an appropriate assemblage of species and suitable structural elements, and have low levels of threat (such as from invasive weeds and animals). The highest priority areas for remedial work are the intact riparian zones and other habitats identified as being critical to the survival of the priority species.
Performance criteria
4. No new high-risk invasive weed or animal species (for example tilapia, catsclaw) become established in areas where they were previously not present.
5. Mary River Aquatic Weed Strategy implementation has been monitored and evaluated by year 5 and actions adjusted where possible by year 10.
6. Feral terrestrial species or incidentally translocated invasive aquatic species density/diversity/range has not increased by year 5 and has decreased by year 10.
7. Water quality has been maintained at priority sites by year 5 and improved by year 10.
8. Environmental flow requirements of the priority species have been incorporated into water resource planning processes and flow delivered by year 10.

Objective 3	**Increase the quality, extent and connectivity of the priority species habitat**
Provision of quality, connected habitat is essential for recovery of the priority species.	
Performance criteria	
9. *Habitat quality, connectivity and extent is maintained until year 5 and improved by year 10.* 10. *Extent (km) of connected riverine and aquatic habitat (for example free of impediments to biopassage) is maintained by year 5 and increased by year 10.* 11. *At least 750 km of vegetated riparian zone maintained by year 5 and increased across all sub catchments by year 10 (including across multiple water management units)* 12. *In-stream and riparian habitat quality has been assessed at priority sites by year 5 and habitat quality improved at these sites by year 10 (to interpret broad-scale impact of changes in extent).*	

Objective 4	**Undertake research and monitoring to close gaps in knowledge related to species recovery**
Addressing crucial knowledge gaps associated with the life cycles, behaviours and specific ecological needs of the priority species will aid recovery as well as fill gaps in ecological health data that currently limit the certainty regarding aspects of the recovery process.	
Performance criteria	
13. *River recovery partnership program with local universities is established and significant research and monitoring projects have commenced by year 3 and informed identification of critical physical and hydraulic habitat of priority species by year 10.* 14. *Catchment monitoring and reporting system established by year 4.* 15. *Mary River cod captive breeding genetic goals/objectives as outlined in outcomes from the Mary River Cod Forum have been met by year 10.* 16. *Knowledge from research on flow and biopassage has been incorporated into existing and new infrastructure modifications.*	

Objective 5	**Ensure effective adaptive implementation of the plan**
Effective coordination of the Recovery Plan by the Recovery Team.	
Performance criteria	
17. *Recovery Team has met at least annually and continues to oversee implementation of the recovery plan.* 18. *All relevant universities, non-government organisations and other groups involved in data sharing arrangements for priority species, water quality, habitat quality and hydrology engaged in the implementation of the Recovery Plan by year 2.* 19. *Regional councils have established, and where possible are enacting, a process for cooperating on issues related to the Plan by year 2.*	

Objective 6	Strengthen the sense of connectedness to the river and increase the capacity and motivation of society to contribute to recovery of priority species and river health
The role that the society plays, which includes the broader community as well as local organisations and institutions, is important for achieving recovery of the priority species.	
Performance criteria	
20. Capacity of community organisations to implement recovery actions has increased.	
21. Knowledge of the Mary River and its ecosystem requirements has increased and is evident in how people, including children, interact with the river	

Objective 7	Create opportunities for Indigenous involvement and leadership in the recovery process and strengthen cultural connections as part of the recovery program
Indigenous involvement and leadership in the recovery process has been recognised explicitly because of the unique role Indigenous people can and would like to play in building a multidimensional recovery process.	
Performance criteria	
22. A framework for addressing cultural, economic and environmental aspirations of Indigenous people has been established by Year 2 and plays an integral role in implementation of the recovery plan	

6.12 Recovery actions

The recovery actions and management practices of this plan will be implemented within an adaptive management framework. Monitoring and research results will be used to assess the success of objectives and make improvements to these where necessary.

The following actions provide for the management and research necessary to support the recovery of the priority species over the next 10 years. Although these actions have a priority species focus all the actions have been developed to support the conservation of the catchment's biodiversity, including threatened species and ecological communities.

6.13 Action prioritisation and timing of implementation

The action list is extensive and recognises that the priorities of future sources of funding will be difficult to predict. The action list is prioritised in an attempt to find a balance between urgent issues that need to be addressed, and actions that support the long-term foundation for the recovery process. Priorities are allocated based on the assumption that the actions will be revised annually. High priority actions would be achieved (or commenced in the case of ongoing actions) within the first two years. The approach to prioritisation is based on ranking of each action against three criteria. These criteria were:

Criterion 1: Urgency - that this action needs to happen in the short term, i.e. in the first two years of implementation of the plan. For example, there could be a window of opportunity that only exists in that time frame and/or because a threat may need to be addressed as soon as possible.

Criterion 2: Significance - that this action will have a significant impact on the recovery of the species considered in the plan.

Criterion 3: Foundational - that this action underpins the ability of the plan to be implemented effectively and to achieve its objectives. Actions that rank highly under this criterion are essential to other actions. If they do not occur the recovery process would be undermined.

Actions in the medium and high priority categories initially will move up the priority scale as progress with the recovery plan is reviewed by the Recovery Team. Timing of the actions links directly to the priority they have been assigned. Very high priority actions are to be achieved in years 1–3 of implementation, high priority actions in years 1–5 and medium priority in years 1–10. Commencement of all actions in year one is in recognition that the Recovery Team will need to review the actions each year. All actions are deemed important for species recovery.

Under each action, sub-actions are grouped according to whether they address a particular issue or threat or are aimed at gathering information to address a particular management issue. Additional information and direction is provided on some of the sub-actions in the Implementation Schedule (Appendix 1). At the conclusion of the section on actions the relevant objectives are listed.

6.14 Action and sub-actions

Action 1. Manage threats to the priority species	**Very high priority**

Sub-actions incorporated into this action are:

1.1 Undertake integrated feral animal control programs at those sites used by priority species for breeding, nesting and feeding (High priority).

1.2 Respond to the threat of feral aquatic animals and weed species as required (Very High priority).

1.3 Undertake Mary River turtle (*Elusor macrurus*) nest protection (Very High priority).

1.4 Continue Mary River cod (*Maccullochella mariensis*) stocking program to reduce threat of low population (High priority).

1.5 Undertake precautions to prevent the introduction and spread of chytrid fungus (Very High priority).

1.6 Manage the impacts of unanticipated direct threats to survival as required (Medium priority).

1.7 Monitor the genetic fitness of Mary River cod (including Tinana Creek) populations and manage threat of failed recruitment if the risk increases (High priority).

Notes

1.1 Feral terrestrial animals

Terrestrial feral animals are a particular threat to the giant barred frog and the Mary River turtle. Specific actions listed in the implementation schedule seek to minimise this threat and build on work that is already happening. Coordination is needed to enable improvement and adaptive management of this issue.

1.2 Feral aquatic animals

Currently the Mary River contains fewer noxious aquatic pests than are present in surrounding catchments. The implementation schedule lists specific actions that should be taken to help prevent introduction of new species, to ensure early detection and to manage populations that have established. This is an action that the Recovery Team would need to oversee in the long term and be ready to respond if any new species are detected.

1.3 Mary River turtle nest protection

This is a very high priority as it addresses the threat of terrestrial predators which is regarded to be very high. The action involves continuing and expanding the nest protection activities currently undertaken, primarily by Tiaro and District Landcare and associates.

1.4 Mary River cod stocking program

Draft recommendations from the Mary River Cod Forum (Kind 2012) will inform this action. This is a high priority. The draft recommendations have been listed as specific actions in the implementation schedule.

Relationship to objectives and performance criteria

Addresses objectives 1 and 2.

Action 2. Manage threats to, and improve, habitat quality **Very high priority**

Manage the habitat to: maintain the extent of habitat critical to survival; improve the extent of preferred habitat; and increase the distribution and diversity of suitable aged-class habitat.

Sub-actions incorporated into this action are:

2.1 Identify priority sites for in stream and riparian rehabilitation and undertake rehabilitation at these sites (Very High priority).

2.2 Manage the threat of invasive weeds at priority sites (High priority).

2.3 Improve stream-bed stability in priority sites (based on retention of key habitat and protection of assets) (High priority).

2.4 Undertake activities that improve water quality (High priority).

2.5 Improve environmental flow provision and compliance (Very High priority).

2.6 Improve and monitor biopassage throughout the catchment (High priority).

2.7 Establish demonstration reaches that have overlapping habitat for priority species and that integrate community, cultural and ecological significance (High priority).

2.8 Assess, and manage if required, the threat of unanticipated disturbance from human activities (High priority).

2.9 Integrate strategies to improve habitat into voluntary management agreements and agency land and water management procedures and plans (Medium priority).

2.10 Secure conservation agreements, covenants or inclusion in reserve tenure on priority sites and continue to implement voluntary management agreements, and agency land and water

management procedures and plans (High priority).

Notes

Management of threats to habitat quality should aim to avoid further reductions in habitat quality and to actively improve habitat at priority sites. Descriptions of quality habitat, habitat restoration techniques (Stockwell 1999) and guidelines (O'Donnell 1998) are available. Priority sites for management to be determined in consultation with the MRTSRT, with reference to the likely current and future importance of the site to the priority species.

2.1 Rehabilitation

This sub-action builds on previous prioritisation frameworks. For example, the Mary River Tributaries and Rehabilitation Plan (Stockwell 2001), Mary River Priority Action Plans (Watson et al. 2005a, Watson et al. 2005b, MRCCC 2005) and existing assessments of the catchment such as the Aquatic Conservation Assessment (State of Queensland 2011c). These frameworks add an additional layer to the prioritisation based on the definition of habitat critical provided in Section 3.

The implementation schedule (Appendix 1) includes a further range of specific actions to prioritise in-stream and riparian habitat for rehabilitation. These pinpoint particular opportunities to undertake these activities that exist at the time of completing this plan.

This sub-action also encompasses replanting of macrophytes after scouring (to maintain macrophyte seed beds) and the re-introduction of beneficial large wood. It is noted that this sub-action also incorporates activities specific to giant barred frog habitat quality and connectivity improvement, as this species has requirements that need to be considered independently of the other four priority species. This information is based on the review of actions in the National recovery plan for Stream Frogs of South-east Queensland (Hines et al. 2002) related to the giant barred frog.

2.2 Invasive weeds

There is an existing aquatic weed management strategy, the implementation of which forms an important part of this task. The recent listing of two of the most significant riparian weeds, Cats claw creeper and Madeira Vine, as Weeds of National Significance in 2012 is of importance to this plan. This sub-action links to Action 3.1 about assessing current levels of weed infestation.

This is a task that the Recovery Team would need to oversee in the long term.

2.3 Stream bed stability:

There are opportunities to combine returning stability to the river bed with asset maintenance and construction activities as well as undertaking projects to protect habitat critical. This sub-action links to sub-actions 2.1, 2.2 and 2.8.

2.4 Water quality

Activities to improve water quality revolve around reducing sediment and salt intake to the river and reducing nutrient and pesticide loads entering the river and tributaries. Loads from the broader landscape as well as point sources from particular industries or sewage treatment plants should be taken into consideration. These activities involve working to improve practices of landowners which have been a strong point of historical activities in the catchment.

2.5 Environmental flow

A significant opportunity to improve environmental flow provision and compliance is approaching with the scheduled expiry of the *Mary Basin Water Resource Plan* (State of Queensland 2006)

and the subsequent review of the Plan. It is crucial that knowledge gaps regarding environmental flow requirements (see sub-action 3.4) in the environmental flow schedules for the Mary Basin are addressed in the review.

2.6 Biopassage

The Burnett Mary Biopassage Strategy (Stockwell et al. 2008) sets priorities for removing barriers to biopassage in the catchment and recommends linking barrier removal projects to demonstrations reaches (see sub-action 2.8).

This is an action that the Recovery Team would need to oversee in the long term.

2.7 Demonstration reaches

Demonstration reaches in the river provide an opportunity to demonstrate the practical actions necessary to improve habitat quality, extent and connectivity and to engage landholders and the broader community in learning about the river (Lovett 1999). Demonstration reaches could be established in each regional council (Sunshine Coast, Gympie and Fraser Coast) to increase local ownership of the river and provide evidence of what has been completed and plan for future activities. Establishment of demonstration reaches could provide quality habitat in the local reach and encourage repetition of similar actions to be undertaken on other parts of the river.

Funding obtained from the Australian Government's Biodiversity Fund has been used to assist in achieving this sub-action.

Relationship to objectives and performance criteria

Addresses objectives 1, 2, 3, 5 and 6.

Action 3. Conduct research essential for future management **Very high priority**

Undertake investigations to inform future management and recovery planning. Sub-actions incorporated into this action are:

3.1 Establish a baseline for river health and habitat quality and integrate ongoing monitoring programs with existing estuarine and marine monitoring programs. Include habitat critical mapping (Very High priority).

3.2 Continue research to determine best practice environmental flow releases and include findings in Water Resource Plan revision (Very High priority).

3.3 Utilise modelling to assess future risks to the Mary River and priority species from increased water extraction, coal and coal seam gas mining proposals and use this information to inform and implement future necessary actions as required. Respond to further identified potential threats as required. (Very High priority).

3.4 Continue research to determine the distribution, population status of priority species and address ecological knowledge gaps associated with these (High priority).

Notes

3.1 Baseline and monitoring for river health and habitat quality

A complete freshwater and estuarine monitoring program for the catchment was proposed by Watson et al. (2005a). In addition to water quality, this action includes establishing a habitat quality guide and recording baseline levels of vegetation, riparian weeds, aquatic weeds and bed stability. Because of the difficulty of establishing the status of the species, river health (which incorporates habitat quality) is an important proxy for assessing the recovery process. Waterwatch and other community involvement should be utilised to undertake this sub-action.

3.2 Environmental flow

The Water Resource Plan (Mary River) (State of Queensland 2006) is due to be reviewed. The review will provide an opportunity to refine environmental flow releases for ecological purposes within the Mary River (link to Action 2.6). In particular, environmental flow requirements for freshwater mullet, Australian lungfish and cod are not well understood. Use of low flow data to model cease to flow events and other critical low flow parameters that relate to habitat quality and connectivity is part of this sub-action.

3.3 Distribution, population status and ecological knowledge of the priority species

This sub-action will fill knowledge gaps for the distribution of the priority species. Currently the status of the populations of each of the species is unknown aside from anecdotal reports. The reports can form an important part of the picture, in combination with various forms of scientific data. This action links closely with the performance criteria and monitoring of the plan.

<u>Relationship to objectives and performance criteria</u>
Addresses objectives 1, 2, 3, 4, 5 and 6

Action 4. Coordinate implementation	**Very high priority**

4.1 Maintain the operation of the Recovery Team to track progress, enable adaptive management and advocate for improved policy and regulation to help achieve objectives 1–7 (Very High priority).

4.2 Operate functional sub-groups of the Recovery Team, as necessary, and in accordance with agreed Terms of Reference.

4.3 Integrate results of monitoring activities into the adaptive management process.

4.4 Prepare and implement two-year implementation plans to outline priority tasks, detail recovery plan implementation and document any changes to priorities or tasks in response to monitoring data and other new information.

4.5 Review implementation plans annually in light of recent monitoring data and any other new information.

4.6 Prepare annual reports to outline progress against implementation plans and recovery plan objectives and criteria, and to identify any changes in recovery priorities.

4.7 Collect, collate and report the outcomes of implementation to the MRTSRT annually (Very High priority).

4.8 Review the recovery plan in year 5 (Very High priority).

Relationship to objectives and performance criteria

Addresses objective 5.

Action 5. Secure resources for implementation	**Very high priority**

Develop a strategic and coordinated approach to secure sufficient resources for implementation of very high and high priority actions, and seek additional resources for all other recovery actions. Use the holistic nature of this plan to access a wide range of funding sources—think creatively/beyond the square. Sub-actions are include:

5.1 Identify and secure funding to support implementation of two-year implementation plans (see Action 4.4) and support a paid Recovery Program Coordinator to facilitate operations of the Recovery Team, and resolution of multi-jurisdictional issues (links to Action 5.2).

5.2 Form and maintain new partnerships for effective delivery, and maintain relationships with existing key delivery partners.

Notes

Full implementation of the highest priority actions in this recovery program is likely to require a commitment of resources from Recovery Team organisations, as well as the development of new partners and new funding sources. A coordinated approach to seeking additional resources will be beneficial to many current and potential future partners.

Relationship to objectives and performance criteria

Addresses objectives 1, 2, 3, 4, 5 and 6.

Action 6. Communicate effectively with partners and engage stakeholders and the community **High priority**

Communicate effectively with partners, stakeholders and the community to develop and maintain support for implementation. Sub-actions include:

6.1 Provide communication products to funding bodies to foster productive partnerships (Medium priority).

6.2 Develop and implement a communications plan to service the information requirements of a range of partners and stakeholders with coordinated communications products (Medium priority).

6.3 Support and reward involvement of stakeholders in implementing the recovery actions (High priority).

6.4 Increase awareness of the general public of the links between general river health, river-bed stability, river restoration, priority species (at multiple life cycle stages) and community values (High priority).

6.5 Work with councils and DNPRSR to increase responsible recreation opportunities associated with the Mary River.

6.6 Provide engagement services such as on-farm advice, incentives, field days and workshops on an ongoing basis (High priority).

6.7 Increase capacity and effectiveness of local organisations involved in activities for river and threatened species recovery (High priority).

6.8 Strengthen involvement of schools (at all levels) in river recovery and incorporate information about the catchment and priority species into classroom activities (High priority).

6.9 Identify linkages to related plans, strategies, monitoring programs and projects and ensure that recovery plan actions complement and link with these and recovery plan actions inform future related planning (High priority).

Notes

Implementation will rely on the support of many partners and stakeholders, including the broader community. Effective communication will develop and maintain this support. The efficiency and effectiveness of the *Codline* newsletter will be considered in the communication planning process.

6.1 Funding

This sub-action aligns closely with Action 5.1 and 5.2 in that one role of a coordination body could be to help obtain funding to support on-ground activities. This action identifies the need to be strategic and creative and to seek new opportunities for funding such as seeking

philanthropic support. This task aims to facilitate networking and coordination between groups to enable more effective lobbying for funds. This could include sharing resources, partnering on project applications and numerous other possibilities. Funding is crucial to the long-term ability to implement the actions in the plan. This is particularly the case for coordination, incentives, training workshops, field days and large projects.

6.3 Support and reward stakeholders

Ongoing support is needed to maintain and enhance stakeholder involvement in recovery. There are several activities listed in the implementation schedule. Overall, this sub-action is rated as high because of the important role that private landholders play in protecting habitat and river health. Maintaining current levels of participation and facilitating deeper involvement is seen as important as attracting new volunteers. This is consistent with the principles of engagement described in accompanying document).

6.4 Increase awareness

This sub-action is focused on the general public. Activities outlined in the implementation schedule (Appendix 1) are critical for maintaining the interest of people and organisations who are involved and for reaching out to new groups and individuals. Activities related to this sub-action need to occur on an ongoing basis.

6.5 Responsible recreation

This sub-action is focussed on access to the river and the specific actions (see the implementation schedule) that are needed to ensure and encourage responsible recreation. Other specific actions include informative and engaging signage and information for recreational fishers that enables them to minimise risks of their activities to the priority species.

6.6 Extension services

Programs such as the Mary River Restoration Stories Project and Healthy Habitats program demonstrate the role that field days and workshops can contribute to encouraging best practice conservation management, help to maintain motivation and encourage individuals who are already improving their practices. An important specific action in the implementation schedule under this sub-action is establishing a mentoring program in which best management practices and techniques are passed on to newly involved landholders.

6.7 Capacity and effectiveness of local organisations

Investing in the capacity of local organisations will help ensure that voluntary momentum is maintained to help continue the voluntary participation of healthy and active groups in the catchment. The volunteer contribution to the recovery of the Mary River to date has been highly significant. A high priority has been placed on this sub-action because of the need to maintain continuity and capacity within community organisations.

6.8 School involvement

There is an opportunity to liaise with the development of the Australian National Curriculum to include local content into the curriculum. Because of the timing of this opportunity the priority for this sub-action is high and the timeframe of years 1–5 is proposed.

6.9 Linkages with other plans, strategies, programs and projects

Clarifying links with other plans, strategies, programs and projects and taking into account during implementation, will boost the effectiveness of the recovery plan. These links include statutory and non-statutory planning processes at the regional natural resource management level, local and state government levels.

Relationship to objectives and performance criteria

Addresses objective 5.

Action 7. Involve and engage Indigenous people **High priority**

This action aims to help create opportunities for Indigenous input, Indigenous leadership in the recovery process and opportunities for cultural connections to be an integral part of the recovery of priority species. Sub-actions include:

7.1 Foster Indigenous engagement, training and employment opportunities associated with river recovery (Very High priority).

7.2 Undertake Reciprocal Science activities where culture and knowledge is shared (Very High priority).

7.3 Raise cultural awareness of non-Indigenous Natural Resource Management organisations and staff (High priority).

7.4 Record knowledge according to cultural protocols (High priority).

Notes

7.1 Indigenous involvement

Fostering employment and training opportunities for Indigenous people associated with recovery actions also provides a situation for which people can reconnect to country and learn from Elders. The Indigenous Work Crew project and Cultural Connections model (Department of Environment Climate Change and Water NSW 2010) can be used to help guide achievement of this sub-action.

7.2 Reciprocal science

Participants in the Indigenous Working Group meeting coined this phrase of Reciprocal Science to imply an exchange of ideas and knowledge between university based river science and Indigenous knowledge of the river. Both sources of knowledge are to be treated with respect and regarded as equal. Walking the country and participating in 'Back to Country' field trips are part of this action.

7.3 Cultural awareness

This sub-action will facilitate the other sub-actions under this action because greater cultural awareness of Natural resource management organisations, provided through training, should help to strengthen partnerships and relationships between these organisations, their staff and Indigenous groups. Materials created for the Fraser Coast campus of the University of Southern Queensland could be useful. This awareness could be formalised in the form of

organisational policy, reconciliation actions plans, memorandum of understanding or other formal mechanisms.

7.4 Knowledge recording

The way in which Indigenous knowledge is recorded needs to provide different levels of access to the information so that control can be exercised by those with responsibility for and authority over this knowledge. The Burnett Mary Regional Group does have an existing knowledge recording database but there was a view expressed that this database should be independent to ensure Indigenous protocol is followed. The database and gaining understanding of the way in which it operates could provide a starting point for implementing this sub-action. Protocols would also need to be established to ensure the authenticity of knowledge is incorporated in the database.

Relationship to objectives and performance criteria

Addresses objective 7.

In addition to the actions listed above, there is a separate implementation schedule which includes a further range of specific actions to prioritise work if required (see Appendix 1). These pinpoint particular opportunities to undertake those activities that exist to assist recovery of species.

6.13 Schedule and costs

Implementation of this plan will involve a wide range of stakeholders and partners. Strong coordination and collaboration will be needed. The MRCCC will take a leadership role in this process as they are well placed to facilitate the ongoing participation and shared ownership of the process among stakeholders.

The cost of implementation of this plan should be incorporated into the core business expenditure of the affected organisations and through additional funds obtained for the explicit purpose of implementing this recovery plan. It is expected that state and Commonwealth agencies will use this plan to prioritise actions to protect the species and enhance its recovery, and that projects will be undertaken according to agency priorities and available resources.

The schedule and costs presented in Table 5 are based on estimates of the cost for the entire recovery plan. Responsibility should be shared among all stakeholders. For some species a number of the actions included in this plan are already being undertaken. This occurs in various forms by numerous agencies and individuals and has varied levels of funding security. Several species included within this recovery plan are the subject of a national single or multi-species recovery plan. Consequently investment in this recovery plan will directly link to these plans. Other actions are new actions, which are needed and are yet to commence.

The priorities for funding each action are listed in Table 5 and the estimated costs of undertaking the actions are presented below. The rationale for developing these costs and the detailed calculations underpinning Table 5 are presented in accompanying document (Australian Government 2016).

Table 5: Summary of implementation costs for actions in this recovery plan

	Priority	Cost of actions (excluding salary costs) (K)				
		Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Action 1: Manage threats to the priority species	Very High	180	170	170	170	170
Action 2: Manage threats to improve habitat quality	Very High	1,255	1,115	1,115	1,010	1,010
Action 3: Conduct research essential for future management	Very High	295	295	295	100	100
Action 4: Coordinate implementation	Very High	123.5	1.5	1.5	0	0
Action 5: Secure resources for implementation	Very High	20	20	20	0	0
Action 6: Communicate effectively with partners, and engage stakeholders and the community	High	313	233	233	183	183
Action 7: Involve and engage Indigenous people	High	36	51	96	36	46
Total cost of actions		**2,222.5**	**1,885.5**	**1,930.5**	**1,599**	**1,609**
Total cost including salaries		**3,247.5**	**2,910.5**	**2,955.5**	**2,624**	**2,634**

Implementation of the plan will rely on additional funding sourced from within and outside of the catchment. Possible potential contributors include Australian and Queensland governments, Regional Councils, the Burnett Mary Regional Group, Seqwater, SunWater Pty Ltd and Wide Bay Water. If the entire budget is not able to be secured the prioritisation of actions is a method to target available funds in each year.

Primarily the responsibility will be the Recovery Team to facilitate recovery coordination and integration. The total funding required to support implementation over five years is estimated to be $13.8 million, $8.8 million of which is for on ground works and materials. Full implementation of the plan would involve funding for positions which would be responsible for coordination, research integration, community engagement, on ground works and their supervision, extension, monitoring and weed management. It is assumed that the same number of positions would be required each year for implementation. These positions could be shared amongst partner organisations in a way that capitalises on the strengths of each organisation.

7.0 Monitoring, evaluation, reporting and improvement

It is recommended that the Recovery Team would review performance annually. A more consolidated review should occur five years after adoption of the plan and another review at 10 years. A 10 year plan is considered appropriate because the species are long-lived and some measurable improvements may not be noticeable after the five year review period. The purpose of a five year review will be to assess performance of implemented actions, review priorities assigned to objectives and actions and to revise performance criteria in light of progress and developments.

7.1 Monitoring

The performance criteria play a strong role in monitoring the effectiveness of whether actions are meeting objectives and should be used to indicate achievement of specific individual tasks. A generalised monitoring program is discussed below.

Logic behind proposed monitoring program

The monitoring program has been split into two categories;

- existing monitoring activities that should be continued and expanded, and
- new monitoring activities that are required.

A priority for the Recovery Team should be to attract funding to support any new monitoring activities. Activities that are listed as ‘new’ activities will be shifted to ‘existing’ activities when they begin, with the intention that all the monitoring activities listed are taking place. Research is also a component that has an important role to improve understanding how to effectively recover the priority species. The research has been separated to distinguish that once the research has been undertaken it can be used to inform better monitoring processes. Research is also crucial for addressing key knowledge gaps related to the ecology of the species and subsequent management decisions.

Current monitoring programs

Mary River cod

DNRM Environmental Flows Assessment Program for the Mary River cod began in 2009. Outcomes of the program include mapping of persistence of waterholes, flow patterns, water and habitat quality, size and movement patterns of the cod. Genetics and ageing studies have also been undertaken. Findings from this program where published in 2016 (DNRM 2016).

Australian Lungfish and Mary River cod

Fish that are caught by recreational fishers have been tagged and a reporting system established to report tagged fish that are recaptured. Australian lungfish were acoustically tagged in 2013 by DNRM.

Mary River turtle nests

Mary River turtle nests were first monitored in 1997 by Flakus (2002). The Tiaro and District Landcare Group have been protecting and monitoring nesting banks since 2001. The Department of Natural Resources and Mines (DNRM) have been mapping nest locations since 2010. Tagging Mary River turtles and using acoustic technology started in 2011.

Giant barred frog

The MRCCC have been monitoring populations of the Giant barred frog at one site since 2005. In 2007, an additional site was included in the monitoring program. In December 2008 another two sites were added to the monitoring program. A new monitoring program under the direction of Barung Landcare commenced in 2012 on Obi Obi Creek in Maleny and monitoring has occurred in Gympie Regional Council area including within the HQPlantations estate. This program has expanded the known distribution range of the species through confirmed sightings of several frogs in new locations on Obi Obi Creek and Tinana Creek. The Department of Transport and Main Roads (Qld) monitored 14 sites between 2010 and 2013.

Water quality

Data is routinely collected by Waterwatch volunteers. It is collated and analysed to provide ratings for the sub-catchments that are monitored. Actions in this plan will seek to further utilise this information to inform recovery activities. Wide Bay Water has also commenced water quality monitoring in Tinana Creek.

The Great Barrier Reef Catchment loads monitoring is conducted by the Queensland Department of Science, Information, Technology and Innovation in collaboration with MRCCC in the Mary River catchment. This event and ambient monitoring program combined with modelling work reported in the Burnett Mary Water Quality Improvement Plan (Burnett Mary Regional Group 2015) and in the ongoing modelling of load reductions as a result of practice change (Fentie et al 2014) provides a means of assessing total loads of sediments, nutrients and pesticides in the Mary River.

In-stream

Index of Stream Condition (ISC) assessments are routinely undertaken by MRCCC. The ISC assessments measure a variety of parameters including beneficial large wood (large woody debris), stability of stream banks and macro invertebrates (which indicate health of the system). These assessments should continue to be undertaken and data collected should be collated and evaluated. This information will contribute greatly to the overall Mary River recovery plan management.

Riparian vegetation

Riparian vegetation data is collected by MRCCC using a standard method called MRCCC Riparian Condition Assessments. BioCondition Assessments according to the Queensland Herbarium methodology have also been conducted and are being used to assess the recovery trajectory of revegetation sites.

WildNet—this is the Queensland Government's wildlife database which contains records of flora and fauna throughout Queensland. This database has potential to be a single repository for monitoring data but it is not currently utilised for this purpose. Using WildNet will assist in collation of data and evaluation purposes to help inform Mary River recovery planning management.

New monitoring

Recovery Team meetings

During any implementation phase of this recovery plan an aim of the Recovery Team could be to oversee the implementation of actions. Evidence that the Recovery Team is meeting can be used as a simple quantitative monitoring indicator. These will demonstrate that coordination of action implementation is taking place. The recovery team could develop surveys or contract social researchers to assist in evaluating implementation of actions and identifying required changes.

Biopassage

Records of removal of barriers to fish and turtle movement could be used as an indicator of increased biopassage for species. For example, data collected from Passive Integrated Transponder (PIT) tag readers recording mullet presence and any increased distribution of this species could also be used as a monitoring indicator of improved biopassage of freshwater mullet.

Species population survey

Currently there is no complete and accurate population estimate for the five priority species. Baseline and any population estimates could inform whether actions implemented are effective for increasing population sizes or not. The current limitation on collection of this type of data is establishing an effective, appropriate and an affordable method for obtaining population data.

Mapping

Mapping of habitat critical could provide a baseline for areas that are critical for the survival of the five priority species. As mapping is updated this could indicate progress on increasing available and suitable habitat. Limitations to producing this mapping involve the lack of suitable identified habitat critical to the survival of each of the five priority species and resource constraints in producing the maps.

Riparian vegetation assessment

A consistent method (for example the MRCCC Riparian Condition Assessment) of monitoring riparian vegetation should be used across all on-ground riparian projects associated with the Mary River to ensure consistent monitoring and evaluation.

Use of high definition landscape scale imagery (lidar) would be able to efficiently assess the presence, density and species composition of riparian vegetation. This could inform priorities for revegetation and weed removal projects. As projects were undertaken further lidar imagery could inform progress. The current limitation on use of this monitoring technique is that lidar imagery is expensive.

7.2 Evaluation

The Recovery Team could be responsible for evaluating the actions, achievements and learnings from this recovery plan. Evaluating relevant information could be undertaken to assess progress towards objectives and to make adjustments where necessary, through:

- review action implementation to assess whether actions implemented are progressing towards achievement of objectives
- review actions that have not been implemented to assess whether their priority for implementation should be varied or whether the action is still appropriate
- consider whether there are any new actions required
- review of process

Social capital, attitudinal change and awareness

Evaluating the social capital, attitudinal change and awareness can be a responsibility for the recovery team. Evaluation of social capital, attitudinal changes to conservation practices and awareness can be explored to show if field days or training are effective or not, and where they can be improved.

The number of field days training delivered; the approximate number of groups and individuals operating on projects linked to the river; the number of members, including Indigenous people, employed, or number of new positions in conservation could all be used as a simple monitoring indicators for quantitative data. In parallel to this, more qualitative information could be extracted. Feedback sessions, unstructured interviews or similar social research methods should be used to add robustness to quantitative data. The Sunshine Coast Council landholder grants monitoring could be used as a guide for wider catchment monitoring for this component. Consideration should be given to standardise methods, key evaluation questions and questioning tools across the catchment in social research activities to obtain robust qualitative data.

Social evaluation and surveys

A large-scale survey of community attitudes towards the conservation of the five priority species could be conducted prior to implementation of the recovery plan. This may provide sufficient baseline data so that in any five year recovery plan review, any changed attitudes or levels of awareness might be properly assessed. Coordination and evaluation of such a survey would require a dedicated and suitably qualified social researcher and any supporting resources.

7.3 Reporting

The Recovery Team should be responsible for producing regular communications regarding reporting on progress of the implementation of the recovery plan. At five years after implementation, the Recovery Team should conduct a review of the plan and report on progress.

Reporting should be made available and could be published on websites such as:

- Australian Government Department of the Environment

- Queensland Government including Department of Environment and Heritage Protection
- The MRCCC, and
- Burnett Mary Regional Group

They should also be distributed to appropriate agencies, industries and interest groups.

Data Storage

Where data is to be included in Queensland DSITI's WildNet database, agencies responsible for collecting this data are required to provide it to the WildNet database. As part of the implementation phase of this plan, data sharing agreements could be arranged for the collection of any data so it is consistent with WildNet. Progress reports on the implementation of the recovery plan can be placed on DEHP's The SPRING (an online tool which provides information to support the conservation and recovery of Queensland’s threatened plant and animal species).

7.4 Linking the objectives, performance criteria and monitoring

Table 6 lists the objectives and performance criteria of the Mary River recovery plan and outlines the existing and new monitoring programs being carried out to measure these objectives over the stated timeframes.

Table 6: Objectives, performance criteria and monitoring

Objective	PC	Performance criteria	Monitoring programs
1. Increase populations of priority species	1	Baseline understanding of recruitment levels of priority species established.	Mary River turtle nest monitoring (existing) Australian lungfish and Mary River cod data collection (existing) Giant barred frog survey (existing)
	2	Population health and distribution is documented for priority species by year 5.	Dept. of Natural Resources and Mines (DNRM) and Environmental Flows Assessment Program (EFAP) monitoring (existing) Griffith / University of Queensland research projects (existing and new) Species population survey (new)
	3	Populations of the priority species increasing in size by year 10	
2. Reduce threats to priority species and to overall river health	4	No new high-risk invasive weed or animal species become established in areas where they were previously not present.	Riparian vegetation data collection (riparian condition assessments etc.)(existing)
	5	Mary River Aquatic Weed Strategy implementation has been monitored and evaluated by year five and actions adjusted accordingly by year 10.	In-stream ISC assessments etc. (existing)
	6	Feral terrestrial species or incidentally translocated invasive aquatic species density/diversity/range has not increased by year five and has decreased by year 10.	
	7	Water quality has been maintained at priority sites by year 5 and improved by year 10.	Water quality monitoring (Waterwatch, Wide Bay Water Corporation, Catchment Loads monitoring and modelling (DISTI)) (existing) new water quality monitoring
	8	Environmental flow requirements of the priority species have been incorporated into water resource planning processes by year 5 and flow delivered by year 10.	DNRM EFAP monitoring (existing) Biopassage monitoring (new)

3. Increase the quality, extent and connectivity of the priority species habitat	9	Habitat quality, connectivity and extent is maintained until year 5 and improved by year 10.	Riparian vegetation data collection (riparian condition assessments etc.) (existing) In-stream ISC assessments etc. (existing) DNRM EFAP monitoring (existing)
	10	Extent (km) of connected riverine and aquatic habitat (for example free of impediments to biopassage) is maintained by year 5 and increased by year 10.	DNRM EFAP monitoring (existing) Biopassage (new)
	11	At least 750 km of vegetated riparian zone maintained by year 5 and increased across sub catchments by year 10 (including across multiple water management units) (with the long-term aim of self sustaining riparian vegetation extent increasing).	Riparian vegetation assessments (high definition landscape scale imagery) (new) In-stream ISC assessments etc. (existing) DNRM EFAP monitoring (existing) Mapping (new)
	12	In-stream and riparian habitat quality has been assessed at priority sites by year 5 and habitat quality improved at these sites by year 10 (to interpret broad-scale impact of changes in extent).	Research (new)

4. Undertake research and monitoring to close gaps in knowledge related to species recovery	13	Significant research and monitoring projects have commenced by year 2 and informed identification of critical physical and hydraulic habitat of priority species by year 10.	Riparian vegetation assessments (high definition landscape scale imagery) (new) In-stream ISC assessments etc. (existing) DNRM EFAP monitoring (existing) Mapping (new)
	14	Catchment monitoring and reporting system established by year 4.	Mary River turtle nest monitoring (existing) Australian lungfish and Mary River cod data collection (existing) Giant barred frog survey (existing) DNRM EFAP monitoring (existing) Species population survey (new)
	15	Mary River cod captive breeding genetic goals/objectives as outlined in outcomes from the Mary River cod Forum have been met by year 10	
	16	Knowledge from research on flow and biopassage has been incorporated into existing and new infrastructure modifications.	DNRM EFAP monitoring (existing) Research (new)
5. Ensure effective adaptive implementation of the plan	17	Recovery Team has met at least annually and continues to oversee implementation of the recovery plan.	Recovery Team is meeting (existing)
	18	All relevant universities, non government organisations and other groups involved in data sharing arrangements for priority species, water quality, habitat quality and hydrology by year 2.	
	19	Regional councils have established and are enacting a process for cooperating on issues related to the Plan by year 2.	

6. Increase society capacity, sense of connectedness and motivation to contribute to recovery of priority species and river health	19	Capacity of community organisations to implement recovery actions has increased.	Social capacity (existing) Social survey (new)
	20	Knowledge of the Mary River and its ecosystems requirements has increased and is evident in how people, including children, interact with the river.	
7. Create opportunities for Indigenous involvement and leadership in the recovery process and strengthen cultural connections as part of the recovery program	21	A framework for addressing cultural, economic and environmental aspirations of Indigenous people has been established by year two and plays an integral role in implementation of the recovery plan.	

8 LEGISLATION AND POLICY

8.1 Affected interests and potential contributors

The main stakeholders and other affected interests in the recovery plan include:

Australian Government
Department of the Environment
Department of Agriculture
Department of Defence

Queensland and local government
Department of Environment and Heritage Protection
Department of Natural Resources and Mines
Department of Science, Information Technology, and Innovation
Department of Agriculture, Fisheries and Forestry
Department of Energy and Water Supply
Department of State Development
Department of National Parks, Sport and Racing
Fraser Coast Regional Council
Gympie Regional Council
Sunshine Coast Council
Noosa Council

Industry organisations and private companies
Seqwater
Sun Water
Wide Bay Water

Primary industry sector groups
Queensland Dairy Farmers Organisation
Australian Macadamia Society
Gympie Beef Liaison Group
Growcom
Agforce
Canegrowers

Non-government organisations
The MRCCC
Burnett Mary Regional Group
Tiaro and District Landcare Group
Barung Landcare
Noosa and District Landcare
Lower Mary Coast and Catchment Care
Lake Baroon Catchment Care Group
Traditional Owners Working Group

Wide Bay Burnett Environment and Natural Resources Working Group
Wide Bay Burnett Environment Council
Save the Mary River Coordinating Group
The Greater Mary Association Inc.
Other Landcare organisations and neighbourhood networks that arise during implementation of the plan
Noosa and Great Sandy Biospheres and the associated management groups
Natural Resource Management regional bodies

Universities and research organisations
University of Queensland
Griffith University
Australian Rivers Institute
James Cook University
University of Sunshine Coast

Other
Landowners

8.2 Guide for management

Subject to assessment and approval processes under the EPBC Act, actions, activities and management practices should be adopted to avoid, reduce or mitigate impacts on species in the Mary River Catchment area. Before recovery activities begin, a number of general principles need to be considered. These are listed below.

- **The Mary River system is in a state of continuous change.**

Some areas of the Mary River system are relatively stable physically while some are highly unstable. Unstable areas often undergo rapid changes during flood events. The Mary River system experiences an extraordinarily wide range of stream flows, which can rise sharply within hours and vary greatly, both throughout the year and from decade to decade. While these events are naturally occurring, human intervention, like modifying the landscape has had a great effect on the river system. Therefore when making any management decisions within the river system, these decisions need to take into account that some recovery actions may be appropriate for a stable section of the river but may be totally unsuitable for another location. Similarly decisions made during low-flow conditions need to take account of the implications during flood events (and vice versa).

- **Management practices should be designed around extreme conditions and events.**

Many adverse impacts which threaten the existence of the five priority species in the Mary River can occur during times of extreme conditions, such as during extended periods of low flows, extreme floods, extreme low and high temperatures, extreme pollution loads or extreme weed infestations. Management actions which mitigate impacts of these extreme conditions should be designed appropriately and supported with sound science. Monitoring these actions could help improve their effectiveness.

- **The priority species can only exist within the fragile connected network of in-stream and riparian habitat, which occupies a very small part of the general landscape.**

Generally the Mary River has a linear downstream network with a thin band of riparian vegetation along the steam edges in most places. A relatively small area of disturbance can easily fragment the habitat required for the recovery of the priority species. When working to maintain connectivity within this habitat, recognition of the fragility of this system is important. For example stream junctions are particularly important habitat locations within the stream network.

- **Rivers and streams are flowing connected systems and management actions in one location may have significant implications for other parts of the system a long way away, upstream and downstream.**

Aquatic and riparian weeds, pests, disease organisms or pollutants introduced in one location can be rapidly distributed downstream during floods by river flows. Poorly designed road culverts can block the upstream movement of fish upstream during periods of low flow.

- **A comprehensive set of state and local government laws and codes apply to the management of riparian zones, terrestrial vegetation, fish habitat, water quality, construction work in streams and water flows.**

Any significant management intervention in the stream network will be subject to state or local government regulation or code. It is important to recognise these management guidelines and requirements which will generally enhance river health and the recovery of the priority species in this plan.

- **Local experts in the Mary River catchment area have considerable depth of knowledge and can provide assistance in best practice land management and rehabilitation actions within the Mary River and its tributaries.**

In addition to government agencies, local industry, catchment management and Landcare groups, this local expertise can provide site-specific best practice management advice. Opportunities to access technical assistance for implementing management practices which enhance stream health and implement recovery actions for the priority species in the plan should be sought.

The Mary River and Tributaries Rehabilitation Plan (Stockwell 2001) has provided a systematic planning framework for coordinating and prioritising on-ground river rehabilitation actions within the Mary River catchment since 2000. The MRCCC will continue to use this framework to support recovery actions for the priority species in this recovery plan.

8.3 Management actions checklist

The systematic five point checklist presented below provides a summary of how particular management activities can support or oppose the recovery objectives of this plan (Table 7).

Table 7: Management actions checklist

Recovery objective	Management practices
Aquatic life and ecosystem	**Supportive practices:** activities which actively enhance the reproduction, recruitment and survival of individuals, such as: turtle nest protection; hygiene protocols for reducing the risk of transfer of diseases, control of pest and weed species; education of recreational fishers; appropriate infrastructure design. **Practices to avoid:** activities which reduce reproduction, recruitment or survival of individuals within populations of the priority species, such as: recreational fishing disrupting cod nesting behaviour, fish traps which drown turtles, the setting of fishing lines, activities that may transfer the chytrid fungus into frog habitat areas, spillway structures which cause fish and turtle injury when overtopping, the illegal take of eggs and adults or the transfer of pest species such as tilapia or water weeds.
Hydrological connectivity	**Supportive practices:** activities which aim to preserve and mimic natural flow regimes (where possible). In areas where flows are altered by existing water supply schemes and infrastructure, management actions should endeavour to preserve or recreate the critical aspects of the flow regime that are required for the life cycles of the priority species. **Practices to avoid:** Activities which significantly alter the timing, quantity and velocity of natural stream flows, such as over-extraction in dry seasons, reduction of flushing flows, changing the timing of seasonal flow events, extreme drawdown of pools and impounded reaches, temporary or permanent stream diversions and barriers should be avoided.
Integrity of riparian zone Includes considerations of the riparian zone's width, longitudinal continuity, structural intactness, cover of exotic vegetation and regeneration	**Supportive practices:** activities which improve the integrity and function of the riparian zone, such as native vegetation management and enhancement, ongoing weed control, appropriate fencing and control of stock access **Practices to avoid:** Activities which fragment riparian habitat or disturb the streamside zone.

Physical river features and habitats Includes bed banks, in-stream bars, erosion sedimentation, in-stream habitat and longitudinal continuity (presence of barriers).	**Supportive practices:** activities which recognise and work with the dynamic geomorphic processes operating within the stream and floodplain, maintain connectivity between natural pool, riffle and sandbar sequences and maintain or enhance in-stream habitat diversity (including wood debris and undercut banks). **Practices to avoid:** activities which induce new bed or bank instability, break connectivity within the stream or floodplain, disrupt pool and riffle sequences or reduce important in-stream habitat structures such as undercut banks and beneficial wood.
Water quality	**Supportive practices:** activities which protect stream water quality, such as reducing contamination of runoff, maintaining effective vegetation buffers around streams and diversion and treatment of waste water away from streams. **Practices to avoid:** activities which cause a decline in water quality, such as: discharges of sediment, nutrients or toxicants from point or diffuse sources, or disturbances which alter the salinity, acidity or temperature of surface waters.

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Useful Websites

<www.environment.gov.au>

The website of the Australian Department of the Environment. Recovery plans are available for download on this website.

<www.maryriverturtle.com>

The website of the Tiaro Landcare Group

<www.mrccc.org.au>

The website of the Mary River Catchment Coordinating Committee (MRCCC).

<http://www.environment.gov.au/water/policy-programs/nwqms/wqip/index.html>

Water quality improvement plans: These identify the most cost-effective and timely projects for investment by all parties including the Australian, state and local governments, and community and environment groups.

<http://www.wettropics.gov.au/rainforest>

A website about conserving, sharing and enriching our knowledge of rainforests. Includes useful descriptions of ways to classify rainforest.

<http://www.issg.org/database/species/search.asp?st=100ss>

List of the world's 100 most invasive species published by the IUCN

APPENDIX 2: Implementation schedule

Action	Sub-action	Specific actions
Action 1: Manage threats to the priority species (Very high priority)	1.1 Undertake integrated feral animal control programs at those sites used by priority species for breeding, nesting and feeding (High priority).	
	1.2 Respond to the threat of feral aquatic animals and weed species as required (Very High priority).	1.2.1 Keep up to date with the latest control measures and monitoring techniques for feral animals (for example eDNA, genetic control options).
	1.3 Undertake Mary River turtle (*Elusor macrurus*) nest protection (Very High priority).	1.3.1 Continue protection of turtle nesting banks especially between October and January at the Tiaro, Traveston and Kenilworth nesting aggregations and protect new aggregations as they are identified. Methods used include fencing (reduction in goanna, fox and dog, cattle access) and in-situ nest protection (see (Back on Track Burnett Mary) BoT BM actions 45.1.1, 45.5.2 and 31.1.5*).
	1.4 Continue Mary River cod (*Maccullochella mariensis*) stocking program to reduce threat of low population (High priority).	1.4.1 Based on the Mary River Cod Forum (2013) - Continue the current position of 'no stocking' in the Tinana/Coondoo Creek sub-catchments. Urgently develop a monitoring program to determine the size and genetic structure of cod populations in these sub-catchments. Use this information to set sustainable levels of brood stock collection from these populations and determine how they can be best utilised in a formal breeding program. 1.4.2 Fisheries Queensland to review moratorium on stocking and, as part of this, assess the size of existing stocks and whether natural recruitment is occurring. Prior to recommencing stocking in the Mary River Catchment, the suitability of habitat where stocking will occur should be checked and included in

		the proposed cod stocking policy. The policy should apply to future stocking programs in the Mary River Catchment Dams in the Mary River Catchment. Lake Borumba, Baroon Pocket Dam and Lake MacDonald should continue to be stocked. Develop specific conditions for stocking these dams and include these in the proposed Mary River cod stocking policy. Investigate whether Mary River cod fingerlings can be calcein (fluorescent dye) marked to help monitor post-release movements and survival. If this is feasible it should be undertaken routinely at dam stocking sites in the Mary Valley. Continue stocking programs in catchments outside the Mary Valley.
	1.5 Undertake precautions to prevent the introduction and spread of chytrid fungus (Very High priority).	1.5.1 Implement strategies, on-ground works and community capacity building to reduce threat of chytrid fungus to giant barred frog (*Mixophyes iteratus*).
	1.6 Manage the impacts of unanticipated direct threats to survival as required (Medium priority).	
	1.7 Monitor the genetic fitness of Mary River cod (including Tinana Creek) populations and manage threat of failed recruitment if the risk increases (High priority).	
Action 2: Manage threats to and improve habitat quality (Very high priority)	2.1 Identify priority sites for in stream and riparian rehabilitation and undertake rehabilition at these sites (Very High priority).	2.1.1 Replant macrophytes after scouring to maintain macrophyte seed beds and re-introduce beneficial large wood.
		2.2.1 Undertake activities that support rehabilitation of giant barred frog habitat on private land, leased land and within the reserve estate.
	2.2 Manage the threat of invasive weeds at priority sites (High priority).	2.2.1 Develop and implement a coordinated landscape scale program to reduce the extent and spread of riparian vine weeds in the Mary River catchment.

		2.2.2 Implement the strategies and actions proposed in the Mary River Aquatic Weed Strategy (2009).
	2.3 Improve stream-bed stability in priority sites (based on retention of key habitat and protection of assets) (High priority).	2.3.1 Seek opportunities to incorporate bed stabilisation projects and biopassage with regular maintenance, construction and protection of bridges and roads where erosion and other processes have damaged infrastructure.
	2.4 Undertake activities that improve water quality (High priority).	2.4.1 Undertake activities to reduce sediment, nutrient and pesticide loads into water courses according to the analysis of sediment sources—for example SedNet sediment network[5], Water Quality Improvement Plans (WQIPs).
		2.4.2 Undertake prevention and management activities in line with catchment Salinity Hazard mapping and localised salinity issues.
	2.5 Improve environmental flow provision and compliance (Very High priority).	2.5.1 Identify flow regimes and refugia requirements (timing, volume depths)—that meet recovery requirements (including avoiding mortality on fishways and spillways) and incorporate into The Mary Basin Water Resource Plan (WRP) (link to BoT BM 43.2.1, 43.3.2, 43.3.3*).
		2.5.2 Support compliance monitoring and transparency regarding environmental flow provisions in The Mary Basin WRP and in EPBC Act controlled actions.
	2.6 Improve and monitor biopassage throughout the catchment (High priority).	2.6.1 Continue implementing the Burnett Mary biopassage strategy. 2.6.2 Incorporate species recovery needs into the location and design of any new in-stream infrastructure.

		2.6.3 Encourage water and infrastructure providers to operate water supply and regulation infrastructure in ways that minimise adverse impacts on river health.
		2.6.4 Initiate site-specific projects with infrastructure organisations, who maintain cross river infrastructure (for example Powerlink, Main Roads, Energex, Queensland Rail, Regional Councils), to restore/maintain habitat connectivity for priority species.
	2.7 Establish demonstration reaches that have overlapping habitat for priority species and that integrate community, cultural and ecological significance (High priority).	2.7.1 Integrate riparian and in-stream habitat protection through recognising Indigenous pathways and sites of community significance.
	2.8 Assess, and manage if required, the threat of unanticipated disturbance from human activities (High priority).	
	2.9 Integrate strategies to improve habitat into voluntary management agreements and agency land and water management procedures and plans (Medium priority).	
	2.10 Secure conservation agreements, covenants or inclusion in reserve tenure on priority sites and continue to implement voluntary management agreements, and agency land and water management procedures and plans (High priority).	

Action 3: Conduct research essential for future management (Very high priority)	3.1 Establish a baseline for river health and habitat quality (High priority).	3.1.1 Establish baseline extent of vegetated riparian zone and sand banks and bars.
		3.1.2 Develop a habitat quality guide to establish a baseline and assist in ongoing monitoring.
		3.1.3 Establish baseline extent of riparian and aquatic weeds.
		3.1.4 Assess the current level of bed stabilisation and prioritise areas for action (linked to riparian rehabilitation and habitat critical and asset protection).
	3.2 Establish integrated and ongoing monitoring programs regarding river health and link to estuarine and marine monitoring programs (Very High priority).	3.2.1 Develop and implement a survey and long-term monitoring program for Australian lungfish, Mary River cod, Mary River turtle, giant barred frog and freshwater mullet (Base freshwater mullet programs on commercial catches).
		3.2.2 Continue water quality monitoring programs, including event monitoring. Coordinate under the Mary Water Quality Improvement Plan (WQIP) to minimise duplication, and to improve and standardise parameters and reporting to the stakeholders and wider community (potentially in the form of a report card similar to healthy waterways).
		3.2.3 Utilise commercial catch data for freshwater mullet to monitoring biopassage.
		3.2.4 Ensure that all relevant data regarding species status/distribution is entered into a central database, that is WildNet, and research findings are collated at a central point, that is Queensland Government's 'The Spring' (Species Recovery Information Gateway)(–an information storage system.)

	3.3 Undertake research to determine the distribution, population status of priority species and address ecological knowledge gaps associated with these (High priority).	3.3.1 Create population model and habitat suitability maps for each species.
		3.3.2 Close key gaps in knowledge regarding cod breeding and population status.
		3.3.3 Identify cod breeding habitat requirements in the wild.
		3.3.4 Research the genetic structure of the cod population, the impact of the captive breeding program on the genetic diversity of the population and its implication for recovery.
		3.3.5 Undertake studies to better understand the life cycle and age ratio of Australian lungfish.
		3.3.6 Undertake studies to better understand the life cycle, behaviour and population size of Mary River turtle.
		3.3.7 Undertake studies to better understand habitat requirements and movement of juvenile Mary River turtles.
		3.3.8 Collection of data and observations of turtle behaviours in tributaries.
		3.3.9 Undertake long-term monitoring of turtle nest bank temperature.
		3.3.10 Determine if there are two sub-populations of wild Mary River turtles.
		3.3.11 Conduct surveys to determine giant barred frog distribution in the catchment (prioritise surveys based on potential habitat areas).

	3.4 Undertake research to determine best practice environmental flow releases and include findings in Water Resource Plan revision (Very High priority).	3.4.1 Review hydrological modeling and environmental flow objectives used in the Water Resource planning in the Mary.
		3.4.2 Install or obtain access to data from low-flow gauges.
		3.4.3 Approach Seqwater regarding data sharing of flows over the upgraded Gympie Weir and the Doppler gauge installed at Coles Crossing.
		3.4.4 Establish flow regime to trigger freshwater mullet migration and determine how this impacts on other species.
		3.4.5 Explore a 'reciprocal science' project with Indigenous groups and conventional scientists regarding freshwater mullet behaviour as freshwater mullet has specific cultural significance for local indigenous groups.
		3.4.6 Establish species-specific flow habitat requirements.
	3.5 Undertake research and monitoring regarding improved biopassage and connectivity relevant to priority species (Medium priority).	3.5.1 Continue/undertake research as to the use and requirements (engineering, design, burst speeds etc.) to improve the design of fish transfer devices for the priority species.
		3.5.2 Monitor the improvement in biopassage in response to the retrofit of the Gympie Weir and develop recommendations for future biopassage projects. Consider use of Passive Integrated Transponders (PIT) on freshwater mullet as mullet move through the entire river system from the estuary so could be a good indicator.
		3.5.3 Map and assess the impact of cross-river infrastructure (bridges, power lines, and railway lines) on connectivity within the riparian zone (particularly in relation to habitat critical).

	3.6 Utilize modeling to assess future risks to the Mary River and priority species from increased water extraction, coal and coal seam gas mining proposals and use this information to inform and implement future necessary actions as required. Respond to further identified potential threats as required. (Very High priority).	
	3.7 Identify and map all habitat critical for survival of priority species (Very high priority).	
	3.8 Identify the likely change to the extent and distribution of priority species habitat due to the impact of climate change and undertake research on the adaptation requirements of priority species due to the impact of climate change (Medium priority).	
	3.9 Undertake research to improve knowledge of the impact of native and feral predators (both terrestrial and aquatic) on the priority species (Medium priority).	3.9.1 Undertake research according to the Queensland program, Back on Track, regarding impact of feral and also natural predators on the Mary River turtle (Link to BoT BM 31.5.1; 31.5.2; 31.5.5*).
		3.9.2 Identify and trial methods for using elements of the natural predator—prey hierarchy (e.g. dingo urine) to reduce predation of Mary River turtle nests.
		3.9.3 Improve understanding of the factors that affect goanna predation of turtle eggs (for example distribution of riparian vegetation) and develop recommendations for future revegetation projects to help minimise this threat.
		3.9.4 Improve knowledge of the impact of fish stocking on the priority species, This relates to actions regarding impact of fish stocking in the Australian lungfish recovery plan .

	3.10 Undertake a social science research project to increase understanding of the secrets of success for increasing community and stakeholder participation in river recovery to enhance adoption of practices to assist in species recovery (Medium priority).	
	3.11 Undertake priority investigations as identified through adaptive management to inform recovery requirements (Medium priority).	
Action 4: Coordinate implementation (Very high priority)	4.1 Maintain the operation of the Recovery Team to track progress, enable adaptive management and advocate for improved policy and regulation to help achieve objectives 1–7 (Very High priority).	
	4.2 Operate functional sub-groups of the Recovery Team, as necessary, and in accordance with agreed Terms of Reference.	
	4.3 Integrate results of monitoring activities into the adaptive management process.	
	4.4 Prepare and implement two-year implementation plans to outline priority tasks, detail recovery plan implementation and document any changes to priorities or tasks in response to monitoring data and other new information.	
	4.5 Review implementation plans annually in light of recent monitoring data and any other new information.	

	4.6 Prepare annual reports to outline progress against implementation plans and recovery plan objectives and criteria, and to identify any changes in recovery priorities.	
	4.7 Collect, collate and report the outcomes of implementation to the MRTSRT annually (Very High priority).	4.7.1 Utilise Queensland Government's The SPRING as a repository for progress reports on implementation of this plan to facilitate sharing information between stakeholders involved in implementing this plan.
	4.8 Review the recovery plan in year 5 (Very High priority).	
Action 5: Secure resources for implementation (Very high priority)	5.1 Identify and secure funding to support implementation of two-year implementation plans (see Action 4.4) and support a paid Recovery Program Coordinator to facilitate operations of the Recovery Team, and resolution of multi-jurisdictional issues (links to Action 5.2).	5.1.1 Encourage interested parties, including community groups, to apply for funding to implement actions.
		5.1.2 Pursue non-conventional funding opportunities (i.e. corporate and philanthropy) to provide further funding streams for on-ground management.
		5.1.3 Liaise directly with water authorities (for example Sunwater, Seqwater, Wide Bay Water) to increase their contribution to catchment management.
	5.2 Form and maintain new partnerships for effective delivery, and maintain relationships with existing key delivery partners.	

Action 6: Communicate effectively with partners and engage stakeholders and the community (High priority)	6.1 Provide communication products to funding bodies to foster productive partnerships (Medium priority).	
	6.2 Develop and implement a communications plan to service the information requirements of a range of partners and stakeholders with coordinated communications products (Medium priority).	6.2.1 Increase the frequency of Mary River related stories in the media.
		6.2.2 Continue to produce *Codline* newsletter and seek support to produce multiple editions each year.
		6.2.3 Develop projects that raise awareness of priority species nationally—for example stamps and coins with local artwork of priority species and /or river. Utilise social media and online activities—for example Instagram, twitter, blogs.
	6.3 Support and reward involvement of stakeholders in implementing the recovery actions (High priority).	6.3.1 Support and encourage hands-on restoration activities, for example Wandering Weeders and Roving Restorers and participation in citizen science projects such as Waterwatch and frog monitoring.
		6.3.2 Continue to involve existing volunteers and develop a volunteer recruitment strategy to attract new local and non-local support for on-ground work on public and private land. Provide safe, supported and engaging opportunities in as many aspects of implementation as possible.
		6.3.3 Provide training and awareness-raising opportunities for staff and decision makers in regional councils about issues that are critical to species recovery.
		6.3.4 Develop and disseminate localised information and educational material targeted at the sub-catchment level.

		6.3.5 Celebrate achievements—for example completion of community projects through public festivals and events.
	6.4 Increase awareness of the general public of the links between general river health, river-bed stability, river restoration, priority species (at multiple life cycle stages) and community values (High priority).	6.4.1 Provide basic information targeted at new residents (renters, owners and leasers) to raise awareness of the catchment and increase connection with local groups. Some councils already send some information to residents.
		6.4.2 Utilise crowd sourcing and social media resources to increase awareness and connectedness to the Mary River.
		6.4.3 Make available targeted, high quality and accurate information on priority species life cycles, habitat critical issues, threats and recovery actions for a general audience.
		6.4.4 Create immersion opportunities, which are a type of learning experience where people are immersed in the ecosystem they are learning about.
		6.4.5 Increase awareness of the community that agricultural businesses ability to contribution to river recovery is impacted by economic circumstances. Use organisations such as Thank a Farmer. <http://www.thankafarmer.org/>
	6.5 Work with councils and DNPRSR to increase responsible recreation opportunities associated with the Mary River.	6.5.1 Increase access to the river by creating carefully designed and located launch pads/picnic areas, walking tracks and limiting vehicular access. Create opportunities to experience the river (for example Deep Creek Walk, Charles Street River Park Kenilworth, Queens Park Gympie, Maleny/Obi Creek boardwalk).
		6.5.2 Provide signage about species and things people can do to minimise impact at access points on the river based on the Kenilworth turtle signs.

		6.5.3 Develop and provide information packs/guidelines for recreational fishers about techniques and fishing gear that reduce impacts on threatened species.
	6.6 Provide extension services such as on-farm advice, incentives, field days and workshops on an ongoing basis (High priority).	6.6.1 Establish a mentoring program—create means for a knowledge exchange between generations.
	6.7 Increase capacity and effectiveness of local organisations involved in activities for river and threatened species recovery (High priority).	6.7.1 Training, networking and mentoring opportunities for community groups that build skills and capacity of groups to be able to deliver activities more effectively on ground and help make volunteering more attractive.
		6.7.2 Support and facilitate formation of neighbourhood and subcatchment groups.
	6.8 Strengthen involvement of schools (at all levels) in river recovery and incorporate information about the catchment and priority species into classroom activities (High priority).	6.8.1 Incorporate awareness of the river in the national curriculum by developing modules relevant to the Mary River for local schools and ensure continuity between levels of schooling (i.e. that the program follows through from prep to high school).
	6.9 Identify linkages to related plans, strategies, monitoring programs and projects and ensure that recovery plan actions complement and link with these and recovery plan actions inform future related planning (High priority).	

Action 7: Involve and engage Indigenous people (High priority)	7.1 Foster Indigenous engagement, training and employment opportunities associated with river recovery (Very High priority).	7.1.1 Explore the Cultural Connections model for application to the Mary River catchment.
		7.1.2 Develop a cultural and environmental mentor program for young Indigenous people.
		7.1.3 Expand Natural Resource Management Work Crews to cover the entire catchment (incorporate sacred sites, sacred trees, mentoring with Elders). The Burnett Mary River Group has had an indigenous Natural Resource Management work crew which only covers part of the catchment.
		7.1.4 Initiate Caring for Country projects in high schools and for young people on the dole. Link to job networks.
	7.2 Reciprocal science—sharing culture and sharing knowledge, closing the gap (Very High priority).	7.2.1 Walking the Mary River events.
		7.2.2 Back to Country camps and field trips.
		7.2.3 Projects/activities that provide healing for young people through reconnecting to country.
		7.2.4 Hold a Mary River day that is designed and run by Indigenous groups (Medium priority).
		7.2.5 Establish intellectual property protocols to safeguard knowledge that is inappropriate for the public domain and formalise process of consultation.
	7.3 Raise cultural awareness of non-Indigenous Natural Resource Management organisations and staff (High priority).	7.3.1 Employ cultural advisors (both male and female) for Mary River NRM groups.
		7.3.2 Develop guidelines and carry out induction in cultural awareness for NRM groups (best result if induction is over a couple of days over a long period e.g. Day 1, then wait a month, Day 2, then wait 3 months, then Day 3).

		7.3.3 Catchment based internships within NRM groups for Indigenous young people (both male and female) that involve strong mentoring by Elders.
	7.4 Knowledge recording according to cultural protocols—Secret, Sacred and Significant (High priority).	7.4.1 Establish an independent database for storing traditional cultural and ecological knowledge.
		7.4.2 Record authentic stories of the Mary for the future and pass these on to youth.

* Department of Environment and Resource Management. (2010). *Burnett Mary NRM Region 'Back on Track' Actions for Biodiversity,* Department of Environment and Resource Management, Brisbane.

APPENDIX 2: Species of conservation significance

Table A1.1: Species in the catchment listed in *Environment Protection and Biodiversity Act 1999* (C'wth), *Nature Conservation Act 1992* (Qld) or *Fisheries Act 1994* (Qld) that benefit from actions undertaken in the plan.

Species	**Common name**	***Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (C'wth)**	***Nature Conservation Act 1992* (NCA Act) (Qld)**
Fauna			
Adelotus brevis	Tusked frog	Not listed	V
Crinia tinnula	Wallum froglet	Not listed	V
Cyclopsitta diophthalma coxeni	Coxen's fig-parrot	E, M	E
Elusor macrurus	Mary River turtle^	E	E
Elseya albagula	White-throated snapping turtle	CE	En
Erythrotriorchis radiatus	Red goshawk	V	E
Euastacus hystorica	Giant spiny crayfish	Not listed	Not listed under NCA. 'No take' under *Fisheries Act 1994* (Qld)
Falco hypoleucos	Grey falcon	Not listed	Vn
Geophaps scripta scripta	Squatter pigeon (southern subspecies)	V	V
Haliaeetus leucogaster	White-bellied sea-eagle*	M	LC
Litoria freycineti	Wallum rocketfrog	Not listed	V
Litoria olongburensis	Wallum sedgefrog	V	V
Litoria pearsoniana	Cascade tree frog	Not listed	V
Maccullochella mariensisis	Mary River cod^	E	Not listed under NCA. 'No take' under *Fisheries Act 1994* (Qld)
Mixophyes fleayi	Fleay's barred frog	E	E
Mixophyes iteratus	Giant barred frog	E	E
Monarcha trivirgatus	Spectacled monarch*	M, Ma	SL
Nannoperca oxleyana	Oxleyan pygmy perch	E	V
Neoceratodus forsteri	Australian lungfish	V	Not listed under NCA. 'No take' under *Fisheries Act 1994* (Qld)
Pezoporus wallicus wallicus	Ground parrot	Not listed	V
Podargus ocellatus plumiferus	Plumed frogmouth	Not listed	V
Poephila cincta cincta	Black-throated finch (white-rumped subspecies)	E	E
Pseudomugil mellis	Honey blue-eye	V	V
Pseudomys oralis	Hastings River mouse	E	V

Pteropus poliocephalus	Grey-headed flying-fox	V	LC
Stictonetta naevosa	Freckled duck	Not listed	NT
Xeromys myoides	Water mouse	V	V
Flora			
Acacia attenuata	a shrub	V	V
Aponogeton elongatus subsp. Elongates		Not listed	NT
Arthraxon hispidus		V	V
Cupaniopsis shirleyana	Wedge-leaf tuckeroo	V	V
Eulophia bicallosa		Not listed	NT
Floydia praealta	Ball nut	Not listed	V
Fontainea rostrata		V	V
Fontainea venosa		V	V
Gossia gonoclada		E	E
Lenwebbia sp. (Blackall Range P.R.Sharpe 5387)		Not listed	E
Lepiderema pulchella	Fine-leaved tuckeroo	Not listed	V
Macadamia integrifolia		V	V
Macadamia ternifolia		V	V
Macadamia tetraphylla		V	V
Marsdenia hemiptera	Rusty vine	Not listed	NT
Melaleuca cheelii		Not listed	NT
Papillilabium beckleri		Not listed	NT
Plectranthus torrenticola		E	E
Ricinocarpos speciosus		Not listed	V
Romnalda strobilacea		V	V
Samadera bidwillii	Quassia	V	V
Streblus pendulinus		E	LC
Symplocos harroldii	Hairy hazelwood	Not listed	NT
Syzygium hodgkinsoniae	Red lilly pilly	V	V
Triunia robusta		E	E
Westringia blakeana		Not listed	NT
Xanthostemon oppositifolius	Southern penda	V	V

Ex — Extinct, CE — Critically Endangered, E — Endangered, V — Vulnerable, M — Migratory, Ma — Marine, NT — Near Threatened, LC — Least Concern, SL – Special Least Concern. * also associated with estuarine and marine environments
^ Endemic to the Mary River